February 12, 2008

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
Greenpoint Section – Brooklyn, New York
Texaco Facility #304209
Phase I Recovery System Evaluation Report

Dear Mr. Hampston:

Science Applications International Corporation (SAIC), on behalf of Texaco Inc. (Texaco), respectfully submits to the New York State Department of Environmental Conservation (NYSDEC) this final version of the Phase I Recovery System Evaluation Report for the Former Paragon Oil Terminal. The submission of this report represents achievement of Milestone #5 as presented in Attachment A of the NYSDEC letter to Texaco, dated August 15, 2007.

If you have any questions concerning the information presented in this report, please do not hesitate to contact either Ms. Gesele Harris of Texaco at 770-984-4190 or Mr. Pete Cagnetta of SAIC at 717-901-8841.

Sincerely,

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

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PHASE I TOTAL FLUIDS RECOVERY SYSTEM PERFORMANCE EVALUATION  
for the Former Paragon Oil Terminal   
Greenpoint Section   
Brooklyn, New York

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1.0 INTRODUCTION

This report presents details concerning the activities performed by Science Applications International Corporation (SAIC) on behalf of Texaco Inc. (Texaco) for the operation of the Phase I total fluids recovery system (Phase I system) that has been in operation since September 14, 2007. The Phase I system currently operates along the steel bulkhead on the shoreline of Newtown Creek in the immediate area of the historical seep of phase-separated hydrocarbon (PSH) into the creek. This report presents a detailed evaluation of the performance of the system and the positive impact the system has had on greatly reducing the seep of PSH into the creek.

1.1 Site Description

The location of the former Paragon Oil terminal (the former Paragon site), a predecessor to Texaco, is currently a liquor distribution facility. Paragon Oil operated a terminal on the property from 1934 to 1958, and Texaco operated a terminal on the property from 1958 through 1968. Neither Paragon Oil nor Texaco ever owned or operated refinery operations on the property. In 1968, the property was purchased by Peerless Importers, who owned and maintained operations on the former Paragon site into 2007. In 2007, Peerless Importers, through a merger, changed names to Empire Merchants, LLC. The property is approximately 11 acres in size with approximately 8 acres being covered by a warehouse (see Figure 1.1).

Newtown Creek borders the northern portion of the former Paragon site, and the creek flows westward toward the East River. The former Paragon site is bound to the south by Bridgewater Street and to the east by Meeker Avenue. The former Paragon site is bound to the west by the 100-120 Apollo Street property (the Apollo Street site). Neither Paragon Oil nor Texaco ever maintained operations on this property and never owned this property. The Apollo Street site is bound to the west by Apollo Street.

The current seep of PSH into Newtown Creek, which has been greatly reduced by the operation of the Phase I system, emanates from both the steel bulkhead on the former Paragon site and
from the older concrete and wood bulkhead on the Apollo Street site. The historical seep on the former Paragon site spans approximately 440 linear feet of bulkhead, while the seep on the Apollo Street site spans approximately 80 linear feet of bulkhead. Both zones have been contained within a primary containment globe boom and also a larger fence boom for secondary containment.

The initial seep of PSH into Newtown Creek occurred in 1979 at the north end of Meeker Avenue, which is not on the former Paragon site. The current seep on the former Paragon site began in 1991, while the current seep on the Apollo Street site began sometime after 1991. Texaco ceased terminal operations on the Paragon property in 1968. Figure 1.2 presents a local site map.

Plate 1.1 presents the distribution of PSH in the subsurface adjacent to and on the former Paragon site. South of the former Paragon site and hydraulically upgradient is the off-site ExxonMobil PSH plume. Based on previous characterization work completed by SAIC (SAIC, 2006b; SAIC, 2007b), the off-site PSH plume is continuous with the PSH plume on the former Paragon site. Underlying the Apollo Street site is PSH. This PSH plume, based on prior characterization work by SAIC, is also continuous with the ExxonMobil off-site plume. Along the eastern boundary of the former Paragon site, Meeker Avenue, the off-site ExxonMobil PSH plume is also present.

### 1.2 Phase I Recovery System Objectives

On August 12, 2005, Texaco entered into an Order on Consent with the New York State Department of Environmental Conservation (NYSDEC). The case number is D2-1111-01-05. The objectives set forth in the SAIC Corrective Action Plan (SAIC, 2005a) and Corrective Action Plan Addendum 1 (SAIC, 2005b) are to identify the source of PSH in the subsurface on the former Paragon site and to design, install, and operate a landside recovery system with the intent of mitigating the PSH seep into Newtown Creek.
The progress that Texaco has made toward stopping the seep has been made through a series of accomplishments on a milestone date schedule that has been incorporated into the Order on Consent. The first remediation-based milestone was accomplished on September 8, 2006, with the submission of the Final Phase I Recovery System Design to the NYSDEC. Upon approval of that design by the NYSDEC, the Phase I system was constructed and start-up was achieved on November 20, 2006, for attainment of the second remediation milestone. However, immediately after start-up of the Phase I system in 2006, the system had to be turned off as NYSDEC approval to send untreated groundwater to the ExxonMobil Off-Site treatment system was not obtained. This resulted in the operation of the Phase I system in an interim mode with all extracted fluids being transported off-site for treatment or disposal.

Subsequent to this activity, the Phase I system was upgraded with water treatment equipment and a permit was obtained from the New York City Department of Environmental Protection (NYCDEP) for the discharge of treated water to the combined sewer system. Once the system was upgraded and the permit obtained, another Phase I system relocation and start-up milestone was achieved on September 14, 2007, with start-up of the system in the fully operational and automated mode.

The fourth remediation milestone was achieved by October 12, 2007, in which the Phase I system operation transitioned from the start-up mode to operations and maintenance (O&M) mode, while maintaining an operational uptime of 82% during the four-week start-up period. During the operation mode, the Phase I system has maintained a 96% uptime. This report represents the submission for the fifth remediation milestone related to the detailed evaluation of the Phase I system performance and recommendations for expansion of the system to Phase II. The accomplishment of all remediation milestones and characterization milestones is documented in correspondence between SAIC, on behalf of Texaco, and the NYSDEC.

This report presents details concerning the following activities:

1. Installation and performance of the grout wall barrier.
2. Installation and performance of the Phase I total fluids recovery system.
3. Groundwater and PSH flow dynamics on the former Paragon site.
4. Seep mitigation considerations for the Apollo Street site.
5. Potential recovery system Phase II upgrades.

### 1.3 Technical Approach

The Phase I system consists of two primary components. The first component was designed and constructed to impede the migration of PSH from the subsurface through the bulkhead and into Newtown Creek. This component consists of a 440-foot-long grout wall which was installed in the fall of 2006. The second component of the Phase I system is the PSH and groundwater extraction component. Six extraction wells are currently operating in both lower and upper bulkhead areas immediately behind the grout wall and are used to capture both PSH and groundwater behind the bulkhead. This component of the system was made fully operational on September 14, 2007.

The current system in place is the first phase in the full mitigation of the seep into Newtown Creek. The initial evaluation of the system performance and its effectiveness in stopping the seep is detailed in this report, and this information will be used to identify upgrades to the current system in order to progress to the Phase II components. Phase II system design and construction milestone dates have been identified for 2008. The Phase II upgrade milestones are as follows:

1. April 14, 2008 - Submission of the conceptual Phase II Recovery System Design Report
2. June 3, 2008 - Submission of the Final Phase II Recovery System Design Report
3. 15 days after NYSDEC design approval - Initiate Phase II construction upgrades
2.0 GROUT WALL BARRIER

From September 27, 2006, through November 20, 2006, a full-scale grout wall was constructed immediately landside in the PSH seep area on the former Paragon site. The purpose of the wall is to mitigate the migration of PSH through the bulkhead and into the creek.

2.1 Construction Methods

A grout wall was installed on the landside subsurface of the former Paragon site northern property boundary and has been constructed to serve as an integral part of the landside PSH seep containment system. The grout wall was installed immediately behind and adjacent to the existing steel sheeting bulkhead in the area where the PSH seep began in 1991. A plan-view map, which details the grout wall dimensions and injection point locations on the upper and lower bulkhead sections, is presented in Figure 2.1. Photographs in Appendix A provide photo-documentation of grout wall construction activities.

The grout wall extends approximately 440 linear feet and spans across both sections of the lower and upper bulkhead. The grout wall extends 10 feet beyond the eastern end of the creek side boom containment system. On the west end, the wall extends to within approximately 20 feet of the former Paragon site property line. Air conditioning units and electrical panels associated with the current Empire Merchants (Peerless) operations are located in this area. However, at the west end of the grout wall, a 20-foot section extends perpendicular to the 440-foot section of the wall. This “L-shaped” end was constructed to assist in the prevention of PSH migration beyond the grout wall in the hydraulically downgradient direction. The injection point spacing along the 440-foot section of the wall was 4 feet. The spacing was reduced to 2 feet for the 20-foot section of the wall on the west end that is perpendicular to the creek. This reduced spacing resulted in a greater volume of grout injected and, therefore, greatly reduced the probability of any PSH migrating beyond the grout wall on the landside.

The grout wall was designed to create a near-contiguous and relatively impermeable grouted mass parallel to the bulkhead, with sufficient extensions past the limits of the mean low and high
tide elevations of the adjacent creek. Therefore, to account for groundwater elevation fluctuating with the tides, the grout wall was installed from five feet below the mean low tide at the base to approximately five feet above the mean high tide level at the top. These targeted dimensions correspond to the base of the wall being at approximately -7 feet mean sea level (MSL) and the top of the wall being at approximately +7 feet MSL. The height of the grout wall is 14 feet.

The former Paragon site current steel bulkhead was constructed in 2002 on the creek side of a former timber and concrete bulkhead, and the space between the bulkheads was filled with pea gravel during installation. The injection of grout in 2006 was completed in the pea gravel material. The removal of the existing steel sheeting cap on the bulkhead facilitated access to the gravel-filled space between the new and old bulkheads.

The sheeting cap was removed, and grout was injected into the pea gravel backfill materials within the zone of interest. Each injection location was pre-drilled to the targeted depth. Injection of grout then began with the insertion of one rod located within the center of each sheeting indentation. The injection rod at each location was installed to an elevation of -7 feet MSL and was driven into the ground using an air-powered track rig.

Injection of grout at each grout hole location was completed in two-foot lifts. The hollow injection rods were inserted to the targeted depth, and grout was injected through the rod into the subsurface at each lift interval. During the injection process, the grout volume and induced subsurface pressure (injection line pressure) were monitored and documented. Maximum allowable values for these two monitored injection parameters were designated as end point indicators for each lift. The targeted injection volume of grout per lift was 40 to 50 gallons, with a maximum injection pressure of 5 pounds per square inch (psi). These end points were implemented to maintain the integrity of the bulkhead structure based on the engineered design while injecting a sufficient volume of grout to create a competent barrier. When either end point at each injection lift interval was attained, the grout injection was temporarily stopped, the rods were then raised two feet with a hydraulic jack, and the injection would resume in the subsequent overlying lift. This process was repeated for each injection point on the lower and upper bulkhead sections.
The grout mixture composition and quantity of each component were documented at each grout location. This included the brand, type, and ratio of each component and the total quantities of injected grout at each location. A summary table of the grout injection program is presented in Table 2.1.

A total volume of 39,847 gallons of grout was injected into 107 injection points during the installation of the grout wall. The grout was composed of potable water, Hercules Type II cement, Baroid Fluid Services Aquagel Gold granular bentonite, and a Fritz-Pak Corp. Kelco-Crete concrete rheology admixture. Slight variations of the mixture were used as subsurface material porosity varied at each injection location. Therefore, some injection points required a slightly more viscous mixture to retain the grout at the targeted intervals.

Plate 2.1 (Stratigraphic Cross-Section N-N’) presents the as-built dimensions of the grout wall based on the grout injection program. The cross section is parallel to the bulkhead. The figure demonstrates that the dimensions of the wall and the depth of the wall are sufficient to prevent both the overflow and underflow of PSH past the wall. In addition, the pumping groundwater elevations are not below the base of the wall, giving the additional assurance that the PSH cannot migrate under the wall, even as the Phase I system operates.

2.2 Seep Mitigation Performance

SAIC has utilized two methods to evaluate the performance of currently employed seep mitigation techniques. A discussion of the use of groundwater fluctuations in response to creek tides and the appearance of the absorbent booms in the boom containment system is presented below.

2.2.1 Groundwater Tidal Fluctuations

In an attempt to determine the extent to which the grout wall may have affected the hydrologic connection between Newtown Creek and the former Paragon site, tidal data was collected and analyzed from bulkhead area monitoring wells. Pressure transducers were used to measure the
tidal behavior in wells along the bulkhead both before and after the grout wall installation. This data was then analyzed for reductions in overall tidal amplitude as measured from pre- and post-grout wall data. Tidal data was collected from both behind and beyond the east and west limits of the grout wall to provide a data control.

In processing the transducer data, amplitudes were calculated and averaged for groundwater level fluctuations measured each at tidal stage. The pre- and post-grout wall tidal surveys were then plotted on the same axes and compared. The percent change in tidal amplitude was then calculated from data gathered before and after wall installation. The results of this analysis are graphically portrayed in Figure 2.2a through Figure 2.2h.

Table 2.2 summarizes the pre- and post-grout wall average tidal amplitudes and the percent reduction calculated after grout wall installation. All six post-grout wall tidal surveys within the area behind the grout wall yielded smaller average tidal amplitudes than the pre-grout wall tidal surveys. Pre- and post-grout wall tidal amplitudes were reduced by up to 76.1% in MW-66 (Figure 2.2a) with a minimum of 25.7% in MW-73R (Figure 2.2d). Pre- and post-grout wall tidal amplitudes in the control wells were reduced by 2.7% in CMW-13 and 22% in CMW-17. The average amplitude reduction from wells behind the wall was 53.3% while the reduction from wells beyond the wall was only 12.5%.

The reduction in measured tidal amplitude in the wells along the bulkhead area indicates that the grout wall is functioning as an impedance to the hydraulic connection between the groundwater and Newtown Creek.

2.2.2 Absorbent Boom Observations

A containment and absorbent boom system is in place on Newtown Creek along 440 linear feet of shoreline of the former Paragon site. In addition, 80 linear feet of boom is present along the shoreline fronting the Apollo Street site. Three types of containment and remediation booms are present in this area. Primary containment is accomplished by a globe boom, and secondary
containment is accomplished by a fence boom system. Remediation of any sheen inside the primary and secondary containment booms is accomplished using floating absorbent booms.

Dividers were installed within the globe boom in order to separate the globe boom into five compartments. Each compartment is approximately 100 feet in length. One divider was installed in December 2006 to separate the former Paragon site and the Apollo Street site, and three dividers were installed in January 2007. The compartments are labeled as C1 to C5 on Figure 2.3. Compartments C1 to C4 are on the former Paragon site while compartment C5 is on the Apollo Street site. The purpose of dividing the boom into compartments was to evaluate changes in the magnitude of seepage along the bulkhead. This ongoing evaluation was used to measure the performance of the grout wall and the Phase I system located on the landside of the former Paragon site.

Two rows of floating absorbent boom are maintained within the primary containment globe boom. In addition, between December 2006 and May 2007, there was also a row of floating absorbent boom within the secondary containment fence boom. The absorbent boom within the primary containment consistently showed more staining than the absorbent boom in the secondary containment. This was due to the minimal presence of PSH in contact with the secondary containment boom. This condition indicated that the majority of the seepage was being contained within the primary globe boom.

The floating absorbent boom in the primary containment globe boom was changed every two weeks from December 2006 through July 2007. In July 2007, the floating absorbent boom in the globe boom was changed every three weeks due to significantly less PSH staining than in previous months. The floating absorbent boom in the secondary containment fence boom was changed monthly from December 2006 through May 2007. The change-out schedule was adjusted as less PSH was seeping through the bulkhead due to the presence of the grout wall. Boat inspections of the boom system occurred while replacing absorbent boom inside the primary containment. A summary of absorbent boom change-outs can be seen in Table 2.3. Visual inspections of the boom system were performed by SAIC personnel three to five times per week from the top of the bulkhead wall.
Between April 30 and May 15, 2007, SAIC supervised the cleaning of the bulkhead located within the boom containment and absorption system. The bulkhead washing removed the residual PSH buildup at the waterline. Pressurized hot water (1,500 psi) was used during cleaning. Removed PSH was contained within the primary globe boom and collected with absorbent booms and pads. All absorbent booms were replaced following the bulkhead cleaning.

On May 17, 2007, a new barrier boom (solidification boom) was installed within the boom containment system along the former Paragon site bulkhead to replace the single row of absorbent boom between the globe boom and the fence boom. The new boom contains a powder agent—approved for use by NYSDEC and the U.S. Environmental Protection Agency (EPA) on surface waters—that binds with hydrocarbons and solidifies the hydrocarbons inside the boom. Four sections of this new solidification boom were installed perpendicular to the flow of surface water in Newtown Creek between the globe boom and the fence boom, with attachment points at the compartment dividers.

On September 6, 2007, a supplemental section of 25-foot-long globe boom was extended along the Apollo Street site to provide primary containment along the entire concrete bulkhead within the secondary fence boom. Absorbent booms were also placed within this additional section adjacent to compartment 5.

Since October 2007, the staining noted on the absorbent booms in compartments 1, 2, and 3 has significantly decreased. As of December 31, 2007, the absorbent booms in compartments 1, 2, and 3 are replaced on an as-needed basis, depending on the level of PSH staining. The absorbent booms in compartments 4 and 5 continue to be replaced every three weeks.

Plate 2.2 presents a photographic history of the conditions of the absorbent booms within the five compartments from May 2, 2006, to November 18, 2007. The staining of the booms within each compartment decreased significantly. Across the compartments, C5, located at the Apollo Street site beyond the current Phase I system, remains the most significantly stained.
3.0 PHASE I TOTAL FLUIDS RECOVERY SYSTEM

The Phase I system was constructed on the former Paragon site with the objective of abating an ongoing PSH seep into Newtown Creek. The system extracts both groundwater and PSH from the subsurface via six recovery wells (see Figure 3.1). The recovered liquids are transferred to an on-site treatment system where the PSH is separated from the groundwater and transported off-site for recycling. The dissolved-phased contaminants are then removed from the groundwater, and the treated effluent water is discharged under permit to the NYCDEP combined sewer. A process flow schematic for the Phase I recovery system is presented in Figure 3.2. Operation of the Phase I recovery system commenced on Friday, September 14, 2007, at 10 a.m. Prior to the full-time start of the system, interim PSH recovery activities were completed from June 2005 to July 2007 with 11,697 gallons of PSH recovered. From system start-up to December 31, 2007, a total of 9,631 gallons of PSH were recovered. SAIC has recovered a total of 21,328 gallons of PSH from the former Paragon site since June 2005.

3.1 Phase I System Relocation/Upgrade

Prior to system start-up, several required activities were completed related to relocating the existing Phase I system equipment, upgrading the system to include a water treatment component, and securing a treated water discharge permit. A summary of completed activities includes the following:

1. The application package for a dewatering permit to discharge treated water to the combined sewer system was submitted to the NYCDEP on March 19, 2007. Water quality approval was received from the Division of Pollution Prevention and Monitoring (DPPM) on June 26, 2007, and dewatering approval was received from the Division of Permitting and Connections (DPC) on June 28, 2007. The permit was received on September 4, 2007, after a payment of $13,713.63 was received by NYCDEP on August 24, 2007. The discharge limit is 20 gallons per minute (gpm).
2. Approval from Empire Merchants, the current property owner, to discharge treated water through the on-site sanitary sewer piping was received May 29, 2007. This approval avoided the lengthy time period that would have been required to obtain a New York City Department of Transportation (NYCDOT) permit needed to connect directly to the combined sewer system under Bridgewater Street.

3. The design and off-site fabrication of the dissolved-phase water treatment building was completed on May 4, 2007. The building contains a 25-micrometer (μm) particulate filter, a 1,000-pound organoclay unit, and two 2,000-pound granular-activated carbon (GAC) units.

4. The design and installation of the mini-pile foundation support system on the upper bulkhead was completed on July 5, 2007. This foundation support system was required to structurally support the water and PSH tanks associated with the treatment system.

5. Acceptance of the design was received from Mueser Rutledge, the bulkhead design engineer, for construction of the mini-pile foundation system on July 11, 2007. This independent foundation support system was required as the current steel bulkhead was not designed and constructed to support the load that the system equipment exerts on the subsurface.

Construction activities for the Phase I recovery system relocation and upgrade began on June 18, 2007, with the installation of the treated water discharge line inside the Empire Merchants warehouse. Construction of the mini-pile foundation system was completed on August 31, 2007. Ten mini-piles were installed to a depth of 72 feet below grade. On September 11, 2007, the untreated water holding tank and the PSH storage tank were relocated to the upper bulkhead.

In a letter to the NYSDEC dated October 12, 2007, SAIC, on behalf of Texaco, reported that start-up of the Phase I system was achieved on Friday, September 14, 2007, at 10 a.m. As of
October 12, 2007, Texaco transitioned from start-up to the operation, maintenance, and monitoring (OMM) phase of the Phase I system operation.

### 3.1.1 Recovery Well Field

The Phase I system extracts both groundwater and PSH from the subsurface via six recovery wells. Groundwater and PSH are extracted using top-loading total fluid pneumatic pumps (QED AP4 auto pumps). Total fluids are extracted from lower bulkhead wells MW-68R and MW-70R; from upper bulkhead wells MW-73R, MW-74R, and MW-75R; and from PW-1R. PW-1R is a 12-inch-diameter recovery well located at the down creek end (west) of the grout wall. Recovery and observation well construction details are presented in Table 3.1. Recovery well and system performance monitoring well locations are presented in Figure 3.1.

### 3.1.2 Fluid Treatment Equipment

Prior to the discharge to the combined sewer, the recovered liquids are transferred to an on-site treatment system where the PSH is separated from the groundwater in an oil-water separator (OWS) and stored in an on-site 1,000-gallon PSH holding tank. PSH is periodically transported off-site for recycling. Untreated water is first passed through 25 μm bag filters to remove particulates and then through a 1,000-pound organoclay unit to remove any traces of oil and grease in the water stream. From there, water is transferred through two 2,000-pound GAC units, connected in series, to remove the dissolved-phase contaminants in the water stream prior to discharge to the combined sewer. A process flow schematic for the Phase I system is presented in Figure 3.2.

### 3.2 Phase I Recovery System Operation and Maintenance

Activities associated with the O&M of the Phase I system are performed by SAIC on behalf of Texaco. O&M activities are comprised of numerous daily, weekly, and monthly tasks including the periodic replacement of GAC and organoclay, the backwashing of GAC and organoclay.
filters, the replacement of bag filters, and the monitoring of flow rates and total volume of fluids treated. A discussion of these activities is included in the following sections.

3.2.1 PSH Recovery and Recycling

PSH Recovery
From September 14, 2007 (start-up), through December 31, 2007, a total of 9,631 gallons of PSH and 879,900 gallons of treated effluent water were processed through the Phase I system. Table 3.2 presents data illustrating both daily and cumulative PSH and water recovery volumes. From June 2005 to July 2007, interim product recovery activities recovered a total of 11,697 gallons of PSH. The total PSH recovered by SAIC on the former Paragon site, as of December 31, 2007, is 21,328 gallons.

As depicted in Figure 3.3, the daily PSH recovery rate decreased between system start-up and December 31, 2007. PSH recovery rates decreased most rapidly between start-up and mid-November 2007; they gradually leveled by December 31, 2007. PSH recovery volumes ranged from an average of 103 gallons per day (gpd) between start-up and November 15, 2007, and 63 gpd between November 15, 2007, and December 31, 2007. During the latter period, daily water recovery values decreased only slightly, as portrayed in Figure 3.4.

The decline in daily PSH recovery is a natural condition and is potentially due to several factors including declining product availability within the recovery well capture zone, declining well yields, and/or possible tidal or seasonal hydrologic variations. In a likely scenario, upon start-up, PSH was extracted from within the recovery well network capture zone. As the available PSH diminished, recovery became limited by the rate of PSH migration toward the recovery well network.

PSH/Water Recovery Ratios
The ratio of recovered water to PSH has increased since system start-up, as depicted in Figure 3.5. Total fluids recovery and PSH/water ratios were monitored as pump intake depths were adjusted. Between September 14, 2007, and December 31, 2007, approximately 91 gallons
of water were recovered for every gallon of PSH (91:1). An initial ratio of 76:1 was calculated between system start-up and November 15, 2007. The ratio increased to 137:1 between November 15, 2007, and December 31, 2007. Table 3.3 portrays recovery well performance as a function of fluid recovery rate (in gpm) and pump intake depth. This trend is graphically portrayed in Figure 3.6. The total system flow rate has ranged from 8.7 to 11.6 gpm, which is under the NYCDEP permit of 20 gpm.

During the initial phases of system operation, pumps were positioned based upon inferred hydrologic conditions. As system operation continued, pump depths were periodically changed in an attempt to optimize total fluids recovery. Table 3.3 contains a chronological summary of pump intake depths and estimated flow rates between system start-up and December 31, 2007. The adjustment of pump intake depths will likely continue as additional wells are added to the recovery well network.

In an attempt to quantify the potential impact of tidal variations on PSH recovery, a series of water/PSH ratio tests was completed for each recovery well. The tests were performed by filling a five-gallon bucket with total fluids recovered from each well during each of the four tidal stages (low to mid tide, mid to high tide, high to mid tide, and mid to low tide).

After a period of time, the volume of PSH and the volume of water recovered were used to calculate the water to PSH recovery ratios per tidal stage. The results are summarized in Table 3.4. The results of these tests indicate that the majority of PSH is recovered during the rising tide (in the mid to high stage). They also indicate that, regardless of tidal stage, MW-74R and MW-75R are the largest producers of PSH in the existing recovery well network. However, all six recovery wells are extracting PSH from the subsurface. These tests may be repeated on a seasonal basis.

**Recovered PSH Recycling**

As recovered fluids are processed through the OWS, PSH is separated and transferred to an on-site holding tank. The PSH and other liquids (well development water, etc.) are periodically transported off-site for recycling. Between September 14 and December 31, 2007, a total
of 17 PSH shipments were transported off-site. The dates of PSH recycling events are summarized in Table 3.5. The bills of lading (BOL) for these shipments are presented in Appendix B.

3.2.2 Water Treatment and Discharge

Per a June 26, 2007, NYCDEP DPPM letter of conditional approval and a September 4, 2007, NYCDEP DPC dewatering permit, effluent discharge commenced to the combined sewer on September 14, 2007. In accordance with NYCD EP water quality permitting guidelines, groundwater discharges are monitored to ensure compliance with applicable sewer discharge requirements.

The NYCDEP-specified effluent monitoring program requires the collection of post-treatment water samples at the commencement of discharge and on a quarterly basis thereafter. In accordance with this monitoring program, a system start-up sample was collected on September 18, 2007, and the first quarterly monitoring sample was collected on December 10, 2007. Both samples were compliant with all NYCDEP-specified constituents and submitted to Mr. Alex Castro of NYCDEP via Mr. Tony Bogolin of TestAmerica in Amherst, New York, as required by the NYCDEP. Table 3.6 presents the results of the September 18, 2007, and December 10, 2007, NYCDEP compliance sampling events and the NYCDEP water quality standards for effluent discharges into the combined sewer system.

In addition to the effluent samples collected for regulatory compliance, a series of untreated influent, partially treated midfluent, and effluent samples was collected as part of an internal quality assurance (QA) monitoring program. The purpose of the internal monitoring program is to evaluate treatment effectiveness, determine the schedule for changing out activated carbon and organoclay, and to ensure regulatory compliance with all NYCDEP discharge criteria.

As part of this monitoring program, treatment system (TS) samples are collected from four sample ports identified as TS-1, TS-2, TS-3, and TS-4. Sample ports are described below:
The internal QA sampling program is comprised of both weekly and monthly sampling events. On a weekly basis, samples are collected and submitted for priority turnaround analysis of benzene, toluene, ethylbenzene, and xylene/methyl tertiary-butyl ether (BTEX/MTBE). On a monthly basis, samples are collected and submitted for the full NYCDEP compliance list. Both weekly and monthly QA samples are collected from sample ports TS-1, TS-2, TS-3, and TS-4. Weekly BTEX/MTBE QA sample results are presented in Table 3.7. Monthly NYCDEP regulatory compliance list QA sample results are presented in Table 3.8. All data from the internal QA sampling program is compliant with the NYCDEP permit requirements.

3.2.3 Equipment and Recovery Well Maintenance

SAIC monitors various Phase I system parameters to evaluate system performance. Recovery wells are periodically redeveloped and down-hole pumps cleaned to maximize well yield. Filtration system components (GAC, organoclay, bag filters, etc.) are backwashed and/or replaced in order to maximize system effectiveness and to ensure NYCDEP compliance with permitted constituents. Phase I recovery system parameters are documented in the field on a daily basis through the use of daily O&M logs. Table 3.5 presents a summary of select O&M parameters monitored to evaluate system performance.
4.0 GROUNDWATER & PSH FLOW DYNAMICS

In an effort to evaluate groundwater and PSH flow dynamics in response to the operation of the Phase I system, characterization activities were conducted on both the former Paragon site and the Apollo Street site. Data extracted from pressure transducers and manual gauging events was used to evaluate hydrologic conditions before, during, and after Phase I system start-up. Plate 4.1 presents the regional groundwater elevation contour map from November 28, 2007, and indicates the regional direction for groundwater flow is toward both the former Paragon site and the Apollo Street site. The following section summarizes groundwater and PSH flow dynamics in response to the Phase I system operation.

4.1 Bulkhead Area

The objective of groundwater and in-situ PSH monitoring activities was to characterize the extent of both hydraulic capture zones and reversed hydraulic gradients in the vicinity of the recovery well network. Ten miniTROLL® pressure transducers were deployed along the bulkhead area between September 12, 2007, and November 15, 2007, to monitor groundwater elevations before, during, and after Phase I system start-up on September 14, 2007. Transducer data collected during this deployment was plotted in a series of hydrographs, depicted in Figures 4.1a through 4.1l. Manual gauging data collected from the wells in the vicinity of the pumping well network is summarized in Table 4.1. On November 1, 2007, several pumps within the Phase I system pump network were lowered to increase total fluids recovery and hydraulic capture. Table 3.3 details the current and historical pumping well information.

4.1.1 Bulkhead Area Conditions – Pre-System Start-up

Transducer data collected on September 13, 2007, prior to the Phase I system start-up, was used to generate groundwater contour maps during both high and low tidal stages. Low and high tide groundwater elevations are depicted in Figure 4.2 and 4.3, respectively. Data points used to generate the pre-system start-up contour maps are located in Table 4.2. Figure 4.2 indicates that
at low tide, the interpreted direction of groundwater flow is toward the creek. In contrast, Figure 4.3 indicates that at high tide, the direction of groundwater flow is away from the creek.

### 4.1.2 Bulkhead Area Conditions – Post-System Start-up – September 2007

Transducer and manual gauging data collected on September 17, 2007, after the Phase I system start-up was used to generate contour maps during both high and low tidal stages. Low and high tide groundwater elevations are depicted in Figures 4.4 and 4.5, respectively. Data points used to generate the post-system start-up contour maps are located on Table 4.2.

On Figure 4.4, at low tide on September 17, 2007, all the directly measured groundwater elevations at both recovery and observations wells are at lower elevations than the estimated low tide elevation for the creek surface water. The measured groundwater elevations and the interpreted contours across the lower bulkhead section are at least two feet lower than the creek surface water elevation at low tide. This data strongly indicates that a reverse gradient is present and water migration is from the creek to the landside at low tide conditions on the lower bulkhead. On the upper bulkhead, the interpreted gradient from the surface water in the creek to the groundwater is not as steep, and it is possible that a reverse gradient is also present at low tide on the upper bulkhead.

On Figure 4.5, the groundwater elevations are presented for high tide conditions in September 2007. With high tide conditions, the reverse gradient is very apparent across both the lower and upper bulkheads. Long-term permanence of this reversed gradient is a prerequisite for stopping the PSH seep into Newtown Creek.

The hydraulic capture zones associated with each recovery well were estimated from the September 2007 groundwater contour maps in Figures 4.4 and 4.5. In addition, these estimates were compared to aquifer stagnation zones for the six recovery wells within the Phase I system described from pumping rate data, regional gradient, and aquifer transmissivity values in a method according to Todd (1979). The capture zone calculations are presented in Appendix C, while the zones are graphically displayed in Figures 4.4 and 4.5. In the lower bulkhead for both
low tide and high tide conditions, the estimated capture zones overlap and reinforce their effective capture on the PSH. The extent of PSH capture is greater at low tide conditions.

The capture zones associated with each well for the upper bulkhead recovery wells are also calculated at both low and high tides for September 2007. The capture zones on the lower bulkhead are greater than the upper bulkhead for the same time period. There is no significant difference in the size of capture zones for each upper bulkhead well when comparing low tide versus high tide estimated capture zones. The data indicates that although a hydraulically reversed gradient appears to be maintained on the upper bulkhead at low and high tides, the extent of capture on the lower bulkhead is greater than the extent of capture on the upper bulkhead, and additional wells are needed on the upper bulkhead to increase the area of the bulkhead that is within a capture zone.

4.1.3 Bulkhead Area Conditions – Post-System Start-up – November 2007

On November 1, 2007, the pump intakes were lowered in four of the six recovery wells. The wells where the pumps were lowered included MW-68R, MW-70R, MW-75R, and PW-1R. In wells MW-73R and MW-74R, the pumps were initially set at the bottom of each of the wells. Groundwater elevation contour maps with estimated capture zones were completed for data collected on November 9, 2007. This data was collected using transducers and manual gauging in the same manner as the data collected in September 2007. In addition, the capture zones were calculated using aquifer transmissivity values generated from slug test analyses and recovery well pumping rates in the same manner as the calculations completed for the September 2007 data.

During the collection of data in November 2007, a transducer was also located in Newtown Creek; therefore, the elevational data collected for the surface water in the creek at both low and high tide are actual direct measurements and not an estimate from National Oceanic and Atmospheric Association (NOAA) predictions. For the lower bulkhead area, a reverse gradient is present in which water flows from the creek to landside. The reverse gradient is similar to the low tide September 2007 data. The November 2007 data set strongly supports the position
that a reverse gradient on the lower bulkhead is being maintained at both low tide (Figure 4.6) and also high tide (Figure 4.7), where the reverse gradient is even steeper. This reverse gradient and the long-term maintenance of this gradient are a prerequisite for stopping the seep of PSH into the creek. On the upper bulkhead at low tide, there still appears to be a hydraulic gradient from the landside to the creek near wells CMW-23 and CMW-59. However, the cone of depression associated with MW-75R increased dramatically in November 2007 as compared to September 2007. This increased cone of depression associated with this well greatly decreased the area on the upper bulkhead where at low tide, the gradient remains toward the creek. The gradient is reversed across the entire lower and upper bulkheads during high tide conditions in November 2007 (Figure 4.7).

4.1.4 Summary of Seep Area Groundwater Flow Dynamics

The groundwater elevation data generated from the first 90 days of operation of the Phase I system indicate that the system has been operated in a manner that has made significant progress in stopping the seep of PSH into Newtown Creek. A summary of the conclusions is as follows:

- Figures 4.2 and 4.3 indicate that under normal conditions, the groundwater gradient at the bulkhead reverses on a regular basis due to the high and low tidal influence on Newtown Creek and that a reverse gradient is naturally present with high tide conditions.
- Due to pumping by the Phase I system, groundwater elevation data indicates that a reverse gradient is present along the entire length of the seep area on the lower bulkhead at both high and low tides, which is a prerequisite to stopping the seep into Newtown Creek; the conditions of the absorbent booms on the creek in compartments C1 and C2 correlate very strongly with the reduced and possibly stopped seepage of PSH into the creek from the lower bulkhead area.
- During high tide conditions on the upper bulkhead, a reverse gradient is present and the landside hydraulic gradient is much steeper under the influence of pumping as compared to the natural gradient prior to start-up of the recovery system. This condition greatly enhances the recovery of PSH from the subsurface on the upper bulkhead.
At low tide conditions, there still appears to be a hydraulic gradient from the landside to the creek in the immediate vicinity of the bulkhead near wells CMW-59 and CMW-23.

### 4.2 PSH Migration from Bridgewater Street

NYSDEC, in a letter dated December 5, 2007, requested an updated evaluation on the potential movement of PSH from Bridgewater Street toward Newtown Creek, particularly considering the impact of pumping on movement. This section addresses the request. The migration evaluation area was bound to the west by the former Paragon site and Apollo Street property line and to the east by the former Morse Street on the former Paragon site (see Figure 4.8a).

#### History

As discussed in *Reconnaissance of the Groundwater Resources of Kings and Queens Counties, New York* (United States Geological Survey [USGS], 1981) and the October 2006 SAIC Site Characterization Report (SAIC, 2006b), from 1900 through 1947, groundwater supply wells for New York City actively extracted as much as 80 million gallons per day (mgd) of groundwater at locations less than three miles south of the Greenpoint project area. At that time, the resulting hydraulic gradient and inferred direction of regional groundwater flow were south away from Newtown Creek and the Paragon and Apollo Street sites toward the pumping center. Based on the 1981 report, pumping was dramatically reduced by 1950 but did not cease. Based on the limited contours presented in the USGS report for 1974, groundwater began reverting to a natural gradient, which was toward the East River and Newtown Creek. By 1981, groundwater contour maps indicate that the groundwater gradient sloped north toward Newtown Creek.

SAIC, on behalf of Texaco, compiled well gauging data collected by Texaco, ExxonMobil, and BP (see Table 4.3). This data was plotted to create quarterly regional groundwater contour maps for the entire Greenpoint project area, which indicated a northerly groundwater gradient from the area south of Bridgewater Street toward the Paragon and Apollo Street sites and Newtown Creek. The magnitude of that gradient ranged from 0.005 to 0.01 ft/ft. The most recent contour map, created from data gathered on November 28, 2007, is consistent with this trend (see Plate 4.1).
As portrayed in Plate 4.1, during the November 28, 2007, gauging event, recovery wells RW-A, RW-C, and RW-D are located south of Bridgewater Street and were actively extracting groundwater and PSH, while RW-B extracts PSH only. Recovery wells RW-E and RW-F are located north of Bridgewater Street on Meeker Avenue and were actively extracting groundwater and PSH. These recovery wells are part of the ExxonMobil off-site plume treatment system. Based on the areas of closed depression and the groundwater gradient surrounding these wells, groundwater and PSH may be able to migrate between these recovery wells and onto the former Paragon site and Apollo Street site.

4.2.1 Evaluation Methods

In order to further address the NYSDEC request to evaluate the potential movement of PSH from Bridgewater Street toward Newtown Creek, a detailed groundwater study was performed during the week of December 15, 2007. A total of 23 pressure transducers were placed into groundwater monitoring wells uniformly spaced across and south of the former Paragon site where PSH is present. One transducer was placed into Newtown Creek to provide a direct measurement of tidal activity during the study. Transducers were placed in monitoring wells whose locations were chosen to provide comprehensive hydrologic coverage across the former Paragon site where PSH is present. Transects through the former Paragon site and Apollo Street site can be seen in Figure 4.8a. As depicted in Figures 4.8b through 4.8e, monitoring wells containing transducers created a series of transects trending generally north-south from Bridgewater Street to Newtown Creek (A-A’, B-B’, C-C’, and D-D’). Transect A-A’ is actually located on the Apollo Street site. Figure 4.8f depicts transect E-E’ fronting Newtown Creek, spanning eastward from the Apollo Street site beyond the area on the former Paragon site containing PSH. Groundwater elevation data was collected continuously across three to four days, and the elevation data was used to create groundwater hydrographs.

Groundwater Hydrographs

Data extracted from the transducers was interpreted in a manner similar to previous tidal surveys (SAIC, 2006b; SAIC, 2007b). From this data, SAIC prepared a time series of localized
groundwater gradient maps, which represents the dynamics of the groundwater gradient during a complete tidal cycle. A list of wells and elevations utilized in this study is presented in Table 4.4. Of the 24 transducers deployed for this event, the one placed into MW-5 malfunctioned early in the study. As such, this data was deemed unusable and not analyzed, but the remaining transducers performed as designed and collected sufficient data for the analysis.

The tidally induced changes in groundwater levels in each of the wells of each transect were observed and compared to those of Newtown Creek and other surrounding wells. The tidal influence noted in this data set ranged from CMW-43, where daily tidal behavior closely mimicked that of Newtown Creek, to CMW-50, where no tidal influence was discernible. The tidal variability depicted in the hydrographs was likely influenced by a range of factors including distance from Newtown Creek, the heterogeneity of fill materials in the subsurface and the resulting localized hydrologic conditions, the presence of the grout wall, and pumping from the Phase I system recovery well network.

Transect A-A’ is comprised of six wells that form the western edge of the transducer deployment. A hydrograph representing the data captured by these transducers is presented as Figure 4.8b. All wells along transect A-A’ are situated west of the grout wall on the Apollo Street site.

Transect B-B’ includes wells along the ramp area of the former Paragon site. Figure 4.8c shows a hydrograph of transducer data from wells along transect B-B’. All wells along transect B-B’ are situated behind the grout wall. CMW-53 is adjacent to the pumping well MW-70R.

Transect C-C’ includes wells along the center of the 42 Bridgewater Street building of the Empire Merchants warehouse. Figure 4.8d shows a hydrograph of transducer data from wells along transect C-C’. All wells along transect C-C’ are situated behind the grout wall. CMW-57 is adjacent to the pumping well MW-68R.

Transect D-D’ includes wells along the east edge of the PSH plume. Figure 4.8e shows a hydrograph of transducer data from wells along transect D-D’. All wells along transect D-D’ are
situated east of the grout wall and in an area where PSH is not present with exception of well CMW-30.

Transect E-E’ includes wells along the bulkhead area. Figure 4.8f shows a hydrograph of transducer data from wells along transect E-E’. All wells in transect E-E’ are included in previous transects. Wells CMW-57 and CMW-53 are both situated behind the grout wall in the vicinity of the recovery well network.

**Groundwater Contour Maps**

A time series of five groundwater contour maps was prepared across one tidal cycle from data collected by the transducers between December 18 and 19, 2007. The elevations used for contouring were collected from transducers deployed across this area. Contour maps are presented in Figures 4.9a through 4.9e.

The series of groundwater contour maps that was prepared to span one tidal cycle includes high tide, ebb tide (mid tide, falling), low tide, flood tide (mid tide, rising), and again at high tide. In each of the five maps, hydraulic gradients were calculated for both the area across Bridgewater Street (calculated using the 0.2-foot contours lines located immediately north and south of Bridgewater Street) and for mid-site (calculated using the first two consecutive 0.2-foot contours lines located north of Bridgewater Street). The hydraulic gradients for each stage of the tidal cycle are included on each contour map.

The first contour map, Figure 4.9a, depicts groundwater as measured at high tide on December 18, 2007, at 15:43. The calculated hydraulic gradient across Bridgewater Street is 0.0004. The hydraulic gradient in the mid-site area is calculated as 0.004. Inferred contours at this tidal interval suggest that the cones of depression from the recovery wells on the upper and lower bulkhead, during this tidal stage, do not appear to extend to the center of the site.

Ebb tide (mid tide, falling), as measured on December 18, 2007 at 18:50, is depicted in Figure 4.9b. The hydraulic gradients remained unchanged across Bridgewater Street at 0.0004 and mid-site as 0.004. Inferred contours at this tidal interval suggest that the cones of
depression from the recovery wells on the upper and lower bulkhead expanded slightly toward each other during this tidal interval but did not extend any further upgradient.

Low tide, as measured on December 18, 2007, at 21:56, is depicted in Figure 4.9c. The hydraulic gradient has increased both across Bridgewater Street to 0.001 and mid-site to 0.01. Inferred contours at this tidal stage suggest that the cones of depression from the recovery wells on the upper and lower bulkhead overlapped the most during this tidal stage but did not extend any further toward the center of the site.

Figure 4.9d depicts flood tide (mid tide, rising), as measured on December 19, 2007, at 01:05. During this tidal stage, the hydraulic gradient across Bridgewater Street remained at 0.001 and decreased mid-site to 0.005. The cones of depression from the recovery wells on the upper and lower bulkhead began to recede toward their original positions during this tidal stage.

The final high tide, as measured on December 19, 2007, at 04:22, is depicted in Figure 4.9e. The hydraulic gradient across Bridgewater Street returned to 0.0004 while the gradient at mid-site increased slightly to 0.008. Inferred contours during this tidal stage suggest that the cones of depression on the upper and lower bulkhead returned to their original positions during this tidal stage and do not appear to extend to the center of the site.

The data from the migration evaluation area (see Figure 4.8a) collected during this tidal survey indicated that the regional and the localized groundwater gradient in the evaluation area is consistently sloped north from Bridgewater Street to Newtown Creek. The groundwater contours appear consistent and low through the center of the former Paragon site (42 and 50 Bridgewater Street) with no indication of a change in gradient that might signal a potential barrier to flow. Higher groundwater elevations are apparent in the western part of 16 Bridgewater Street, southwest portions of 50 Bridgewater Street, and the Apollo Street site. These areas of higher groundwater elevation respond less to the tidal change than areas of lower groundwater elevation.
The Texaco Phase I recovery system was operating at the time of the data collection. The limited influence of the pumping, due to the large distance of the recovery wells to Bridgewater Street (over 400 feet), exerts little to no influence on the groundwater at Bridgewater Street in the PSH migration evaluation area.

The ExxonMobil off-site recovery system was operating at the time of the survey. The nearest recovery well is RW-D, located over 500 feet south of the evaluation area. Well RW-D appears to be located hydraulically side-gradient to the PSH migration evaluation area. The extent of capture from RW-D does not appear to extend to the PSH migration evaluation area; however, it is likely that steeper localized hydraulic gradients northward may exist when the ExxonMobil off-site recovery system is not pumping.

The presence of the Texaco Phase I pumping wells does not appear to influence the hydraulic gradient at the center of the site or south to Bridgewater Street. Therefore, the data indicates the operation of the Phase I system is not accelerating the migration of PSH from Bridgewater Street to the bulkhead. The transducer data supports the prior indications of the hydraulic gradient as northward from Bridgewater Street to the bulkhead throughout the tidal cycle.

**Hydraulic Conductivity Tests**

As reported in the SAIC October 16, 2006, Site Characterization Report (SAIC, 2006b), a series of slug tests was completed at 35 wells across the former Paragon site and Apollo Street site. A summary of hydraulic conductivity values calculated from these tests is presented in Table 4.5. Contours constructed from these conductivity values are presented in Figure 4.10. The testing indicated that the hydraulic conductivity of the subsurface ranges from approximately 1 to 424 gallons per day per square foot (gpd/ft\(^2\)). This magnitude of variability is due to the heterogeneity of the saturated fill materials—with respect to source, texture, sequence, and care in compaction of the fill materials—which comprise much of the subsurface and the shallow groundwater zone.

In general, the areas of low hydraulic conductivity (less than 50 gpd/ft\(^2\)) include the western portion of the 16 Bridgewater Street building. The historic review of this property indicates that...
it was separately surrounded by a timber retaining wall and filled for development prior to 1886 and prior to the Paragon use of the property beginning in 1934. In addition to the partial hydraulic barrier afforded by the timber, the placed material was apparently well-compacted. This material supports a higher groundwater elevation due to the material’s low hydraulic conductivity (SAIC, 2006b; SAIC, 2007a). The free water table is above this low conductivity fill zone. This low permeability fill zone could be causing groundwater mounding that is apparent in the western part of 16 Bridgewater Street. Another area of low hydraulic conductivity consists of the south and southwest portions of 50 Bridgewater Street and the Apollo Street site, respectively. Areas of high hydraulic conductivity (greater than 50 gpd/ft²) are located in the eastern portion of 50 Bridgewater Street, along the bulkhead at 42 Bridgewater Street, and along Meeker Avenue extending into 16 Bridgewater Street. These areas of low and high hydraulic conductivity influence the hydraulic gradient, the tidal amplitude, and the migration of groundwater and PSH onto the site from the south.

4.2.2 Evaluation Results

A comparison of the groundwater contour maps presented in Figures 4.9a-e with the hydraulic conductivity values portrayed in Figure 4.10 points toward the presence of preferential hydraulic pathways between the area south of Bridgewater Street and Newtown Creek. The preferential pathways in the saturated fill zone are defined by the zones of high hydraulic conductivity relative to zones of low hydraulic conductivity also in the saturated fill zone. One of the pathways for both PSH and groundwater migration trends north from the southwestern corner of 42 Bridgewater Street to the eastern portion of 50 Bridgewater Street and the northern portion of 42 Bridgewater Street (see Figure 4.10). This pathway contains PSH, which is contiguous between the ExxonMobil off-site plume and the seep area at the bulkhead.

Another potential preferential pathway trends northwest from Meeker Avenue across the 16 Bridgewater Street warehouse; however, the hydraulic gradient is not consistently toward Newtown Creek in this area. This pathway does not support PSH migration, and it is not associated with the PSH seep area.
Groundwater Flow
The groundwater velocity was estimated at various locations in the migration evaluation area at Bridgewater Street and the center of the former Paragon site using the hydraulic conductivity values, the hydraulic gradients, and an estimate of the aquifer porosity in accordance with Darcy’s Law (Appendix D, Table D-1). The apparent velocities onto the site in the PSH migration evaluation area range from a low of 0.001 feet per day (ft/d) to a high of almost 0.2 ft/d. This range encompasses the variations due to tidal fluctuation and the heterogeneous character of the subsurface materials. The higher groundwater velocities (approximately 0.02 to 0.2 ft/d) are inferred in the area of the preferential pathway across Bridgewater Street at 42 and 50 Bridgewater Street. The lower groundwater velocities (approximately 0.001 to 0.01 ft/d) infer limited groundwater flow across Bridgewater Street at the Apollo Street site and the 16 Bridgewater Street warehouse. Across the center of the site between Bridgewater Street and Newtown Creek, the hydraulic gradient is steeper and the estimated groundwater velocity is higher at approximately 0.006 ft/d to 0.4 ft/d (Appendix D, Table D-2).

PSH Velocity
In the same manner as with groundwater, the velocity of PSH was estimated by applying the kinematic viscosity of the PSH to Darcy’s Law (Appendix D, Table D-1). This estimate is based on assumptions that the entire aquifer sequence penetrated by the respective monitoring wells is consistent through the PSH-bearing zone. Based on these methods, the velocity of PSH across Bridgewater Street is north at approximately 0.001 ft/d to 0.19 ft/d. As with the analysis of groundwater flow, a north-trending preferential pathway for PSH flow exists in the subsurface at 42 Bridgewater Street and 50 Bridgewater Street on the former Paragon site. The area of limited groundwater flow at 16 Bridgewater Street and the Apollo Street site is similarly restrictive to PSH flow. This character is manifested by the lack of PSH in wells such as CMW-5 and CMW-9 at 16 Bridgewater Street and MW-26 at the Apollo Street site.

The PSH migration velocity calculation is a simplification of a relatively complex relationship between the gradient, which causes the PSH to migrate, and the forces of capillary tension and water and PSH saturation in the subsurface materials. These forces may reduce the rate of PSH migration through the saturated fill zone. Nonetheless, the hydraulic gradient is consistently
north from Bridgewater Street to Newtown Creek, and the sand-based textural classification promotes PSH migration in the same direction as the hydraulic gradient. SAIC is currently collecting the necessary data to further refine the migration velocity calculation.

Based on the gradients on Bridgewater Street (the 42 and 50 Bridgewater Street warehouses) and at the center of the site, the Phase I system does not appear to have a significant influence on accelerating the migration of PSH from Bridgewater Street toward Newtown Creek; however, once the PSH moves past the center of the site, the pumping influence appears to increase the velocity of PSH between the center of the site and Phase I recovery wells along Newtown Creek.
5.0 POTENTIAL RECOVERY SYSTEM ENHANCEMENTS

The purpose of the Phase I recovery system was to initiate full-time automated recovery of both PSH and groundwater immediately behind the bulkhead in the area of the seep. The data generated from the operation of the system and the knowledge gained in understanding the PSH and groundwater flow dynamics in the recovery zone is then used to determine the most appropriate enhancements to the Phase I system in order to more effectively mitigate the seep. Based on the NYSDEC milestone schedule, Phase II enhancements are not scheduled to be initiated in the field until September 2008. This section presents a discussion of Phase II enhancements that have already been initiated during the first quarter of 2008 ahead of the regulatory schedule and also discusses longer term (Phase II) enhancements that will be considered for more effectively mitigating the seep.

This section also discusses the PSH seep emanating from the bulkhead on the Apollo Street property and presents a summary of activities that will be implemented to evaluate and mitigate that seep.

5.1 Initial Phase II Enhancements

Based on a review of the groundwater elevation contours and the estimated capture zone associated with each of the six Phase I recovery wells, Phase II enhancements have been identified and are being implemented. The focus of the Phase II enhancements is to increase the zone of capture in the upper bulkhead and to further depress the groundwater elevations landside in the seep area.

Therefore, well locations CMW-59 and PW-2R, as presented on Figure 3.1, have been identified as Phase II recovery wells. A total fluids recovery pump was installed in CMW-59, and above-grade piping, which was heat-traced insulated, was connected to the existing OWS. Recovery well CMW-59 was activated on January 9, 2008. Data from the initial performance of this well is currently being collected and evaluated.
A second planned well location is PW-2R. Well PW-2R is planned to be installed in February 2008 and will be constructed from six-inch-diameter wire-wrapped screen. This well will also contain a total fluids recovery pump for connection to the existing OWS. The above-grade piping to transfer fluids to the OWS from the well is currently being installed. This well will provide additional capture of PSH landside and immediately behind the boom divider of compartments C3 and C4 of the boom system. Likewise, well CMW-59 will provide for additional PSH and groundwater capture immediately behind compartment C3 of the boom system.

A third existing well located on the Apollo Street property, CMW-43, contains a total fluids recovery pump and will be brought on-line in February 2008, as part of the Phase II upgrades. This well is currently located outside the original treatment area for the Phase I recovery system and is located beyond the current western end of the grout wall. The groundwater and PSH recovered from this well will be transferred to the existing OWS by way of an aboveground heat-traced and insulated pipe. The conversion of this existing monitoring well to a recovery well represents the first well on the Apollo Street property that will operate as a recovery well. Data generated from the performance of this well will be used to evaluate remedial options for mitigating the seep on the Apollo Street property as discussed in Section 5.3.

5.2 Milestone Phase II Enhancements

SAIC will continue to monitor the performance of the recovery system in order to evaluate and identify additional enhancements to further mitigate the seep. Based on the data collected to date, additional Phase II enhancements may include additional total fluids recovery wells and/or a vapor-phase recovery component.

Based on the performance of the initial Phase II additional recovery wells, the groundwater elevations and capture zones will be evaluated to identify the locations of potential additional vertical wells on either the upper or lower bulkhead. Based on the anticipated volume of PSH and groundwater extracted from any Phase II upgrades, additional above-grade separation and
treatment equipment may be needed, as well as modification of the existing NYCDEP discharge permit, which has a limit of 20 gpm treated water discharged to the combined sewer system.

Recovery of PSH in the vapor phase may be an applicable removal mechanism. The PSH in the vicinity of the seep area contains upwards of 60% of the PSH being comprised of hydrocarbons in the volatile gasoline range (less than the C10 range). SAIC will perform vapor extraction pilot tests on selected recovery wells in order to confirm the feasibility of such a removal mechanism and also to collect the engineering design parameters needed to potentially upgrade the system as part of the Phase II enhancements. If such an upgrade was applicable, the above-grade equipment would also have to be supplemented with vapor treatment equipment and all applicable air discharge permits would need to be obtained.

5.3 100-120 Apollo Street Property

The Phase I system was designed and constructed to mitigate the seep on the former Paragon site. The system has been highly effective in mitigating the seep on that property. The Apollo Street site is adjacent to and directly west of the former Paragon site. Texaco never owned nor maintained operations on this property. The current Phase I system appears to have minimal impact on mitigating the seep on the Apollo Street property.

The bulkhead on the Apollo Street site is an older bulkhead constructed from wood and concrete. In contrast, the bulkhead on the former Paragon site was constructed in 2002 and is made from steel sheets. In addition, the bulkhead on the Apollo Street site is undercut, with the undercut visible at very low tide from the creek. This condition increases the complexity of mitigating the seep on this property.

SAIC, on behalf of Texaco, has committed to submitting a work plan for remedial options mitigating the seep on this property for the NYSDEC. The work plan would be for the completion of a remedial options assessment to identify the most appropriate option to mitigate the seep on the Apollo Street site. Conceptually, the approach would likely include some type of barrier—whether it be an impermeable bulkhead or a landside grout wall in combination with a
recovery system. As such, SAIC and Texaco will initiate this evaluation in February 2008 with the use of an underwater diver to complete an initial construction and engineering evaluation of the bulkhead. Texaco neither owned nor maintained operations on the Apollo St. property, and therefore, nothing in this report should be construed as suggesting that Texaco is liable for any hydrocarbons on this property.
6.0 CONCLUSIONS

Based on the first 108 days of operation of the Phase I recovery system, which consists of a grout wall and six extraction wells, the following conclusions are drawn:

1. The grout wall has been effective in mitigating the seep of PSH into the creek as evidenced by reductions of up to 76% in the groundwater elevation tidal amplitudes measured in wells directly behind the grout wall, as compared to measurements in the same wells prior to construction of the grout wall.

2. Additional support for the effectiveness the grout wall has on the seep is evidenced by the improved visual appearance of the absorbent booms in the creek side containment system since the grout wall was constructed and even before the Phase I recovery system was activated.

3. From September 14, 2007, through December 31, 2007, the Phase I recovery system has recovered 9,631 gallons of PSH and 879,900 gallons of groundwater and has maintained an operational uptime of 96% throughout this period. From June 2005 to July 2007, interim PSH recovery activities recovered a total of 11,697 gallons of PSH. The total PSH recovered by SAIC on the former Paragon site, as of December 31, 2007, is 21,328 gallons.

4. The recovery wells on the lower bulkhead have created a reversed hydraulic gradient during both low and high tide stages where water flow has been maintained from the creek to the landside.

5. The seep into the creek from the lower bulkhead appears to have stopped; however, long-term permanence of this condition will be maintained by operation of the recovery system.
6. The recovery wells on the upper bulkhead have been effective in maintaining a reversed gradient at high tide across the entire upper bulkhead and have induced a reversed gradient on part of the upper bulkhead at low tide. Additional extraction wells are needed to extend the area of the reversed gradient on the upper bulkhead.

7. Texaco is currently implementing Phase II recovery system upgrades in advance of the NYSDEC milestone schedule.

8. Groundwater flow onto and in the vicinity of the former Paragon site is generally northward toward the bulkhead and seep area from the area south of Bridgewater Street (at the 42 and 50 Bridgewater Street warehouses).

9. PSH is migrating onto the former Paragon site from south of Bridgewater Street (at the 42 and 50 Bridgewater Street warehouses), down a hydraulic gradient, and through a preferential pathway in the saturated zone consisting of a zone of elevated conductivity.

10. The Phase I system is not accelerating the rate of PSH migration onto the former Paragon site from the area south of Bridgewater Street.

11. The Phase I system, consisting of the grout wall and six recovery wells, has been very effective in slowing the seep of PSH into the creek on the upper bulkhead on the former Paragon site, and this effectiveness has been greater on the lower bulkhead where the seep has apparently stopped.

12. Texaco is currently developing a work plan to perform a remedial options assessment and implement the selected remedy for mitigating the seep on the Apollo Street site.
7.0 REFERENCES


