7.0 Qualitative Human Health Exposure Assessment

This section of the RI assesses the potential for exposure to constituents present in impacted soils, groundwater, soil vapor, and indoor air. This assessment identifies the potential release and transport mechanisms for the constituents of concern (COCs), point of exposure and exposure routes, and the receptors that could be exposed to COCs originating from the Current Site. It is assumed that direct contact with NAPL will pose an unacceptable risk and will not be evaluated as part of the QHHEA. The evaluation follows guidelines specified in the "NYSDEC DER-10 Technical Guidance for Site Investigation and Remediation" (NYSDEC, 2010a).

7.1 Current Site Setting

The Current Site is owned by individual third parties and used by multiple tenants for commercial uses. The Current Site contains one and two-story buildings and includes a vacant lot (Block 1007, Lot 18 and Block 1025, Lot 100), and a paved parking area. The buildings are serviced by public utilities including electric, water, and sewer.

The Current Site is located in a mixed commercial/industrial area of Brooklyn, NY and is located east of the Gowanus Canal, between the Gowanus Expressway (Highway I-278) and the New York City Transit train bridge and associated subway rail line. The Current Site is bounded by 11th Street and the 11th Street Basin to the north, 2nd Avenue to the east, 13th Street to the south, and the Gowanus Canal to the west.

The Current Site is underlain by approximately 15 feet of sand and silt fill identified by anthropogenic material (brick, glass, asphalt, etc.). A peat and organic silt layer is encountered below the fill followed by a sandy silt unit, a silty sand unit, with discontinuous units of silt with fine sand and fine gravel, sand with gravel and cobbles, to depths of approximately 121 ft bgs. A regional confining clay unit known as the Gardiners Clay was detected at the one deep boring location from 121 to 135 ft bgs and underlain by a brown, well graded medium to coarse sand and gravel known as the Jameco Gravel. Groundwater is encountered beneath the Current Site at minimum depths of approximately 3 to 10 ft bgs, and flows towards the west. The nearest water body in the direction of groundwater flow is the Gowanus Canal located directly adjacent to the west of the Current Site.

7.2 Exposure Assessment

Exposure is the process by which humans come in contact with constituents in their environment. Humans can be exposed to constituents in a variety of environmental media including surface soil, subsurface soil, soil vapor, groundwater and ambient/indoor air. Exposure to these media can occur through several routes including ingestion, dermal contact, and inhalation. The exposure assessment identifies likely pathways by which humans are potentially exposed to COCs.

The assessment includes the following:

- Development of a conceptual site model (CSM)
- Discussion of potential sources
- Evaluation of Current Site and off-Current Site data using health-based screening criteria

- Discussion of potential release mechanisms
- Identification of potential human receptors and receptor-specific exposure pathways

Residential and commercial properties in the vicinity of the Current Site obtain drinking water from municipal sources. Municipal sources in the area obtain water from up-state surface water and not from local groundwater. Therefore, the potential for exposure to Historic MGP Site derived constituents in drinking water has not been considered further in this assessment as it is not considered likely to be a complete exposure pathway.

Figure 6-1 presents the CSM for potential release and transport mechanisms for COCs at the Current Site. Included on the figure is information regarding the known or potential sources of COCs at the Current Site, the identified release mechanisms, and the affected source media. Potential migration pathways, exposure media and the potential exposure routes have also been presented. It should be noted that the exposure routes are considered potential unless there is an ongoing or documented exposure.

7.2.1 Contamination Sources

The sources of environmental impact being evaluated for the Current Site are residual materials associated with former MGP activities. Potential locations of residual contamination within or adjacent to the Current Site include:

- The former MGP structures where Hamilton Plaza (Block 1007, Lot 172) and Lowes (Block 1007, Lots 1, 118,219, and 220) are currently located.
- The former location of Holder 5 with additional gas storage (valve house) facilities (Block 1025, Lots 20 and 100).
- The area along 12th Street between the Gowanus Canal and 2nd Avenue, adjacent to several former MGP structures (Block 1007, Lot 18).
- Upgradient of the Current Site, near the intersection of 12th Street and 2nd Avenue at the former Department of Sanitation Site where BTEX was reported in shallow upgradient well MW-1S.
- Downgradient Current Site boundaries along 13th Street and Gowanus Canal. (Block 1025, Lots 1 and 200).

Surface soil (September 2010), subsurface soil (April, May, and September 2010; April, September through October 2011, and April 2012), groundwater, soil vapor and sub-slab vapor (March 2010; March and April 2011 and March 2012), indoor air and ambient air (March and April 2010) samples have been collected from the Current Site and analyzed for a range of constituents. Available analytical data were compared to New York State recommended standards and guidance values on a sample-by-sample basis. Comparison tables are presented in Section 5 of this report. The results of these comparisons are summarized below.

7.2.1.1 Surface Soil

Analytical data for surface soil (0 to 0.5 feet bgs) indicate that constituent concentrations are below New York State (NYS) Part 375 soil clean-up objectives (NYSDEC, 2006b) for a commercial land use scenario.

7.2.1.2 Subsurface Soil

For the purposes of this QHHEA, subsurface soils have been divided into those soils between 1-15 ft bgs and subsurface soils deeper than 15 ft bgs. This depth division is based on the assumption that intrusive

construction activities undertaken at the Current Site are likely to occur at depths between 0 and 15 feet bgs, therefore construction workers may be directly exposed to chemical constituents reported in soils between 0 – 15 ft bgs.

The following constituents were detected in subsurface soils between 1-15 ft bgs above New York State (NYS) Part 375 soil clean-up objectives (NYSDEC, 2006) for a commercial land use scenario:

- Arsenic (SB07[4-5]) at a concentration of 24.2 mg/kg; barium and lead (SB-13[4-5]) at concentrations of 424 mg/kg and 1230 mg/kg, respectively
- Benzo(a)anthracene (SB06[4-5]); SB07[4-5]; SB-07[10-12]; SB-08[3-4]; SB-11[4-5]; SB-16[10-13]; SB-17[4-5]; SB-18[1-2]) concentrations range from 6.41 mg/kg to 96.7 mg/kg
- Benzo(a)pyrene (SB-05_4-5; SB-06_4-5; SB-07_4-5; SB-07_10-12; SB-08_3-4; SB-09_4.5-5.0; SB-11_4-5; SB-16_4-5; SB-16_10-13; SB-17_4-5; SB-18_1-2) concentrations range from 1.16 mg/kg to 81.2 mg/kg
- Benzo(b)fluoranthene (SB06[4-5]; SB07[4-5]; SB-07[10-12]; SB-08[3-4]; SB-09[4.5-5.0]; SB-18[1-2]) concentrations range from 8 mg/kg to 35.6 mg/kg
- Chrysene (SB-07[10-12]) at a concentration of 96.5 mg/kg
- Dibenz(a,h)anthracene (SB-06[(4-5]; SB-08[3-4]; SB-09[4.5-5.0]; SB-11[4-5]) concentrations range from 0.835 mg/kg to 4.1 mg/kg
- Indeno(1,2,3-c,d)pyrene (SB-06[4-5]; SB-07[4-5]; SB-07[10-12]; SB-08[3-4]; SB-09[4.5-5.0]; SB-18[1-2]) concentrations range from 6.43 mg/kg to 24.1 mg/kg
- Naphthalene (SB-07[10-12]; SB-15[4-5] concentrations were reported at two locations (SB-07[10-12]; SB-15[4-5]) at 949 mg/kg and 525 mg/kg, respectively
- Phenanthrene was detected above soil clean-up objectives at a single location (SB-07[10-12])at 518 mg/kg

The following constituents were detected in subsurface soils deeper than 15 feet bgs, above NYS Part 375 soil clean-up objectives (NYSDEC, 2006) for a commercial land use scenario:

- Arsenic
- Benzene, ethylbenzene and toluene
- Acenaphthene, acenaphthylene, benzo(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(k)fluoranthene; chrysene; dibenz(a,h)anthracene; fluoranthene; fluorene; indeno(1,2,3-c,d)pyrene; naphthalene, phenanthrene and pyrene

7.2.1.3 Groundwater

Constituents detected in shallow groundwater (from wells screened between 3 and 30 feet below ground level), both Current Site and off-Current Site, at concentrations above AWQSGVs provided in the NYSDEC - Division of Water –TOGS 1.1.1 (NYSDEC, 1998, with addendums) include:

- benzene, ethylbenzene, toluene, and xylenes (BTEX)
- 1,4-dichlorobenzene (MW-7S), chlorobenzene (MW-7S), isopropylbenzene, MTBE
- acenaphthene, benzo(a)anthracene (off-Current Site only; MW20S), naphthalene, styrene

- phenol
- antimony, arsenic, barium iron, lead, magnesium, manganese, selenium, sodium, thallium
- cyanide (MW-4S and MW-7S)

Constituents detected in intermediate and/or deep groundwater (from wells screened at greater than 30 feet below ground level) at concentrations above AWQSGVs include:

- BTEX
- cis-1,2-dichloroethene, isopropylbenzene, PCE, trans-1,2-dichloroethene, trichloroethene (TCE), MTBE (off-Current Site only; MW20S), styrene, vinyl chloride
- acenaphthene, fluorene, naphthalene, phenanthrene
- 1,1-biphenyl, phenol
- antimony, arsenic, barium, iron, magnesium, manganese, sodium

7.2.1.4 Sub-Slab Vapor and Indoor/Ambient Air

In March 2010, 2 paired sub-slab vapor and indoor air samples (SV-1/IA-1 and SV-2/IA-2) were collected within the Current Site buildings located at in Block 1007, Lot 172. One outdoor (ambient) air sample was also collected outside Block 1007, Lot 172 during this March 2010 sampling event. In March and April 2011, 2 paired sub-slab vapor and indoor air samples (SV-3/IA-3 and SV-4/IA-4) were collected within two buildings within the Current Site located in Block 1025, Lot 26. Two ambient air samples were also collected during the March and April 2011 sampling events.

Constituent concentrations detected in indoor air were compared to NYSDOH background indoor air values (NYSDOH, 2006), site-specific outdoor air concentrations, and the paired sub-slab vapor concentrations. Constituents detected in indoor air above NYSDOH's indoor air values are discussed below:

- No MGP-related constituents were detected in indoor air during either sampling event above NYSDOH's background indoor air values.
- Carbon disulfide was the only MGP-related constituent detected in sub-slab vapor (2010 sampling event) above NYSDOH's background indoor air values. However, carbon disulfide was not detected in the paired indoor air sample and therefore does not pose a health concern via the vapor intrusion pathway.
- Three non-MGP constituents, 1,4-dichlorobenzene, chloroform, and Freon 11, were detected in at least one of the indoor air samples during the 2010 sampling event above NYSDOH background indoor air values. 1,4-Dichlorobenzene was not detected in any of the sub-slab vapor samples, therefore, 1,4-Dichlorobenzene is not considered to be from a subsurface source that has migrated to indoor air via the vapor intrusion pathway. Freon 11 was detected in the sub-slab vapor samples at concentrations approximately equal to or lower than in indoor air. Therefore, Freon 11 is also not considered to be from a subsurface source that has migrated to indoor air via the vapor intrusion pathway. Chloroform was detected in sub-slab vapor samples at concentrations less than paired indoor air samples. Therefore, chloroform is not considered to be from a subsurface source that has migrated to indoor air via the vapor intrusion pathway.
- One non-MGP constituent, 1,2-dichloropropane, was detected in one of the indoor air samples (IA-3) during the 2011 sampling event above NYSDOH's background indoor air value. However, 1,2-

dichloropropane was not detected in any of the sub-slab vapor samples. Therefore, 1,2-dichloropropane is not considered to be from a subsurface source that has migrated to indoor air via the vapor intrusion pathway.

7.2.2 Potential Release Mechanisms

There are several potential release mechanisms by which the constituents detected in soil, groundwater, and soil vapor may be transported to other media. Each mechanism is considered for identified media and potential receptor group. It is assumed that direct contact with NAPL will pose an unacceptable risk and will not be evaluated as part of the QHHEA. Potential release mechanisms for soil include the following:

- Fugitive dust – Constituents detected in surface and subsurface soil could be a potential source for fugitive dust as a result of physical disturbance.
- Volatilization – Volatile constituents detected in surface and subsurface soil may potentially be transported by volatilizing into soil-pore space and eventually emanate into outdoor or indoor air.
- Leaching – Constituents detected in surface and subsurface soil could potentially leach to groundwater.

Migration of chemical constituents in groundwater can act to transfer Current Site derived constituents off-Current Site. There are three mechanisms by which constituents in groundwater can be transported to other media. These migration pathways include the following:

- Adsorption – Constituents in groundwater may be sorbed onto subsurface soils.
- Volatilization – Volatile constituents in groundwater may potentially desorb into soil vapor and be transported into outdoor or indoor air.
- Extraction – Constituents in groundwater may migrate to other media by extraction and use of impacted groundwater.

There are two mechanisms by which volatile constituents in soil vapor can be transported to other media. These migration pathways include the following:

- Migration – Volatile constituents in soil vapor may migrate to indoor air through building foundations (i.e., vapor intrusion to indoor air).
- Migration – Volatile constituents in soil vapor may migrate to other media through soil to outdoor air.

7.2.3 Potential Human Receptors and Exposure Pathways

The section discusses identified potential human receptors and the potentially complete exposure pathways by which receptors may be exposed to Current Site-derived constituents.

7.2.3.1 Current Site Receptors

An assessment of potential exposure pathways for receptors in the Current Site area is presented in Figure 7-1. The analysis includes an identification of each potential receptor group, a listing of each potential exposure media and potential pathway, and a rationale for inclusion or exclusion of each potential receptor in the consideration of remedial actions for the Current Site where complete or potentially complete pathways exist. Potential receptor groups and potential exposure pathways that may exist for the Current Site are discussed below.

Current Site Indoor Commercial/Maintenance Workers

The Current Site is used for commercial purposes and is zoned for commercial land use. Current land use at the Current Site is expected to continue in the future. Commercial workers occupy the Current Site buildings, including full-time indoor commercial workers and intermittent indoor maintenance workers. These workers may be exposed to volatile constituents present in the subsurface of the footprint of the buildings through the migration of impacted vapors to the indoor air of the building. However, MGP-derived volatile constituents in sub-slab vapor and indoor air within Current Site buildings have not been detected above NYSDOH's background indoor air values. Therefore, inhalation of MGP-derived volatile constituents in indoor air is not considered to be complete for Current Site commercial/maintenance workers.

Exposure to groundwater via drinking water is not a complete exposure pathway because the buildings are supplied by a municipal water source, which is derived from surface water sources up-state. Municipal water in the area is not derived from local groundwater.

Direct contact exposure to constituents in soil and groundwater is not considered complete for Current Site commercial/maintenance workers because there were no constituents detected in surface soils above NYS Part 375 soil clean-up objectives (NYSDEC, 2006) for a commercial land use scenario, and because Current Site commercial/maintenance workers are not considered likely to conduct intrusive works at the Current Site and so are unlikely to directly contact soil and groundwater beneath the Current Site.

Current Site Outdoor Commercial/Maintenance Workers

Outdoor workers may potentially be exposed to constituents in surface soil from direct contact pathways (i.e., incidental ingestion, dermal contact) and inhalation of volatiles and particulates in outdoor air originating from soil while performing light maintenance activities such as lawn care. Since no constituents have been reported in surface soils above NYSDEC Part 375 Commercial use SCO, and the Current Site has limited un-paved areas, direct contact and particulate inhalation pathways are not considered likely to be complete for these receptors.

MGP-related constituents were detected at low concentrations in the ambient air samples collected at the Current Site, and sub-slab vapor concentrations were generally detected below NYSDOH's background indoor air levels, therefore inhalation of MGP-derived volatile constituents in outdoor air is not considered likely to be a complete exposure pathway for these receptors.

Current Site Construction Workers

Constituents have been reported in subsurface soil and groundwater at concentrations in excess of NYSDEC Part 375 Commercial use SCOs and AWQSGVs. Outdoor construction workers may potentially be exposed to constituents in subsurface soils and groundwater through direct contact (dermal contact or incidental ingestion) or inhalation of particulates during intrusive construction activities. Sub-slab vapor concentrations were generally detected below NYSDOH's background indoor air levels, therefore inhalation of MGP-derived volatile constituents in outdoor air is not considered likely to be a complete exposure pathway for these receptors.

Impacted groundwater is present beneath the Current Site at depths from approximately 2 ft to approximately 11 ft bgs, making it potentially available for contact by a construction worker. Only properly trained field personnel should complete the subsurface utility work in this area using methods specified in a site-specific HASP until the area has been cleared of impacted soils and groundwater.

Current Site Visitors and Trespassers

The Current Site is covered almost entirely with impermeable surfaces and large commercial buildings therefore direct contact with the subsurface is unlikely for Current Site visitors and trespassers. The absence of MGP-related constituent detections in surface soils also limits the potential for Current Site visitors and trespassers to contact constituents in soil.

These receptors are unlikely to conduct intrusive work in the area, therefore, direct contact with reported constituents in subsurface soils and groundwater is not considered to be a complete exposure pathway.

Concentrations of MGP constituents detected in indoor and outdoor air are below NYSDOH's background indoor air levels, therefore inhalation exposure to MGP-derived volatile constituents in indoor and outdoor air by these receptors is not considered to be a complete exposure pathway.

7.2.3.2 Off-Current Site Receptors

Potential off-Current Site receptor groups and potential exposure pathways for off-Current Site areas are discussed below. Analysis of each potential receptor group, potential media and pathways, and a rationale for inclusion or exclusion of each potential receptor in the consideration of remedial actions for the off-Current Site area have been included.

Off-Current Site Residential/Commercial Receptors in Upgradient and Cross-Gradient Areas

The flow of groundwater at the Current Site has been observed to be towards Gowanus Canal. Therefore, commercial and residential receptors to the east, southeast, and south are considered to be upgradient or cross gradient of the Current Site. Commercial receptors to the northeast and southwest are considered to be cross-gradient, however subsurface conditions beneath these receptors are considered likely to be similar to those observed beneath upgradient properties. The following exposure pathways have been considered for residential and commercial receptors in upgradient and cross-gradient areas:

Inhalation of volatile constituents in indoor and outdoor air:

Inhalation of MGP-derived constituents in indoor and outdoor air as a result of groundwater impacts are considered unlikely to be complete for these receptors given the expected flow of groundwater. Current Site sub-slab vapor concentrations were generally below NYSDOH's background indoor air values; based on off-Current Site groundwater concentrations, it is not expected that off-Current Site MGP-related soil vapor concentrations would be higher than Current Site concentrations. Detected constituents in groundwater are petroleum hydrocarbon based, and as petroleum hydrocarbons in subsurface vapor are not expected to migrate more than a distance of 30 feet due to their ability to biodegrade (ASTM, 2008; NJDEP, 2005), it is considered unlikely that MGP constituents will be present in off-Current Site subsurface soil vapor.

Direct contact with constituents in groundwater:

Groundwater has been reported at depths between 2.5 and 7 ft bgs off-Current Site to the northeast of the Current Site. Based on the westerly direction of groundwater flow observed in the RI, it is considered unlikely that MGP-related groundwater impacts would be present or migrate to off-Current Site receptors to the northeast and east of the Current Site. Residential and commercial receptors are considered unlikely to conduct intrusive work and therefore direct contact with constituents in groundwater is considered unlikely.

Direct contact with and incidental ingestion of constituents in subsurface soil:

Detected constituent concentrations in subsurface soil are not considered likely to be present in off-Current Site upgradient soils unless off-Current Site filling activities were undertaken during decommissioning of the MGP facility. Therefore, it is considered unlikely that residential or commercial receptors would directly contact MGP-derived constituents in soil.

Off-Current Site Commercial Properties Downgradient of the Current Site

The flow of groundwater at the Current Site has been observed to be towards the Gowanus Canal. Therefore, commercial receptors identified to be present to the north, northwest, and west of the Current Site (on the other side of Gowanus Canal) are considered to be downgradient of the Current Site. The following exposure pathways have been considered for off-Current Site commercial receptors in downgradient areas:

Inhalation of volatile constituents in indoor and outdoor air:

Based on detected concentrations in shallow groundwater wells (MW-19S and MW-20S) it is considered unlikely that MGP-derived volatile constituents would be present in soil vapor beneath the commercial properties downgradient of the Current Site. Volatile constituents have been reported in intermediate depth groundwater (MW-19I and MW-20I), however, these constituents were not reported in shallow groundwater, therefore, they are considered unlikely to contribute to soil vapor concentrations.

Direct contact with constituents in groundwater:

Off-Current Site commercial workers are not considered likely to perform intrusive works on off-Current Site commercial properties; and exposure to groundwater via drinking water is not considered likely to be a complete exposure pathway because the buildings are supplied by a municipal water source (that is not derived from local groundwater). Therefore, direct contact and ingestion pathways for off-Current Site groundwater are not considered complete for these receptors.

Direct contact with and incidental ingestion of constituents in subsurface soil:

Reported constituent concentrations in subsurface soil are present at depths greater than 30 ft bgs at off-Current Site locations. However, given the shallow groundwater table and the depth the impacts were noted, off-Current Site commercial receptors are unlikely to directly contact MGP-derived constituents in soil.

Off-Current Site Construction Workers

MGP-derived constituents have been detected in shallow groundwater in off-Current Site areas surrounding the Current Site. As groundwater has been reported at depths between 2.5 and 11 feet below top of casing in off-Current Site areas, there is potential for direct dermal contact and incidental ingestion of groundwater during intrusive works in off-Current Site areas surrounding the Current Site.

Due to the shallow nature of groundwater in the area, any off-Current Site soil impacts are expected to be a result of the presence of impacted groundwater. However, reported constituent concentrations in soil have not above adopted screening criteria between 0 and 15 ft bgs. Therefore, direct dermal contact and incidental ingestion of constituents in subsurface soils are not considered to be complete exposure pathways for off-Current Site construction workers.

It is recommended that only properly trained field personnel should complete the subsurface utility work in this area using methods specified in a site-specific HASP until the area has been cleared of impacted groundwater or if deep excavation (greater than 15 feet bgs) is planned.

7.2.4 Summary of Receptors and Potentially Complete Exposure Pathways

A summary of the environmental media, potential receptors and potentially complete exposure pathways has been provided in the following table. Potential receptors are based on current site use and adjacent site uses, and the potential for future uses and activities (i.e., construction/utility activities). Potentially complete exposure pathways are identified if a receptor has a current or potential future exposure to impacted media.

Location	Media	Exposure Routes	Indoor Commercial/ Industrial Worker	Outdoor Commercial/ Industrial Worker	Construction/ Utility Worker	Visitor/ Trespasser	Off-Current Site Resident
Current Site	Surface Soil	Inhalation (volatiles and particulates) Direct Contact (incidental ingestion, dermal contact)	×	×	×	×	×
	Subsurface Soil	Inhalation (volatiles and particulates) Direct Contact (incidental ingestion dermal contact)	×	×	✓	×	×
	Groundwater	Ingestion Direct Contact	×	×	✓	×	×
	Soil Vapor	Inhalation	×	×	×	×	×
	Indoor Air	Inhalation	×	×	×	×	×
	Ambient Air	Inhalation	×	×	×	×	×
Off-Current Site	Surface Soil	Inhalation (volatiles and particulates) Direct Contact (incidental ingestion, dermal contact)	×	×	×	×	×
	Subsurface Soil	Inhalation (volatiles and particulates) Direct Contact (incidental ingestion, dermal contact)	×	×	×	×	×
	Groundwater	Ingestion Direct Contact	×	×	✓	×	×
	Soil Vapor	Inhalation	×	×	×	×	×

Note:

× Incomplete Exposure Pathway

✓ Complete Exposure Pathway

7.3 Conclusions

Complete exposure pathways have not been identified for current site and off-Current site commercial industrial workers, visitors and trespassers, and off-current site residential receptors.

Current site and off-Current site construction workers who perform excavation work on or adjacent to the Current Site may potentially be exposed to PAHs, metals, and/or VOCs in subsurface soil and groundwater if subsurface excavation work is needed adjacent to or at the Current Site. Only properly trained field personnel should complete the subsurface utility work in this area using methods specified in a site-specific HASP until the area has been cleared of impacted soils and groundwater.