GEI Consultants

Geotechnical
Environmental and
Water Resources
Engineering

Interim Remedial Investigation Report

Stuyvesant Town
Former Manufactured Gas Plant Sites

East 14th Street Station (NYSDEC Site #V00535)
East 17th Street Station (NYSDEC Site #V00541)
East 19th Street Station (NYSDEC Site #V00542)
New York, New York

VCA Index D2 -0003-02-08

Volume 1 of 2
Text, Tables, Figures, and Plates

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Abbreviations and Acronyms

ADT	Aquifer Drilling and Testing, Inc.
Air Toxics	Air Toxics Ltd.
AOC	Area of Contamination
ASTs	Aboveground Storage Tanks
AWQSGVs	Ambient Water Quality Standards and Guidance Values
BaP	Benzo[a]pyrene
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CAMP	Community Air-Monitoring Plan
Clean Earth	Clean Earth of North Jersey, Inc.
Con Edison	Consolidated Edison Company of New York, Inc.
COCs	Compounds of Concern
DNAPL	Dense Non-aqueous Phase Liquid
FDR	Franklin D. Roosevelt
GEI	GEI Consultants, Inc.
GPR	Ground Penetrating Radar
H&A	Haley & Aldrich, Inc.
HASP	Health and Safety Plan
HSA	Hollow-Stem Auger
IDW	Investigation-Derived Waste
Langan	Langan Engineering and Environmental Services, P.C.
LNAPL	Light Non-aqueous Phase Liquid
MGP	Manufactured Gas Plant
MSL	Mean Sea Level
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MTA	Metropolitan Transportation Authority
MTBE	Methyl Tert Butyl Ether
NAPL	Non Aqueous Phase Liquids
NAD	North American Datum
NAVD	North American Vertical Datum
NOAA	National Oceanic & Atmospheric Administration
NTUs	Nephelometric Turbidity Units
NYCDEP	New York City Department of Environmental Protection
NYCRR	State of New York Codes, Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
Air Study	*Summary of Indoor and Outdoor Levels of Volatile Organic Compounds from Fuel Oil Heated Homes in NYS, 1997-2003* (NYSDOH)
NYSDOT	New York State Department of Transportation
PAHs	Polycyclic Aromatic Hydrocarbons

Abbreviations and Acronyms (cont.)

PCBs	Polychlorinated Biphenyls
PID	Photoionization Detector
PPE	Personal Protection Equipment
PVC	Polyvinyl chloride
PVC/ST	Peter Cooper Village and Stuyvesant Town
QA/QC	Quality Assurance/Quality Control
QHHEA	Qualitative Human Health Exposure Assessment
RETEC	The RETEC Group, Inc.
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RIWP	RI Work Plan
RSCOs	Recommended Soil Cleanup Objectives
ROD	Record of Decision
ROWs	Right of Ways
SC	Site Characterization
SCGs	Standards, Criteria and Guidance Values
SCR	Site Characterization Report
SSBV	Site Specific Background Value
SVOCs	Semivolatile Organic Compounds
TAGM	Technical and Adminsitrative Guidance Memorandum (NYSDEC)
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TOGS	Technical and Operational Guidance Series (NYSDEC)
TWA	Time Weighted Average
USC	Utility Survey Corporation
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USTs	Underground Storage Tanks
VCA	Voluntary Cleanup Agreement
VOCs	Volatile Organic Compounds

MEASUREMENTS

bgs	Below Ground Surface
cm/s	Centimeters Per Second
mg/kg	Milligrams Per Kilogram
mg/L	Milligrams Per Liter
ppb	Parts Per Billion
ppm	Parts Per Million
µg/L	Micrograms Per Liter
$\mu g/m^3$	Micrograms Per Cubic Meter

Executive Summary

In 2006, GEI Consultants, Inc. (GEI) performed a Remedial Investigation (RI) of three former manufactured gas plant (MGP) sites located within the Stuyvesant Town residential complex on the Lower East Side of Manhattan, New York. The three sites were the former East 14th Street, East 17th Street and East 19th Street holder stations that operated from the mid 1800s until the early part of the 20th century. GEI performed the activities on behalf of Consolidated Edison Company of New York, Inc. (Con Edison) in accordance with the Voluntary Cleanup Agreement (VCA) Index #D2-0003-02-08, dated August 25, 2002, between Con Edison and the New York State Department of Environmental Conservation (NYSDEC). The scope and findings of the RI complement previous environmental investigations performed at the property from 2002 through 2004 by other consultants. These previous indoor air, soil gas and subsurface investigations were documented in reports that were submitted and approved by the NYSDEC. The results of the RI and previous investigations were combined into this interim RI report to facilitate a comprehensive evaluation of environmental impacts associated with the three sites. In addition, observations made during an underground valve replacement project conducted at the property in 2006 and 2007 were documented by GEI in an addendum summary report included as an appendix to this interim RI report and augment the findings of previous investigation work at the property.

The objectives of the RI were to conduct additional historical research to increase understanding of MGP-era conditions at the three former station sites; to perform a limited geophysical survey at the East 19th Street Station site to determine whether MGP-associated holder structures are still present; to collect additional soil gas samples in conjunction with proposed soil borings to assess the extent of MGP-related impacts in the vadose zone; to complete additional soil borings near each of the former holder stations and analyze subsurface-soil samples to refine the extent of MGP-related impacts; to install additional monitoring wells within and adjacent to the East 14th Street and East 17th Street Station sites and collect additional groundwater quality data; to characterize further the geology and hydrology beneath the three sites; and to evaluate contaminant exposure pathways and perform a qualitative human health exposure assessment. An air sampling program addendum to the RI was also implemented to supplement previous indoor air sampling at the East 14th Street Station site.

The investigation included indoor air, ambient air, soil gas, surface soils, subsurface soils and groundwater sampling and analysis. A limited geophysical survey was conducted at the former East 19th Street Station to explore for the presence of remnant gas holder foundations. Intrusive activities included advancement of 23 soil borings and 9 monitoring wells at the

East 14th Street Station site, 22 soil borings and 12 monitoring wells at the East 17th Street Station site, and 4 soil borings and 2 monitoring wells at the East 19th Street Station site. The underground valve replacement program entailed the excavation, removal and replacement of 58 water and hydrant valves across Stuyvesant Town.

The historical review of the investigation shows that the section of Manhattan which housed the three holder stations was actually land created on fill brought into the area in the mid 1800s to extend the shoreline of the Lower East Side. The three holder stations were built between 1855 to 1867 by predecessor companies of Con Edison. All three holder stations were removed sometime between 1903 and 1924 prior to the general area-wide demolition that took place to create Stuyvesant Town in the mid 1940s. For the East 17th Street and East 19th Street Stations, the sites were sold to other entities (i.e., Reconstruction Garage, Inc. and Improvement Garage, Inc., respectively) before the development of Stuyvesant Town.

In general, subsurface materials encountered during the investigations were similar across the station sites. The RI was inconclusive regarding the existence of subsurface holder foundations. However, there were a number of locations where rubble fill was encountered 10 to 20 feet below the ground surface near the former holders, possibly indicating the use of the holder tanks as demolition debris repositories. Four geologic units were defined beneath and adjacent to the station sites. They included fill, organic deposits/peat, glacial lacustrine and outwash deposits, and bedrock. The water table is located within the fill unit generally around 5 to 10 feet below grade. Groundwater generally flows east toward the East River.

At each of the station sites, the RI indoor air and soil gas samples contained volatile organic compounds (VOCs) that are common to both petroleum and MGP byproducts. However, the difference in the concentrations and distribution of these and other VOCs in the two media suggest that the two media are not linked via a vapor intrusion pathway. The results appear to support initial findings reported in 2003 by The RETEC Group, Inc., which indicate that the common VOCs in soil gas appear primarily attributable to non-MGP-type sources (e.g., gasoline, chlorinated solvent) and that VOCs in indoor and ambient air samples appear attributable to indoor air sources (such as cigarette smoke, floor waxes, cleaning products) and outdoor air sources (such as vehicle emissions). Physical observations and analytical results from all investigations support the presence of non-MGP related impacts in the subsurface and often at shallower depths than MGP-associated residues.

At the former East 14th Street and East 17th Street Stations, the RI field activities focused on characterizing the extent of MGP-related impacts identified during previous characterization work. Visual impacts of MGP tar were identified in subsurface soils at these two former station sites; however, they were restricted to soils deeper than 20 feet bgs and found in discrete lenses and small non-continuous layers at investigation locations. The tar impacts were confirmed by the presence of common MGP-related VOCs and semivolatile organic

compounds (SVOCs) (i.e., benzene, toluene, ethylbenzene, xylene [BTEX] and polycyclic aromatic hydrocarbons [PAHs]) in the subsurface soils where the impacts were noted. MGP-related groundwater impacts were observed only at the former East 14th and East 17th Street Stations during the investigations. Compound concentrations exceeding New York State water quality standards were primarily BTEX compounds and naphthalene. The highest concentrations appeared in wells near the former holders and diminished downgradient. There exist a number of potential receptors to exposure from MGP constituents in soil and groundwater but only if the contaminated soil is uncovered or disturbed and/or groundwater is encountered or extracted. Administrative controls, such as soil and groundwater management and worker health and safety plans and procedures, can be put in place to protect on-site workers and potential receptors during such activities.

Observations made during the valve replacement program indicated that subsurface tar impacts are located outside the former East 17th Street Station footprint to the south along the Avenue C Loop Road and to the northeast of the station footprint near Avenue C. These impacts were generally encountered between depths of 9 and 13 feet bgs. Locations excavated near the station footprint exhibited a variable mix of MGP-related and petroleum-type impacts within the fill material, which is consistent with the investigation findings. The locations and/or depths of these findings do not represent exposure routes or concerns beyond those identified during the RI.

The RI activities conducted at the former East 19th Street Station was intended to provide physical and analytical confirmation regarding the absence of media impacts attributable to the former holder station. Previous environmental reports submitted to the NYSDEC for the former station site indicate that the limited, low-level impacts identified at and near the site were most likely attributable to other urban sources. Impacts of MGP residuals at the East 19th Street Station were limited to only one 13.5 inch soil sample interval located away from the footprint of the former gas holder. No MGP-related impacts to groundwater beneath the former East 19th Street Station were detected during the RI sampling round. Based on the evaluation of field and analytical results collected to date, it appears that MGP-related constituents are at concentrations below NYSDEC standards beneath the former East 19th Street Station site. During the valve replacement project, MGP-related impacts were observed in several excavations conducted outside the former station footprint and along the East 20th Street Loop Road; these impacts were encountered at depths typically between 5 and 13 feet bgs, were observed within and/or beneath the fill horizon, and were variable and localized in degree and extent.

For the former East 14th Street, East 17th Street, and East 19th Street Stations, there are no significant or imminent threats to human health that warrant an interim remedial action. Given the depths of the MGP-related impacts, the current and future planned use of the site, and the characteristics of the subsurface and the compounds of concern, exposure to human

health or the environment to residual MGP tar residues is unlikely outside of significant construction or land development work for which environmental and health and safety controls would be warranted. Due to field observations made during the valve replacement project conducted subsequent to the RI field activities, additional investigation may be warranted to further delineate MGP-related impacts encountered outside the previous study areas along the Avenue C Loop Road and East 20th Street Loop Road of the Stuyvesant Town residential complex.

1. Introduction

On behalf of Consolidated Edison Company of New York, Inc. (Con Edison), GEI Consultants, Inc. (GEI) conducted a Remedial Investigation (RI) and prepared this interim RI report to address environmental conditions related to three former manufactured gas plant (MGP) sites within the present-day Stuyvesant Town Housing Development, located on the Lower East Side of the Borough of Manhattan, New York, New York. The three former MGP sites are referred to as the East 14th Street Station, the East 17th Street Station, and the East 19th Street Station. The stations were located on non-contiguous parcels during operation and were once owned and operated by predecessor companies of Con Edison. Currently, the three former station sites comprise ±4 acres of Block 972 Lot 1, a nearly 61-acre residential campus known as the Stuyvesant Town Housing Development (Stuyvesant Town). A site location map is included as Figure 1. Plate 1 shows the layout of both Stuyvesant Town and the former MGP sites.

GEI conducted the RI in accordance with Voluntary Cleanup Agreement (VCA) Index #D2-0003-02-08, dated August 25, 2002, between Con Edison and the New York State Department of Environmental Conservation (NYSDEC). The activities described in this report were performed in 2006, pursuant to the NYSDEC-approved RI Work Plan (RIWP), titled *Remedial Investigation Work Plan, Stuyvesant Town Former Manufactured Gas Plant Sites* (GEI, February 2006). GEI designed the RI work scope to build upon previous investigation data collected by others for the former station sites. As such, this RI report incorporates previous investigation findings into the evaluation and discussion of environmental conditions associated with the former MGP holder stations.

This interim RI report also includes observations made during a large-scale, capital improvement project conducted in 2006 and 2007 at Stuyvesant Town. The underground valve replacement program entailed the excavation, removal and replacement of 58 water and hydrant valves across the residential campus. Con Edison contracted GEI to serve in an observational role during the subsurface project activities and to document field observations regarding general subsurface conditions and potential environmental impacts in order to augment the findings of the previous investigation work at the property. GEI prepared the *Valve Replacement Project, Observation Summary Report*, presented in Appendix A, to supplement the RI findings presented herein.

1.1 Remedial Investigation Purpose and Objectives

The purpose of the RI is to gather sufficient information to assess whether remedial actions are necessary and, if so, to support analysis of remedial alternatives and selection of a remedy. GEI developed the RI scope to supplement previous investigation findings documented by Haley & Aldrich, Inc. (H&A) of Parsippany, New Jersey, in a Site Characterization Report (SCR, October 2004/revised April 2005), which was submitted to and approved by the NYSDEC. Based on review of the data collected during the site characterization (SC) work, GEI formulated specific RI objectives that were then used as the foundation for the RIWP, from which the RI field activities were planned and implemented.

As presented in the RIWP, the RI objectives are as follows:

- Conduct additional historical research to increase understanding of MGP-era conditions at the three former station sites.

- Perform a limited geophysical survey at the East 19th Street Station site to determine whether MGP-associated holder structures are still present in the subsurface and to assist in evaluating subsurface conditions at the site.

- Complete additional soil borings near each of the former station sites and analyze subsurface soil samples to refine the extent of MGP-related impacts.

- Collect additional soil gas samples in conjunction with proposed soil borings to assess the extent of MGP-related impacts in the vadose zone.

- Install additional monitoring wells within and adjacent to the East 14th Street and East 17th Street Station sites and collect additional groundwater quality data to assess horizontal and vertical extent of MGP-related impacts to groundwater.

- Characterize further the geology and hydrology beneath the three former station sites.

- Evaluate contaminant exposure pathways and perform a qualitative human exposure assessment for the former station sites.

In addition, GEI submitted a sub-slab vapor and air sampling program addendum to the NYSDEC to augment the soil gas sampling objectives provided for in the RIWP. The addendum prepared by GEI and dated March 6, 2006, provided supplemental information regarding sampling locations and collection procedures for soil vapor and indoor and ambient air samples to be collected at the East 14th Street Station site. The purpose of the plan was to

essentially duplicate the sampling conducted by The RETEC Group, Inc. (RETEC) in 2003, while incorporating new guidance from the NYSDEC and New York State Department of Health (NYSDOH).

The purpose and objectives set forth for the RI are consistent with the NYSDEC's comprehensive site characterization and remedial investigation goals, as described in the NYSDEC *Draft DER-10 Technical Guidelines for Site Investigation and Remediation* (December 2002).

1.2 Report Organization

This report has been prepared as an interim RI report and is organized into nine sections. Following this introduction, Section 2 presents a summary on the project background, including physical setting, property ownership and operational history, and previous environmental investigations completed for the former station sites. Section 3 includes a discussion of the scope and methods used to collect, analyze, and present the RI data. Section 4 addresses the geologic and hydrogeologic characteristics specific to the former station sites. Section 5 presents an interpretation of the nature and extent of contaminant impacts by station and medium. Section 6 presents a Qualitative Human Health Exposure Assessment (QHHEA), and Section 7 includes an overall conceptual site model of environmental conditions for the three station sites. Section 8 closes the report with a summary of findings and associated conclusions from the RI.

To support the material presented herein, tables, figures and plates follow the text to enhance project understanding and discussions. RI photographic documentation, indoor air survey forms, soil boring logs and well construction logs, well purging records, hydrogeologic testing results, investigation-derived waste records, previous background statistic analysis documentation and laboratory analytical results and data usability reports are included as appendices to this report. In addition, the *Valve Replacement Project, Observation Summary Report* (GEI, September 2007) is also included as an appendix to this report.

As indicated above, GEI has incorporated findings from previously noted H&A and RETEC investigation and sampling work into the RI report text and supporting materials. Although the previously noted site work and findings have been included in associated reports already submitted to the NYSDEC, GEI has included the information herein to present the reader with a more complete understanding of documented site conditions than would be immediately attainable through the presentation of RI data alone. As such, the illustration of field and analytical findings by others may differ from previous report submittals in order to provide a more inclusive yet concise visual representation of known site conditions.

2. Site Setting and Background

GEI obtained information summarized in this section from both previous site investigation and research reports prepared by others and supplemental historical records review conducted by GEI as part of the RI. Previous reports used in completing this section include the H&A SCR (rev. 2005), as well as the Langan Engineering and Environmental Services, P.C. (Langan) MGP Research Reports for the East 14th Street Works and the East 17th and East 19th Street Stations (2002/2003). Sources of supplemental research conducted as part of this RI are included in Section 3, and additional source details for information included in this Section are listed in the References Section at the end of this report.

2.1 Site Description

The three former MGP station sites that are the subject of this RI report are located within the present-day residential campus known as Stuyvesant Town. Stuyvesant Town occupies Block 972 Lot 1 in the Borough of Manhattan within the City, County, and State of New York. Located in the Lower East Side section of Manhattan, the property is bounded by and extends from East 14th Street north to East 20th Street and from First Avenue east to Avenue C. The property boundaries are shown on Figure 1, which is taken from a portion of the United States Geological Survey (USGS) Topographic Map of Brooklyn, New York Quadrangle (1995).

Stuyvesant Town encompasses approximately 61 acres and contains residential high-rise apartment buildings, playgrounds and courts, and private underground parking garages. Landscaped areas and paved walkways are located throughout the complex. Four "loop" roads onto the property are accessible from each respective city street and a service road with available parking is located along the northern, western and southern perimeter of the complex. The majority of the property is currently designated a R7-2: Moderate to High-Density Residential District, according to Zoning Map 12C of The New York City Planning Commission. Commercial segments (C1: Light Commercial) of the property are located along its perimeter and include a bank, laundry service and a number of retail stores. The management offices for both Stuyvesant Town and the adjacent Peter Cooper Village are located within Stuyvesant Town at 317 Avenue C, and a day care center, Manhattan Kids Club II, is located on the south side of the complex at 629 East 14th Street.

When constructed in the 1940s, Stuyvesant Town replaced the former buildings, industries and streets within its 18-block footprint, including three former MGP holder stations. The three former MGP stations were located on non-contiguous parcels that together occupied

approximately 4 acres in total. The former station footprints and associated main structures are shown in Plate 1. The stations were situated as follows:

- The East 14th Street Station was located near the corner of East 14th Street and Avenue C. Sanborn® maps show six gas holders, one meter house, and one purifying house on the ±2-acre station site. Currently, portions of residential buildings at 245 Avenue C and 625-645 East 14th Street, an underground parking garage, and a child day care center (629 East 14th Street) occupy the area of the former East 14th Street Station. In addition, a portion of the adjacent service road and pedestrian walkways along Avenue C and East 14th Street appear to have also been located within the former station footprint.

- The East 17th Street Station was located off the present-day Stuyvesant Town Avenue C Loop Road. Sanborn® maps show two gas holders, material-storage areas, and an area subsequently labeled "cinder yard" on the ±1.5-acre station site. Portions of residential buildings at 285-287 Avenue C and 16 Stuy Oval and an underground parking garage currently occupy the area of the former East 17th Street Station. Additionally, the segment of the Avenue C Loop Road between the noted residential buildings, as well as adjacent walkways and a small portion of a basketball court, lie within the former station footprint.

- The East 19th Street Station was located off the present-day Stuyvesant Town East 20th Street Loop Road. Sanborn® maps show one gas holder and a small unidentified structure located on the ±0.3-acre station site. Portions of a residential building at 522-524 East 20th Street and an underground parking garage currently occupy this area.

Due to the number and focus of previous studies related to these three former MGP stations, different descriptors have been used to identify, in whole or part, each of the station sites. For purposes of this RI, Stuyvesant Town references the property stretching from East 14th Street north to East 20th Street and from First Avenue east to Avenue C. Each of the three former MGP stations is referenced as a station and/or site regardless of number or type of associated structures that had been contained within. In addition, the station or site reference is meant to denote the area within the known or inferred footprint of each former MGP as shown in Plate 1.

To further clarify the relationship between the RI report nomenclature and other current and past station identifiers, a cross-reference guide is provided below.

Station Name for RI Report	Other Station Identifiers
East 14th Street Station	NYSDEC Site Number V00535 Former East 14th Street Station (*H&A SCR, rev. April 2005*) East 14th Street Works/East 14th Works (*RETEC report, October 2003*) *Partials of station site:* Areas of Concern (AOCs) 1-3 (*H&A SC Work Plan, September 2003*) ▪ AOC 1 Former East 14th Street Station Gas Holders Nos. 1-6 ▪ AOC 2 Former East 14th Street Station Meter House ▪ AOC 3 Former East 14th Street Station Purifying House East 14th Street Works (*Langan report, January 2003*)
East 17th Street Station	NYSDEC Site Number V00541 Former East 17th Street Station (*H&A SCR, rev. April 2005*) East 17th Street Works/Station (*RETEC report, October 2003*) *Partials of station site:* AOCs 4-5 (*H&A SC Work Plan, September 2003*) ▪ AOC 4 Former East 17th Street Station Gas Holders Nos. 1&2 ▪ AOC 5 Former East 17th Street Station Cinder Yard
East 19th Street Station	NYSDEC Site Number V00542 Former East 19th Street Station (*H&A SCR, rev. April 2005*) East 19th Street Works/Station (*RETEC report, October 2003*) *Partials of station site:* AOCs 6-7 (*H&A SC Work Plan, September 2003*) ▪ AOC 6 Former East 19th Street Station Gas Holder No. 1 and Adjacent Building ▪ AOC 7 Groundwater* (*H&A notes that groundwater subsequently addressed on per station level.)

2.2 Adjoining Property Description

The immediate area surrounding Stuyvesant Town is primarily residential and light commercial, with several public institutions and Con Edison facilities located within ½- mile radius of Stuyvesant Town. Current land cover and general use within the vicinity of Stuyvesant Town is illustrated on Figure 2 and is summarized below:

- **North of the Site:** Peter Cooper Village, a residential complex built in conjunction with Stuyvesant Town, occupies the property between East 20th Street north to East 23rd Street and First Avenue east to Avenue C. Peter Cooper Village and Stuyvesant Town form the PCV/ST campus that is currently owned and managed as a single entity.

- **West and South of the Site:** A mix of residential and light commercial properties are located along First Avenue and East 14th Street to the west and south of Stuyvesant Town respectively. Beth Israel Medical Center is located on the west side of First Avenue between East 16th Street and East 17th Street.

- **East of the Site:** Con Edison-owned and operated facilities, including the East River Generating Station and the East 16th Street Service Center, are located to the east of Stuyvesant Town. The Franklin D. Roosevelt (FDR) Drive is elevated in this area and parallels the east side of Avenue C near the northeastern corner of Stuyvesant Town. Public parking and a riverwalk are located beneath and to the east of the FDR Drive roadway. The East River is located adjacent to the riverwalk.

Additional information pertaining to the physical setting of Stuyvesant Town is provided in subsection 2.4 below.

2.3 Site Ownership and Operational History

2.3.1 Post-MGP Era to Present

As stated above, Stuyvesant Town is part of the larger ±80-acre PCV/ST complex that includes Peter Cooper Village to the north. Metropolitan Life Insurance Company (MetLife®), which sponsored construction of the housing complex in the mid to late 1940s, owned the residential campus post-construction and conveyed it to PCV/ST LLC in 2001. Metropolitan Insurance and Annuity Company, an affiliate of MetLife®, acquired the property and its establishments in 2002. Since establishment, the PCV/ST complex has been occupied by high-rise apartment buildings and support facilities, such as playgrounds and underground parking garages. A number of perimeter buildings with frontage along city streets are used for light commercial uses. A day care facility, Manhattan Kids Club II, is located on East 14th Street on the south

side of the complex, between Avenue C and the East 14th Street Loop Road (Avenue B extension).

2.3.2 MGP Era

Prior to development of the residential campus, Stuyvesant Town was occupied by a variety of residential, commercial and industrial properties. Working with the New York City Housing Authority, MetLife® acquired properties within the 18-block footprint of Stuyvesant Town during the early to mid 1940s, through eminent domain or private sale. MetLife® took title of the properties through the Stuyvesant Town Corporation, which was formed by MetLife® to implement construction of the post-war housing. Articles from *The New York Times* during that period indicate that approximately 600 buildings, which contained ±3,100 families and ±500 commercial and industrial facilities, were razed as part of the project. Aside from existing apartments and tenements within the project boundaries, some of the establishments demolished included machine shops, ice plants, auto garages, iron works and foundry yards, brick works, coal yards, lumber and construction storage yards, livery stables, house-ware storage facilities, churches and private and public schools. In addition, a number of MGP stations, three of which were within the boundaries of the planned Stuyvesant Town, were located within and around the area, which historically were part of "The Gas House District of Manhattan." Figure 3 shows a snapshot of local area development circa 1897.

Located within present-day Stuyvesant Town, the East 14th, 17th and 19th Street Stations were in operation between the mid 1800s and early 1900s and were owned and operated by Con Edison's predecessor companies, primarily the Consolidated Gas Company of New York, the New York Steam Company, the Standard Gas Company and the Manhattan Gas Light Company. A detailed discussion of the ownership history of these three former MGP stations is provided in the respective Langan MGP Research Reports. A summary of the site history for each station is provided below.

2.3.2.1 East 14th Street Station

The East 14th Street Station was part of a greater Consolidated Gas Company facility known as the East 14th Street Works, the majority of which was located on the eastern side of Avenue C between East 14th and East 16th Streets. The East 14th Street Station was located on the west side of Avenue C and occupied the majority of the block between Avenues B and C and East 14th and East 15th Streets. The station operated for gas storage and purification from circa 1857 to some time between 1903 and 1920. Historic Sanborn® maps show six gas holders with approximately 350,000 cubic-feet capacity each, one meter house, and one purifying house on the ±2-acre station site. The gas holders do not appear on the 1920 Sanborn® Map and 1921 *Atlas of the Borough of Manhattan*, and a 1924 aerial photograph of New York City (Fairchild, July 1924) and a 1928 site photograph from the New York Library Digital Gallery confirm their absence. The gas holders were removed

prior to demolition of the purifying house, which occurred sometime between 1924 and 1934. Consolidated Gas/Con Edison subsequently used the site for a warehouse and storage yard until 1944 when the property was sold for construction of Stuyvesant Town.

2.3.2.2 East 17th Street Station

The East 17th Street Station reportedly began operations between 1860 and 1867 and was a gas storage facility. Historic Sanborn® maps indicate that two gas holders, with approximately 270,000 cubic-feet capacity each, were located at the western portion of the ±1.5-acre station site, while the eastern portion of the site was used for pipe and material storage and an office. The site was situated approximately mid-way between Avenues B and C and stretched from East 17th Street north to East 18th Street. Based on review of the 1921 *Atlas of the Borough of Manhattan* and 1924 aerial photograph of New York City (Fairchild, July 1924), the station was decommissioned (with removal of the holders) some time between 1921 and 1924. The site was then used as a possible "cinder yard" based on historic Sanborn® maps. Con Edison sold the property in 1943 to Reconstruction Garage, Inc., and Stuyvesant Town Corporation acquired the property in 1944 for the housing development.

2.3.2.3 East 19th Street Station

The East 19th Street Station occupied the least amount of property of the three MGP sites. The station was located on the south side of East 19th Street, between Avenues A and B, and occupied ±0.3 acres within the block. The station reportedly began operations between 1863 and 1868. Based on historic Sanborn® maps, one gas holder, estimated at a 500,000 cubic-feet capacity, and one small unidentified structure were present at the site. Based on review of historic Sanborn® maps and the 1921 *Atlas of the Borough of Manhattan*, the station was replaced by an auto/truck garage between 1920 and 1921. The property was sold to Improvement Garage, Inc., in 1943 and acquired by the Stuyvesant Town Corporation in 1944.

2.3.3 Pre-MGP Era

Based on reviewed historic survey maps and plates from the late 1700s and early 1800s, it appears that the 18-block area developed as Stuyvesant Town was part of the East River and associated marsh lands well into the 1800s. A number of creeks and streams that fed into the East River traversed the area, which appears to have been mainly farms and orchards during the colonial period. To accommodate the growing city, the area gave way to more industrial development planning in the early 1800s. As a result, most of the area east of First Avenue, between East 13th and East 26th Streets, required filling and reworking of the local land to elevate the grade and extend the shoreline. In some instances, tenements existed for a brief period on the newly made land before the development of the station sites as gas storage and/or gas plant facilities. An 1815 map depicting the historic shoreline and design plans for the expansion of the Lower East Side is included as Figure 4.

2.4 Physical and Environmental Setting

2.4.1 Site Design and Infrastructure

As discussed above and shown in Plate 1, the surface topography of Stuyvesant Town is made-land and ranges from approximately 4 to 22 feet above Mean Sea Level (MSL). Areas not covered by buildings are developed with four loop roads with available parking, paved pedestrian walkways, turf playgrounds, multi-use game courts, and landscaped areas. Additionally, six underground parking garages are located at Stuyvesant Town. These garages are single-level parking structures that are situated only partially below the adjacent street grade. The top of the garage structures were constructed to support pedestrian walkways, landscaped areas, and play courts and provide building access to upper floors; therefore, the ground level above the garages is typically 10-12 feet above the surrounding street grade, or 18-22 feet above MSL. The design of Stuyvesant Town provides a general radial symmetry to the complex with a large fountain located at the hub. Based on this construction and the overall symmetrical layout of the campus buildings and features, precipitation reaching the surface will generally infiltrate landscaped areas and/or drain towards the stormwater basins located along the four loop roads and perimeter streets.

Given the size and support demands of Stuyvesant Town, a complex utility infrastructure is located beneath the property. H&A conducted a review of available site utility maps as part of their SC work and determined that a dense network of numerous, large and small, private and public utility lines traversed the site subsurface. Aside from active lines, the extent of older, abandoned utilities that once served pre-Stuyvesant Town residential, commercial and industrial buildings are unknown and may further populate the site subsurface. In addition to the utilities located beneath the residential complex, the 14th Street – Canarsie Subway, the Pollution Control Intercepting Sewer and several main feeders into the East River Generating Station are located near Stuyvesant Town beneath the perimeter city streets.

The 14th Street – Canarsie Line, known as the "L" train, runs beneath 14th Street, from 8th Avenue in Manhattan eastward across the East River and into Brooklyn. H&A reported that the rail bases for the east and west bound subway trains near Stuyvesant Town were located approximately 47 feet below East 14th Street at the intersection with Avenue C and that the typical tunnel cross section near the property was shown as approximately 15 feet in diameter. H&A cited the Metropolitan Transportation Authority (MTA) microfilm drawings 388 and 338, dated March 1916, as the source of this information.

H&A reviewed a drawing of the New York City Department of Environmental Protection (NYCDEP) showing the North Branch Intercepting Sewer (sheet 6, July 1967). H&A indicated that the sewer line was constructed as a pollution-control measure, is ±108 inches in diameter and is located approximately 40 feet below grade along the east side of First

Avenue between East 21st and East 23rd Streets. The sewer reportedly continues eastward along the south side of East 20th Street and then turns south along the west side of Avenue C, where intercepted wastewater from lateral-combined lines feeding into the East River is then pumped to the Newtown Creek Water Pollution Control Plant via the East 13th Street Pump Station.

Consideration of the above-mentioned subsurface utilities and transportation corridors is integral to the evaluation of environmental conditions beneath the former MGP stations. Combined with the known in-filling of the area in the 1800s, these underground piping networks and structures create significant heterogeneities within the site subsurface that can influence the local groundwater flow gradients, affect contaminant fate and transport dynamics and provide insight into "anomalies" regarding subsurface contaminant chemistry.

2.4.2 Environmental Setting

2.4.2.1 Regional Geology

The regional geologic setting and a summary of the stratigraphy of subsurface materials in the vicinity of Stuyvesant Town is presented below in order to provide the context for how the RI findings fit within the regional environmental setting. A detailed discussion of the geologic findings specific to the RI is presented within Section 4 of this report.

Beneath the RI study area, the following materials were encountered in order of increasing depth:

- Fill
- Organic deposits
- Glacial Lacustine (glacial lake)/Glacial Outwash deposits
- Bedrock

The regional characteristics of each of these units will be discussed in terms of stratigraphic order, starting from the deepest geologic unit (bedrock) and progressing upward to the shallowest unit (fill). The discussion is based on published information on the known and anticipated subsurface conditions in the vicinity of Stuyvesant Town.

According to published information, the bedrock underlying the East 14th Street and East 17th Street Stations is Ravenswood Granodiorite (Baskerville, 1994). The Ravenswood Granodiorite is an igneous rock that is described as a medium to dark gray granodiorite with a texture similar to granite and gneiss that was formed in the Middle Ordovician to Middle Cambrian geologic periods, approximately 460 to 500 million years ago (Baskerville, 1994). The bedrock surface dips sharply to the northeast. Bedrock is located approximately 40 to 80

feet below ground surface (bgs) in the vicinity of the East 14th Street Station and more than 80 feet bgs at the East 17th Street Station footprint (Baskerville, 1994).

The East 19th Street Station is underlain by Inwood Marble. The Inwood Marble is a metamorphic rock that is generally described as a white to bluish-gray fine to coarse grained calcitic to dolomitic marble that is middle Ordovician to Late Cambrian in age (Baskerville, 1994). According to published information, the Inwood Marble is present between approximately 60 to 80 feet bgs (Baskerville, 1994). The Inwood Marble unit is part of the Cameron thrust fault which bisects the Stuyvesant Town property. The Cameron thrust fault trends northeast-southwest. According to Langan's 2002 *MGP Research Reports*, the bedrock in the vicinity of the fault dips at approximately 45 degrees to the northwest. The fault is a dominant geologic feature in the Lower East Side of Manhattan that is a remnant of an ancient collision between the North American and African tectonic plates (Shah, 2004).

Within Manhattan and nearby western Kings County (Brooklyn), bedrock is generally overlain by Upper Pleistocene (Wisconsin) age glacial deposits, Holocene age organic deposits, and recent artificial fill (Baskerville, 1994).

Glacial deposits in the vicinity of Stuyvesant Town include fine to coarse silty sand (till) and varved silt and clay materials that are referred to as rhythmites (Baskerville, 1994). Based upon published information, these deposits range in thickness from 10 to 140 feet thick in Manhattan and are present on the Lower East Side of Manhattan east of First Avenue (Baskerville, 1994). Rhythmite deposits were deposited within an ancestral glacial lake associated with the damming of the Hudson River by the Harbor Hill Terminal Moraine, located to the south at the Narrows section of New York Harbor (Meguerian 2003, Baskerville 1994).

Holocene age organic deposits consist of black to grey organic clay-silts that contain marine shell fragments and peat deposits associated with marshes. As discussed within subsection 2.3, the East River and associated shoreline and marshes covered most of the area within and around the PCV/ST development well into the 1800s. The area was subsequently land filled with an assortment of materials and soils to expand the Lower East Side of Manhattan in the mid to late 1800s.

2.4.2.2 Regional Hydrogeology/ Hydrology

This section discusses the regional Upper Glacial Aquifer present beneath Stuyvesant Town and the nearest surface water body, the East River. A detailed discussion of the hydrogeologic findings specific to the RI is discussed within Section 4 of this report.

The Upper Glacial Aquifer consists of Pleistocene age glacial deposits, within which Holocene age deposits and fill are grouped. According to Baskerville (1994), thick layers of

stratified drift cover the lower portion of Manhattan in the vicinity of 14th Street and can yield large quantities of water; however, the groundwater is impacted with salt water from the saline East River. The Upper Glacial Aquifer is generally unconfined; however, it may be confined locally by the occurrence of less permeable silts and clays. The Upper Glacial Aquifer is characterized by typical horizontal hydraulic conductivities of 270 feet per day [$9.5x10^{-2}$ centimeters per second (cm/s)] within glacial outwash sand and 135 feet per day ($4.4x10^{-2}$ cm/s) within poorly sorted till deposits nearby on Long Island (Cartwright, 2002).

Information regarding groundwater flow within the Upper Glacial Aquifer on Manhattan was not found during this RI. However, Baskerville (1994) indicates that streams and tidal marshes that were buried in the mid 19th century influence water flow on Manhattan. Filled tidal wetlands in the vicinity of Stuyvesant Town can be affected by tidal fluctuations within the nearby East River. Based upon historic maps of the area and stream patterns, the inferred groundwater flow beneath Stuyvesant Town is towards the East River. According to H&A's SCR (rev. 2005), the depth to groundwater is approximately 10 feet bgs in the vicinity of Stuyvesant Town, and the NYSDEC classifies the groundwater beneath the property and vicinity as GA, which by definition indicates that the water is potable water suitable for drinking.

The East River is located to the east of Stuyvesant Town and ranges in proximity from approximately 200 – 1,500 feet from the eastern boundary of the property to 1,750 – 2,250 feet from the western boundary of the property (Figures 1 and 2). The East River is a tidal saline water body. The NYSDEC classifies the East River as "I" indicating that the river is suitable for fishing and secondary contact. Class I waters are suitable for fish propagation and survival. The west shoreline of the East River is listed as part of the National Wetlands Inventory (Langan, 2002).

2.4.2.3 Regional Water Use

The Stuyvesant Town complex and surrounding areas of Manhattan are served by the New York City Water Supply System. The New York City Water Supply obtains water from reservoirs within the Catskill/ Delaware and Croton watersheds that are located 50 to 125 miles to the north of New York City.

2.5 Previous Investigations

Prior to the RI, several investigations had been conducted by others concerning the former MGP stations within Stuyvesant Town. GEI reviewed the following investigation reports as part of the RI and summarized the findings of each in the subsections below:

- H&A's *Site Characterization Report, Former Consolidated Edison Manufactured Gas Plants, Stuyvesant Town Housing Development*, prepared for Consolidated Edison Company of New York, Inc., dated October 2004, revised April 2005.

- RETEC's *E.14th Works and E.17th and E.19th Street Stations, Report of Evaluation of Indoor Air and Soil Gas Sampling*, prepared for Consolidated Edison Company of New York, Inc., dated October 7, 2003.

- Langan's *MGP Research Report, East 14th Street Works*, prepared for Consolidated Edison Company of New York, Inc., dated January 19, 2003.

- Langan's *MGP Research Report, East 17th Street Station*, prepared for Consolidated Edison Company of New York, Inc., dated September 9, 2002.

- Langan's *MGP Research Report, East 19th Street Station*, prepared for Consolidated Edison Company of New York, Inc., dated August 30, 2002.

In addition to the above reports, GEI was also provided the H&A Site Investigation Reports for the East River Facility (Operable Unit No. 1), dated October 2005, and the East River Station Ball Fields, dated April 2005. Information provided in these reports was used in the evaluation of findings from borings and wells advanced along the east side of Avenue C as part of RI activities associated with the former East 14th Street Station.

Aside from the MGP-related investigations conducted for Stuyvesant Town, H&A and RETEC have also conducted intrusive environmental investigations at Peter Cooper Village, located north of East 20th Street. Work performed for Peter Cooper Village is associated with the former MGP stations located within that particular housing complex and not affiliated with the former MGP operations at the Stuyvesant Town property. Based on historic research and field and analytical data obtained for the Stuyvesant Town former MGPs to date, it appears that MGP-related impacts beneath the Peter Cooper Village and Stuyvesant Town properties remain distinct and separate. Therefore, reports associated with the Peter Cooper Village environmental activities were not reviewed and are not included in discussions presented in this RI report.

2.5.1 H&A Site Characterization (2004)

In 2004, H&A conducted an environmental site investigation for the former MGP station sites within Stuyvesant Town. On behalf of Con Edison, H&A conducted the SC work in accordance with the VCA between Con Edison and the NYSDEC and the H&A September 2003 SC Work Plan, which was approved by the NYSDEC. H&A documented the methods and findings of their investigation work in their SCR for Stuyvesant Town dated October 2004 and revised April 2005.

The purpose of the SC was to investigate impacts from the three former MGP stations at the Stuyvesant Town property. The SC work consisted of test pit excavations, soil borings, soil sampling, monitoring well installations and groundwater sampling. It also included an evaluation of background soil and groundwater conditions to assess compounds of concern (COCs) present within non-MGP areas, in order to better evaluate the significance of impacts within the former MGP footprints. The SC investigation locations are shown on Plate 1 of this RI report, and the field and analytical findings are incorporated and addressed in the discussions, tables, and illustrations of this RI report.

The following is a summary of results taken directly from the SCR:

- *A total of six background borings were conducted during the investigation. The surface and subsurface soils were found to contain concentrations of semivolatile organic compounds (SVOCs) and arsenic above NYSDEC Recommended Soil Cleanup Objectives (RSCO). The surface and subsurface soil samples also contained lead and the subsurface soils contained cyanide; there is no specific RSCO criterion for lead and cyanide.*

- *Two monitoring well couplets were installed to evaluate background groundwater quality. Analytical results indicate that all four monitoring wells exceeded NYSDEC Technical and Operational Guidance Series (TOGS) primarily for metals and inorganic parameters, many of which are not typically associated with MGP-related materials. One monitoring well exceeded the VOC [volatile organic compound] criteria. Cyanide, which is related to MGP operations, was detected in a background well.*

- *At the former East 14th Street Station, subsurface soil and groundwater exceed their applicable screening criteria. Seventeen soil borings were conducted to investigate the former gas holders, meter house and purifying house. Although a total of seventeen soil borings were conducted at this station, only one surface soil sample was collected because most of this area is covered with concrete and cobblestones. The surface soil sample was below RSCO criteria for VOCs and SVOCs and below SSBV [Site-Specific Background Values] and RSCO for arsenic, lead and cyanide. Subsurface soil testing results indicate concentrations of VOCs and SVOCs above RSCO and arsenic, lead and cyanide concentrations above RSCO and/or SSBV. Two well couplets were installed and groundwater testing results show concentrations of VOCs, SVOCs and cyanide above the TOGS.*

- *At the former East 17th Street Station, surface soil, subsurface soil and groundwater exceed their applicable screening criteria. A total of fourteen surface soil samples were collected from this area and all fourteen samples exceeded either RSCO for*

SVOCs or SSBV for arsenic or lead. Sixteen subsurface soil borings were conducted to investigate the former gas holders and cinder yard. The soil borings contained concentrations of VOCs and SVOCs above RSCO and arsenic and lead above RSCO and/or SSBV. Groundwater contained concentrations of VOCs, SVOCs, lead and cyanide above TOGS.

- *At the former East 19th Street Station, surface soil, subsurface soil and groundwater exceed applicable screening criteria. In general, this station has fewer soil and groundwater exceedances than the other two MGP stations. One surface soil sample was collected from the area. The surface soil sample exceeds RSCO for SVOCs. Arsenic exceeded RSCO and/or SSBV in the surface soil sample. Three subsurface soil borings were conducted to investigate the former gas holder and adjacent building. The soil samples collected from the three borings exceed RSCO for SVOCs. Arsenic exceeded RSCO and SSBV in one soil sample. Groundwater testing results from the monitoring well couplet contained concentrations of SVOCs and lead slightly exceeding TOGS.*

In addition, the SCR stated:

- *Indoor air and soil gas sampling and evaluation were conducted in January 2003 and August 2003 by RETEC. The results of the indoor air and soil gas sampling were presented separately in a report entitled E.14th Works and E.17th and E.19th Street Stations, Report of Evaluation of Indoor Air and Soil Gas Sampling, dated October 7, 2003. The report concluded that the sources of the VOC compounds detected in the indoor air samples collected in the Stuyvesant Town apartment buildings appear to be moth balls, cigarette smoke, floor waxes, paints, or cleaning products used in the building, with a contribution from vehicle emissions (as evidenced by VOC detections in outdoor air). However, based on the results of the SC, MGP-related compounds could be contributing to the VOCs in the soil gas. The concentrations of these compounds were at low levels – at least two orders of magnitude below the Worker Guidance Values and similar to typical background concentrations.*

- *A QHHEA identified potentially completed exposure pathways at the former East 14th Street, East 17th Street, and East 19th Street MGP Stations for surface soil, subsurface soil, groundwater and outdoor air due to the presence of VOCs, SVOCs, lead, arsenic and/or cyanide in these exposure media. Some or all of these exposure pathways may be rendered incomplete upon further assessment or action. Since potentially complete exposure pathways have been identified, further evaluation of contaminant fate and transport is needed.*

Based on the SC activities and results, as well as the results reported in RETEC's 2003 air and soil gas sampling report, H&A concluded that MGP-related impacts, above the NYSDEC standards, were present at the former East 14th and East 17th Street Stations. Although limited contaminant impacts were identified at the former East 19th Street Station, H&A indicated that the impacts might not be MGP related but that limited access issues prevented a complete investigation of that area. As a result of their findings, H&A stated that additional investigation was needed to further delineate the extent of impacts at the former East 14th and East 17th Street Stations and to confirm the absence of MGP residuals at the former East 19th Street Station.

2.5.2 RETEC Air and Soil Gas Sampling (2003)

RETEC, under contract to Con Edison, conducted an evaluation of indoor air and soil vapor at the Stuyvesant Town property. The primary goal of the sampling activity was to determine if VOCs associated with the former MGP residuals at Stuyvesant Town were adversely affecting the air quality of the apartment buildings. RETEC conducted the sampling in two phases. In January 2003, RETEC collected indoor and ambient air samples from apartment buildings and exterior areas within the footprints of the East 14th, East 17th and East 19th Street Stations. In August 2003, RETEC collected soil gas samples from each of the former station sites. RETEC documented the findings in their report entitled *E.14th Works and E.17th and E.19th Street Stations, Report of Evaluation of Indoor Air and Soil Gas Sampling,* dated October 7, 2003.

RETEC's investigation locations are shown on Plate 1 of this RI report, and the field and analytical findings are incorporated and addressed in the discussions, tables, and illustrations of this report. A brief summary of RETEC's results is provided below:

- Potential MGP-related and non MGP-related compounds were detected in soil gas samples collected from within the former East 14th Street Station site; however, the elevated detection of the gasoline additive methyl-tert-butyl-ether (MTBE) suggests that concentrations are not MGP-related. Two out of seven indoor air samples from the buildings within the station footprint contained concentrations of naphthalene and/or xylenes above typical background indoor air values.

- The soil gas sample collected from within the former East 17th Street Station site contained low levels of potentially MGP-related and non MGP-related compounds. Indoor air samples from buildings within the station footprint did not contain concentrations of potentially MGP-related constituents above background levels.

- The VOC concentrations in the soil gas samples from within the former East 19th Street Station site were attributed to non MGP-related compounds based on the detection of MTBE. Naphthalene was detected above the range of background levels;

however, the elevated concentrations were higher than adjacent soil gas concentrations and were attributed to naphthalene-containing moth balls used nearby. The remaining detected concentrations of potentially MGP-related compounds were reportedly within the range of typical background levels in indoor air.

The RETEC report concluded that air quality at the Stuyvesant Town property was not impacted by the intrusion of MGP-related compounds. The sources of VOC concentrations within indoor air samples were attributed to non MGP-related sources (i.e. moth balls, paints, and cleaning products) with contributions from vehicle emissions in ambient (outdoor) air. These concentrations were generally consistent with expected background concentrations within indoor air. RETEC did recommend that the results of the air sampling be reviewed periodically, as applicable, based on future site characterization findings.

2.5.3 Langan MGP Research (2002/2003)

2.5.3.1 East 14th Street Works

On behalf of Con Edison, Langan conducted historical research regarding MGP operations at the East 14th Street Works and prepared a report of findings entitled *MGP Research Report, East 14th Street Works,* dated January 19, 2003. The East 14th Street Works was defined as two areas: the eastern portion (the majority of the Works site) encompassed 9.2 acres and included the area located between East 14th Street to East 16th Street between Avenue C and the FDR Drive, and the western portion (a/k/a East 14th Street Station) included 1.8 acres at the southeastern corner of the Stuyvesant Town development. The objective of the report was to review available historical and environmental records to summarize the former MGP operations of Con Edison and its predecessor companies. The MGP research was conducted as part of Con Edison's efforts to rank and prioritize sites with MGP operations for future investigations as part of the VCA between Con Edison and the NYSDEC. A summary of Langan's findings are provided below:

- **East 14th Street Works-Eastern Portion:** Con Edison currently owns the eastern portion of the former East 14th Street Works, which is currently developed with the East River Generating Station, electrical substation, service and vehicle fueling center, maintenance garage, and baseball fields. The East 14th Street Works reportedly operated as early as 1853 and continued to produce gas until 1922 when it was decommissioned and redeveloped as the Con Edison East River Generating Station. Gas storage and transmission continued on the property until at least 1962. Numerous spills/releases of petroleum and dielectric fluid have occurred at or adjacent to the property and are being investigated under an Order of Consent with the NYSDEC. Petroleum impacted soil and former building foundations were encountered during a 1999 geotechnical investigation. Numerous oil and chemical

underground storage tanks (USTs) and aboveground storage tanks (ASTs) were historically operated on the site, and Con Edison has investigated a number of USTs as part of an Order of Consent with the NYSDEC. The property has been listed as a Resource Conservation Recovery Act (RCRA) Large Quantity and Small Quantity Generator that has incurred violations for previous waste handling practices.

- **East 14th Street Works-Western Portion:** The western portion of the former East 14th Street Works is located in the southeast corner of the Stuyvesant Town housing complex that is privately owned. The MGP operated for gas storage and purification from 1859 until some time after 1920. Con Edison used the site for a warehouse and storage yard until 1944 when the property was sold. The property was redeveloped with multi-story residential buildings with basements, day care, underground parking garage, playground and landscaped areas. No regulatory information was encountered regarding the western portion of the East 14th Street Works.

Based upon the redevelopment of the East 14th Street Works, Langan reported that a limited potential of exposure to MGP-related impacts exists. Langan indicated that there is a potential exposure to soil vapor for building occupants and also for exposure for subsurface utility activity. Langan also stated that the East River and its shore (identified in the National Wetlands Inventory) were environmental receptors of potential offsite impacts from the former East 14th Street Works.

2.5.3.2 East 17th Street Station

Langan, under contract to Con Edison, conducted research regarding the former MGP operations at the East 17th Street Station within the Stuyvesant Town property and documented their findings in the report entitled *MGP Research Report, East 17th Street Station*, dated September 9, 2002. The objective of the report was the same as for the 14th Street Station. A summary of Langan's findings are provided below:

- The East 17th Street Station reportedly began operations between 1860 and 1867 and was decommissioned at some time between 1920 and 1943 when the property was sold. (Updated information shows this site as being decommissioned in the early 1920s.)

- The East 17th Street Station encompassed approximately a 2-acre area that has been redeveloped with three multi-story residential buildings with basements, adjacent landscaped areas and a portion of paved playing courts.

- A site reconnaissance revealed that no former holder structures were observed in public areas; however, it is unknown if buried structures and foundations exist or how

decommissioned wastes were handled during the construction of the Stuyvesant Town complex.

- Soil vapor, groundwater, soils and utility conduits were identified as potential pathways by which residents and utility workers could be exposed to impacts (if present).

- The East River and its shore (identified in the National Wetlands Inventory) were identified as environmental receptors of potential offsite impacts.

- The East 17th Street Holder Station was not found on any regulatory databases.

Based upon these findings, Langan proposed a visual inspection of basement foundations and utility manholes and the characterization of subsurface materials prior to any future excavation at the site.

2.5.3.3 East 19th Street Station

Langan, under contract to Con Edison, conducted research regarding the former MGP operations at the East 19th Street Station within the Stuyvesant Town property and documented their findings in the report entitled *MGP Research Report, East 19th Street Station*, dated August 30, 2002. Again the objectives of the historical research were the same as the other two Stations. A summary of Langan's findings are provided below:

- The East 19th Street Station reportedly began operations between 1863 and 1869 and was decommissioned at some time between 1920 and 1943 when the property was sold. (Recent information shows this holder being decommissioned in the early 1920s.)

- The East 19th Street Station encompassed approximately a 0.3-acre area that has been redeveloped as a 13-story residential building with a basement, adjacent landscaped areas and a portion of an underground parking garage.

- A site reconnaissance revealed that no former holder structures were observed in public areas; however, it is unknown if buried structures and foundations exist or how decommissioned wastes were handled during the construction of the Stuyvesant Town complex.

- Soil vapor, groundwater and utility conduits were identified as potential pathways that residents and utility workers could be exposed to impacts (if present).

- Potential environmental receptors identified include the East River and the shore of the East River (National Wetlands Inventory) that are located to the east of the former station.

- The 19th Street Holder Station was not found on any regulatory databases.

Based upon these findings, Langan proposed a visual inspection of basement foundations and utility manholes for indications of MGP-related impacts. In addition, Langan proposed a limited characterization of subsurface materials prior to any future excavation at the site to address potential health and safety and regulatory compliance issues.

3. Remedial Investigation Scope and Methods

The RI scope of work consisted of the following tasks:

- Historical data/records review
- Geophysical survey
- Permitting and underground utility clearance
- Community air monitoring
- Indoor air sampling
- Soil gas sampling
- Soil borings and monitoring well installation
- Soil sampling and analysis
- Well development
- Groundwater sampling and analysis
- Site survey
- Hydraulic conductivity testing
- Waste management
- Data reduction and reporting

In addition to the noted task, GEI implemented a site-specific Health and Safety Plan (HASP), Field Sampling Plan, and Quality Assurance Project Plan during the RI program. These Plans were included as appendices to the RIWP.

GEI conducted the RI field activities from March through June 2006, with subsequent hydrogeolgic testing conducted in October 2006. Table 1 presents the climatological conditions during the March through June 2006 RI field work. Table 2 presents a summary of each phase of field work, the dates that each phase occurred and the primary objectives of each phase.

The RI field work was conducted in general accordance with the RIWP and sub-slab vapor and air sampling program addendum (March 6, 2006) prepared by GEI on behalf of Con Edison. Due to conditions encountered during field investigation work, GEI modified proposed sample locations and/or intrusive sample collection methods (i.e., drilling techniques), as necessary, to maintain the goals of the RI. These modifications are noted in the appropriate subsections below. GEI maintained communications with the NYSDEC during the course of the field activities, and representatives of the NYSDEC visited the site periodically during the RI field tasks to observe work progress and encountered conditions.

GEI contracted with the following firms to assist in the implementation of the field work and in the analysis of samples collected as part of the program:

- Utility Survey Corporation (USC) of New Windsor, New York, performed the geophysical survey and private utility clearance survey.

- Aquifer Drilling and Testing, Inc. (ADT) of New Hyde Park, New York, constructed and maintained equipment, waste and decontamination staging areas; performed the intrusive utility clearance, drilling and well installation work; and assisted in the installation of temporary soil gas points and the development of newly-installed monitoring wells.

- Air Toxics Ltd. (Air Toxics) of Folsom, California, performed laboratory analysis and reporting for all air and soil gas samples collected and submitted for this program.

- ChemTech of Mountainside, New Jersey, performed laboratory analysis and reporting for all soil, groundwater and waste characterization samples collected and submitted for this program.

- Clean Earth of North Jersey, Inc. (Clean Earth) of South Kearny, New Jersey, conducted transportation and disposal of investigation-derived waste (IDW).

GEI implemented the Community Air Monitoring Plan (CAMP), maintained field sampling and screening equipment, collected samples for laboratory analysis and provided oversight for the RI work during the field program. In addition, GEI kept dedicated log books for the documentation of field activities and observations throughout the RI program.

3.1 Historical Data/Records Review

In order to better understand the possible sources and locations of potential MGP-related impacts at the Stuyvesant Town, GEI reviewed previous environmental reports prepared for the stations and conducted additional research of available historical resources. As mentioned and summarized above, GEI reviewed reports generated by H&A, RETEC, and Langan to gain a comprehensive understanding of the property and project background. To supplement historic information provided in each of the referenced reports, GEI completed on-line and on-site research of New York City Public Library archives and various New York City building record repositories.

3.2 Geophysical Survey

As part of the RI program, USC completed a limited geophysical survey on March 5, 2006, within areas of the former East 19th Street Station not presently covered by buildings or structures. The purpose of the survey was to identify the potential presence of subsurface structures that may have been remnants of the associated former station, particularly the gas holder. GEI contracted the survey in lieu of supplemental test pitting within the area due to the close proximity of the station footprint to existing building foundations.

USC used ground penetrating radar (GPR) and an electro-magnetic pipe, cable and box locator to survey the area between the East 20th Street Loop Road and the 522-524 East 20th Street building. The results of the survey indicate and/or confirm the presence of a number of utilities and subsurface debris beneath the ground surface, but are inclusive regarding the potential presence of MGP-related substructures in the area. USC used marking paint to designate the results of the survey on the ground surface, and the proposed boring location was adjusted accordingly. Photographic documentation of the results of the USC survey is included in Appendix B.

3.3 Indoor Air Survey

On March 16, 2006, GEI completed a building assessment survey during the collection of indoor air samples within Stuyvesant Town buildings at the former East 14th Street Station site. At each indoor air sample location, an assessment of the building construction and chemical storage was completed in order to prepare the NYSDOH Indoor Air Quality Questionnaire and Building Inventory form provided within Appendix B of the *Draft Guidance for Evaluating Soil Vapor Intrusion in the State of New York*, dated February 2005 (Draft NYSDOH Soil Vapor Guidance). Indoor air survey and air locations were generally completed coincident with locations sampled by RETEC in 2003, as shown in Plate 1. Consequently, the March 2006 building survey and chemical storage information was used to update the previous information collected by RETEC. Updated building survey forms and representative photographs are located in Appendix C.

3.4 Underground Utility Clearance

Underground utility clearance was performed in general accordance with the *Con Edison Utility Clearance Process for Intrusive Activities EH&S Remediation Program*, Revision 2, dated September 24, 2004.

Prior to commencing any intrusive work, GEI and/or ADT initiated mark-outs for both public and private utilities, reviewed a number of utility drawings and plans, and applied for the necessary City permits for work at proposed investigation locations:

- ADT notified the New York City One Call Center, which coordinated the mark out of underground utilities (electric, gas, and communication) on public Right-of-Ways (ROWs) adjacent to Stuyvesant Town. USC provided non-intrusive private utility clearance at all proposed borehole locations within the property and its perimeter. GEI was on-site to identify the areas of proposed subsurface sampling, to accompany USC during the location-specific utility clearance survey, and to work with USC to identify alternate locations as appropriate.

- Con Edison provided the sewer and water utility line maps obtained from the NYCDEP for the public ROWs adjacent to Stuyvesant Town, as well as copies of Con Edison electrical and gas main utility maps for the area. A utility map of the Stuyvesant Town complex, which was previously compiled by H&A was also referenced to check the proposed sidewalk borehole/well locations. Based on information provided by Con Edison regarding H&A's work along East 14th Street and their communications with the MTA, GEI did not request a new MTA review of work planned in close proximity to H&A's previous locations.

- ADT arranged, obtained and maintained the necessary permits from the New York State Department of Transportation (NYSDOT) for soil borings/well installations (as required) and sidewalk opening/occupancy for East 14th Street, between Avenue C and Avenue B, and Avenue C, between East 14th Street and East 20th Street, for the duration of intrusive project field activities.

ADT performed the intrusive utility clearance at each of the proposed boring locations, following the public and private utility clearance activities. The intrusive clearance work was completed using a concrete saw to cut surfaces, when necessary, and a combination of hand tools and vacuum extraction for clearing the locations. The locations were cleared to a minimum five feet below grade or to refusal (i.e., obstruction), in which case the borehole was shifted and the new location cleared. The utility clearance excavations were logged for lithography, visually inspected for MGP-related impacts and field screened with a photoionization detector (PID). Grab soil samples were collected from a number of utility clearance excavations to further characterize surficial and/or shallow subsurface soil conditions. GEI collected soil and quality control samples for laboratory analysis as described in subsections 3.8 and 3.13 respectively and as summarized in Tables 3 and 4. Pertinent information associated with the utility clearance excavations is included on the soil boring logs provided in Appendix D.

Once cleared, each location was either prepared to accommodate a temporary soil gas point, as discussed in the following subsection, or backfilled with the removed materials to close the hole until drilling commenced. Spoils from the intrusive activities were containerized in

55-gallon NYSDOT-approved drums for subsequent off-site transportation and disposal, as discussed in subsection 3.12.

3.5 Soil-Gas Point Installation

GEI installed eleven temporary soil gas points and two temporary sub-slab vapor points to facilitate the collection of soil gas samples as part of the RI. GEI installed the soil gas points to screen soil vapor associated with each of the former holder stations as follows:

- ST14SV01 and ST14SV03 through ST14SV05 were installed within and adjacent to the East 14th Street Station footprint.
- ST17SV01 through ST17SV06 were installed within and adjacent the East 17th Street Station footprint.
- ST19SV01 was installed within the East 19th Street Station footprint.

The locations of soil vapor monitoring points are shown on Plate 1. Each temporary soil vapor point was installed within the utility clearance excavation for a soil boring and monitoring well location or cluster. Soil vapor points were installed at depths ranging from 3.5 to 6 feet bgs depending upon the apparent groundwater table level observed during utility clearance activities. Each soil vapor monitoring point was constructed of an expendable KVA® soil gas point, Teflon® tubing with stainless steel fittings at the surface. Soil gas points were installed within a clean sand filter that was overlain by a bentonite clay seal and backfilled with native material in general accordance with the approved RIWP and work plan addendum.

Two temporary sub-slab soil vapor locations (ST14SG01 and ST14SG02) were installed within the Underground Parking Garage #5 as shown on Plate 1. Each point was installed through a pilot hole in the concrete foundation of the underground parking garage utilizing an electric hammer drill. Each sub-slab vapor point was constructed with Teflon® tubing with stainless steel fittings at the surface. The sub-slab vapor pilot holes were backfilled with clean sand and capped with a bentonite clay seal to the surface in general accordance with the approved RIWP and work plan addendum.

3.6 Subsurface-Soil Borings

Thirteen soil borings with continuous sampling were advanced as part of the RI field program. Eight of the thirteen borings were also completed as groundwater monitoring wells. The purpose and sampling rationale for each completed soil boring are summarized in Table 3, and the locations of the borings are shown on Plate 1. The nomenclature for

identifying the borings remained consistent with that listed in Table 2 of the RIWP. The borings were located as follows:

- ST14SB01 was located within the East 14th Street Station footprint inside the Underground Parking Garage #5; ST14SB03 through ST14SB05 were located along the perimeter of the Stuyvesant Town property within the former station footprint. ST14SB06 and ST14SB08 were located east and south-southeast of the station on the eastern side of Avenue C, adjacent to the East River Generating Station.

- ST17SB01 through ST17SB04 were located within the East 17th Street Station footprint, and ST17SB05 and ST17SB06 were located southeast and south of the footprint along the eastern perimeter sidewalk of Stuyvesant Town.

- ST19SB01 was located within the East 19th Street Station footprint.

Of the borings proposed in the RIWP, only two borings were not completed:

- ST14SB02 was to be located within the Underground Parking Garage #5 between ST14SB01 and the entrance of the garage on the western side of Avenue C. Fill materials within the subsurface, particularly boulders, prevented advancement of the drilling equipment at this location.

- ST14SB07 was to be located on the eastern side of Avenue C, between ST14SB06 and ST14SB08, and was designated a contingent boring within the RIWP. The boring was not advanced during the RI due to Con Edison safety concerns from active underground and adjacent station utilities located in the vicinity of the proposed boring location.

In general, the exterior soil borings were advanced with a track-mounted hollow-stem-auger (HSA) drill rig outfitted with stainless-steel split spoon samplers. Several borings were completed by driving casing and using mud-rotary drilling methods. This alternative method was employed due to HSA drilling complications arising from characteristics of the deeper subsurface, mainly silty sands and widely-graded sands. Although mud-rotary was used at several locations, continuous split spoon sampling was maintained at each exterior boring location as originally proposed in the RIWP.

In order to accommodate access and ventilation constraints in the underground parking garage, a propane-powered Geoprobe®-type rig was utilized to obtain continuous soil cores of the subsurface. Soil cores from ST14SB01 were obtained using Macro-core® samplers outfitted with dedicated and disposable acetate liners.

ADT performed all RI drilling activities and advanced the soil borings to the target depth, or to equipment refusal, whichever occurred first. GEI logged the soils in the field in general conformance with the Unified Soil Classification System; soils were evaluated for environmental (vs. geotechnical) purposes and were not subject to field or laboratory testing to verify observed soil characteristics. Blow counts were also recorded during advancement of the split spoon samplers. PID measurements of VOC vapors were typically taken directly from the split spoon and from headspace samples, when volume was sufficient, to field screen for potential VOC impacts to the subsurface. GEI collected soil and quality control samples for laboratory analysis as described in subsections 3.8 and 3.13 respectively and as summarized in Tables 3 and 4. Soil descriptions, sample collection intervals, relevant drilling information and VOC field screening measurements are included on the individual boring logs provided in Appendix D.

Subsequent to reaching the target depth or boring refusal, ADT completed each boring with a monitoring well, as described in the following subsection, or grouted the borehole to the surface. Due to the method of drilling and conditions encountered, limited auger spoils were generated. Auger spoils and mud-rotary fluids/mix were placed in 55-gallon NYSDOT-approved drums for subsequent off-site transportation and disposal, as discussed in subsection 3.12. In addition, waste waters from the steam-cleaning of the auger flights, rods and casing, which was performed on a dedicated, lined pad within the secured equipment and waste storage area, and from the decontamination of the sampling spoons were containerized in drums for off-site disposal.

3.7 Groundwater Monitoring Well Installation

Thirteen monitoring wells were installed as part of the RI field program and were located within or adjacent to the East 14th Street and East 17th Street Stations. Eight wells were co-located in sampled soil borings. The other five wells were drilled for completing a well cluster at designated locations. The purpose and sampling rationale for each completed well are summarized in Table 3, and the locations of the wells are shown on Plate 1. The nomenclature for identifying the wells remained consistent with that listed in Table 2 of the RIWP. The wells were located as follows:

- Five wells were installed within or near the former East 14th Street Station. 14MWDD01 and 14MWDD02 were located at the southern perimeter of the property near the corner of East 14th Street and Avenue C; each of the deep wells completed a well cluster initiated during H&A's 2004 SC work. 14MWDD03 and 14MWD05/DD05 were located along the eastern sidewalk of Avenue C, between East 14th and East 15th Streets.

- Eight wells were located within or near the former East 17th Street Station. 17MWDD03 and 17MWDD04 were located on the eastern and western sides of the Avenue C Loop Road respectively; each of the deep wells completed a well cluster initiated during H&A's 2004 SC work. 17MWS05/D05/DD05 and 17MWS06/D06/DD06 were well trios located along the eastern perimeter of the property southeast and south of the former station footprint respectively.

Cluster wells were installed in zones identified as shallow (S), intermediate (D), and deep (DD) to evaluate the relationships between potentially different flow regimes beneath the RI study area and to identify and isolate potentially impacted groundwater zones. In general, shallow monitoring wells straddle the groundwater table and were installed to a depth of approximately 17 bgs. The intermediate wells were typically installed to a depth of approximately 32 feet bgs and were set to intercept the zone where soil impacts were observed by H&A, during their 2004 SC, and GEI during the RI. In general, deep monitoring wells were installed to depths at or below 50 feet bgs to intercept the zone below observed MGP-related impacts, as practical, based on lithology and/or equipment refusal.

ADT constructed and installed all RI monitoring wells. Each monitoring well was completed as a 2-inch inner diameter monitoring well with flush-threaded polyvinyl chloride (PVC) 0.010-inch slotted screen, solid PVC riser, and a flush-mounted protective cover. In general, screen lengths of 10 feet were placed at the bottom of the borehole, and the annular space between the well screen, the borehole wall, and approximately 2 feet above the screen was backfilled with a uniform silica sand filter pack. An approximately 1- to 3-foot bentonite clay seal was placed above the sand pack in each monitoring well. The remaining annular space was filled to grade with cement-bentonite grout slurry. A concrete pad surrounds each flush-mounted well cover, and each well was sealed with an expandable well cap. Table 5 provides information on well depths and elevations, top of casing information, and screen depths and elevations. RI well design is shown on the respective boring logs and are also detailed on separate well construction logs included in Appendix D.

Following installation, each monitoring well was developed to remove silt and clays from the well and to stabilize the well filter pack. Approximately 10 well volumes were evacuated from each newly installed well. Development water was placed in 55-gallon NYSDOT-approved drums for subsequent off-site transportation and disposal, as discussed in subsection 3.12.

3.8 Sample Collection and Analysis

The following summarizes the collection and analysis scope and methods for the sampling of air, soil gas, soils and groundwater during the RI. Table 3 presents the sample collection rationale and analysis for each investigation location and medium.

Quality assurance and control (QA/QC) samples were also collected during RI field sampling activities and included ambient air samples, trip blanks, blind and laboratory duplicates, and field blanks (equipment rinsates). Table 4 summarizes the number and types of QA/QC samples collected for each sample medium.

3.8.1 Indoor Air

Seven indoor air samples (IA-1E14-1 through IA-7E14-1) and one duplicate sample were collected within 5 buildings located in whole or part within the former footprint of the East 14th Street Station. The addresses of these buildings are as follows: 615 E. 14th Street, 625 E. 14th Street, 629 E. 14th Street, 635 E. 14th Street, 645 E. 14th Street, and 245 Avenue C. Each indoor air sample location was collected at or near locations sampled as part of investigation activities by RETEC in 2003. Indoor air sample locations are shown on Plate 1. Indoor air samples were generally collected over an 8-hour period at a rate of 0.2 liters per minute or less. Each sample was shipped under chain-of-custody documentation to Air Toxics in Folsom, California. Air Toxics is a NYSDOH-approved laboratory for the analyses requested during the RI. Each sample was analyzed for VOCs [including naphthalene, 2-methylpentane, isopentane (2-methylbutane), 2,3-dimethylpentane, isooctane (2,2,4-trimethylpentane), indene, indane and thiophene] by United States Environmental Protection Agency (USEPA) Method TO-15.

Air quality questionnaires and building inventory survey forms were completed at each indoor air location during the collection of the indoor air samples. Each survey was completed as discussed above within subsection 3.3.

In addition to the indoor air samples, two outdoor air samples (AMB-2 and AMB-4) were collected in the vicinity of the former East 14th Street Station site at the time of the RI indoor air sampling. The outdoor air samples were collected to evaluate ambient air conditions at the time and in the proximity of the indoor air sampling. Ambient air sample locations are shown on Plate 1.

3.8.2 Soil Gas

Thirteen soil vapor samples and one duplicate sample were collected from eleven temporary soil vapor monitoring points and two temporary sub-slab vapor points installed as part of the RI activities. Soil vapor and sub-slab installation methods employed were discussed above within subsection 3.5.

Each soil vapor sample location was sampled in general accordance with the NYSDOH Soil Vapor Guidance and approved RIWP and March 6, 2006 addendum. Each soil vapor sample location was equipped with a plastic enclosure seated within a bentonite clay seal for helium tracer-gas monitoring prior to sampling. One tubing volume of air was removed from each

soil vapor sample location prior to the sample collection. Each soil vapor sample was collected using a certified-clean Summa® canister. Each soil vapor sample was generally collected over an approximate 1-hour period with a calibrated flow controller at a rate of 0.2 liter per minute or less. Each of the two sub-slab soil vapor samples was generally collected over an 8-hour period at a rate of 0.2 liter per minute or less. Each soil vapor sample was analyzed by Air Toxics for VOCs [including naphthalene, 2-methylpentane, isopentane (2-methylbutane), 2, 3-dimethylpentane, isooctane (2,2,4-trimethylpentane), indene, indane and thiophene] by USEPA Method TO-15.

3.8.3 Surficial and Subsurface Soils

During the RI, 61 soil samples and 16 QA/QC samples were collected at thirteen soil boring locations (Plate 1). Per Table 2 of the RIWP, soil samples were collected for vertical and horizontal delineation of impacts that were observed in the field and/or indicated through analytical results as part of the SC by H&A in 2004. Based on RI field screening measurements and observations, additional soil samples were collected from borings within and/or near the former East 14th Street Station and East 17th Street Station footprints. Table 3 presents the sample location and sample collection rationale, as well as a summary of laboratory analyses completed for each soil sample. Table 4 presents a summary of investigation and QA/QC samples collected for each medium.

Soil samples were collected as grab samples from the walls of the utility clearance excavations or from split spoon recovery during drilling activities. Surface soils were collected from 0 to 0.2 feet below the vegetative root mat where "exposed" soils were present. In areas that were concealed beneath pavement or cobblestones, "surface" soils were collected from 0 to 0.2 feet below the pavement or cobblestone base.

Soil samples collected for laboratory analysis, including QA/QC soil samples, were placed directly into laboratory-supplied containers appropriate for the requested analytical suite. The samples were placed directly into coolers and preserved with ice. The samples were then transported, via courier under chain-of-custody documentation, to ChemTech of Mountainside, New Jersey, a NYSDOH-approved laboratory for the requested chemical analyses.

3.8.4 Groundwater

Twenty-eight groundwater samples from 11 well clusters, along with QA/QC samples, were collected from previously and newly installed monitoring wells as part of the RI activities. In June 2006, GEI collected groundwater samples from 13 wells installed during the H&A SC work, 13 wells installed during the RI program, and 2 wells installed during previous work associated with the East River Generating Station. Groundwater from monitoring well 14MWD02 was not sampled during the RI because accumulated non-aqueous phase liquid

(NAPL) was encountered in the bottom of the well. Monitoring well locations are shown in Plate 1. Sample collection rationale and laboratory analyses are summarized in Table 3 and a summary of investigation and QA/QC samples collected for the event is included in Table 4.

Newly installed monitoring wells were sampled approximately two weeks after their installation and development. The sampling technique used minimized stress to the aquifer by employing low flow pumping rates in order to provide representative water samples with minimal alterations to water chemistry. Prior to sampling, each well was gauged for depth to water and depth to product, if present, from the top of the well casing. Based on the measurements, field calculations were made to determine the minimum volume of groundwater to be purged from each well before sampling. Field parameters (such as temperature, conductivity, pH and turbidity) were monitored during purging to ensure that representative formation water would be sampled. Table 6 presents the depth-to-groundwater measurements for the June 2006 sampling round, and Table 7 presents the stabilized field parameters for each well at the time of sample collection. Appendix E includes the individual well purging records for the June 2006 RI sampling event.

Groundwater samples were collected and contained in laboratory-provided glassware. Samples were collected using dedicated polyethylene tubing and a peristaltic pump. Samples were collected for analysis in the following order: Target compound list (TCL) VOCs, TCL SVOCs, total and amenable cyanide, and target analyte list (TAL) metals. In cases where turbidity of the water samples exceeded the maximum NYSDEC allowable level of 50 nephelometric units (NTUs) for turbidity, two samples were collected for total and dissolved metals analysis. All samples were preserved upon collection, if necessary, and kept on ice before and during shipment to the laboratory. The samples were transported, via courier under chain-of-custody documentation, to ChemTech for analysis.

3.9 Hydrogeologic Analysis

Horizontal hydraulic conductivities were calculated using the Bower Rice Method based on in-situ (slug) tests performed on October 9 and 10, 2006 on monitoring wells 14MWS01, 17MWS04, and 14MWD01 screened in the water table and deep groundwater zones of the overburden aquifer. The tests were conducted several months subsequent to the RI groundwater sampling event due to unrelated construction activities that occurred in the interim within the vicinity of the selected wells. In-situ monitoring of aquifer conditions during the slug tests was conducted using a downhole data logger; information was supplied in real time to an on-site computer and filtered through the Win-Situ Instrument Control Software. Table 8 presents a summary of hydraulic conductivity values, and Appendix F includes the slug test data files and hydraulic conductivity calculations.

3.10 Site Survey

A site survey was performed after the RI field activities by a GEI, New York-licensed surveyor to obtain information necessary for production of a composite base map that accurately illustrates the locations and elevations of the RI borings and monitoring wells. Monitoring well elevations were determined with a vertical accuracy of 0.01 feet. The vertical datum used was North American Vertical Datum (NAVD) 88 expressed in feet above approximate MSL. The horizontal datum used was North American Datum (NAD) 83 expressed in New York State Plane Coordinate System in feet.

GEI integrated the information obtained from the site survey with the base map prepared by H&A as part of their SC work. The composite survey map was used to develop the figures and plates included in this RI Report.

3.11 Community Air Monitoring

Pursuant to the NYSDEC and NYSDOH requirements, GEI implemented a CAMP at Stuyvesant Town during utility clearance and borehole drilling. The objective of the CAMP was to provide a measure of protection for the downwind community (i.e., off-site receptors, including residences and businesses and on-site workers not involved with the site activities) from potential airborne contaminant releases as a direct result of RI field activities. GEI implemented the CAMP in accordance with the RIWP, with noted exceptions based on precipitation events and associated weather conditions.

Real-time air monitoring stations were set up downwind and upwind of the RI field work area. The downwind station was used to measure potential airborne contaminants leaving the work area during the RI activities. The upwind station measured background air quality data in the vicinity of the site work. Wind direction was determined at the start of each workday using a temporary flag and re-evaluated periodically throughout the workday to evaluate station adjustment needs.

VOCs in air were measured using a PID, and particulate dust was measured using a MIE pDR-1000AN connected to a SKC single-port low-flow module to measure PM-10 particulates. Response levels were programmed into the meters, which would trigger an alarm sound to alert site workers that targeted compounds in the ambient air had exceeded response levels. The instruments used for CAMP activities were tested and/or re-calibrated daily and were set in logging mode, which permitted storage and download of air quality measurements. The VOC and Particulate Air Monitoring Response Levels and Actions, if exceedances of those levels occurred, were included in Appendix B of the RIWP.

Additional air monitoring was implemented for work-zone air quality. Air quality was monitored within the breathing zone (4 to 5 feet above ground level) at each utility clearance

and soil boring/well location during intrusive operations. A PID was used to monitor the levels of organic vapors in the work zone during intrusive field activities. In addition, a V-Rae™ multi-gas meter was used to measure the lower explosive limit, oxygen, hydrogen cyanide, hydrogen sulfide, and carbon monoxide levels during intrusive field activities. The instruments used to measure these parameters were tested and/or re-calibrated daily before each use. Details regarding the implemented worker health and safety air-quality monitoring are provided in the HASP included in Appendix D of the RIWP.

Throughout the entire intrusive activities, GEI monitored the CAMP equipment and documented CAMP interferences, exceedances and response measures. Throughout the duration of the RI field activities, three separate incidences of a CAMP exceedance involving particulates occurred. The first was associated with the saw-cutting of the concrete and the drilling located in the parking garage. Improper ventilation was noted and drilling and other activities were halted until proper piping of exhausts and dusts was achieved. The second occurrence occurred on March 14, 2006; the upwind dust monitor recorded a four-minute exceedance, qualifying the 15-minute Time Weighted Average (TWA), which exceeded 150 mcg/m^3. Since this was recorded on the upwind monitoring station and review of the down-wind data revealed no hits, this exceedance was determined to be caused from an off-site activity. The third exceedance was noted on May 8, 2006, when there was a three-minute particulate exceedance. Upon further review of the data, the exceedance was an isolated hit and no further action was warranted.

3.12 Investigation-Derived Waste Management

IDW generated during the RI activities consisted of the following:

- Waste Type 001: concrete and debris generated during the underground utility clearance work and all disposable plastic and personal protection equipment (PPE), such as nitrile gloves, generated during the RI field program;

- Waste Type 002: soils generated during the completion of soil-vapor points, advancement of soil borings, and installation of monitoring wells; and

- Waste Type 003: liquids generated during the cleaning of drilling and sampling equipment; the development, purging, and sampling of monitoring wells; and the preparation and use of a mud-rotary mix, as well as excess grout used to backfill the annulus within monitoring wells.

A total of 103 IDW drums were generated and removed as part of the RI program: 32 drums of Waste Type 001, 29 drums of Waste Type 002, and 42 drums of Waste Type 003. The liquid and soil wastes generated during the activities were characterized to ensure proper

disposal of these materials. Table 4 summarizes the waste characterization sampling frequency and parameters for the RI.

With the exception of four drums, all containerized soils and liquids were characterized as non-hazardous under the federal and state coal-tar exemption policy. Samples collected from four drums with material generated from soil boring activities at locations ST14SB06, ST14SB08 and ST17SB06, had reported concentrations of lead by the Toxicity Characteristic Leaching Procedure (TCLP) above the respective RCRA hazardous waste criterion. The TCLP lead result from the drum composite was 21.4 milligrams/Liter (mg/L), which is above the 5 mg/L regulatory level. Although the exemption covers TCLP exceedance for benzene, there is no regulatory precedence for inclusion of TCLP lead exceedances under the policy as well. Therefore, these four drums were re-characterized as hazardous for lead and disposed of accordingly.

All IDW was stored in NYCDOT-approved 55-gallon drums and temporarily staged at one of two secured locations during the RI: (1) inside a fenced-in area at the Stuyvesant Town complex during the access agreement timeframe and/or (2) a fenced-in parking section located underneath the FDR. Clean Earth of South Kearny, New Jersey, arranged and managed transportation and disposal of the IDW drums.

GEI maintained a waste tracking summary log during the RI field program. The summary log and waste shipping records are included in Appendix G.

3.13 Quality Assurance/Quality Control

QA/QC protocols and procedures were implemented during the RI to ensure accuracy, precision, and completeness of chemical data collected during investigation activities. QA/QC samples were collected during each phase of RI sampling activities in order to evaluate the validity of the sampling, decontamination, and analytical methods used during the investigation activities.

QA/QC samples collected during field sampling activities included trip blanks, duplicates, and field blanks (equipment rinsates). Table 4 summarizes the number and types of QA/QC samples collected for each sample medium. Field duplicates consisted of two types: coded "blind" duplicates and matrix spike/matrix spike duplicate (MS/MSD) samples. Coded duplicates were split samples from the same source, analyzed by the laboratory as separate samples, with no indication given to the laboratory that the samples were duplicates. This precaution allowed GEI to verify the laboratory reproducibility of analytical data. MS/MSD samples were identified on the chain-of-custody documents so that the laboratory could perform internal quality checks on instrument performance and laboratory sample handling and preparation. Field blanks (i.e., equipment rinsates) were used to monitor the adequacy of

field equipment decontamination procedures that were used to prevent cross-contamination from one sample location to another sample location. Trip blanks were used to monitor possible sources of contamination from sample transport and storage.

Samples submitted to ChemTech for analytical characterization were evaluated and reported by the laboratory according to USEPA methodologies 8260B (VOCs), 8270C (SVOCs), 8082 (polychlorinated biphenyls [PCBs]), 6010/7000 (TAL metals), and 9012/9013 (cyanide). ChemTech provided a full data evaluation package in accordance with NYSDEC Electronic Data Deliverables requirements. Data usability was independently conducted by GEI based on the following parameters:

- Preservation and Technical Holding Times
- Calibration Verification Results
- Blanks
- Field Duplicates
- Laboratory Fortified Blank Recovery

Copies of the ChemTech data packages and data usability reports are provided in Appendix H. Data qualifiers used in the presentation of the analytical results are included with those reports.

3.14 Data Reduction and Reporting

Field observations and empirical data collected during the RI was analyzed to refine the known extent of MGP-related impacts and support remedial design, as appropriate. As stated previously, data from both H&A and RETEC investigation programs were used during evaluation of the RI data to provide a more complete interpretation of subsurface conditions. A composite base map that illustrates the locations and elevations of previous and current sampling locations was developed, along with cross-sectional views of the subsurface beneath the former station sites.

Laboratory analytical data obtained from RI soil and groundwater samples were validated to determine if the data met acceptable criteria for precision, accuracy, and completeness. Copies of the data usability reports are provided in Appendix H.

Validated RI analytical data, along with H&A's and RETEC's results, were tabulated and compared to NYSDEC criteria for each medium. The resultant database was then used to produce analytical summary plates and figures. Field observations were compared and correlated with the combined analytical data to characterize impacted areas, as discussed in the following Sections.

4. Geologic and Hydrogeologic Characterization

This section discusses the geologic and hydrogeologic characteristics of the subsurface in and adjacent to the East 14th Street, East 17th Street, and East 19th Street Station footprints. Interpretation of the subsurface characteristics is based upon specific environmental boring and monitoring well data collected during the RI and during the previous SC by H&A in 2004.

4.1 Site Geology

Four major stratigraphic units, in order of increasing depth, were identified during the investigation drilling programs: (1) fill, (2) organic deposits/peat, (3) glacial deposits, and (4) weathered bedrock (Ravenswood Granodiorite). The overburden units were previously described and characterized within the 2005 SCR prepared by H&A. Site-specific characteristics of each of the four major units are summarized below and are graphically represented on geological cross sections shown on Plates 2, 3 and 4. These cross sections were expanded from those originally provided in the H&A to include the findings of the RI and illustrate the subsurface conditions underlying each of the former MGP stations as follows:

- The East 14th Street Station geology is summarized on cross sections D-D′, E-E′ and F-F′ on Plate 2.

- The East 17th Street Station geology is summarized on cross sections A-A′ and C-C′ on Plate 3.

- The East 19th Street Station geology is summarized on cross section B-B′ on Plate 4.

Aside from encountered geologic conditions, these cross sections also depict the physical observations of MGP-related impacts and petroleum impacts related to non-MGP sources. A summary of total VOC and SVOC concentrations detected in soil and groundwater samples collected during the SC and RI are also presented on the cross sections. The distribution of chemical compounds and the observations of tar and petroleum are discussed in Section 5. Detailed geologic descriptions and monitoring well construction details are provided in boring logs and monitoring well logs, which were completed as part of the SC and RI and are included in Appendix D.

4.1.1 Fill

Fill materials and soils comprise the most extensive overburden horizon beneath Stuyvesant Town. Present immediately beneath ground and constructed surfaces of the property (e.g., landscaped areas, concrete sidewalks, asphalt pavement), fill was encountered within each of the soil borings and monitoring well boreholes completed at and adjacent to the former MGP stations. In general, the thickness of the fill horizon beneath the former MGP stations ranges from 14 feet to 47 feet. The fill consists of dark gray to black, loose, non-cohesive sand and silt, with varying amounts of gravel, cobbles, ash, clinkers, slag, brick and concrete fragments, metal fragments, wire, cloth, and wood fragments. In addition, fine-grained organic deposits and glacial deposits were also found intermingled with the anthropogenic fill materials at Stuyvesant Town.

Although evidence of significant brick debris was encountered in borings located across the three holder stations, the foundations for the former holders were not conclusively encountered during the investigations. During the SC drilling work, boring refusal on concrete or brick materials was reportedly encountered in a number of locations within and/or adjacent to the former holders of the East 14th Street and East 17th Street Stations, at depths between 11 and 28.6 feet bgs. Based on the characteristics of the materials recovered during sampling, it is uncertain whether the materials were from former holder foundations or from other building debris used in the development of the site. At the former holder locations for the East 17th Street and East 19th Street Stations, H&A reported that no holder foundation walls were encountered in the respective SC test pits, which extended 6 to 10 feet bgs.

The thickness and composition of the fill encountered beneath the three former MGP stations are consistent with and supported by the local development history of the Stuyvesant Town area. As discussed in Section 2, the Lower East Side of Manhattan underwent extensive in-filling operations during the mid to late 1800s to extend land development beyond the marsh lands and western shoreline of the East River. Infilling and grading of the area most likely transpired in stages over that time, as reflected in the overall thickness of the fill observed and the inconsistent influence of reworked native soils. Based on the gradual eastward expansion of the area, an influx and settling of native river sediments between development events would have occurred along the advancing shoreline, as evidenced in intermixed organic silts and shell deposits encountered within the fill horizon during the SC and RI. The variety of building debris (e.g., brick, concrete, metal) encountered throughout the fill further suggests on-site burying and reworking of demolition debris during general construction and redevelopment of pre-Stuyvesant Town city blocks in the early and mid 1900s. However, the most significant contribution of building-related materials to the fill was most likely from the large-scale demolition and grading activities conducted as part of Stuyvesant Town and Peter Cooper Village construction in the mid 1900s.

4.1.2 Organic Deposits/Peat

Organic deposits were encountered within and beneath the fill horizon at each of the former MGP station sites and nearby adjacent areas. The organic deposits consist of gray to black clayey silt, organic silt and brown peat. Although primarily intermingled with fill materials and difficult to identify as a distinct horizon, a relatively narrow layer of organic deposits is sporadically present beneath the fill at the former station sites. This layer was encountered in at least one investigation location at each former station site; the thickness of the organic layer appears to range from approximately 1 foot to 6 feet beneath Stuyvesant Town.

The organic deposits encountered during the environmental drilling activities are consistent with a low energy marsh/mud flat environment, which existed in the area up through the early 1800s. As stated above and in Section 2, the area was located in the East River prior to extensive infilling that occurred through the mid to late 1800s. Thus, the silt, silt-clay, clay, and peat deposits reflect the former mud flats of the shoreline and sediments of creeks and streams known to have fed the East River in this area. The inconsistencies in the presence of the horizon is most likely due to disturbances during the infilling and regarding operations that occurred to extend the shoreline eastward.

4.1.3 Glacial Deposits

Glacial deposits were encountered in the subsurface of the former MGP station sites beneath the fill horizon or organic deposits/peat layer (where present) and above the weathered bedrock. The glacial deposits consist primarily of glacial lacustrine (glacial lake) deposits that were inter-bedded and underlain in areas by layers of glacial outwash sands and glacial till. These deposits were encountered in environmental borings at Stuyvesant Town at depths ranging from approximately 16 feet to 85.5 feet bgs. Although the majority of environmental borings conducted as part of the SC and RI terminated within the fill or glacial deposits, three borings were advanced to the weathered bedrock surface within the former East 14th Street Station; samples from those borings suggest that the thickness of glacial deposits beneath portions of Stuyvesant Town is in excess of 60 feet.

The glacial lacustrine deposits consist of layers of gray to red-brown sand, varved silt and clay, clay layers and silt-sand layers. The glacial lacustrine deposits are thinnest beneath the southeast corner of the former East 14th Street Station and thickest near the eastern extent of the former East 17th Street Station. A fine-grained sand layer is generally present beneath the fill or organic deposits (where present) beneath each of the former stations. The fine-grained glacial silt and clay layers may be remnants of the historic damming of the Hudson River by the Harbor Hill Terminal Moraine to the south (Meguerian, 2003). The glacial outwash sands were encountered in isolated layers within and below the fine-grained glacial lacustrine deposits near the southeastern portion of the former East 14th Street Station. These sands

were characterized as red-brown to olive-gray sand, with fine-grained silt and clay lenses, and were encountered from approximately 30 feet to 85 feet bgs.

4.1.4 Bedrock

The inferred bedrock surface was encountered beneath the southeastern portion of the former East 14th Street Station. The bedrock surface was encountered as shallow as 49.5 feet bgs and as deep as 85.5 feet bgs. The bedrock surface was determined though split-spoon refusal and was confirmed through auger refusal. Black and white weathered rock fragments containing striations were encountered and are consistent with published descriptions of the Ravenswood Granodiorite that is reported to underlie the former East 14th Street Station. Furthermore, in published bedrock information (Baskerville, 1994), the location of the bedrock surface within the area of the former East 14th Street Station is indicated to be between 40 feet bgs to more then 80 feet bgs. The borings advanced at the former East 17th Street and East 19th Street Station sites did not extend to bedrock.

4.2 Site Hydrogeology

The site hydrogeology will be discussed below in terms of the closest surface water body (East River) and the groundwater table aquifer (Upper Glacial Aquifer) located beneath Stuyvesant Town.

The East River is located east of Stuyvesant Town from distances ranging from approximately 200-2,250 feet from the property boundaries. One groundwater aquifer (the Upper Glacial Aquifer) has been identified beneath the property. The Upper Glacial Aquifer is generally an unconfined aquifer; however, deeper portions of the aquifer exhibit leaky confined conditions (semi-confined) due to the presence of tighter silty sand and silty clay materials.

For the purposes of this RI, the Upper Glacial Aquifer was subdivided into a shallow (water table) and deep groundwater zone to evaluate groundwater flow conditions within the aquifer. Groundwater contour maps for the shallow and deep zones were created and are illustrated in Figures 5 and 6 respectively. The contour maps were created using groundwater table elevations calculated from depth-to-groundwater measurements collected on June 6, 2006, as presented in Table 6. The contour maps were used to evaluate groundwater flow and hydraulic gradients beneath Stuyvesant Town for each zone.

Horizontal hydraulic conductivities were calculated using the Bower Rice Method based upon in-situ (slug) tests performed on two monitoring wells screened in the shallow water table zone, and one well screened within the deep groundwater zone of the Upper Glacial Aquifer. A summary of hydraulic conductivities is presented on Table 8. Appendix F includes the slug test data files with the associated hydraulic conductivity calculations.

Linear flow velocities for the two groundwater zones of the Upper Glacial Aquifer were calculated using the site-specific hydraulic gradients and hydraulic conductivities. A summary of the linear flow velocities is presented on Table 8.

Finally, the potential for vertical groundwater flow between the shallow and deep overburden groundwater zones was evaluated using data from well clusters installed at each of the former MGP sites. Table 9 presents a summary of the vertical head potentials for evaluated well pairs.

4.2.1 Upper Glacial Aquifer –Shallow (Water Table) Zone

The shallow (water table) groundwater zone beneath the former East 14th, 17th and 19th Street Stations and adjacent areas resides primarily within the fill horizon. Nine monitoring wells are located in this shallow zone. As shown on Figure 5, these wells are designated with an "S" symbol, with the exception of MW10 and MW36 which were installed on the east side of Avenue C as part of previous investigation activities related to the East River Generating Station. Additionally, two shallow background monitoring wells (00MWS06 and 00MWS07), which are located to the west of the station footprints and within Stuyvesant Town, reside in fill, organic deposits and glacial deposits.

Water table elevations within the shallow zone ranged from as high as 4.75 feet NAVD, at background monitoring well 00MWS06, to as low as -0.17 feet NAVD, at 17MWS05 on the west side of Avenue C. The screened intervals within the shallow zone wells ranged between 7.25 to -10.85 feet NAVD.

As shown in Figure 5, the groundwater table in the water table aquifer generally flows east to southeast from the area of background monitoring wells (00MWS06 and 00MWS07) towards the East River. The groundwater flow beneath Stuyvesant Town may be locally affected by man-made structures and utilities and heterogeneity of fill materials, resulting in the localized perturbations in the flow direction.

The average hydraulic gradient of the shallow groundwater aquifer ranges from 0.0018 foot/foot to 0.01 foot/foot. The steepest hydraulic gradient is located in the southeast corner of the East 14th Street Station along East 14th Street. Lower horizontal hydraulic gradients are evident within the central portion of the Stuyvesant Town complex to the west of the three former MGP stations.

The hydraulic conductivity of the shallow zone of the Upper Glacial Aquifer was estimated using data generated from single well permeability tests (rising head slug tests) conducted on monitoring wells 14MWS01 and 17MWS04. These two wells are screened in a sand-and-clay fill material and silty-sand fill material. The calculated hydraulic conductivity is 15 feet per day for 14MWS01 and 169 feet per day for 17MWS04.

Average linear flow velocities for the shallow zone were calculated based on the calculated horizontal hydraulic gradients and hydraulic conductivities. The estimated average linear flow velocities range from 370 feet per year, in the central portion of the East 17th Street Station near 17MWS04, to approximately 1,825 feet per year, in the southeastern corner of the East 14th Street Station near the East 14th Street ROW and "L" line subway.

4.2.2 Upper Glacial Aquifer –Deep Groundwater Zone

The deep groundwater zone within the East 14th, 17th and 19th Street Station footprints and adjacent areas resides within fill material, organic deposits and glacial deposits. Sixteen monitoring wells are located in this deeper groundwater zone. Additionally, two background monitoring wells (00MWD06 and 00MWD07), located to the west of the former holder stations within the Stuyvesant Town complex, reside in glacial deposits.

The deep overburden groundwater zone is monitored by a cluster of monitoring wells designated "D" and "DD" that are screened as follows:

- Ten monitoring wells designated as "D" are screened as shallow as -8.17 feet NAVD (19MWD05) to as deep as -26.23 feet NAVD (14MWD05) within fill material, organic and glacial deposits.

- Seven monitoring wells designated as "DD" are screened as shallow as -29.51 feet NAVD (17MWDD04) to as deep as -52.52 feet NAVD (14MWDD03) and are primarily screened within glacial deposits at or near the East 14th and East 17th Street Stations. No "DD" well was installed at the former East 19th Street Station, and no "DD" background wells were installed.

Groundwater elevations measured within the "D" and "DD" wells ranged from as high as 4.86 feet NAVD, at background monitoring well 00MWD07, to as low as -1.85 feet NAVD, at monitoring well 17MWDD06 in the vicinity of Avenue C. Due to the lack of site-wide distribution of the "DD" wells, only the "D" wells were used in generating the contour map for the deep groundwater zone (Figure 6).

As shown in Figure 6, the groundwater in this deeper zone appears to flow eastward towards the East River. The groundwater flow beneath Stuyvesant Town may be locally affected by man-made structures and utilities and heterogeneity of fill materials, resulting in the localized perturbations in the flow direction. In addition, two sewer lines that flow from east to west bisect the Stuyvesant Town property and most likely intersect the Pollution Control Interceptor Sewer that runs along East 20th Street and south along Avenue C. Although not reflected in the "D" wells, the groundwater flow within the East 14th Street Station may be affected by the MTA subway structures and foundations for the "L" line that are located beneath the adjacent East 14th Street ROW and roadway.

The average hydraulic gradient of the deep groundwater zone within the Upper Glacial Aquifer ranges from 0.0015 foot/foot to 0.003 foot/foot. The steepest hydraulic gradient is located in the southeast corner of the East 14th Street Station along East 14th Street. Lower horizontal hydraulic gradients are evident within the eastern portion of the Stuyvesant Town complex between 17MWD04 and 17MWD06.

The hydraulic conductivity of the deep portion of the Upper Glacial Aquifer was estimated using data generated from a single well permeability test (rising head slug test). The test was conducted on monitoring well 14MWD01, which is screened in a silty-sand material. The hydraulic conductivity was calculated for 14MWD01 as 129 feet per day.

Average linear flow velocities for the deep groundwater zone were calculated based on the calculated horizontal hydraulic gradients and hydraulic conductivities. The estimated average linear flow velocities range from 235 feet per year, in the vicinity of the East 17th Street Station, to 470 feet per year, within the East 14th Street Station footprint near the East 14th Street ROW and "L" line subway.

4.2.3 Vertical Head Potentials

As discussed above, the groundwater flow for a specific aquifer or flow zone is typically depicted on a contour map that represents the potentiometric surface of the groundwater. From such a map, one can infer the direction of groundwater flow. The potential for vertical groundwater flow between aquifers, or groundwater flow zones, is often of interest in assessing how contaminants may migrate from one aquifer, or flow zone, to another. Calculation of the vertical hydraulic head differentials (vertical head potential) between two aquifers (or groundwater flow zones) provides a means to assess the potential for groundwater to migrate (either upward or downward) between separate aquifers or flow zones. It is important to note that if a confining layer is present between two aquifers (i.e., varved silt-clay (e.g., rhythmite deposits), that groundwater may not actually move across the confining layer and, therefore, the calculated vertical head potential will simply represent the difference in hydraulic pressures between the two aquifers or groundwater zones.

Vertical head potentials were calculated for well clusters screened between the shallow and deep zones of the Upper Glacial Aquifer and within well pairs screened within the deep zone of the Upper Glacial Aquifer. There is a slight downward head potential between the shallow zone and the deep zone of the Upper Glacial Aquifer for the majority of the well clusters within the East 14th, 17th and 19th Street Stations and adjacent areas. The downward head potentials ranged between -0.012 for 17MW(S/D)06 to -0.137 for 19MW(S/D)05. Slight upward potentials were present within background monitoring well cluster 00MW(S/D)07 at 0.009 and 17MW(S/D)05 at 0.053.

Both upward and downward head potentials were observed between the "D" and "DD" well pairs within the deep zone of the Upper Glacial Aquifer. Within the East 17th Street Station area, slight upward potentials were observed within 14MW(D/DD)01 at 0.003, 17MW(D/DD)03 at 0.022 and 17MW(D/DD)04 at 0.036. However, downward head potentials were noted nearby in well pairs 17MW(D/DD)05 and 17MW(D/DD)06 and at 14MW(D/DD)02 and 14MW(D/DD)05 within the East 14th Street Station footprint.

5. Nature and Extent of Impacts

The nature and extent of chemical constituents in the air, soil and groundwater are determined by a number of factors, including but not limited to the following: type and condition of current on-site structures; geologic conditions; groundwater flow patterns; subsurface utility locations and construction; historic parcel use; and processes and structures once located at each station site. In order to evaluate the nature and extent of impacts associated with the subject MGP sites, GEI reviewed and combined previous field and analytical results reported by H&A (rev. 2005) and RETEC (2003) with those of the RI. Physical evidence and analytical results were incorporated into summary tables, figures and plates to provide a more complete interpretation and analysis of site conditions. A discussion of observed impacts and the distribution of compounds detected in air, soil gas, soils and groundwater for the noted investigations is presented below for each of the three MGP holder stations. Additional information on subsurface conditions observed during the subsequent valve replacement project at Stuyvesant Town is provided in the respective summary report included in Appendix A.

5.1 Identification of Environmental Impacts

5.1.1 Physical Observations and Descriptions

Visual and olfactory observations made during the RI field investigation were characterized and recorded according to the terminology and descriptions presented below. These terms are used in this report to describe the nature of observed materials during the RI. Field findings recorded on boring logs in the H&A SCR (rev. 2005) are also included and presented in accordance with these terms. Terms used and their definitions are as follows:

- **Saturated:** the entirety of the pore space of the soil matrix for a given soil sample appeared to be filled with a NAPL. The characteristics of the observed NAPL were used in the description (i.e., tar-saturated or petroleum-saturated). This most likely represents a mobile phase.

- **Blebs:** observed discrete sphericals or pockets of NAPL were observed within a soil sample. The majority of the soil matrix did not exhibit the presence of NAPL beyond these discrete blebs. The characteristics of the observed NAPL were used in the description (i.e., tar blebs or petroleum blebs). This most likely represents a residual phase.

- **Sheen:** iridescence was observed within a soil sample. Sheens are typically noted in moist to wet soils.

- **Stained:** the soil sample exhibited a discoloration not associated with natural processes. The color of the observed stain was used and if the characteristics of the staining material were discernible, they were also noted (i.e., tar-stained or petroleum-stained).

- **Odor:** if an odor was observed, it was described based on its relative intensity and characteristics. Modifier terms such as strong, moderate, and faint or slight were used to describe relative odor intensity. Descriptive terms such as tar-like or petroleum-like odors were also used if the characteristics of the odor were discernible.

As observed, physical evidence of impacts were recorded in the field and are presented on the RI and H&A boring logs included in Appendix D. These observations are summarized on the geologic cross sections A-A′ through F-F′ shown on Plates 2 through 4. Observations made during the valve replacement project are illustrated in Figures 3 through 6 of the *Valve Replacement Project, Observation Summary Report* in Appendix A.

5.1.2 Analytical Results and Comparisons

Results from laboratory analyses of air, soil-gas, soil and groundwater samples from the RI, and from previous H&A and RETEC investigation work at Stuyvesant Town, are summarized in the tables, plates and figures of this report. The numeric results are presented in the following units:

- Air and soil-gas sample results are reported in micrograms per cubic meter ($\mu g/m^3$).

- Soil sample results are reported in milligrams per kilogram (mg/kg), which are equivalent to parts per million (ppm).

- Groundwater sample results are typically reported in micrograms per liter (µg/L), with the exception of some inorganic concentrations reported in milligrams per liter (mg/L). Parts per billion (ppb) are equivalent units to µg/L; ppm are equivalent units to mg/L.

The analytical results for the indoor air samples, soil-gas samples and subsurface-soil and groundwater samples collected during the RI were compared to applicable New York State standards. As stated, the analytical results from the H&A SCR (rev. 2005) and RETEC Air Sampling Report (2003) were reviewed and are presented along with the RI data in this report. Detected concentrations of the target compounds analyzed were compared as follows:

- Compounds detected in air and soil gas samples were compared to the NYSDOH study entitled *Summary of Indoor and Outdoor Levels of Volatile Organic Compounds from Fuel Oil Heated Homes in NYS, 1997-2003*, (NYSDOH Air Study) dated 2004. In addition, results from ambient air samples collected from Stuyvesant Town were used to evaluate the potential for soil gas versus urban air quality impacts; the ambient air sample results are presented in Table 10.

- Compounds detected in soil samples were compared to the Recommended Soil Cleanup Objectives (RSCOs), presented in the NYSDEC *Technical and Administrative Guidance Memorandum* (TAGM) *#4046*, as well as to the Site-Specific Background Values (SSBVs) presented in the H&A SCR (rev. 2005). H&A's Background Statistical Analysis was provided in Appendix B of their SCR, and is also included in Appendix I of this RI Report. Typical background concentrations of metals for the Eastern United States were also referenced to evaluate potential MGP-related impacts versus background conditions; Table 11 lists regional background PAH and metals concentrations as reported by Bradley, et. al. (1994) and Shacklette and Boerngen (1984). For surface soils, carcinogenic PAHs (polycyclic aromatic hydrocarbons) were evaluated as benzo(a)pyrene equivalents and compared against the risk-based RSCO. The benzo(a)pyrene equivalents were calculated by applying a equivalency factor to the concentration of each carcinogenic PAH and summing for a total benzo(a)pyrene equivalent value, which was then compared to the respective SSBV.

- Compounds detected in groundwater samples were compared to the NYSDEC Ambient Water Quality Standards and Guidance Values (AWQSGVs), presented in the NYSDEC *Technical and Operational Guidance Series* (TOGS) *1.1.1*. In addition, results obtained from background well sampling from the RI and from the H&A SCR (rev. 2005) were reviewed to evaluate potential MGP-related impacts versus background conditions. Analytical results from background well sampling events are presented in Table 12.

During the preparation of this report, the NYSDEC promulgated new soil cleanup standards under Title 6 of the State of New York Codes, Rules and Regulations (NYCRR) Part 375. Although these numbers were not incorporated into the data tables for purposes of this RI report, a brief comparison of the new Part 375 standards to the TAGM 4046 RSCOs was conducted. Based on the nature and extent of the SC and RI findings, it is not expected that the new soil cleanup standards will affect the overall assessment and conclusions concerning the environmental condition of the site.

In general, the analytical results for each former MGP station are discussed in terms of total VOCs and SVOCs, as well as arsenic and cyanide. Unless otherwise indicated, BTEX compounds (benzene, toluene, ethylbenzene and xylenes) comprise the majority of the total VOCs reported, while PAHs comprise the majority of the total SVOCs reported. BTEX and PAHs are groups of compounds that are commonly associated with former MGP operations as well as non-MGP sources. For purposes of this report, compounds considered when referencing PAHs include those listed below:

2-Methylnaphthalene	Pyrene
Acenaphthene	Benz(a)anthracene
Anthracene	Benzo(a)pyrene
Benzo(g,h,i)perylene	Benzo(b)fluoranthene
Fluoranthene	Benzo(k)fluoranthene
Fluorene	Chrysene
Naphthalene	Dibenz(a,h)anthracene
Phenanthrene	Indeno(1,2,3-cd)pyrene

Of the above-listed PAHs, the following constituents are considered carcinogenic PAHs by the USEPA.

Benz(a)anthracene	Chrysene
Benzo(a)pyrene	Dibenz(a,h)anthracene
Benzo(b)fluoranthene	Indeno(1,2,3-cd)pyrene
Benzo(k)fluoranthene	

Concentrations of total and amenable cyanide were also reported as part of the RI analytical program and are included in the discussions of the soil and groundwater results. Cyanide is included as it was a common by-product of the gas purification process.

The analytical results tables are summarized and organized by sample medium and station, as listed below, and include the H&A SC results, RETEC air sampling results and GEI RI results.

- **East 14th Street Station Media:** Tables 13 and 16 through 18 summarize the detected laboratory analytical results for air and soil gas samples, subsurface soil samples and groundwater samples collected at or near the East 14th Street Station site.

- **East 17th Street Station Media:** Tables 14 and 19 through 21 summarize the detected laboratory analytical results for air and soil gas samples, subsurface soil samples and groundwater samples collected at or near the East 17th Street Station site.

- **East 19th Street Station Media:** Tables 15 and 22 through 24 summarize the detected laboratory analytical results for air and soil gas samples, subsurface soil samples and groundwater samples collected at or near the East 19th Street Station site.

- **Statistical Summaries:** Tables 25 through 33 present statistical summaries of the analytical results for soil and groundwater for each of the three former MGPs.

To complement the analytical summary tables, analytical exceedances in soils and groundwater are also summarized and illustrated in Plates 5 through 12. Appendix H presents the data usability report and an electronic data deliverable of the chain-of-custody forms, laboratory generated Form Is, and data validation reports for the RI.

5.2 Former East 14th Street Station Investigation Results

5.2.1 Indoor Air and Soil Gas

Indoor air samples were collected from crawlspaces, stairwells, and other interior areas within 615, 625, 629, 635 and 645 East 14th Street and 245 Avenue C by RETEC in January 2003 and GEI in March 2006. GEI sample locations were set to duplicate those of RETEC, to the extent possible, based on available information. The findings of the GEI indoor air survey, conducted prior to the indoor sampling round, are provided on the respective forms within Appendix C. The sample locations are shown on Plate 1, and the analytical results are summarized in Table 16.

Soil gas was also sampled by RETEC in 2003 and by GEI in 2006 within and adjacent to the former East 14th Street Station. RETEC collected two soil vapor samples from beneath the underground parking garage slab (Garage #5). GEI collected six soil gas samples from the station site: two were collected near the RETEC sample locations as sub-slab vapor samples, and four were collected as slightly deeper soil gas samples. Soil gas sample locations are shown on Plate 1, and the analytical results are summarized in Table 16.

Volatile organic compounds that are common to both petroleum materials and MGP byproducts, as well as compounds specifically related to gasoline and chlorinated solvents, were detected within the indoor air and soil gas samples. The distribution and magnitude of many of these compounds differ between the two types of sampled media, while indoor and outdoor air samples (Table 10) contained similar constituents and concentrations.

For indoor air, benzene concentrations for all fifteen air samples ranged from non-detect to 13 $\mu g/m^3$ and were at or below the NYSDOH Air Study's 75th percentile for benzene of 13 $\mu g/m^3$. In general, other detected BTEX compounds in both the RETEC and GEI air samples were only slightly above the NYSDOH Air Study's 75th percentile and were at or below the

respective 95th percentile with few exceptions. In comparison, benzene concentrations in soil gas samples collected from beneath or adjacent to the sampled buildings ranged from non-detect to 150 µg/m^3. Other BTEX compounds were typically present within the soil gas samples at concentrations at least one order of magnitude higher than those reported in the indoor air samples.

Several constituents that were present in soil gas at significant concentrations were generally absent in the indoor air samples. For example, carbon disulfide and cyclohexane in soil gas were detected at concentrations ranging from 9 µg/m^3 to 746 µg/m^3, and 7 µg/m^3 to 230 µg/m^3, respectively. Carbon disulfide was detected in only two indoor air samples and at a maximum concentration of 8 µg/m^3, while cyclohexane was not detected in any of the indoor air samples. Moreover, concentrations of MTBE and other gasoline-related additives were detected in soil gas at concentrations up to three orders of magnitude greater than respective concentrations, when detected, in indoor air samples.

In comparing the indoor air results with the soil gas and ambient air sample results, it appears that the chemical constituents and concentrations in indoor air more closely reflect the ambient air quality than that of the subsurface soil gas.

5.2.2 Soils

Soils within and adjacent to the former East 14th Street Station footprint were collected from beneath building structures, concrete or asphalt pedestrian paths and ROWs, and landscaped areas. The SC and RI investigation locations from which the soil samples were collected are shown on Plate 1, and field observations are graphically depicted on the subsurface profiles of Plate 2. Surficial and subsurface soil sample analytical results are summarized in Tables 13 and 17 respectively, and statistical analytical summaries are presented in Tables 25 and 26 respectively. Analytical exceedances of RSCOs and SSBVs for surficial and subsurface soil sample results are depicted on Plates 6 and 7 respectively, and are summarized by depth horizons in Figures 8 through 10. A discussion of the investigation field observations and laboratory findings concerning soils at and adjacent to the former East 14th Street Station is presented below.

Surficial Soils

As discussed in previous sections, the soils immediately beneath the constructed and landscaped surfaces are fill materials, which extend to approximately 14 to 25 feet bgs in this area. Surface samples taken from within the former East 14th Street Station were collected beneath concrete, cobblestone or landscaped surfaces and did not exhibit evidence of MGP-related impacts. As shown in Table 13, detected VOCs and non-carcinogenic PAHs were below both the respective RSCOs and SSBVs in the surficial soil samples. Concentrations of individual carcinogenic PAHs and several metals in the surface soil samples were generally

consistent across the site but exceeded the individual RSCOs and SSBVs. The benzo[a] pyrene (BaP) equivalents concentrations within surface soils for the carcinogenic PAHs ranged from 1 mg/kg to 14 mg/kg, which met or exceeded the SSBV of 1 mg/kg. The total SVOC concentrations in the samples exceeding for BaP ranged from 13 mg/kg to 123 mg/kg, which fall well below the TAGM 4046 threshold of 500 ppm for total SVOCs.

Due to the urban setting and historic commercial/industrial use of this station site and adjacent properties, concentrations of carcinogenic PAHs and metals within surface soils were also compared to New England urban soil background levels and/or Eastern United States background values, as referenced and summarized in Table 11. All detected carcinogenic PAH concentrations within surface soil samples were within the reported range of background PAH levels for comparative urban soils with the exception of those within sample 14GH007, which was collected beneath the floor of the parking garage near the corner of East 14th Street and Avenue C. With regards to metals that exceeded the RSCOs and/or SSBVs, respective concentrations were within the researched background concentration ranges with the exception of copper and lead. These compounds are typically not associated with MGP operations and are most likely related to the type and quality of fill materials present at the site.

Subsurface Soils

Physical evidence of MGP-related impacts, that is blebs, staining, and MGP-like odors, were observed below 10 feet of grade at SC and RI borings adjacent to former holder locations, as shown on Plate 2. These impacts were generally observed in soils from borings along East 14th Street (the south side of the former holders). Heavier MGP-related impacts, that is, tar-saturated soils, were observed in isolated and discrete depths within and immediately adjacent to the former northernmost gas holders, specifically within 14GH004 between 24 and 28 feet bgs, and 14GH007 between 14 and 15 feet bgs. An isolated tar-saturated lens was also present at location ST14SB06 (corner of Avenue C and East 15th Street) from approximately 25 to 26 feet bgs; based upon non-impacted soils along the western ROW of Avenue C, as shown on cross section E-E′ (Plate 2), this lens appears to be associated with the former East 14th Street Works located to the east of Avenue C.

Petroleum-like impacts were observed in several perimeter investigation locations. Petroleum-coated and stained soils were encountered at or near the water table at ST14SB05 (along East 14th Street) and as deep as 36 feet bgs within ST14SB01 (northwest corner of East 14th Street and Avenue C). Petroleum-like, oil-coated and stained soils were also encountered at sample location ST14SB06 within the Avenue C ROW (east side) and may be associated with historic petroleum releases.

During H&A's SC, laboratory fingerprint analysis was completed on three soil samples that exhibited elevated PID readings and/or petroleum-like or gasoline-like odors. These samples were collected from locations 14GH002, 14GH009, and 14PH001. Samples from 14GH002 and 14GH009 were collected as surface samples directly beneath the parking garage floor and exhibited fingerprint patterns suggesting highly-weathered coal tar and/or motor-oil type contaminants were present within these soils. The fingerprint analysis of 14PH001, which exhibited a gasoline (petroleum-like) odor within the sampled 13-15 feet bgs interval, showed chemical signatures that were consistent with a #6 fuel oil.

In general, the highest concentrations of total VOCs and SVOCs detected in investigation subsurface soil samples were associated with soils that exhibited observable MGP-related impacts in the form of residual tar, blebs, or staining. In such cases, the total BTEX and total PAH concentrations were the primary contributors to the total VOC and total SVOC concentrations in the samples. In comparison, sample locations exhibiting MGP-type odors only or no apparent MGP-related impacts generally yielded total VOC and total SVOC concentrations at least one to two orders of magnitude below the TAGM 4046 10 ppm and 500 ppm threshold respectively, as illustrated in the cross sections of Plate 2.

Specifically, concentrations of total VOCs and SVOCs in the vicinity of the gas holders ranged from not detected within fill and deeper glacial deposits to 1,177 mg/kg and 7,927 mg/kg, respectively. The on-site maximum for total VOCs and total SVOCs occurred at 14GH004 (Table 17) and was within an observed tar-saturated lens at 24 to 26 feet bgs. The highest total VOC and SVOC detections of 1,520 mg/kg and 15,213 mg/kg occurred at sample location ST14SB06 (Table 17) and was within a tar-saturated lens within 24 to 25 feet bgs. Based on the location of the boring near the southeast corner of Avenue C and East 15th Street, this lens is more likely associated with historic impacts from the adjacent former East 14th Street Works rather than the former East 14th Street Holder Station located at Stuyvesant Town.

RSCO and SSBV exceedances of individual VOC and SVOC concentrations in the East 14th Street Station subsurface investigation samples are summarized on Plate 7. Individual compound exceedances of BTEX and PAHs were reported in shallow fill materials (2-7 feet below surface) and within the above-mentioned intervals of observed MGP-related impacts. In addition, a number of metals not associated with MGP operations were detected above the RSCOs and SSBVs in both the fill and native overburden horizons beneath the site, primarily at the perimeter of and adjacent to the former station footprint.

Arsenic concentrations ranged from not detected within native materials at soil borings ST14SB01, -03, -04, and -08 to 17.8 mg/kg in ST14SB01 (12 to 16 feet bgs) within fill material beneath the underground parking garage (Table 17). This concentration of arsenic exceeded the SSBV concentration and RSCO value.

Cyanide was not detected in approximately 75 percent of the subsurface soils analyzed at the East 14th Street Station (Table 17). Detected cyanide concentrations ranged from 0.77 mg/kg to 8.56 mg/kg, with the exception of 56 mg/kg detected in sample 14PH002 (5 to 7 feet bgs). Detected cyanide concentrations were above the SSBV concentration of 0.705 mg/kg.

5.2.3 Groundwater

During the RI, groundwater was collected from two groundwater monitoring well clusters 14MWS01/D01/DD01 and 14MWS02/D02/DD02 within the East 14th Street Station footprint and two monitoring well clusters MW36/14MWDD03 and MW10/ 14MWD05/DD05 within the ROW along the eastern side of Avenue C (Plate 8). As discussed within subsection 3.8.4, monitoring well 14MWD02 was not sampled during the RI because tar-like NAPL was encountered during well gauging activities in preparation for the June 2006 sampling event. Monitoring well clusters 14MWS01/D01 and 14MWS02/D02 were previously sampled in 2004 as part of the H&A SC work. The analytical results from both groundwater events are summarized in Table 18, and a statistical summary analysis of results is presented in Table 27. A summary of detected compounds exceeding regulatory standards for both events is depicted on Plate 8, and a summary of the June 2006 event is shown in Figure 11.

Shallow (Water Table) Zone

As presented in Table 18 and on Plate 8, several BTEX and PAH compounds in exceedance of the NYSDEC AWQSGVs were present in groundwater samples collected from 14MWS02 in both 2004 and 2006. In 2004, total VOCs and total SVOCs were detected in groundwater at 29,940 µg/L and 11,529 µg/L respectively at 14MWS02, which is located on the south side of the former holders. Downgradient of the former holders at 14MWS01, total VOC and total SVOC concentrations in groundwater decreased to 4 µg/L and 0.4 µg/L, respectively, for the same sampling event. H&A installed 14MWS02 as part of the SC work and screened across soils that exhibited gasoline and petroleum odors that were characteristic of #6 fuel oil, which suggests that the shallow zone groundwater is influenced by non-MGP sources. Although results indicate that total VOC and SVOC concentrations in groundwater from 14MWS02 dropped significantly between the 2004 and 2006 sampling events, the overall concentrations of BTEX and PAHs remained higher within 14MWS02 than in 14MWS01 (Table 18).

Downgradient of the East 14th Street Station across Avenue C, only a trace detection (an estimated 0.4 µg/L) of xylene was present within groundwater at MW10 during the RI event. Total PAH compounds and the VOCs of benzene, toluene and ethyl benzene were not detected downgradient of the East 14th Street Station within monitoring well MW10. Trace concentrations of MTBE and non-carcinogenic PAHs were detected in the sample from

MW36. Benz(a)anthracene was detected within the MW36 sample at 1.5 µg/L, which exceeded the AWQSGVs.

Across the two sampling events, cyanide concentrations ranged between non-detect at MW10 to 3.6 mg/L at 14MWS02, which is below the established AWQSGV of 200 mg/L. Total arsenic was detected at concentrations ranging from non-detect to 6.2 µg/L at 14MWS02 and which are all below the applicable standard of 25 µg/L.

Deep Overburden Groundwater Zone

Total VOCs and total SVOCs were generally present at the highest concentrations in the deeper screened wells 14MWD02/DD02, which are located on the south side of the former gas holders, and decreased in comparable wells to the southeast. Within the 2004/2006 samples from the 14MWD02/DD02 monitoring wells, total VOCs were detected at concentrations of 10,850 µg/L and 9,761 µg/L respectively, and total SVOCs were detected at concentrations of 11,713 µg/L and 4,204 µg/L respectively (Table 18). Downgradient of the former holders at wells 14MWD01/DD01, total VOC concentrations within associated groundwater samples decreased to a range of 339 µg/L (14MWD01, 2004) to 3,898 µg/L (14MWD01, 2006). Total SVOC concentrations fluctuated between sampling events in the range of 246 µg/L (14MWD01, 2004) and 6,510 µg/L (14MWDD01, 2006). Downgradient of the former East 14th Street Station site (i.e., across Avenue C), the 14MWD05/DD05 cluster yielded samples in 2006 with a total VOC concentration of less than 2 µg/L and a total SVOC concentration of less than 9 µg/L (Table 18). While groundwater from 14MWDD03 had an elevated total VOC concentration of 1,058 µg/L and total SVOC concentration of 848 µg/L, this well is located on the east side of Avenue C and cross- and/or downgradient of the on-site and 14MWD05/DD05 well clusters; therefore, associated concentrations may be indicative of historic releases associated with the adjacent East 14th Street Works.

As expected, the highest VOC and SVOC, and highest BTEX and PAH concentrations respectively, were detected in samples from wells that were screened across soils exhibiting MGP-related impacts. The highest BTEX and PAH concentrations occurred in groundwater from monitoring well 14MWD02, screened at 22 to 32 feet bgs, which was adjacent to soils that exhibited black staining, sheen, blebs, and veins of tar during the 2004 SC; this well was not sampled in 2006 due to accumulated NAPL in the bottom of the well. Elevated concentrations of BTEX and PAHs were present within groundwater samples from monitoring well 14MWDD02, which was screened in soils with naphthalene-like odors, and from well 14MWDD01, which was screened across soils with an observed sheen and naphthalene-like odors. Individual BTEX and/or PAH compounds detected within 14MWD01/DD01 and 14MWD02/DD02 exceeded established AWQSGVs, as shown on Plate 8.

Cyanide was detected within groundwater samples from monitoring wells 14MWD01/DD01, 14MWD02/DD02, 14MWDD03, and 14MWDD05 at concentrations ranging from 0.01 mg/L (14MWDD03) to an estimated 0.68 mg/L (14MWDD02), which were below the established AWQSGV of 200 mg/L. Total arsenic concentrations ranged from not detected to an estimated 11.8 µg/L (14MWDD03), which is below the AWQSGV of 25 µg/L.

5.3 Former East 17th Street Station Investigation Results

5.3.1 Indoor Air and Soil Gas

Two indoor air samples, and a field duplicate, from within the 16 Stuy Oval building were collected as part of the January 2003 indoor air sampling activities by RETEC. The 16 Stuy Oval building is the only building located within the footprint of the two gas holders of the former East 17th Street Station. Soil gas was also sampled by RETEC in 2003 and by GEI in 2006 within and adjacent to the former East 17th Street Station. The indoor air and soil gas sample locations are shown on Plate 1, and the analytical results are summarized in Table 19.

BTEX compounds, acetone, ethanol and a few chlorinated compounds were detected in the indoor air samples. Benzene was detected at concentrations ranging from 3 µg/m^3 to 4 µg/m^3, which is well below the NYSDOH Air Study's 75th percentile for benzene of 13 µg/m^3. Other individual BTEX compounds were also below the NYSDOH Air Study's 75th percentile, with one exception: m, p-xylene concentrations were slightly above the respective 75th percentile, but below the 95th percentile, in sample STY-1A-2E17. Ethanol was the highest concentration VOC detected in the indoor air samples; ethanol was reported at a concentration of 1,100 µg/m^3 in STY-1A-2E17, which is above the respective NYSDOH Air Study's 75th percentile, and below the 95th percentile. This concentration was two to three orders of magnitude greater than that detected in soil gas samples. The chemicals present and concentrations detected in indoor air were similar to those within the ambient (outdoor) air samples collected as part of the January 2003 sampling activities (Table 10).

Soil gas samples collected within and adjacent to the former station footprint contained many of the same constituents as the indoor air; however, the magnitude of these compounds and distribution of other chemical compounds in the subsurface were inconsistent among the soil gas samples and between the soil gas and indoor air samples. Benzene concentrations ranged from 5 µg/m^3 to 192 µg/m^3 in the soil gas samples. Concentrations of other BTEX compounds were generally higher in soil gas than indoor air samples, although two of the seven soil gas samples did not exhibit detectable concentrations of ethylbenzene or xylenes. Other VOCs detected in the indoor air samples were detected at both higher and lower concentrations in the soil gas samples, with no clear relationship apparent. Furthermore,

carbon disulfide, cyclohexane, heptane and MTBE were among compounds detected in soil gas samples that were not reported present in indoor air.

5.3.2 Soils

Soils within and adjacent to the former East 17th Street Station footprint were collected from beneath building structures, concrete or asphalt pedestrian paths and ROWs, and landscaped areas. The SC and RI investigation locations from which the soil samples were collected are shown on Plate 1, and field observations are graphically depicted on the subsurface profiles of Plate 3. Surficial and subsurface soil sample analytical results are summarized in Tables 14 and 20 respectively, and statistical analytical summaries are presented in Tables 28 and 29 respectively. Analytical exceedances of RSCOs and SSBVs for surficial and subsurface soil sample results are depicted on Plates 6 and 9 respectively, and are summarized by depth horizons in Figures 12 through 14. A discussion of the investigation field observations and laboratory findings concerning soils at and adjacent to the former East 17th Street Station is presented below.

Surficial Soils

As discussed in previous sections, the soils immediately beneath the constructed and landscaped surfaces are fill materials, which extend to approximately 22 to 47 feet bgs in this area. As shown in Table 13, detected VOCs and non-carcinogenic PAHs were below both the respective RSCOs and SSBVs in the surface soil samples. Concentrations of individual carcinogenic PAHs in the surface soil samples were generally consistent across the site but slightly exceeded the individual RSCOs and/or SSBVs. The BaP equivalents concentrations within surface soils for the carcinogenic PAHs ranged from 0.2 mg/kg to 4 mg/kg, with 11 of the 23 samples having BaP equivalents concentrations less than the SSBV of 1 mg/kg. The total SVOC concentrations in the samples exceeding for BaP ranged from 11 mg/kg to 35 mg/kg, which fall well below the TAGM 4046 threshold of 500 ppm for total SVOCs. Several metals were also detected above respective RSCOs and/or SSBVs, but concentrations were generally consistent across the site.

Due to the urban setting and historic commercial/industrial use of this station site and adjacent properties, concentrations of carcinogenic PAHs and metals within surface soils were also compared to New England urban soil background levels and/or Eastern United States background values, as referenced and summarized in Table 11. All detected carcinogenic PAH concentrations within surface soil samples were within the reported range of background PAH levels for comparative urban soils. With regards to metals that exceeded the RSCOs and/or SSBVs, respective concentrations were within the researched background concentration ranges listed in Table 11.

Subsurface Soils

Physical evidence of MGP-related impacts, in the form of tar-like sheens and/or staining, were observed in a few SC and RI investigation locations at the former station at depths generally greater than 20 feet bgs. Isolated intervals of tar staining and/or sheens were observed within the fill and organic deposits beneath the former holder locations and adjacent areas within the East 17th Street Station footprint, particularly at locations 17CY006, 17GH006 and ST17SB04 (Plate 3). These MGP-related impacts were typically encountered within soils between 26 feet and 29 feet bgs. Naphthalene-like odors were observed in the vicinity of these isolated lenses as well as within fill materials from several boring conducted in the vicinity of the former southernmost gas holder. To the east of the Avenue C Loop Road (downgradient of the former holders), naphthalene-like odors were the only MGP-related impacts observed within subsurface soils.

Sporadic wood chips (possible purifier materials) were encountered within fill material at six boring locations – ST17SB03, ST17SB04, 17GH002, 17GH005, 17CY006 and 17CY007 (Plate 1) – and at depths ranging from approximately 7 feet to approximately 25 feet bgs. Based upon the depths, it appears these materials were potentially incorporated into fill used for the development of the site and may have been whole or partially imported from other local fill sources during historic property-wide grading operations.

Petroleum-like odors and staining were encountered in several borings upgradient and within the former station footprint (Plate 3). Petroleum-related impacts were noted at or near the apparent water table near 17MWS04 and as deep as 32 feet within the fill at ST17SB04. During the SC, laboratory fingerprint analysis was completed on four subsurface soil samples, collected from with the fill horizon that exhibited petroleum-like, gasoline, or paint-thinner odors. The fingerprint analysis of 17GH001, collected from 17 to 19 feet bgs, indicated that fill soils contained chemical signatures that are consistent with petroleum products similar to #2 or #4 fuel oil. Analysis of 17CY007, collected from 14 to 16 feet bgs, yielded results suggesting potential coal tar and/or motor oil contaminants present in the sample. Motor oil was also the suspected contaminant source in sample 17MWS04, which was collected from 2 to 4 feet bgs. Analysis of 17CY010, collected from 9 to 11 feet bgs, yielded results suggesting #2 fuel oil impacts were present in the sample and potentially commingled with low-level, weathered coal tar residues.

In general, the highest concentrations of total VOCs and SVOCs were associated with subsurface soils that exhibited observable MGP-related staining and/or sheens. In such cases the total BTEX and total PAH concentrations were the primary contributors to the total VOC and total SVOC concentrations in the samples. In comparison, sample locations exhibiting MGP-type odors only or no apparent MGP-related impacts generally yielded total VOC and

total SVOC concentrations at least one to two orders of magnitude below the TAGM 4046 10 ppm and 500 ppm threshold respectively, as illustrated in the cross sections of Plate 3.

In the vicinity of the former gas holders, concentrations of total VOCs ranged from less than 1 mg/kg within fill samples collected at sample locations 17GH001 through 17GH006 and ST17SB01 through ST17SB03 to 1,149 mg/kg at ST17SB04 (Table 20). The high VOC concentration in ST17SB04 was within a tar-stained fill interval at 27 to 29 feet bgs. Only one other sample exceeded the TAGM 4046 threshold of 10 ppm for total VOCs: the sample, collected from soils exhibiting a tar-like staining/sheen from 25 to 25.5 feet bgs in 17CY006, yielded a total VOC concentration of 39 mg/kg. Aside from the two samples mentioned, all other SC and RI subsurface soil samples from within and adjacent to the former East 17th Street Station footprint had total VOC concentrations below the TAGM 4046 threshold of 10 ppm.

Total SVOC concentrations ranged from non-detect to a maximum of 2,253 mg/kg, within the 27 to 27.8 feet bgs sample from 17GH005 (Table 20). This boring was located within the former southernmost gas holder, and the sample exhibited heavy tar-like staining. Only one other sample exceeded the TAGM 4046 threshold of 500 ppm for total SVOCs: the sample, collected from soils exhibiting a tar-like staining from 27 to 29 feet bgs in ST17SB04, yielded a total SVOC concentration of 887 mg/kg. As stated above, this sample also exceeded the total VOC threshold of 10 ppm. Aside from the two samples mentioned, all other SC and RI subsurface soil samples from within and adjacent to the former East 17th Street Station footprint had total SVOC concentrations below the TAGM 4046 threshold of 500 ppm.

RSCO and SSBV exceedances of individual VOC and SVOC concentrations in the East 17th Street Station subsurface investigation samples are summarized on Plate 9. Individual compound exceedances of PAHs were reported in shallow fill materials within and adjacent to the former station footprint and within the above-mentioned intervals of observed MGP-related impacts. Individual compound exceedances of BTEX were confined to discrete intervals of observed MGP-related impacts below 20 feet bgs. In addition, a number of metals not associated with MGP operations were detected above the RSCOs and SSBVs in both the fill and native overburden horizons beneath the site and site perimeter.

Arsenic concentrations ranged from non-detect within native materials at soil borings ST17SB01, ST17SB02, ST17SB04, and ST17SB06 to 21.5 mg/kg in the 17CY008 (2 to 4 feet bgs) sample from within shallow fill material, and exceeded the RSCO and SSBV within fill at several sample locations within and adjacent to the station footprint (Plate 9).

Cyanide was not detected in approximately 80 percent of the subsurface soils analyzed from the East 17th Street Station site (Table 20). The five detections of cyanide ranged from

0.0891 mg/kg to 2.17 mg/kg, with the exception of the concentration detected in sample ST17SB04 (27 to 29 feet bgs) of an estimated 96 mg/kg. These concentrations were above the SSBV of 0.705 mg/kg for cyanide (Plate 9).

5.3.3 Groundwater

As part of the RI, groundwater was collected from two well clusters within the former East 17th Street Station, 17MWS04/D04/DD04 and 17MWS03/D03/DD03, and from two well clusters within the Avenue C ROW, 17MWS05/D05/DD05 and 17MWS06/D06/DD06 (Plate 10). Monitoring wells 17MWS03/D03 and 17MWS04/D04 were also previously sampled in 2004 as part of the SC. The analytical results from both groundwater events are summarized in Table 21, and a statistical analysis of results is presented in Table 30. A summary of detected compounds exceeding regulatory standards for both groundwater events is depicted on Plate 10, and a summary for the June 2006 event is shown on Figure 15.

Shallow (Water Table) Zone

As presented in Table 21 and Plate 10, total VOC and SVOC concentrations for groundwater samples collected from the water table wells within and adjacent to the former holder station ranged from non-detect to 160 µg/L (VOCs) and 1,099 µg/L (SVOCs) for 17MWS03. Only a few VOCs and SVOCs were detected in groundwater samples collected from the water table wells within the former station footprint. Well 17MWS04, which was located adjacent to a former holder and is screened within petroleum-stained soils, yielded groundwater samples exhibiting a trace concentration of benzene (0.3 µg/L) and exceedances of three PAHs in 2004, but yielded groundwater samples exhibiting no detectable VOCs or SVOCs in 2006. Downgradient of the holders within 17MWS03, total VOC concentrations increased from 60 µg/L to 160 µg/L in the 2004 and 2006 samples respectively, with benzene remaining an order of magnitude above the NYSDEC AWQSGV and xylene just exceeding the criteria in the 2006 sample. Total SVOC concentrations in the 2004 and 2006 groundwater samples from the same well were 12 µg/L and 8 µg/L respectively, with no individual PAHs exceeding the AWQSGVs. Concentrations of SVOCs within groundwater from 17MWS03 and 17MWS04 were generally lower for the 2006 RI sampling event than the 2004 SC sampling event. With the exception of trace amounts of chloroform, VOCs and SVOCs were not detected within 17MWS05 and 17MWS06 groundwater samples taken during the RI sampling event (Table 21).

Total cyanide was generally detected at higher concentrations within the groundwater samples from 17MWS04 than within samples from 17MWS03. Cyanide concentrations ranged between 0.014 mg/L at 17MWS05 to 0.085 mg/L at 17MWS04. These concentrations are well below the established AWQSGV of 200 mg/L. Total arsenic was detected in the 17MWS04 sample at 9.2 µg/L and within the 17MWS06 sample at an estimated 14.4 µg/L, which are below the AWQSGV of 25 µg/L.

Deep Overburden Groundwater Zone

As shown in Table 21 and Plate 10, detectable VOC and SVOC concentrations are generally lower in the deeper groundwater zone beneath the East 17th Street Station. The notable exception to this trend is the 2004 sample from 17MWD04, which yielded a total VOC concentration of 4,830 µg/L and a total SVOC concentration of 2,413 µg/L. Moreover, each of the BTEX compounds within that sample exceeded their respective AWQSGV by at least two orders of magnitude and a number of PAHs also exceeded their AWQSGVs. The 2006 groundwater sample from this well showed benzene and ethylbenzene in exceedance of the AWQSGVs, but with a total VOC concentration of only 61 µg/L and a total SVOC concentration of 148 µg/L. The VOC and SVOC concentrations within groundwater from 17MWD03 and 17MWD04 are otherwise generally similar in magnitude, with exceedances primarily seen in the BTEX compounds. Likewise, BTEX concentrations in groundwater from the deeper 17MWDD04 well persist at only slightly above the criteria. Benzene is also reported slightly above the criteria in groundwater from the deep well 17MWDD03. SVOCs were not detected in samples from either of these two deeper wells installed and sampled in 2006. Downgradient of the station footprint, BTEX and PAH concentrations were not detected or found at trace concentrations in samples from 17MWD06/DD06 and 17MWDD05. In groundwater from 17MWD05, only benzene, naphthalene and four chlorinated compounds exceeded the AWQSGVs for the VOC and SVOC compounds.

Cyanide was detected within groundwater from monitoring wells 17MWD04/DD04, 17MWD03, and 17MWD05 at concentrations ranging between 0.016 mg/L (17MWD05) to 4.7 mg/L at (17MWD04), which are below the established AWQSGV of 200 mg/L. Arsenic was only detected in groundwater from 17MWD05 and 17MWD03 and ranged in concentration from an estimated 12.3 µg/L to 16 µg/L respectively, which is below the established AWQSGV of 25 µg/L.

5.4 Former East 19th Street Station Investigation Results

The RI activities conducted at the former East 19th Street Station was intended to provide physical and analytical confirmation regarding the absence of media impacts attributable to the former holder station. Both the RETEC and H&A reports for the former station site indicated that the limited, low-level impacts identified at and near the site were most likely attributable to other urban sources. Therefore, the majority of the physical and analytical investigation findings summarized and discussed below have been previously presented in reports submitted to and approved by the NYSDEC.

5.4.1 Indoor Air and Soil Gas

Although not sampled as part of the RI, the indoor air was sampled within a crawlspace of 524 East 20th Street (STY-IA-1E19) and within the stairwell of 522 East 20th Street (STY-IA-

2E19) as part of the January 2003 indoor air sampling activities conducted by RETEC. The sampled building is located at the site of the former East 19th Street Station gas holder. RETEC collected one soil gas sample (SG-1-E19) in August of 2003 and GEI collected one soil gas sample (ST19-SV01) in March of 2006. The indoor air and soil gas sample locations are illustrated on Plate 1, and the analytical results are summarized on Table 22.

Several chlorinated compounds, chloroform, acetone and xylenes were present in the crawlspace sample at concentrations only slightly above the NYSDOH Air Study's 75th percentile. Benzene was present in the two samples at concentrations of 3 $\mu g/m^3$ and 5 $\mu g/m^3$, which is well below the 75th percentile for benzene of 13 $\mu g/m^3$. VOCs in the stairwell sample were detected at similar, or in some cases higher, concentrations as those in the crawlspace sample. BTEX concentrations within the indoor air samples ranged from 25.1 $\mu g/m^3$ at sample location STY-IA-2E19 to 30.9 $\mu g/m^3$ at sample location STY-IA-1E19. BTEX compounds were detected within outdoor ambient air samples at concentrations ranging from 15.8 to 26.6 $\mu g/m^3$ (Table 10), suggesting a strong correlation between outdoor and indoor air quality. Naphthalene was detected at 18 $\mu g/m^3$ at sample location STY-IA-1E19 within the crawlspace. According to RETEC, this compound was possibly associated with residential activity, such as the use of naphthalene-containing mothballs within an adjacent trunk room storage area and/or maintenance activities within the building.

Soil gas samples collected at the former East 19th Street Station contained higher concentrations of each of the BTEX compounds than those reported for the indoor air samples; however, the presence and concentrations of other VOCs in soil gas appear inconsistent with the presence and concentrations of VOCs in the indoor air samples. A number of VOCs were found present in soil gas that were not detected in the indoor air samples, while compounds like ethanol and 2-propanol were detected at higher concentrations in indoor air samples than in the soil gas samples.

As indicated in the RETEC report, the low concentrations of VOCs detected within indoor air at the East 19th Street Station appear to be linked to outdoor air concentrations containing vehicle-combustion components, gasoline-related compounds and chemicals used as part of regular building activities. The RI soil gas results supports the conclusion that soil gas does not appear to be affecting indoor air based upon inconsistent concentrations detected between indoor air and soil gas beneath the former holder site.

5.4.2 Soils

As shown on Plate 11, portions of the 522 and 524 East 20th Street residential buildings and associated sidewalks and landscaped areas currently occupy the footprint of the former East 19th Street Station. The SC and RI investigation locations from which the soil samples were collected are shown on Plate 1, and field observations are graphically depicted on the subsurface profile of Plate 4. Surficial and subsurface soil sample analytical results are

summarized in Tables 15 and 23 respectively, and statistical analytical summaries are presented in Tables 31 and 32 respectively. Analytical exceedances of RSCOs and SSBVs for surficial and subsurface soil sample results are depicted on Plates 6 and 11 respectively, and are summarized by depth horizons in Figures 16 through 18. A discussion of the investigation field observations and laboratory findings concerning soils at and adjacent to the former East 19th Street Station is presented below.

Surficial Soils

As discussed in previous sections, the soils immediately beneath the constructed and landscaped surfaces are fill materials, which extend to approximately 23 to 35 feet bgs in this area. As shown in Table 15, detected VOCs and non-carcinogenic PAHs were below both the respective RSCOs and SSBVs in the surface soil samples. Concentrations of two carcinogenic PAHs in the surface soil samples slightly exceeded the individual RSCOs and/or SSBVs in one instance each. The BaP equivalents concentrations within surface soils for the carcinogenic PAHs ranged from 0.1 mg/kg to 1.1 mg/kg, with 3 of the 4 samples having BaP equivalents concentrations less than the SSBV of 1 mg/kg. The total SVOC concentrations in the one sample exceeding for BaP was 11 mg/kg, which is well below the TAGM 4046 threshold of 500 ppm for total SVOCs. Several metals were detected above respective RSCOs and/or SSBVs, but concentrations were generally consistent across the site.

Due to the urban setting and historic commercial/industrial use of this station site and adjacent properties, concentrations of the carcinogenic PAHs and metals within surface soils were also compared to New England urban soil background levels and/or Eastern United States background values, as referenced and summarized in Table 11. All detected carcinogenic PAH concentrations within surface soil samples were within the reported range of background PAH levels for comparative urban soils. With regards to metals that exceeded the RSCOs and/or SSBVs, respective concentrations were within the researched background concentration ranges listed in Table 11 with the exception of lead in one sample.

Subsurface Soils

Physical impacts observed during the SC borings included a piece of solid "tar-like material" encountered at sample location 19GH003, between 16 to 17.5 feet bgs, and "slight petroleum-like/bituminous-like odors" within soil boring 19GH001 at 9 to 11 feet bgs (Plate 11). No MGP-related impacts, such as tar blebs, staining, sheens or odors, were noted during the SC or RI boring activities.

As shown in Table 23, the highest concentrations of total VOCs and SVOCs, and total BTEX and PAHs, respectively, were generally present within shallower fill material. Total VOC

and total SVOC concentrations within the subsurface samples were at least one order of magnitude below the TAGM 4046 threshold values of 10 ppm and 500 ppm, respectively (Plate 4). No detected VOCs exceeded either the RSCOs or SSBVs in any of the subsurface soil samples. BTEX and PAH compounds were not detected or were at trace concentrations within deeper native materials (Table 23). Concentrations of individual PAH compounds and arsenic exceeded the established RSCOs and/or SSBVs within shallow fill material at or adjacent to the former station footprint (Plate 11, Table 23). Cyanide was not detected within subsurface soils at the East 19th Street Station site.

5.4.3 Groundwater

Groundwater was collected from a shallow water table monitoring well 19MWS05 and intermediate monitoring well 19MWD05 during the SC in 2004 and recently in 2006 during RI activities. These wells are located adjacent to the former East 19th Street Station, as shown on Plate 1. The analytical results from both sampling events are summarized on Table 24, and a statistical summary analysis of results is presented in Table 33. Regulatory exceedances of detected compounds in groundwater for each well and sampling event are depicted on Plate 12 and are summarized for the June 2006 event in Figure 19.

The groundwater at the East 19th Street Station does not appear to be impacted by MGP residuals. Low levels of BTEX, non-carcinogenic PAH compounds, and arsenic were initially detected in groundwater sampled from monitoring well 19MWS05 in 2004 and were at concentrations below the respective NYSDEC AWQSGVs. These compounds were not detected in groundwater from either 19MWS05 or 19MWD05 during the 2006 sampling event. Cyanide was not detected within groundwater collected from either of the monitoring wells in 2004 and 2006.

Elevated levels of chlorinated VOCs (including trichloroethene and cis-1,2 dichloroethene) were detected in groundwater samples collected in 2004 and 2006. These chlorinated compounds were the major contributors to the total VOC concentrations, which ranged from 4.1 µg/L to 42 µg/L, in groundwater from the two events. In 2006, cis-1,2 dichloroethene was detected at 7.1 µg/L, which is above the 5 µg/L standard, within groundwater from 19MWD05. These compounds are not associated with the operation of the former MGP operations, but can be attributed to dry cleaning and other commercial activities.

6. Qualitative Human Health Exposure Assessment

This QHHEA identifies potential human exposures associated with COCs detected in soil, groundwater, soil gas, and indoor air within the study area that are common to MGP-related residuals and were reported at concentrations in excess of specific regulatory screening criteria and standards. The purpose of the assessment is to identify potential pathways of exposure of these COCs to the on-site and surrounding community and to indicate the potential need for mitigative measures to reduce potential exposures. The QHHEA is consistent with Appendix 3B of *Draft DER-10, Technical Guidance for Site Investigation and Remediation* (NYSDEC, 2002).

This QHHEA uses data collected as part of the RETEC indoor air and soil gas sampling (2003), the H&A SCR (2004/2005) and the recent remedial investigation conducted by GEI. Based on the objectives and findings of the RI, the QHHEA was performed for the former East 14th Street Station and East 17th Street Station sites; the RI investigation results from the former East 19th Street Station site did not warrant its inclusion in this assessment. Investigation data and findings are included in this report, and discussions on the site setting and background (Section 2), site geologic and hydrogeologic characteristics (Section 4), and the nature and extent of environmental impacts identified at the site (Section 5) are presented in the referenced report sections. Since the QHHEA is a component of this report, and not a separate document, information previously presented in this report is not re-iterated in this section and should therefore be referenced by the reader as needed.

For the purposes of the QHHEA, the Stuyvesant Town campus and surrounding properties are considered separately with respect to potential exposure to human populations. Current and potential future exposures occurring within the confines of the Stuyvesant Town property will be referred to hereafter as "on-site" exposures. Current and potential future exposures that could potentially occur outside the confines of this area will be referred to as "off-site" exposures. Figure 7 shows potential off-site sensitive receptor population within a ½ mile radius of the Stuyvesant Town Property.

6.1 QHHEA Scope and Limitations

As stated above, the QHHEA addresses the qualitative exposures potentially posed to human receptors by COCs that are common to MGP-related residuals and that are present in environmental media at concentrations in excess of the screening criteria and guidance values provided by NYSDEC and other sources. These other sources include SSBVs provided by H&A (2005) and federal risk-based screening values (EPA 2004; 2006).

An exposure pathway describes the means by which a potential receptor may be exposed to contaminants originating from a site. Assessment of potential exposure pathways includes the following five elements (NYSDEC, 2002):

(1) A contaminant source
(2) Contaminant release and transport mechanisms
(3) A point of exposure
(4) A route of exposure
(5) A receptor population

The qualitative exposure assessment summarizes the COCs at the study area (elements 1 and 2), the media in which COCs are present (potential exposure points; element 3), the potential exposure routes of the COCs (i.e., ingestion, inhalation, dermal absorption; element 4), and the assumed potential receptors (element 5). The NYSDEC and NYSDOH consider an exposure pathway complete when all five elements of an exposure pathway are documented. An exposure pathway may be eliminated from further evaluation when any one of the five elements comprising an exposure pathway has not existed in the past, does not exist in the present, and will never exist in the future (NYSDEC, 2002).

It is important to note that this QHHEA assumes that contaminant conditions have not or will not be mitigated. In this sense, a "baseline" of potential exposures is presented. This evaluation is conducted in accordance with Appendix 3B of the *Draft DER-10 Technical Guidance for Site Investigation and Remediation* (NYSDEC 2002), which summarizes the approach for preparing a QHHEA.

In addition, it should be noted that while TAGM 4046 RSCOs are used as the screening criteria, the introduction to TAGM 4046 states:

> "Project Managers should use these cleanup objectives in selecting alternatives in the Feasibility Study (FS). Based on the proposed selected remedial technology (outcome of FS), final site-specific cleanup levels are established in the Record of Decision (ROD) for these sites. It should be noted that even after soil cleanup levels are established in the ROD, these levels may prove to be unattainable when remedial construction begins."

This statement recognizes that site-specific values should ultimately be used as the cleanup criteria for a site. The derivation of the site-specific cleanup values may include such items as calculating the quantitative risk posed to potential receptors to determine if a risk is indeed present, and may also include the use of institutional controls (i.e., deed notices or restrictions) or possibly even engineering controls such as barriers to mitigate potential exposure. Therefore, it is important to recognize that determination of a complete or

potentially complete pathway as determined through the qualitative exposure assessment process does not necessarily mean that there is an actual risk posed to a potential receptor.

For the purposes of this assessment, it is assumed that future land uses of Stuyvesant Town will remain primarily residential for the foreseeable future. A summary of complete qualitative exposure pathways is presented below. The following subsections discuss the identification of COCs, exposure points, exposure routes, and potential receptors.

6.2 Complete Qualitative Exposure Pathways Summary

6.2.1 Contaminants of Concern

For purposes of this RI and QHHEA, COCs are identified as those VOCs, SVOCs, metals and/or cyanide that are common to MGP-related residuals and exceed NYSDEC TAGM 4046 values in soil and/or NYSDEC AWQSGVs in water [Standards, Criteria, and Guidance values (SCGs)]. As defined in subsection 5.1.2, the COCs within this category are: the four BTEX compounds, a subset of VOCs; sixteen PAH compounds, a subset of SVOCs; and arsenic and cyanide. Where SCGs do not exist (e.g., cyanide criteria for soil), risk-based screening criteria for residential exposures from EPA are used for the screening comparison. Where SCGs are recommended by NYSDEC as "SB" (site background, e.g., aluminum), the H&A SSBVs are used. Tables 34 and 35 summarize the COCs and their maximum detections and SCGs for this QHHEA.

Chemicals within the COC category that were not detected at least once above the limit of detection are excluded from the QHHEA, regardless of the size of the data set. Chemicals with a frequency of detection of less than 5% in a data set of 20 or more samples also are excluded as a COC. With these exceptions, if one or more COCs at the maximum detected concentration exceeded the screening criteria, there exists a potential exposure pathway.

For purposes of this RI and QHHEA, evaluation of COCs in surface soil was not performed. Given that the site and local area is built on man-made land, and based on the historical development of the property, the surface soils at the site are considered urban fill. Based on the nature and extent of MGP-related impacts within the site subsurface, and an extensive sampling and evaluation program of the surface soils, COCs present within the surface soils are not indicative of MGP-related impacts associated with the former holder stations or plant. Tables 34 and 35 identify the COCs for subsurface soil and groundwater at Stuyvesant Town and identify the exceeded screening criteria, thus creating a potential exposure point as summarized below.

6.2.2 Contaminant Release and Transport Mechanisms

The potential mechanisms for migration of the COCs include volatilization, sorption, fugitive dust, and solubility. Potential MGP-related COCs in each environmental media are discussed with respect to their affinity to each of these mechanisms. These mechanisms are summarized below:

- **Volatilization:** this action describes the movement of a chemical from the surface of a liquid or solid matrix to a gas or vapor phase. While BTEX compounds, and to a lesser extent naphthalene, tend to volatilize, PAHs and inorganics do not tend to volatilize outside of extreme pressure and/or temperature conditions.

- **Sorption**: this action is usually defined as the reversible binding of a chemical to a solid matrix. However, there is evidence in the published literature that there is a partially irreversible component related to the time that the compound has been sorbed to a soil matrix (Brusseau, et al., 1989; Brusseau, et al., 1991; Loehr, et al., 1996). Sorption of BTEX, PAHs, and metals limits the fraction available for other fate processes such as volatilization and/or solubility. In general, BTEX compounds have low sorption potential, coupled with high water solubility and high volatility, which make sorption a relatively minor environmental fate process for BTEX compounds compared to other mechanisms. PAHs exhibit varying degrees of binding affinity to organic matter and soil particles; this affinity is dependent upon their individual molecular structures. In general, the higher molecular weight PAHs (e.g., benzo(a)pyrene) are strongly sorbed, whereas the lighter PAHs (e.g., naphthalene) are less strongly sorbed (EPA, 1979; EPA, 1986). Therefore, the higher molecular weight PAHs are expected to remain sorbed to soils, while the lighter PAHs may be desorbed and transported by other mechanisms. Metals may remain sorbed to soils depending on oxidation-reduction conditions and the availability of anions with which the metals could bind. Metals that do not remain sorbed to soils could be available for transport through surface or groundwater in solution.

- **Fugitive Dust:** COCs sorbed to soil particulates could be transported as fugitive dust if exposed to wind erosion. As discussed above, PAHs exhibit varying degrees of binding affinity to organic matter and soil particles; this affinity is partly dependent upon their individual molecular structures. In general, the higher molecular weight PAHs (e.g., benzo(a)pyrene) are strongly sorbed, whereas the lighter PAHs (e.g., naphthalene) are less strongly sorbed (EPA, 1979; EPA, 1986). Therefore, the higher molecular weight PAHs are expected to remain sorbed to soils, while the lighter PAHs may be desorbed and transported by other mechanisms. Inorganics also generally exhibit an affinity to particulates.

- **Solubility:** this is the measure of a chemical's ability to dissolve in water. COCs sorbed to surface soil may dissolve in water and may be transported as surface water, while COCs sorbed to subsurface soils may dissolve in water and be transported via the groundwater aquifer system. PAHs have varying degrees of solubility. The lighter PAHs are more soluble, while the heavier PAHs are less soluble and typically do not dissolve into water. Metals in the subsurface soils could dissolve and continue to leach into the groundwater system. However, the solubility of metals is highly dependent upon the pH and oxidation-reduction conditions of the aquifer, the valance state of the specific metal, and the availability of anions that the metals could bind with to become immobile.

6.2.3 Potential Receptors and Routes of Exposure

The potential receptors for each COC in each media are determined based on current land use at Stuyvesant Town and based on foreseeable potential future land uses. Table 36 summarizes the information contained below.

The following potential receptors at Stuyvesant Town were identified and evaluated:

- **Stuyvesant Town Resident** – This receptor includes all residents living at the Stuyvesant Town property, regardless of their approximate location to the areas of the former MGP sites. Potential exposure concerns for Stuyvesant residents would be inhalation of particulates during subsurface utility and other underground construction activities. Based on previous and current investigations, vapor intrusion to indoor air is not considered to be a complete pathway.

- **Child Day Care Attendee** – This receptor includes both children and adults that are present at the on-site day care facility. Potential exposure concerns for the child day care attendee would be inhalation of particulates during subsurface utility and other underground construction activities. Based on previous and current investigations, vapor intrusion to indoor air is not considered to be a complete pathway.

- **Landscape/Maintenance Worker** – This receptor includes those on-site workers who maintain landscaped areas and the housing development. Potential exposure concerns for the landscape/maintenance worker would be inhalation of particulates during subsurface utility and other underground construction activities.

- **Parking Lot Attendant** – This receptor includes those individuals stationed at the entrances of each of the underground parking garages at the Stuyvesant property. Potential exposure concerns for the parking lot attendant would be inhalation of particulates during subsurface utility and other underground construction activities.

- **Adjacent Off-site Receptors** – This receptor includes individuals residing and/or visiting the surrounding community. Potential exposure concerns for off-site individuals would be inhalation of particulates during subsurface utility and other underground construction activities.

- **Utility Worker** – This receptor includes individuals who perform short duration repairs to underground utilities at the property. These individuals may be exposed to COCs in subsurface soils during excavation activities via incidental ingestion, dermal contact, and inhalation of volatilized compounds and particulates (fugitive dust). They may also have an exposure pathway to COCs in shallow groundwater via incidental ingestion and dermal contact and to COCs in soil gas via inhalation.

- **Construction Worker** – This receptor includes individuals who perform short duration construction activities at the property that require disturbance of the subsurface. These construction workers may contact COCs via subsurface soils, groundwater, and soil gas. The construction worker may be exposed to contaminants in subsurface media through incidental ingestion, dermal contact, and inhalation of volatilized compounds (soil gas) and particulates (fugitive dust).

6.2.4 Assessment of Exposure Pathways

Using the data collected within the study area and summarized in the tables, figures and plates of this report, each potential exposure pathway identified above was assessed. A complete exposure pathway exists when a COC is present in a media above the screening criteria (potential exposure point) and a potential receptor can be exposed to that COC through one or more of the exposure routes previously identified based on the specific land use (Section 2) and impacted media (Section 5).

An example of a complete exposure pathway would be an on-site utility worker excavating a 3-foot-deep pit to perform utility repairs on gas lines. If the soils contain COCs (VOCs, SVOCs/PAHs, arsenic or cyanide) at concentrations greater than the SCGs (exposure point), then a complete exposure pathway exists for the utility worker potentially contacting those soils via ingestion, dermal contact, or inhaling particulates from the excavation (route of exposure).

Table 36 presents the matrix for the study area where COCs are known to exist. The matrix identifies the COCs, compares them against identified screening criteria, and then determines if a complete exposure pathway exists for the potential receptors. A discussion of the potential exposure based on specific site conditions follows.

6.2.4.1 Soils

A complete exposure pathway to COCs in subsurface soils exists for utility workers and construction workers engaging in excavation activities. Based on known utility networks beneath the site, these excavation activities are expected to occur at depths of 16 feet bgs or less, and generally within urban fill materials. For other current and potential future receptors, exposure to subsurface soils is only possible if the subsurface soils are disturbed.

Any future construction workers would have to wear PPE appropriate for the COC concentrations anticipated, based on the data collected for the site, and the potential exposure routes exposed. Implementation of appropriate PPE and procedures would need to follow an established site-specific HASP that includes, or is amended as needed to include, task-specific health and safety procedures. Work zone and community air monitoring plans and a soil and groundwater management plan would also have to be developed and implemented to ensure that they and other present receptors (e.g., on-site residents and child day care attendees) are not exposed to COCs in subsurface soils during disturbance. The use of such precautions will mitigate potential exposures to impacted subsurface soils.

6.2.4.2 Groundwater

Groundwater beneath Stuyvesant Town was sampled at various depth intervals and is not used for consumption at the property or in the surrounding community. It is highly unlikely under any existing or future scenarios that an exposure pathway could exist for anything other than exposure to groundwater at the water table, which is located generally 4 to 10 feet bgs at the site (Table 6). Therefore, only groundwater up to 20 feet bgs is considered in evaluating the presence of a complete exposure pathway.

A complete exposure pathway to COCs in groundwater exists for the utility workers and construction workers engaging in excavation activities. Exposure to COCs in groundwater through inhalation, dermal contact, and incidental ingestion is only possible if excavation to or below the water table occurs.

Any workers involved in excavation activities would have to wear PPE appropriate for the COC concentrations anticipated, based on the data collected for the site, and the potential exposure routes exposed. Implementation of appropriate PPE and procedures would need to follow an established site-specific HASP that includes, or is amended as needed to include, task-specific health and safety procedures. Monitoring of their work zone would need to be addressed in the HASP and have to be conducted to ensure that they are not exposed to COC-containing groundwater. Proper handling and disposal of affected groundwater would need to be implemented per a site-specific soil and groundwater management plan. The use of such precautions will mitigate potential exposures to the impacted groundwater.

6.2.4.3 Soil Gas

VOCs common to both petroleum and MGP-related residuals (e.g., BTEX compounds) have been detected in soil gas beneath Stuyvesant Town. Construction and utility workers involved in excavation activities at the property may have complete exposures to soil gas COCs via inhalation. Work zone monitoring of VOCs and implementation of established actionable levels during excavation work will need to occur in accordance with a site-specific HASP and will mitigate potential exposures to the VOCs in soil gas.

6.2.4.4 Indoor and Ambient Air

Based on the current and previous investigations for indoor air, VOCs common to both petroleum and MGP-related residuals (e.g., BTEX compounds) are not considered to have impacted indoor air above NYSDOH established background concentrations. VOCs detected at greater than background conditions are not typically associated with former MGP operations (tetrachloroethene, chloroform). For ambient air, only one compound (toluene) was detected above background in the most recent round of sampling; however, evaluation of the indoor and ambient air and soil gas results indicates that the detection is most likely attributable to indoor source (e.g., paints, cleaning products, maintenance fluid) and/or urban sources (e.g., vehicle emissions.) Therefore, complete exposure pathways for receptors exposed to indoor and ambient air are not considered to exist. A future pathway to indoor air is unlikely given the length of time the development has existed over the former MGP sites, but may be monitored further in future investigations.

6.2.4.5 Exposure Pathway Assessment Summary

In summary, subsurface media (soil, groundwater, soil gas) may provide an exposure pathway if excavation activities are conducted at the property. Receptors involved in excavation activities (construction and utility workers) may come into contact with subsurface soil, groundwater (in the event that dewatering does not occur), and soil gas. On-site and off-site receptors may have a complete exposure pathway to air-borne particulates (as fugitive dusts) during times of excavation work when subsurface materials are disturbed. The implementation of worker protection plans, such as HASPs that include PPE procedures and action levels, as well as the implementation of work zone and community air monitoring plans and soil and groundwater management plans during subsurface activities, can mitigate potential exposure issues and eliminate a complete exposure pathway.

7. Conceptual Site Model

Based on the history, subsurface characteristics and nature and extent of compounds detected in indoor air, soil gas, soils and groundwater at the former MGP holder stations within Stuyvesant Town, GEI has developed an overall conceptual site model regarding the MGP-related environmental impacts. The site model was developed through the evaluation of the location and concentrations of contaminants of concern in light of site-specific features, which serve to either mitigate or enhance the impact of these chemicals to human health and the environment. Furthermore, the site model incorporates the anticipated future property use and subsequent contaminant exposure potential in the assessment of active and/or passive remedial needs or approaches to MGP-related impacts. Other contaminant impact issues and potential exposure concerns, such as those relating to chlorinated solvents, gasoline, and non MGP-related metals (e.g., lead, aluminum), are not addressed by this RI.

As discussed in Sections 2 and 4, the former station sites are underlain by significant man-made land. Infilling and grading of the area most likely transpired in stages over the mid to late 1800s, resulting in the creation of a fill horizon ranging from 14 feet to greater than 47 feet in thickness across the three sites. Organic silts and shell deposits, from periodic river sediment influxes, are intermixed with the man-made materials and reworked native soils comprising the fill. The variety of building debris (e.g., brick, concrete, metal) encountered throughout the fill further suggests on-site burying and reworking of demolition debris during general construction and redevelopment of pre-Stuyvesant Town city blocks as well as during the large-scale demolition and grading activities conducted as part of Stuyvesant Town and Peter Cooper Village construction. A relatively thin and inconsistent horizon of organic deposits underlies the fill in the area, which in turn is underlain by glacial lacustirne sediments and outwash sands. Bedrock (Ravenswood Granodiorite) was encountered at depths between 50 feet and 86 feet bgs beneath the East 14th Street Station and is expected to dip sharply to the northeast, although confirmation borings were not completed to bedrock at the former East 17th and East 19th Street Stations.

Although evidence of significant brick debris was encountered in borings and test pits located across the station sites, the foundations for the former holders were not conclusively encountered during the investigations. Furthermore, major sources of MGP tar or tar residuals, which can be co-located with former holder foundations, were not encountered beneath the station sites. Given the dates of operation of the three former stations, the holder foundations were most likely constructed of brick and masonry and demolished well before the construction of Stuyvesant Town.

7.1 East 14th Street Station

The footprint of the East 14th Street Station site is approximately 2 acres in size. Portions of five residential buildings, an underground parking garage, pedestrian pathways and the perimeter service road occupy the footprint of the former station. Volatile organic compounds common to both petroleum materials and MGP byproducts, as well as compounds specifically related to gasoline and chlorinated solvents, were detected within the indoor air and soil gas samples. However, comparison of the distribution and concentrations of the compounds in indoor air, ambient air and soil gas support the previous RETEC findings indicating that the chemical constituents and concentrations in indoor air more closely reflect the ambient air quality than that of the subsurface soil gas. Thus, the air and soil gas results to date appear to demonstrate that soil vapor intrusion is not occurring at the buildings within the former station site.

Soils beneath the former East 14th Street Station site are impacted by both petroleum and/or MGP-related constituents above the RSCOs and SSBVs in discrete near-surface fill materials and delineated deeper intervals of fill and glacial deposits. Carcinogenic PAHs are present in the surface and near-surface soils within the former station footprint above the respective RSCOs and SSBVs; the concentrations of individual PAHs in this subset are consistent across the site, and are primarily located beneath impervious surfaces, such as sidewalks, building foundations and the parking garage floor. Some BTEX is also present above RSCOs and SSBVs in these soils, particularly in those located beneath the parking garage. Taken in combination with the results of the soil gas sampling, the contaminant concentrations in the near-surface soils appear influenced by gasoline-related sources in addition to the heterogeneous quality of the fill used at the site. Observed petroleum staining and odors and similar concentrations of BTEX and carcinogenic PAHs are generally found throughout the fill materials beneath the site, suggesting these impacts are a characteristic of the historic fill used rather than MGP tar and MGP-related residues noted at deeper intervals, i.e. those located below 20 feet bgs in native materials. MGP tar impacts, and associated BTEX and PAH RSCO and SSBV exceedances, were encountered at 20 to 30 feet bgs within sandy lenses of the glacial lacustrine deposits beneath the site. MGP-related impacts were also observed in deeper glacial outwash deposits overlying the bedrock interface at perimeter borings; however, samples from these intervals did not exhibit MGP-related constituents above the RSCOs, with the exception of slight benzene exceedances.

Groundwater beneath the East 14th Street Station site is impacted at both the water table and deeper overburden zone above AWQSGVs. The high concentrations of BTEX, naphthalene and non-carcinogenic PAH compounds in groundwater throughout the overburden aquifer suggest contributions from both petroleum-impacted and MGP-impacted soils. Monitoring wells for the East 14th Street Station site are located in close proximity to a number of significant underground utilities and/or structures, including a MTA subway line and a

Pollution Control Intercepting Sewer, which may be creating preferential pathways for off-site contaminant contribution. DNAPL tar was noted in one well along East 14th Street (14MWD02, screened 22-32 feet bgs) during the RI. Based on the time elapsed between the SC and RI activities, and the subsurface conditions at the corresponding depth, well 14MWD02 may be serving as a DNAPL sump for the immediate area; therefore, the thickness of DNAPL present in the surrounding formation is expected to be significantly less than that observed in the well.

Based on the current and past structures within the East 14th Street Station footprint, and the findings of site investigations conducted by H&A, RETEC, and GEI, MGP-related impacts appear to be confined to the immediate station site and within materials below 20 feet bgs and observed tar residuals are not considered to be mobile. Near-surface concentrations of constituents common to petroleum and MGP-related residuals are located in heterogeneous fill materials beneath building foundations, an underground garage, paved pedestrian pathways and limited landscaped areas. These near-surface constituents are considered typical of urban fill and are not associated with the site-specific MGP-related impacts encountered at deeper intervals. Observed and analytical findings suggest that soil gas, soils and groundwater beneath the station site are affected by commingled sources of contamination, as evidenced by the vertical and horizontal distribution of chemical constituents in the subsurface beneath the site and adjacent areas. Inconsistencies in concentration distributions, and discrete veins of petroleum and MGP impacts at depth, suggest contaminant contributions from present and/or historic releases in the area and/or the tracking of present and/or historic releases along preferential pathways created by the dense network of underground structures and utilities under East 14th Street and Avenue C.

7.2 East 17th Street Station

The footprint of the East 17th Street Station site is approximately 1.5 acres in size. Portions of three residential buildings, an underground parking garage, and segments of the Avenue C Loop Road and associated pedestrian pathways currently occupy the majority of the former station site. Limited landscaped areas and a small portion of a basketball court comprise the remaining portions of the former site. Soil gas samples collected within and adjacent to the former station footprint contained many of the same constituents as the indoor air; however, the magnitude of these compounds and distribution of other chemical compounds in the subsurface were inconsistent among the soil gas samples and between the soil gas and indoor air samples. The air and soil gas results to date appear to support the previous RETEC findings, which indicate that the chemical constituents and concentrations in indoor air more closely reflect the ambient air quality than that of the subsurface soil gas and, therefore, suggest that soil vapor intrusion is not occurring at the building at the former holder locations.

Soils beneath the station site contain MGP tar residuals and MGP-related constituents in excess of the RSCOs and SSBVs in delineated intervals of fill and reworked glacial lacustrine sediments. Within the station footprint, carcinogenic PAHs and arsenic are present at concentrations slightly above the RSCOs and SSBVs at depths above 7 feet; at three locations at or adjacent to the former gas holders, these constituents are at slightly greater concentrations at depths ranging from 9 to 15 feet bgs. However, impacts observed and detected at these locations also consist of petroleum odors and staining, which are present at various depths in the fill material and into the native materials both within and adjacent to the station footprint. This mix of MGP and petroleum related impacts in the site subsurface is also shown in the soil gas analytical findings for the site. As previously noted, indoor air analytical findings for the 16 Stuy Oval building suggest that a soil gas intrusion condition at the building does not currently exist.

During the valve replacement project, MGP-related impacts were also observed in excavations to the northeast and south of the former station site along the Avenue C Loop Road. These impacts, characterized by stained soils and associated odors and sheens on groundwater, were generally encountered between depths of 9 and 13 feet bgs. Locations excavated near the station footprint exhibited a variable mix of MGP-related and petroleum-type impacts within the fill material, which is consistent with the investigation findings.

Individual PAH, BTEX and arsenic exceedances in investigation soil samples were generally confined to intervals of discrete MGP tar impacts at depths of 25 to 30 feet bgs, within and adjacent to the former gas holders; these impacts appear to be situated near the transition of the fill and reworked silts to native glacial lacustine soils. Samples collected from soils beneath this interval show a sharp decreasing concentration gradient over the next 5 to 10 feet, with PAH and BTEX concentrations decreasing to below detection limits or below RSCOs. Additionally, a decreasing concentration gradient also extends horizontally within that 25 to 30 feet bgs interval, from the immediate area of the former gas holders along the transition from fill to native materials.

With respect to groundwater, the highest total BTEX and PAH concentrations are present within groundwater in contact with soils exhibiting petroleum-type staining and odors and naphthalene-like odors. The highest total BTEX and PAH concentrations occur in monitoring wells within the station footprint – 17MWS03/D03 and 17MWD04. Elevated concentrations of benzene appear to be persistent in the shallow and intermediate groundwater zones beneath the site and within the intermediate groundwater zone (i.e., within 17MWD05) just east of the former station. Groundwater from wells screened at depths ranging from 41 to 53 feet bgs exhibit decreases in overall BTEX and PAH concentrations; conversely, this deeper groundwater zone beneath the site contains chlorinated compounds. Shallow water table wells within the station footprint yielded

groundwater with BTEX and a few PAHs above the AWQSGVs, but perimeter water table wells exhibited no MGP or petroleum-related impacts.

Based on the current and past structures within the East 17th Street Station footprint, and the findings of site investigations conducted by H&A, RETEC, and GEI, MGP tar and related impacts appear confined within a discrete zone below 20 feet bgs in the immediate station site area. Observations made during the valve replacement project indicate that subsurface MGP-related impacts are also present outside the study area along the Avenue C Loop Road. Near-surface concentrations of MGP-related constituents are located beneath building foundations, the Loop Road, paved pedestrian pathways and limited landscaped areas. Heterogeneous fill materials comprise the subsurface at these shallower depths and include remnants of a historic roadway, as evidenced by a relatively consistent concrete and brick sub-layer in the investigation area. In addition, observed and analytical findings indicate that soil gas, soils and groundwater beneath the station site are affected by commingled sources of contamination, as evidenced by a number of non MGP-related compounds, many at concentrations in excess of regulatory standards.

7.3 East 19th Street Station

The footprint of the East 19th Street Station site is less than half an acre in size. Portions of an underground parking garage and residential building occupy the majority of the former station. Soil gas and indoor air contain detectable concentrations of BTEX compounds; however, as indicated in the previous RETEC findings, the low concentrations of VOCs detected within indoor air at the East 19th Street Station appear to be linked to outdoor air concentrations containing vehicle-combustion components, gasoline-related compounds and chemicals used as part of regular building activities. The RI soil gas results supports the conclusion that soil gas does not appear to be affecting indoor air based upon inconsistent concentrations detected between indoor air and soil gas beneath the former holder site.

The RI findings confirm the previous findings of RETEC and H&A which suggested that MGP-related impacts beneath the East 19th Street holder site were either absent or very limited in extent. No MGP-related impacts in the form of tar-saturated soils, blebs, staining, or sheens were noted in subsurface soils in the area of the former East 19th Street Station during the investigation programs. During the valve replacement project, stained soils and MGP-type odors were observed in several excavations conducted outside the former station site and along the East 20th Street Loop Road; these impacts were generally encountered within and/or beneath the fill horizon at depths between 5 and 13 feet bgs. In addition, product globules and sheens on groundwater within several of the impacted excavations were also noted.

Subsurface soil contaminant impacts above individual RSCOs and SSBVs in the station area appear to be limited in depth and extent (Plates 4 and 11) and are below TAGM threshold values for total VOCs and SVOCs. Arsenic and carcinogenic PAHs were detected above the SSBVs in soil samples taken from just beneath the concrete floor of the parking garage and from 5-7 feet below grass areas along the north side of the East 20th Street Loop Road. Heterogeneous fill materials comprise the subsurface at these depths and include remnants of a historic roadway, as evidenced by a relatively consistent concrete and brick sub-layer across the investigation area. Analytical results from the investigation groundwater sampling events do not indicate groundwater impacts from historic MGP operations at the site (Plate 12).

Based on the current and past structures within the East 19th Street Station footprint, and the findings of site investigations conducted by H&A, RETEC, and GEI, MGP-related impacts do not appear to be present at the former station site at concentrations that pose a threat to the residential population or environment.

8. Summary and Conclusions

In 2006, GEI conducted a remedial investigation of three former MGP sites located within the Stuyvesant Town residential complex, located on the Lower East Side of Manhattan. The work was performed pursuant to a Voluntary Cleanup Agreement between Con Edison and the NYSDEC and was implemented in general accordance with the NYSDEC approved February 2006 Remedial Investigation Work Plan and March 6, 2006 addendum, prepared by GEI. The purpose of the RI was to gather sufficient information to assess whether remedial actions are necessary and, if so, to support analysis of remedial alternatives and selection of a remedy. GEI developed and implemented the RI to supplement previous site characterization work conducted by H&A in 2004 and previous air and soil gas sampling conducted by RETEC in 2003.

In addition to implementation of the RI program, Con Edison contracted GEI to serve in an observational role during the implementation of a subsequent underground valve replacement program at the Stuyvesant Town residential campus. The capital improvement work was conducted in 2006 and 2007 and entailed the excavation, removal and replacement of 58 water and hydrant valves across the residential campus. GEI served in an observation role during the related subsurface project activities and documented field observations regarding general subsurface conditions and potential environmental impacts in order to augment the findings of previous investigation work at the property.

The RI field program focused on the delineation of MGP-related subsurface impacts within and adjacent to the site footprints of the former East 14th Street, the East 17th Street and the East 19th Street Stations. The following summary and conclusions are based on a comprehensive evaluation of all the data presented in this report, including findings reported earlier by others and observations made during the subsequent valve replacement project, and are presented to address the specific RI objectives set forth in the RIWP.

8.1 Stuyvesant Town Setting

As part of the RIWP, additional investigation of the historic, geologic, and hydrologic conditions of the three station sites was conducted. Data collected provided background information pertinent to all three sites as well as information on station-specific conditions. A summary of historic and environmental setting information common to all sites is presented below.

8.1.1 Site-wide History

Based on reviewed historic survey maps and plates from the late 1700s and early 1800s, it appears that the 18-block area developed as Stuyvesant Town was part of the East River and associated marsh lands well into the 1800s. A number of creeks and streams that fed into the East River traversed the area, which appears to have been mainly farms and orchards during the colonial period. To accommodate the growing city, the area gave way to more industrial development planning in the early 1800s. As a result, most of the area east of First Avenue, between East 13th and East 26th Streets, required filling and reworking of the local land to elevate the grade and extend the shoreline. In most cases, tenements briefly existed at the Stuyvesant MGP sites between creation of the man-made urban land and development of the plant or holder stations.

8.1.2 Site-wide Geology and Hydrology

Subsurface conditions reported and encountered during the site characterization and remedial investigation activities indicate the presence of four major stratigraphic units beneath the three sites. These units, in order of increasing depth, are: (1) fill, (2) organic deposits/peat, (3) glacial deposits, and (4) weathered bedrock (Ravenswood Granodiorite).

Fill comprised the most extensive soils encountered during the RI and previous site characterization activities. Fill is present beneath all three areas and is a result of extending the East River shoreline in the mid to late 1800s to expand the Lower East Side of Manhattan. The fill ranges in depth between 12 feet bgs and 45 feet bgs and consists of dark grey to black, loose, non-cohesive sand and silt, with varying amounts of gravel, cobbles, ash, clinkers, slag, brick and concrete fragments, metal fragments, wire, cloth, and wood fragments. In addition, fine-grained organic deposits and glacial deposits are also part of the fill and are most likely reworked native materials. Shallow drilling equipment refusal was encountered between 10 and 20 feet below grade in areas near all the former holder locations. It is likely that this was a result of backfilling those areas with building debris during plant demolition. Also cobblestones in areas of former city streets were encountered within the fill.

The organic deposits/peat was generally encountered beneath the fill at each of the former MGP station sites. However it is not consistently present. The organic deposits consist of gray to black clayey silt, organic silt and brown peat. Thicknesses of this low energy deposit ranged from 1 to 7 feet.

Glacial deposits were encountered beneath the fill and organic deposits/peat (where present) and above the weathered bedrock. Glacial deposits were encountered beneath each of the former station sites typically as shallow as 16 feet bgs to as deep as 85.5 feet bgs. These deposits were present at thicknesses up to 60 feet as encountered in one boring adjacent to

the East 14th Street Station. The glacial deposits consisted primarily of glacial lacustrine (glacial lake) deposits that were inter-bedded and underlain in areas by layers of glacial outwash sands and glacial till.

Three borings were drilled at the East 14th Street Station to the bedrock surface. The bedrock was encountered as shallow as 49.5 feet bgs to as deep as 85.5 feet bgs. Rock fragments recovered at the borings were consistent with published descriptions of the Ravenswood Granodiorite that is reported to underlie the former East 14th Street Station. Borings were not extended to bedrock and bedrock was not encountered at the other two stations.

Except for the landscaped areas of the Stuyvesant Town residential district, the site is covered by impermeable surfaces. Stormwater is directed overland and through the city storm sewers east toward the East River located between 200-2,250 feet from the property. One groundwater aquifer (the Upper Glacial Aquifer) has been identified beneath the site. This is generally an unconfined aquifer; however, deeper portions of the aquifer exhibit leaky confined conditions (semi-confined) due to the presence of tighter silty sand and silty clay materials.

The shallow groundwater zone beneath the three former holder stations resides primarily in fill material. Nine monitoring wells are located in the shallow groundwater zone within the former stations and adjacent areas. Depth to groundwater ranged between 4.25 and 17.39 feet bgs in these wells. Shallow groundwater flow at the site may be locally affected by man-made structures such as sewer mains or subway structures. Two sewer lines that flow from east to west bisect the Stuyvesant Town property and most likely intersect the Pollution Control Interceptor Sewer that runs along East 20th Street and south along Avenue C. The groundwater flow within the East 14th Street Station may be affected by the MTA subway structures and foundations for the "L" line that are located beneath the adjacent East 14th Street ROW and roadway.

The average hydraulic gradient of the shallow groundwater aquifer ranges from 0.0018 foot/foot to 0.01 foot/foot. The hydraulic conductivity (K) of the water table portion of the Upper Glacial Aquifer was estimated using wells that were screened in a sand and clay fill material and silty-sand fill material. The hydraulic conductivity was calculated between 15 feet/day and 169 feet/day. The estimated average linear flow velocities ranged from 370 feet per year in the central portion of the East 17th Street Station to approximately 1,825 feet per year in the southeastern corner of the East 14th Street Station in the vicinity of the East 14th Street ROW and "L" line subway.

Depth to water in wells screened in the deeper groundwater zone with the overburden aquifer ranged between 4.78 and 17.15 feet bgs under most of the site. The groundwater in this deeper zone appears to flow eastward towards the East River. The average hydraulic

gradient of the deep groundwater zone ranges from 0.0015 foot/foot to 0.003 foot/foot. The hydraulic conductivity (K) of the deep portion of the Upper Glacial Aquifer was estimated from a well screened in a silty-sand material. The hydraulic conductivity was calculated as 129 feet/day. The estimated average linear flow velocities ranged from 235 feet per year in the vicinity of the East 17th Street Station to 470 feet per year within the East 14th Street Station footprint.

Regarding vertical head potentials there is a slight downward head potential between the shallow zone and the deep zone of the Upper Glacial Aquifer for the majority of the well clusters within the East 14th, 17th and 19th Street Stations and adjacent areas.

8.1 East 14th Street Station

The following summary and conclusions addresses the RIWP objectives, and associated characterization and remedial investigation findings, specific to the former East 14th Street Station.

8.1.1 Site History

Additional research was conducted on the development and demolition of the East 14th Street Station and involved mainly a review of historic maps and aerial photographs located at the New York City Public Library and the Municipal Archives at Chambers Street.

The East 14th Street Station with its distinctive six gas holders each containing 350,000 cubic feet of manufactured gas was originally built by the Manhattan Gas Light Company around 1857 and became part of the Consolidated Gas Company in the 1880s. The station operated for gas storage and purification up until the period between 1903 and 1920. Consolidated Gas (renamed Con Edison 1936) subsequently used the site for a warehouse and storage yard until 1944 when the property was sold for construction of Stuyvesant Town.

8.2.2 Extent of MGP Impacts in the Vadose Zone and Indoor Air

Soil gas samples were collected at and adjacent to the former East 14th Street Station between 2003 and 2006. VOCs common to both petroleum and MGP byproducts, that is BTEX and naphthalene, were detected in most soil gas samples; however, other petroleum-related constituents, primarily those associated with gasoline, were also pervasively present in the soil gas samples, suggesting that petroleum-related residuals in the subsurface may be a more significant contributor to the overall BTEX and naphthalene concentrations than MGP-related tar and tar residues in the subsurface. The vadose zone is comprised of heterogeneous urban fill, and physical observations and analytical findings for the SC and RI soil borings indicate that petroleum-related impacted soils are present beneath the site and are generally at

shallower depths than those in which MGP-related impacts are noted (e.g., depths greater than 20 feet bgs.)

VOCs common to both petroleum materials and MGP byproducts, as well as compounds specifically related to gasoline and chlorinated solvents, were detected within the indoor air samples collected at the site between 2003 and 2006. However, comparison of the distribution and concentrations of the compounds in indoor air, ambient air and soil gas support the previous RETEC report, which indicated that the chemical constituents and concentrations in indoor air more closely reflect the ambient air quality than that of the subsurface soil gas. Thus, the results to date suggest that indoor air within residential buildings currently occupying the former station sites is not adversely affected by the soil gas concentrations beneath the former station.

8.2.3 Extent of MGP Impacts in Subsurface Soils

For the East 14th Street Station, isolated areas of tar-impacted soils were encountered within sandy layers of the glacial lacustrine deposits. Tar impacts were typically encountered in discrete lenses or thin soil layers between 20 and 30 feet bgs within the station footprint, but were also present in soils at 12 feet at one location and as deep as 49 feet bgs at another location. A free-phase tar was observed during the RI program within one previously-installed monitoring well screened between 22 and 32 feet bgs along East 14th Street. Given the observations and analytical results from surrounding wells and borings during the RI, it is likely that the well had progressively accumulated the free-phase tar since installation in 2004.

8.2.4 Extent of MGP Impacts in Groundwater

For the East 14th Street Station, the greatest MGP-impacts to groundwater were generally in wells screened below the water table. The highest total VOC and SVOC concentrations (and highest total BTEX and PAH concentrations, respectively) were typically found in groundwater adjacent to the footprint of the former holders in areas where soils were impacted with tar residuals. One well along East 14th Street was not sampled due to the presence of tar at its base. Otherwise concentrations of VOCs and SVOCs generally decreased in both the shallow (water table) zone and deeper zones in downgradient wells near Avenue C. Downgradient and across from Avenue C, groundwater does not appear to be impacted from the MGP operations at the former East 14th Street Station.

8.2.5 Qualitative Human Health Exposure Assessment

There are several distinct human populations, both on and in the vicinity of the former East 14th Street Station site, who have the potential for exposures to MGP constituents if the subsurface soils are uncovered or disturbed. The on-site populations include residents, day care attendees and on-site workers (landscape, maintenance, and parking lot attendants)

under current site use conditions. Relevant current off-site receptor populations include adult and child residents and adult and child receptors at adjacent establishments that may be exposed to fugitive dusts during subsurface construction and/or earth movement activities. Under future site use and activities, potential receptors may include construction workers and utility workers involved in excavation activities in the area of the former MGP sites.

In summary, subsurface media (soil, groundwater, soil gas) may provide an exposure pathway if excavation activities are conducted at the property. The QHHEA indicates there are no significant or imminent threats to human health that warrant an interim remedial action, and the emplacement and implementation of soil and groundwater management, community air monitoring, and worker health and safety monitoring programs during disturbance of surface and subsurface materials can mitigate the majority of potential exposure issues and eliminate complete exposure pathways.

8.2.6 Conclusions

There are no significant or imminent threats to human health that warrant an interim remedial action. Given the depths of the MGP-related impacts, the current and future planned use of the site, and the characteristics of the subsurface and the compounds of concern, exposure to human health or the environment to residual MGP tar residues is unlikely outside of significant construction or land development work for which environmental and health and safety controls would be warranted.

8.2 East 17th Street Station

The following summary and conclusions addresses the RIWP objectives, and associated characterization and remedial investigation findings, specific to the former East 17th Street Station.

8.2.1 Site History

Additional research was conducted on the development and demolition of the East 17th Street Station and involved mainly a review of historic maps and aerial photographs located at the New York City Public Library and the Municipal Archives at Chambers Street.

The East 17th Street Station reportedly began operations between 1860 and 1867 and was a gas storage facility. It too was built by the Manhattan Gas Light Company. Historic Sanborn® maps indicate that two gas holders, with approximately 270,000 cubic-feet capacity each, were located at the western portion of the ±1.5-acre station site, while the eastern portion of the site was used for pipe and material storage and an office. The site was situated approximately mid-way between Avenues B and C and stretched from East 17th Street north to East 18th Street. Based on historic maps and aerial photographs the holder was removed between 1921 and

1924. The site was then used as a possible "cinder yard". Con Edison sold the property in 1943 to Reconstruction Garage, Inc., and Stuyvesant Town Corporation acquired the property in 1944 for the housing development.

8.3.2 Extent of MGP Impacts in the Vadose Zone and Indoor Air

Seven soil gas samples were collected within and adjacent to the former East 17th Street Station footprint. As with the former East 14th Street Station site, VOCs common to both petroleum and MGP byproducts, that is BTEX and naphthalene, were detected in most soil gas samples; however, other petroleum-related constituents, primarily those associated with gasoline, were also pervasively present in the soil gas samples, suggesting that petroleum-related residuals in the subsurface may be a more significant contributor to the overall BTEX and naphthalene concentrations than MGP-related tar and tar residues in the subsurface. The vadose zone is comprised of heterogeneous urban fill, and physical observations and analytical findings for the SC and RI soil borings indicate that petroleum-related impacted soils are present beneath the site and are generally at shallower depths than those in which MGP-related impacts are noted (e.g., depths greater than 20 feet bgs.)

No indoor air samples were collected as part of the RI, but comparison of the distribution and concentrations of the compounds in previous indoor and ambient air samples, and RETEC and RI soil gas samples, support the previous RETEC report findings. The RETEC findings indicate that the chemical constituents and concentrations in indoor air more closely reflect the ambient air quality than that of the subsurface soil gas. Thus, the results to date suggest that indoor air within residential buildings currently occupying the former station sites is not adversely affected by the soil gas concentrations beneath the former station.

8.3.3 Extent of MGP Impacts in Subsurface Soils

For the East 17th Street Station, isolated intervals of tar–like material were encountered within the East 17th Street Station footprint to the west of the Avenue C Loop Road. Sporadic lenses of tar staining and or residual tar blebs were observed within fill and organic deposits. Tar impacts were typically encountered within soils between 26 feet and 29 feet bgs, but were present as shallow as 15 feet bgs at one location and as deep as 30.5 feet bgs at another location. During the valve excavation activities, tar impacts were also encountered at locations to the south of the station footprint along the Avenue C Loop Road and to the northeast of the station footprint near Avenue C. These impacts were generally encountered between depths of 9 and 13 feet bgs. In total, approximately 275 tons of non-hazardous characterized soils with potential MGP-impacts were removed from along the Avenue C Loop Road during the valve excavation activities.

8.3.4 Extent of MGP Impacts in Groundwater

At the East 17th Street Station, MGP constituents were measured in wells installed adjacent to the footprint of the former holders and in downgradient areas toward Avenue C. Interestingly the highest concentration of VOCs and SVOCs (and BTEX and PAHs, respectively) was generally found away from the former holder locations in shallow groundwater. BTEX and PAHs were primarily detected within groundwater samples from 17MWS03, which is downgradient of the former holders. Only trace concentrations of total BTEX and PAH compounds were detected in samples collected from 17MWS04, located adjacent to the former holders. The pattern of VOC and SVOC concentrations (and BTEX and PAH concentrations respectively) was reversed for the deeper wells. Here the highest VOC and SVOC concentrations were found in groundwater from deep wells located near the holder footprints than in downgradient wells.

During the valve replacement program, excavations where soil staining and MGP-type and/or petroleum-type odors were observed also exhibited sheens on the groundwater. These excavations were located both within and in the vicinity of the former station footprint.

8.3.5 Qualitative Human Health Exposure Assessment

As with the former East 14th Street Station site, there are several distinct human populations, both on and in the vicinity of the former East 17th Street Station site, who have the potential for exposures to MGP constituents if the subsurface soils are uncovered or disturbed. The on-site populations include residents and on-site workers (landscape, maintenance, and parking lot attendants) under current site use conditions. Relevant current off-site receptor populations include adult and child residents and adult and child receptors at adjacent establishments that may be exposed to fugitive dusts during subsurface construction and/or earth movement activities. Under future site use and activities, potential receptors may include construction workers and utility workers involved in excavation activities in the area of the former MGP sites.

In summary, subsurface media (soil, groundwater, soil gas) may provide an exposure pathway if excavation activities are conducted at the property. The QHHEA indicates there are no significant or imminent threats to human health that warrant an interim remedial action, and the emplacement and implementation of soil and groundwater management, community air monitoring, and worker health and safety monitoring programs during disturbance of surface and subsurface materials can mitigate the majority of potential exposure issues and eliminate complete exposure pathways.

8.3.6 Conclusions

There are no significant or imminent threats to human health that warrant an interim remedial action. Given the depths of the MGP-related impacts, the current and future planned use of

the site, and the characteristics of the subsurface and the compounds of concern, exposure to human health or the environment to residual MGP tar residues is unlikely outside of significant construction or land development work for which environmental and health and safety controls would be warranted. Given the observations made during the valve replacement activities, additional investigation activities may be warranted to further delineate tar impacts outside the original RI study area.

8.4 East 19th Street Station

The following summary and conclusions addresses the RIWP objectives, and associated characterization and remedial investigation findings, specific to the former East 19th Street Station.

8.4.1 Site History

Additional research was conducted on the development and demolition of the East 19th Street Station and involved mainly a review of historic maps and aerial photographs located at the New York City Public Library and the Municipal Archives at Chambers Street.

The East 19th Street Station occupied the least amount of property of the three MGP holder station sites. The station was located on the south side of East 19th Street, between Avenues A and B and occupied ±0.3 acres within the block. The station reportedly began operations between 1863 and 1868 as part of the New York Steam Company. Based on historic Sanborn® maps, one gas holder, estimated at a 500,000 cubic-feet capacity, and one small unidentified structure were present at the site. Based on review of historic maps, the holder was removed and replaced by an auto/truck garage between 1920 and 1921. The property was sold to Improvement Garage, Inc. in 1943 and acquired by the Stuyvesant Town Corporation in 1944.

8.4.2 Presence of Subsurface Structures

A limited geophysical survey was conducted within areas of the former East 19th Street Station not presently covered by buildings or structures. The purpose of the survey was to identify the potential presence of subsurface structures that may have been remnants of the associated former station, particularly the gas holder. GEI contracted the survey in lieu of supplemental test pitting within the area due to the co-location of the former holder footprint with the existing building foundations.

A subcontractor to GEI used ground penetrating radar (GPR) and an electro-magnetic pipe, cable and box locator to survey the area between the East 20th Street Loop Road and the 522-524 East 20th Street building. The results of the survey indicated the presence of a number of utilities and subsurface debris beneath the ground surface, but were inclusive regarding the potential presence of MGP-related substructures in the area.

8.4.3 Confirmation of Limited MGP Impacts

The RI activities conducted at the former East 19th Street Station was intended to provide physical and analytical confirmation regarding the absence of media impacts attributable to the former holder station. Previous environmental reports submitted to the NYSDEC for the former station site indicate that the limited, low-level impacts identified at and near the site were most likely attributable to other urban sources. Soil gas and indoor air contain detectable concentrations of BTEX compounds; however, as indicated in the previous RETEC findings, the low concentrations of VOCs detected within indoor air at the East 19th Street Station appear to be linked to outdoor air concentrations containing vehicle-combustion components, gasoline-related compounds and chemicals used as part of regular building activities. The RI soil gas results supports the conclusion that soil gas does not appear to be affecting indoor air based upon inconsistent concentrations detected between indoor air and soil gas beneath the former holder site.

Impacts of MGP residuals identified at the East 19th Street Station during the RI were limited to only one 13.5 inch soil sample interval located away from the footprint of the former gas holder, and no MGP-related impacts to groundwater beneath the former East 19th Street Station were detected during the RI sampling round. During the valve replacement program, stained soils and MGP-type odors were observed in several excavations conducted along the East 20th Street Loop Road at depths typically between 5 and 13 feet bgs; in addition, product globules and sheens on groundwater within several of the impacted excavations were also noted. These excavations were located outside the former station footprint and investigation study area. The impacts were observed within and/or beneath the fill horizon, which may or may not be associated with former operations at the property, and were variable and localized in degree and extent. In total, approximately 415 tons of non-hazardous characterized soils with potential MGP-impacts were removed from along the East 20th Street Loop Road during the valve excavation activities.

8.4.4 Conclusions

The RI findings confirm the previous findings of RETEC and H&A which suggested that MGP-related impacts beneath the East 19th Street holder site were either absent or very limited in extent. Based on the current and past structures within the East 19th Street Station footprint, and the findings of site investigations conducted by H&A, RETEC, and GEI, MGP-related impacts do not appear to be present at concentrations that pose a threat to the residential population or environment. However, based on the evaluation of field observations made during the valve replacement activities, additional investigation may be warranted to delineate subsurface tar impacts observed near the former East 19th Street Station along the East 20th Street Loop Road.

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