August 12, 2011

Mr. Edward Hampston, P.E.
New York State Department of Environmental Conservation
Division of Environmental Remediation
Remedial Bureau D – 12th Floor
625 Broadway
Albany, NY 12233-7013

Re: Former Paragon Oil Terminal and
the 100-120 Apollo Street Property
Texaco Facility #304209
Greenpoint Section – Brooklyn, New York
Groundwater and PSH Alternatives Analysis Report

Dear Mr. Hampston:

SAIC Energy, Environment & Infrastructure, LLC (SAIC), on behalf of Texaco Inc. (Texaco), respectfully submits to the New York State Department of Environmental Conservation (NYSDEC) this Groundwater and Phase Separated Hydrocarbons (PSH) Alternatives Analysis Report. This report identifies and compares remedial alternatives for the groundwater and PSH media of concern at the above referenced sites. The report also proposes the selected remedies for both media. This report has been completed in accordance with the amended Order on Consent Case No. D2-1111-01-09AM between Texaco and NYSDEC dated May 15, 2009.

If you have any questions concerning the information presented in this report, please do not hesitate to contact either Ms. G. M. Harris of Chevron Environmental Management Company on behalf of Texaco at 713-432-2248 or Mr. Peter Cagnetta of SAIC at 717-901-8841.

Sincerely,

SAIC Energy, Environment & Infrastructure, LLC

Peter J. Cagnetta

Peter J. Cagnetta, CPSS
Senior Project Manager/Soil Scientist

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GROUNDWATER AND PHASE SEPARATED HYDROCARBONS (PSH) ALTERNATIVES ANALYSIS REPORT FOR THE FORMER PARAGON OIL TERMINAL AND THE 100-120 APOLLO STREET PROPERTY GREENPOINT, BROOKLYN, NEW YORK FACILITY #304209

Prepared for:

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August 12, 2011

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1.0 INTRODUCTION

SAIC Energy, Environment & Infrastructure, LLC (SAIC), on behalf of Texaco Inc. (Texaco), respectfully submits to the New York State Department of Environmental Conservation (NYSDEC) an Alternatives Analysis Report for Groundwater and Phase Separated Hydrocarbons (PSH) media of concern. The report is for the former Paragon Oil Terminal properties located at 16, 42, and 50 Bridgewater Street (Paragon site) and the adjacent 100-120 Apollo Street properties (Apollo Street site) in Brooklyn, New York. Figure 1-1 presents the location of these sites and the regional site setting.

In May 2009, Texaco signed an Amended Order on Consent for Case No. D2-1111-01-09AM. This Order provides for the implementation of site-wide corrective action on both the Paragon site and the Apollo Street site. This report identifies and compares the remedial alternatives for groundwater and PSH media of concern and evaluates proposed remedies for both media.

Specifically, this report presents the following information:

1. A summary of historical operations for both the Paragon site and Apollo Street site.
2. A summary of the remedial investigations and remedial actions that have been conducted on the sites.
3. The identification of remedial goals and remedial action objectives for groundwater and PSH.
4. A presentation of the remedy selection criteria established by the NYSDEC.
5. The development and evaluation of remedial alternatives for the groundwater and PSH.
6. The identification of the proposed selected remedies for the groundwater and PSH at the site.

2.0 SITE OPERATIONS

Paragon Oil Company operated a petroleum bulk storage terminal on the Paragon site from 1934 to 1958, and Texaco operated a petroleum bulk storage terminal on the Paragon site from 1958 to 1968. Neither Paragon Oil Company nor Texaco ever owned or maintained petroleum refining operations on the Paragon site. There is no record of any commercial petroleum activities on the Apollo Street site. Currently, Empire Merchants operates a wholesale wine and spirits distribution business from the warehouses located at the Paragon and Apollo Street sites. The Paragon site and Apollo Street site are completely developed, with a series of interconnected warehouses, driveways, and paved parking lots at grade. Nearly the entire surface of these sites is covered with concrete warehouse floors or asphalt pavement. The following sections describe historic property operations in more detail.

The sites are located in the New York City Planning Commission M3-1 manufacturing zoning district, designated for heavy industrial use (Figure 2-1). The sites are bound by the M3-1 manufacturing zoning district to the east beyond Meeker Avenue, to the west beyond Apollo Street, and to the southeast beyond Bridgewater Street. The land across Bridgewater Street from the Apollo Street site is designated M1-2 manufacturing zoning.

The sites are also located within a Significant Maritime and Industrial Area (SMIA) as identified by the City of New York in the New York Comprehensive Waterfront Plan (NYC Department of City Planning, 1992) and the New York City New Waterfront Revitalization Program (NYC Department of City Planning, 2002). This is one of six SMIAs throughout the City of New York. These two documents describe SMIAs as areas where the City of New York supports a future use as a functioning industrial waterfront.

2.1 Former Paragon Oil Terminal Site

The Paragon site is located north of Bridgewater Street and is bound by Newtown Creek to the north, Meeker Avenue to the east, and the Apollo Street site to the west. It operated as a petroleum fuel and lubricants terminal from 1934 to 1968. Approximately 80% of the products stored at the Paragon site in 1954 were lubricating oils and fuel oils (No.'s 2, 4, and 6). In 1958, Texaco purchased the Paragon site and operated a petroleum bulk storage terminal until 1968. In 1965, approximately 77% of the products stored at the terminal were lubricating oils and fuel oils (No.'s 2, 4, and 6). Products stored at the Paragon site between 1934 and 1968 also included kerosene, diesel fuel, and gasoline.

Peerless Importers, a wholesale wine and spirits distribution company, purchased the Paragon site in 1969. In 2006, Peerless Importers and Charmer Industries merged to form a new entity, Empire Merchants. Empire Merchants operates the warehouses on the Paragon site.

2.2 100-120 Apollo Street Site

The Apollo Street site is bound by Newtown Creek to the north, the Paragon site to the east, Bridgewater Street to the south, and Apollo Street to the west. Neither Paragon Oil nor Texaco owned or operated on the Apollo Street site, and historical searches have not found any petroleum terminal or refinery operations located on this site. Empire Merchants operates the warehouses on the Apollo Street Site. Table 2-1 is a list of historic property owners and operators at the Apollo Street site.

The entity identified at the Apollo Street site prior to 1928 was the D. Cosagliola & Company Ship Yard in 1916. In 1928, the Brooklyn Ash Removal Company owned the Apollo Street site. Aerial photography of the same year shows no visible structures.

2.2.1 New York City Incinerator Operations

In 1933, the City of New York Sanitation Department purchased the property and subsequently began operating an incinerator plant there. The presence of this incinerator was confirmed by 1941 and 1951 Sanborn Fire Insurance maps and 1938, 1954, and 1960 aerial photographs. The 1965 Sanborn Fire Insurance map shows no structures on the property, and a 1966 aerial photograph confirms that there were no buildings on the property at that time. Figure 2-2 presents a 1960 aerial photograph of the Apollo Street site.

2.2.2 Current Operations

The warehouses at 100-120 Apollo Street were constructed around 1969 when the Bridge Apollo Company purchased that property. The warehouses were used to house various operations over the years, including the S. & P. Drug Company, J. B. Williams Exp. Company, and SP Ventures, Inc. The property was sold to Apollo Steel, LLC in 2000. The Apollo Street site warehouses are currently leased to Empire Merchants.

3.0 SUMMARY OF REMEDIAL INVESTIGATIONS AND REMEDIAL ACTIONS

Texaco has been conducting investigation and remedial action activities for petroleum compounds at the Paragon site since June 2005 and at the Apollo Street site since May 2009. Investigation activities have included:

- delineating the extent of petroleum-impacted soil,
- delineating the extent of petroleum-impacted groundwater, and
- delineating and identifying the source of the subsurface PSH in the saturated zone.

SAIC detailed the procedures, results, and interpretations of site characterization activities in the Site Characterization Report (2006) and Supplemental Site Characterization Reports (2007 and 2010).

An interim remedial measure (IRM) at the sites included efforts focused on eliminating a completed pathway for stopping a petroleum seep into Newtown Creek. The efforts included:

- installation of a below grade grout wall along the bulkhead,
- sealing seams on the steel bulkhead,
- completion of a creek-side barrier on the Apollo Street site timber crib bulkhead,
- operation of a 13-well Total Fluids Recovery (TFR) system, and
- maintenance of a creek-side containment boom system.

The collective efforts described above were initiated in 2006 and have successfully stopped petroleum seepage into the creek.

The grout wall is located immediately behind the steel bulkhead on the Paragon site in the vicinity of a historical seep of PSH into Newtown Creek. Grout wall construction was completed in November 2006. This grout wall extends 7 feet above and below mean sea level to provide a barrier to PSH flow (SAIC, 2008).

Seams in the existing steel bulkhead were sealed with marine epoxy in September 2008. Monthly inspections are made and maintenance activities have been performed to maintain the competence of the sealed seams.

An impermeable HDPE barrier was installed on the face of the wooden timber crib bulkhead along the easternmost 67 feet of the Apollo Street site in 2008. The concrete gravity wall was

resurfaced and cracks repaired with hydraulic cement. The combination of the grout wall, the sealing of the seams, and the timber crib barrier has effectively blocked PSH from entering the creek.

A TFR system recovers groundwater and PSH from a system of 13 recovery wells located immediately behind the grout wall on the Paragon site and extends behind the HDPE barrier on the Apollo Street site bulkhead. The mass removal of PSH and impacted groundwater, combined with the maintenance of a groundwater gradient away from the creek, has contributed to stopping the seep.

Remedial actions at the sites have focused on eliminating the vapor intrusion pathway and have included:

- the voluntary operation of a sub-slab depressurization system (SSD),
- the maintenance of the warehouse floors to remove potential preferential pathways, and
- biannual ambient air sampling on both sites.

Ongoing voluntary measures include operating an SSD system in the north office space of 50 Bridgewater Street on the Paragon site and sealing the warehouse floor slab throughout the two properties. The mechanical SSD system extracts subsurface air from immediately below the office space floor, thus mitigating potential aboveground risk. The system has been operating since 2010. In addition, SAIC has been periodically sealing cracks and seams in the warehouse floors at both the Paragon site and the Apollo Street site since July 2009. This activity ensures the concrete warehouse floor is a competent barrier to eliminate the vapor intrusion pathway.

3.1 Saturated Zone Conditions

A description of the geomorphology of the site area, including documentation of the development and filling of part of the former Newtown Creek out to the present bulkheads, was provided by SAIC (2006, 2007, and 2010). The sites are located on the south side of Newtown Creek (Figure 1-1). The area under the northern half of the sites was historically part of the Newtown Creek channel and is now filled. Figure 3-1 shows development of a portion of the Paragon site in 1886, improved with a bulkhead and fill into the former channel. Subsequent bulkhead and fill activity resulted in the present shoreline.

Soil borings and well logs identified the presence of a natural layer of silt above the coarser strata (sand and gravel) that make up the regional aquifer. These low energy areas of the creek bed filled naturally with fine grained material. With the installation of bulkheads and additional fill to provide improved marine access to the sites, the channel was forced northward, altering sediment deposition patterns. Figure 3-2 presents the lateral extent of the silt layer that was

originally part of the creek bed. The site was built up to its current extent and grade in stages, with bulkheads and fill (consisting of sand, silt, gravel, wood, brick, and ashes) used to create the land.

With the arrival of the Brooklyn Ash Disposal Company at the Apollo Street site (circa 1928), there was a potential new source of fill material. Based upon accounts of other Brooklyn Ash Disposal sites, this material (including residential ash and locally generated ash) may have been used for fill in this area.

3.1.1 Stratigraphic Model

Based on the results of all past site characterization activities, a conceptual site model has been developed (SAIC, 2010). This section presents the physical components of the model, contaminant sources, and affected media. The physical conceptual site model is derived from the field soil descriptions, groundwater, and PSH gauging data, and general details of recovery systems that affect the site conditions.

Figures 3-3 through 3-6 present generalized three-dimensional views of the subsurface stratigraphy underlying both the Paragon and Apollo Street sites. These conceptual diagrams are based on detailed soil descriptions and stratigraphic cross sections previously presented in the SAIC Site Characterization Report (2006) and the Supplemental Site Characterization Report (2007).

Figure 3-3 presents a subsurface view along Meeker Avenue and Bridgewater Street, which are the eastern and southern boundaries for the sites. Along Bridgewater Street, the subsurface stratigraphy is comprised of an upper fill zone and a lower naturally occurring sand and gravel zone with the free water table present within the sand and gravel zone. By Meeker Avenue, the subsurface is comprised of the same stratigraphic zones, with the addition of a naturally occurring silt zone located at the northern end of Meeker Avenue that is the former bed of Newtown Creek. In Figure 3-3, along both streets, the presence of PSH in the saturated zone is noted with a red line and, where PSH are absent, a blue line is used to denote the groundwater table.

Figure 3-4 presents a three-dimensional view of the stratigraphy along Apollo Street and Bridgewater Street. Along Apollo Street, an uppermost fill zone is present and tends to thicken within the northward direction. Underlying the fill zone in the vicinity of Newtown Creek is the same naturally occurring silt layer as depicted on Figure 3-3. The absence of PSH in groundwater monitoring wells at the north end of Apollo Street is depicted on Figure 3-4 with a blue-coded water table at the end of Apollo Street.

Figure 3-5 presents a section from Apollo Street but through the midpoint of the Paragon site and the Apollo Street site and parallel to Bridgewater Street. In this view, the naturally occurring silt layer is present from the west end of the Apollo Street site and extends nearly to the east end at Meeker Avenue. As presented in previous characterization reports, both the free water table and the upper surface of the PSH zone are present within the fill zone and above the silt layer. The fill is comprised of coarse-textured sand and gravel with man-made artifacts such as bricks, nails, glass, and other materials. Underlying the silt layer at two locations are naturally occurring peat zones, and at greater depth, the alluvial sand and gravel zone is present.

Figure 3-6 is a view from Apollo Street but presents a cross section of the sites perpendicular to Bridgewater Street. The cross-sectional view presents the naturally occurring silt layer under the fill zone that extends from Newtown Creek and southward toward Bridgewater Street. This silt zone is interpreted to be the base of Newtown Creek prior to 1886 when fill was placed in this area.

3.1.2 Groundwater Conditions

The shallow water-bearing zone at this site exists under either unconfined or semi-confined conditions. On the north side of the site, near Newtown Creek, the water table is in the fill zone with unconfined conditions. Deeper groundwater is found in the regional alluvial sand and gravel and is semi-confined. Farther south, along Bridgewater Street where the silt layer is absent, the unconfined water table is in the alluvial sand and gravel. Groundwater conditions are changing as dewatering by the ExxonMobil remediation system continues.

3.1.2.1 Flow Conditions

The current groundwater flow conditions are presented on Plate 1 with the data summarized in Table 3-1. The current groundwater contours and flow conditions as of June 29, 2011, on the sites are influenced by the groundwater extraction systems both on the sites and off the sites (particularly ExxonMobil RW-21, RW-23, RW-25, RW-26, RW-D, RW-E, RW-H, RW-I and RW-J). With the Texaco TFR system along the bulkhead and ExxonMobil's off-site recovery wells, the general groundwater flow conditions are toward the different pumping centers and away from Newtown Creek.

3.1.2.2 Constituents of Concern

The petroleum constituents of concern in the site groundwater are presented on Plates 2 and 3. Plate 2 presents the volatile constituents in the groundwater that exceed the NYSDEC ambient water quality standards for GA classified groundwater. GA classified groundwater is defined as a source of drinking water and as such is protected for human consumption (NYSDEC, 1998). The data were from the 2010 annual groundwater sampling and analysis event. Only wells that did not contain measureable PSH thicknesses were sampled. These results were presented in the

SAIC Supplemental Site Characterization Report (SAIC, 2010). The impacted groundwater is closely associated with the presence of PSH in the saturated zone. The groundwater that generally contained concentrations below the ambient water quality standards is not associated with the PSH and is present along the northeast part of the Paragon site, within the Paragon site by wells CMW-4 and CMW-5, and then along the northwest bulkhead of the Apollo Street site. The distribution of impacted groundwater and non-impacted groundwater indicates the PSH is the source of dissolved phase constituents in the groundwater. Table 3-2 summarizes the results for the volatile constituents from the 2010 groundwater sampling.

Plate 3 presents the concentrations of semi-volatile organic compounds (SVOCs) in the groundwater that exceed the ambient water quality standards. The distribution of the concentration exceedances is also with the PSH in the saturated zone. However, the number of SVOCs that exceed the water quality standards and the number of locations are less than the VOC exceedances in the groundwater. The four polyaromatic hydrocarbons (PAHs) that exceed the water quality standards are benzo-a-anthracene, benzo-b-fluoranthene, crysene, and indeno(1,2,3-cd)pyrene. They are generally present at less than 1 microgram per liter (μg/L), and the water quality standard for all four compounds is 0.002 μg/L. Table 3-3 summarizes the results for the SVOCs from the 2010 groundwater sampling.

Table 3-4 presents results for nonpetroleum-related compounds. No aroclors are present in the groundwater. Seven of the eight Resource Conservation and Recovery Act (RCRA) metals are not present above the NYSDEC Ambient Water Quality Standards (AWQSs) for human health. Arsenic is present at only one location above the AWQSs at 0.0324 milligrams per liter (mg/L).

Figure 3-7 presents the distribution of the conductivity values for the groundwater across the sites. These data were collected during the 2010 groundwater sampling event. Although groundwater conductivity is not a regulated condition, it does, however, affect the long-term potential uses for the groundwater and is relevant within the evaluation of remedial alternatives.

Conductivity is a measure of the groundwater to pass an electrical current. The presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and other naturally occurring ions affects the conductivity of the water. Organic compounds such as petroleum constituents do not conduct an electrical current and therefore have a very low effect on the conductivity of groundwater. The higher the ion content or soluble salts, the greater the conductivity value for the groundwater.

The groundwater conductivity is greatest in the northern part of the site along Newtown Creek and decreases toward Bridgewater Street. The average conductivity within 100 feet of the bulkhead is 19,300 microSiemens per centimeter (μS/cm). The average conductivity within the remainder of the sites is 2,800 μS/cm. The mixing of the brackish surface water from Newtown Creek with the groundwater in the vicinity of the bulkheads is evidenced by the much greater conductivity values nearest the creek. Conductivity values of non-saline surface waters and

rivers within the United States generally range from 50 to 1,500 μS/cm. Groundwater used for industrial purposes can range as high as 10,000 μS/cm (EPA, 2010). The conductivity of the groundwater at the site likely prohibits the use of the water for many purposes, with the exception of possible industrial use.

3.1.3 Phase Separated Hydrocarbons

Plate 4 presents the lateral extent of the PSH in the saturated zone in June 2011. The distribution of PSH on the Paragon site and the Apollo Street site has been fairly consistent since PSH delineation activities began in 2005. PSH that is closest to the bulkhead by Newtown Creek is where the existing Texaco TFR system has been in operation since 2007. The performance of this system is summarized in section 3.3 of the report.

3.2 Ambient Air Monitoring Summary

The ambient air monitoring has been ongoing at the site since 2005. CA Rich Consultants, Inc., on behalf of Empire Merchants, completed this task through 2009. With the amendment of the Texaco Order on Consent in May 2009, SAIC began completing the ambient air monitoring events in the winter of 2010. The current program consists of collecting indoor and outdoor ambient air data twice each year to include the winter heating season and the summer cooling season. The current sampling program consists of 17 locations that are presented on Figure 3-8. During each event, three ambient air samples are collected from outside the buildings, eight samples are collected from the warehouses, and six samples are collected from within the office spaces. Table 3-5 presents a summary of the ambient air sampling data collected from July 2005 through February 2011. Complete data sets have previously been submitted to NYSDEC in quarterly reports. The data presented in Table 3-5 identify the number of times a sample was analyzed for a particular compound, the minimum and maximum value for that compound at that sampling location, and the average concentration collected across all data points.

The analytical results were not screened against standards, criteria, or guidance (SCG) values because very few exist for petroleum compounds in this medium in New York State. Therefore, as a reference data set for the Greenpoint area, the residential data collected by the NYSDEC during the 2006 and 2007 heating season were generally compared to the data collected for the Paragon site and Apollo Street site (Ecology and Environment Engineering, PC, 2007). Specifically, the compound benzene was utilized in this comparison. Table 3-6 presents the actual benzene data results collected from the 50 residences over or within the vicinity of the ExxonMobil off-site plume where both indoor basement air samples and indoor first-floor air samples were collected. Figures 3-9 through 3-11 present a relative comparison of the data sets from the residential area and the Paragon and Apollo Street sites. The residential results are distributed along the X axis on the graph. The figures present the range of residential data within close proximity of the Paragon and Apollo Street sites data.

Figure 3-9 presents the actual benzene concentrations collected in the three current ambient air sampling locations on the Paragon and Apollo Street sites along with the three historical ambient air sampling locations that are no longer being used. The three previous locations were on the roof of the warehouses and were discontinued due to safety concerns associated with the collection of these samples, especially during winter months. Site data generally show that the benzene concentrations from the outdoor air range between 1 and 8 micrograms per cubic meter ($\mu g/m^3$). Since February 2009, the data show a downward concentration trend. This trend represents an improvement in the outdoor air quality on the site. One contributing activity completed by Texaco was the installation and operation of the TFR system to stop the seepage of PSH into Newtown Creek. By the first quarter of 2009, the seep was reduced significantly and only intermittent sheens were present. This activity may have had a positive effect on the outdoor air quality at the site. The data indicate that the benzene concentration in the outdoor air at the sites is similar to the concentration of benzene in the indoor air of residences in the community. This comparison suggests that the outdoor air on the site is not being adversely affected by the below grade PSH.

Figure 3-10 presents the benzene concentration in the indoor office ambient air for the sites. The complete data set from 2005 through February 2011 for each of the six office sampling locations are presented on the graph. The site office concentrations are primarily within 1 to 8 $\mu g/m^3$ concentration range but also show a decline since February 2009. This decline could possibly be related to the improvement of outdoor air quality and also the sealing of the cracks and seams in the warehouse floors, as there could be some connectivity between the warehouse air and the office air. Presented on this figure are also the NYSDEC residential data from the 50 residences. This figure includes the indoor basement air concentrations and the indoor first-floor air concentrations. The residential indoor air data set is similar but yet slightly lower than the site benzene data set prior to February 2009. However, since February 2009, the concentration of benzene in the office ambient air has been within the residential indoor ambient air range.

Figure 3-11 presents a comparison of the data from the indoor warehouse ambient air samples versus the residential indoor air data for benzene. The declining trend since February 2009 is also evident on this graph, and concentrations are generally below 10 $\mu g/m^3$ since August 2009. This declining concentration could be a function of the mitigation of the seep, the ongoing sealing of cracks and seams in the warehouse, and also the operation of the SSD system in the 50 Bridgewater Street rear office space.

The operation of the SSD, the biannual ambient air sampling program, and the ongoing pathway elimination program will continue at the site.

3.3 Seep Mitigation Action Summary

Since September 2007 (see Figure 3-12), Texaco has operated a TFR system along the bulkheads at the location of a former PSH seep through the bulkhead. The primary objective of the TFR

system was to stop the seepage of PSH and sheens into Newtown Creek by maintaining hydraulic control of the gradients behind the bulkhead. The current objective of the TFR system is to maintain the permanent stoppage of the PSH seep.

The TFR system has been successful at stopping the seep of PSH entirely and reducing the presence of sheens to an infrequent occurrence. Only one observed sheen was recorded within the booms during the fourth quarter of 2010, and only two were recorded in 2011 through the second quarter. Figure 3-13 presents the decrease in sheens in the boom system since the system was installed. The success of the TFR system in stopping the seep has contributed to both the improvement of surface water quality in Newtown Creek and air quality on the sites, both indoor and outdoor.

The groundwater flow dynamics and the PSH conditions underlying areas where the former PSH seep was observed on the Paragon site and the Apollo Street site have been primarily controlled by the TFR system, the ExxonMobil off-site recovery system, and tidal fluctuations in Newtown Creek. The following paragraphs discuss the effectiveness of maintaining a reversed gradient in stopping the PSH seep.

The water elevation in Newtown Creek is subject to a five-foot semidiurnal astronomic tidal range. The performance of the TFR system is presented in Figures 3-14 and 3-15. The figures present the PSH and groundwater capture zone induced by the recovery wells behind the bulkhead at high tide and low tide. Figure 3-14 illustrates the capture zone of the TFR system at high tide. The groundwater pumping level and the top of the PSH in the wells behind the bulkhead are maintained at a lower elevation than the water in Newtown Creek. This capture zone created by the high tide condition and TFR pumping behind the bulkhead ensures that groundwater and PSH do not seep into Newtown Creek.

During low tide conditions (Figure 3-15), groundwater and PSH capture is maintained behind the bulkhead despite the lower elevation of the surface water on Newtown Creek. During low tide, groundwater and PSH pumping elevations are maintained below the elevation of Newtown Creek. This means that even at low tide, the TFR system maintains the hydraulic gradient from Newtown Creek inland to behind the bulkheads. This reversed gradient indicates that the capture zone is still preventing seepage of groundwater and PSH into Newtown Creek at low tide.

The reversed PSH and hydraulic gradients have been maintained by the extraction of groundwater and the recovery of PSH from behind the bulkheads. Figure 3-16 presents a summary of the PSH recovery data. Through the second quarter of 2011, 42,752 gallons of PSH have been recovered from immediately behind the former seep area. The decline in the PSH recovery rate indicates the mass of recoverable PSH in the area has declined. This is attributed to the effective recovery of the PSH and the absence of a continuing source of PSH. With the absence of a PSH source, the driving force for the migration of the PSH (PSH gradient) diminishes with time and the PSH plume becomes functionally stable. The stability of the plume

along with the ongoing natural attenuation processes may preclude the need for pumping to maintain the long term permanence of stopping the PSH seep.

Figure 3-17 presents the concentration of benzene in the untreated groundwater entering the TFR system. In the nearly four years of operating the system, the benzene concentration has declined from over 2,000 μg/L to approximately 100 μg/L. The benzene concentration data indicate that the groundwater quality in the vicinity of the bulkhead has improved. This is in part due to the removal of PSH from the saturated zone using a containment and extraction approach.

3.4 Exposure Assessment

The discussion in this section references Figure 3-18, which presents the exposure routes and current mitigation activities. Specifically, this section will discuss the potential source or sources of contamination, the affected media and exposure route, possible receptors, and the current mitigation activities and conditions that are present at the Paragon site and the Apollo Street site.

The Paragon site ceased to be an active petroleum terminal in 1968. The Apollo Street site was never a petroleum storage or distribution facility. The subsurface PSH is considered the primary source of ongoing impacts to the groundwater and the subsurface soil vapor. As previously stated, the distribution of PSH on the site has been consistent since 2005, when detailed characterization activities were initiated. Based on the current use of the property as a wholesale wine and liquor distribution facility and not a petroleum terminal, the contribution of additional PSH to the subsurface is extremely unlikely. In addition, the Texaco TFR system continues to remove PSH from the subsurface on the sites as does the ExxonMobil off-site recovery system adjacent to the sites.

If left unmitigated, PSH in the saturated zone has the potential to impact site employees and construction workers through three primary exposure routes that include vapor intrusion, dermal contact, and incidental ingestion. The current mitigation activities that are being completed at the Paragon site and the Apollo Street site and the future planned mitigation activities have been documented in the Soil and Soil Vapor Alternatives Analysis Report (SAIC, July 2011). However, a listing of the mitigation activities is presented in Figure 3-18.

With respect to dermal contact, the PSH in the saturated zone ranges from approximately 5 feet below grade (fbg) in the northern part of the property by the bulkhead to approximately 25 fbg along Bridgewater Street. The subsurface that contains PSH is covered by either concrete or asphalt. The properties are only accessible through controlled security fences which limit that access to the sites.

Since the PSH are the source for hydrocarbon vapors in the subsoil, vapor intrusion is a potential exposure route, if left unmitigated. Texaco continues to implement several mitigation tasks to remove this pathway. Since 2005, there has been an active program to seal all seams and cracks in the warehouse floors that may act as preferential vapor pathways. Texaco operates a voluntary SSD system under the 50 Bridgewater rear office space. In addition, ExxonMobil maintains three precautionary vapor extraction wells located on Bridgewater Street by the two office locations at 16 and 50 Bridgewater Street. Texaco conducts a biannual ambient air monitoring program at the site with one event during the winter heating season and one event during the summer cooling season. As detailed in the earlier section of this chapter, the ambient air data on the site are consistent with the residential ambient air data collected by the NYSDEC during the 2006 and 2007 heating season. In addition, Texaco conducts monthly inspections of all indoor monitoring wells to ensure surface integrity to prevent vapor intrusion.

The sites are also located in the M3-1 manufacturing zoning district for heavy industrial operations. In addition, the site is also located within an SMIA as designated by New York City. These two conditions currently preclude the use of the properties for residential use.

If left unmitigated, PSH have the potential to migrate to the surface water of Newtown Creek. Since September 2007, Texaco has been operating a TFR system along the bulkhead where a former seep into Newtown Creek existed. As documented in previous quarterly reports and also in this document, the seep of PSH into the creek has been stopped, and the occurrence of intermittent sheens has only occurred twice in 2011 through the second quarter. In addition, ExxonMobil's off-site recovery system also maintains PSH and groundwater containment and recovery along Bridgewater Street and Meeker Avenue for further protection of Newtown Creek. In addition, there are no surface waters located on the Paragon site or the Apollo Street site that could act as discharge points for PSH.

Many of the mitigation strategies that are in place or planned for the PSH also remove the exposure pathways for the groundwater, and they are summarized in Figure 3-18. In addition, the high concentrations of soluble salts in the water preclude the use as a potable drinking water source and potentially preclude the use of this groundwater for even industrial purposes based on the conductivity of the groundwater. There are no opportunities for casual dermal contact with site groundwater.

4.0 REMEDIAL GOALS AND REMEDIAL ACTION OBJECTIVES

This section defines the media and constituents of concern and identifies the Remedial Action Objectives (RAOs) for the site.

4.1 Media and Constituents of Concern

Petroleum constituents are present in groundwater and PSH is present at the site. The constituents consist of petroleum VOCs and SVOCs. The petroleum VOCs consist of the following components:

- 1,2,4-trimethylbenzene
- 1,3,5-trimethylbenzene
- benzene
- ethylbenzene
- isopropylbenzene
- m,p-xylenes
- n-propylbenzene
- o-xylene
- p-cumene
- toluene
- methyl tertiary-butyl ether (MTBE)
- n-butylbenzene
- sec-butylbenzene

The petroleum VOC concentrations listed above exceed the AWQSs and are associated with the PSH in the saturated zone and not the upper unsaturated zone.

Limited SVOCs are present in the groundwater above the AWQSs. They are related to pyrogenic activities and were likely present in soil used as fill material when it was placed at the site in the current day saturated zone. The SVOCs are pyrogenic polyaromatic hydrocarbons and are as follows:

- benzo(a)anthracene
- benzo(b)fluoranthene
- chrysene
- indeno(1,2,3-cd)pyrene

4.2 Remedial Action Objectives

RAOs have been developed using guidelines specified in DER-10. They are medium-specific objectives for protection of human health and the environment. RAOs are considered for identification of remedial technologies, formulation of alternatives, and during evaluation of the remedial alternatives. The RAOs are as follows:

1. Prevent ingestion and direct contact with impacted groundwater and PSH.
2. Prevent vapor intrusion into on-site structures from petroleum VOCs emanating from the PSH.
3. Reduce the mass and toxicity of PSH and constituents dissolved in groundwater.
4. Prevent discharge of PSH and groundwater with petroleum constituents into Newtown Creek.

The selected remedy shall address the four RAOs and eliminate or mitigate threats to public health and the environment. The evaluation of the alternatives will focus on removal and/or treatment of dissolved phase constituents in the groundwater and the PSH. The dissolved constituents and PSH shall be removed to the extent feasible and a containment strategy will be implemented. The elimination of exposures to receptors at the site will be a primary component of the selected remedy.

The alternatives analysis for groundwater will consider groundwater protection and control measures. The measures to be considered include:

1. Source removal or control.
2. Groundwater restoration based on current or reasonably anticipated future use.
3. Dissolved phase plume containment/stabilization.

PSH remediation measures that are being considered in the alternatives analysis are as follows:

1. Source removal and control.
2. PSH plume containment/stabilization.

5.0 REMEDY SELECTION CRITERIA

Chapter 4 of the NYSDEC publication DER-10 "Technical Guidance for Site Investigation and Remediation" provides guidance for developing Remedial Goals and Objectives, criteria to consider, and provides a framework to evaluate and select remediation alternatives using the criteria. The first two selection criteria are "threshold" criteria which must be met for an alternative to be considered for selection. The remaining criteria are intended to help guide the selection through a balanced approach. After the decision document is finalized and any public comments are received, community acceptance (part of the Land Use evaluation) is weighed by the NYSDEC prior to selecting a remedy.

5.1 Overall Protectiveness of the Public Health and the Environment

Overall protectiveness of public health and the environment is a threshold criterion. It is to evaluate how the alternative controls any existing or potential human exposures or environmental impacts and achievement of each of the RAOs. It draws on the assessments of the other criteria.

5.2 Conformance with Standards, Criteria, and Guidance

Conformance with AWQSs for GA classified groundwater is a second threshold criterion which must be met for an alternative to be considered for selection. AWQSs are to be identified, and the remedy is evaluated for compliance with each. For AWQSs that will not be met, documentation must be submitted to the NYSDEC. Consideration is also to be given to guidance which, through the application of scientific and engineering judgment, is determined to be applicable.

5.3 Long-Term Effectiveness and Permanence

Constituents remaining on-site after the implementation of the selected remedy, including engineering and institutional controls, would be evaluated for human or environmental exposures and impacts. Evaluation of any engineering and/or institutional controls includes description of the mechanisms to assure their continued application and enforcement, as well as possible public costs or financial assurance requirements.

5.4 Reduction of Toxicity, Mobility, or Volume of Constituents

Preference is given to remedies that significantly reduce toxicity, mobility, or the volume of constituents.

5.5 Short-Term Impact and Effectiveness

The short-term impact and effectiveness criterion reviews the human health and environmental exposures which may occur during implementation of the selected alternative, including measures or controls needed to mitigate these exposures.

5.6 Implementability

The implementability criterion evaluates the feasibility of implementing and monitoring the remedy. This includes expected construction challenges, such as availability of labor and materials, access, permitting, not impacting site operations, likelihood of success for novel approaches, and the reliability and viability of the controls. Impracticability of implementation for the selected remedy may be a conclusion of this analysis.

5.7 Cost-Effectiveness

Total estimated cost of designing and implementing a solution—including engineering, permitting, construction, operation and maintenance, monitoring and institutional management—is compared to the effectiveness of the solution. This criterion defines its cost effectiveness.

5.8 Land Use

This evaluation considers the current use and the reasonably anticipated future land use, considering the current use of a fully developed site the best guide for future use. Consistency of proposed use with zoning, comprehensive master plans, and local waterfront revitalization plans as formally adopted by a municipality is considered. This evaluation also considers community concerns including proximity to residential land uses, and citizen participation activities.

6.0 GROUNDWATER AND PSH DYNAMICS

This chapter presents a discussion and interpretations related to the groundwater and PSH gradients and capture.

6.1 Groundwater Table Mapping

Plate 1 presents corrected groundwater elevations in wells throughout the former Paragon and Apollo Street sites, and the Offsite Plume during the June 29, 2011 quarterly monitoring event. The cone of depression that is being created in the regional aquifer by ExxonMobil's remediation pumping of the Offsite Plume is being seen in the groundwater elevations on the sites. This is particularly evident in the site wells that monitor the regional aquifer, but it is also reflected in the decline of shallow water-bearing zone wells above the silt layer.

A groundwater divide line was added to this groundwater contour map. This line represents the capture zones created by the ExxonMobil, and Texaco remediation pumping systems. It demonstrates hydraulic capture areas on the Paragon and Apollo Street sites where both impacted groundwater and PSH are present. Hydrographs presented in Appendix A indicate that the groundwater elevations continue to decline, suggesting that the cone of depression continues to expand and is not yet at equilibrium. Therefore, in the future, the capture zones are likely to expand beyond their current limits.

Plate 5 provides corrected groundwater contour maps at five annual time snapshots, including the June 2011 event. The May 2007 map represents no pumping conditions, when the ExxonMobil Offsite Recovery system was not extracting groundwater. The 2008 map demonstrates relatively flat site gradients and water stage conditions. Only five offsite recovery wells were operational at this time. From May 2008 through June 2011, additional ExxonMobil Offsite Recovery wells were brought online. The table inserted into Plate 5 presents the sequence when these wells became operational. As these additional wells were brought online, the cone of depression continued to expand further north into the Paragon and Apollo Street sites.

6.2 PSH Characteristics

Plate 4 presents the 2011 lateral extent of the PSH and Plate 6 presents five annual snapshots of the extent. The maximum extent of the PSH plume on the Paragon and Apollo Street sites has remained unchanged, demonstrating the plume is stable and not expanding. Within the body of the plume and at the Bridgewater Street and Meeker Avenue intersection, PSH has reappeared in monitoring wells. This is attributed to declining water levels, which have exposed previously submerged PSH above residual saturation that has drained into the wells. This demonstrates the effect of declining water levels on mobilizing PSH in the immediate vicinity of the wells.

Plate 7 presents the mapping of the elevation for the top of the PSH. PSH contour lines are presented on and adjacent to the sites. The combined influence of all the pumping centers have created clear elevation gradients with interpreted PSH flow direction arrows toward pumping centers. A PSH flow divide in the north part of the Paragon and Apollo Street sites corresponds to the groundwater flow divide between the Texaco TFR system at the bulkhead and the ExxonMobil Offsite Recovery system, including wells RW-25 and RW-26.

7.0 DEVELOPMENT AND EVALUATION OF REMEDIAL ALTERNATIVES

Various remediation alternatives to address documented conditions for the site groundwater and PSH are presented in this section. This chapter also includes the evaluation of the alternatives with respect to the remedy selection criteria.

7.1 Development of Alternatives

Remediation technologies and processes were identified for further evaluation based on the RAOs, general response actions, and treatment technologies available. This report is focused on actions to remediate groundwater and PSH on the Paragon site and Apollo Street site.

ExxonMobil recovery wells are located east of Meeker Avenue and along the southern property line of the Paragon site and the Apollo Street site. In addition, BP operates a recovery well (RW-9) on the west side of Apollo Street. This well is located along the property line of the BP terminal site. The development and evaluation of alternatives for the Paragon site and the Apollo Street site also consider the effects of the perimeter pumping centers with respect to their ability to contain and remove both impacted groundwater and PSH from both the Paragon site and the Apollo Street site.

7.1.1 No Action

Consideration of the No Action alternative is required by DER-10. The No Action alternative involves taking no further action to remedy site conditions. This alternative does not include remedial action, institutional or engineering controls, or long-term monitoring.

7.1.2 Monitored Natural Attenuation

The monitored natural attenuation (MNA) alternative relies upon the naturally occurring biological, physical, and chemical processes that would act collectively upon the PSH and the dissolved phase constituents to reduce the mass, toxicity, mobility, volume, and concentrations without active intervention. The attenuation of the PSH and dissolved phase constituents would be monitored to evaluate the progress of reductions to meet the AWQSs and to ensure the elimination of all pathways that could lead to the impact of a receptor.

7.1.3 Long-Term Monitoring, Pathway Elimination, and Institutional Controls

The long-term monitoring, pathway elimination, and institutional controls alternative combines a series of risk mitigation activities. The institutional control is the M3-1 manufacturing zoning district where the site is located. The long-term monitoring component includes monitoring the quality of groundwater, groundwater flow directions, and the PSH dynamics in the saturated zone. Currently, an annual groundwater sampling and analysis program has been ongoing since 2010 to monitor the water quality on the sites. In addition, a quarterly site-wide gauging program has been in effect and will continue as part of the selected remedy. The quarterly gauging events allow for the mapping of groundwater elevations and the lateral extent of the PSH that allows for the tracking of the groundwater and PSH dynamics in the saturated zone. There has also been an ongoing ambient air monitoring program at the site where outdoor ambient air, warehouse ambient air, and office space ambient air are monitored twice a year during both the heating season and the cooling season. This program has been ongoing since 2005 and will continue as part of this alternative. Pathway elimination is an ongoing program of engineering controls to maintain the competency of the floor throughout the series of warehouses on the site in order to prevent the vapor intrusion. This activity involves sealing cracks in the floors with a high-strength epoxy while expansion seams in the floor are sealed with a durable caulking material.

Another component of this alternative involves additional voluntary precautionary measures taken at the three office locations on-site. The three locations are presented on Figure 3-8. The alternative includes the continued operation of the SSD system in the rear office space of 50 Bridgewater Street. This alternative also includes precautionary vapor intrusion soil vapor extraction (SVE) wells installed by ExxonMobil adjacent to the two office spaces along Bridgewater Street. At the front office location of 50 Bridgewater Street, well SVE-13 is located. At the office space for 16 Bridgewater Street, extraction wells SVE-11 and SVE-12 are located. These wells are currently not operational but are being held in reserve if ambient air data in the future suggest operation of these wells is necessary.

7.1.4 Groundwater and PSH Containment and Extraction

The groundwater and PSH containment and extraction alternative is an active mass removal scenario based upon hydraulic recovery pumping. This alternative is an extension and expansion of the TFR system currently operating on the site. In addition to mass removal, this active pumping alternative provides containment of both PSH and groundwater plumes onsite. This alternative is already demonstrably working on the site. The TFR system is currently capturing the plume in the vicinity of the former PSH seep at the bulkhead of Newtown Creek. Groundwater and PSH are removed concurrently by a single pump in each well and the recovered fluids are processed through an onsite treatment system. PSH are accumulated and removed periodically for offsite treatment and recycling.

The ExxonMobil Offsite Recovery system nearby provides regional mass reduction and containment for the plume. Performance of these systems is currently demonstrated by monitoring the capture zone both physically (measuring and mapping water levels) and chemically (measuring presence or absence of PSH and sampling for laboratory analysis of groundwater chemical constituents). A groundwater sampling and analysis program, with quarterly site-wide gauging coordinated with offsite remediation efforts, are ongoing.

Periodic monitoring and analysis of this collected data is used to guide system maintenance and improvement. Improvements identified for the TFR system in the near future include the replacement and addition of pumping capabilities. Recovery well CMW-65R is a new recovery well planned to replace MW-74R and MW-75R and would be located between them (see Plate 8). The bottom of the 6-inch well screen would be set at approximately 18 ft fbg. This replacement well will reduce overall solids recovery and therefore reduce maintenance requirements and increase the efficiency of the TFR system. A second new pumping well (CMW-66R) is proposed for installation between existing wells CMW-8 and CMW-53R, in the parking area at 50 Bridgewater Street (see Plate 8). The bottom of the 6-inch well screen will be set at approximately 25 ft fbg. Each new recovery well would have a targeted pumping rate of 5 gpm. Both wells would expand the PSH and groundwater capture zones in the south direction and into the interior of the sites. Section 7.3.1 presents additional information regarding the two proposed recovery wells.

7.1.5 PSH Vapor Phase Removal

Removal of PSH through the vapor phase exploits the tendency of volatile compounds in the PSH to partition from the liquid phase into the vapor phase in the soil. Removal of the air vapor from the soil matrix removes constituent compound mass. This technology generally is a secondary recovery technique, applied once a liquid-based removal technology has reduced the PSH to residual saturation.

As an added remediation benefit, when volatile PSH components are removed in the vapor phase, the composition of the PSH changes to increase the concentration of non-volatile, and generally less mobile, compounds. The vapor phase removal approach reduces the PSH saturation remaining in the ground to residual saturation. This reinforces the reduction of PSH mobility in the future. This technology would also need to be combined with groundwater extraction to expose PSH within normally submerged zones.

Monitoring vapor phase recovery generally includes measuring induced vacuum at field wells to evaluate the physical radius of influence of the system. Influent vapor phase chemistry and flow are monitored to evaluate the mass removal of the volatile PSH compounds.

7.2 Evaluation of Alternatives

The detailed analysis of alternatives consists of the analysis and presentation of the relevant information needed to select a site remedy. Each proposed alternative is assessed by the evaluation criteria prescribed by NYSDEC and summarized in Section 5.0 of this report. The results of this assessment will provide sufficient information to compare the alternatives and to document the methodical selection of an appropriate remediation for the site groundwater and PSH. Table 7-1 presents a summary of the comparison of remedial alternatives.

7.2.1 No Action

The No Action alternative at this site will not remove or contain the petroleum constituents in the site groundwater nor the PSH. It relies upon the efforts of others to eliminate PSH from entering the site. Hydraulically slow properties of the shallow water-bearing zone where the petroleum constituents dissolved in groundwater and PSH are found could limit the extent of recovery from offsite wells. Thus, it cannot achieve the RAOs. In addition this alternative would not effectively reverse the hydraulic gradient at the bulkhead to prevent PSH from reentering the creek. This option is not compliant with the remediation goals and objectives, which include reduction in the mass, toxicity, mobility, volume, or concentration of compounds of concern. Since these two evaluation criteria are NYSDEC-mandated threshold criteria, the No Action alternative is not considered for selection.

7.2.2 Monitored Natural Attenuation

Monitored Natural Attenuation (MNA) relies on existing natural biological, physical, and chemical processes to reduce the mass, toxicity, mobility, volume, or concentration of the constituents of concern. Using this approach, no attempt is made to introduce amendments to the subsurface to accelerate the removal process. By definition, MNA requires that the source of contamination first be eliminated. Hydraulic capture of the off-site plume by ExxonMobil meets this condition, as it prevents additional PSH from entering the site; however, onsite PSH remains the source for the dissolved phase constituents.

Given enough time, RAOs may be met by natural processes. However, this alternative may not be completely protective of the public health and the environment because without continued maintenance of the TFR system, there could be discharges of PSH and impacted groundwater to the Newtown Creek. Because of the risks to receptors and the presence of PSH as the source for dissolved phase impacts, MNA is not selected.

7.2.3 Long-Term Monitoring, Pathway Elimination, and Institutional Controls

The long-term monitoring, pathway elimination, and institutional controls alternative combines a series of risk mitigation activities. It eliminates the vapor pathway with an ongoing program to maintain the competency of the floor throughout the warehouses. This activity began in 2005, when cracks in the floors are sealed with a high-strength epoxy while expansion seams in the floor are sealed with a durable caulking material. Operation of the SSD system in the rear office space of 50 Bridgewater Street (since 2010), in conjunction with the ambient air monitoring program (since 2005), further ensures and incomplete pathway. Monitoring has shown that these activities are effective. With this alternative, the continued collection and evaluation of the ambient air data will be used to determine if additional mitigation measures are warranted.

The mass of the constituents is expected to decline with time. Given enough time, RAOs may be met by natural processes. The institutional controls for this alternative include the M3-1 manufacturing zoning district where the site is located.

This alternative also includes precautionary vapor intrusion wells installed by ExxonMobil adjacent to the two office spaces along Bridgewater Street. At the front office location of 50 Bridgewater Street, well SVE-13 is located. At the office space for 16 Bridgewater Street, extraction wells SVE-11 and SVE-12 are located. These wells are currently not operational but are being held in reserve if ambient air data in the future suggest operation of these wells is necessary.

The pathway elimination and institutional controls alternative removes all possible pathways including inhalation, incidental ingestion, and incidental contact with groundwater and PSH. This alternative achieves all RAOs, and with the long-term monitoring and maintenance program, the long-term effectiveness and permanence is rated as high. With the pathway elimination, the potential for toxicity and mobility is removed.

The implementability of this alternative within the very active warehouses is rated highly effective and desirable, as there is very minimal disruption to the current site business operations. Coordination and completion of the activities during off-hours such as weekends or between work shifts are still required. This type of scheduling has been required in the past and will continue, to avoid the physical hazards associated with the extensive forklift traffic in the warehouse. This type of off-hour scheduling also removes warehouse workers from potential vapor exposure when monitoring well caps are removed for various monitoring and sampling tasks.

Other site conditions contribute to the elimination of completed pathways and reduction of site worker risk. This includes factors that contribute to the exchange of air within the series of warehouses and include garage bays and ventilation fans associated with Empire Merchants operations. These features are presented on Figure 3-8. In 2009, six large ventilation fans were installed in the Apollo Street site, and an additional six fans were installed in the 50 Bridgewater Street warehouse. Each fan is 4.5 feet by 4.5 feet in size and was installed to decrease humidity

buildup within the warehouses and to maintain more comfortable working conditions for the employees in the warehouses. These fans contribute to the air exchanges in the 42 Bridgewater Street warehouse and to an extent the 16 Bridgewater warehouse because all four warehouses are connected. The fans operate primarily from the late spring to early fall. Operation of the ventilation system is on an intermittent basis. On the north side of the 16 Bridgewater Street warehouse, there are a total of 30 garage bays, each 8 feet wide by 9 feet high, and at the south end of 50 Bridgewater Street are three large garage bays. These bays are part of the facility operations and are used to load outgoing trucks and offload incoming trucks. The daily use of these garage bays contributes to air exchanges in the warehouses. Actions being taken on-site and in the off-site areas contribute to lessening the total amount of PSH present in the subsurface, thus reducing the source for subsurface vapor creation.

7.2.4 Groundwater and PSH Containment and Extraction

The groundwater and PSH containment and extraction alternative involves the active pumping of both groundwater and PSH from the saturated zone. This approach actively removes dissolved phase constituents and PSH from the saturated zone and also acts to ensure containment of both the groundwater plume associated with the PSH and the PSH plume. The overall protectiveness of the public health and the environment is considered very high.

This approach would achieve the RAOs. Specifically, this alternative reduces the mass of PSH in the subsurface, which is the source of vapors and potential vapor intrusion. This alternative also serves to maintain a gradient away from Newtown Creek, which protects that receptor.

The long-term effectiveness and permanence of this remedy are rated as high. In order to ensure the long-term effectiveness, this alternative would also need to be combined with the Long-Term Monitoring, Pathway Elimination, and Institutional Controls alternative.

With this alternative, PSH is removed from the site as evidenced by the current performance of the existing pumping centers on and adjacent to the site. The mobility of the PSH has been observed primarily in the zones of capture from the pumping centers as the configuration of the PSH plume has been fairly constant since the initial delineation on-site in 2005. The groundwater extraction component which has demonstrated an increasing zone of capture on the sites since May of 2007 ensures stabilization of the groundwater plume and the mass removal of dissolved phase constituents. Combining this alternative with the pathway elimination alternative for vapor intrusion ensures the reduction of toxicity, mobility, and the volume of impacts.

This alternative can be readily implemented at the site as it is essentially an extension of the currently implemented pumping centers. The expansion of the pumping centers on the sites would occur outside the existing buildings. The installation of recovery wells and recovery

system infrastructure inside the warehouses would cause potential risk to workers and significant disruption of operations, and therefore, it is not considered feasible to construct wells and install equipment inside the buildings. Based on the current zones of capture and the estimated zones of capture with the supplemental recovery wells outside the buildings, the implementability of this approach is considered high.

The primary viable option for land use would be a continuation of the manufacturing zoning district. Mass removal of the impacts to the subsurface, although feasible, will be slowed by limiting the installation of recovery wells to outside the warehouses. .

7.2.5 PSH Vapor Phase Removal

PSH vapor phase removal presents potential vapor exposure risks for warehouse employees during system construction and operations. Every penetration through the concrete floor is a potential vapor pathway and if collection pipes are exposed in the warehouse, there is a constant risk of damage by warehouse forklift operations, which can result in an exposure scenario. Such indoor remediation infrastructure is a potential disruption to normal warehouse operations. Therefore, implementability is low.

PSH vapor phase recovery can be an effective means of reducing PSH mass to residual saturation levels for volatile PSH compounds. This means that it is protective of the environment and may achieve RAOs for volatile compounds. It is not effective for PAHs and non-volatile compounds. In combination with liquid recovery techniques, it can be effective in reducing the mass of contamination. It can be expected to decrease the toxicity of the contamination, because the volatile components of PSH are typically more toxic than the non-volatile ones.

7.3 Selected Remedy and Remedy Components

This section presents a discussion of the selected remedy and the primary components of the remedy. The remedy selection was based primarily on the RAOs and the criteria presented in DER-10, as previously discussed. Based on the evaluation of alternatives, the recommended remedy is one identified as pathway elimination and institutional controls. This alternative was selected because it satisfies the threshold criteria and provides the best balance of criteria previously described. The six primary components of this remedy are described in the following subsections.

7.3.1 Groundwater and PSH Containment and Extraction

Continued operation and expansion of the TFR system is selected for remediation of the PSH and groundwater conditions at the site. Operation of this system has proved its effectiveness in reducing the mass of PSH on site and eliminating the pathway for PSH to Newtown Creek. As discussed, the TFR system currently includes 13 active fluid pumping wells and an onsite treatment system. Enhancements to the system have been identified and focus on site-wide collection of PSH and groundwater further south of the bulkhead.

A new proposed well, CMW-65R, would be located midway between existing wells MW-74R and MW-75R, would be constructed with the bottom of the 6-inch stainless steel well screen set at approximately 18 ft fbg, and would have a target pumping rate of 5 gpm. Recovery wells MW-74R and MW-75R currently recover groundwater and PSH, but also collect a substantial load of sediment to the treatment system. This larger, formally constructed recovery well should be more effective at recovering PSH and groundwater than MW-74R and MW-75R. Removing these two wells from service will increase the treatment efficiency of the process equipment. With less suspended sediment entering the treatment equipment, optimal flow through can more frequently be maintained; as bag filters, the organoclay unit and activated carbon units will not foul with sediment.

A second new recovery well, CMW-66R, is planned to capture more of the plume that is beyond the capture zone of the existing TFR wells. It would be installed between existing wells CMW-8 and CMW-53R, in the parking area at 50 Bridgewater Street. The bottom of the 6-inch stainless steel well screen would be set at approximately 25 ft fbg and it would have a target pumping rate of 5 gpm (see Plate 8).

As stated before, the ExxonMobil Offsite recovery well system exerts hydraulic capture onto the sites and forms part of the remedy. In particular, the newer recovery wells RW-25, RW-26W and RW-26P, as well as recovery wells RW-D, RW-E and RW-F have the greatest effect on the sites. The analysis of capture zones and well hydrographs suggests that the Offsite system has not yet reached equilibrium, and the capture zone is expected to increase from the present condition when equilibrium is reached. These recovery wells will continue to address the migration of PSH impacted groundwater onto the sites and recover some PSH and groundwater from the sites.

7.3.2 Long-Term Monitoring, Pathway Elimination, and Institutional Controls

Extensive site monitoring has been and will continue to be conducted regularly to confirm the appropriateness of the selected remedy. The biannual ambient air sampling and analysis program will continue to verify the adequacy of the pathway elimination program. The SSD system will continue to be monitored on a weekly basis. The Texaco TFR system will continue to be monitored several days per week to ensure the uptime is maximized and the necessary subsurface changes are induced to capture and remove groundwater and PSH

Annual groundwater sampling and analysis would verify stability of the groundwater plume and decreases in constituent concentrations. Quarterly gauging will monitor systems performance, PSH plume stability, and mass removal.

The vapor pathway elimination program will continue with the maintenance of the concrete warehouse floors. Cracks and seams that have been previously sealed will continue to be inspected and seals maintained. In addition, the SSD system will continue to operate and the three ExxonMobil precautionary vapor intrusion extraction wells will continue to be held in reserve and will be activated if needed. The ambient air inside the warehouses and office space will continue to be sampled and analyzed by EPA method TO-15 on a biannual basis. These activities have shown demonstrable effectiveness and will continue to be performed to further remove potential pathways of exposure.

The current zoning of the site as M3-1 heavy industrial and the designation as a SMIA by the city of New York is an institutional control that limits the potential use of the site as anything other than its current use or a similar use for the foreseeable future.

7.3.3 Reporting

All activities will be implemented in conjunction with the selected remedy and will be reported to NYSDEC in the current quarterly reporting program within the consent order. All components of this selected remedy will be evaluated in detail on an annual basis in order to ensure the protection of site employees. With each annual review, qualifications to the selected remedy through either upgrades or downgrades will be presented to the NYSDEC.

8.0 CONCLUSIONS

Based on the results of the groundwater and PSH alternatives analysis, the following conclusions are drawn concerning the Paragon site and the Apollo Street site:

1. The onsite PSH plume is stable and is not expanding.
2. The dissolved phase groundwater plume is stable and is not expanding.
3. The performance of the ExxonMobil Offsite Recovery system continues to create an expanding cone of depression in the north direction and onto the sites.
4. Based on the capture zone from the ExxonMobil Offsite Recovery system and the onsite TFR system, a groundwater divide is evident on the sites.
5. Recovery system induced PSH elevation gradients have been established in the direction of the different pumping centers.
6. Texaco proposes 2 additional recovery wells to the TFR system in order to amend its operation, to enhance site-wide recovery.
7. The proposed site-wide remedy includes groundwater and PSH containment and extraction; long-term monitoring; pathway elimination; and institutional controls.

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