FINAL
COMPREHENSIVE REMEDIAL INVESTIGATION REPORT
STANDARD MOTOR PRODUCTS, INC. SITE
(Site No. 2-41-016)
Long Island City, Queens, New York

Prepared for

Standard Motor Products, Inc.
37-18 Northern Boulevard
Long Island City, New York 11101

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Acronyms and Abbreviations

AOC	area of concern
AQ	aqueous blank
ARAR	applicable and relevant and appropriate requirements
ASP	Analytical Services Protocol
atm	atmosphere
ATSDR	Agency for Toxic Substances and Disease Registry
BASE	EPA Building Assessment and Survey Evaluation
BCF	bioconcentration factor
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene and xylene
CDM	Camp Dresser & McKee Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
COPC	constituents of potential concern
CPP	citizen participation plan
CSM	conceptual site model
DCA	dichloroethane
DCE	dichloroethene
DD	deep direct push
D.O.	dissolved oxygen
DUSR	data usability summary report
Eh	oxidation-reduction potential
ELAP	Environmental Laboratory Approval Program
EnviroAudit	EnviroAudit Ltd.
EPA	United States Environmental Protection Agency
FB	field blank
FD	field duplicate
Freon 113	1,1,2-trichloro-1,2,2-trifluoroethane
f_{oc}	fraction of the soil/sediment that is organic carbon
FS	feasibility study
FSP	Field Sampling Plan
GES	Groundwater & Environmental Services, Inc.
gpm	gallon per minute
GRO	gasoline-range organics
GW	groundwater
H2M	H2M Group
HASP	health and safety plan
HEAST	Health Effects Assessment Summary Tables
Hg	mercury
HHRA	human health risk assessment
HSTF	High Speed Transit Facility
I.D.	identification
ID	inner diameter
IRIS	Integrated Risk Information System

IT	IT Corporation
K_{OC}	organic carbon partition coefficient
K_d	distribution coefficient
K_{OW}	octanol-water partition coefficient
LIRR	Long Island Rail Road
LOAEL	lowest-observed-adverse-effect-level
MCL	maximum contaminant level
MEE	methane, ethene, and ethane
MRL	minimal risk level
MTA	Metropolitan Transportation Authority
MTBE	methyl *tert*-butyl ether
MW	monitoring well
n	effective porosity
NAD	North American Datum
NAVD	North American Vertical Datum
ND	non-detect
NOAEL	no-observed-adverse-effect-level
NTU	Nephelometric Turbidity Units
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OD	outer diameter
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PCA	tetrachloroethane
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PVC	polyvinylchloride
PID	photo-ionization detector
RAO	remedial-action objective
REL	reference exposure level
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
ROD	Record of Decision
SA	shallow angled direct push boring
SAP	sampling and analysis plan
SB	sub-slab
SCG	standards, criteria, and guidance
SCO	soil cleanup objectives
SD	shallow direct push
SF	slope factor
SG	soil gas
SM	building sump
SMP	Standard Motor Products, Inc.
SS	soil
SSL	soil screening level
SL	screening level

STL	Severn Trent Laboratory, Inc.
SVOC	semi-volatile organic compound
TAGM	Technical and Administrative Guidance Memorandum
TAL	Target Analyte List
TB	trip blank
TBC	to be considered
TCA	trichloroethane
TCE	trichloroethene
TCL	Target Compound List
TCLP	toxicity characteristic leaching procedure
TEL	tetraethyl lead
TML	tetramethyl lead
TOC	total organic carbon
TOGS	Technical and Operational Guidance Series
TPH	total petroleum hydrocarbon
TSD	treatment, storage, and disposal
UCL	upper confidence limit
UR	unit risk
USGS	United States Geological Survey
UST	underground storage tank
UV	ultraviolet
v	velocity
VC	vinyl chloride
VI	vapor intrusion
VOC	volatile organic compound

Unit of Measure

^{o}F	degree Fahrenheit
atm	atmosphere
ft	feet
g	gram
L	liter
mg	milligram
kg	kilogram
ml	milliliter
mm	millimeter
mol	mole
µg	microgram
m^3	cubic meter

Section 1
Introduction

Camp Dresser & McKee Inc. (CDM) is submitting on behalf of Standard Motor Products, Inc. (SMP) this Comprehensive Remedial Investigation (RI) Report in accordance with the March 30, 1998 Order on Consent Index (No. W2-0807-96-10) between New York State Department of Environmental Conservation (NYSDEC) and SMP. This Order on Consent stipulates requirements for the development and implementation of a Remedial Investigation/Feasibility Study (RI/FS) for the SMP site located at 37-18 Northern Boulevard in Long Island City, New York (herein referred to as the "Site"). The Order on Consent requires the development of all documents in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of March 8, 1990 [40 C.F.R. Part 300], the United States Environmental Protection Agency (EPA) guidance document entitled "*Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*", dated October 1988 (EPA 1988), and any subsequent revisions to that guidance document. The Comprehensive RI was also developed in accordance with the recent New York State guidance entitled "*Draft DER-10 Technical Guidance for Site Investigation and Remediation*", dated December 2002 (NYSDEC 2002) and "*Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York*", dated October 2006 (NYSDOH 2006).

This RI Report details the results of four phases of field investigations conducted between August 2000 and February 2008, evaluates the nature and extent of contamination, and qualitatively assesses the risks to human health posed by exposure to contaminated media. The RI Report was prepared and the field investigations were conducted, in accordance with the following documents:

- Final Work Plan dated August 25, 2000 (IT Corporation [IT] 2000)
- Field Sampling Plan (FSPP) dated September 16, 2002 (Groundwater & Environmental services, Inc. [GES] 2002a)
- Project Plan Addendum A dated May 26, 2003 (GES 2003)
- Project Plan Addendum B dated August 5, 2005 (CDM 2005)
- Project Plan Addendum C dated April 6, 2007 as modified by the December 10, 2007 Comprehensive Comment/Response Package (CDM 2007)

The Final Work Plan, Final SAP, and Project Plan Addendums A, B, and C were prepared in accordance with the March 30, 1998 Order on Consent.

1.1 Scope and Objectives

In general, the RI consists of two primary tasks: data collection, and data evaluation. Data collection includes completion of borings, installation of wells, installation of soil vapor and sub-slab vapor ports, and sampling and analysis of soil, soil vapor, sub-slab vapor, indoor and ambient air, and groundwater. Data evaluation includes an assessment of the nature and extent of contamination, fate and transport of contaminants, and a qualitative human health risk assessment. These tasks, along with conclusions and recommendations, are described in detail in this report.

The primary objectives of the RI are to characterize the nature and extent of contamination and identify areas that pose an unacceptable risk to human health and the environment. As stipulated in the project plans referenced above, the field investigation for the SMP RI/FS was conducted in a phased approach.

The Phase I Investigation, completed in November 2002, includes the collection of soil samples using hand augers and direct push drilling to delineate the nature and extent of soil contamination. Groundwater samples were also collected via direct push drilling during the Phase I Investigation. The results of the Phase I Investigation were utilized to determine the locations for the screened interval depths and the placement of groundwater monitoring wells.

The major objectives of the Phase I Field Investigation were the following:

- Determine the nature and extent of soil contamination in the vicinity of the loading dock located along the south side of the SMP building
- Determine if groundwater contamination exists in the vicinity of the loading dock and beneath the SMP building
- Determine where permanent monitoring wells should be located based upon the results of the direct push investigation

The Phase II Investigation, completed in June and July 2003, includes the installation of eight new monitoring wells at five locations. All eight new monitoring wells, one existing interior monitoring well, and one sump were sampled during the Phase II Investigation.

The major objectives of the Phase II Field Investigation were the following:

- Install monitoring wells at locations and with screened intervals as determined from the results of the Phase I Field Investigations
- Determine groundwater flow direction and characteristics
- Delineate any existing groundwater contamination emanating from the "hot spot" in the vicinity of the loading dock located along the south side of the SMP building
- Gather sufficient data to perform a qualitative human health exposure assessment
- Gather data to adequately evaluate remedial alternatives

The Phase III Investigation, conducted in September 2005 and March 2006, includes two sampling rounds of all existing monitoring wells and one round of soil gas, sub-slab vapor and indoor and ambient air sampling.

The major objectives of the Phase III Field Investigation were the following:

- Delineate and evaluate the nature and extent of the soil gas and sub-slab vapor contamination
- Determine if there is a potential for vapor intrusion into the SMP building
- Confirm the initial monitoring well sampling results collected during the Phase II investigation by performing two additional rounds of monitoring well sampling

The Phase IV Investigation, completed in January and February 2008, includes the installation of four new monitoring wells at three locations and installation of sixteen sub-slab vapor ports and twelve soil gas ports. All existing and new monitoring wells and soil gas and sub-slab ports were sampled during the Phase IV investigation. In addition, direct push groundwater and soil samples were collected during the Phase IV Investigation.

The major objectives of the Phase IV Field Investigation were the following:

- Delineate and evaluate the nature and extent of soil gas, sub-slab vapor, and groundwater contamination present underneath the onsite structure
- Confirm the "hot spot" location in the vicinity of the loading dock located along the south side of the SMP building by performing soil borings, groundwater sampling, and soil vapor sampling
- Gather enough data to adequately evaluate remedial alternatives

1.2 Site Background

The following sections describe the site location, site description and history, and a summary of previous investigations.

1.2.1 Site Location

The SMP property is in the northwestern section of Queens County, New York (Figure 1-1) and is located at 37-18 Northern Boulevard in Long Island City, New York (Figure 1-2). The property was owned and operated by SMP until March 2008 and is located in an urban and industrial area. The property is approximately rectangular in shape and occupies approximately one acre of land (Figure 1-3). The property contains a large, six-story, industrial building with approximately 42,000 square feet per floor. The building occupies most of the property and SMP is the major occupant of the building. SMP manufactured car parts until March 2008 at this facility, and it is the SMP corporate headquarters.

Bordering the Site is Northern Boulevard to the north; Sunnyside Freight Railroad Yard (Sunnyside Yard) to the south; 39th Street, an automobile dealership, and a Hess (formerly Merit) gasoline station to the east; and commercial and industrial properties to the west. Various industrial and commercial properties are located across from SMP on Northern Boulevard. A narrow strip of land on the south side of the property contains a loading dock and a dirt access path for vehicles. This strip of land is owned by the Metropolitan Transportation Authority (MTA) and is part of a lease to SMP. Contamination has been identified in the soil adjacent to the loading dock. Thus, the Site includes the SMP property and the adjacent strip of land where contamination has been identified. This adjacent area is mostly dirt and gravel covered with some concrete remaining from a nearby road-paving project. Access to this area is limited. The means of access to this area is from doors at the rear of the SMP building, and a locked access gate surrounding the perimeter of the leased strip of land. A highly industrialized area with a wide variety of activities ranging from small-scale assembly to large-scale manufacturing is located within the general vicinity of the Site.

1.2.2 Site Description and History

The Site has historically been involved in industrial and manufacturing activities since 1919 (EnviroAudit 1996). SMP has occupied the on-site building since the mid-1900s. S. Karpen & Brothers occupied the building prior to that time.

SMP maintained a small plating line for chrome plating of small machine parts from approximately 1975 to 1984. The wastes generated from the chrome plating process were temporarily stored on-site prior to off-site disposal. In addition, SMP was previously engaged in painting automobile parts prior to distribution. In 1984, aqueous based paints replaced the previously used solvent-based paints. All painting operations were gradually eliminated between 1990 and 1991. SMP performed several other processes that also generated hazardous wastes. These included die-casting operations that ceased in the 1970s; rubber production that was eliminated around 1985; and degreasing which utilized chlorinated solvents that ended in 1990.

Until March 2008, SMP produced automobile parts and components at the Long Island City facility primarily in the basement within recent years. The manufacturing operations included metal fabrication and machining, plastic injection molding, and assembly. SMP also operated a small photography laboratory for production of newsletters, brochures, etc. Hazardous or toxic materials involved in plant operations are lubricating oils for machinery, caustics for degreasing, phenolics used in molding processes, epoxies for coil production, and water-based inks involved in their small-scale printing. All wastes were temporarily stored on-site in secure containers prior to off-site disposal at a licensed treatment, storage, and disposal (TSD) facility.

The building and associated property was sold by SMP in March 2008 to XEXII Northern Boulevard Acquisition, LLC, who will continue to operate this facility as commercial office space. SMP continues to occupy most of the office space within this building.

1.2.3 Summary of Previous Investigations

Several studies have been conducted at the Site or at adjacent sites (i.e., Sunnyside Yard and the Hess [formerly Merit] gasoline station). These previous investigations are summarized in the following sections.

1.2.3.1 Summit Environmental Evaluations, Inc.

Following the observation of an oily sheen in a puddled area in the southeast side of the Site off the loading dock, a preliminary investigation was initiated by Summit Environmental Evaluations, Inc. in September 1990. An area of approximately 2,700 square feet (30 feet by 90 feet) was excavated to a depth of 1 to2 feet. The excavated soils (approximately 4,050 cubic feet) were either stockpiled or placed in roll-off containers located along the loading dock (Figure 1-4). Analysis of soil samples collected on October 11, 1990, indicated that this area contained elevated levels of petroleum hydrocarbons and volatile organic compounds (VOCs), particularly 1,1,1-trichloroethane (TCA).

Based on the elevated levels of VOCs, Summit Environmental Evaluations, Inc. recommended remediation of the soils via high temperature incineration at a TSD facility (Summit Environmental Evaluations, Inc. 1990).

1.2.3.2 Public Service Testing Laboratories, Inc.

Subsequent to the Summit Environmental Evaluations, Inc. investigation, SMP contracted Public Service Testing Laboratories, Inc. to conduct additional analyses on the soil. Analyses were conducted for toxicity characteristic leaching procedure (TCLP) metals, VOCs, and semi-volatile organic compounds (SVOCs). The results of these additional analyses indicated non-detectable levels of VOCs. However, levels of lead detected from TCLP analyses yielded results above the hazardous toxicity thresholds in three of the five samples. Public Service Testing Laboratories, Inc. recommended disposal of the soils as a hazardous waste.

1.2.3.3 H2M Group Soil Investigation

In early 1991, H2M Group (H2M) conducted an assessment of the soil quality in the area off the loading dock. This assessment included a soil gas survey and analysis of additional soil samples. The results of this assessment are documented in the "*Soil Investigation Report*" prepared by H2M Group in 1991. The soil gas survey included 50 test points covering an area of approximately 10,000 square feet (Appendix A). A photo-ionization detector (PID) was used to screen the soil for VOCs. The highest concentrations were found immediately adjacent to the loading dock. In addition, an oily sheen was noted in the flooded excavation on the west side of the study area during the soil gas survey. Eleven soil samples were collected based on the results of the soil gas survey and visual inspections. Six samples were collected from the stockpiled soils and five (two on-site and three off-site background) samples were collected from undisturbed soils. Soil samples were collected at a depth of 18 inches below grade. These samples were analyzed for total petroleum hydrocarbons (TPH), VOCs, lead, and TCLP lead. Elevated levels of TPH and VOCs were found in the stockpiled soils and in the undisturbed soils off the loading dock in the south eastern portion of the Site. Though TPH and VOCs were also detected in background samples, the concentrations were up to three orders of magnitude less than those detected in the stockpiled soils and near the eastern portion of the loading dock. Based on the results, H2M reported that the soils could be classified as an environmental media contaminated with a listed hazardous waste and not as a hazardous waste. However, because contamination in non-excavated soils had also been found, H2M recommended further delineation of the impacted area, and remediation via soil vapor extraction either *in-situ* or in soil venting piles (H2M 1991).

1.2.3.4 H2M Remedial Investigations

Later in 1991, H2M began an RI in order to determine the nature, type, and physical state of soil and/or groundwater contamination associated with the operation of the SMP facility. Groundwater and soil samples were collected through the installation of six monitoring wells and thirteen soil borings in the eastern half of the Site. The results of this investigation are documented in the *"Remedial Investigation Report"* prepared by H2M in 1992.

Forty soil samples were collected at depths ranging from 5 to 40 feet below grade and were analyzed for VOCs. In addition, select samples were analyzed for TPH and TCLP metals. Total VOC concentrations were as high as 35 milligrams per kilogram (mg/kg) (Appendix B). The most prevalent compounds detected in the shallow soil samples (above 7 feet) were chlorinated solvents, such as 1,1,1-TCA, tetrachloroethene (PCE), methylene chloride, and trichloroethene (TCE). Results indicated that soil contamination existed along the loading dock from the suspected source area near the southeast corner westward for approximately 200 feet and southward for approximately 15 to 20 feet. Though most chlorinated solvent contamination was found at shallow depth, elevated levels of benzene, toluene, ethylbenzene, and xylenes (BTEX) were detected at depths greater than 10 feet (beneath the water table) which could have originated from the upgradient Hess (formerly Merit) gasoline station site.

Of the six monitoring wells installed, four were along the loading dock and two were located inside the northwest portion of the SMP building (Appendix B). Groundwater level measurements indicated a northerly direction of groundwater flow that was contradictory to the general regional groundwater flow direction which is south to southwest, according to a 1981 United States Geological Survey (USGS) regional map. The differences in groundwater flow direction were presumed to be due to a sump pump that operates continually in the SMP basement to prevent flooding, as well as potential dewatering operations in the local subway system and other nearby buildings (H2M 1992). Subsequent to the H2M RI, the remedial investigation of the adjacent Sunnyside Yard has documented groundwater flow from the east to the west.

Groundwater samples were collected from the wells and analyzed for VOCs, TPH, and metals. Several metals and VOCs were found to exceed the NYSDEC groundwater standards in effect in 1991. VOCs ranged from non-detect to 2,600 micrograms per liter (µg/L) for xylenes. Xylenes are a BTEX constituent which could have originated from the upgradient Hess (formerly Merit) gasoline station site. Chlorinated solvents were also detected to a lesser extent. Metals detected in groundwater samples included iron, manganese, sodium, lead, chromium, copper, and zinc (H2M 1992).

The 1992 RI report determined that unacceptable risks were unlikely from exposure to contaminated soils and that there is no exposure to groundwater. Therefore, No Action with site controls (e.g., paving and additional fencing) and continued groundwater monitoring was recommended in lieu of remediation.

1.2.3.5 EnviroAudit Ltd.

In 1995, EnviroAudit Ltd. (EnviroAudit) conducted an investigation of surface and subsurface soils at the site and of the groundwater conditions within the upper aquifer. This investigation included the drilling of 15 soil borings with two borings completed as groundwater monitoring wells, collection and analysis of forty-four soil samples, and collection and analysis of three groundwater samples and two sump samples. The results of this investigation were documented in "*A Phase II EnviroAudit Subsurface Investigation and Summary Report of an Industrial Property Located at 37-18 Northern Boulevard in Long Island City, New York*", prepared by EnviroAudit in 1996.

Elevated levels of VOCs were found in the area of the loading dock, in site soils and groundwater (Appendix C). The primary compounds detected in excess of clean-up guidelines in effect in 1996 were 1,1,1-TCA, 1,1-dichloroethane (DCA), and TCE. Lead was only detected at low levels using the TCLP analysis (EnviroAudit 1996).

1.2.3.6 Sunnyside Yard Remedial Investigations

The Sunnyside Yard is a train makeup and maintenance facility that is located south and west of the Site (Appendix D). It is listed as a Class II Site in the NYSDEC Registry of Inactive Hazardous Waste Disposal Sites (Site Number 2-41-016), and has been the subject of a remedial investigation since 1989. Due to the proximity of the Sunnyside Yard to the Site, the previous investigations at the Sunnyside Yard are relevant to this RI because they concern groundwater in the vicinity of and potentially downgradient of SMP.

The Sunnyside Yard was subdivided into the following six operable units (OUs) in order to address remedial efforts and accommodate construction schedules at The Sunnyside Yard (Appendix D):

- Operable Unit 1: OU 1 is designated as the soils above the water table within the footprint of the High Speed Transit Facility (HSTF) Building.
- Operable Unit 2: OU 2 is designated as the soils above the water table within the footprint of the HSTF ancillary structures.
- Operable Unit 3: OU 3 is designated as the soils and separate-phase petroleum above the water table in the area of highest contamination.
- Operable Unit 4: OU 4 is designated as the soils above the water table in the remainder of the Sunnyside Yard.

- Operable Unit 5: OU 5 is designated as the sewer system beneath The Sunnyside Yard.
- Operable Unit 6: OU 6 is designated as the saturated soils and the groundwater beneath The Sunnyside Yard.

To date, investigations at OU 1 and OU 2 have been accelerated and Records of Decision (ROD) have been issued in order to proceed with the construction of the HSTF which has now been completed. The investigation at OU 3 has been completed and a ROD has been finalized. Currently, investigation for OU 4 has been initiated and is in the RI stage of the RI/FS process. The investigation at OU 5 has not been initiated. The field work for OU 6 has been completed during the late spring of 2008 and the Draft RI is anticipated in the fall of 2008. OU 5 and OU 6 are the OUs that are particularly relevant to the investigation at the Site.

OU 5 was designated as the sewer system beneath the Sunnyside Yard. The sewer system is a combined sewer system, receiving septic only from historical buildings on the Site which are no longer in use. Thus, the sewer system is primarily a storm sewer that drains surface runoff primarily from the Sunnyside Yard. A portion of this storm sewer runs behind the SMP facility. There are three manholes located adjacent to the SMP facility that are connected by a round brick 42-inch conduit that was built around 1908 or 1912 (Roux Associates, Inc. 2002). To date, the investigation for OU 5 has not been initiated, and thus, any potential contamination within these sewers has not been determined.

OU 6 was designated as the groundwater OU and included the saturated soil beneath the Sunnyside Yard. Several RI Reports have been issued to date for OU6; however, the most comprehensive RI Report is anticipated to be developed in the fall of 2008. Previous groundwater investigations of the Sunnyside Yard are discussed in this section since the most comprehensive RI is currently not available.

A Phase I Remedial Investigation (Roux Associates, Inc. 1992) was conducted in 1990 and 1991. The results of the Phase I RI shallow groundwater monitoring indicated the following:

- No VOCs or SVOCs were detected above standards
- Only a limited number of SVOCs, predominantly polycyclic aromatic hydrocarbons (PAH), were detected
- Polychlorinated biphenyls (PCBs) were detected in only one monitoring well, which also contained separate-phase petroleum
- Iron, lead, manganese, and sodium were detected above the NYSDEC standards in most samples, which is typical for background conditions in industrialized urban environments with historical saltwater intrusion

Subsequent investigations of the groundwater were conducted to further delineate the extent of contaminants, determine if migration of contaminants in groundwater is occurring either on-site or off-site; and develop additional information regarding groundwater flow characteristics. These were reported in the previous OU 6 RI Report (Roux Associates, Inc. 1999) and are summarized below.

Several VOCs, including BTEX, chlorinated solvents, styrene, carbon disulfide, and 4-methyl-2-pentanone, were detected in groundwater. Chlorinated solvents were detected in monitoring wells adjacent to the Site and west (i.e., downgradient) of the Site. The concentrations of *cis*-1,2-dichloroethene (*cis*-1,2-DCE), TCE, and PCE are presented in Figure D-1 of Appendix D for these wells and generally show a decrease over the sample collection period. Though groundwater flows westward from the Site, the water table is nearly flat in the vicinity of SMP, indicating that the detected VOCs in these wells on the Sunnyside Yard may be due to groundwater contamination at SMP.

Several SVOCs were also detected in the Sunnyside Yard groundwater samples. Due to the proximity of the wells containing SVOCs to the separate-phase petroleum plume at the Sunnyside Yard, these detections are likely due to that plume. Several metals were also found at concentrations above local background concentrations.

1.2.3.7 Hess (formerly Merit) Gasoline Station

The Hess (formerly Merit) gasoline station (Hess Station) is an active retail gasoline station with a one-story building, car wash, and kiosk. It is located east of the Site and was the subject of an environmental investigation (GES 1998). In 1995, five underground storage tanks (USTs) at the Hess Station were decommissioned and removed while two additional USTs were decommissioned by abandonment in place. A subsurface investigation as part of the site investigation was performed. The main objective of this investigation was to define the vertical and horizontal extent of the hydrocarbon impact detected during the post-excavation sampling. Four monitoring wells were drilled at the Hess (formerly Merit) site in 1996 to assess groundwater quality. Soil samples were analyzed for BTEX, methyl *tert*-butyl ether (MTBE), and gasoline-range organics (GRO). Groundwater samples were analyzed for BTEX, MTBE, and TPH. The highest concentrations of contaminants in groundwater were detected in the northeast section of the Hess Station near the former location of the larger USTs. The lowest concentrations were detected in the southeast section of the Hess Station, and concentrations were intermediate in the northwest and southwest sections of the Hess Station. BTEX concentrations ranged from below detection limits in the southwest section of the site to a maximum of 1,110 µg/L benzene; 11,600 µg/L toluene; 4,250 µg/L ethylbenzene; and 20,500 µg/L xylenes. MTBE concentrations in groundwater ranged from 11.4 µg/L to 8,770 µg/L. TPH concentrations in groundwater ranged from below detection limits to 8,400 µg/L. BTEX concentrations in groundwater at the Hess Station were significantly greater than concentrations detected on the Site. Selected figures and tables from the Site Investigation Report (GES 1998) are presented in Appendix E.

1.3 Organization of the Report

This RI Report is comprised of eight sections. The following identifies the organization of the report and the contents of each section.

Section 1: Introduction. This section provides the background information regarding the project scope and objectives; the Site background including the Site location, description and history, summary of previous investigations, and the organization of this RI report.

Section 2: Study Area Investigation. Section 2 details the field activities associated with each of the four phases comprising the field investigation for this RI/FS. The Phase I Investigation included the collection of soil and groundwater samples via direct push boring and hand auguring. The results of the Phase I Investigation were utilized to locate permanent monitoring wells to collect high quality groundwater data. The Phase II Investigation included installing and sampling new and existing permanent monitoring wells. The Phase III Investigation included two rounds of monitoring well sampling, as well as one round of soil gas and sub-slab vapor sampling. The Phase IV Investigation included direct push groundwater and soil sampling, monitoring well sampling, and soil gas and sub-slab vapor sampling.

Section 3: Physical Characteristics. The physical characteristics of the study area and surrounding environment are described in Section 3. Demography and land use, metrology, surface features, regional and site-specific geology, and hydrogeology are discussed in this section. The goal of this section is to gather sufficient data to evaluate potential transport pathways and receptors.

Section 4: Nature and Extent of Contamination. This section presents data quality management, approach to evaluation of contamination, assessment of soil quality in Phase I and IV investigations, assessment of groundwater quality in all four phase investigations, and assessment of soil vapor quality in Phase III and IV investigations.

Section 5: Contaminant Fate and Transport. This section identifies the potential migration pathways of the contaminants and evaluates the chemical and physical properties of those constituents whose concentrations exceed screening levels. These data are used to evaluate the environmental fate and transport mechanisms of contaminants. A conceptual site model is also presented in this section.

Section 6: Exposure Assessment. Section 6 discusses qualitatively the potential adverse human health impacts due to exposure to the contaminants in environmental media in the absence of any actions to control or mitigate the releases.

Section 7: Summary and Conclusions. This section summarizes the significant conclusions of the RI Report, identifies any gaps in the data, makes recommendations for future work, and preliminarily identifies remedial action objectives.

Section 8: References. A complete list of the references cited in the RI Report is presented in this section.

Section 2
Site Investigation

This section describes the field tasks, drilling, sampling, and testing associated with each of the four phases of the field investigation for this RI/FS.

2.1 Phase I Field Investigation

The Phase I Field Investigation was mobilized by GES on November 4, 2002 and demobilized on November 15, 2002. The Phase I Field Investigation consisted of the collection of surface soils via hand auger and a direct push investigation during which both soil and groundwater samples were collected (Figure 2-1). The objectives of the investigation were to characterize the nature and extent of contamination and to identify areas that pose an unacceptable risk to human health and the environment. Boring logs for the direct push borings are presented in Appendix F.

2.1.1 Soil Investigation

During the Phase I Field Investigation, surface soil samples were collected utilizing a hand auger, and subsurface soil samples were collected via direct push drilling. A total of 89 soil samples were collected from five surface soil sampling locations, 21 vertical direct push locations, and 6 angled direct push sample locations in order to determine the nature and extent of soil contamination beneath the Site (Figure 2-1).

The 21 vertical direct push soil sample locations consisted of the following:

- Eleven shallow direct push soil sample locations (SD05, SD07, SD08, SD14, SD15, SD18 through SD22, and SD24)
- Five deep direct push soil sample locations (DD06, DD10, DD12, DD16, and DD17)
- Five deep direct push soil and groundwater sample locations (DD09, DD11, DD13, DD23, and DD25)

The six angled direct push sample locations consisted of the following:

- Six angled direct push soil and groundwater sample locations (SA01 through SA06)

All soil samples were analyzed for Target Compound List (TCL) VOCs (Table 2-1). In order to facilitate the evaluation of remedial alternatives, 10 percent of the samples were analyzed for TCLP organic compounds and metals and 20 percent of the samples were analyzed for total organic carbon (TOC), grain size, and four rubber manufacturing compounds (i.e., aniline, benzothiazole, *N*-nitroso-di-*N*-propylamine, and phenothiazine). In addition, eight surface soil samples (0-1 foot depth) in the area of the excavated soils and stockpiled soils were analyzed for TCLP lead.

2.1.1.1 Surface Soil Sampling Locations

Five surface soil samples, SS01 through SS05, were collected via hand auger in the vicinity of the previously excavated soils and the "hot spot" area adjacent to the loading dock (Figure 2-1). Of these five surface soil samples, two were located at the fringe of the "hot spot" area adjacent to the loading dock.

2.1.1.2 Direct Push Soil Sampling Locations

A total of 78 soil samples were collected from the following direct push soil sampling locations (Figure 2-1):

- 22 soil samples from the 11 shallow direct push locations
- 44 soil samples from the 10 deep direct push locations
- 12 soil samples from the 6 angled direct push locations

The shallow, deep, and angled direct push sampling programs are described below.

2.1.1.2.1 Shallow Direct Push Soil Sampling

A total of 11 shallow direct push soil borings (SD05, SD07, SD08, SD14, SD15, SD18 through SD22, and SD24) were drilled, and 2 soil samples per location were collected for a total of 22 samples. These shallow borings were located within both the "hot spot" area and the previously excavated soil area since both areas contain surface contamination. Shallow borings have been utilized to characterize both the center and the fringes of the previously excavated soil area. Shallow borings have also been used to characterize only the fringes of the "hot spot" area since the center of the "hot spot" requires deeper sampling.

The shallow vertical soil borings were advanced using a direct push drill rig equipped with a dual tube sampler. Subsurface soils were collected from approximately 0-1 foot below grade and across the water table which occurs at a depth of approximately 5-7 feet below grade. Continuous sampling was conducted during the installation of the shallow direct push borings for geological logging of the borehole.

2.1.1.2.2 Deep Direct Push Soil Sampling

A total of 10 deep direct push soil borings (DD06, DD09 through DD13, DD16, DD17, DD23, and DD25) were drilled, and 5 soil samples per location, except DD11 (4 samples), DD12 (4 samples), and DD16 (1 sample), were collected for a total of 44 samples. The soil samples were collected at depths of approximately 0.5, 6, 11, 16, and 21 feet (ft) below grade surface (bgs). The four samples at DD11 were collected at depths of approximately 0.5, 6, 16, and 21 ft bgs. The four samples at DD12 were collected at depths of approximately 0.5, 11, 16, and 21 ft bgs. The one sample at DD16 was collected at 0.5 ft bgs.

Continuous sampling was conducted during the installation of seven of the ten deep direct push borings for geological logging of the borehole. Eight out of ten of these deep borings were located primarily within the center and around the fringes of the "hot spot" area located adjacent to the loading dock. The placement of these eight deep borings was intended to characterize the center of the "hot spot" as well as the southern, eastern, and western fringes of the "hot spot". Deep borings were installed in this location primarily for two reasons. First, deep borings were necessary to determine the vertical extent of the chlorinated volatile organic contamination in the area of the hop spot. Second, deep borings were necessary to determine the extent and source of non-chlorinated BTEX contamination. Since elevated levels of the BTEX contamination have primarily been detected beneath the water table interface, the source of this contamination is suspect, and an off-site upgradient source may be responsible.

Both shallow and deep characterization within this area is necessary to examine the relationship between the shallow chlorinated solvents and the deeper non-chlorinated BTEX contamination. The last two deep borings were placed under the bridge in the most upgradient on-site location to aid in the determination of background levels of BTEX potentially emanating from upgradient sources.

2.1.1.2.3 Angled Direct Push Soil Sampling

A total of 6 angled direct push borings (SA01 through SA06) were drilled, and 2 soil samples per location were collected for a total of 12 samples. These angled borings were located within the "hot spot" area and the previously excavated soil area since the contamination in both areas may have extended under the loading dock in the northern direction. Along the loading dock, 6 soil borings were advanced at approximately a 45-degree angle toward the SMP building to determine whether subsurface soil contamination may be present under the loading dock of the SMP building. Soil samples were collected at effective depths of approximately 6 and 11ft bgs extending under the loading dock. Continuous sampling was not conducted at the locations of the angled direct push borings.

2.1.2 Groundwater Investigation

A total of 23 direct push groundwater samples were collected from the Site in order to aid in the determination of the nature and extent of groundwater contamination and to determine the optimum placement of permanent monitoring wells. These 24 direct push groundwater samples were collected from the following locations (Figure 2-1):

- 17 groundwater samples from the 9 deep direct push locations (DD01 through DD04, DD09, DD11, DD13, DD23, and DD25)

- 6 groundwater samples from the 6 angled direct push locations (SA01 through SA06)

All groundwater samples were analyzed for TCL VOCs and the eleven shallow groundwater samples collected in the "hot spot" area (SA01 through SA06, DD09, DD11, DD13, DD23, and DD25) were also analyzed for aniline, a rubber manufacturing compound (Table 2-2).

2.1.2.1 Deep Direct Push Groundwater Sampling

A total of nine deep direct push groundwater borings were drilled and two groundwater samples per location, except DD02, were collected for a total of 17 samples. Three of these deep direct push groundwater locations (DD09, DD13, and DD11) were located primarily within the center and around the fringes of the "hot spot" area located adjacent to the loading dock. The placements of these three deep borings were intended to characterize the southern, eastern, and western fringes of the "hot spot". Deep borings were taken in this location primarily for two reasons. First, deep borings were necessary to determine the vertical extent of the chlorinated VOC contamination in the area of the hop spot. Second, deep borings were necessary to determine the extent and source of non-chlorinated BTEX contamination. Since elevated levels of the BTEX contamination had primarily been detected significantly beneath the water table interface, the source of this contamination is suspect and an off-site upgradient source may be responsible.

Both shallow and deep characterization within this area was necessary to examine the relationship between the shallow chlorinated solvents and the deeper non-chlorinated BTEX contamination. The two deep borings (DD23 and DD25) were drilled beneath the 39th Street Bridge in the most upgradient on-site location to aid in the determination of background levels of BTEX emanating from potential upgradient sources. The last four deep groundwater borings (DD01, DD02, DD03, and DD04) were installed to determine the groundwater quality in the downgradient southwestern direction and to aid in the placement of permanent monitoring wells MW12 and MW13.

2.1.2.2 Angled Direct Push Groundwater Sampling

A total of six angled direct push borings were drilled, and one groundwater sample per location was collected for a total of six samples. These angled borings were located within both the "hot spot" area and the previously excavated soil area since the contamination in both of these areas may have extended under the loading dock in the northern direction. Along the loading dock, six borings were advanced at approximately a 45-degree angle toward the SMP building to determine whether groundwater contamination was present under the loading dock of the SMP building. Groundwater samples were collected at an effective depth of approximately 6 feet below grade.

2.1.3 Sample Location and Site Survey

A site survey was performed at the Site to locate all monitoring wells and sample points. A New York State licensed surveyor performed all surveying. This information was utilized to plot the monitoring wells and sample points on figures contained within this report. The field measurements are oriented according to existing benchmarks around the Site.

The minimum precision for locating each monitoring well and the traverse baseline is 0.5 ft horizontal distance, 0.01 ft vertical distance, and to the nearest 10 seconds for horizontal angle. Each well casing was marked where the elevation was established.

2.2 Phase II Field Investigation

Based on the analytical data collected during the Phase I Field Investigation, locations were selected for the installation of permanent groundwater monitoring wells. Three deep/shallow monitoring well clusters: MW09, MW11, and MW13, and two additional shallow monitoring wells: MW10 and MW12, were installed during the Phase II Field Investigation by GES. The monitoring wells were installed and developed between July 7, 2003 and July 11, 2003. Monitoring well boring logs are presented in Appendix F. Following installation and monitoring well development, groundwater sampling and aquifer testing activities were completed. The aquifer was allowed to equilibrate for 14 days after the completion of monitoring well development activities. Groundwater samples were collected on July 28, 2003 from newly installed monitoring wells MW09 through MW13, the existing building sump, and existing monitoring well MW06. Two aquifer tests were performed on each newly installed monitoring well on July 29 and July 30, 2003. The Phase II Field Investigation activities are described in further detail in the following sections.

2.2.1 Monitoring Well Installation

Eight monitoring wells in five locations were installed during the Phase II Field Investigation. The five locations were selected based on the results of the soil and groundwater samples from the Phase I Field Investigation. The five monitoring well locations include three cluster well locations (MW09, MW11, and MW13), consisting of a shallow and deep well, and two single well locations (MW10 and MW12) consisting of only a shallow well (Figure 2-1).

MW09 was installed cross gradient (south) from the “hot spot” to determine the extent of the cross gradient diffusion of contaminants. The selected location approaches the farthest southern point that can be monitored without infringing on the High Speed rail lines. MW09 is a cluster well consisting of a shallow and deep well.

MW10 is a single shallow well and is located at the farthest upgradient location within the Site. Its location is essential in determining the immediate upgradient shallow groundwater quality. This monitoring well was installed adjacent to soil sample DD23 since this sample contained the highest BTEX concentration. In addition, MW10 is located adjacent to the most hydraulically upgradient portion of the sewer line that was behind the SMP property and is within close proximity to the storm water drain spout draining the 39th Street Bridge.

MW11 is located in the center of the “hot spot” as defined in Section 4. This monitoring well location monitors the “hot spot” as defined by the Phase I Field Investigation results. MW11 is a cluster well consisting of a shallow and deep well to provide data regarding the vertical extent of groundwater contamination that can be monitored in the “hot spot” area.

MW12, a single shallow well, is located immediately downgradient (southwest) of the “hot spot” area and MW11. The location of this well aids in the determination of the extent of the immediate downgradient contamination and helps to define the chlorinated VOC plume.

MW13 is the farthest downgradient well and is located at the edge of the chlorinated VOC plume. It approaches the farthest southern point that can be monitored without infringing on the High Speed Rail lines. This well was installed close to the chlorinated VOC plume in a downgradient direction as inferred by assuming that the contaminant concentration contours mimic the groundwater flow patterns on the Site. This well helps determine if significant levels of contamination are leaving the Site and migrating under the adjacent High Speed Rail lines. MW13 is a cluster well and aids in the determination of both the horizontal and vertical extent of contamination.

The five shallow wells were installed utilizing 4-inch polyvinylchloride (PVC) casing and screens to a depth of approximately 20 ft. The 15-ft screened interval of each shallow well extends from approximately 5 to 20 ft bgs. The three deep wells were also installed utilizing 4-inch PVC casing and screens to a depth of approximately 40 ft. The 10-ft screened interval of each deep well extends from approximately 30 to 40 ft bgs. All wells were drilled by hollow stem auger methods following the procedures outlined in the Final SAP dated September 16, 2002. Monitoring well logs for monitoring wells MW09 through MW13 are presented in Appendix F.

In addition to the eight newly installed wells, one monitoring well installed during a previous investigation (MW06) and the on-site sump are located inside the SMP building and were accessible for sampling during this investigation. MW06 and the sump aided in the determination of the northwestern extent of groundwater contamination and the extent of influence the sump well has on the local hydrogeologic regime. Therefore, a total of nine wells and one sump (SM01) were utilized for groundwater sampling to characterize the horizontal and vertical extent of groundwater contamination in the vicinity of the Site.

2.2.2 Monitoring Well Development

Following installation, the monitoring wells were developed between July 8 and 10, 2003 by over-pumping with a submersible and/or a peristaltic pump and mechanical surging. Monitoring well development was completed in order to remove fine material from the gravel pack and re-establish normal hydraulic conditions in the sampling interval. Well development was completed a minimum of 24 hours following the installation of each well under the supervision of a GES hydrogeologist.

During well development, field measurements, including turbidity, specific conductivity, pH, and temperature, were collected from the discharge water approximately every 15 minutes. Monitoring well development was not considered complete until a turbidity of 50 Nephelometric Turbidity Units (NTU) or less was obtained for a period of one hour. Monitoring well development water was either processed through a carbon filter and discharged to the ground surface or collected in 55-gallon drums for disposal. Monitoring Well Development Forms for each newly installed monitoring well are presented in Appendix G.

2.2.3 Monitoring Well Sampling

Groundwater sampling via low-flow sampling techniques was completed on July 28, 2003. Existing monitoring well MW06, the existing building sump (SM01), and the eight newly installed monitoring wells were sampled. All groundwater samples were analyzed for TCL VOCs (Table 2-3). Prior to sampling, synoptic water level measurements were obtained from all wells. Monitoring well sampling was conducted in accordance with the procedures outlined in the SAP dated September 16, 2002.

2.2.4 Aquifer Testing

Aquifer testing refers to the physical testing methods used to determine the hydrologic characteristics of confined or unconfined aquifers. The physical testing method employed at the Site was slug testing. A slug test is an aquifer test in which the water level in a well is instantaneously changed by removing, adding, or displacing a known volume of water. The water level response in the well is monitored over a period of time in the slugged well, and it is generally proportional to aquifer transmissivity and hydraulic conductivity. To instantaneously "remove" a known volume of water, the insertion and removal of a solid slugging rod was utilized.

Rising head slug tests were performed at the Site on July 29 and 30, 2003. Two slug tests were performed at each of the eight newly installed monitoring wells in accordance with the following procedures.

The solid slugging rod was inserted into the well below the water table causing the water level in the well to rise. The water level then fell to pre-test static as the water displaced by the solid slugging rod was dissipated by the aquifer. Once the water level in the well was within 90 percent of the static water level, the slugging rod was withdrawn and the water level in the well fell. The water level in the well then rose to account for the simulated removal of a slug of water.

During slug testing, the water levels were measured with a water level indicator. In addition, pressure transducers with associated data loggers were used to measure water levels as they can efficiently record a large number of measurements. The field data were graphed and analyzed using the Bouwer and Rice Method (1976; 1989). The Bouwer and Rice Method is based on the Theim (1906) equation of steady-state flow to a well and is applicable to completely or partially penetrating wells in unconfined aquifers as well as confined aquifers that receive water from an upper confining layer.

The calculated hydraulic conductivities ranged from 48.96 ft/day to 665.08 ft/day. The geometric mean hydraulic conductivity for the Site was 233.17 ft/day. The calculated hydraulic conductivities are within the range of values for the geologic formation present beneath the Site. The slug test analysis worksheets and data are included as Appendix H.

2.3 Phase III Field Investigation

The field investigation specified in the Final Work Plan, dated August 25, 2000, and the Final SAP, Health and Safety Plan (HASP) and Citizen Participation Plan (CPP) dated September 16, 2002, was conducted and completed in 2003 by CDM. A draft RI report was prepared and submitted to NYSDEC on January 30, 2004. Due to the differences in results between the direct push sampling and the monitoring well sampling, two additional rounds of monitoring well sampling were conducted under a Phase III investigation. During the scoping of the Phase III investigation, the vapor intrusion issue evolved as a state-wide initiative. Thus, the Phase III investigation also included soil vapor and sub-slab vapor samples. All field activities, methods and requirements for the additional rounds of groundwater sampling followed the original FSP (GES 2002a). In addition, as directed by NYSDEC and NYSDOH, a vapor investigation was performed and was conducted in accordance with the Project Plan Addendum B, dated August 4, 2005 (CDM 2005).

2.3.1 Groundwater Investigation

Two rounds of groundwater samples were collected from one interior and eight exterior monitoring wells (Figure 2-2) using conventional monitoring well sampling techniques. The first round of monitoring well sampling of all wells was conducted between September 12, 2005 and September 13, 2005. The second round of monitoring well sampling of all wells, except MW13S and MW13D, was conducted between March 27, 2006 and March 30, 2006.

Groundwater samples were analyzed for TCL VOCs (Table 2-4). The two additional rounds of monitoring well sampling followed the same sampling procedures as those followed for initial round of monitoring well sampling as documented in the FSP (GES 2002a).

2.3.2 Vapor Investigation

A total of six exterior soil gas and two interior sub-slab vapor samples were collected between March 27, 2006 and March 30, 2006 to investigate the vapor medium (Figure 2-2).

2.3.2.1 Soil Gas Samples

A total of six soil gas samples were collected from the area adjacent to the loading dock using drive point samplers and SUMMA® canisters (Figure 2-2). One sample was collected from each location approximately two feet above the groundwater table. In order to assess the precision (reproducibility) of the sample collection process one field duplicate was collected for every 20 samples collected. Therefore, in addition to the six soil gas samples one duplicate was collected.

Prior to sample collection, vapor sample probes were purged with a vacuum pump in accordance with the NYSDOH *Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York*, dated October 2006 (NYSDOH 2006). Sample probes were fitted with sealing, quick-connect fittings and were sealed at the ground surface to minimize leakage in accordance with the Project Plan Addendum B. A helium tracer gas was used to check for surface leakage at the ground surface. Samples were collected with a pre-evacuated Summa® canister and sent for offsite analysis of VOCs via EPA method TO-15 (Table 2-5).

2.3.2.2 Sub-Slab Vapor Samples

Two sub-slab soil gas samples were taken from inside the SMP building (Figure 2-2). Since the SMP building is an active manufacturing facility, these two locations were selected to avoid the destruction of underground utilities. The procedure for installing the sub-slab vapor probe and sampling listed below are in accordance with the NYSDOH 2006 Soil Vapor Intrusion guidance document. These samples were analyzed for VOCs via EPA method TO-15 (Table 2-5).

2.4 Phase IV Field Investigation

The Phase IV Field Investigation was mobilized by CDM on January 14, 2008 and demobilized on February 28, 2008. This investigation was prompted by elevated sub-slab readings detected during the Phase III Field Investigation. The Phase IV Field Investigation consisted of the collection of direct push soil and groundwater sampling, monitoring well installation and sampling, vault inspection and sampling, sump sampling, soil vapor sampling, and sub-slab and indoor air sampling. The objectives of this investigation are to delineate the contamination present under the SMP building and further delineate the localized “hot spot” at the water table interface.

2.4.1 Exterior Direct Push Sample Collection

Exterior direct push sample collection includes exterior direct push soil and groundwater collections.

2.4.1.1 Exterior Direct Push Soil

Subsurface soil sampling was conducted at 10 exterior locations (SG01 through SG10) using direct push technology via Geoprobe® (Figure 2-3). Macrocore samples were collected continuously from ground surface to refusal at each location. The lithology, absence/presence of contamination, and organic vapor (screened by a PID) were recorded for each boring and presented in Appendix F. A total of 28 samples (26 field samples and 2 field duplicate samples) were collected from the ten direct push locations. Soil samples were collected from 0-2 ft bgs, at the water table interface, and at refusal from direct push locations (SG01 through SG06). Soil samples were collected from the water table interface and at refusal from direct push locations (SG01 through SG10). The water table interface was generally located from 3 to5 ft bgs and refusal was encountered anywhere from 35 to 48 ft bgs.

Elevated organic vapors and staining were present in the macrocores generally from 5-15 ft bgs, starting just below the water table interface. Soil samples were collected exactly at the water table interface, 3 to 5 ft bgs.

All samples were analyzed for VOCs via EPA Method SOM01.2. Selected samples were also analyzed for SVOCs, pesticides, and PCBs via EPA Method SOM01.2 and

Target Analyte List (TAL) metals including mercury via EPA Method ILM05.3. A summary of the exterior direct push soil samples collected is presented in Table 2-6.

Upon completion of sampling, the boreholes were backfilled with indigenous soil and/or clean sand and marked with a stake/spray paint which has been labeled with the proper sample identification. .

2.4.1.2 Exterior Direct Push Groundwater

Groundwater sampling was conducted at 10 exterior locations (SG01 through SG10) using direct push technology via Geoprobe® (Figure 2-3). Prior to sample collection, water quality parameters were observed using a Horiba U-22 and LaMotte 2020 turbidity meter and recorded into the field log book. The water quality parameters are presented in Table K-1 in Appendix K.A total of 24 samples (22 field samples and 2 field duplicate samples) were collected from ten direct push locations. Groundwater samples were collected from 5-9, 10-14, and 15-19 ft bgs at SG01 through SG06. Groundwater samples were collected from 5-9 ft bgs at SG07 through SG10.

The direct push groundwater samples were analyzed for VOCs via EPA Method SOM01.2. Selected samples were also analyzed for SVOCs via EPA Method SOM01.2 and TAL metals including mercury via EPA Method ILM05.3. A summary of the exterior direct push groundwater samples collected is presented in Table 2-7.

Upon completion of sampling, the boreholes were backfilled with indigenous soil and/or clean sand and marked with a stake/spray paint which has been labeled with the proper sample identification.

2.4.2 Soil Vapor Sample Collection

Soil vapor sampling was conducted at 12 exterior locations (SG01 through SG12), see Figure 2-3. Direct push permanent soil vapor implants were advanced to 1 foot above the water table interface (approximately 3 ft bgs) at each direct push location. Soil vapor boreholes were drilled using direct-push technology to drive steel rods equipped with a detachable steel drive point to the desired depth. The implants were completed with a 2-inch well box.

The tubing was connected to a vacuum/volume system which is a combined diaphragm pump and calibrated gauge system specifically designed for soil gas sampling. The tubing was fitted with a needle valve regulator which can easily be throttled to a flow rate of less than 100 milliliters (ml) per minute. Approximately three probe volumes (i.e. volume of sample probe and tubing) were purged at a flow rate less than 100 ml per minute. Purging for the 2-foot (with an additional 4 feet of tubing) vapor locations yields a purging volume of 174.24 ml over a 1.74 minute time frame. After purging the tubing, the soil gas was screened using the PID meter and recorded in the field log book. The vacuum/volume system was then disconnected and the end of the tubing was connected directly to the SUMMA® canister intake valve. The samples were collected using laboratory-certified clean SUMMA® canisters with flow regulators set for 2-hour sample collection and a vacuum of approximately 28 ± 2 millimeters (mm) mercury (Hg). A vacuum of approximately five ± 1 mmHg was targeted to be present when sample collection was terminated. If the final vacuum pressure was above 5 mmHg, it was noted on the chain-of-custody and field log book. Soil vapor sample parameters are presented in Table K-3 in Appendix K.

A tracer gas test was performed at every borehole during the soil vapor investigation in accordance with the NYSDOH guidance for evaluating soil vapor intrusion. The flow rate during sampling did not exceed 100 ml per minute to minimize outdoor air infiltration during sampling. Outdoor ambient air samples were collected for each day of soil vapor sampling. The soil vapor samples were analyzed for VOCs via EPA Method TO-15. The analysis for air samples achieves a detection limit of 1 microgram per cubic meter ($\mu g/m^3$) in most samples except where dilution was necessary.

One issue arose during soil vapor sampling due to inappropriate vacuum pressurization and/or flow meter malfunction. At borehole SG01, the SUMMA® canister's pressure decreased from -27 to -19 mmHg over a five hour sample collection period. After the initial two hour period, the field technician observed that the SUMMA® canister's pressure was declining slower than normal. A field decision was made to leave the soil vapor sampling setup rather than completing the sampling after the designated two hour sample collection period to reach an appropriate final vacuum pressure. The air sampling at SG01 was completed when the field technician no longer observed a decrease in the SUMMA® canister's pressure, resulting in a total collection time of five hours and a final pressure of -19 mmHg.

2.4.3 Interior Direct Push Sample Collection

Interior direct push sample collection includes interior direct push soil and groundwater sample collections.

2.4.3.1 Interior Direct Push Soil

Subsurface soil sampling was conducted at 16 interior direct push locations (SB01 through SB16) using direct push technology via Geoprobe® (Figure 2-3). Macrocore samples were collected continuously from ground surface to refusal at each location. The lithology, absence/presence of contamination, and organic vapor (screened by a PID) were recorded for each boring and presented in Appendix F. A total of 32 samples (32 field samples and 1 field duplicate sample) were collected from the 16 direct push locations. Soil samples were collected from the water table interface and at refusal, except SB06. Soil boring SB06 encountered refusal at 6 feet bgs, therefore only one soil sample was collected at this direct push location. The water table interface was generally located from 7 to10 feet bgs (inside the building) and refusal was encountered anywhere from 11 to 27 ft bgs.

Elevated organic vapors and staining were present in the macrocores generally from 12 to 20 feet bgs, starting just below the water table interface. Soil samples were collected at the water table interface, 7-10 feet bgs.

All subsurface samples were analyzed for VOCs via EPA Method SOM01.2. Selected subsurface samples were also analyzed for SVOCs, pesticides, and PCBs via EPA

Method SOM01.2 and TAL metals including mercury via EPA Method ILM05.3. A summary of the interior direct push subsurface soil samples collected is presented in Table 2-6.

Upon completion of sampling, the boreholes were backfilled with indigenous soil and/or clean sand and marked with a stake/spray paint which has been labeled with the proper sample identification. Borings performed in concrete areas were backfilled and refinished at the ground surface with a concrete patch.

2.4.3.2 Interior Direct Push Groundwater

Groundwater sampling was conducted at 16 interior locations (SB01 through SB16) using direct push technology via Geoprobe® (Figure 2-3). Prior to sample collection, water quality parameters were observed using a Horiba U-22 and LaMotte 2020 turbidity meter and recorded into the field log book. The water quality parameters are presented in Table K-1 in Appendix K. A total of 15 field samples were collected from fifteen direct push locations. The soil boring location SB06 encountered refusal before reaching the water table; therefore a groundwater sample could not be collected at this location. Groundwater samples were collected from a four interval from the water table interface which varied from 6 to14 ft bgs, depending on the soil boring location.

The direct push groundwater samples were analyzed for VOCs via EPA Method SOM01.2. Selected subsurface samples were also analyzed for SVOC analysis via EPA Method SOM01.2 and TAL metals including mercury via EPA Method ILM05.3. A summary of the interior direct push groundwater samples collected is presented in Table 2-7.

Upon completion of sampling, the boreholes were backfilled with indigenous soil and/or clean sand and marked with a stake/spray paint which has been labeled with the proper sample identification. Borings performed in concrete areas were backfilled and refinished at the ground surface with a concrete patch.

2.4.4 Sub-Slab Soil Vapor Sample Collection

Seventeen sub-slab soil vapor samples (16 field samples and 1 field duplicate sample) were collected at the on-site structure (Figure 2-3). The sub-slab sample locations were installed as permanent points to facilitate future sampling events. After the slab had been inspected, the location of subsurface utilities determined, and the ambient air surrounding the proposed sampling location screened with a PID, a hammer drill was used to advance a boring to a depth of approximately two inches beneath the building slab. A permanent port constructed of stainless steel tubing and fittings was installed in the opening. The annular space between the borehole and the sample tubing was filled and sealed with anchoring cement.

The tubing was connected to a vacuum/volume system which is a combined diaphragm pump and calibrated gauge system specifically designed for soil gas sampling. The tubing was fitted with a needle valve regulator which can easily be throttled to a flow rate of less than 100 ml per minute. Approximately three probe volumes (i.e. volume of sample probe and tubing) were purged at a flow rate less than 100 ml per minute. Purging for the sub-slab (with an additional five feet of tubing) vapor locations yields a purging volume of 145.2 ml over a 1.45 minute time frame. After purging the tubing, the soil gas was screened using the PID meter and recorded in the field log book. The vacuum/volume system was then disconnected and the end of the tubing was connected directly to the SUMMA® canister intake valve. The samples were collected using laboratory-certified clean SUMMA® canisters with flow regulators set for 24-hour sample collection and a vacuum of approximately 28± 2 mmHg . A vacuum of approximately 5 ± 1 mmHg was targeted to be present when sample collection was terminated. If the final vacuum pressure was above 5 mmHg, it was noted in field log book. Soil vapor sample parameters are presented in Table K-3 in Appendix K.

The flow rate during sampling did not exceed 100 ml per minute to minimize outdoor air infiltration during sampling. Outdoor ambient air and indoor air samples were collected for each day of sub-slab soil vapor sampling. The sub-slab soil vapor samples were sent to an off-site laboratory for VOC analysis via EPA Method TO-15. The analysis for air samples achieves detection limits of 1 $\mu g/m^3$ in most samples except where dilution was necessary.

Several issues arose during soil vapor sampling due to inappropriate vacuum pressurization and/or flow meter malfunction. At borehole SB05, the total sample collection time was 24 hours and 26 minutes and the final pressure was -8 mmHg. At borehole SB13, the total sample collection time was 24 hours and 12 minutes and the final pressure was -9 mmHg. After the designated 24 hour collection period, the field technician observed that several of the SUMMA® canisters pressures were declining slower than normal. A field decision was made to leave the soil vapor sampling setups rather than completing the sampling after the designated 24 hour period to reach an appropriate final vacuum pressure. The air sampling was completed when the field technician no longer observed a decrease in the individual SUMMA® canister's pressure. This was also noted in the field log book.

At borehole SB07, the total sample collection time frame was 23 hours and the final pressure was -1 mmHg. The field decision was made to stop the soil vapor collection one hour early to prevent the SUMMA® canister from reaching a final pressure of 0 mmHg.

2.4.5 Indoor Air Sample Collection

Three indoor air samples were collected at the on-site structure (Figure 2-3). All indoor air samples were collected with a laboratory-certified SUMMA® canister regulated for a 24-hour sample collection. The SUMMA® canister was placed in such a location as to collect a representative sample from the breathing zone. The indoor air parameters are presented in Table K-3 in Appendix K. The NYSDOH Indoor Air Quality Questionnaire and Building Inventory was completed for the on-site structure. The completed NYSDOH questionnaire is provided in Appendix I.

The indoor air samples were sent to an off-site laboratory for VOC analysis via EPA Method TO-15. The analysis for air samples achieves detection limits of 1 $\mu g/m^3$ in most samples except where dilution was necessary.

One issue arose during indoor air vapor sampling due to inappropriate vacuum pressurization and/or flow meter malfunction. At indoor air location IA01, the SUMMA® canister's pressure decreased from -28 to 0 mmHg over a 23-hour-50-minute time period. The sample collection for IA01 was completed immediately after the field technician observed the 0 mmHg pressure associated with SUMMA® canister.

2.4.6 Outdoor (Ambient) Air Sample Collection

A total of three outdoor ambient air samples (AA1, AA2, and AA) were collected to represent the outdoor air quality surrounding the on-site structure (Figure 2-3). Two of the three outdoor air samples were collected with a laboratory-certified SUMMA® canister regulated for a 2-hour sample collection. Ambient air sample AA1 was placed upwind at the loading dock near the SG05 boring location. Ambient air sample AA2 was placed upwind at the SG11 boring location.

One of the three outdoor air samples was collected with a laboratory-certified SUMMA® canister regulated for a 24-hour sample collection. Ambient air sample AA was placed upwind at the loading dock near the SG03 boring location. The outdoor air parameters are presented in Table K-3 in Appendix K.

The outdoor ambient air samples were sent to an off-site laboratory for VOC analysis via EPA Method TO-15. The analysis for air samples achieves detection limits of 1 $\mu g/m^3$ in most samples except where dilution was necessary.

One issue arose during outdoor air vapor sampling due to inappropriate vacuum pressurization and/or flow meter malfunction. At ambient air location AA, the SUMMA® canister's pressure decreased from -27 to 0 mmHg over a 23-hour-16-minute time period. The sample collection period for AA was completed immediately after the field technician observed the 0 mmHg pressure associated with SUMMA® canister.

2.4.7 Direct Push Monitoring Well Installation and Sample Collection

Four direct push monitoring wells (MW14S, MW14D, MW15, and MW16) were installed and developed, see Figure 2-3. Monitoring wells MW14S, MW14D, and MW16 were installed to replace monitoring well clusters MW09 and MW13. These two monitoring wells could not be accessed due to being located along a high speed rail line. Monitoring well MW15 was installed to assist in delineating groundwater contamination under the building. Approximately 15 feet, for the shallow wells (MW14S, MW15, and MW16), and 10 feet, for the deep well (MW14D), of pre-packed 2.5-inch outer diameter (OD) (1.5-inch inner diameter [ID]) well screens with 5 feet of 1.5 inches PVC riser was installed for each monitoring well. The monitoring wells were completed with flush mount well covers. Monitoring well construction details are presented in Appendix J.

The aquifer at the Site was allowed to equilibrate for a little over two weeks. After equilibration, groundwater sampling and water level measurements were performed at the four direct push monitoring wells. Each well was developed via low flow purging methods until the water quality parameters stabilized. The purge water was displaced to the ground surface and/or back down the monitoring well.

Prior to groundwater sample collection, water quality parameters were observed using a Horiba U-22 and La Motte 2020 turbidity meter and recorded into the field log book. The water quality parameters and water level measurements are presented in Appendix K. Groundwater parameters are presented in Table K-2 in Appendix K.

The groundwater samples were analyzed for VOCs and SVOCs via EPA Method SOM01.2, methane, ethane, and ethene (MEE) analysis via Method 3810, sulfide via Method 9031, TOC via Method SM5310 B, TAL metals including mercury via EPA Method ILM05.3, ferrous iron via Method HACH 8146, anions via Method 300, and alkalinity via Method SM2320 B.

2.4.8 Existing Monitoring Well Sample Collection

Water level measurements and groundwater sampling was performed at five existing monitoring wells (MW06, MW10, MW11D, MW11S, and MW12), see Figure 2-3. Prior to groundwater sample collection, water quality parameters were observed using a Horiba U-22 and La Motte 2020 turbidity meter and recorded into the field log book. The water quality parameters and water level measurements are presented in Tables K-1 and K-2 in Appendix K, respectively.

The groundwater samples were analyzed for VOCs and SVOCs via EPA Method SOM01.2, MEE via Method 3810, sulfide via Method 9031, TOC analysis via Method SM5310 B, TAL metals including mercury via EPA Method ILM05.3, ferrous iron via Method HACH 8146, anions via Method 300, and alkalinity via Method SM2320 B.

2.4.9 Vault Inspection and Sample Collection

Three vaults (former 1,1,1-TCA Tank Vault, Vault 1, and Vault 2) were inspected during the Phase IV Field Investigation and a sample was collected from Vault 1 (see Figure 2-3).

2.4.9.1 Former 1,1,1-TCA Tank Vault

The former 1,1,1-TCA Tank Vault located along the northern wall inside the on-site building near soil boring location SB04 was inspected. The former 1,1,1-TCA Tank Vault is sealed by a metal hinged lid and is currently connected to the sewer line. The vault was observed to be infested with cockroaches and no sample was collected.

2.4.9.2 Vault 1

Vault 1 is located in the office area/desk area just north of monitoring well MW15 and is sealed by two layers of plywood which was removed for inspection. No more than six inches of standing water was present at the bottom of the vault. The vault was approximately 3-4 feet in depth. A sample was collected from standing water inside the vault. The water was a clear yellowish color and had a visible sheen.

Upon completion of sampling, the vault was resealed with nails and plywood. Orange traffic cones were then placed on the vault to prevent any safety hazards.

The Vault 1 water sample was analyzed for VOCs and SVOCs via EPA Method SOM01.2, and TAL metals including mercury via Method ILM05.3. Sample parameters are presented in Table 2-7.

2.4.9.3 Vault 2

Vault 2 is located in the equipment area just south of the former 1,1,1-TCA Tank Vault and is sealed by two layers of plywood which was removed for inspection. The vault was approximately one foot in depth. The bottom of the vault was concrete and contained no standing water or residual soil, therefore no sample was collected. Subsequently, the vault was resealed with nails and plywood. Orange traffic cones were then placed on the vault to prevent any safety hazards.

2.4.10 Sump Inspection and Sampling

A total of three sumps were inspected during the Phase IV Field Investigation and a sample was collected from each of the three sumps, see Figure 2-3. The sumps are located in the sub-basement of the onsite building.

2.4.10.1 Sump 1

Sump 1 is located in the northeastern section of the sub-basement and is approximately 4-5 feet in depth. Sump 1 contains two submersible pumps. The flow rates of the submersible pumps were measured using a Grey Line Doppler Flow Meter. The combined flow rate of the two submersible pumps is 65 gallons per minute (gpm) (shallow pump at 50 gpm and submersible pump at 15 gpm).

A sample was collected from Sump 1 using a bailer. The water sample was analyzed for VOCs and SVOCs via EPA Method SOM01.2, and TAL metals including mercury via Method ILM05.3. Sample parameters are presented in Table 2-7.

2.4.10.2 Sump 2

Sump 2 is located in the northeastern section of the sub-basement and is approximately 25-30 feet in depth. Sump 2 contains one submersible pump. The flow rate of the submersible pump was measured using a Grey Line Doppler Flow Meter. The flow rate of the submersible pump is 130 gpm.

A sample was collected from Sump 2 using a bailer. The water sample was analyzed for VOCs and SVOCs via EPA Method SOM01.2, and TAL metals including mercury via Method ILM05.3. Sample parameters are presented in Table 2-7.

2.4.10.3 Sump 3

Sump 3 is located in the northwestern section of the sub-basement and is positioned in a crack on the floor about six inches in depth. Sump 3 contains one submersible pump. The flow rate of the submersible pump was not measured since the pump was not purging water.

A sample was collected from Sump 3 using sterilized glassware. The water sample was analyzed for VOCs and SVOCs via EPA Method SOM01.2, and TAL metals including mercury via Method ILM05.3. Sample parameters are presented in Table 2-7.

2.4.11 Decontamination

All non-dedicated equipment and tools used to collect samples for chemical analysis were decontaminated prior to and between each sample interval using an Alconox rinse.

2.4.12 Sample Location and Site Survey

Upon completion of the field work, all exterior and interior boring locations and monitoring wells were surveyed by a New York State licensed surveyor, YEC. A detailed topographic base map of the Site and the immediate vicinity was developed, see Figure 2-3. Contours were plotted at one-foot intervals. Property lines of the parcels were placed on the base map utilizing available tax maps. Site maps and sampling location maps were updated with this information. All elevations are referenced to the North American Vertical Datum (NAVD) 88 and all horizontal locations are referenced to the North American Datum (NAD) 83.

2.5 Sample Identification

Each collected sample is labeled by an alphanumeric code that identifies the type of sampling location, the sampled matrix, and the specific sample designation (identifier). Samples are labeled with a sequential code consisting of two segments. The first segment designates the location type and specific sample location. Location types are identified by a two-letter code, for example: MW (monitoring well), DD (deep direct push), SD (shallow direct push), etc. The specific sampling location is identified using a two-digit number. For groundwater monitoring wells, a "D" or "S" follows the sampling location to indicate a deep or shallow monitoring well. The second segment identifies the matrix type and a sample designation, or identifier, that identifies the sample depth, the sampling event number, or other designation depending on the sample type. The matrix type is designated by a two-letter code, for example: GW (groundwater) or SS (soil). The sample identifier is represented by a two-digit code. For sequential depth intervals of soil samples, the sample identifier will correspond to depth increments. The previously described project plans that contain the scope-of-work for the specific phase of investigation also contains the exact sample identification system utilized.

2.6 Field Documentation and Reporting

Field log books were used during all on-site work. The dedicated field log books were maintained by the field manager overseeing the site activities. A copy of the field log books for each phase of the field investigations is provided in Appendix K. In addition to the log books, field and sampling procedures during Phase IV Field Investigation, including installation of the sample boreholes, collection of soil vapor, sub-slab, indoor air, and outdoor air samples, etc., were photo-documented and presented in Appendix K.

Section 3
Physical Characteristics

The physical characteristics of the Site and surrounding area are important to understanding the current nature and extent of contamination and future transport of contaminants. These characteristics can be described in terms of the demography and land use, meteorology, surface features and drainage, geology and hydrogeology. This section describes the physical characteristics of the Site and surrounding environment.

3.1 Demography and Land Use

The Site is located in Long Island City, Queens County, New York. According to the 2000 Census from the United States Census Bureau, 142,886 people reside in Long Island City, which covers an aerial extent of 2.6 square miles. Therefore, Long Island City has a population density of 54,956 people per square mile, making it the neighborhood in Queens County with the highest population density. With 2,229,379 people residing in Queens County and a land area of 109 square miles, the population density of Queens County is 20,453 people per square mile.

Located in the westernmost section of Queens, Long Island City covers approximately 1,664 acres (approximately 500 square blocks). Long Island City is bounded by Newton Creek to the south and the East River to the west (Figure 3-1). The north and east sides of Long Island City are defined by 31st Road and 34th Avenue to the north, and Barrett Avenue, 39th Street and the Brooklyn Queens Expressway to the east. The Queens-Midtown Expressway runs east-west through the southern part of the study area, while the Queens-Midtown Tunnel and the Queensboro Bridge connect the study area to midtown Manhattan. Figure 3-1 summarizes the year 2000 land use. Long Island City is predominantly industrial with manufacturing occupying 32% of the area. Transportation (Sunnyside Yard), utilities and other infrastructural types of uses occupying 22% of the area, commercial and auto storage service occupying 15% of the area, and residential/mixed residential commercial occupying 22% of the area.

3.2 Meteorology

The mean monthly temperature in Long Island City is presented in Figure 3-2. The average annual temperature is 55 degrees Fahrenheit (°F). The coldest month January averages a monthly temperature of 36°F, while the warmest month July averages a monthly temperature of 79 °F.

Average monthly precipitation in Long Island City is approximately 4.2 inches with the wettest months being June through October. Figure 3-3 presents the total monthly precipitation for the years 2002, 2003, 2005, 2006, 2007, and 2008 and the 30-year mean for the month. The Phase I Field Investigation was performed during November 2002, during typical dry conditions. The Phase II Field Investigation was performed during June and July 2003 when precipitation events were significantly above the 30-year mean monthly values. Phase III Field Investigation was performed during September of 2005 and March 2006, during typical dry conditions. Phase IV Field Investigation was performed during January and February of 2008 when precipitation events were slightly above the 30 year mean monthly values. The prevailing winds are from northwest. However, during the summer the prevailing winds are from southwest.

3.3 Surface Features

The SMP property is mostly occupied by a six story building whose first floor is approximately at the same elevation as Northern Boulevard. The "backyard" of the SMP building (i.e., the area behind the building) is at a lower elevation than the basement floor. There is about a 15-20 foot drop in elevation between the front of the building and the backyard where most of the contamination was detected. The surface of the backyard or adjacent property is covered by soil, gravel, scattered vegetation, and miscellaneous construction debris and refuse. Several abandoned railroad lines which are presently being renovated pass through the southern portion of the Site and multiple active railroad lines are located beyond the southern extent of the Site (south of MW09 and MW13). Scattered vegetation is present throughout the "back yard" area - becoming denser towards the western part of the SMP rear yard - and is also present along the abandoned railroad lines.

3.4 Surface Topography and Drainage

The topography and drainage of the Site and the Sunnyside Yard are similar and were modified in a similar manner during the original construction of the Sunnyside Yard at the turn of the last century. The regional surface topography and drainage discussion below focuses on historical drainage of the region prior to the construction of the Sunnyside Yard between 1890 and 1910. The excavation of high points to use as fill for the wetland areas (headwaters of Dutch Kills) and Dutch Kills have significantly impacted surface topography and drainage of the Site and the Sunnyside Yard. Understanding the historical drainage is critical for understanding contaminant transport (Sections 4 and 5) within and adjacent to the Site. The regional and site surface topography and drainage are presented in Section 3.4.1 and Section 3.4.2, respectively.

3.4.1 Regional Surface Topography and Drainage

The Sunnyside Yard located to the south of the Site encompasses approximately 105 acres and lies in a basin-like area with ground elevations that range from approximately 10-25 feet below the surrounding land surface (Northern Boulevard). The topography of the Sunnyside Yard is generally flat and slopes gently to the west. During the evaluation of the geologic and hydrogeologic data for the Sunnyside Yard by Roux Associates, Inc., a historical topographic map for western Queens dated 1890 (Appendix D, Figure 5) was obtained for reference (Julius Bien & Co. 1890). Utilizing this map, a 1910 Yard map and recent area maps, a comparison was made between the historical and current topographic features of The Sunnyside Yard and adjacent properties (Roux Associates, Inc. 1995). The comparison indicated that:

- The majority of topographic changes that occurred at the Sunnyside Yard took place between 1890 and 1910

- Current land surface elevation throughout much of the Sunnyside Yard and adjacent properties is actually lower than the original 1890 elevation
- The current elevation of the Long Island Railroad (LIRR) main line approximately correlates with the 1890 topography
- Two former surface-water bodies at the Sunnyside Yard have been filled

The topography shown on the 1890 map for the land now occupied by the Sunnyside Yard differs from present topographic conditions. The topographic high point in 1890 was located in the southeastern corner of the Sunnyside Yard while the wetlands (headwaters of the Dutch Kills) and the Dutch Kills flowed from the northeast corner of the Sunnyside Yard adjacent to the Site along Northern Boulevard (designated Jackson Avenue on the 1890 map) toward the southwest corner of the Sunnyside Yard. During construction of the Sunnyside Yard, the high points were excavated and used to fill in the wetlands and Dutch Kills along Northern Boulevard. The map (Appendix D, Figure 5) indicates that approximately 750 feet east of Dutch Kills was filled in during the construction of the Sunnyside Yard. Glacial deposits were excavated from the central and southeastern portions of the Sunnyside Yard to fill these wetlands and stream areas between 1890 and 1910. Geologic logs from boring in the northwest corner of the Sunnyside Yard describe fine to medium sands overlying wetland-deposited meadow mat and clays. These logs support the theory that local glacial deposits were used to fill the former wetland (Roux Associates, Inc. 1995).

During the Roux Phase II RI of the Sunnyside Yard, 6 deep boreholes were drilled. From these logs, an approximately 4-foot thick cobble zone is located in the subsurface. This unit may be a relict stream channel deposit and therefore, may not be laterally continuous (Roux Associates, Inc. 1995). A similar cobble zone is encountered at the Site in the area where the highest chlorinated solvent contamination was detected during the direct push investigation (Section 4.3)

The Sunnyside Yard is underlain by a combined sanitary/storm sewer drainage system, consisting of two drainage subsystems (Appendix D, Plate 2). However, the system is no longer used for sewerage. The primary subsystem whose northeast lateral is located behind the SMP building drains approximately 90 percent of the Sunnyside Yard (Appendix D, Plate 2). Storm water from the primary subsystem leaves the Sunnyside Yard to the north, approximately 360 feet west of Honeywell Street. The secondary drainage subsystem is located in the southwest corner of The Sunnyside Yard and drains approximately 10 percent of the Sunnyside Yard. Storm water from the secondary subsystem exits the Sunnyside Yard to the south, approximately 360 feet west of the intersection of Skillman and Thompson Avenues. In the primary subsystem, most of the sewer is located below the water table. Surface runoff containing a petroleum sheen was observed flowing into some of the catch basins during rain events **(**Roux Associates, Inc. 1995).

3.4.2 Site Topography and Drainage

Sand and gravel cover the surface of the Site beneath the 39th street overpass and south of the open loading dock near the former excavation that was completed during the Summit Environmental investigation in September 1990. Underneath the 39th street overpass, a drain spout channels storm water from the bridge into the back yard and drains into the manhole that is in the vicinity of the former exaction (Figure 3-1). Storm water runoff also drains into the manhole located south of the covered and fenced drum area. These manholes freely allow surface runoff to drain into the storm sewer line. The manholes located south of the SMP building are interconnected by a 36-inch pipe (Appendix D, Plate 2) and are a part of the primary sewer subsystem that drains over 90 percent of the Sunnyside Yard**.**

Even though the general storm water runoff drains from east to west (which is consistent with the general drainage of the Sunnyside Yard), a slight topographic high point exists between the central and eastern manholes in the location of DD09 and SA03. During heavy precipitation events, storm water runoff collected in the previous excavation area (near the eastern manhole) and the central manhole in the vicinity of SD05 (Figure 2-1). There is a significant quantity of vegetation around the western manhole preventing measurable soil erosion.

A petroleum sheen was observed on the storm water runoff from the bridge and other portions of the Sunnyside Yard as noted in previous investigations. The NYSDEC representative was made aware of this situation during a routine site walk.

The sewer system is located at an approximate depth of 12 feet below land surface. Currently, the water table elevation is usually between 4 and 5 feet below land surface; thus, the sewer system is below 8 feet of water during a high water table. Historically, prior to public water being supplied, the quantity of private drinking water wells in the area significantly depressed the water table by almost eight feet. The subbasement of the SMP building must have been constructed during this period since an intermittent sump pump is currently needed to keep the groundwater table from rising to a level of eight feet above the subbasement slab**.** The sump discharges directly into the sewer line located along Northern Boulevard and not into the Sunnyside Yard storm water drainage system.

3.5 Geology

The regional and site geology were characterized based on published reports and observations made during previous investigations and during the Phase I, II, and IV Field Investigations.

3.5.1 Regional Geology

Queens and King Counties are located within the Atlantic Coastal Plain Physiographic Province. Though Queens County soil mapping is limited, the geologic formations underlying the region are reported to be composed of a series of unconsolidated sand, gravel, and clay deposits of late Cretaceous and Pleistocene age. Crystalline bedrock of Precambrian age underlies these unconsolidated deposits and outcrops in northwestern Queens County near the East River (Table 3-1, Figures 3-4, 3-5, and 3-6).

The strata in the area dip gently to the southeast, following the topography of the bedrock surface (Soren 1978). Boreholes drilled within northwestern Queens County indicate that the unconsolidated deposits are predominantly Upper Pleistocene glacial deposits ranging from approximately 30 to 150 feet in thickness. The Upper Pleistocene deposits are cover by a thin veneer of recent and Holocene deposits (Table 3-1). The saturated portion of the Upper Pleistocene deposits forms the Upper Glacial aquifer of Long Island. Unconsolidated Upper Pleistocene glacial (ground moraine) deposits of unstratified, poorly sorted mixtures of sand and silt with some gravel and cobbles (Buxton *et al*. 1981) overlie the Lower Pleistocene deposits (where present).

The Lower Pleistocene deposits, consisting of the Jameco gravel overlain by the Gardiner's clay unit, may be discontinuously present beneath Long Island City. These Lower Pleistocene deposit, unconformably overlie bedrock (Roux Associates, Inc. 1995). Depth to bedrock ranges from zero feet in small areas of outcrop in northwestern Queens County to as much as 300 feet in buried valleys.

3.5.2 Site Geology

Observations made during the historical and recent field investigations at the Site indicate the presence of fill, including sand, silt, concrete fragments, and wood railroad ties, from the ground surface to approximately two feet below ground surface. Below the fill material, sands and gravel were observed to a depth of approximately 40 feet bgs. These observations are consistent with published information on subsurface geology in the area.

According to logs of borings drilled on the Site and the adjacent Sunnyside Yard during investigation of the Site, the area is underlain by the following units (in order by increasing depth); fill, Upper Pleistocene glacial deposits (including both till and channel deposits), and bedrock (Figures 3-7 through 3-12). The fill is predominantly comprised of reworked glacial deposits (sand, silt, clay, and gravel) and railroad ballast with minor amounts of construction debris and other materials. The Upper Pleistocene glacial deposits consist mainly of ground moraine deposits; unstratified, poorly sorted mixtures of sand, silt, clay, and gravel. In addition, a cobble layer was encountered in three soil borings drilled at the Site and three deep borings drilled at the Sunnyside Yard. This unit may represent a relict stream channel that was formed by glacial meltwater (Section 3.4). One borehole was drilled to the bedrock surface beneath the Sunnyside Yard. In this soil boring located within the Sunnyside Yard due west of the Site, bedrock was encountered at a depth of 74 feet below land surface (i.e., 53 feet below mean sea level). In the southwestern portion of the Sunnyside Yard, a Holocene wetland deposit was encountered below the fill and above the Upper Glacial formation. This deposit consisted of organic silty clay and meadow mat. This deposit is associated with a buried stream channel (Roux Associates, Inc. 1995).

3.6 Hydrogeology

The hydrogeology of the Site has been characterized based on previously published reports and observations made during historical and recent field investigations at the Site. The hydrogeologic units correspond to the previously discussed geologic units.

3.6.1 Regional Hydrogeology

The Upper Glacial aquifer is the uppermost hydrogeologic unit on Long Island. It consists of till deposits (clay, silt, sand, gravel, and boulders) along the north shore and outwash deposits (mostly sand, gravel, and boulders) to the west and south. The outwash deposits are highly permeable horizontal hydraulic conductivity is estimated to be 270 ft/day (Franke and Cohen 1972). However, the till deposits are typically less than half as permeable (Smolensky *et al*. 1989; Buxton and Shernoff 1995). The published horizontal hydraulic conductivity of the Upper Glacial aquifer in Queens County ranges from 214 ft/day (McClymonds and Franke 1972) to 270 ft/day (Franke and Cohen 1972)

Groundwater in the area occurs under water table (unconfined) conditions in the Upper Glacial aquifer. Regional groundwater flow in the area is generally to the west (Figure 3-13), eventually discharging approximately one mile west of the Site into the East River (McClymonds and Franke 1972). Thickness of the upper glacial aquifer in central Kings County is more than 200 feet (de Laguna 1948). In Queens County, it ranges from 0 to 300 feet (Soren 1978; Buxton and Shernoff 1995).

The water table contours from March 1997 (Figure 3-13) show local mounds in the water table with steep gradients in the northern part of Queens County, where low permeability bedrock and the clay member of the Raritan Formation are near sea level (Soren 1978; Buxton and Shernoff 1995) and poorly permeable till deposits are present. Similar anomalously high water levels can be found on the peninsulas along the north shore of Nassau County to the east. The contours along the East River and in the central and southern part of Kings and Queens Counties indicate a gentler gradient than in the northern part of Queens because the outwash deposits in these areas have higher hydraulic conductivities than the deposits to the north. Small depressions are likely to form in eastern Queens County as a result of public supply pumping.

Roux Associates, Inc., performed a records search for well data within a 2-mile radius of the Sunnyside Yard (Roux Associates, Inc. 1995). From available well information, approximately 21 Upper Glacial aquifer wells may still be active. Of these 21 Upper Glacial wells, five are described as being diffusion wells, while the remainders are pumping wells. These pumping wells were predominantly used to supply water for car washing, with a smaller number of wells used to supply cooling water. Approximately ten of the bedrock wells identified during the well search are potentially active pumping wells. All wells that were active upon last inspection were installed between 1924 and 1966. This suggests that many of these “potentially” active wells may no longer be in use (Roux Associates, Inc. 1995).

Published water-level data for Long Island show that from the early 1930s to about 1960, the water table within Kings County and western Queens County was depressed to elevations below sea level due to over pumpage. The cone of depression caused significant salt-water intrusion into the Upper Glacial and confined aquifers beneath these areas and as far inland as the center of the Kings County (Smolensky 1983). Historical data for wells near the Sunnyside Yard indicate that salt-water intrusion also affected the aquifers beneath the Sunnyside Yard. Two bedrock wells (within 500 feet of the Sunnyside Yard) reported brackish water conditions during 1925 and 1932. Due to the corrosive nature of the water both wells were shut down before 1936. However, published data indicate that by the late-1950s, the cone of depression within Queens County had recovered (Smolensky 1983). Current water-level elevations at the Sunnyside Yard range from 8 to 23 feet above mean sea level, precluding salt-water intrusion in this area. However, the effects of the historical salt-water intrusion can still be detected in ground-water quality, which exhibits elevated concentrations of sodium and chloride (Soren 1971).

Regional groundwater quality of the Upper Glacial aquifer is characterized as having a wide range of iron and manganese concentrations (Buxton *et al.* 1981). Concentrations of iron and manganese increase as conditions become anoxic (i.e., as the dissolved oxygen content decreases). Anoxic conditions are typically associated with swamp or wetland deposits, such as those identified in the western portion of The Sunnyside Yard (Roux Associates Inc. 1995).

3.6.2 Site Hydrogeology

The groundwater beneath the Site occurs under water table (unconfined) conditions. The depth to groundwater in the vicinity of the Site is approximately 5 feet below ground surface but may be influenced by surface runoff that results in standing water across most of the Site during rain events. The water table occurs in either fill or glacial deposits. Beneath the Site, the saturated fill deposits and the shallow Upper Glacial aquifer were not always distinguishable and are therefore, collectively referred to as shallow deposits.

Previous investigations performed at the Sunnyside Yard document groundwater flow to the west (Appendix D). The groundwater eventually discharges to the East River or one of its tributaries. Vertical groundwater movement is restricted by the Gardiners Clay where present or by the Precambrian bedrock which is considered to be the bottom hydrogeologic boundary of the groundwater flow system.

Groundwater elevation data collected in February 2008 (Figure 3-14) is consistent with previous investigations and show that, underneath the Site, flow is primarily from east to west (Figures 3-15 and 3-16). Due to the proximity to the East River, the hydraulic gradients are gentle which is consistent with the regional groundwater contour map (Figure 3-13) and the groundwater contours present in the Sunnyside Yard (Appendix D). For example, the February 2008 elevation contours ranged from a maximum of 16.3 feet on the east side of the Site to 16 feet at the west side of the Site. A gradient of 0.001 was calculated using data from monitoring wells MW10 and MW08. The deep groundwater contours were not prepared because, in February 2008, CDM could only access two wells. The deep potentiometric surface from 2003 is shown in Figure 3-16 for reference. In February 2008 the water level elevation readings from monitoring wells MW11S and MW11D were essentially the same: 16.18 and 16.19 respectively. The elevations at MW14S and MW14D were 15.89 and 16.06, respectively, which indicates an upward gradient at this location. Based on the aquifer testing performed at the Site during the Phase II Field Investigation, the geometric mean hydraulic conductivity was calculated as 233.17 ft/day.

Using this data the groundwater flow rate was estimated as follows:

$$V = \frac{Ki}{n}$$

Where: V = groundwater flow rate
K = hydraulic conductivity: 233 feet/day
i = gradient, 0.001
n = effective porosity, assumed to be 30% or 0.3

Using these values V is calculated as follows:

$$V = \frac{(233\, feet/day) * (0.001)}{0.3}$$
$$V = 0.78\, ft/day$$

A sump pump is located in the basement of the SMP building. As previously stated, published regional data and historical investigations at the adjacent Sunnyside Yard site have documented groundwater flow to the west. The previous H2M 1992 RI Report speculated that groundwater flow direction in the immediate vicinity of the Site was to the north toward the basement sump pump. During the Phase IV investigation, three sumps were inspected. The flow rate for Sump 1 and Sump 2 were measured as 65 gpm and 130 gpm, respectively. Based on the hydrogeologic properties of the underlying formation, it is not anticipated that the operation of the sump pump has a major effect on the groundwater flow in the vicinity of the Site.

Section 4
Nature and Extent of Contamination

The field investigation for the RI was conducted in four phases. The aforementioned Phase I Field Investigation involved the collection of soil samples using hand augers and direct push drilling in order to delineate the nature and extent of soil contamination. Groundwater samples were also collected during the direct push sampling. In the Phase II Field Investigation, the results of the hand auger and direct push samples were utilized to determine the locations for placement of groundwater monitoring wells and the depths of the screened interval. The Phase III Field Investigation involved two rounds of monitoring well groundwater sampling to verify the results of the Phase II Field Investigation as well as one round of soil vapor sampling. The Phase IV Field Investigation involved direct push soil and groundwater sampling inside and outside the facility, monitoring well sampling, sub-slab vapor sampling, and soil gas sampling to further delineate contamination under the building and in the "hot spot" area identified during the previous phases of investigation.

This section presents the methodologies used to evaluate the analytical results, the analytical data of each medium that exceed their respective selected screening levels. A detailed discussion of the quality of each medium and the potential sources of contamination is also presented.

4.1 Data Quality Management

As stated in the Final Work Plan (IT 2000) and the Quality Assurance Project Plan (GES 2003), the quality of analytical data was ensured by using standard field sampling and analytical laboratory procedures. The analytical data reported from the laboratory were reviewed and evaluated. One hundred percent of the data reported from the laboratory were reviewed in detail, and data usability summary reports (DUSRs) for these data were prepared to determine whether or not the data meet the project specific criteria for data quality and data usability. The DUSRs were conducted in compliance with NYSDEC's *Guidance for the Development of Data Usability Summary Reports* (NYSDEC 1997).

The samples from the Phase I, II, and III Investigations were analyzed by Severn Trent Laboratory, Inc. (STL), Edison, New Jersey, a NYSDOH Environmental Laboratory Approval Program (ELAP) certified laboratory (NY Lab ID No: 11452; EPA Lab Code: NJ003412). All analytical data received from STL were validated by EDV, Inc., an independent data validator, in Pittsburgh, Pennsylvania. The samples from the Phase IV Investigation were analyzed by Chemtech Laboratories, Mountainside, New Jersey, a NYSDOH ELAP certified laboratory (NY Lab ID No: 11376; EPA Lab Code: Chem). All analytical data received from Chemtech were validated by Nancy Potak, an independent data validator, in Greensboro, Vermont. The analytical data with data qualifiers used for this assessment are shown in Appendix L.

4.2 Approach to Evaluation of Contamination

The objective of this section is to develop preliminary chemical screening levels as a baseline for quantifying the horizontal and vertical extent of contamination, if any, in soil, groundwater, and soil vapor for the Site. The screening levels were used to identify potential source areas of contaminants, to evaluate their distribution patterns, and to assess their potential migration pathways. Although these concentrations were based upon regulatory standards, criteria, and guidance (SCGs), the screening levels do not represent remediation goals. Remediation goals will be developed during the Feasibility Study.

4.2.1 Identification of Screening Criteria

To evaluate the nature and extent of contamination in soil, groundwater, and soil vapor, State and Federal SCGs were assessed for each medium. The SCGs for each medium were classified according to one of the following categories:

- **Applicable Requirements** are those requirements promulgated under Federal or State law that specifically address a hazardous substance, remedial action, or other circumstance at a hazardous waste site.

- **Relevant and Appropriate Requirements** are those requirements promulgated under Federal or State law that are not applicable to a hazardous substance, remedial action, or other circumstance at a hazardous waste site, but address situations similar to those encountered. Their use is well-suited to hazardous waste sites.

- **To Be Considered (TBC) Guidance** are those guidance's (e.g., health advisories, guidance documents, proposed regulations) that have not been promulgated, but are considered appropriate in the absence of other superseding requirements.

The regulatory SCGs identified for each medium and the applicability of these SCGs to the Site are summarized in the following sections.

4.2.1.1 Soil Screening Criteria

Soil screening criteria are employed for Phase I and IV Investigations. Promulgated regulations which set forth chemical-specific cleanup criteria for contaminants in soils have not been adopted by NYSDEC or EPA. Therefore, there are no applicable or relevant and appropriate requirements (ARARs) for soils. However, NYSDEC has developed soil cleanup objectives for inactive hazardous waste sites regulated under the State Superfund program. The documented objectives utilized during soil screening for Phase I and IV Investigations are described below.

During the Phase I Investigation, soil screening objectives were attained from both NYSDEC and EPA. These objectives are documented in the NYSDEC Technical and Administrative Guidance Memorandum (TAGM) No. 4046, *Determination of Soil Cleanup Objectives and Cleanup Levels*, January 24, 1994 and in the EPA *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, Exhibit A-1 Generic SSLs* *for Residential Scenario*, March 2001 (EPA 2001a). Acceptable soil levels based on the potential for contaminants to migrate from soil to groundwater were established. The cleanup objectives also consider human health-based criteria.

Chemical screenings for TCLP constituents during the Phase I Investigation are based on the EPA non-wastewater standards for TCLP in 40 CFR §268.48 (Universal Treatment Standards).

During the Phase IV Investigation, soil screening objectives were attained from NYSDEC. These objectives are documented in the NYSDEC Brownfield and Superfund Regulation 6 NYCRR Part – 375 Environmental Remediation Programs, *Restricted Use Soil Cleanup Objectives – Industrial,* December 14, 2006 and in the NYSDEC Technical and Administrative Guidance Memorandum (TAGM) No. 4046, *Determination of Soil Cleanup Objectives and Cleanup Levels*, January 24, 1994.

4.2.1.2 Groundwater Screening Criteria

Groundwater screening criteria are employed for all four phases of investigations. During Phase I, II, and III Investigations, groundwater screening criteria were attained from both NYSDEC and EPA. These standards are documented in the NYSDEC Groundwater Quality Standards and Groundwater Effluent Limitations (6 NYCRR Part 703), August 1999, the EPA National Primary Drinking Water Regulations (40 CFR Part 141 Subpart G and Part 143), July 2001, and the EPA Region 3 Tap Water RBC Table, April 23, 2003. All standards are considered relevant and appropriate to groundwater at the Site. These requirements establish standards based on the classification of the water body. In accordance with 6 NYCRR Part 701, groundwater at the Site is classified as Class GA (fresh groundwater).

The Federal maximum contaminant levels (MCLs) in 40 CFR Part 141 (primary MCLs) and 40 CFR Part 143 (secondary MCLs) are promulgated standards applicable to public drinking water systems. However, groundwater at the Site is not utilized for public drinking water. Therefore, these standards are considered TBC criteria.

During the Phase IV Investigation, groundwater screening criteria were attained from NYSDEC. These standards are documented in the NYSDEC Technical & Operational Guidance Series (TOGS) 1.1.1, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations*, June 1998, Addendums April 2000 and June 2004. These requirements establish standards based on the classification of the water body. In accordance with TOGS 1.1.1 groundwater at the Site is classified as Class GA (fresh groundwater).

4.2.1.3 Soil Vapor Screening Criteria

The *Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York* (NYSDOH 2006) is considered relevant and appropriate to soil vapor at the Site. The 2006 NYSDOH Vapor Intrusion guidance indicates that the State of New York does not have any standards, criteria, or guidance values for subsurface vapors. However, air guideline values and the sub-slab vapor/indoor air matrices in the 2006 NYSDOH

Vapor Intrusion guidance are compared to soil vapor concentrations that do not have a set standard, in order to identify if soil gas and sub-slab vapor should be mitigated.

4.2.2 Selection of Chemical Screenings

Screening levels are selected for soil, groundwater, and soil vapor based on a thorough review of SCGs for chemical constituents analyzed at the Site.

4.2.2.1 Soil Screening Levels

During the Phase I Investigation, the soil screening levels for constituents in soil are presented in Table 4-1. The soil screening concentrations for TCLP constituents in soil used during the Phase I Investigation are presented in Table 4-2. During the Phase IV Investigation, the soil screening levels for constituents in soil are presented in Table 4-3.

For Phase I soil, the EPA generic soil screening levels are based on a residential land-use scenario and do not consider site-specific conditions. Due to the conservative assumptions used in developing these screening levels, they are considered overly conservative for the study area. Therefore, if a parameter does not exceed the generic soil screening level, “no further action” is warranted.

For Phase IV soil, the NYSDEC TAGM objectives were utilized when an SCG did not exist for a constituent under the NYSDEC Brownfield and Superfund Regulation.

4.2.2.2 Groundwater Screening Levels

The groundwater screening levels for TCL volatile organics and a rubber manufacturing compound (aniline) used during the Phase I, II, and III Investigations are presented in Table 4-4. The groundwater screening levels for TCL volatile, semi-volatile, and TAL metals used during the Phase IV Investigation are presented in Table 4-5.

For Phase I, II, and III groundwater, the more stringent of the NYSDEC groundwater quality standards for a constituent was selected as the screening level. The Federal MCLs were utilized when NYSDEC groundwater quality standards did not exist for a constituent. As previously discussed, rubber manufacturing compounds were incorporated into the analytical program after the Work Plan was finalized in accordance with the NYSDEC comments on the Draft SAP. Thus, the analysis of aniline was not included in the Final Work Plan. However, the analytical program documented in the Final Work Plan is superseded by the analytical program documented in the Final SAP.

For Phase IV groundwater, only NYSDEC Groundwater Quality Standards and Groundwater Effluent Limitations were selected as the screening level.

4.3 Assessment of Soil Quality - Phase I and IV Investigations

Soil quality is assessed utilizing the results of both the surface soil sampling investigation and the direct push boring investigations. These investigations are described in the following section. The analytical data collected from these investigations are compared with the screening levels selected via the above described methodology and any concentrations that exceed these concentrations are presented and evaluated in this section**.** Tables 4-6 and 4-7 present the detection frequency, the maximum concentration, and the minimum concentration of the constituents detected in soil for the Phase I Investigation and the Phase IV Investigation, respectively. Appendix L contains the soil analytical results for the Phase I and IV Investigations.

Soil samples collected during the Phase I Investigation show five VOC constituents, 1,1,1-TCA, 1,1-DCA, ethylbenzene, TCE, and xylenes, detected above the screening levels (Table 4-8 and Figure 4-1). Lead was also detected above the screening level during Phase I Investigation.

Exterior direct push soil samples collected during the Phase IV Investigation do not show any VOC constituents detected above the screening level. Four SVOCs, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene, were detected above the screening levels (Table L-4.4 in Appendix L) and three metal constituents, arsenic, iron, and vanadium, were detected above the screening levels (Table L-4.8 in Appendix L). Exterior direct push soil samples were also analyzed for pesticide and PCBs, but no constituents were detected above the screening criteria (Tables L-4.6 in Appendix L).

Interior direct push soil samples collected during the Phase IV Investigation do not show VOC constituents detected above the screening levels (Table L-4.2, Appendix L). Three SVOCs, 2-chlorophenol, 4-chloro-3-methylphenol, 4-nitrophenol, were detected above the screening levels (Table L-4.3 in Appendix L), and only one metal, iron, was detected above the screening level (Table L-4.7 in Appendix L). Interior direct push soil samples were also analyzed for pesticides and PCBs, but no constituents were detected above the screening criteria (Table L-4.5, Appendix L).

Since the contaminant distribution patterns are significantly different among the chlorinated VOCs, non-chlorinated VOCs, SVOCs, and metals, these contaminants are discussed in separate sections.

4.3.1 Chlorinated Volatile Organic Compounds

4.3.1.1 Summary of Soil Results for Phase I Investigation

Two subsurface soil samples contained levels of 1,1,1-TCA that exceeded the screening level of 0.8 mg/kg. Sample DD09-SS07 contained the highest concentration of 1,1,1-TCA at 4,800 mg/kg, and sample DD10-SS07 contained the second highest concentration of 1,1,1-TCA at 9.4 mg/kg (Table 4-8). These results are consistent with the groundwater sampling results since the highest levels of chlorinated volatile organic constituents were detected at the six-foot interval from location DD09 which is located adjacent to DD10 (only soil samples were collected from DD10). The groundwater table is approximately six feet below grade; thus, most of the contamination is detected at the groundwater table interface within the unsaturated zone.

Only one sample (DD09-SS07) had an elevated level of 1,1-DCA above the screening level. The detected concentration of 1,1-DCA in this sample was 280 mg/kg, compared to the screening level of 0.2 mg/kg (Table 4-8). This sample was collected at a depth of 6 feet below grade which corresponds to the groundwater table interface.

Three samples (DD10-SS07, DD09-SS07, and SD07-SS01) contained concentrations of TCE above the screening level of 0.7 mg/kg, with the highest concentration of 160 mg/kg at DD10-SS07 (Table 4-8). The sample SD07-SS01 was the only unsaturated zone soil sample (collected at a depth of 0.5 ft bgs) that contained a chlorinated volatile organic concentration above the screening level. However, the level of TCE within this sample was 0.85 mg/kg, which only slightly exceeds the screening level of 0.7 mg/kg.

All of the analytical results described above, except TCE from sample SD07-SS01, were from subsurface soil samples collected from a depth of 6 ft bgs, which coincides with the groundwater table interface.

4.3.1.2 Summary of Soil Results for Phase IV Investigation

No exterior or interior direct push soil sample contained elevated levels of a chlorinated VOC. As stated in Section 2.4.1.1, elevated organic vapors and staining were present in the macrocores generally from 5 to 15 ft bgs, starting just below the water table interface. Soil samples were collected at the water table interface, 3-5 ft bgs.

4.3.1.3 Conclusions

The subsurface soil samples containing elevated concentrations of chlorinated VOCs above screening levels were observed in the alleyway of the loading dock extending from the western edge of the totally enclosed storage area to approximately 20 feet west of the MW11 monitoring well cluster. The analytical results that exceeded screening levels for chlorinated VOCs were from subsurface soil samples collected from 0 to 6 feet bgs, which coincides with the groundwater table interface and supersaturated areas.

The highest 1,1,1-TCA concentrations were observed at DD09 at 4,800 mg/kg in 2002, but it was detected below the screening criterion at an adjacent boring location SG03 in 2008. The consistency of the highest concentration of 1,1,1-TCA being in this localized area confirms the location of a "hot spot" identified during the Phase I and II Investigations. The significant decrease in concentration, however, suggests that there is an extensive degradation of 1,1,1-TCA and that the source is a historical release.

According to historical investigations, the surface soils within close proximity to DD09 contained significant levels of chlorinated VOC. In 1991, during the soil investigation, H2M detected the highest total VOCs in sample S-6 at a depth of 18 to 24 inches below grade at 894.21 mg/kg (Appendix A). Sample S-6 is located approximately 150 feet west of the southeast corner of the building. Unfortunately, only the 18- to 24- inch depth increment was sampled from all the soil borings. In 1992, during the remedial investigation, H2M performed soil sample screening (from various locations at depth increments of 5, 10, 15, and 20 feet bgs). Selected samples were analyzed for VOCs. The highest VOC, 1,1,1-TCA, was detected in soil samples collected from a depth of 5-7 ft bgs (saturated soil) at levels ranging from non-detect (ND) to 26 mg/kg. The most contaminated samples were again the samples collected closest to the surface although only saturated soil samples were collected during the 1992 investigation. Soil samples from the 0- to 2- foot depth increment were not collected. When comparing the 1991 H2M investigation to the 1992 H2M investigation, the 18- to 24- inch depth increment contained higher concentrations of VOCs. The H2M investigations did not sample the surface soil near the loading dock within the vicinity of 120 feet west of the southeast corner of the building.

During the 1996 EnviroAudit investigation (Appendix C), the highest VOC, 1,1,1-TCA, was detected in sample AB-2, located 120 feet west of the southeast corner of the building, collected from a depth of 0-2 feet bgs. This sample contained a concentration of 1,1,1-TCA of 7,000 mg/kg. The sample collected from the 10- to 12-foot increment (7 mg/kg) contained significantly less VOCs. A soil sample from the 5- to 7- foot depth increment was not collected in boring AB-2. However, the sample AB-1 collected from a depth of 0-2 feet bgs contained a concentration of 1,1,1-TCA of 1,600 mg/kg. Samples collected from the 5- to 7- foot depth increment (4.6 mg/kg) and 10- to 12- foot increment were ND containing significantly less VOCs. The sample AB-1 is located approximately 100 feet west of the southeast corner of the building. These were the two borings that contained the highest detected levels of VOCs.

Since all historical investigations detected the highest concentration of chlorinated VOCs near the surface soil, the source of the chlorinated VOCs must have been a surface spill located immediately adjacent to the loading docks, approximately 120 feet west of the southeast corner of the building. The data collected during this RI supports this finding with the exception that currently the VOC contamination has been flushed over time from the surface soils into the subsurface unsaturated soils and finally into the subsurface saturated soils located a foot or two below the water table interface, indicating the absence of a continuing source of contamination. The highest mass of chlorinated VOC contamination currently resides in the groundwater instead of the unsaturated soils as demonstrated by a comparison of Figures 4-1 through 4-6.

4.3.2 Non-chlorinated Volatile Organic Compounds

4.3.2.1 Summary of Soil Results for Phase I Investigation

Eight subsurface soil samples contained concentrations of ethylbenzene and xylenes (total) above the screening level. These eight samples were SA02-SS07, SA02-SS12, SA04-SS12, SA05-SS12, SA06-SS12, DD17-SS12, DD23-SS12, and DD23-SS17 (Table 4-8). The ethylbenzene concentrations ranged from 8.1 mg/kg at SA06 to 15 mg/kg at SA04. The xylenes (total) concentrations ranged from 2.5 mg/kg at DD23 to 91 mg/kg at SA04. The screening levels for ethylbenzene and xylenes (total) are 5.5 mg/kg and 1.2 mg/kg, respectively (Table 4-8).

All of the analytical results described above were from subsurface soil samples collected in the loading dock alleyway from a depth of 7-12 feet bgs which falls 2 feet below the water table interface.

4.3.2.2 Summary of Soil Results for Phase IV Investigation

None of the exterior or interior direct push soil samples contained elevated levels of non-chlorinated VOCs. As stated in Section 2.4.1.1, elevated organic vapors and staining were present in the macrocores generally from 5-15 feet bgs, starting just below the water table interface. Soil samples were collected at the water table interface, 3-5 feet bgs.

4.3.2.3 Conclusions

Ethylbenzene and xylenes were the two common non-chlorinated VOCs that exceeded the screening level within the soil matrix. Almost all of the soil samples that contain elevated levels of ethylbenzene and xylenes were collected from a depth of 8-12 feet below grade. The 0- to 2- foot samples and the 5- to 7- foot samples collected during the Phase I Field Investigation did not contain elevated levels of these substances. The historical investigations conducted by H2M and EnviroAudit also detected elevated levels of ethylbenzene and xylene at a depth between 10 to 15 feet.

Since the water table interface is located between 4-5 feet below grade, the exterior soil boring contamination is detected at a depth which is significantly below the water table interface. If the historical source was located within the Site, contamination would be detected at the groundwater table interface. Contamination in the unsaturated zone migrates downward with gravity and precipitation. Once contacting the groundwater interface, the direction of contaminant migration is along the groundwater flow path which at the Site is in the western direction. No significant downward groundwater flow gradient exists at the Site (Section 3.6). Also, the organic partition coefficients (K_{OC}) for ethylbenzene and xylene are fairly low and the solubility are fairly high, indicating that sorption onto soil particulates would only occur in areas of high groundwater concentrations (Section 5.1 and Table 5-1). Thus, a contaminant source must exist at approximately 11 to 12 feet. Also, as presented in Section 4.4, there is no indication of an on-site source of non-chlorinated VOCs.

Since the sewer line is located at a depth of 12 feet and most of the non-chlorinated VOCs are located within close proximity to the sewer line, this sewer line may be a source of the non-chlorinated VOC contamination. Non-chlorinated VOCs may be entering the sewer line either via the drain spout that drains the 39th Street Bridge and adjacent Hess gasoline station and discharges contaminated storm water runoff overland into the on-site manholes or through upgradient sewer lines that convey non-chlorinated contamination from the adjacent Sunnyside Yard into the on-site sewer line. Both the Hess gasoline station and the Sunnyside Yard have detected non-chlorinated VOC contamination that is several orders of magnitude above those levels detected on the Site (Appendix D and E).

The locations of the three manholes that connect the sewer line were surveyed during the November 2002 investigation and the approximate depth of the manholes and connecting sewer line was measured at 12 feet. Conversations with Roux Associates indicated that there were no as-built drawings available for this sewer line. However, Roux interpreted the location and size of the sewer system during The Sunnyside Yard investigations (Appendix D). The information collected from Roux Associates, Inc., in October 2002 included the following:

- The 36-inch round brick conduit was built around 1908 or 1912
- This brick conduit carries the combined sanitary discharge (from old Sunnyside Yard buildings only) and storm water runoff
- The sewer line runs straight between manholes behind the SMP building
- Drainage is from Sunnyside Yard only (with the exception of the 39th Street drain spout)
- The three man-holes that were surveyed did not contain man-hole covers that would prevent surface water runoff from entering these man-holes and subsequently discharging along the sewer line.

In addition, located directly adjacent to the southeast corner of the building is a discharge drain that drains surface water runoff from the 39th Street overpass. Thus, any surface water discharge from the street above or the Hess site can be discharged onto the Site via the drain spout located under the 39th Street Bridge and flow directly into these man-holes and enter the sewer line.

In particular, during the Phase I Field Investigation, significant surface water runoff was being discharged onto the Site from this drain spout and flooding the SMP property. Storm water routinely floods the vicinity of the previously excavated soil (near the western manhole) and the area adjacent to the central manhole (SD05). An oily sheen was noticed within this surface drainage from the drain spout. The NYSDEC environmental manager was on-site at the time and the project team directed her attention to this condition.

In conclusion, the highest non-chlorinated volatile organic concentrations are located at the same depth as the sewer line and in close proximity to the sewer line. Thus, it is reasonable to conclude that the non-chlorinated volatile organic contamination is caused by upgradient sources. This conclusion is also supported by the elevated levels of SB13 which is located in the further most northwest corner.

In addition, the contaminant distribution pattern for chlorinated VOCs is significantly different from the contaminant distribution pattern of the non-chlorinated VOCs. Thus, the data collected during the Phase I and IV Investigations and prior investigations indicate that the non-chlorinated VOCs are from an upgradient source. The Hess Station is located immediately upgradient and significant non-chlorinated VOCs contamination has been confirmed on this property as is the source of non-chlorinated VOCs on the Site.

4.3.3 Semi -Volatile Organic Compounds

4.3.3.1 Summary of Exterior Direct Push Soil Results for Phase IV Investigation

Soil sample at SG09 detected elevated concentrations of the following SVOC above the screening level: benzo(a)anthracene at 13 mg/kg (screening level of 11 mg/kg), benzo(a)pyrene at 12 mg/kg (screening level of 1.1 mg/kg), benzo(b)fluoranthene at 11 mg/kg (screening level of 11 mg/kg), and dibenz(a,h)anthracene at 1.7 mg/kg (screening level of 1.1) (Table L-4.4 in Appendix L). SG09 is located along the perimeter of the loading dock. The analytical results described above were from subsurface samples collected from a depth of 4-5 feet bgs, which is three feet above the water table interface.

4.3.3.2 Summary of Interior Direct Push Soil Results for Phase IV Investigation

Soil sample at SB04 displayed elevated levels of the following semi-volatile constituents above the screening level: 2-chlorophenol at 1.4 mg/kg (screening level of 0.8 mg/kg), 4-chloro-3-methylphenol at 1.4 mg/kg (screening level of 0.24 mg/kg), and 4-nitrophenol at 1.3 mg/kg (screening level of 0.1 mg/kg) (Table L-4.3 in Appendix L). Soil boring SB04 is located on the northern side of the building just south of the former 1,1,1-TCA tank. The analytical results described above were from a subsurface sample collected from refusal at a depth of 18 feet bgs.

4.3.3.3 Conclusion

The exterior and interior subsurface soil samples displayed significantly different SVOCs and therefore no correlation is made between the two.

The exterior soil boring sample, SG09, detected SVOCs found in no other borings throughout the Site. The constituents detected are common gasoline components (such as benzo(a)anthracene and dibenz(a,h)anthracene) and occur ubiquitously in products of incomplete combustion. Since the constituents are present along the loading dock area (not under the building) at relatively low depths, the source of these constituents are from the drainage pipe from the 39th Street bridge, debris stored in the alleyway, and/or degradation products of a gasoline plume migrating from an off-site source.

The interior soil boring sample from SB04 detected SVOCs found in no other borings throughout the Site as well. The constituents detected have an array of uses: 4-chloro-3-methylphenol is used as a fungicide and preservative; 4-nitrophenol is also used as a fungicide; and 2-chlorophenol is most likely a xenobiotic produced from the degradation products of the gasoline and chlorinated constituent plumes mixing together.

Since the constituents are present only at this isolated location at a depth of 18 feet bgs, it is concluded that the source of these constituents is from the sewer connection which is connected to the former 1,1,1-TCA tank, the gasoline plume migrating onsite from the southeast, and/or machine operational and maintenance practices.

4.3.4 Inorganic Compounds

4.3.4.1 Summary of Soil Results for Phase I Investigation

Lead exceeded the screening level of 400 mg/kg from two surface soil samples at DD17 and SD19, 483 and 465 mg/kg, respectively.

4.3.4.2 Summary of Exterior Direct Push Soil Results for Phase IV Investigation

Iron is present in all seven direct push soil samples above the screening level of 2,000 mg/kg. The detections of iron ranged from 4,550 mg/kg from SG09 at 35-38 feet bgs to 21,600 mg/kg from SG09 at 4-5 feet bgs (Table L-4.8 in Appendix L). The subsurface samples collected at the shallower depth located at the water table interface displayed relatively higher concentrations of iron then the samples collected at refusal, which ranged from 35-47 feet bgs. Arsenic (19 mg/kg) exceeded the screening level of 16 mg/kg at SG09, 19 mg/kg. Vanadium also exceeds the screening level of 150 mg/kg at SG03 (545 mg/kg) and SG33 (224 mg/kg) (Table L-4.8 in Appendix L).

4.3.4.3 Summary of Interior Direct Push Soil Results for Phase IV Investigation

Iron is present in all fourteen direct push soil samples above the screening level of 2,000 mg/kg, except at 18 feet bgs sample from SB12. The exceedance detections of iron ranged from 2,530 mg/kg from SG01 at 7-8 feet bgs to 10,900 mg/kg at SB07 from 8-9 feet bgs. The subsurface samples collected at the shallower depth located at the water table interface displayed similar concentrations of iron with the samples collected at refusal, which ranged from 6 to 27 feet bgs.

4.3.4.4 Conclusion

During Phase I, within two samples, lead exceeded the screening level. The two samples that contained concentrations that exceeded lead screening levels are located within the area of previously excavated soil which corresponds to an area that is a low point within the Site and is frequently flooded via upgradient storm water.

Unlike ethylbenzene and xylene, lead has no partitioning coefficient between organic carbon in soil and groundwater since lead is insoluble and sorbs readily onto soil. Thus, these elevated levels of lead are probably due to leaded petroleum products migrating via storm water runoff. Since lead is transported primarily via particulate migration, settling particulates from the stagnant storm water after storm events in the area adjacent to the eastern manhole create elevated levels of lead on surface soils in this area.

The screening level for lead is 400 mg/kg and was selected based upon the EPA risk-based soil screening level for the ingestion-dermal exposure for a residential scenario, which is very conservative. However, the NYSDEC soil cleanup objective is 500 mg/kg. Even though two samples contained lead levels (483 and 465 mg/kg) that exceeded the screening concentration of 400 mg/kg, lead levels in these samples are below the NYSDEC criterion of 500 mg/kg.

Iron is the major inorganic constituent above screening level present at all subsurface sampling locations. Since iron is ubiquitous in the environment in particular to urban settings such as Long Island City, Queens, New York where construction, adjacent rail transportation and industry is prevalent, this constituent is not assumed to be a Site-related contaminant.

Other constituents present in one or two borings located within the alleyway of the loading dock include arsenic and vanadium. Since these metal constituents were detected in isolated areas at relatively low concentrations their presence can be attributed to urban fill and urban setting where construction, adjacent rail transportation and general industry is prevalent.

4.4 Assessment of Groundwater Quality - Phase I, II, III, and IV Investigations

Groundwater quality is assessed utilizing the results of both the direct push boring investigations conducted during the Phase I and IV Field Investigations and the monitoring well investigations conducted during the Phase II, III, and IV Field Investigations. These investigations are described in the following section. The results of the analytical data collected from these investigations are compared with the screening levels selected via the described methodology in Section 4.2 and any concentrations that exceed these concentrations are presented and evaluated in this section.

Tables 4-9 through 4-12 present the detection frequency, the maximum concentration, and the minimum concentration of the constituents detected in groundwater during the Phase I Investigation through Phase IV Investigation, respectively. Groundwater analytical results are provided in Appendix L.

Due to significant differences in sample collection methodology and sample quality, the direct push groundwater samples collected during the Phase I and IV Investigations are discussed separately from the monitoring well samples collected during the Phase II, III, and IV Investigations. The direct push samples were utilized during the Phase I Investigation as a field screening technique to approximate locations of highest groundwater contamination and to properly place the permanent monitoring wells. The direct push samples were utilized during the Phase IV Investigation to further delineate contamination under the building and the previous identified "hot spot" area near the loading dock.

A significant difference in the constituents detections are observed between the direct push groundwater and monitoring well collection results. The direct push groundwater results detect a greater number of constituents and at significantly higher concentrations than the monitoring well results. It is concluded that screen interval variance between the direct push groundwater samples and monitoring wells plays an important role in sample collection and analysis. The screen interval of the direct push groundwater sampling tool is approximately 4 feet in length, while the screen interval of the monitoring wells are 15 feet in length for the shallow wells and 10 feet in length for the deep wells. The extra 6-11 feet of screen collects a greater amount of water over a larger depth resulting in a dilution effect in turn decreasing the number of detected constituents and their concentrations. This is particularly vital when analyzing the results of the shallow wells since the contamination is observed to be at the water table interface.

4.4.1 Assessment of Direct Push Groundwater Quality

4.4.1.1 Chlorinated Volatile Organic Compounds

4.4.1.1.1 Summary of Direct Push Groundwater Results for the Phase I Investigation

There were a total of 14 constituents detected within direct push groundwater samples at concentrations above respective screening levels. Among these 14 constituents, there are 10 chlorinated volatile organic constituents (i.e., 1,1,1-TCA, 1,1,2-trichlorotrifluoroethane, 1,1-DCA, 1,2-dichlorobenzene, chloroethane, *cis*-1,2-DCE, *trans*-1,2-DCE, PCE, TCE, and vinyl chloride [VC]) (Table 4-9).

For 1,1,1-TCA, concentrations were detected above the screening level of 5 µg/L in 12 groundwater samples, with the highest 1,1,1-TCA concentration of 2,500 µg/L detected at DD09-GW07 (Table 4-13)**.** The majority of these 12 samples were collected at 6 feet bgs which is the groundwater table interface, except DD09-GW37 which was collected at 36 feet bgs.

For 1,1-DCA, analytical concentrations exceeded the screening level of 5 µg/L in 8 samples, with the highest 1,1-DCA concentration of 970 µg/L detected in sample DD09-GW07 (Table 4-13). All of the sample locations with 1,1-DCA exceedances also contained 1,1,1-TCA concentrations above the screening levels. The majority of these 8 samples were collected at 6 feet bgs, except DD09-GW37 which was collected at 36 feet bgs. .

For PCE, four samples contained concentrations that exceeded the screening level (5µg/L) with the highest PCE concentration of 44 µg/L detected in sample DD09-GW07. All four of these samples were collected at 6 feet bgs.

For TCE, twelve samples contained concentrations that exceeded the screening level of 5 µg/L with the highest TCE concentration of 800 µg/L detected in DD09-GW07 (Table 4-13). Many of the sample locations with TCE exceedances also contained PCE and 1,1,1-TCA concentrations above the screening level. Most of these 12 samples were collected at 6 feet bgs, except DD09-GW37 and DD11-GW37 which were collected at 36 feet bgs. The exact depth of the sump sample (SM01) cannot be determined due to lack of construction details.

For *cis*-1,2-DCE, twelve samples contained concentrations that exceeded the screening level of 5 µg/L with the highest concentration of 400 µg/L was detected in sample SA01-GW07 (Table 4-13). Many of these sample locations also contained TCE and 1,1,1-TCA concentrations above the screening level. The sample location SA01-GW07 contained the third highest 1,1,1-TCA concentration and the second highest 1,1-DCA and TCE concentrations. The second highest *cis*-1,2-DCE concentration was detected at sample location DD09-GW07 at a concentration of 240 µg/L. Only 6 of the 12 samples cited above were collected from a depth of 6 feet. Samples collected from DD09-GW37 (36 feet), DD04-GW37 (36 feet), DD11-GW37 (36 feet), DD03-GW32 (31 feet) and DD23-GW26 (25 feet) were collected from depths that varied between 25 and 36 feet bgs. The highest *cis*-1,2-DCE concentrations detected within this deeper groundwater zone are from samples DD09-GW37 and DD04-GW37 at concentrations of 83 µg/L and 53 µg/L, respectively. The exact depth of the sump sample (SM01) cannot be determined due to lack of construction details.

For VC, 6 samples contained concentrations that exceeded the screening level of 2 µg/L (Table 4-13). The highest concentration of 110 µg/L detected in sample DD09-GW07 exceeded the screening level. Three of the six samples with exceedances were collected from a depth of 6 feet bgs (DD09-GW07, DD11-GW07, and SA02-GW07). Samples from DD04-GW37 and DD03-GW32 were collected from greater depths at 36 feet and 31 feet, respectively. The VC concentration detected within this deeper groundwater zone were from samples DD03-GW32 and DD04-GW37 having concentrations of 7 µg/L and 4 µg/L, respectively. The exact depth of the sump sample (SM01) cannot be determined due to lack of construction details.

For chloroethane, two samples contained concentrations exceeding the screening level of 5 µg/L. They are sample DD09-GW07 taken from 6 feet below grade measuring 220 µg/L, and SM01 measuring 17 µg/L.

For 1,1,2-trichlorotrifluoroethane, 5 samples contained concentrations that exceeded the screening level of 5 µg/L. They are SA01-GW07, SA02-GW07, SA-03-GW07, SA04-GW07, and DD11-GW07. The highest concentration of 14 µg/L was detected in sample SA02-GW07. All samples were collected at a depth of 6 feet bgs. Since this constituent is a common refrigerant and detected at such low concentrations, 1,1,2-trichlorotrifluoroethane is determined to be a non-Site related contaminant.

For 1,2-dichlorobenzene, only one sample contained a concentration that exceeded the screening level of 3 µg/L. A concentration of 9 µg/L was detected in sample SA02-GW07 at a depth of 6 feet bgs.

4.4.1.1.2 Summary of Exterior Direct Push Groundwater Results for Phase IV Investigation

A total of 20 samples were collected from 9 outdoor direct push locations that detected several chlorinated volatile organic constituents above the screening levels. The nine chlorinated volatile organic constituents detected during the Phase I Investigation (i.e., 1,1,1-TCA, 1,1,2-trichlorotrifluoroethane, 1,1-DCA, 1,2-dichlorobenzene, chloroethane, *cis*-1,2-DCE, PCE, TCE, and VC) were present among the compounds detected. The direct push groundwater samples were collected from 3 depths (5-9, 10-14, and 15-19 feet bgs).

For 1,1,1-TCA, concentrations were detected above the screening level of 5 µg/L in 12 samples (Table 4-14). The highest 1,1,1-TCA concentration of 3,100 µg/L was detected at SG03-GW59 followed by 1,600 µg/L at SG03-GW1014. The concentrations of the remaining exceedances ranged from 5.1 to 270 µg/L. Eight of the 12 samples were collected from 5 to9 feet bgs, and 4 of the 12 from 10 to14 feet bgs.

For 1,1-DCA, analytical concentrations exceeded the screening level of 5 µg/L in 8 samples (Table 4-14). The highest concentration (2,300 µg/L) of 1,1-DCA was detected at SG03-GW59 followed by 610 µg/L at SG03-GW1014. The concentration range for the remaining exceedances was from 7.8 to 100 µg/L. The majority of the samples were collected from 5-9 feet bgs followed by 10-14 feet bgs.

For TCE, 13 samples contained concentrations that exceeded the screening level of 5µg/L (Table 4-14). Many of these sample locations are also contained 1,1,1-TCA concentrations above the screening level. The highest detected TCE concentration was in SG03-GW59 at 2,300 µg/L followed by 930 µg/L in SG03-GW1014. The TCE concentration detected at SG03-GW59 is 17 to 400 times the concentrations detected in the remaining samples.

For *cis*-1,2-DCE, 10 samples contained concentrations that exceeded the screening level of 5 µg/L (Table 4-14). These samples also contained concentrations of TCE and 1,1,1-TCA above the screening level. The highest detected *cis*-1,2-DCE concentration was in SG03-GW59 at 1,700 µg/L followed by 520 µg/L in SG03-GW1014. The *cis*-1,2-DCE concentration detected at SG03-GW59 is 35 - 283times the concentrations detected in the remaining samples.

For VC, 10 samples contained concentrations that exceeded the screening level of 2 µg/L (Table 4-14). These samples also contained concentrations of 1,1,1-TCA, TCE, and *cis*-1,2-DCE above the screening level. The VC concentrations ranged from 3.8 to 41 µg/L and varied among sample location and depth. The highest VC concentrations were detected in samples collected from 15-19 feet bgs.

Methylene chloride was detected at boring locations SG01 (5-9 and 10-14 ft bgs), SG02 (5-9 ft bgs), and SG03 (5-9 and 10-14 ft bgs). The detected concentrations ranged from 0.63 to 54 µg/L, with the highest concentration at SG01-GW59 (Table 4-14). Methylene chloride is a common lab contaminant and should be disregarded as a Site-related constituent.

1,1,2-TCA was detected at boring locations SG02 and SG03. The detected concentrations ranged from 1.3 to 22 µg/L, the highest concentration at SG03-GW59. 1,1,2-Trichlorotrifluorethane was detected at boring locations SG01 and SG03. The detected concentrations ranged from 5 to 47 µg/L, the highest concentration at SG03-GW59 (Table 4-14). Since this constituent is a common refrigerant and detected at such low concentrations, 1,1,2-trichlorotrifluoroethane is determined to a non-Site related contaminant.

Soil boring SG01 also detected dichlorodifluoromethane at 21 µg/L at 5-9 feet bgs. Soil boring SG03 also detected 1,1-DCE at 13 µg/L, 1,2-dichlorobenzene at 9.9 µg/L, chloroethane at 100 µg/L, PCE at 92 µg/L, trans-1,2-DCE at 9.1 µg/L, and trichlorofluoromethane at 33 µg/L (Table 4-14). The highest concentrations of these constituents were found in the samples collected from 5-9 feet bgs followed by 10-14 feet bgs.

4.4.1.1.3 Summary of Interior Direct Push Groundwater Results for Phase IV Investigation

A total of nine samples were collected from nine indoor direct push locations that detected chlorinated volatile organic constituents, i.e. 1,1,2-trichlorotrifluoroethane, chloroethane, dichlorodifluoromethane, methylene chloride, TCE, PCE, and VC, above screening levels. Of these constituents 1,1,2-trichlorotrifluoroethane, chloroethane, TCE, PCE, and VC were detected in both the Phase I and Phase IV outdoor direct push groundwater samples. The samples were collected from a 4-ft interval between 6 and 14 feet bgs.

For methylene chloride, six samples contained concentrations that exceeded the screening level of 5 µg/L (Table 4-15). The methylene chloride detections ranged from 7.4 to 150 µg/L. Methylene chloride is a common lab contaminant, thus, it may not be Site-related.

For 1,1,2-trichlorotrifluorethane, two samples contained concentrations that exceeded the screening level of 5 µg/L. The constituent was detected in SB01-GW812 at 160 µg/L and SB03-GW711 at 32 µg/L. These groundwater samples also contained methylene chloride. The groundwater sample collected at SB01-GW812 also contained 17 µg/L of dichlorodifluoromethane (Table 4-15). Since this constituent is a common refrigerant and detected at such low concentrations, 1,1,2-trichlorotrifluoroethane is not a Site-related contaminant.

For TCE, two samples contained concentrations that exceeded the screening level of 5 µg/L. TCE was detected in SB09-GW812 and SB15-GW610 at 5.6 µg/L. The groundwater sample collected at SB15-GW610 also contained 11 µg/L of PCE. The only other indoor sample containing PCE concentration above the screening level was SB01-GW812 at 8.7 µg/L (Table 4-15).

The groundwater sample collected at SB07-GW812 exceeded the screening level of chloroethane with a detection of 2,200 µg/L. The groundwater sample collected at

SB12-GW914 exceeded the screening level of VC with a detection of 19 µg/L. These groundwater samples did not contain any other chlorinated constituents (Table 4-15).

4.4.1.1.4 Conclusions

The majority of the highest chlorinated volatile organic concentrations detected during the Phase I Investigation are in the samples DD09-GW07, DD13-GW07, DD11-GW07, SA01-GW07, SA02-GW07, and SA03-GW07 within the shallow 6-foot depth interval which coincides with the groundwater table interface (Figure 4-2). The Phase IV outdoor samples which detected the highest chlorinated volatile organic concentrations, SG02-GW59, SG03-GW59, SG03-GW1014, SG04-GW59, and SG05-GW59, are also associated with the groundwater table interface (5-9 feet bgs) and in close proximity to the Phase I borings mentioned above. These results are consistent with soil analytical data in that the highest concentrations of both the soil and groundwater are located immediately adjacent to the loading dock approximately 120 feet west of the southeast corner of the building.

These results are also consistent with the previous soil and groundwater data in that they indicate a “hot spot". Soil boring locations DD09 collected in 2002 and SG03 collected in 2008 both detect a wide range of chlorinated volatile constituents, including 1,1,1-TCA, 1,1-DCA, 1,1-DCE, chloroethane, TCE, and VC, and usually detecting the highest concentration. The soil borings also detected elevated concentrations of these constituents at depths below the water table interface. It can be confirmed that the “hot spot” is along the loading dock northeast of MW11, approximately 120 feet west of the southeast corner of the building.

In addition, the analytical results from the Phase I and Phase IV Investigations from these sampling locations conclude significant degradation of PCE. During the Phase I Investigation four direct push groundwater locations detected concentrations of PCE, DD09, SA01, SA02, and SA03. The highest concentration of PCE among those samples was 44 µg/L at DD09. The Phase IV Investigation identified only two locations containing PCE at relatively low concentrations, SB15 at 11 µg/L and SB01 at 8.7 µg/L. The majority of the constituents detected during the Phase IV Investigation are TCE, *cis*-1,2-DCE, and VC, which are breakdown products of PCE. Also during the Phase I Investigation groundwater samples collected downgradient of the “hot spot” (DD03 and DD04) detected 1,1,1-TCA, 1,1-DCE, and VC, while similar placed borings SG10 and SG09 analyzed during the Phase IV investigation only detected 1,1,1-TCA at 7.7 µg/L.

Indoor direct push groundwater samples collected during the Phase IV Investigation detected a small variety of chlorinated volatile constituents at very low concentrations, except SB07-GW812. The groundwater sample collected from this location detected chloroethane at 2,200 µg/L. The increased concentration of chloroethane at SB07 can be contributed to the former 1,1,1-TCA tank located upgradient (northeast) of the soil boring. Since chlorinated VOC concentrations significantly diminish underneath the building, the source of the chlorinated VOCs was confirmed to be located adjacent to the loading dock and not underneath the building.

4.4.1.2 Non-Chlorinated Volatile Organic Compounds

Six non-chlorinated volatile organic constituents were detected at concentrations above screening levels, i.e. benzene, ethylbenzene, toluene, xylene, isopropylbenzene, and MTBE in the Phase I and Phase IV indoor investigation. Phase IV outdoor investigation detected the same compounds except MTBE and with the addition of chloroform.

4.4.1.2.1 Summary of Direct Push Groundwater Results for Phase I Investigation

Six samples contained concentrations of benzene that exceeded the screening level (Table 4-13). They are SA02-GW07, SA05-GW07, SM01, DD11-GW07, DD13-GW34, and DD23-GW07. The highest benzene concentration of 27 µg/L was detected in sample DD23-GW07. The screening level for benzene is 1 µg/L. All of these samples were collected from a depth of 6 feet except for DD13-GW34, which was collected from a depth of 33 feet. There was no groundwater samples collected from a depth of approximately 12 feet which would have corresponded to the depth of the sewer line. Only two depth profiles (approximately 5-7 and 30-37 ft bgs) for groundwater were collected during the direct push investigation which corresponds to the groundwater table interface and the deeper 30-37 feet groundwater zone.

Three samples contained concentrations of toluene exceeding the screening level of 5 µg/L (DD23-GW07, SA02-GW07, and SA03-GW07). The highest concentration of 90 µg/L was detected in sample DD23-GW07. All of these samples were collected from a depth of 6 feet bgs (Table 4-13).

Four samples contained concentrations of ethylbenzene that exceeded the screening level of 5 µg/L (Table 4-13). The highest detected concentration of ethylbenzene was 580 µg/L contained in sample DD23-GW07. All of these samples were collected from a depth of 6 feet bgs (Table 4-13).

Eight samples contained concentrations of xylenes (total) that were above the screening level of 5 µg/L (Table 4-13). Sample SA02-GW07 contained the highest xylene concentration of 470 µg/L, while the second highest xylene concentration of 420 µg/L was detected in sample DD23-GW07. All of these samples, except DD23-GW26 (25 ft bgs), were collected from a depth of 6 feet bgs.

Four samples contained concentrations of isopropylbenzene that were above the screening level of 5µg/L (Table 4-13). The highest concentration of isopropylbenzene (54 µg/L) was reported in sample DD23-GW07. All four of these samples were collected from a depth of 6 ft bgs.

Eight samples contained concentrations of MTBE that were above the screening level (DD11-GW07, DD13-GW07, DD13-GW34, DD23-GW07, DD09-GW37, SA05-GW07, SA06-GW07, and SM01). The highest MTBE concentration of 630 µg/L was detected in sample DD11-GW07. The second highest MTBE concentration of 490 µg/L was detected in sample DD09-GW37. The screening level for MTBE is 10 µg/L. All of these samples, except DD13-GW34, DD09-GW37, and SM01, were collected from a depth of 6 feet bgs (Table 4-13).

4.4.1.2.2 Summary of Exterior Direct Push Groundwater Results for Phase IV Investigation

Six non-chlorinated volatile organic constituents were detected at concentrations above screening levels, i.e. benzene, ethylbenzene, toluene, xylenes, isopropylbenzene, and chloroform. These constituents exceeded screening levels in the Phase I direct push groundwater borings as well, except chloroform.

For benzene, 7 samples from four direct push locations contained concentrations which exceeded the screening level of 1 µg/L, SG01-GW59, SG02-GW59, SG03-GW1014, SG06-GW59, SG06-GW1014, and SG06-GW1519. The highest concentration of 51 µg/L was detected in sample SG01-GW59. The benzene concentration detected at SG01 is 25 times greater than the remaining sample concentrations except SG06-GW1519 with a detection of 30 µg/L (Table 4-14).

For xylenes (total), 6 samples from three direct push locations contained concentrations which exceeded the screening level of 5 µg/L, SG01-GW59, SG01-GW1014, SG01-GW1519, SG03-GW1014, SG03-GW1519, and SG08-GW59. The highest concentration of 590 µg/L was detected at SG01-GW1014 followed by 300 µg/L at SG01-GW59. The xylenes (total) concentrations detected at SG01 are 30 to 95times greater than the concentrations detected at SG03 and SG08 locations.

For ethylbenzene, six samples from two direct push locations contained concentrations which exceeded the screening level of 5 µg/L, SG01-GW59, SG01-GW1014, SG01-GW1519, SG03-GW59, SG03-GW1014, and SG03-GW1519. The highest concentration of 200 µg/L was detected at SG01-GW1014, followed by 76 µg/L at SG01-GW59. The ethylbenzene concentrations at SG01 are 30 times greater than the concentrations detected at SG03.

For isopropylbenzene, three samples from two direct push locations contained concentrations with exceeded the screening level of 5 µg/L, SG01-GW59, SG01-GW1014, and SG08-GW59. The highest concentration of 60 µg/L was detected at SG01-GW1014. The isopropylbenzene concentration at SG01 is three times greater than the concentration detected at SG08 (Table 4-14).

Soil boring location SG01 also detected toluene at concentrations exceeding the screening level. Groundwater samples collected from 5-9 and 10-14 feet bgs contained 20 µg/L and 14 µg/L of toluene, respectively. Soil boring location SG03 at 5 to 9 ft bgs contained chloroform at concentration of 7.1 µg/L slightly exceeding the screening level of 7 µg/L (Table 4-14).

4.4.1.2.3 Summary of Interior Direct Push Groundwater Results for Phase IV Investigation

Six non-chlorinated volatile organic constituents were detected at concentrations above screening levels, i.e. benzene, ethylbenzene, toluene, xylenes, isopropylbenzene, and MTBE. These constituents also exceeded screening levels in the Phase I direct push groundwater borings. The indoor direct push groundwater samples were collected from a 4-ft interval between 7 and 14 feet bgs. The water table interface was encountered from 8 to9 feet bgs inside the building.

For xylenes (total), 7 samples contained concentrations which exceeded the screening level of 5 µg/L, SB01-GW812, SB03-GW711, SB05-GW914, SB07-GW812, SB08-GW914, SB11-GW812, and SB13-GW914. The exceedance range of xylenes (total) is from 15 to 4,200 µg/L. The highest concentration was detected in sample SB05-GW914 (Table 4-15).

For toluene, 7 samples contained concentrations which exceeded the screening level of 5 µg/L, SB01-GW812, SB03-GW711, SB05-GW914, SB07-GW812, SB08-GW914, SB10-GW711, and SB11-GW812. The exceedance range of toluene is 5.5 to 640 µg/L. The highest concentration was detected in sample SB03-GW711. Groundwater samples collected from SB05 and SB08 contained elevated concentrations of toluene at 250 and 110 µg/L, respectively (Table 4-15).

For isopropylbenzene, 8 samples contained concentrations which exceeded the screening level of 5 µg/L, SB01-GW812, SB03-GW711, SB04,-GW812, SB05-GW914, , SB08-GW914, SB11-GW812, SB13-GW914, and SB16-GW812. The exceedance range of isopropylbenzene is from 11 to 240 µg/L. The highest concentration was detected in sample SB13-GW914. Groundwater samples collected from SB01, SB03, SB05, and SB08 ranged between 98 and 180 µg/L (Table 4-15).

For benzene, 6 samples contained concentrations which exceeded the screening level of 1 µg/L, SB03-GW711, SB05-GW914, SB07-GW812, SB08-GW914, SB11-GW812, and SB13-GW914. The exceedance range of benzene is from 82 to 410 µg/L. The highest concentration was detected in sample SB08-GW914. Groundwater samples collected from SB03, SB05, SB07, and SB13 concentrations ranged between 180 and 200 µg/L (Table 4-15).

For ethylbenzene, 6 samples contained concentrations which exceeded the screening level of 5 µg/L, SB01-GW812, SB03-GW711, SB05-GW914, SB08-GW914, SB11-GW812, and SB13-GW914. The exceedance range of ethylbenzene is from 20 to 1,800 µg/L. The highest concentration was detected in sample SB13-GW914. Groundwater samples collected from SB03, SB05 and SB08 concentrations ranged between 1,000 and 1,500 µg/L (Table 4-15).

For MTBE, 3 samples contained concentrations which exceeded the screening level of 10 µg/L, SB03-GW711, SB07-GW812, and SB08-GW914. The exceedance range of MTBE is from 18 to 73 µg/L. The highest concentration was detected in sample SB03-GW914 (Table 4-15).

4.4.1.2.4 Conclusions

The direct push groundwater samples were collected from two discrete depth intervals: across the water table interface (approximately 6-14 feet), and at a depth of 30-35 feet. Seven non-chlorinated volatile organic constituents were detected at concentrations above screening levels, i.e. benzene, ethylbenzene, toluene, xylene, isopropylbenzene, MTBE, and chloroform. Since chloroform is present in one groundwater sample at a low concentration the constituent is determined to be non-Site related.

The contaminant distribution of the BTEX constituents is different from the chlorinated VOC contamination. The highest levels of BTEX contamination are detected in the most hydraulically upgradient borings adjacent to the eastern portion of the building. In 2002 DD23 and in 2008 SG01, SB13, SB08, SB05, and SB03 displayed the highest concentrations of BTEX constituents. The soil boring SB13 is located in the northeast corner of the building near an office/storage area. The increased levels of BTEX constituents present at this location indicate an offsite source.

The BTEX plume distribution does not coincide with the chlorinated constituent distribution. The highest chlorinated VOC contamination is located at the “hot spot” approximately 120 feet west of the southeast corner of the building. This “hot spot” location was also identified during previous investigations. The highest concentration of BTEX in the groundwater at the most hydraulically upgradient location is due to the upgradient contaminant plume emanating from the Hess gasoline station (Appendix C). The concentrations of BTEX detected at the Hess gasoline station are several orders of magnitude higher than the Site. The contaminant plume maps presented in Appendix C indicate that the contamination is migrating in the direction of the Site and is the source of the BTEX contamination detected at the water table interface.

In addition to BTEX being transported from the Hess gasoline site via groundwater migration, storm water runoff from the following three sources are collected in the Site sewer line and contribute to the BTEX contamination at the water table interface:

- storm water runoff from the upgradient Hess gasoline station (Appendix E)
- storm water runoff from the upgradient and cross gradient portions of the Sunnyside Yard (Appendix D)
- storm water runoff from the 39th Street Bridge

Both the Hess gasoline station and the Sunnyside Yard have documented BTEX contamination that is orders of magnitude higher than the levels detected at the Site. These results indicate that the BTEX contamination detected on the Site originates from an upgradient off-site source.

The contaminant distribution of the MTBE is not only different from the BTEX contamination, but it is also different from the chlorinated VOC contamination. The highest levels of BTEX contamination are detected in the most hydraulically upgradient boring adjacent to the southeast corner of the building. The highest chlorinated VOC contamination is located at the "hot spot" approximately 120 feet west of the southeast corner of the building. In contrast, the highest MTBE contamination is located in the southwestern most samples at significant depth. Since MTBE has the lowest K_{oc} value of any volatile organic contaminant (chlorinated or non-chlorinated), it is highly mobile with almost no sorption onto soils to retard solute migration with groundwater. MTBE is also highly persistent, and does not significantly biodegrade (Steffan *et. al,* 1997). Thus, the presence of MTBE located at significant depth on the southwestern edge of the Site is most likely attributable to a previous release from the Hess gasoline station.

4.4.1.3 Semi-Volatile Organic Constituents

Two semi-volatile organic constituents, bis(2-ethylhexyl)phthalate and phenol, were detected exceeding the screening levels in the exterior direct push borings collected from the water table interface. Exceedance of bis(2-ethylhexyl)phthalate ranged from 6.7 to 9.4 µg/L. Phenol was detected in SG03-GW59 at 3.3 µg/L (Table L-4.17 in Appendix L).

One semi-volatile organic constituent, naphthalene, was detected in the interior direct push borings collected from the water table interface exceeding the screening level of 10 µg/L. Groundwater sample SB01-GW812 detected 260 µg/L of naphthalene (Table L-4-14 in Appendix L).

The three semi-volatile constituents, bis(2-ethylhexyl)phthalate, naphthalene, and phenol, are detected in an isolated incidents and at relatively low concentrations. Since bis(2-ethylhexyl)phthalate is a common laboratory contaminant and detected at relatively low concentrations it will be disregarded as a Site related contaminant. Naphthalene and phenol however are common products of gasoline and should be attributed to the BTEX plume migrating onsite.

4.4.1.4 Inorganic Compounds

Several metal constituents detected in the exterior direct push groundwater samples exceeded their respective screening levels (Table L-4.18 in Appendix L). The groundwater samples were collected from the water table interface (5-9 feet bgs) from direct push locations SG03, SG08, and SG09. Additional groundwater samples were collected from 10-14 and 15-19 feet bgs from SG03.

A filtered metal sample was collected from SG09 to provide a realistic assessment of inorganic levels that are mobile in the groundwater flow regime. Since direct push sampling techniques typically contain an elevated level of particulates, inorganic analyses of direct push groundwater samples are not representative of constituents that are mobile in the aquifer. The SG09 filtered sample detected one TAL metal constituent above the screening level, iron (Table L-4.18 in Appendix L). Since iron is ubiquitous in the environment in particular to urban settings such as Long Island City, Queens where increased construction, adjacent rail transportation and industry is prevalent, this constituent is likely not a Site-related contaminant.

Several metal constituents were also detected in the interior direct push groundwater samples which exceeded their respective screening levels (Table L-4.15, Appendix L). A filtered indoor groundwater sample was not collected during this sampling round.

The high concentrations of the other constituents are attributed to soil particulates suspended in the direct push sample. As discussed in Section 4.3.4.4, the elevated levels of these inorganic constituents are due to urban fill, adjacent rail transportation and urban setting with increased construction and industrial production.

4.4.2 Assessment of Monitoring Well Groundwater Quality

4.4.2.1 Chlorinated Volatile Organic Compounds

Monitoring wells sampling was conducted during Phase II, III, and IV Investigations. A total of 8 constituents (i.e., 1,1,1-TCA, chloroethane, *cis*-1,2-DCE, 1,1-DCA, 1,2-dichloropropane, PCE, TCE and VC) were detected above the respective screening levels (Tables 4-16 through 4-18 and Figure 4-6).

For PCE, two monitoring well samples contained concentrations which exceeded the screening level of 5 µg/L, MW06 and MW14D. The sample from MW06 contained PCE concentration that has increased from 10 µg/L in 2003 to 17 µg/L in 2008 The sample from MW14D contained PCE at a level of 5.8 µg/L, which is close to the screening level of 5 µg/L.

For TCE, four monitoring wells contained concentrations which exceeded the screening level of 5 µg/L, MW06, MW11S, MW11D, and MW14D. TCE concentration in MW06 has increased from 6 to 8.2 µg/L between 2003 and 2008. MW11S detections declined slowly from 13 µg/L to non-detect from 2003 to 2008. MW11D detections declined from 18 µg/L in 2003 to non-detect in 2008 with a spike of 78 µg/L in 2005. MW14D detected TCE at 5.1 µg/L, which is close to the screening level of 5 µg/L.

For *cis*-1,2-DCE, 10 monitoring wells contained concentrations which exceeded the screening level of 5 µg/L, MW09D, MW11S, MW11D, MW12, MW13S, MW13D, MW14S, MW14D, MW15, and MW16. MW09D sample contained detections that fluctuated between 2003 and 2006, the concentrations ranged from 48 to 36 µg/L. The sample from MW11S contained *cis*-1,2-DCE concentrations that declined slowly from 71 µg/L in 2003 to non-detect in 2008. The sample from MW11D contained concentrations that declined from 93 µg/L in 2003 to 43 µg/L in 2005 and 2008. The sample from MW12 contained *cis*-1,2-DCE concentrations that declined slowly from 64 µg/L in 2003 to non-detect in 2008. The samples from MW13S and MW13D contained concentrations that declined from 44 µg/L in 2003 to 17 µg/L in 2005, and 34 µg/L in 2003 to 20 µg/L in 2005, respectively. The samples from MW14S and MW14D contained detected *cis*-1,2-DCE concentrations at 14 and 21 µg/L, respectively. The samples from MW15 and MW16 contained detected concentrations of 19 and 9.4 µg/L, respectively.

For VC, 7 monitoring wells yielded samples whose concentrations exceeded the screening level of 2 µg/L, MW09S, MW09D, MW11S, MW11D, MW12, MW13S, and

MW15. The sample from MW09S contained VC at 11 µg/L in 2003 and 0.1 µg/L in 2006. The sample from MW09D contained VC at a constant concentration of 4 µg/L from 2003 to 2006. The sample from MW11S contained VC concentrations that declined slowly from 31 µg/L in 2003 to non-detect in 2008. The sample from MW11D contained detections that fluctuated between 2003 and 2008, the concentrations ranged from 12 µg/L in 2003, 6 µg/L in 2006, and 8.5 µg/L in 2008 The sample from MW12 contained VC concentrations that declined slowly from 13 µg/L in 2003 to non-detect in 2008. The sample from MW13S contained VC concentrations that declined from 3 µg/L in 2003 to 0.5 µg/L in 2008. The sample from MW15 contained a VC concentration of 19 µg/L in 2008.

The samples from MW10 and MW11D displayed detections of 1,1,1-TCA above the screening levels of 5 µg/L. The sample from MW10 contained 1,1,1-TCA at 13 µg/L in 2003 to non-detect in 2005, and increased to 9.2 µg/L in 2008. The same well, MW10 also detected 1,1-DCA at 74 µg/L in 2005, but the concentration decreased to 8.2 µg/L in 2008. The relatively flat gradient may cause more outward dispersion than advection. MW10 is also located underneath the 39th Street Bridge which could be a potential source for this relatively low contamination. The sample from MW11D contained 1,1,1-TCA at 6 µg/L in 2003 and increased to 180 µg/L in 2008.

The sample from MW11S also contained chloroethane at 10 µg/L in 2003 which declined to non-detect in 2008. The sample from MW11D also contained 1,2-dichloropropane concentration increased from non-detect in 2003 to 5.8 µg/L in 2008, the screening level is 1 µg/L.

In conclusion, chlorinated volatile organic compound groundwater contamination is declining significantly over time. MW09S, MW11S, MW11D, MW12, MW13S, and MW13D yielded samples that displayed low to non-detect concentrations in 2005 and 2008. The major constituents consist of *cis*-1,2-DCE, TCE, and VC which are degradation products of PCE. Newly installed wells MW14S, MW14D, MW15, and MW16 also contained these degradation products.

The TCE and *cis*-1,2-DCE are detected in both the direct push groundwater samples and the monitoring well groundwater samples. The solubility of *cis*-1,2-DCE is higher than the solubility of the other chlorinated VOCs exceeding screening levels (with the exception of VC). The biodegradation process converts PCE into TCE; TCE into *cis*-1,2-DCE; and *cis*-1,2-DCE into VC. Thus, VC is also detected at concentrations exceeding screening levels at the same locations that *cis*-1,2-DCE is detected (Section 5).

The levels of *cis*-1,2-DCE, TCE, and VC from the monitoring well data are clearly more representative of the mobile constituents in groundwater at the Site since these constituents extend beyond the immediate vicinity of the initial historical source area.

4.4.2.2 Non-Chlorinated Volatile Organic Compounds

Monitoring wells sampling was conducted during Phases II, III, and IV Investigations. A total of six constituents (i.e., benzene, ethylbenzene, isopropylbenzene, MTBE, toluene, and total xylenes) were detected within the monitoring well groundwater samples at concentrations above their respective screening levels (Tables 4-16 through 4-18 and Figure 4-6).

For MTBE, 5 monitoring wells contained concentrations which exceeded the screening level of 10 µg/L, MW09D, MW10, MW13S, MW13D, and SM01. MW09D, MW13S, and MW13D were only analyzed for MTBE in 2003 due to access complications. MW09 detected MTBE at 45 µg/L, MW13S at 230 µg/L, and MW13D at 1,000 µg/L. MW10 concentrations declined slowly from 100 µg/L in 2003 to non-detect in 2008. MTBE concentration in SM01 was 17 µg/L in 2003 (Table 4-16).

For benzene, 5 monitoring wells contained concentrations which exceeded the screening level of 1 µg/L, MW09D, MW10, MW11D, MW12, and SM1. MW09D was only sampled in 2003 and detected benzene at 8 µg/L. Benzene concentration in MW10 was detected at 5 µg/L in 2003 to non-detect in 2008. MW11D and MW 12 had benzene concentrations at non-detect in 2003, 2005, and 2008, but a spike in 2006 of 13 µg/L in MW11D and 2 µg/L in MW12.

For total xylenes, 3 monitoring wells contained concentrations which exceeded the screening level of 5 µg/L, MW10, MW11S, and MW12. MW10 detections fluctuated constantly from 2003 (1,700 µg/L) to 2008 (880 µg/L) with a concentration range of 350 to 5,400 µg/L. Total xylenes concentrations in MW11S and MW12 declined from 7 and 9 µg/L, respectively, in 2003 to non-detect in 2008.

MW10 also detected ethylbenzene, isopropylbenzene, and toluene above screening levels. The ethylbenzene concentrations fluctuated constantly from 2003 to 2008 with a range of 120 to 1,500 µg/L. The isopropylbenzene concentrations increased from 21 to 83 µg/L during 2003 to 2008. Toluene concentrations also fluctuated constantly from 2003 to 2008 with a range of 22 to 280 µg/L.

The six non-chlorinated volatile organic constituents, benzene, ethylbenzene, toluene, xylene, isopropylbenzene, and MTBE, detected at concentrations above screening levels from samples collected from the monitoring wells were also detected at concentrations above screening levels from samples collected from direct push borings.

The monitoring well samples were collected from shallow and deep monitoring wells. The shallow monitoring wells were screened across the water table interface using a 15- foot screen to accommodate a fluctuating water table interface. Groundwater samples were collected from the center of the screened interval which was approximately 10 to 12 feet bgs (water table interface was located at approximately 5 feet). The deep monitoring wells were screened approximately from

30-40 feet with a 10- foot screen. The samples were collected from the center of the screened interval at approximately 33-35 feet.

Similar to the direct push groundwater result, the monitoring well groundwater results indicate that the contaminant distribution of the BTEX constituents is different from the chlorinated VOC contamination. As in the direct push groundwater results, the monitoring well results detected the highest levels of BTEX contamination in the most hydraulically upgradient boring adjacent to the southeast corner of the building. In contrast, the highest chlorinated VOC contamination is located at the "hot spot" approximately 120 feet west of the southeast corner of the building. This "hot spot" location was also identified during historical investigation. The highest concentration of BTEX in the groundwater at the most hydraulically upgradient location is most likely due to the upgradient contaminant plume emanating from the Hess gasoline station (Appendix C). The concentrations of BTEX detected at the Hess gasoline station are several orders of magnitude higher than the Site. The contaminant plume maps presented in Appendix C indicate that the contamination is migrating in the direction of the Site and is most likely the cause of the BTEX contamination. In addition to BTEX being transported from the Hess gasoline site via groundwater migration, storm water runoff from overland flow, 39th Street Bridge and the buried sewer line are all potential upgradient sources of BTEX and associated constituent contamination.

4.4.2.3 Semi-Volatile Organic Compounds

Two semi-volatile constituents were detected above or equal to the screening levels, 1,1′biphenyl and naphthalene. 1,1′Biphenyl was detected at 5 µg/L in groundwater sample MW16-GW16 in 2008 (Table L-4.10, Appendix L). This constituent was not detected in any other sample and is at its screening level; therefore it is determined that 1,1′biphenyl is not a Site-related contaminant.

Naphthalene was detected at 46 µg/L in sample MW10-GW14 in 2008 (Table L-4.10, Appendix L). This constituent was only detected in one other groundwater sample also at a low concentration. Naphthalene is a common product of gasoline and should be attributed to the BTEX plume migrating from an upgradient source.

4.4.2.4 Inorganic Compounds

As previously discussed, samples collected from a developed and purged monitoring well are more representative of the aquifer's soluble metal constituents since particulates are not present. Soil particulates do not migrate with groundwater flow due to the filtering action of the saturated geologic formation. Thus, samples containing high particulate levels are not representative of contaminant migration patterns due to groundwater flow.

Four inorganic constituents were detected in the monitoring well samples which exceeded the screening levels, i.e. iron, magnesium, manganese, and sodium (Table L-4-11, Appendix L). For iron, 7 groundwater samples (MW10-GW14, MW11S-GW16, MW11D-GW38, MW12-GW16, MW14D-GW35, MW15-GW17, and MW16-GW16) exceeded the screening level of 300 μg/L. The iron detections ranged from 1,130 to 17,000 μg/L.

For magnesium, 6 groundwater samples (MW11S-GW16, MW11D-GW38, MW12-GW16, MW14S-GW18, MW14D-GW35, and MW16-GW16) exceeded the screening level of 35,000 μg/L. The magnesium detections ranged from 36,200 to 44,300 μg/L.

For manganese, 8 groundwater samples (MW10-GW14, MW11S-GW16, MW11D-GW38, MW12-GW16, MW14S-GW18, MW14D-GW35, MW15-GW17, and MW16-GW16) exceeded the screening level of 300 μg/L. The manganese detections ranged from 614 to 2,110 μg/L.

Sodium was detected in all samples and had concentrations ranging from 61,100 μg/L in MW06-GW12 to 127,000 μg/L in MW12-GW16. However, sodium and most of these inorganic constituents are ubiquitous in the environment due to geologic formations and urban settings such as Long Island City, Queens. As discussed in Section 4.3.4.4, the elevated levels of these inorganic constituents are not Site-related.

4.4.3 Assessment of Sump and Vault Groundwater Quality

One sample was collected from SM01 during Phase II Investigation, and a sample was collected from each of three sumps (Sump 1, Sump2, and Sump3) located in the sub-basement during Phase IV Investigation. Groundwater samples from SM01 have chlorinated and non-chlorinated volatile organic compounds above the screening level (Table 4-16). Groundwater samples from Sump 1 and 2 have only chlorinated volatile organic constituents above the screening level (Table 4-18). An aqueous sample was collected from a Vault which contained chlorinated volatile organic compounds and inorganic compounds above the screening levels.

4.4.3.1 Sump Samples Water Quality

SM01 contained three chlorinated VOCs above the screening levels, chloroethane, *cis*-1,2-DCE, and VC, at concentrations of 12, 20, and 5 μg/L, respectively (Table 4-16). Sump 1 contained one chlorinated volatile organic constituent above the screening level, 1,1-DCA, at a concentration of 6.1 μg/L. Sump 2 contained two chlorinated volatile organic constituents above the screening levels, *cis*-1,2-DCE and TCE, at concentrations of 20 and 6.3 μg/L, respectively (Table 4-18).

1,1-DCA, *cis*-1,2-DCE, and TCE were detected in the sump sample collected in 2003, SM01, at relatively similar concentrations. The SM01 sample, however detected four additional volatile organic constituents which were non-detect in 2008 (benzene, chloroethane, MTBE, and VC). Therefore, it is concluded that the concentration of the overall contamination onsite is decreasing over time.

4.4.3.2 Vault Sample Water Quality

Vault 1 contained two chlorinated volatile organic constituents above the screening levels, 1,1,1-TCA and 1,1-DCA, at concentrations of 110 and 15 μg/L, respectively (Table L-4.22, Appendix L). Aqueous sample in Vault 1 also contained TAL metal constituents above the screening levels: iron at 5,420 µg/L, lead at 32.2 µg/L, magnesium at 39,200 µg/L, manganese at 1,130 µg/L, and sodium at 342,000 µg/L (Table L-4.24, Appendix L).

Vault 1 is located in the desk/office area directly south of the former 1,1,1-TCA tank. The chlorinated VOCs detected in the aqueous vault sample can be attributed to its downgradient position from the former tank location or to its proximity to the "hot spot" area. Since this vault is located immediately upgradient of the sub-basement which extends eight feet into the groundwater table, slight mounding can be inferred in this area from the potentiometric contour maps presented in Section 3. These constituents were also present in direct push and monitoring well groundwater samples therefore the water inside the vault is assumed to be groundwater.

The TAL metal constituents detected in the vault were also detected in the monitoring wells and direct push groundwater samples. The constituents are representative of urban background and are not Site-related contaminants.

4.5 Assessment of Soil Vapor Quality - Phase III and IV Investigations

Soil vapor quality is assessed utilizing the results of both the soil gas and sub-slab vapor investigations during the Phase III and IV investigations. These investigations are described in the following section. The results of the analytical data collected from these investigations are compared with screening levels selected via the described methodology in Section 4.2 and any concentrations that exceed these concentrations are presented and evaluated in this section. Soil vapor analytical results for Phase III Investigation and the Phase IV Investigation are provided in Appendix L.

Table 4-19 presents the detection frequency, the maximum concentration, and the minimum concentration of the volatiles detected in soil gas for the Phase III Investigation. Table 4-20 presents the detection frequency, the maximum concentration, and the minimum concentration of the volatiles detected in soil gas, sub-slab, and indoor air for the Phase IV Investigation.

4.5.1 Soil Gas and Sub-Slab Phase III Investigation

The vapor contaminant distribution pattern follows the elevated groundwater pattern in that the highest soil vapor concentrations are located in the vicinity of the "hot spot" adjacent to monitoring well MW11 (Figure 4-7). The soil vapor sample SG03 located adjacent to the loading dock contained the highest 1,1,1- TCA concentration of 51,000,000 µg/m^3 and the highest TCE concentration of 1,800,000 µg/m^3 (Table 4-21). This sample is located adjacent to "hot spot" in the vicinity of monitoring well MW11. Vapor concentrations generally diminish with the distance from the "hot spot".

Both of the two sub-slab vapor sample results are orders of magnitude less contaminated than the exterior soil vapor samples. However, sub-slab vapor sample SB01 confirms the localized nature of the elevated levels of chlorinated solvents. Sub-slab vapor sample SB01 is located in the vicinity of the "hot spot" and contains elevated levels of chlorinated solvents whereas sub-slab vapor sample SB02 is located farther away from this "hot spot" and contains minimal levels of chlorinated solvents. According to the 2006 NYSDOH *Final Guidance for Evaluating Soil Vapor Intrusion*, , a 1,1,1-TCA level of 1,000 μg/m^3 and a TCE level of 250 μg/m^3 in a sub-slab sample would require mitigation regardless of the indoor air concentration. Indoor air was not sampled at the Site during the Phase III Investigation since this was an active manufacturing facility. Only one sub-slab sample, SB01, exceeds these levels. The elevated levels of chlorinated solvents in the SB01 sub-slab sample are due to the localized exterior "hot spot".

4.5.2 Chlorinated Volatile Organic Compounds for Phase IV Investigation

4.5.2.1 Summary of Chlorinated Volatile Organic Compounds in Soil Gas

PCE and/or its degradation products were detected in nine of the twelve soil gas samples collected during the Phase IV Investigation (Tables 4-20 and 4-22). PCE detections ranged from 12 to 950 μg/m^3 (Table 4-20). The highest concentrations, 950 μg/m^3, were detected in samples collected from SG03 and SG07, followed by 390 μg/m^3 at SG04, 280 at SG01 μg/m^3, and 190 μg/m^3 at SG02. These soil gas sampling locations are positioned in the localized exterior "hot spot" (Figure 4-8).

Degradation products of PCE were also prominent at these samples locations. SG01 detected TCE at 12,000 μg/m^3; SG02 detected 1,1-DCE at 6,700 μg/m^3 and TCE at 31,000 μg/m^3; SG03 detected TCE at 31,000 μg/m^3 and VC at 140,000 μg/m^3; SG04 detected 1,1-DCE at 1,400 μg/m^3, *cis*-1,2-DCE at 1,700 μg/m^3, and TCE at 120,000 μg/m^3; and SG07 detected TCE at 9,700 μg/m^3 (Table 4-22)

1,1,1-TCA and/or its degradation products were also detected in all twelve of the soil gas samples. 1,1,1-TCA detections ranged from 14 to 820,000 μg/m^3. The highest concentration, 820,000 μg/m^3, was detected in SG02, followed by 600,000 μg/m^3 at SG04, 380,000 μg/m^3 at SG07, 150,000 μg/m^3 at SG03, 93,000 μg/m^3 at SG01, and 52,000 μg/m^3 at SG08 (Table 4-22). These soil gas sampling locations are also positioned in the localized exterior "hot spot".

Degradation products of 1,1,1-TCA were also prominent at these sample locations. SG01 detected 1,1-DCA at 5,300 μg/m^3; SG02 detected 1,1,-DCA at 57,000 μg/m^3 and chloroethane at 250 μg/m^3; SG03 detected 1,1-DCA at 270,000 μg/m^3 and chloroethane at 920,000 μg/m^3; SG04 detected 1,1-DCA at 49,000 μg/m^3 and chloroethane at 317 μg/m^3; SG07 detected 1,1-DCA at 5,700 μg/m^3; and SG08 detected 1,1-DCA at 8,900 μg/m^3 (Table 4-22).

Ambient air samples collected near the SG05 location on the loading dock (AA1) and SG11 location on the corner of 37th street and northern boulevard (AA2) also detected elevated levels of chlorinated volatile constituents. The prominent constituent detected was 1,1,1-TCA with concentrations ranging from 160 to 170 μg/m^3 (Table 4-22)

4.5.2.2 Summary of Chlorinated Volatile Organic Compounds in Sub-Slab and Indoor Air

PCE was detected in all sixteen of the sub-slab air samples (SB01 through SB16) collected during the Phase IV Investigation (Table 4-22). PCE detections ranged from 8.8 to 620 µg/m^3. The highest concentration, 620 µg/m^3, was detected in the sample collected from SB05, followed by 420 µg/m^3 at SB08, 340 µg/m^3 at SB15, and 140 µg/m^3 at SB06 (Table 4-22 and Figure 4-8).

TCE was detected in 14 out of the 16 sub-slab air samples and TCE detections ranged from 7.5 to 2,800 µg/m^3, with the highest concentration at SB05, followed by 2,200 µg/m^3 at SB03, by 1,600 µg/m^3 at SB06, 1,200 µg/m^3 at SB08, and 640 µg/m^3 at SB11.

cis-1,1-DCE was detected in 7 out of the 16 sub-slab air samples with concentrations ranging from 4.8 to 52 µg/m^3. The sub-slab location SB05 detected the highest concentration followed by SB 11 with 30 µg/m^3 (Table 4-22)

1,1,1-TCA was detected in 14 out of the 16 sub-slab air samples and its detections range from 19 to 5,200 µg/m^3, with the highest detection at SB05, followed by 2,700 µg/m^3 at SB11, 2,500 µg/m^3 at SB08, 1,400 µg/m^3 at SB06, and 710 µg/m^3 at SB03 (Tables 4-20 and 4-22). 1,1-DCA was detected in 5 out of the 16 sub-slab air samples and its detections ranged from 11 to 450 µg/m^3, with the highest concentration at SB05, followed by 140 µg/m^3 at SB11, and 85 µg/m^3 at SB03 (Tables 4-20 and 4-22).

These sub-slab air samples displaying the highest concentrations of chlorinated volatile constituents are located east of the exterior localized "hot spot", except for SB15. A stairwell is located in the southeastern portion of the building potentially increasing the stack effect in this portion of the building. The sub-slab SB15 location is at the far northwest corner of the building. The sub-slab air sample locations which detected elevated PCE related contaminants also detected elevated 1,1,1-TCA related constituents.

The indoor air sample collected from the office/desk area near MW15 and SB01 detected 1,1-DCA at 0.4 µg/m^3. No other chlorinated volatile constituents were detected in the three indoor air samples collected during the Phase IV Investigation. The ambient air collected during the sub-slab air sampling event, AA, did not detect any chlorinated volatile constituents (Table 4-22).

4.5.2.3 Conclusion

The soil gas samples which detected elevated concentrations of chlorinated volatile constituents during the Phase III and Phase IV Investigations are located within the exterior "hot spot". Sub-slab air samples displaying the highest concentrations of chlorinated volatile constituents are located to the east of the exterior localized "hot spot" in the vicinity of a stair well that may be impacting pressure gradients across the building. Vapor constituents detected diminish in the western side of the building and loading dock. The soil vapor results confirm the previously identified "hot spot" location.

The chlorinated volatile constituent concentrations in total have diminished over time, from 2006 to 2008. The Phase III Investigation detected the highest 1,1,1-TCA and TCE concentrations at 51,000,000 µg/m^3 and 1,800,000 µg/m^3, respectively. The Phase IV Investigation detected the highest 1,1,1-TCA and TCE concentrations at 820,000 µg/m^3 and 120,000 µg/m^3, respectively. This decrease in concentrations of Site-related contaminates suggest significant degradation of the source over time.

Ambient air samples detected elevated levels of 1,1,1-TCA, however the concentration was less than the soil vapor detections. The ambient air contamination could be potential soil vapor pathways and/or being situated in a highly industrial and commercial area. The indoor air samples detected one chlorinated volatile constituent, 1,1-DCA, at an isolated area and at a very low concentration, 0.4 µg/m^3. According to the 2006 NYSDOH *Final Guidance for Evaluating Soil Vapor Intrusion*, a 1,1,1-TCA level of 1,000 µg/m^3 and a TCE level of 250 µg/m^3 in a sub-slab sample would require mitigation regardless of the indoor air concentration; therefore mitigation is recommended.

4.5.3 Non-Chlorinated Volatile Organic Compounds for Phase IV Investigation

4.5.3.1 Summary of Non-Chlorinated Volatile Organic Compounds in Soil Gas

Non-chlorinated volatile constituents were detected in 10 out of the 12 soil gas samples (SG01, SG02, SG03, SG04, SG5, SG6, SG07, SG08, SG19, and SG11) collected during the Phase IV Investigation (Table 4-22). The prominent constituents detected were benzene, cyclohexane, ethylbenzene, and xylenes (total), which are all components of gasoline.

Benzene was detected in 6 out of the 12 soil gas samples and its concentrations ranged from 3.2 to 45 µg/m^3, with the highest concentration at SG03 (Table 4-20). Cyclohexane was detected in 5 out of the 12 samples and its concentrations ranged from 30 to 210 µg/m^3, with the highest concentration at SG07. Ethylbenzene was detected in 3 out of the 12 samples and its concentrations ranged from 5.2 to 43 µg/m^3, the highest detection at SG03. Toluene was detected in 9 out of the 12 samples and toluene concentrations ranged from 4.5 to 20 µg/m^3, with the highest concentration at SG03. m&p-Xylenes concentrations ranged from 4.8 to 110 µg/m^3, with the highest detection at SG01. o-Xylenes concentrations ranged from 8.7 to 61 µg/m^3, with the highest detection at SG03 (Table 4-20).

Other constituents of gasoline were also detected at these locations, SG02 and SG03 detected hexachlorobutadiene and SG08 and SG09 detected 2,2,4-trimethylpentane. The soil gas sample collected at SG03 detected the greatest number of non-chlorinated volatile constituents including *n*-hexane, 1,2-dichlorobenzene, and 1,2,4-trichlorobenzene (Tables 4-20 and 4-22).

Ambient air samples collected near the SG05 location on the loading dock and SG11 location on the corner of 37th street and northern boulevard also detected levels of non-chlorinated volatile constituents above the screening levels. Cyclohexane was detected at concentrations ranging from 1 to 3 µg/m^3 and tetrahydrofuran was detected at concentrations ranging from 0.3 to 0.6 µg/m^3 at both ambient air locations. Tetrahydrofuran was also detected at the soil gas sample collected at SG03, at a concentration of 88 µg/m^3. This compound is a common degreaser of metal parts and PVC adhesives in industrial settings.

4.5.3.2 Summary of Non-Chlorinated Volatile Organic Compounds in Sub-Slab and Indoor Air

A total of six sub-slab samples out of sixteen collected (SB01, SB02, SB03, SB05, SB12, and SB13) detected non-chlorinated volatile constituents above the screening level, i.e. cyclohexane, tetrahydrofuran, and toluene. Cyclohexane and toluene are common components of gasoline. Tetrahydrofuran is a common degreaser of metal parts and PVC adhesives in industrial settings. Indoor air samples collected from three different locations detected a wide variety of non-chlorinated volatile constituents at relatively low concentrations.

Cyclohexane was detected in sub-slab air sample, SB05, at a concentration of 3.8 µg/m^3. Toluene was detected in 14 out of the 16 sub-slab air samples, SB01 and SB02 had highest concentrations, 120 and 170 µg/m^3, respectively. Tetrahydrofuran was detected in three sub-slab air samples, SB03, SB12, and SB13, at concentrations of 5.3, 17, and 17 µg/m^3, respectively.

The three indoor air samples detected gasoline components, such as 1,2-dichlorobenzene and 2,2,4-trimethylpentane, at concentrations greater or equal to 1.0 µg/m^3. The prominent elevated non-chlorinated volatile constituents detected are 1,2,4-trichlorobenzene, hexachlorobutadiene, and tetrahydrofuran.

1,2,4-Trichlorobenzene was detected in all three indoor air samples at concentrations ranging from 6 to 7.4 µg/m^3. Hexachlorobutadiene was detected in all three indoor air samples at concentrations ranging 11 to 16 1.0 µg/m^3. Tetrahydrofuran was detected in all three indoor samples at concentrations ranging from 8.3 to 18 1.0 µg/m^3. Indoor air IA1 also detected 1,2-dichlorobenzene at 2 1.0 µg/m^3. Indoor air IA2 also detected cyclohexane at 3 1.0 µg/m^3 (Table 4-22)

The ambient air collected during the sub-slab air sampling event (AA) detected 1,2,4-trichlorobenzene at 5 µg/m^3, 2,2,4-trimethylpentane at 0.5 µg/m^3, and hexachlorobutadiene at 9 µg/m^3. This ambient air samples was located on the loading dock next to the freight entrance near SG01 (Table 4-22).

4.5.3.3 Conclusion

The highest non-chlorinated VOC concentrations in the soil vapor samples were detected in SG02, SG03, SB01, and SB02. These four soil vapor locations detected non-chlorinated volatile constituents at concentrations greater than 50 µg/m^3. Soil vapor ports SG02 and SG03 are located within the exterior “hot spot” where chlorinated volatile constituents are detected at very high concentrations. The non-chlorinated volatile constituent detections at these locations suggest a mixture of the chlorinated and non-chlorinated plumes.

The soil vapor port SB01 is located along the southern wall of the office desk area. The soil vapor port SB02 is located in the western portion of the building. The elevated levels of non-chlorinated volatile constituents can be attributed to the gasoline plume and/or historical localized releases.

The ambient air samples collected during the soil gas and sub-slab events detected relatively low concentrations of non-chlorinated volatile constituents, unlike the indoor air. All three indoor air samples detected elevated levels of non-chlorinated constituents. The three indoor air samples were located throughout the building to gain a representative composite of indoor air quality. The elevated detections of non-chlorinated volatile constituents suggest a recent gasoline-related source present in the subsurface and degreasers (e.g., tetrahydrofuran) present in the building in poor conditioned containers. It should be noted that large containers storing degreasers were not identified during the onsite investigation. The only product identified with the potential to affect indoor air quality was W-D40 aerosol cans in relatively good condition.

Section 5
Fate and Transport

After a chemical is released to the environment, it may be transported; transformed physically, chemically, or biologically; or accumulated in one or more media. The physical/chemical and environmental fates of the contaminants were evaluated in the context of the site-specific characteristics that may influence their fate and transport.

To focus on those contaminants that are predicted to pose the greatest risks to human health and the environment, the evaluation of the contaminants' fate and transport was limited to the constituents of potential concern (COPCs) defined in Section 6 and the contaminants identified in Section 4. The fate and transport of those constituents identified as potentially of concern at the Site were evaluated to aid in predicting future exposures, and to help link sources with currently contaminated media.

5.1 Physical/Chemical Properties

The major class of constituents found in soil, groundwater, and soil vapor at the Site is volatile organic compounds. In soil, constituents of potential concern are one metal (lead), three chlorinated VOCs (1,1-DCA, 1,1,1-TCA, and TCE), and two non-chlorinated VOCs (ethylbenzene and total xylenes). In groundwater, seven chlorinated VOCs (chloroethane, *cis*-1,2-DCE, 1,1-DCA, PCE, 1,1,1-TCA, TCE, and VC), and six non-chlorinated VOCs (benzene, ethylbenzene, isopropyl benzene, MTBE, toluene and total xylenes) were detected above the respective screening levels and were identified as the constituents of potential concern at the Site. In soil vapor, constituents of potential concern are six chlorinated VOCs (*cis*-1,2-DCE, 1,1-DCA, PCE, 1,1,1-TCA, TCE, and VC) and six non-chlorinated VOCs (benzene, ethylbenzene, cyclohexane, toluene, tetrahydrofuran, and total xylenes) were detected above the respective screening levels and were identified as the constituents of potential concern at the Site.

Table 5-1 lists the physical/chemical and environmental fate properties of these chemical constituents. Many of the physical and chemical properties of these constituents were taken from the document entitled *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Volume 2, Appendix A* (EPA 1999). The properties are defined in the following paragraphs and the physical/chemical properties of the individual contaminants are discussed in the next two sections.

The K_{OC} provides a measure of the extent of chemical partitioning between organic carbon and water at equilibrium. The higher the K_{OC}, the more likely a chemical is to bind to soil or sediment rather than remain dissolved in water.

The soil distribution coefficient (K_d) provides a soil- or sediment-specific measure of the extent of chemical partitioning between soil or sediment and water, unadjusted for dependence upon organic carbon. K_d is adjusted using the fraction organic carbon (f_{OC}) of the soil/sediment as shown in the formula $K_d = K_{OC} \times f_{OC}$. A higher K_d, indicates that a chemical is more likely to bind to soil or sediment rather than remaining in the dissolved phase, thereby reducing the transport capability.

The octanol-water partition coefficient (K_{OW}) provides a measure of the extent of chemical partitioning between water and octanol at equilibrium. The greater the K_{OW}, the more likely a chemical is to partition to octanol rather than to remain in water. Octanol is used as a surrogate for lipids, and K_{OW} is used to predict bioconcentration in living organisms.

The solubility of a chemical is an upper limit on its dissolved concentration in pure water at a specified temperature. Aqueous concentrations in excess of solubility may indicate sorption onto sediments, the presence of solubilizing chemicals such as solvents, or the presence of a non-aqueous phase liquid.

The bioconcentration factor (BCF) provides a measure of the extent of chemical partitioning at equilibrium between a biological medium, such as fish tissue or plant tissue and an external medium such as water. The higher the BCF, the greater the accumulation in living tissue is likely to be.

Henry's Law constant provides a measure of the extent of chemical partitioning between air and water at equilibrium. The higher the Henry's Law constant, the more likely a chemical is to volatilize rather than to remain in water.

Vapor pressure is the pressure exerted by a chemical vapor in equilibrium with its solid or liquid form at any given temperature. It is used to calculate the rate of volatilization of a pure substance from a surface or in estimating a Henry's Law constant for chemicals with low water solubility. The higher the vapor pressure, the more likely a chemical is to exist in a gaseous state.

Chemical half-lives are media specific and provide a relative measure of the persistence of a chemical in a given medium, although actual values can vary greatly depending on site-specific conditions. The greater the half-life, the more persistent a chemical is likely to be.

5.2 Environmental Fate

The contaminants identified as potentially of concern in SMP can be separated into three groups: the groundwater, soil, and air contaminants. In general, most contaminants found in groundwater at the Site are volatiles and are considered relatively mobile. They do not bind to soil or sediment, and they have moderate to high water solubility, low to moderate K_{OC} values, moderate to high Henry’s Law constant and low K_d. All of the contaminants, except lead, identified as potentially of concern in soil at SMP are also volatiles showing the same properties as those in groundwater, being relatively mobile with no strong tendency to adsorb to soil particles and remain relatively mobile in the soils, as demonstrated by their low K_{OC} and K_d values. The environmental fate properties of specific Site-related constituents are discussed in the following sections.

5.2.1 Metals

The fate of metals in aquatic systems depends on partitioning between soluble and insoluble particulate solid phases. Partitioning is affected by adsorption, precipitation, co-precipitation, and complexation. These processes are governed by pH, oxidation-reduction potential (Eh), ionic strength of the water, concentration of the complexing ions, and the concentration and type of metals.

5.2.1.1 Lead

Soil concentrations of lead were found at slightly exceeding the screening concentration from surface soil collected DD17-SS01 and SD19-SS01 located within the previous excavated and stockpiled soil area.

Lead is a naturally occurring metal in the earth's crust. Lead is very soft, highly malleable, ductile, and a relatively poor conductor of electricity. It is very resistant to corrosion but tarnishes upon exposure to air. Airborne deposition from many anthropogenic sources including gasoline and coal combustion has increased lead concentration in the environment.

In the atmosphere, lead exists primarily in the particulate form. Upon release to the atmosphere, lead particles are dispersed and ultimately removed from the atmosphere by wet or dry deposition. Approximately 40 – 70% of the deposition of lead is by wet fallout; 20 – 60% of particulate lead emitted from automobiles is deposited near the source. An important factor in determining the atmospheric transport of lead is particle size distribution. The amount of lead scavenged from the atmosphere by wet deposition varies widely; wet deposition can account for 40 – 70% of lead deposition (ATSDR 2007). The average residence time of lead particles in the atmosphere is expected to range from 7 to 30 days with the shorter residence times occurring in areas of acid rain.

Lead may also exist atmospherically as organic-lead compounds. The tetra alkyl lead compounds, specifically tetraethyl lead (TEL) and tetra methyl lead (TML), are primary organic lead compounds used as automotive gasoline additives in the United States until 1996 and are still used today in racing –car and aviation gasoline. Based on vapor pressure of TEL and TML, these two compounds are expected to exist almost entirely in the vapor phase in the atmosphere. When exposed to sunlight, they decompose rapidly to trialkyl and dialkyl lead compounds by a combination of direct photolysis, reaction with hydroxyl radicals, and reaction with ozone (ATSDR 2007).

The fate of lead in soil is affected by the specific or exchange adsorption at mineral interfaces, the precipitation of sparingly soluble solid forms of the compound, and the formation of relatively stable organic-metal complexes or chelates with soil organic matter. These processes are dependent on factors, such as soil pH, soil type, particle size, organic matter content of soil, the presence of inorganic colloids and iron oxides, cation exchange capacity, and the amount of lead in soil (ATSDR 2007).

The downward movement of elemental lead and inorganic lead compounds from soil to groundwater by leaching is very slow under most natural conditions except for highly acidic environments.

The chemistry of lead in aqueous solution is highly complex because this element exists in a multiple forms. Lead has a tendency to form compounds of low solubility with the major anions found in water. In the natural environment, the divalent form is the stable ionic species. Hydroxide, carbonate, sulfide, and sulfate may act as solubility controls in precipitating lead from water. The amount of lead that remains in solution depends upon the pH of the water and the dissolved salt content. Lead is more soluble in softer and low pH water (ATSDR 2007).

In water, the tetra alkyl lead compounds are subject to photolysis and volatilization. Degradation proceeds from trialkyl lead to dialkyl lead to inorganic lead. Tetraethyl lead is susceptible to photolytic decomposition in water. Triethyl and trimethyl lead are more water-soluble and, therefore, more persistent in the aquatic environment than tetraethyl or tetramethyl lead.

Lead is mostly retained in the soil and very little is transported into surface water or groundwater (EPA 1986). In sediments, it is expected to remain as sorbed ions or surface coatings on sediment mineral particles.

5.2.2 Volatile Organic Compounds

The fate of volatile organic compounds is dominated by their volatility. Their presence in surface soils or surface water is, therefore, usually short-lived providing their input is interrupted. The VOCs were detected in soil, groundwater, and soil vapor as well as their fate and transport are discussed below.

5.2.2.1 Chlorinated VOCs

Seven chlorinated VOCs, namely, chloroethane, 1,1-DCA, *cis*-1,2-DCE, PCE, 1,1,1-TCA, TCE, and VC, were determined to be the constituents of concern at the Site. The fate and transport of these compounds are discussed below.

5.2.2.1.1 Chloroethane

Chloroethane is used as a refrigerant and solvent and is also used in organic synthesis. In the atmosphere, chloroethane exists in the vapor phase due to a high vapor pressure (160 atmospheres [atm]) (EPA 1999). Vapor-phase chloroethane will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals. The half-life for this reaction in air is estimated to be 39 days (HSDB 2008).

In soils, chloroethane is expected to have very high mobility based on a K_{oc} value of 371 (EPA 1999). Volatilization is an important fate process of chloroethane in soils due to its vapor pressure and Henry's Law constant of 1.8 atmospheres cubic meters per mole (atm-m^3/mol) (EPA 1999).

The dominant fate of chloroethane in surface waters is also volatilization as chloroethane is not expected to adsorb to suspended solids and sediment based on its Henry's Law constant and K_{oc} value. A BCF value of 134 suggests that the potential for chloroethane to bioconcentrate in aquatic organisms is low (EPA 1999).

5.2.2.1.2 1,1-Dichloroethane

The primary use of 1,1-DCA is as a solvent and as a degreaser (HSDB 2008). In the atmosphere, 1,1-DCA is expected to be present in the vapor phase rather than sorbed to particulate matter based on its vapor pressure of 0.3 atm (= 228 mm Hg) and a K_{oc} value of 53 (EPA 1999). Removal of 1,1-DCA during wet precipitation is expected because of its relatively high water solubility (5.16 grams per Liter [g/L]). Vapor-phase 1,1-DCA will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals with an estimated half-life of 49 days (HSDB 2008).

In soil, volatilization from moist or dry soil surfaces is an important fate process based on 1,1-DCA's vapor pressure and Henry's Law constant of 5.75×10^{-3} atm-m^3/mol. 1,1-DCA is expected to be highly mobile in soil based on a K_{oc} value of 53. Thus, 1,1-DCA has the potential to migrate through the soil into the groundwater. Biodegradation under anaerobic conditions in soil and groundwater may occur at a relatively slow rate; 1,1-DCA has a half-life on the order of months or longer (EPA 2001b).

The dominant fate of 1,1-DCA in surface waters is also volatilization due to its Henry's Law constant. Bioconcentration (BCF = 13.6) and sorption to sediments and suspended solids are not expected to be significant fate process for 1,1-DCA (EPA 1999).

5.2.2.1.3 cis-1,2-Dichloroethene

cis-1,2-DCE is primary used as a solvent. In the atmosphere, *cis*-1,2-DCE is expected to be present in the vapor phase rather than sorbed to particulate matter based on a vapor pressure of 0.3 atm (= 175 mm Hg) and a K_{oc} value of 498 (EPA 1999). Removal by scavenging during wet precipitation is expected because of the high solubility of *cis*-1,2-DCE (water solubility = 4.94 g/L) (EPA 1999). The predominant degradation process of *cis*-1,2-DCE is photo-oxidation by hydroxyl radicals with a predicated half-life of 8 days (EPA 2001b).

The dominant fate of *cis*-1,2-DCE in surface soils is volatilization. Some *cis*-1,2-DCE may leach downward in the soil column because of the high water solubility and low K_{oc} values. In addition, *cis*-1,2-DCE is formed under anaerobic conditions in soil, groundwater, and sediments as a breakdown product from microbial reductive dechlorination of the common industrial solvents, e.g., TCE, PCE and tetrachloroethane (PCA). The fate of *cis*-1,2-DCE in subsurface soils and groundwater is slow anaerobic degradation with the formation of VC as a chlorinated degradation product.

Volatilization is also the dominant fate of *cis*-1,2-DCE in surface waters having a predicted half-life of three hours, and based on its Henry's Law constant of 4.51×10^{-3} atm-m^3/mol. Bioconcentration (BCF = 18.9) and sorption to suspended solids and sediment (Koc = 498) are not expected to be significant transport/partitioning processes (EPA 1999). Although biodegradation is not expected to be a significant degradation process, any *cis*-1,2-DCE that reaches the sediment will undergo slow anaerobic biodegradation (EPA 2001b).

5.2.2.1.4 Tetrachloroethene

PCE is used as a metal degreaser (EPA 2001b). In the atmosphere, PCE is expected to be present primarily in the vapor phase and not sorbed to particulates because of its high vapor pressure of 0.042 atm (= 18 mm Hg) (EPA 1999). Vapor-phase PCE will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 96 days. Direct photolysis is not expected to be an important environmental fate process since PCE only absorbs light weakly in the environmental ultraviolet (UV) spectrum (HSDB 2008).

The dominant fate of PCE in soils is volatilization. Based on its K_{oc} value of 265, PCE is moderately mobile in soils. Consequently, PCE has the potential to migrate through the soil into groundwater. Biodegradation under anaerobic conditions in soil and groundwater may occur at a relatively slow rate with half-lives on the order of months or longer (EPA 2001b).

Volatilization is also an important fate process of PCE in surface waters based on its Henry's Law constant of 1.73×10^{-2} atm-m^3/mol (EPA 1999). PCE is also not expected to adsorb to suspended solids and sediment in water based upon its K_{oc} value. The biodegradation half-lives of PCE in aerobic and anaerobic waters were reported as 180 and 98 days, respectively (HSDB 2008). A reported BCF value of 50.6 in fish suggests that the potential for PCE to bioconcentrate in aquatic organisms is low.

5.2.2.1.5 1,1,1-Trichloroethane

1,1,1-TCA is used as a meter degreaser (EPA 2001b). 1,1,1-TCA is fairly stable in the atmosphere and can be transported long distances. 1,1,1-TCA will evaporate fairly rapidly into the atmosphere because of its high vapor pressure. The major degradation process of 1,1,1-TCA is photo-oxidation by hydroxyl radicals.

The dominant fate of 1,1,1-TCA in surface soils is volatilization. Because of its moderate mobility in soils, 1,1,1-TCA has the potential to migrate through the soil into groundwater.

Primary loss of 1,1,1-TCA in water is by evaporation into the atmosphere. Biodegradation and adsorption onto particulate matter are not significant relative to volatilization. The potential of 1,1,1-TCA to bioconcentrate in aquatic organisms is low; it has a BCF of 40.8 (EPA 1999).

5.2.2.1.6 Trichloroethene

The major use of TCE is degreasing. About 85 percent of TCE produced is used in metal cleaning. In the atmosphere, TCE is expected to be present primarily in the vapor phase rather than sorbed to particulates because of its high vapor pressure of 0.0948 atm (= 72 mm Hg) at 25°C (EPA 1999). Some removal by scavenging during wet precipitation is expected because of the moderate solubility of TCE in water (1.18 g/L) (EPA 1999). The major degradation process affecting vapor phase TCE is photo-oxidation by hydroxyl radicals; the half-life for this reaction in air is estimated to be 7 days (HSDB 2008).

The dominant fate of TCE released to surface soils is volatilization. Because of its moderate to high mobility in soils, TCE has the potential to migrate through the soil into groundwater. Biodegradation in soil and groundwater may occur at a relatively slow rate with half-lives on the order of months to years (EPA 2001b).

The dominant fate of TCE in surface waters is volatilization with a predicted half-life of minutes to hours (EPA 2001b). TCE is resistant to aerobic biodegradation although biodegradation may proceed co-metabolically. Under anaerobic conditions, as might be seen in soil microsites, flooded soils or aquifer sites, TCE is slowly biodegraded via reductive dechlorination; the extent and rate of degradation are dependent upon the strength of the reducing environment (HSDB 2008). Bioconcentration and sorption to suspended solids and sediments of TCE are not thought to be significant based on the reported BCF of 41.6 and K_{oc} value of 94 (EPA 1999).

5.2.2.1.7 Vinyl Chloride

VC is an anaerobic biodegradation product of higher chlorinated compounds such as PCE and TCE. In the atmosphere, VC will exist solely as a gas; its vapor pressure is 3.68 atm (= 2,800 mm Hg) (EPA 1999). Vapor-phase VC will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 55 hours. Direct photolysis is not expected to be an important environmental fate process since this compound only absorbs light weakly in the environmental UV spectrum (HSDB 2008).

Volatilization is a significant fate process of VC in soil based on its vapor pressure and Henry's Law constant (0.315 atm-m^3/mol) (EPA 1999). According to its K_{oc} value VC is highly mobile.

In surface waters, volatilization is also a significant fate process of VC due to its high Henry's Law constant. It is also not expected for VC to adsorb suspended solids and sediment in water based upon the K_{oc} value. The biodegradation half-life of VC in aerobic and anaerobic waters was reported as 28 days and 110 days, respectively (HSDB 2008). The potential for VC to bioconcentrate in aquatic organisms is low based on a BCF value of 4.37 (EPA 1999).

5.2.2.1.8 Summary

These chlorinated hydrocarbons are synthetic solvents used throughout many industrial activities and found in numerous household cleaning products. They can occur in the environment directly from product usage or as a byproduct of the degradation of other solvents, particularly PCE and 1,1,1-TCA.

The dominant fate process for these chlorinated VOCs in surface soils or surface water is volatilization to the atmosphere. However, it is not a mode of transport of these contaminants in the groundwater at SMP.

The dominant degradation process is hydrolysis and biodegradation. However, degradation of these compounds is expected to be slow in these subsurface environments. Therefore, they may persist in unconsolidated groundwater for some time. Transformation of PCE is relatively slow compared to the other chlorinated VOCs.

Chlorinated VOCs are considered to have medium-to-high mobility in water depending on their degree of chlorination. Sorption to soils is expected to be relatively minor; thus, transport in groundwater from contaminant sources is expected to be the dominant transport pathway.

5.2.2.2 Non-Chlorinated VOCs

Eight non-chlorinated VOCs (benzene, cyclohexane, ethylbenzene, isopropyl benzene, MTBE, tetrahydrofuran, toluene, and total xylenes) are identified as the constituents of potential concern in soil and groundwater at the Site. Their environmental fate and transport are discussed below.

5.2.2.2.1 Benzene

Benzene is found in and isolated from petroleum products. The primary use of benzene is as a gasoline additive, as a solvent and intermediate chemical in industrial chemical production. The dominant fate process of benzene is partitioning to the atmosphere through direct volatilization with a high vapor pressure of 0.125 atm (= 95 mm Hg) at 25°C (EPA 1999). Vapor-phase benzene will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals or by ozone radicals and nitrate. Since benzene is very soluble, with a water solubility of 1.78 g/L, it may be removed from the atmosphere by rain.

In soil, benzene is expected to be very mobile based on a K_{oc} of 62 milliliters per gram (mL/g). Volatilization from moist soil surfaces is expected to be an important fate process based on a Henry's Law constant of 5.49×10^{-3} atm-m^3/mol. Benzene may also volatilize from dry soil surfaces based on its vapor pressure (EPA 1999).

In water, benzene is not expected to adsorb to suspended solids and sediment based upon a K_{oc} of 62 mL/g. Volatilization from water surfaces is expected to be an important fate process based on its Henry's Law constant. A reported BCF value of

24.8 suggests that the potential for benzene to bioconcentrate in aquatic organisms is low.

5.2.2.2.2 Cyclohexane

Cyclohexane occurs naturally in petroleum crude oil. Cyclohexane's production and use as a solvent and its presence in gasoline may result in its release to the environment through various waste streams. If released to air, its vapor pressure of 97 mm Hg at 25°C indicates cyclohexane will exist solely as a vapor in the ambient atmosphere (HSDB 2008).

In soil, cyclohexane is expected to have moderate mobility based upon an estimated K_{oc} of 160 L/kg. Volatilization from moist soil surfaces is expected to be an important fate process based upon an experimental Henry's Law constant of 0.15 atm-m^3/mole (HSDB 2008).

In water, cyclohexane is expected to adsorb to suspended solids and sediment in the water column based upon the estimated K_{oc}. Cyclohexane is highly resistant to biodegradation and is catabolized chiefly by cooxidation (use of other organic matter as a carbon and energy source). Volatilization from water surfaces is expected to be an important fate process based upon this compound's estimated Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 3 hrs and 3.6 days, respectively. An estimated BCF of 89 suggests the potential for bioconcentration in aquatic organisms is moderate (HSDB 2008).

5.2.2.23 Ethylbenzene

Ethylbenzene is present in automotive and aviation fuels. With a vapor pressure of 0.0126 atm (= 9.5 mmHg) at 25°C, ethylbenzene exists solely as a vapor in the ambient atmosphere (EPA 1999). Vapor-phase ethylbenzene will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals.

In soil, ethylbenzene is expected to have moderate mobility based on a K_{oc} of 204 mL/g. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry’s Law constant of 7.73×10^{-3} atm-m^3/mol. Ethylbenzene may volatilize from dry soil surfaces based upon its vapor pressure. Biodegradation in soil takes place via nitrate-reducing processes (HSDB 2008).

In water, ethylbenzene may adsorb to suspended solids and sediment in water based upon the K_{oc}. Biodegradation in a gasoline contaminated aquifer ranged from 10 – 16 days under aerobic conditions. Volatilization from water surfaces is expected to be an important fate process based on its Henry’s Law constant. A reported BCF of 139 liters per kilogram (L/kg) in fish indicates that the potential for bioconcentration in aquatic organisms is low.

5.2.2.2.4 Isopropylbenzene (Cumene)

Cumene occurs in a variety of natural substances including essential oils from plants, marsh grasses, and a variety of foodstuffs (HSDB 2008).

Cumene, which has a vapor pressure of 6×10^{-3} atm (= 4.56 mmHg) (EPA 1999), is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase cumene is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals. The half-life for this reaction in air is estimated to be 2.5 days (HSDB 2008). Cumene is also degraded in the atmosphere by reaction with ozone radicals; the half-life for this reaction in air is estimated to be three years (HSDB 2008).

Cumene with a K_{oc} of 9,310 mL/g (EPA 1999) is expected to have a moderate mobility in soil and adsorbs to suspended solids and sediment. Volatilization from moist soil surfaces is expected to be an important fate process given a Henry's Law constant of 1.29×10^{-2} atm-m^3/mol (EPA 1999). The potential for volatilization of cumene from dry soil surfaces may exist based upon a vapor pressure of 6×10^{-3} atm (= 4.56 mmHg) (EPA 1999).

Volatilization from water surfaces is expected based upon a Henry's Law constant of 1.29×10^{-2} atm-m^3/mol (EPA 1999). A reported BCF of 328 in fish suggests that the potential for bioconcentration of cumene in aquatic organisms is moderate.

5.2.2.2.5 *Methyl tert-Butyl Ether*

MTBE is used as an octane booster in gasoline. MTBE, which has a vapor pressure of 0.322 atm (= 245 mmHg), is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase MTBE is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals and nitrate radicals (HSDB 2008).

Volatilization of MTBE from moist soil surfaces is expected to be an important fate process given a Henry's Law constant of 6.54×10^{-4} atm-m^3/mol (EPA 1999). The potential for volatilization of MTBE from dry soil surfaces may exist based on a vapor pressure of 0.322 atm (= 245 mmHg) (EPA 2004).

Given its K_{oc} value of 11, MTBE is expected to be adsorbed to suspended solids and sediment in water. MTBE readily volatilizes from water surfaces, based on its Henry's Law constant. The potential for MTBE to bioconcentrate in aquatic organisms is low due to its low BCF (1.5).

5.2.2.2.6 *Tetrahydrofuran*

Tetrahydrofuran's production and use as a solvent for natural and synthetic resins and in organic synthesis may result in its release to the environment through various waste streams (HSDB 2008).

In air, a vapor pressure of 162 mm Hg at 25°C indicates tetrahydrofuran will exist solely as a vapor in the ambient atmosphere. The half-life for tetrahydrofuran in air is about 1 and 3 days. In soil, tetrahydrofuran is expected to have very high mobility based upon K_{oc} values of 23 and 18. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry's Law constant of 7.1×10^{-5} atm-m^3/mole. Tetrahydrofuran may volatilize from dry soil surfaces based upon its vapor pressure (HSDB 2008).

In water, tetrahydrofuran is not expected to adsorb to suspended solids and sediment based upon the K_{oc}. Tetrahydrofuran is expected to biodegrade under aerobic conditions but may be resistant to biodegradation in anaerobic environments. Volatilization from water surfaces is expected to be an important fate process based upon this compound's Henry's Law constant. An estimated BCF of 3 suggests the potential for bioconcentration in aquatic organisms is low (HSDB 2008)

5.2.2.2.7 Toluene

Toluene is a major constituent of the gas phase of the mainstream smoke of unfiltered cigarettes (HSDB 2008). Toluene is expected to exist solely as a vapor in the ambient atmosphere based on its vapor pressure of 0.0371 atm (= 28.2 mmHg) (EPA 1999). Vapor-phase toluene is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals, nitrate radicals and ozone molecules (HSDB 2008).

Based on a K_{oc} value of 140, toluene is expected to have moderate mobility in soil. Volatilization of toluene from moist soil surfaces is expected to be an important fate process given a Henry’s Law constant of 6.13×10^{-3} atm-m^3/mol (EPA 1999). Toluene may volatilize from dry soil surfaces based on a vapor pressure of 0.0371 atm (= 28.2 mmHg) (EPA 1999).

In water, toluene is not expected to adsorb to suspended solids and sediment. Volatilization from water surfaces is expected based on its Henry’s Law constant. The potential for toluene to bioconcentrate in aquatic organisms is low because of having a BCF of 62 (EPA 1999).

5.2.2.2.8 Xylenes

Xylenes are used in petroleum products, as a chemical solvent (HSDB 2008). All of three xylenes isomers (m-, o-, and p-), have the same vapor pressure of 1.39×10^{-5} atm (= 0.01 mmHg) (EPA 1999), will exist solely as a vapor in the ambient atmosphere. Vapor-phase xylene is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the atmospheric lifetime of xylenes is about 1 – 2 days (HSDB 2008).

The reported K_{oc} values of o-xylene, m-xylene, and p-xylene are in the range of 200 – 300, indicating a moderate mobility in soil. Volatilization of xylenes from both dry and moist soil surfaces is expected due to Henry’s Law constants being around 6.7×10^{-6} atm-m^3/mol to 9.3×10^{-6} atm-m^3/mol (EPA 1999). It is also expected that xylenes will volatilize from water surfaced based on the Henry’s Law constant.

5.2.2.2.9 Summary

The dominant fate process of these non-chlorinated VOCs is partitioning to the atmosphere through direct volatilization. Degradation through reaction with hydroxyl radicals accounts for the majority of the atmospheric removal. In surface soils, volatilization to the atmosphere should dominate. In subsurface soils, leaching to groundwater will occur to the extent that it is not retarded by high levels of organic carbon. In surface water, volatilization also dominates through photolysis. None of these compounds are expected to bioconcentrate in aquatic organisms.

5.3 Transport Mechanisms

Potential migration/exposure mechanisms for constituents in contaminated media at this Site include leaching from soil to groundwater; groundwater transport; biodegradation, and vaporization. Since most of the contamination at the site has been flushed from the unsaturated zone into the groundwater aquifer, leaching from soil to groundwater is no longer a transport mechanism at this Site.

5.3.1 Groundwater Transport

The mechanisms which govern contaminant transport in the groundwater flow regime (i.e., solute transport) include various physical and chemical processes. These transport processes include advection, dispersion, and retardation (primarily via adsorption). Each of these processes and how they influence contaminant migration are described below.

5.3.1.1 Advection

Advection describes the process of solute migration due to the average bulk movement of groundwater and typically is the most important factor governing the transport of contaminants in groundwater. Advection defines the direction and velocity of a plume's center of mass. The advective transport term is computed using velocities determined by solving the groundwater flow equation, which is a function of hydraulic conductivity, hydraulic gradient, and flow cross-sectional area. Average linear groundwater velocity (v) is a function of hydraulic conductivity, hydraulic gradient, and 96` Effective porosity values typically fall within the range of values of specific yield and total porosity. Specific yield, i.e., the amount of water released from storage per unit drop in piezometric head, represents the lower limit of reasonable effective porosity values.

5.3.1.2 Hydrodynamic Dispersion

Hydrodynamic dispersion describes the spread of contaminants around an average groundwater flow path, beyond the region they would normally occupy due to advection alone. Hydrodynamic dispersion is the sum of two processes: mechanical dispersion and molecular diffusion. Mechanical dispersion results from mixing that occurs as a consequence of local variations in groundwater velocity and the aquifer's matrix. Molecular diffusion results from variations in solute concentrations within the groundwater system. However, this effect is generally secondary to and negligible compared to the mechanical dispersion effect (Zheng 1992).

A dispersion term is incorporated to account for variability of flow (Reilly et al. 1987). The most important variable in this respect is hydraulic conductivity (Domenico and Schwartz 1997). The coefficient of hydrodynamic dispersion is, therefore, typically reduced to the following equation:

$$D = \alpha v$$

where:

D = coefficient of hydrodynamic dispersion [L^2/T]

α = dispersivity [L]

v = average linear groundwater velocity [L/T]

In evaluating solute transport, dispersion is quantified by specifying longitudinal dispersivity and transverse dispersivity. Longitudinal dispersion, i.e., the magnitude of dispersion along, or parallel, to the average direction of groundwater flow in the horizontal plane, depends on longitudinal dispersivity [multiplied by advective velocity (v)]. Similarly, transverse dispersion, or the magnitude of dispersion perpendicular to the average direction of groundwater flow, depends on transverse dispersivity. Typically, for fully three-dimensional solute transport evaluations involving dispersion, values are specified for longitudinal dispersivity (α_L), and the ratios of both horizontal transverse dispersivity (α_{Th}) and vertical transverse dispersivity (α_{Tv}) to the longitudinal dispersivity are specified.

5.3.1.3 Retardation

Dissolved contaminants may interact with aquifer solids encountered along the flow path via adsorption, partitioning, ion-exchange reactions, and other chemical and physical processes which remove the dissolved constituent from groundwater. These interactions distribute the contaminant between the aqueous phase and the aquifer solids, diminish concentrations of the contaminants in the aqueous phase, and retard the movement of the contaminant relative to groundwater flow (MacKay et al., 1985). The higher the fraction of contaminant sorbed, the more its transport is retarded. Due to the various physical and chemical removal processes (primarily adsorption), a solute may move slower than the groundwater. A typical method of generally describing this phenomenon in solute transport evaluations is by using a retardation factor. This factor, which has the form of a correction of the velocity of the movement of groundwater, is shown in the following equation (Freeze and Cherry, 1979):

$$v / v_a = 1 + (\rho_b / \eta) K_d = R$$

where:

v = average linear groundwater velocity [L/T]

v_a = apparent mean velocity of solute [L/T]

ρ_b = effective bulk density [M/L^3]

η = effective porosity [D]

K_d = distribution coefficient [L^3/M]

R = retardation factor [D].

The distribution coefficient is a function of the soil's and solute's chemistry, and therefore, is compound-specific. For volatile organic compounds, the amount of organic carbon present in the aquifer matrix is a key factor. The distribution coefficient is defined by:

$$K_d = C_s / C_w = f_{oc} K_{oc}$$

where:

C_s = concentration by weight in soil

C_w = concentration by volume in water

f_{oc} = fraction of organic carbon

K_{oc} = partitioning coefficient (L^3/M)

These equations assume rapid reversible adsorption with a linear isotherm. Generally, the larger the value of K_d, the greater the compound's affinity for the solid matrix (Rutgers University 1993).

Some contaminants are described as being conservative, indicating very low adsorptive capacity (low K_d). For plumes characteristic of these contaminants, the contaminant's mass moves at essentially the same rate as the average linear groundwater velocity.

5.3.2 Biodegradation

During the February 2008 monitoring round, monitoring well groundwater samples were tested for a series of non-contaminant parameters to evaluate biodegradation potential. These bioparameters included pH, total organic carbon (TOC), oxidation-reduction (redox) potential, and several terminal electron acceptors and metabolic byproducts. The monitoring natural attenuation parameter results are provided in Table 5-2.

Five of the nine tested wells (MW10, MW11S, MW12, MW14S, and MW15) yielded groundwater that was anaerobic (dissolved oxygen-D.O.-less than 1 mg/L) and nitrate reducing (nitrate < 1 mg/L). These groundwater samples had neutral pH (approximately 7 units) and contained very little organic carbon (TOC < 7 mg/L). A sixth well, MW14D, yielded groundwater that was oxygen poor but not nitrate-reducing, with neutral pH and very low TOC (1.8 mg/L). Thus, the predominant groundwater environment, based on the February 2008 sampling round, is oxygen limited, mildly reducing, and with minimal organic carbon present.

Under reducing conditions, many chlorinated VOCs can undergo microbially mediated reductive dechlorination via sequential replacement of chlorine atoms by hydrogen atoms. Chlorinated ethenes and ethanes can be biodegraded by this process to yield ethene and ethane as final breakdown products. In reductive dechlorination, the bacteria utilize a separate carbon source for food and they respire the chlorinated

VOCs, which serve as terminal electron acceptors much like oxygen serves aerobic bacteria (or animals).

Site groundwater, with its very low TOC concentrations, provides minimal carbon source to fuel reductive dechlorination. Thus, biodegradation is not expected to be a dominant process affecting chlorinated VOC fate. Under the site groundwater's predominant mildly reducing conditions, any microbial breakdown of PCE is expected to stop at the *cis*-1,2-DCE intermediate, which can accumulate as it is produced. The fact that some VC is observed in groundwater samples probably indicates that higher concentrations of TOC and lower redox potentials existed earlier in the plume's history. TOC could have been supplied by previous hydrocarbon contamination from fuel-related sources. Under these hypothesized carbon rich, reducing conditions, dechlorination beyond *cis*-1,2-DCE to VC could have occurred previously.

Hydrocarbon VOCs, such as BTEX, biodegrade most rapidly under aerobic conditions. In the predominantly mildly reducing groundwater, hydrocarbons including MTBE would be expected to biodegrade slowly (if at all) to ultimately generate carbon dioxide and water.

Two other monitoring wells, MW11D and MW16, yielded aerobic groundwater with dissolved oxygen (D.O.) between 7.5 and 8.5 mg/L. Groundwater pH at these locations was rather low at 4.6 units. Aerobic groundwater here might support aerobic biodegradation of both hydrocarbons and the chlorinated VOCs that are not fully saturated with chlorine atoms. However, the low pH would be expected to keep most microbial activity to a minimum.

Near the northeast corner of the site, MW06 groundwater was weakly aerobic with a D.O. level of 1.5 mg/L and a neutral pH. In the vicinity of MW06, aerobic biodegradation of hydrocarbons and not fully chlorinated VOCs is possible.

5.3.3 Volatilization

When a chemical of sufficient volatility and toxicity is present in the subsurface, there are several transport mechanisms by which the chemicals can migrate. There are four main transport mechanisms that influence volatilization or vapor migration

- Diffusion of vapors from sources in the unsaturated zone
- Diffusion of vapors from sources in shallow groundwater (groundwater table interface)
- Advective/convective transport of vapors
- Vapor migration through preferential pathways

At the SMP Site, it has been proven that unsaturated sources do not currently exist. Therefore, diffusion of vapors from unsaturated sources is not a transport mechanism that is occurring at this Site.

Diffusion of vapors from sources in shallow groundwater occurs as a result of a concentration gradient between the source and the surrounding area; in this case, the source is shallow groundwater contamination. This can result in the upward or lateral migration of vapors through the vadose zone. Since the groundwater table interface at the Site has elevated levels of constituents, particularly underneath the eastern portion of the building, upward diffusion due to the concentration gradient between the contaminated groundwater table interface and the uncontaminated unsaturated zone is occurring at this Site.

The horizontal and vertical movement of vapors located near the building foundation is affected via advective/convective transport mechanisms. Volatilized chemicals are drawn into the SMP building via soil gas advection and convection which is the result of a negative pressure that the building interior exhibits on sub-slab vapors. The reasons for this negative pressure differential include:

- Factors relating to operation of HVAC systems
- Use of combustion sources resulting in venting to the exterior
- Higher temperatures indoors relative to outdoors during the heating season; and
- Pressure exerted on the wall of a building caused by wind movement over the building.

The combination of these actions/conditions results in a net convective flow of sub-slab vapors from the subsurface through the building foundation to the building interior. Thus, indoor air volatile concentrations are generally higher during the heating season.

Another advective transport mechanism called “barometric pumping” is caused by cyclic changes in atmospheric pressure. These changes create a “piston like” force on soil gas possibly causing a cyclic up and down flow of contaminant vapors in the affected interval. The magnitude of a barometric pressure cycle is typically a small percentage of atmospheric pressure and its effect decreases with depth. The soil texture, soil air permeability, and moisture content affect the depth to which the pressure change may affect vapor transport. Soil gas compression and expansion in response to barometric pressure fluctuations may alternately enhance or inhibit vapor intrusion.

Vapor migration can occur more rapidly via man made or natural preferential pathways. Some manmade preferential pathways include:

- Underground conduits
- High permeable bedding materials (underneath building foundations, pipelines, etc.)
- Cracks in building foundations

- Utilities penetrating foundations that are not air-tight

Some natural preferential pathways include:

- Heterogenic soil conditions
- Heterogenic groundwater conditions
- Fractures in bedrock

Since the Site geologic and hydrologic conditions in the vicinity of the water table interface are relatively homogeneous, most of the preferential pathways that exist at this Site are manmade and consist of foundation bedding materials, utilities penetrating the foundation and cracks in the foundation.

5.4 Summary of Constituent Fate and Transport

The fate of a constituent in the environment is a function of its chemical properties and the physical nature of the Site. The potential for environmental transport was examined by reviewing the topographic and hydrogeologic characteristics of the Site and a review of the available physical constants and chemical characteristics of each constituent. The following summarizes the most significant fate and transport processes for the Site:

- The greatest potential for transport of contaminants at the Site is via groundwater migration. Volatile organic compounds, including chlorinated compounds (i.e., *cis*-1,2-DCE, 1,1-DCA, chloroethane, VC, PCE, TCE, and 1,1,1-TCA) and non-chlorinated VOCs, (i.e., benzene, isopropyl benzene, MTBE, toluene, and xylenes) have been detected in groundwater plumes indicating their ongoing transport.
- Biodegradation has likely occurred over time due to an elevated carbon source from the commingled BTEX contamination.
- Volatilization is considered significant based on the results of the soil gas and sub-slab vapor results.

5.5 Conceptual Site Model

Before initiation of field activities, a preliminary conceptual site model (CSM) was developed for the Site to understand the Site's dynamics. The four primary goals of the CSM are the following:

- to describe the Site and its environs
- to present hypotheses on the suspected sources and types of constituents of concern
- to define the potentially affected media
- to determine constituent-specific release and transport mechanisms,

As the results of the remedial investigation and qualitative risk assessment became available, the CSM was refined to reflect actual Site conditions. The final CSM is presented in Figure 5-1.

The Site is located in an industrial/commercial area. The Site is boarder to the north by a car dealership, to the south by the High Speed Rail station, to the west by a commercial building, and to the east by the Hess station. The chlorinated contamination is originates from the Site as shown on Figure 5-1. Based upon an extensive amount of data, it has been determined that the chlorinated groundwater "hot spot" is located external to the building, along the loading dock northeast of MW11, approximately 120 feet west of the southeast corner of the building. Based upon this same extensive database, it has been determined that the non-chlorinated groundwater contamination originates from an upgradient source, the Hess station (east of the Site). Unsaturated soil contamination is minimal and previously detected soil contamination has been flushed into the saturated zone.

Both chlorinated and non-chlorinated constituents are retained in the eastern portion of the building, whereas the western portion of the building remains relatively uncontaminated even though groundwater flow is from east to west. Also, the highest levels of contamination exist in the capillary fringe of the water table interface on the eastern side of the building. In addition to capillary forces retaining contamination, it is evident by the direct push profiles that contamination significantly diminishes with depth. The sub-basement extends approximately eight feet into the groundwater table and acts as a hydraulic barrier to groundwater transport. Also, the Subway tunnel located along Northern Boulevard also acts as a hydraulic barrier to groundwater transport. These two structures impede groundwater flow in the northern and western direction in the vicinity of the sub-basement. This impediment to groundwater flow is also indicated on the shallow groundwater potentiometric surface map presented in Figure 3-14, since there is groundwater mounding present immediately upgradient of the sub-basement. Thus, stagnant groundwater immediately upgradient of the sub-basement has not been flushed over time and contains an elevated level of contamination. At depths greater than 8 feet, beyond the depth of the sub-basement, groundwater quality significantly improves due to hydraulic flushing and attenuation. This is also demonstrated on the VOC plume contour and cross-section maps presented in Figures 4-9 through 4-15

Even though contamination has been relatively stagnant in the capillary fringe on the eastern side of the building, contamination has biodegraded over time when comparing monitoring well data collected from 2003 through 2008 (Figure 4-6). Biodegradation can be enhanced with the addition of nutrients provided proper site-specific conditions are present.

In addition to groundwater transport and biodegradation, vapor migration is currently occurring at the Site. Vapors from the "hot spot" are being transported from the water table interface and are being drawn upward during the heating season due to stack effects. However, even though sub-slab concentrations are elevated, primarily along the south east perimeter of the building, current indoor air concentrations do not exceed guidance values. It is recommended that sub-slab vapors be mitigated to eliminate the potential for vapor intrusion and potential exposure in the future.

Potential exposure to the elevated levels of contamination in the groundwater and vapor are discussed and evaluated in Section 6.

Section 6
Exposure Assessment

A preliminary screening based on "*Draft DER-10 Technical Guidance for Site Investigation and Remediation*" (NYSDEC 2002) was performed to determine that a Fish and Wildlife Resources Impact Analysis (FWRIA) was not needed for the Site since there are no fish and wildlife resources on or adjacent to the Site or area of concern. There is also very limited vegetation present on the Site or in the immediate vicinity; thus, there is negligible potential environmental risk at the Site. Consequently, the main focus of the exposure assessment is human health. A qualitative human health exposure assessment (HHRA) was performed at the Site.

The purpose of the HHRA is to qualitatively evaluate the potential risks to human health associated with Site-specific compounds in soil, groundwater, and air under no remedial action and institutional control conditions.

Potential risks to human health and the environment are evaluated following a tiered approach consisting of a screening evaluation and a qualitative risk assessment. The risk assessment is performed in a manner consistent with the requirements of EPA, NYSDEC, and NYSDOH guidance set forth in the following documents:

- *Draft DER-10 Technical Guidance for Site Investigation and Remediation* (NYSDEC 2002)
- *New York State Brownfield Cleanup Program Development of Soil Cleanup Objectives Technical Support Document* (NYSDEC and NYSDOH 2006)
- *Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York* (NYSDOH 2006)
- *NYCRR Part 375: Environmental Remediation Program* (NYSDEC 2006)
- *NYCRR Part 703: Surface Water and Groundwater Standards and Groundwater Effluent Limitations* (NYSDEC 1999)
- *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part A* (EPA 1989)
- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (EPA 2002)
- *Regional Screening Levels for Chemical Contaminants at Superfund Sites* (Oak Ridge National Laboratory 2008)

The HHRA consists of six components, including a brief description of Site background, COPC, exposure assessment, toxicology assessment, risk characterization, and summary and conclusions.

6.1 Site Background

As described in Section 3, the Site is located in a highly industrialized area with a wide variety of activities ranging from small-scale assembly to large-scale manufacturing. A large six-story industrial building occupies most of the Site. A narrow strip of land on the south side of the property contains a loading dock and a dirt access path for vehicles. Immediately adjacent to this narrow strip is the Sunnyside Yard, which consists of a railroad maintenance and storage facilities encompassing approximately 105 acres. There is very limited vegetation present on the Site or in the immediate vicinity and ecological receptors/habitats have no exposure to groundwater; thus, there is negligible potential environmental risk at the Site. Consequently, the main focus of this risk assessment is human health.

The Site is currently used for industrial purposes only and future land use will likely remain the same. According to the New York City Planning Commission Zoning Map, the Site is classified as "M" and restricts it to manufacturing uses. The Site is surrounded by well-established industrial facilities. There is no residential area present in the immediate vicinity.

The Long Island City is currently supplied with potable water from the NYSDEC Water Supply System. Public water supply derives from a series of reservoirs located in upstate New York. Based on a NYSDEC online database water well search, there are no water wells, including, but not limited to, agricultural, commercial, public, and residential wells, located in Queens County.

NYSDEC classifies all fresh groundwater in the state as "Class GA fresh groundwater," for which the assigned best usage is as a source of potable water supply. The NYSDEC groundwater standards for Class GA fresh groundwater are based on the assumption that the water is used by residents as drinking water. Therefore, although there are no known current users of groundwater at or near the Site, the groundwater is assumed to be a source of drinking water in the future.

6.2 Chemicals of Potential Concern

The soil, groundwater, soil vapor, sub-slab vapor, indoor air, and outdoor air quality are assessed in a screening evaluation. The primary objectives of the screening evaluation are to identify COPCs, media of concern, and areas of concern (AOCs) for the risk assessment.

The screening evaluation involves comparison of the maximum detected concentration of Site-specific compounds to a screening level (SL) established by the NYSDEC. If the maximum concentration of a chemical exceeds its respective SL, then the chemical is selected as a COPC and is further assessed in the risk assessment. If the maximum concentration of a chemical does not exceed the SL, then the chemical is eliminated from further evaluation. Details on identification of COPCs and AOCs are provided in the following subsections.

6.2.1 Selection of Data for Use in the Risk Assessment

For risk assessment purposes, only the most recently collected analytical data during Phase IV investigation are used. These data represent the most current conditions of the Site.

Analytical data used for the risk assessment are provided in Appendix L. Occurrence and distribution of chemicals in soil, groundwater, soil vapor, sub-slab vapor, indoor air, and outdoor air are summarized in Tables 6-1 through 6-6.

Aluminum, iron, magnesium, potassium, and sodium were analyzed in soil and groundwater samples. These metals are either abundant elements of the earth or are essential nutritional metals. They are not assessed in the risk assessment.

6.2.2 Screening Process

Risk-based screening is conducted to determine which detected chemicals should be further evaluated for the HHRA. Screening helps to focus on the chemicals that may potentially pose a risk. The risk-based screening process is described as follows:

- Frequency of Detection – All detected chemicals in soil and groundwater are evaluated for their frequency of detection. Chemicals detected in less than five percent of the samples for each medium with 20 samples or more are assumed to be isolated occurrences and not representative of the Site or the data set, unless it is classified as known human carcinogens (Group A carcinogens). Chemicals detected in greater than five percent of the samples are carried forward in the screening process.

- Concentration-Risk Screen – Chemicals identified in the frequency screening are further evaluated in a concentration-risk screen for the selection of COPCs. The concentration-risk screen consists of comparing maximum detected concentrations of chemicals in each medium against appropriate human health risk-based screening criteria.

6.2.3 Identification of Screening Levels

Restricted use Soil Cleanup Objectives (SCOs) for protection of public health for industrial use (NYCRR Subpart 375-6) are used as screening levels for soil. To evaluate potential for soil-to-groundwater migration pathway, SCOs for the protection of groundwater are also listed as references in the soil screening table. NYSDEC Groundwater Quality Standards for Class GA (NYCRR Part 703) are selected as screening levels for groundwater.

Screening levels for indoor air for methylene chloride, PCE, and TCE are based on air guideline values derived by NYSDOH (2006). Screening levels for other VOCs are based on background levels of VOCs in indoor air provided in the NYSDOH vapor intrusion guidance (2006). The 90th percentile values from the EPA Building Assessment and Survey Evaluation (BASE) Database for indoor air are used as screening levels. For VOCs detected in indoor air and are not listed on the EPA BASE database, screening levels are selected from background levels from other databases provided in the NYDOH guidance (2006).

Screening levels for outdoor air for methylene chloride, PCE, and TCE are based on air guideline values derived by NYSDOH (2006). Screening levels for other VOCs are based on background levels of VOCs in outdoor air provided in the NYSDOH vapor intrusion guidance (2006). The 90th percentile values from the EPA BASE database for outdoor air are used as screening levels. For VOCs detected in outdoor air and are not listed on the EPA BASE database, screening levels are selected from background levels from other databases provided in the NYDOH guidance (2006).

There are no standards, criteria, or guidance values for concentrations of VOCs in soil vapor or sub-slab vapor. Background levels for indoor air are used as screening levels for sub-slab vapor. Since attenuation of VOC concentration from sub-slab vapor concentration to indoor air is not considered, this approach is extremely conservative.

In accordance with NYSDOH guidance (2006), potential vapor intrusion exposure is evaluated primarily based on sub-slab vapor, indoor air, and outdoor air sampling results. Soil vapor results are primarily used as a tool to guide sub-slab and air sampling and for understating of cross media transfer of volatile constituents. Thus, soil vapor data are only evaluated qualitatively in the screening process.

6.2.4 Identification of Chemicals of Potential Concern

The screening levels are compared to the maximum detected chemical concentrations in soil, groundwater, sub-slab vapor, indoor air, and outdoor air of the Site. Tables 6-1 through 6-6 document the decision process for identifying COPCs in each medium. Details of selection of COPCs in each medium are summarized below.

6.2.4.1 Soil

Comparisons of maximum detected concentrations to health risk-based SCOs indicates that several PAHs, including benzo(a)anthracene, benzo(a)pyrene, dibenz(a,h)anthracene, and arsenic are at levels exceeding screening level (Table 6-1).

Additionally, several chemicals have their maximum concentrations exceeding their respective SCOs for protection of groundwater. These include: 1,1,1-TCA, 1,1-DCA, 1,1-DCE, 1,2-DCA, acetone, *cis*-1,2-DCE, ethylbenzene, methylene chloride, PCE, TCE, vinyl chloride, m,p-xylene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, pentachlorophenol, phenol, arsenic, chromium, and lead. 1,2-DCA and pentachlorophenol were not detected in groundwater and thus are not of concern. Potential leaching of rest of residual chemicals from soil will be addressed in the feasibility study (Table 6-1).

6.2.4.2 Groundwater

Comparisons of maximum detected concentrations to the screening levels indicate that several chemicals are at levels exceeding drinking water standards (Table 6-2). These include 23 VOCs (1,1,1-TCA, 1,1,2-TCA, 1,1,2-trichlorotrifluoroethane, 1,1-DCA, 1,1-DCE, 1,2-dichlorobenzene, 1,2-dichlorpropane, benzene, chloroethane, chloroform, *cis*-1,2-DCE, *trans*-1,2-DCE, dichlorodifluoromethane, ethylbenzene, isopropylbenzene, MTBE, methylene chloride, PCE, toluene, TCE, trichlorofluoromethane, vinyl chloride, and xylenes), 4 SVOCs (1,1-biphenyl, bis(2-ethylhexyl)phthalate, naphthalene, and phenol), and 13 metals (antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, and thallium).

The majority of groundwater contamination is limited to the suspected primary source area in the immediate vicinity to the southeast of the building. Impacted groundwater is mostly contained at the Site based on the results obtained from monitoring wells MW-13, MW-14 S, and MW-14D that are located at the southwestern portion of the Site. The only Site-related chlorinated VOC that has been reported in these three wells at levels consistently above drinking water standard is *cis*-1,2-DCE. *cis*-1,2-DCE was reported at concentrations ranging from 14 to 44 µg/L (Figure 4-6). As discussed in Section 6.3, there is no direct exposure to groundwater through ingestion and dermal contact for offsite receptors. For the protection of indoor air quality, EPA (2002) screening level for groundwater is 210 µg/L for *cis*-1,2-DCE. Since the concentration of *cis*-1,2-DCE at the southwestern property boundary is predicted to be 44 µg/L or less, which is much lower than the screening level of 210 µg/L. ,it is not a concern for indoor air quality for downgradient offsite receptors.

6.2.4.3 Soil Vapor

Soil vapor sampling was conducted at 12 exterior locations. Ten of the soil vapor samples, SG01 through SG10, were collected along the southern perimeter of the SMP building. Two of the soil vapor samples, SG11 and SG12, were collected north of Northern Boulevard.

Elevated levels (>950 µg/m^3) of chlorinated VOCs are present in soil vapor samples (Table 6-3). These include 1,1,1-TCA, 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113), 1,1-DCA, 1,1-DCE, *cis*-1,2-DCE, trans-1,2-DCE, chloroethane, chloromethane, methylene chloride, PCE, TCE, trichlorofluoromethane, and vinyl chloride. The highest concentrations of chlorinated VOCs in soil vapor are found in the immediate vicinity of the southeastern corner of the building, coinciding with the highest mass of chlorinated VOCs existing in the groundwater.

6.2.4.4 Sub-slab Vapor and Indoor Air

As aforementioned, background levels for indoor air are used as screening levels for sub-slab vapor since there are no NYSDOH established criteria available. Comparisons of maximum detected concentrations to the indoor air background levels indicate that several chlorinated chemicals are present in sub-slab vapor at levels exceeding background level. These include: 1,1,1-TCA, Freon 113, 1,1,2-TCA, 1,1-DCA, 1,1-DCE, *cis*-1,2-DCE, chloroform, PCE, tetrahydrofuran, toluene, TCE, and trichloromethane (Table 6-4).

Comparison of indoor air samples results to the background or air guideline values indicates that all chlorinated VOCs are present in indoor air at levels below detection limits or below screening levels. These results indicate that the presence of elevated levels of chlorinated VOCs in subsurface at the Site has not caused unacceptable impacts to indoor air quality.

Several chlorinated VOCs present in sub-slab vapor are not detected in indoor air, including Freon 113, 1,1,2-TCA, 1,1-DCE, *cis*-1,2-DCE, chloroform, and trichloromethane (Table 6-5). These constituents are thus not selected as COPCs for vapor intrusion evaluation due to lack of impact to indoor air.

There are, however, several constituents detected in the indoor air samples at levels exceeding background. These include 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, hexachlorobutadiene, and *n*-hexane (Table 6-5). These VOCs are not present in sub-slab vapor and are not related to Site-specific organics. They are probably attributed to previous solvent or other chemicals utilized inside the building. For example, chlorobenzenes, including 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, and 1,4-dichlorobenzene, probably come from plastic foam insulation used in building construction and previous uses of products containing chlorobenzenes such as paints and degreasing solvent. Hexachlorobutadiene and n-hexane are ingredients commonly found in lubricants such as WD-40 that was used inside the building as documented on the inventory list. These constituents are not related to site-specific constituents present in subsurface and thus are selected as COPCs for the vapor intrusion evaluation.

Tetrahydrofuran was detected in sub-slab vapor and indoor air at similar concentrations. Tetrahydrofuran could be released from a variety of common household products including paint and paint related products, furniture polish and cleaners, laundry starch, lubricating oils, and glue. It was detected in indoor air of heated homes according to the NYSDOH 2003 survey (NYSDOH 2006). It is not present in soil and groundwater and is not related to Site-specific organics. Thus it is not selected as a COPC for the vapor intrusion evaluation.

Toluene was detected in both sub-slab vapor and indoor air. Its maximum concentration in indoor air is 6.8 $\mu g/m^3$, well below the background level of 43 $\mu g/m^3$. Toluene can be degraded by indigenous soil microbes in the presence of oxygen. Toluene vapor potentially emanating from subsurface is likely to be degraded before reaching the plant building. It is much less toxic when compared to chlorinated VOCs. Thus, it is not selected as a COPC for the vapor intrusion evaluation.

In accordance with NYSDOH guidance (2006), site-related chlorinated VOCs, include 1,1,1-TCA, 1,1-DCA, PCE, and TCE, are retained as COPCs for vapor intrusion evaluation even though they are present in indoor air at levels below background or air guideline values.

6.2.4.5 Outdoor Air

A total of three outdoor air samples were collected to represent the outdoor air quality surrounding the on-Site structure. Comparisons of maximum detected concentrations to the screening levels indicate that several chemicals are at levels exceeding background or air guideline values. These include 1,1,1-TCA, 1,1,2-trichloro-1,2,2-trifluoroethane, 1,1-DCA, cyclohexane, hexachlorobutadiene, tetrahydrofuran, and TCE. These chemicals are also present in soil vapor samples. However, hexachlorobutadiene and tetrahydrofuran are not Site-related chemicals and they are not detected in soil and groundwater. As mentioned in Section 6.2.4.4, tetrahydrofuran could be released from various household, industrial, and commercial products such as paint and paint related products, furniture polish and cleaners, laundry starch, lubricating oils, and glue, whereas hexachlorobutadiene is commonly used in lubricating oils and rubber. Their presence in soil gas and outdoor air are probably attributed to the heavy industrial nature of the area.

The presence of above background levels of 1,1,1-TCA, 1,1,2- trichloro-1,2,2-trifluoroethane, 1,1-DCA, cyclohexane, and TCE in outdoor air could be attributed to vapors released from the impacted groundwater at the Site. They could also be contributed, or partly contributed, from other sources near the Site, such as gasoline stations and automobile dealership, dry cleaners, and other industrial areas in the vicinity. In accordance with NYSDOH guidance (2006), these chemicals are selected as COPCs for further evaluation.

6.3 Exposure Assessment

As a component of the human health risk assessment, the exposure assessment strives to predict the potential receptor's exposure to COPCs in affected media at the Site and in the vicinity. The exposure assessment consists of a description of the exposure scenarios, potential human receptor populations, and routes of exposure. The results of the exposure assessment are combined with chemical-specific toxicity information to characterize potential risks.

Based on the investigation results and screening evaluation, media of concern at the Site include soil, groundwater, soil vapor, and air. COPCs in soil and groundwater can be released through direct contact to a potential human receptor. Or they could serve as a continuing secondary source of the COPCs through volatilization and subsurface vapor intrusion to impact air quality.

For exposure and potential risks to occur, a complete exposure pathway must exist. A complete pathway requires the following elements (EPA 1989):

- A source and mechanism for release of constituents
- A transport or retention medium
- A point of potential human contact (exposure point) with the affected medium
- An exposure route (e.g., ingestion, dermal contact, and inhalation) at the exposure point

If any of these elements is missing, no complete exposure pathway exists. Considering the sources of COPCs, potential release mechanisms and likely exposure media, potential exposure pathways at the Site are illustrated in a site exposure model (Figure 6-1) and summarized as follows:

- Direct contact with COPCs in soils through incidental ingestion, dermal contact, and inhalation of dust.
- Inhalation of indoor vapors potentially released from subsurface into the enclosed Site building *via* vapor intrusion.
- Inhalation of outdoor vapors potentially released from subsurface into outdoor air *via* volatilization.
- Direct contact with COPCs in shallow groundwater through incidental ingestion, dermal contact, and inhalation of vapors.

Currently, the shallow groundwater is not used for any purposes at the Site and in the Queens County. Potable water is supplied to the Site by NYSDEC Water Supply System. Therefore, no current direct exposure *via* ingestion and dermal contact with groundwater can occur. Shallow groundwater is unlikely to be used as a potable water source in the foreseeable future since potable water will continually be supplied by NYSDEC Water Supply System. Based on these considerations, direct exposure pathways to groundwater *via* ingestion and dermal contact for onsite workers and downgradient offsite receptors are incomplete and are likely to be remained incomplete in the future, except for construction and utility workers while performing in excavation activities at the Site. Impacted groundwater is contained mostly within Site boundary with the exception of lower levels of *cis*-1,2-DCE in groundwater near the southwestern boundary. However, the presence of *cis*-1,2-DCE in groundwater will not cause a concern for indoor air for downgradient offsite receptors since it is at levels well below the EPA screening level for groundwater for the protection of indoor air.

The Site is currently used for industrial purposes only and future land use will likely remain the same. The New York City Planning Commission Zoning regulations classify the Site as "M" and restrict it to manufacturing uses. The Site is surrounded by well-established industrial facilities. There is no residential area present in the immediate vicinity. Thus, potential receptor scenarios are identified based on current and anticipated future industrial uses of the Site. These include:

- Outdoor Worker
- Indoor Worker
- Construction Worker
- Trespasser

The key characteristics of each receptor population scenario are summarized below.

Outdoor Worker -Outdoor workers may be potentially exposed to surface soil and outdoor air while engaging in activities involving moderate digging, landscaping, repairing, or other activities. Routes of exposure under a hypothetical outdoor worker scenario include incidental ingestion of soil, dermal contact with soil, and inhalation of fugitive dust and volatiles.

Indoor Worker_- Indoor workers (i.e., shop workers and office workers) may be potentially exposed to vapors released from subsurface into the enclosed building *via* vapor intrusion.

Construction Worker - If construction occurs at the Site in the future, workers involved with the construction could be potentially exposed to Site soils, shallow groundwater, and outdoor air during excavation for building foundations or utilities. Routes of exposure under a hypothetical construction worker scenario include incidental ingestion of soil and groundwater, dermal contact with soil and groundwater, and inhalation of fugitive dust and volatiles. Construction workers may also be potentially exposed to chemical vapors within a trench, resulting from migration of soil gas into a trench while performing excavation activities at areas with elevated soil gas concentrations.

Trespassers—Trespassers, especially adolescents, could gain unauthorized access, however infrequently, to most or all areas of the Site. These individuals may be potentially exposed to COPCs in surface soil and outdoor air through incidental ingestion of soil, dermal contact with soil, and inhalation of fugitive dust and volatiles.

In addition to the four receptor populations identified above, other possible receptors, such as commercial and industrial workers who work in facilities bordering the Site and pedestrians, may also be potentially exposed to Site-related COPCs in outdoor air. However, outdoor workers have both the highest exposure potential (both to surface soil and outdoor air) and are assumed to be present at the Site for the longest duration. Therefore, the outdoor exposure scenario will provide a conservative basis for evaluating potential exposures to other possible receptors such as offsite workers and pedestrians.

6.4 Toxicity Assessment

The majority of toxicological knowledge of chemicals comes from experiments on laboratory animals. Experimental animal data have historically been relied upon by regulatory agencies and other expert groups to assess the hazards of human chemical exposures. Although this reliance has been generally supported by empirical observations, there are known interspecies differences in chemical absorption, metabolism, excretion, and toxic response. There are also uncertainties concerning the relevance of animal studies using exposure routes that differ from the human routes that may be relevant to any given site or situation. However, despite the limitations of experimental animal data, such information is essential for chemical toxicity assessment, especially in the absence of human epidemiological evidence.

6.4.1 Reference Doses and Reference Concentrations

Reference doses (RfDs) and reference concentrations (RfCs) are the toxicity values used to evaluate noncancer health effects in humans. A chronic RfD is defined as an estimate of a daily exposure level *via* oral route for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is expressed in unit of milligram per kilogram per day (mg/kg/day). A chronic RfC is defined as a continuous inhalation exposure to the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfC is reported as a concentration in air (mg/m^3).

Chemicals that produce noncancer effects are generally thought to have a threshold dose below which there are no observable health effects. In developing a toxicity value for noncancer effects, the approach is to identify this threshold dose or the no-observed-adverse-effect level (NOAEL) through studies with experimental animals or from epidemiological studies. A NOAEL is an experimentally (or epidemiologically) calculated maximum dose at which there is no statistically or biologically significant effect of concern, often called the "critical toxic effect". For certain chemicals, only a lowest-observed-adverse-effect level (LOAEL) has been calculated. This is the lowest dose of a chemical that produces either a statistically or biologically significant indication of the critical toxic effect. The NOAEL or LOAEL may then be used to calculate the RfD by dividing the NOAEL or LOAEL by uncertainty factors, which generally range from 3 to 1,000. Uncertainty factors are applied based on variations in the sensitivity of individuals within a given population and the extrapolation of data from experimental animals to humans. Such an approach ensures that the resulting toxicity factor will be conservative.

The EPA, states, and international regulatory or advisory public health organizations have developed various types of RfDs depending on the exposure route (ingestion or inhalation), the critical toxic effect, and the length of exposure being evaluated (chronic or subchronic). NYSDEC and NYSDOH evaluated available toxicity values from these authoritative bodies and selected RfDs to be used for the calculation of Soil

Cleanup Objectives (NYSDEC and NYSDOH 2006). Reference doses for site-specific COPCs are obtained from the following hierarchy of sources:

- Tier 1 – NYSDEC and NYSDOH, 2006, New York State Brownfield Cleanup Program Development of Soil Cleanup Objectives Technical Support Document
- Tier 2 - EPA's Integrated Risk Information System (IRIS)
- Tier 3 – Regional Screening Levels for Chemical Contaminants at Superfund Sites (ORNL 2008)

RfDs and RfCs for site-specific COPCs are summarized in Tables 6-7a and 6-7b, respectively.

6.4.2 Slope Factors and Unit Risk

The cancer slope factor (SF) is likewise an experimentally derived value and represents the upper bound estimated risk of cancer per unit of exposure. A unit risk (UR) is defined as the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 µg/L in water, or 1 µg/m^3 in air. SFs are based largely upon animal data. This requires the assumption that chemicals which are carcinogenic in animals are also carcinogenic in humans. Evidence of carcinogenicity in humans is available for only a few chemicals since ethical considerations preclude intentionally exposing humans to potential cancer causing agents. Further, a relatively small number of chemicals have been shown to be carcinogenic in humans on the basis of occupational exposure data. In using animal data, it is assumed that humans are as sensitive as the most sensitive animal species. This policy is designed to minimize the potential for underestimating risk at the expense of increasing the likelihood that risk will be overestimated.

Under EPA's risk assessment guidelines, classification of the overall weight of evidence has the following five categories:

- A - known human carcinogen based on human data
- B1 - probable human carcinogen based on limited human data and/or sufficient animal data
- B2 - probable human carcinogen based on sufficient animal data
- C - possible human carcinogen based on limited animal data
- D - not classifiable as to human carcinogenicity based on inadequate human and animal data

To develop the SF, the dose response data obtained from the animal studies are run through mathematical models which extrapolate from the high doses used in the animal studies to the lower doses typically encountered by humans in the environment. EPA assumes that any exposure level is associated with a potential cancer response, however small, because a single molecule of the carcinogen can trigger the reactions leading to a cancer response at the cellular level (i.e., a no threshold approach). The slope on the extrapolated dose-response curve therefore only reaches zero response at zero dose.

The SF is the slope of the upper 95th percent confidence limit on the slope of the extrapolated dose-response curve. EPA uses the upper 95th percent confidence limit to account for uncertainties in the extrapolation, in a manner similar to that used in deriving RfDs. Use of the 95th percent confidence limit of the slope introduces an element of conservatism (i.e., protectiveness) into the risk assessment process.

Slope factors for site-specific COPCs are obtained from the following hierarchy of sources:

- Tier 1 – NYSDEC and NYSDOH, 2006, *New York State Brownfield Cleanup Program Development of Soil Cleanup Objectives Technical Support Document*
- Tier 2 - EPA's Integrated Risk Information System (IRIS)
- Tier 3 - Regional Screening Levels for Chemical Contaminants at Superfund Sites (ORNL 2008)

Slope factors and URs for site-specific COPCs are summarized in Tables 6-8a and 6-8b, respectively.

6.5 Risk Characterization

The final step in risk assessment combines the information gained and analysis performed during the first three stages to estimate possible cancer risks and health hazards. The risk characterization presented in this section is qualitative in nature and takes into consideration the unique site-specific features of the Site and associated receptors.

Potential risks are evaluated for the following receptors:

- Outdoor Worker
- Indoor Worker
- Construction Worker
- Trespasser

6.5.1 Outdoor Worker

Outdoor worker performs landscaping, ground keeping, maintenance activities at the Site may be potentially exposed to COPCs in soil via incidental ingestion, dermal contact, and inhalation of dust and to outdoor air via inhalation of vapors. Potential health risks to an outdoor worker are evaluated for each COPC and described below.

6.5.1.1 Soil

Benzo(a)anthracene – The SCO of 11 mg/kg is based on the protection of an outdoor worker. Benzo(a)anthracene concentrations in Site soil range from 0.066 to 13 mg/kg, with an average concentration of 0.92 mg/kg and a 95% upper confidence limit (UCL) concentration of 2.22 mg/kg. Exceedance of the SCO is limited to one isolated location of SG-09 at a depth of 4 to 5 ft. This depth exceeds common landscaping and maintenance depths which generally involve surface soils less than two ft bgs. Outdoor workers are not expected to come into direct contact with this slightly elevated benzo(a)anthracene in soil at a depth of 4 to 5 ft.

Benzo(a)pyrene – The SCO of 1 mg/kg is based on the protection of an outdoor worker and modified in consideration of state background level. Benzo(a)pyrene concentrations range from 0.13 to 12 mg/kg in Site soil, with an average concentration of 0.7 mg/kg and a 95%UCL concentration of 7.78 mg/kg . Exceedance of SCO is noted at two locations SG-03 (0 to 2 ft bgs) and SG-09 (4 to 5 ft bgs). The elevated level of benzo(a)pyrene at SG-09 occurs at a depth exceeding common landscaping and maintenance depths.

Dibenz(a,h)anthracene - The SCO of 1 mg/kg is based on the protection of an outdoor worker and modified in consideration of state background level. Dibenz(a,h)anthracene was only detected at one isolated location of SG-09 between the depths of 4 to 5 ft at 1.7 mg/kg, slightly exceeding the SCO. This depth exceeds common landscaping and maintenance depths. Outdoor workers are not expected to come into direct contact with this slightly elevated dibenz(a,h)anthracene in soil.

Arsenic - The SCO for arsenic of 16 mg/kg is based on state background level. Arsenic concentrations in Site soil range from 0.5 to 19 mg/kg, with an average concentration of 2.4 mg/kg and a 95%UCL concentration of 7.2 mg/kg. Exceedance of the SCO is limited to one isolated location of SG-09 at a depth of 4 to 5 ft. This depth exceeds common landscaping and maintenance depths. Outdoor workers are not expected to come into direct contact with this slightly elevated arsenic in soil.

6.5.1.2 Outdoor Air

1,1,1-TCA – 1,1,1-TCA was detected in outdoor air samples at levels of 160 and 170 $\mu g/m^3$, exceeding background outdoor air level. There is no NYSDOH air guideline value established for 1,1,1-TCA. RfC for 1,1,1-TCA is 5 $\mu g/m^3$, assuming continuous lifetime exposure (i.e., 24 hours per day, 365 days per year for a lifespan of 70 years) (IRIS). Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Level (MRL) for 1,1,1-TCA for intermediate exposure, i.e. 2 weeks to 1 year, is 3,819 $\mu g/m^3$ (or 0.7 ppm). 1,1,1-TCA is classified as "inadequate information to assess carcinogenic potential" by IRIS. Regional screening level established by Oak Ridge National Laboratory (ORNL) and EPA Regions 3, 6, and 9 (ORNL 2008) for industrial air for 1,1,1-TCA is 22,000 $\mu g/m^3$. Based on these evaluations, the presence of above background 1,1,1-TCA in outdoor air is unlikely to cause unacceptable health risk to an outdoor worker.

Freon 113 - This VOC was detected in outdoor air samples at levels of 14 and 16 µg/m^3, exceeding background outdoor air level of less than 7.8 µg/m^3. RfC for Freon 113 is 30 µg/m^3, assuming continuous lifetime exposure (i.e., 24 hours per day, 365 days per year for a lifespan of 70 years) (HEAST 1997). The reported Freon 113 levels in outdoor air are below the RfC; therefore are not of concern for air quality.

1,1-DCA – 1,1,DCA was detected in outdoor air samples at levels of 4.9 and 5.7 µg/m^3, exceeding background outdoor air level of less than 0.6 µg/m^3. RfC for 1,1-DCA is 0.5 µg/m^3, assuming continuous lifetime exposure (i.e., 24 hours per day, 365 days per year for a lifespan of 70 years) (HEAST 1997). Subchronic RfC for 1,1-DCA is 5 µg/m^3, assuming continuous subchronic exposure of 6 years or less (HEAST 1997). Regional screening level (ORNL 2008) for industrial air for 1,1-DCA is 7.7 µg/m^3 based on carcinogenic endpoint, and 2,200 µg/m^3 based on noncarcinogenic endpoint. The reported concentrations of 1,1-DCA in outdoor air are below the Regional screening level; thus are not of concern for an outdoor worker.

Cyclohexane – This VOC was detected in outdoor air samples at levels of 1 and 3 µg/m^3, exceeding background outdoor air level of 1.3 µg/m^3. RfC for cyclohexane is 6 µg/m^3, assuming continuous lifetime exposure (i.e., 24 hours per day, 365 days per year for a lifespan of 70 years) (IRIS). The reported cyclohexane levels in outdoor air are below the RfC therefore are not of concern for outdoor air quality.

TCE – TCE was detected in outdoor air samples at levels of 7.5 and 8.1 µg/m^3, slightly exceeding NYSDOH air guideline value of 5 µg/m^3. Regional screening level (ORNL 2008) for industrial air for TCE is 6.1 µg/m^3 based on carcinogenic endpoint, and 2,600 µg/m^3 based on noncarcinogenic endpoint. The California Environmental Protection Agency (Cal/EPA) Chronic Reference Exposure Level (REL) for TCE is 600 µg/m^3, based on an occupational study from workers exposed to TCE for over 8 years. The RfC value recommended by NYSDOH for TCE is 40 µg/m^3, derived from the same occupational study used by the Cal/EPA for the derivation of REL. Although the detected TCE concentrations in outdoor air slightly exceed the air guideline value and Regional screening level, they are well below the RfC and Cal/EPA REL values. Potential health risks associated with inhalation of TCE in outdoor air for an outdoor worker is thus minimal.

6.5.1.3 Summary

In summary, elevated levels of PAHs and arsenic in soil were limited to an isolated location (SG-09) at the Site and the impacted soils are located at least 4 feet bgs. This depth exceeds common landscaping and maintenance depths which generally involve surface soils less than two ft bgs. Outdoor workers are not expected to come into direct contact with these COPCs in soil. Although an outdoor worker may hypothetically come into contact with surface soil at one location (SG-03) with slightly elevated benzo(a)pyrene level of 6.4 mg/kg, potential health risk associated with soil exposure is insignificant since the exceedance is limited to an isolated small area at the Site.

1,1,1-TCA, Freon 113, 1,1-DCA, cyclohexane, and TCE were detected in outdoor air at levels above background or air guideline values. Detected concentrations of 1,1,2-Trichlorotrifluoroethane and hexane in outdoor air are below their respective chronic RfCs and are thus not of concern for air quality. 1,1-DCA and 1,1,1-TCA were detected in outdoor air at levels below their respective Regional screening levels for industrial air. TCE was detected in outdoor air at levels slightly exceeding air guideline value, but well below its chronic RfC and Cal/EPA chronic REL. Based on these evaluations, the presence of above background 1,1,1-TCA, 1,1,2-rrichloro-1,2,2-trifluoroethane, 1,1-DCA, cyclohexane, and TCE in outdoor air is unlikely to cause unacceptable health risk to an outdoor worker.

6.5.2 Indoor Worker

Indoor worker may be potentially exposed to contaminants in soil and groundwater *via* inhalation of indoor vapor. The 2006 NYSDOH Vapor Intrusion guidance provides the State of New York guidance values for the sub-slab vapor/indoor air matrices. Potential risks to an indoor worker are evaluated for each COPCs and described below.

PCE - The sub-slab vapor concentration of PCE ranges from 8.8 to 620 μg/m³. The indoor air concentrations of PCE are 1 μg/m³ collected from three locations. Using the soil vapor/indoor air matrix 2, the NYSDOH suggests monitoring to determine whether concentrations of PCE in the indoor air or sub-slab vapor have changed.

TCE - The sub-slab vapor concentration of TCE ranges from 7.5 to 2,800 μg/m³. The indoor air concentrations of TCE ranges from 0.5 to 1.3 μg/m³ in samples collected from three locations. Using the soil vapor/indoor air matrix 1, the NYSDOH suggests mitigation because the potential for subsurface vapor intrusion to affect indoor air is high regardless of the measured indoor air TCE levels.

1,1,1-TCA – 1,1,1-TCA is classified as "inadequate information to assess carcinogenic potential" by IRIS. Therefore the soil vapor/indoor air matrix 2 is used for evaluation of 1,1,1-TCA. The sub-slab vapor concentration of 1,1,1-TCA ranges from 19 to 5200 μg/m³. The indoor air concentrations of 1,1,1-TCA ranges from below detection limit to 2 μg/m³ collected from three locations. Using the soil vapor/indoor air matrix 2, the NYSDOH suggests mitigation because the potential for subsurface vapor intrusion to affect indoor air is high regardless of the measured indoor air 1,1,1-TCA levels.

1,1-DCA – 1,1-DCA is classified as a Group C, possible human carcinogen. Unit risk for 1,1-DCA is 1.6×10^{-6} per μg/m³, between the UR values for PCE and TCE. Therefore the soil vapor/indoor air matrix 2 is used for vapor intrusion evaluation of 1,1-DCA. The sub-slab vapor concentration of 1,1-DCA ranges from 11 to 450 μg/m³. 1,1-DCA was only detected at one location of indoor air at 0.4 μg/m³. Using the soil vapor/indoor air matrix 2, the NYSDOH suggests monitoring to determine whether concentrations of 1,1-DCA in the indoor air or sub-slab vapor have changed.

In summary, although the sub-slab samples from beneath the SMP building show elevated PCE, TCE, 1,1,1-TCA, and 1,1-DCA concentrations, none of these VOCs are present inside the building at levels exceeding indoor air background or air guideline values. These results indicate that the presence of residual contamination in the subsurface does not pose adverse health effects to indoor workers. However, mitigation is recommended because there is a potential for future migration of TCE and 1,1,1-TCA vapors from subsurface into the Site building, based on NYSDOH guidance.

6.5.3 Construction Worker

If construction occurs at the Site in the future, workers involved with the construction could be exposed to Site soils and shallow groundwater during excavation for building foundations or utilities. Routes of exposure under a hypothetical construction worker scenario include incidental ingestion of soil and groundwater, dermal contact with soil and groundwater, and inhalation of fugitive dust and volatiles.

Although construction may lead to significant direct contact soil and groundwater exposures as a result of soil-disturbing activities, excavation is typically of relatively short duration of several months. The SCO established for industrial use is based on the protection of an outdoor worker. Because an outdoor worker scenario is based on more frequent and longer exposure compared to a construction worker, SCO for an outdoor worker will provide a conservative basis for evaluating potential exposures to construction workers with limited exposure duration. Potential health risks associated with exposure to a construction worker are evaluated for each COPC and described below.

6.5.3.1 Soil

Benzo(a)anthracene – The SCO of 11 mg/kg is based on the protection of an outdoor worker. Benzo(a)anthracene concentrations in Site soil range from 0.066 to 13 mg/kg, with an average concentration of 0.93 mg/kg and a 95%UCL concentration of 2.22 mg/kg. Although the maximum concentration slightly exceeds the SCO, the average and 95%UCL concentrations of benzo(a)anthracene are below the SCO.

Benzo(a)pyrene – The SCO of 1 mg/kg is based on the protection of an outdoor worker and modified in consideration of state background level. Benzo(a)pyrene concentrations range from 0.13 to 12 mg/kg in Site soil, with an average concentration of 0.7 mg/kg and a 95%UCL concentration of 7.78 mg/kg . Exceedances of benzo(a)pyrene SCO are noted at two locations SG-03 and SG-09.

Dibenz(a,h)anthracene - The SCO of 1 mg/kg is based on the protection of an outdoor worker and modified in consideration of state background level. Dibenz(a,h)anthracene was only detected at one isolated location of SG-09 at 1.7 mg/kg, slightly exceeding the SCO.

Arsenic - The SCO for arsenic of 16 mg/kg, based on state background level. Arsenic concentrations in Site soil range from 0.5 to 19 mg/kg, with an average concentration of 2.4 mg/kg and a 95%UCL concentration of 7.2 mg/kg. Exceedance of the SCO is noted at one isolated location at SG-09. Both the average and 95%UCL concentrations of arsenic are below the SCO.

6.5.3.2 Groundwater

Residual levels of chlorinate VOCs, BTEX, SVOCs, and metals are present in the shallow groundwater at levels exceeding drinking water standards. Potential health risks associated with groundwater exposure to construction and utility workers while performing excavation activities may be a concern, especially in the area immediately to the southeast of the building. Construction workers may be potentially exposed to contaminants in groundwater *via* incidental ingestion, dermal contact, and inhalation of vapors.

6.5.3.3 Outdoor Air and Trench Air

As mentioned in Section 6.5.1, 1,1,1-TCA, Freon 113, 1,1-DCA, cyclohexane, and TCE were detected in outdoor air at levels above background or air guideline values. However, the presence of these VOCs in outdoor air is unlikely to cause unacceptable health risk to an outdoor worker, based on comparisons with RfC, Cal/EPA REL, MRL, and air guideline values. When potential risks associated with outdoor air exposure to an outdoor worker is minimum, unacceptable exposure associated with COPCs present in outdoor air is not expected for construction and utility workers of limited duration at the Site.

However, construction and utility workers may be potentially exposed to chemical vapors within a trench, resulting from migration of soil gas into a trench while performing excavation activities at areas with elevated soil gas concentrations.

6.5.3.4 Summary

In summary, the average and 95%UCL concentrations of benzo(a)anthracene and arsenic are present in Site soil at levels below the SCOs. Exceedances of the SCOs for benzo(a)pyrene and dibenz(a,h)anthracene are limited to two small areas at the Site. Potential health risk associated with soil exposure to a construction worker is thus minimal.

However, potential health risks associated with groundwater and trench air exposure to construction and utility workers may be a concern due the presence of elevated levels of chlorinated VOCs in the shallow groundwater and soil vapor.

6.5.4 Trespasser

Trespassers could gain unauthorized access, however infrequently, to most or all areas of the Site. A trespasser who visits the Site may be exposed to contaminants in soil *via* incidental ingestion, dermal contact, and inhalation of fugitive dust and volatiles.

As discussed in Section 6.5.1, most of COPCs identified in soil are present at the Site at depths greater than 4 feet. A trespasser is not expected to come into direct contact with these COPCs in subsurface soil. Exceedance of SCO in surface soil only occurs at one isolated location at the Site. Trespassers may hypothetically come into contact with soil containing elevated benzo(a)pyrene while visiting the Site. However, the SCO is based on the protection of an outdoor worker who is assumed to be present at the Site much more frequently and for a longer duration. The presence of residual level benzo(a)pyrene at one isolated area at the Site is unlikely to cause unacceptable health risk to trespassers that visit the Site infrequently. Similarly, when potential risks associated with outdoor air exposure to an outdoor worker is minimum, then unacceptable exposure associated with COPC present in outdoor air is not expected for trespassers with limited exposure frequency and duration.

6.6 Summary and Conclusions

A qualitative estimate of potential health risks associate with site-specific COPCs under the current and future industrial use scenarios are evaluated at the Site. All methodologies and procedures are consistent with current NYSDOH and EPA guidance for human health risk assessments.

Under both the current and future land use scenarios, the primary exposure pathways at the Site are potential exposures to impacted groundwater through incidental ingestion and dermal contact, and to trench air through inhalation for construction and utility workers while engaging in excavation activities. Risks associated with potential groundwater and trench air exposure pathways could be mitigated through engineering controls, health and safety measures, and groundwater and soil gas mitigations.

The presence of residual chlorinated organics in the subsurface does not pose adverse health effects to current indoor workers, outdoor workers, and trespassers. However, mitigation is recommended because there is a potential for future migration of TCE and 1,1,1-TCA vapors from subsurface into the building.

Section 7

Summary and Recommendations

This RI Report characterized the nature and extent of contamination migration, and the qualitative human health risks. This chapter presents a summary of site description, summary of study area investigation, summary of the nature and extent of contamination, summary of the fate and transport, and summary of the exposure assessment. Any remaining data gaps and future recommendations are also presented.

7.1 Summary of Site Description

The SMP property is situated in an urban area in the northwestern section of Queens County, New York and is located at 37-18 Northern Boulevard in Long Island City, New York. The property was owned and operated by SMP until March 2008 when SMP sold the property to Time Equity for commercial office space. The Site is located in an urban and industrial area. The property is approximately rectangular in shape and occupies approximately one acre of land. The SMP property contains a large, six-story, industrial building with approximately 42,000 square feet per floor. The building occupies most of the property and SMP is the major occupant of the building. SMP manufactures car parts at this facility in the basement until March 2008 and it is still the SMP corporate headquarters even after the sale of the property.

Bordering the Site is Northern Boulevard to the north; Sunnyside Freight Railroad Yard (Sunnyside Yard) to the south; 39th Street, an automobile dealership and a Hess (formerly Merit) gasoline station to the east; and commercial and industrial properties to the west. Various industrial, commercial, and residential properties are located across from SMP on Northern Boulevard. A narrow strip of land on the south side of the property contains a loading dock and a dirt access path for vehicles. This strip of land is owned by the Metropolitan Transportation Authority (MTA) and is part of a lease to SMP. Contamination has been identified in the soil adjacent to the loading dock. This adjacent area is mostly dirt and gravel covered with some concrete remaining from a nearby road-paving project. Access to this area is limited. The means of access to this area is from doors at the rear of the SMP building, and a locked access gate surrounding the perimeter of the leased strip of land. A highly industrialized area with a wide variety of activities ranging from small-scale assembly to large-scale manufacturing is located within the general vicinity of the Site.

7.2 Summary of Study Area Investigation

The SMP RI was conducted to characterize the nature and extent of contamination in the Site and to identify areas that pose a potential risk to human health and the environment. The field investigation for the RI/FS was conducted in four phases from November 2002 through February 2008. The Phase I Investigation involved the collection of soil samples using hand augers and direct push drilling to delineate the nature and extent of soil contamination. Groundwater samples were also collected during the direct push sampling. In Phase II Investigation, the results of the hand auger and direct push samples were used to determine the locations for placement of groundwater monitoring wells and the depths of the screened intervals. Following installation of the monitoring wells, monitoring well development and aquifer testing was completed and groundwater samples were collected to evaluate water quality beneath the site. The Phase III Investigation involved two rounds of monitoring well groundwater sampling to verify the results of the Phase II Field Investigation as well as one round of soil vapor sampling. The Phase IV Field Investigation involved direct push soil and groundwater sampling inside and outside the facility, monitoring well sampling, sub-slab vapor sampling, and soil vapor sampling to further delineate contamination under the building and in proposed "hot spot" area identified during the previous phases. Sampling and analyses for these investigations consisted of the following:

Phase I Investigation
- Surface soil sampling
  - 5 surface soil samples collected via hand auger
- Direct push sampling of soil
  - 22 soil samples from the 11 shallow direct push locations
  - 40 soil samples from the 10 deep direct push locations
  - 12 soil samples from the 6 angled direct push locations
- Direct Push Sampling of Groundwater
  - 17 groundwater samples from the 9 deep direct push locations
  - 6 groundwater samples from the 6 angled direct push locations
- One Interior Sump Sample

Phase II Investigation
- Monitoring Well Installation and Development
  - 8 monitoring wells in 5 locations
- Monitoring Well Sampling
  - 8 newly installed monitoring wells
  - 1 interior existing monitoring well
- One Interior Sump Sample
- Aquifer Testing
  - 2 slug tests at each of the 8 newly installed monitoring wells

Phase III Investigation
- Two Rounds of Monitoring Well Sampling
  - 8 exterior existing monitoring wells
  - 1 interior existing monitoring well
- Soil Vapor Sampling
  - 6 exterior soil gas ports at 3 feet bgs
  - 2 interior sub-slab ports

Phase IV Investigation
- Exterior Direct Push Sampling of Soil
  - 26 samples from 10 direct push locations

        - 6 samples from 0 to 2 feet bgs
        - 10 samples from water table interface
        - 10 samples from deepest achievable depth
- ■ Exterior Direct Push Sampling of Groundwater
    - □ 22 samples from 10 direct push locations
        - 10 samples from 5 to 9 feet bgs
        - 6 samples from 10 to 14 feet bgs
        - 6 samples from 15 to 19 feet bgs
- ■ Exterior Soil Gas Sampling
    - □ 12 exterior soil gas ports at 3 feet bgs
    - □ 2 ambient air samples
- ■ Interior Direct Push Sampling of Soil
    - □ 31 samples from 16 direct push locations
        - 15 samples from water table interface
        - 16 samples from deepest achievable depth
- ■ Interior Direct Push Sampling of Groundwater
    - □ 15 samples from 15 direct push locations
        - 15 samples from water table interface
- ■ Interior Sub-Slab Vapor Sampling
    - □ 16 interior sub-slab air ports
    - □ 3 indoor air samples
    - □ 1 ambient air sample
- ■ Monitoring Well Sampling
    - □ 5 existing monitoring wells
    - □ 4 newly installed monitoring wells
- ■ Vault Inspection and Sampling
    - □ 1 vault sample
- ■ Sump Inspection and Sampling
    - □ 3 sump samples

7.3 Summary of Nature and Extent of Contamination

The objective of this section is to develop Preliminary chemical screening levels were developed as a baseline for quantifying the horizontal and vertical extent of contamination, if any, in soil, groundwater, and soil vapor for the Site. The screening levels were used to identify potential source areas of contaminants, to evaluate their distribution patterns, and to assess their potential migration pathways. Although these concentrations were based upon regulatory standards, criteria, and guidance (SCGs), the screening levels do not represent remediation goals. Remediation goals will be developed during the Feasibility Study.

7.3.1 Soil Contamination

7.3.1.1 Chlorinated Volatile Organic Compounds

The subsurface soil samples containing elevated concentrations of chlorinated VOCs above screening levels were observed in the alleyway of the loading dock extending from the western edge of the totally enclosed storage area to approximately 20 feet west of the MW11 monitoring well cluster. The analytical results that exceeded screening levels for chlorinated VOCs were from subsurface soil samples collected from 0 to 6 feet bgs, which coincides with the groundwater table interface and supersaturated areas.

The highest 1,1,1-TCA concentrations were observed at DD09 at 4,800 mg/kg in 2002, but it was detected below the screening criteria at an adjacent boring location SG03 in 2008. The consistency of the highest concentration of 1,1,1-TCA being in this localized area confirms the location of a "hot spot" identified during the Phase I and II Investigations. The significant decrease in concentration, however, suggests that there is an extensive degradation of 1,1,1-TCA and that the source is a historical release.

According to historical investigations, the surface soils within close proximity to DD09 contained significant levels of chlorinated VOC. In 1991, during the soil investigation, H2M detected the highest total VOCs in sample S-6 at a depth of 18 to 24 inches below grade at 894.21 mg/kg (Appendix A). Sample S-6 is located approximately 150 feet west of the southeast corner of the building. Unfortunately, only the 18- to 24- inch depth increment was sampled from all the soil borings. In 1992, during the remedial investigation, H2M performed soil sample screening (from various locations at depth increments of 5, 10, 15, and 20 feet bgs). Selected samples were analyzed for VOCs. The highest VOC, 1,1,1-TCA, was detected in soil samples collected from a depth of 5 to 7 ft bgs(saturated soil) at levels ranging from non-detect to 26 mg/kg. The most contaminated samples were again the samples collected closest to the surface although only saturated soil samples were collected during the 1992 investigation. Soil samples from the 0- to 2- foot depth increment were not collected. When comparing the 1991 H2M investigation to the 1992 H2M investigation, the 18- to 24- inch depth increment contained higher concentrations of VOCs. The H2M investigations did not sample the surface soil near the loading dock within the vicinity of 120 feet west of the southeast corner of the building.

During the 1996 EnviroAudit investigation (Appendix C), the highest VOCs, 1,1,1-TCA, was detected in sample AB-2, located 120 feet west of the southeast corner of the building, collected from a depth of 0 to 2 feet bgs. This sample contained a concentration of 1,1,1-TCA of 7,000 mg/kg. The sample collected from the 10- to 12-foot increment (7 mg/kg) contained significantly less VOCs. A soil sample from the 5- to 7- foot depth increment was not collected in boring AB-2. However, the sample AB-1 collected from a depth of 0 to 2 feet bgs contained a concentration of 1,1,1-TCA of 1,600 mg/kg. Samples collected from the 5- to 7- foot depth increment (4.6 mg/kg) and 10- to 12- foot increment were ND containing significantly less VOCs. The sample AB-1 is located approximately 100 feet west of the southeast corner of the building. These were the two borings that contained the highest detected levels of VOCs.

Since all historical investigations detected the highest concentration of chlorinated VOCs near the surface soil, the source of the chlorinated VOCs must have been a surface spill located immediately adjacent to the loading docks, approximately 120 feet west of the southeast corner of the building. The data collected during this RI supports this finding with the exception that currently the VOC contamination has been flushed over time from the surface soils into the subsurface unsaturated soils and finally into the subsurface saturated soils located a foot or two below the water table interface, indicating the absence of a continuing source of contamination. The highest mass of chlorinated VOC contamination currently resides in the groundwater instead of the unsaturated soils.

7.3.1.2 Non-Chlorinated Volatile Organic Compounds

Ethylbenzene and xylenes were the two common non-chlorinated VOCs that exceeded the screening level within the soil matrix. Almost all of the soil samples that contain elevated levels of ethylbenzene and xylenes were collected from a depth of 8 to 12 feet below grade. The 0- to 2- foot samples and the 5- to 7- foot samples collected during the Phase I Field Investigation did not contain elevated levels of these substances. The historical investigations conducted by H2M and EnviroAudit also detected elevated levels of ethylbenzene and xylene at a depth between 10 to 15 feet.

Since the water table interface is located between 4 to 5 feet below grade, the exterior soil boring contamination is detected at a depth which is significantly below the water table interface. If the historical source was located within the Site, contamination would be detected at the groundwater table interface. Contamination in the unsaturated zone migrates downward with gravity and precipitation. Once contacting the groundwater interface, the direction of contaminant migration is along the groundwater flow path which at the Site is in the western direction. No significant downward groundwater flow gradient exists at the Site (Section 3.6). Also, the organic partition coefficients (K_{OC}) for ethylbenzene and xylene are fairly low and the solubility are fairly high, indicating that sorption onto soil particulates would only occur in areas of high groundwater concentrations (Section 5-1 and Table 5-1). Thus, a contaminant source must exist at approximately 11 to 12 feet.

Since the sewer line is located at a depth of 12 feet and most of the non-chlorinated VOCs are located within close proximity to the sewer line, this sewer line may be a source of the non-chlorinated VOC contamination. Non-chlorinated VOCs may be entering the sewer line either via the drain spout that drains the 39th Street Bridge and adjacent Hess gasoline station and discharges contaminated storm water runoff overland into the on-site manholes or through upgradient sewer lines that convey non-chlorinated contamination from the adjacent Sunnyside Yard into the on-site sewer line. Both the Hess gasoline station and the Sunnyside Yard have detected non-chlorinated VOC contamination that is several orders of magnitude above those levels detected on the Site (Appendix D and E).

The locations of the three manholes that connect the sewer line were surveyed during the November 2002 investigation and the approximate depth of the manholes and connecting sewer line was measured at 12 feet. Conversations with Roux Associates indicated that there were no as-built drawings available for this sewer line. However, Roux interpreted the location and size of the sewer system during The Sunnyside

Yard investigations (Appendix D). The information collected from Roux Associates, Inc., in October 2002 included the following:

- The 36-inch round brick conduit was built around 1908 or 1912
- This brick conduit carries the combined sanitary discharge (from old Sunnyside Yard buildings only) and storm water runoff
- The sewer line runs straight between manholes behind the SMP building
- Drainage is from Sunnyside Yard only (with the exception of the 39th Street drain spout)
- The three man-holes that were surveyed did not contain man-hole covers that would prevent surface water runoff from entering these man-holes and subsequently discharging along the sewer line.

In addition, located directly adjacent to the southeast corner of the building is a discharge drain that drains surface water runoff from the 39th Street overpass. Thus, any surface water discharge from the street above or the Hess site can be discharged onto the Site via the drain spout located under the 39th Street Bridge and flow directly into these man-holes and enter the sewer line.

In particular, during the Phase I Field Investigation, significant surface water runoff was being discharged onto the Site from this drain spout and flooding the SMP property. Storm water routinely floods the vicinity of the previously excavated soil (near the western manhole) and the area adjacent to the central manhole (SD05). An oily sheen was noticed within this surface drainage from the drain spout. The NYSDEC environmental manager was on-site at the time and the project team directed her attention to this condition.

In conclusion, the highest non-chlorinated volatile organic concentrations are located at the same depth as the sewer line and in close proximity to the sewer line. Thus, it is reasonable to conclude that the non-chlorinated volatile organic contamination is caused by upgradient sources. This conclusion is also supported by the elevated levels of SB13 which is located in the further most northwest corner.

In addition, the contaminant distribution pattern for chlorinated VOCs is significantly different from the contaminant distribution pattern of the non-chlorinated VOCs. Thus, the data collected during the Phase I and IV Investigations and prior investigations indicate that the non-chlorinated VOCs are from an upgradient source. The Hess Station is located immediately upgradient and significant non-chlorinated VOCs contamination has been confirmed on this property as is the source of non-chlorinated VOCs on the Site.

7.3.1.3 Semi-Volatile Organic Compounds

The exterior and interior subsurface soil samples displayed significantly different SVOCs and therefore no correlation is made between the two.

The exterior soil boring sample, SG09, detected SVOCs found in no other borings throughout the Site. The constituents detected are common gasoline components (such as benzo(a)anthracene and dibenz(a,h)anthracene) and occur ubiquitously in products of incomplete combustion. Since the constituents are present along the loading dock area (not under the building) at relatively low depths, it is concluded that the source of these constituents are from the drainage pipe from the 39th Street bridge, debris stored in the alleyway, and/or degradation products of a gasoline plume migrating from an off-site source.

The interior soil boring sample from SB04 detected SVOCs found in no other borings throughout the Site as well. The constituents detected have an array of uses: 4-chloro-3-methylphenol is used as a fungicide and preservative; 4-nitrophenol is also used as a fungicide; and 2-chlorophenol is most likely a xenobiotic produced from the degradation products of the gasoline and chlorinated constituent plumes mixing together.

Since the constituents are present only at this isolated location at a depth of 18 feet bgs, it is concluded that the source of these constituents are from the sewer connection which is connected to the former 1,1,1-TCA tank, the gasoline plume migrating onsite from the southeast, and/or machine operational and maintenance practices.

7.3.1.4 Inorganic Constituents

Within two samples, lead exceeded the screening level. The two samples that contained concentrations that exceeded lead screening levels are located within the area of previously excavated soil which corresponds to an area that is a low point within the Site and is frequently flooded via upgradient storm water.

Unlike ethylbenzene and xylene, lead has no partitioning coefficient between organic carbon in soil and groundwater since lead is insoluble and sorbs readily onto soil. Thus, these elevated levels of lead are probably due to leaded petroleum products migrating via storm water runoff. Since lead is transported primarily via particulate migration, settling particulates from the stagnant storm water after storm events in the area adjacent to the eastern manhole create elevated levels of lead on surface soils in this area.

The screening level for lead is 400 mg/kg and was selected based upon the EPA risk-based soil screening level for the ingestion-dermal exposure for a residential scenario, which is very conservative. However, the NYSDEC soil cleanup objective is 500 mg/kg. Even though two samples contained lead levels (483 and 465 mg/kg) that exceeded the screening concentrations, lead levels in these samples are below the NYSDEC criterion of 500 mg/kg.

Iron is the major inorganic constituent above screening level present at all subsurface sampling locations. Since iron is ubiquitous in the environment in particular to urban settings such as Long Island City, Queens, New York where construction, adjacent rail transportation and industry is prevalent, this constituent is not assumed to be a Site-related contaminant.

Other constituents present in one or two borings located within the alleyway of the loading dock include arsenic and vanadium. Since these metal constituents were detected in isolated areas at relatively low concentrations their presence can be attributed to urban fill and urban setting where construction, adjacent rail transportation and general industry is prevalent.

7.3.2 Assessment of Groundwater Quality

Groundwater quality is assessed utilizing the results of both the direct push boring investigations conducted during the Phase I and IV Field Investigations and the monitoring well investigations conducted during the Phase II, III, and IV Field Investigations. The results of the analytical data collected from these investigations are compared with the groundwater screening levels. The direct push samples were utilized during the Phase I Investigation as a field screening technique to approximate locations of highest groundwater contamination and to properly place the permanent monitoring wells. The direct push samples were utilized during the Phase IV Investigation to further delineate contamination under the building and the previous identified "hot spot" area near the loading dock.

A significant difference in the constituents detections are observed between the direct push groundwater and monitoring well collection results. The direct push groundwater results detect a greater number of constituents and at significantly higher concentrations than the monitoring well results. It is concluded that screen interval variance between the direct push groundwater samples and monitoring wells plays an important role in sample collection and analysis. The screen interval of the direct push groundwater sampling tool is approximately 4 feet in length, while the screen interval of the monitoring wells are 15 feet in length for the shallow wells and 10 feet in length for the deep wells. The extra 6 to 11 feet of screen collects a greater amount of water over a larger depth resulting in a dilution effect in turn decreasing the number of detected constituents and their concentrations. This is particularly vital when analyzing the results of the shallow wells since the contamination is observed to be at the water table interface. Thus, in this section, greater emphasis will be placed on the direct push groundwater samples as a true indicator of overall site groundwater quality.

7.3.2.1 Direct Push Groundwater Quality

There were a total of 14 constituents detected within direct push groundwater samples at concentrations above respective screening levels. Among these 14 constituents, there are 10 chlorinated volatile organic constituents (i.e., 1,1,1-TCA, 1,1,2-trichlorotrifluoroethane, 1,1-DCA, 1,2-dichlorobenzene, chloroethane, *cis*-1,2-DCE, *trans*-1,2-DCE, PCE, TCE, and vinyl chloride) and 5 non-chlorinated volatile organic constituents (BTEX compounds and isopropylbenzene).

7.3.2.1.1 Chlorinated Volatile Organic Compounds

The majority of the highest chlorinated volatile organic concentrations detected during the Phase I Investigation are in the samples DD09-GW07, DD13-GW07, DD11-GW07, SA01-GW07, SA02-GW07, and SA03-GW07 within the shallow 6-foot depth interval which coincides with the groundwater table interface. The Phase IV outdoor samples which detected the highest chlorinated volatile organic concentrations, SG02-GW59, SG03-GW59, SG03-GW1014, SG04-GW59, and SG05-GW59, are also associated with the groundwater table interface (5 to 9 feet bgs) and in close proximity to the Phase I borings mentioned above. These results are consistent with soil analytical data in that the highest concentrations of both the soil and groundwater are located immediately adjacent to the loading dock approximately 120 feet west of the southeast corner of the building.

These results are also consistent with the historical soil and groundwater data in that they indicate a “hot spot". Soil boring locations DD09 collected in 2002 and SB03 collected in 2008 both detect a wide range of chlorinated volatile constituents, including 1,1,1-TCA, 1,1-DCA, 1,1-DCE, chloroethane, TCE, and VC, and usually detecting the highest concentration. The soil borings also detected elevated concentrations of these constituents at depths below the water table interface. It can be confirmed that the “hot spot” is along the loading dock northeast of MW11, approximately 120 feet west of the southeast corner of the building.

In addition, the analytical results from the Phase I and Phase IV Investigations from these sampling locations conclude significant degradation of PCE. During the Phase I Investigation four direct push groundwater locations detected concentrations of PCE, DD09, SA01, SA02, and SA03. The highest concentration of PCE among those samples was 44 µg/L at DD09. The Phase IV Investigation identified only two locations containing PCE at relatively low concentrations, SB15 at 11 µg/L and SB01 at 8.7 µg/L. The majority of the constituents detected during the Phase IV Investigation are TCE, *cis*-1,2-DCE, and VC, which are breakdown products of PCE. Also during the Phase I Investigation groundwater samples collected downgradient of the “hot spot” (DD03 and DD04) detected 1,1,1-TCA, 1,1-DCE, and VC, while similar placed borings SG10 and SG09 analyzed during the Phase IV investigation only detected 1,1,1-TCA at 7.7 µg/L.

Indoor direct push groundwater samples collected during the Phase IV Investigation detected a small variety of chlorinated volatile constituents at very low concentrations, except SB07-GW812. The groundwater sample collected from this location detected chloroethane at 2,200 µg/L. The increased concentration of chloroethane at SB07 can be contributed to the former 1,1,1-TCA tank located upgradient (northeast) of the soil boring. Since chlorinated VOC concentrations significantly diminish underneath the building, the source of the chlorinated VOCs was confirmed to be located adjacent to the loading dock and not underneath the building.

7.3.2.1.2 Non-Chlorinated Volatile Organic Compounds

The direct push groundwater samples were collected from two discrete depth intervals: across the water table interface (approximately 6 to 14 feet), and at a depth of 30 to 35 feet. Seven non-chlorinated volatile organic constituents were detected at concentrations above screening levels, i.e. benzene, ethylbenzene, toluene, xylene, isopropylbenzene, MTBE, and chloroform. Since chloroform is present in one groundwater sample at a low concentration the constituent is determined to be non-Site related.

The contaminant distribution of the BTEX constituents is different from the chlorinated VOC contamination. The highest levels of BTEX contamination are detected in the most hydraulically upgradient borings adjacent to the eastern portion of the building. In 2002 DD23 and in 2008 SG01, SB13, SB08, SB05, and SB03 displayed the highest concentrations of BTEX constituents. The soil boring SB13 is located in the northeast corner of the building near an office/storage area. The increased levels of BTEX constituents present at this location suggest an offsite source proposed below.

It should also be noted that the BTEX migration pathway does not coincide with the chlorinated constituent pathway. The highest chlorinated VOC contamination is located at the “hot spot” approximately 120 feet west of the southeast corner of the building. This “hot spot” location was also identified during historical investigation. The highest concentration of BTEX in the groundwater at the most hydraulically upgradient location is most likely due to the upgradient contaminant plume emanating from the Hess gasoline station (Appendix C). The concentrations of BTEX detected at the Hess gasoline station are several orders of magnitude higher than the Site. The contaminant plume maps presented in Appendix C indicate that the contamination is migrating in the direction of the Site and is most likely the cause of the highest level BTEX detected at the water table interface.

In addition to BTEX being transported from the Hess gasoline site by the direct groundwater migration pathway, storm water runoff from the following three sources are collected in the Site sewer line and contribute to the BTEX contamination at the water table interface:

- storm water runoff from the upgradient Hess gasoline station (Appendix E)
- storm water runoff from the upgradient and cross gradient portions of the Sunnyside Yard (Appendix D)
- storm water runoff from the 39th Street Bridge

Both the Hess gasoline station and the Sunnyside Yard have documented BTEX contamination that is orders of magnitude higher than the levels detected at the Site. These results indicate that the BTEX contamination detected on the Site originates from an upgradient off-site source.

The contaminant distribution of the MTBE is not only different from the BTEX contamination, but it is also different from the chlorinated VOC contamination. The highest levels of BTEX contamination are detected in the most hydraulically upgradient boring adjacent to the southeast corner of the building. The highest chlorinated VOC contamination is located at the "hot spot" approximately 120 feet west of the southeast corner of the building. In contrast, the highest MTBE contamination is located in the southwestern most samples at significant depth. Since MTBE has the lowest K_{oc} value of any volatile organic contaminant (chlorinated or non-chlorinated), it is highly mobile with almost no sorption onto soils to retard solute migration with groundwater. MTBE is also highly persistent, and does not significantly biodegrade. Thus, the presence of MTBE located at significant depth on the southwestern edge of the Site is most likely attributable to an historical release from the Hess gasoline station.

7.3.2.1.3 Semi-Volatile Organic Compounds

The three semi-volatile constituents, bis(2-ethylhexyl)phthalate, naphthalene, and phenol, are detected in isolate incidents and at relatively low concentrations. The bis(2-ethylhexyl)phthalate is a common laboratory contaminant and detected at relatively low concentrations it will be disregarded as a Site related contaminant. Naphthalene and phenol however are common products of gasoline and should be attributed to the BTEX plume migrating onsite.

7.3.2.1.4 Inorganic Constituents

Several metal constituents detected in the outdoor groundwater samples exceeded the screening levels. The groundwater samples were collected from the water table interface (5 to 9 feet bgs) from direct push locations SG03, SG08, SG09. Additional groundwater samples were collected from 10 to 14 and 15 to 19 feet bgs from SG03.

A filtered metal sample was collected from SG09 to provide a realistic assessment of inorganic levels that are mobile in the groundwater flow regime. Since direct push sampling techniques typically contain an elevated level of particulates, inorganic analyses of direct push groundwater samples are not representative of constituents that are mobile in the aquifer. The SG09 filtered sample detected one TAL metal constituent above the screening level, iron. Since iron is ubiquitous in the environment in particular to urban settings such as Long Island City, Queens where increased construction and industry is prevalent, the constituent is likely not a Site related contaminant.

Several inorganic constituents were also detected in the indoor groundwater samples which exceeded the screening levels. A filtered indoor groundwater sample was not collected during this sampling round.

Since the filtered sample contains significantly less inorganic constituents than the unfiltered sample, the high concentrations of inorganic constituents are attributed to suspended soil particulates. As discussed in Section 4.3.4.3, the elevated levels of these inorganic constituents are due to urban fill and urban setting with increased construction and industrial production.

7.3.2.2 Monitoring Well Groundwater Quality

Monitoring wells sampling was conducted during Investigation Phases II, III, and IV. A total of 14 constituents were detected within the monitoring well groundwater samples at concentrations above the respective screening levels. Among these 13 constituents, 8 chlorinated volatile organic constituents (i.e., 1,1,1-TCA, chloroethane, *cis*-1,2-DCE, 1,1-DCA, 1,2-dichloroprppane, PCE, TCE, and VC). The remaining 6 constituents were non-chlorinated volatile organic constituents (i.e., benzene, ethylbenzene, isopropylbenzene, MTBE, toluene, and total xylenes).

7.3.2.2.1 Chlorinated Volatile Organic Compounds

Chlorinated volatile organic groundwater contamination is declining significantly over time. MW09S, MW11S, MW11D, MW12, MW13S, and MW13D yielded samples that displayed low to non-detect concentrations in 2005 and 2008. The major constituents consist of *cis*-1,2-DCE, TCE, and VC which are degradation products of PCE. Newly installed wells MW14S, MW14D, MW15, and MW16 also contained these degradation products. The sample from MW14D contained PCE at a concentration of 5.8 µg/L, which is close to the screening level of 5 µg/L.

The sample from MW06 contained PCE and TCE at higher concentrations in 2008 then 2003 by 1.5 times. Low detections of PCE of 17 µg/L and TCE of 8.2 µg/L from this 2008 sample as well as the increase of 1.5 times the concentrations from 2003 suggest a slow migration of the plume from the initial source area.

The sample from MW10 contained 1,1,1-TCA and 1,1-DCA concentrations that increased to 9.2 and 8.2 µg/L from non-detect, respectively, in 2008. The relatively flat gradient may cause more outward dispersion than advection. MW10 is also located underneath the 39th Street Bridge which could be a potential source for this relatively low contamination.

The TCE and *cis*-1,2-DCE are detected in both the direct push groundwater samples and the monitoring well groundwater samples. The solubility of *cis*-1,2-DCE is higher than the solubility of the other chlorinated VOCs exceeding screening levels (with the exception of VC). The biodegradation process converts PCE into TCE; TCE into *cis*-1,2-DCE; and *cis*-1,2-DCE into VC. Thus, VC is detected at concentrations exceeding screening levels at the same locations that *cis*-1,2-DCE is detected. The levels of *cis*-1,2-DCE, TCE and VC from the monitoring well data are clearly more representative of the mobile constituents in groundwater at the Site since these constituents extend beyond the immediate vicinity of the localized source area.

7.3.2.2.2 Non-Chlorinated Volatile Organic Compounds

The six non-chlorinated volatile organic constituents (benzene, ethylbenzene, toluene, xylene, isopropylbenzene, and MTBE) were detected at concentrations above screening levels from samples collected from the monitoring wells. These same six compounds were also detected at concentrations above their respective screening levels from samples collected from direct push borings.

The monitoring well samples were collected from shallow and deep monitoring wells. The shallow monitoring wells were screened across the water table interface using a 15- foot screen to accommodate a fluctuating water table interface. Groundwater samples were collected from the center of the screened interval which was approximately 10 to 12 feet bgs (water table interface was located at approximately 5 feet). The deep monitoring wells were screened approximately from 30 to 40 feet with a 10- foot screen. The samples were collected from the center of the screened interval at approximately 33 to 35 feet.

Similar to the direct push groundwater result, the monitoring well groundwater results indicate that the contaminant distribution of the BTEX constituents is different from the chlorinated VOC contamination. As in the direct push groundwater results, the monitoring well results detected the highest levels of BTEX contamination in the most hydraulically upgradient boring adjacent to the southeast corner of the building. In contrast, the highest chlorinated VOC contamination is located at the "hot spot" approximately 120 feet west of the southeast corner of the building. This "hot spot" location was also identified during historical investigation. The highest concentration of BTEX in the groundwater at the most hydraulically upgradient location is most likely due to the upgradient contaminant plume emanating from the Hess gasoline station (Appendix C). The concentrations of BTEX detected at the Hess gasoline station are several orders of magnitude higher than the Site. The contaminant plume maps presented in Appendix C indicate that the contamination is migrating in the direction of the Site and is most likely the cause of the BTEX contamination. In addition to BTEX being transported from the Hess gasoline site via groundwater migration, storm water runoff from overland flow, 39th Street Bridge and the buried sewer line are all potential upgradient sources of BTEX and associated constituent contamination.

7.3.2.2.3 Semi-Volatile Organic Compounds

Two semi-volatile constituents were detected above or equal to the screening levels, 1,1'biphenyl and naphthalene. 1,1'Biphenyl was detected at 5 µg/L in groundwater sample MW16-GW16. This constituent was not detected in any other sample and is at its screening level; therefore it is determined that 1,1'biphenyl is not a Site-related contaminant.

Naphthalene was detected at 46 µg/L in sample MW10-GW14. This constituent was only detected in one other groundwater sample also at a low concentration. Naphthalene is a common products of gasoline and should be attributed to the BTEX plume migrating onsite.

7.3.2.2.4 Inorganic Constituents

As previously discussed, samples collected from a developed and purged monitoring well are more representative of the aquifer's soluble metal constituents since particulates are not present. Particulates do not migrate with groundwater flow due to the filtering action of the saturated geologic formation. Thus, samples containing high particulate levels are not representative of contaminant migration patterns due to groundwater flow.

Four inorganic constituents were detected in the monitoring well samples which exceeded the screening levels, i.e. iron, magnesium, manganese, and sodium. Most of these inorganic constituents are ubiquitous in the environment due to geologic formations and urban settings such as Long Island City, Queens. As discussed in Section 4.3.4.3, the elevated levels of these inorganic constituents are not Site-related.

7.3.3 Assessment of Vapor Intrusion

7.3.3.1 Soil Gas and Sub-slab Vapor Chlorinated Volatile Organic Compounds

The soil gas samples which detected elevated concentrations of chlorinated volatile constituents during the Phase III and Phase IV Investigations are located within the exterior "hot spot". Sub-slab air samples displaying the highest concentrations of chlorinated volatile constituents are located to the east of the exterior localized "hot spot" in the vicinity of a stair well that may be impacting pressure gradients across the building. Vapor constituents detected diminish in the western side of the building and loading dock. The soil vapor results confirm the previously identified "hot spot" location.

The chlorinated volatile constituent concentrations in total have diminished over time, from 2006 to 2008. The Phase III Investigation detected the highest 1,1,1-TCA and TCE concentrations at 51,000,000 $\mu g/m^3$ and 1,800,000 $\mu g/m^3$, respectively. The Phase IV Investigation detected the highest 1,1,1-TCA and TCE concentrations at 820,000 $\mu g/m^3$ and 120,000 $\mu g/m^3$, respectively. This decrease in concentrations of Site-related contaminates suggest significant degradation of the source over time.

Ambient air samples detected elevated levels of 1,1,1-TCA, however the concentration was less than the soil vapor detections. The ambient air contamination could be due to potential soil vapor pathways and/or being situated in a highly industrial and commercial area. The indoor air samples detected one chlorinated volatile constituent, 1,1-DCA, at an isolated area and at a very low concentration, 0.4 $\mu g/m^3$. According to the 2006 NYSDOH Final *Guidance for Evaluating Soil Vapor Intrusion*, a 1,1,1-TCA level of 1,000 $\mu g/m^3$ and a TCE level of 250 $\mu g/m^3$ in a sub-slab sample would require mitigation regardless of the indoor air concentration, therefore mitigation is recommended.

7.3.3.2 Soil Gas and Sub-slab Vapor Non-Chlorinated Volatile Organic Compounds

The highest non-chlorinated VOC concentrations in the soil vapor samples were detected in SG02, SG03, SB01, and SB02. These four soil vapor locations detected non-chlorinated volatile constituents at concentrations greater than 50 $\mu g/m^3$. Soil vapor ports SG02 and SG03 are located within the exterior "hot spot" where chlorinated volatile constituents are detected at very high concentrations. The non-chlorinated volatile constituent detections at these locations suggest a mixture of the chlorinated and non-chlorinated plumes.

The soil vapor port SB01 is located along the southern wall of the office desk area. The soil vapor port SB02 is located in the western portion of the building. The elevated levels of non-chlorinated volatile constituents can be attributed to the gasoline plume and/or historical localized releases.

The ambient air samples collected during the soil gas and sub-slab events detected relatively low concentrations of non-chlorinated volatile constituents, unlike the indoor air. All three indoor air samples detected elevated levels of non-chlorinated constituents. The three indoor air samples were located throughout the building to gain a representative composite of indoor air quality. The elevated detections of non-chlorinated volatile constituents suggest a recent gasoline-related source present in the subsurface and degreasers (e.g., tetrahydrofuran) present in the building in poor conditioned containers. It should be noted that large containers storing degreasers were not identified during the onsite investigation. The only product identified with the potential to affect indoor air quality was W-D40 aerosol cans in relatively good condition.

7.4 Summary of Fate and Transport

The fate of a constituent in the environment is a function of its chemical properties and the physical nature of the Site. The potential for environmental transport was examined by reviewing the topographic and hydrogeologic characteristics of the Site and a review of the available physical constants and chemical characteristics of each constituent. The following summarizes the most significant fate and transport processes for the Site:

- The greatest potential for transport of contaminants at the Site is via groundwater migration. Volatile organic compounds, including chlorinated compounds (i.e., *cis*-1,2-DCE, 1,1-DCA, chloroethane, VC, PCE, TCE, and 1,1,1-TCA) and non-chlorinated VOCs, (i.e., benzene, isopropyl benzene, MTBE, toluene and xylenes) have been detected in groundwater plumes indicating their ongoing transport.

- Biodegradation has likely occurred over time due to an elevated carbon source from the commingled BTEX contamination.

- Volatilization is considered significant based on the results of the soil gas and sub-slab vapor results.

7.5 Summary of Exposure Assessment

A preliminary screening based on "*Draft DER-10 Technical Guidance for Site Investigation and Remediation*" (NYSDEC 2002) was performed to determine that a Fish and Wildlife Resources Impact Analysis (FWRIA) was not needed for the Site since there are no fish and wildlife resources on or adjacent to the site or area of concern. There is also very limited vegetation present on the Site or in the immediate vicinity and ecological receptors/habitats have no exposure to groundwater; thus, there is negligible potential environmental risk at the Site. Consequently, the main focus of the exposure assessment is human health. A qualitative human health exposure assessment was performed at the Site.

A qualitative estimate of potential health risks associate with site-specific COPCs under the current and future industrial use scenarios are evaluated at the Site. All methodologies and procedures are consistent with current NYSDOH and EPA guidance for human health risk assessments.

Under both the current and future land use scenarios, the primary exposure pathways at the Site are potential exposures to groundwater contaminations through incidental ingestion and dermal contact, and to trench air through inhalation for construction and utility workers while engaging in excavation activities. Risks associated with potential groundwater and trench air exposure pathways could be mitigated through engineering controls, health and safety measures, and groundwater and soil gas mitigations.

Although the presence of residual contamination in the subsurface does not pose adverse health effects to current indoor workers, outdoor workers, and trespassers, mitigation is recommended because there is a potential for future migration of TCE and 1,1,1-TCA vapors from subsurface into the building.

7.6 Identification of Data Gaps and Recommendations

Since the Site investigation was performed in a phased approach, the subsequent phases of the investigation were designed to fill any remaining data gaps that would preclude the comprehensive evaluation of remedial alternatives in the FS Report. Thus, no additional RI data gaps remain at the Site.

7.7 Recommended Remedial Action Objectives

Based on the evaluation of the nature and extent of contamination in soils, groundwater and vapor, the assessment of human risk associated with exposure to contaminants of potential concern, the following preliminary remedial-action objectives (RAOs) were developed:

- Minimize potential exposure to building occupants from elevated sub-slab vapor concentrations
- Minimize the off-site migration of volatile organic compounds in groundwater at concentrations that pose a potential risk to off-site receptors
- Protect human health and the environment

These remedial action objectives will be evaluated in detail and further defined in the SMP FS Report.

Section 8
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