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Engineering

2012/2013 Annual Groundwater Monitoring and Operations, Maintenance & Monitoring Report

Bay Shore/Brightwaters Former Manufactured Gas Plant Site

Town of Islip

NYSDEC Consent Index No. D1-0001-98-11

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Executive Summary

This report presents the 2012/2013 Annual groundwater monitoring (GM) and operations, maintenance and monitoring (OM&M) results for the Bay Shore/Brightwaters former manufactured gas plant (MGP) site located in Bay Shore, Suffolk County, New York. GM and OM&M activities include monitoring groundwater, soil vapor, and ambient air, as well as maintenance and monitoring of the dense non-aqueous phase liquid (DNAPL) recovery and groundwater treatment systems. The period for this report includes Third Quarter (Q3) 2012 through Second Quarter (Q2) 2013.

Quarterly monitoring reports for the site had been prepared and submitted to the agencies and provided to the public since the initial site remediation report was prepared in 2004 through Q2 2012. Reductions to the reporting frequency, the long term groundwater and soil vapor monitoring programs, as well as the establishment of remediation system shutdown criteria were approved by the New York State Department of Environmental Conservation (NYSDEC) in a letter dated August 22, 2012. The specific objectives included:

- Provide criteria for future reductions in groundwater sampling based on analytical results,
- Provide analytical requirements for monitoring groundwater,
- Provide criteria for shut down and removal of groundwater treatment systems,
- Reduce soil vapor sampling, and
- Reduce the frequency of the quarterly OM&M reporting cycle to annual.

Implementation of the reduction program began in Fourth Quarter (Q4) 2012.

Remediation

Non-Aqueous Phase Liquid (NAPL) Gauging and Recovery

Light non-aqueous phase liquid (LNAPL) was not present in monitoring wells gauged over the past year (Q3 2012 through Q2 2013). Trace amounts of LNAPL were first observed in the central section of Operable Unit 1 (OU-1) in one monitoring well in First Quarter (Q1) 2010, reaching a maximum thickness of approximately 2 feet in Q4 2010. DNAPL was observed in monitoring wells in the same area and further south in OU-1 during the past year at a maximum thickness of approximately 6.5 feet. DNAPL has historically been gauged and recovered from OU-1 since Q1 2006. Over the past year, approximately 27 gallons of DNAPL were recovered from recovery well BBRW-02, located in the vicinity of maximum product thicknesses.

Groundwater Treatment

The constituents of concern (COCs) in site groundwater consist of benzene, toluene, ethylbenzene and xylene (BTEX) and polycyclic aromatic hydrocarbons (PAHs), primarily naphthalene and 2-methylnaphthalene. Groundwater remediation systems have been installed to treat the impacted groundwater. An ozone injection system was installed in OU-1 to reduce concentrations of COCs as they pass through the perforated section of the subsurface containment barrier wall and into Operable Unit 2 (OU-2). Eight oxygen injection systems were installed to treat impacted groundwater in OU-1, OU-2 and Operable Unit 3 (OU-3). These systems are maintained monthly. Operational parameters are adjusted to optimally treat groundwater. These systems have been effective in reducing the COCs in groundwater, as discussed below. Several areas where lingering contamination is present have been selected for the installation of additional oxygen injection systems or modifications to the present systems. The new installations and system modifications currently underway and are scheduled for completion in late Q3 or early Q4 2013.

Hydrogeologic Setting and Groundwater Flow

The hydrogeologic regime in the vicinity of the site includes glacial deposits comprising the Upper Glacial aquifer. These deposits consist mainly of inter-bedded layers of permeable sand and gravel, and intermittent less permeable layers of silty sand. The thickness of these deposits is approximately 70 feet.

Groundwater elevation monitoring is conducted annually to aid in monitoring the groundwater plumes, confirm groundwater flow patterns, and to assist in remedy planning. The depth to groundwater at the site is shallow, generally between approximately 2 and 12 feet below ground surface (bgs). The groundwater flow direction throughout the site is generally towards the south/southeast. The Q2 2013 groundwater elevations are near average groundwater levels measured over the past 10 years.

Groundwater Quality

The groundwater quality data indicate that remedial activities have generally been successful at reducing the overall concentrations of COCs in groundwater.

Concentrations of COCs in groundwater in OU-1, OU-2 and OU-3 have generally been significantly reduced since the implementation of remedial activities. The groundwater treatment systems have been effective at reducing the area and concentrations of impacted groundwater in OU-2. Several areas, where elevated concentrations have persisted, are currently being addressed by the installation of additional oxygen injection systems, or the modification of current systems to focus treatment on the zones with residual impacts.

The Interim Remedial Measure (IRMs) conducted in OU-3 included the Long Island Railroad (LIRR) Excavation/Temporary Track Relocation IRM (Phases 1 and 2) and the LIRR

Excavation IRM, Phase 3 (Brightwaters Yard), and supplemental remedial efforts as summarized in Section 1 of this report. It is expected that these remedial activities will result in continued decreasing constituent trends in groundwater throughout the impacted areas of OU-3. Although BTEX and total PAH concentrations continue to vary, the majority of the monitoring wells within the excavation area of the Brightwaters Yard and in the area immediately south of the LIRR tracks have decreasing concentrations, or have remained at or near, detection levels. Decreasing concentrations in intermediate monitoring wells in the area have become evident within the past year. However, elevated concentrations, particularly of BTEX, remain in the area immediately downgradient of the excavation IRM in shallow and intermediate wells. In order to address the residual impacts in the area immediately south of the LIRR track, an additional oxygen injection system is currently being installed with start-up planned for late Q3 or early Q4 2013.

In the downgradient portion of OU-3 (south of Union Boulevard), decreasing trends of BTEX and total PAHs in shallow and intermediate groundwater are evident. Shallow BTEX and total PAH impacts above 100 micrograms per liter (µg/L) are no longer present in the area downgradient of Union Boulevard. Intermediate impacts have also been reduced, but some still remain.

In order to address the downgradient impacts in OU-3, a groundwater investigation targeting shallow and intermediate zone impacts was conducted in early Q2 2013. Following the groundwater investigation, a targeted remedial injection program utilizing Oxygen Release Compound – Advanced (ORC-A) was conducted to treat the identified impacts. Several new monitoring wells were installed in the area to monitor the groundwater quality and evaluate the effectiveness of the ORC-A injection program. Results from these monitoring wells have indicated reductions in concentrations which can likely be directly attributed to the effectiveness of the ORC-A injection program. A second round of injections targeted to treat lingering impacts, including those identified in area upgradient of the initial injection area was conducted during Q3 2013. It is anticipated that the ORC-A injection program along with the remedial systems previously or currently being installed, and excavation IRMs discussed above, will further reduce downgradient impacts in future sampling events.

The area of impacted groundwater in Operable Unit 4 (OU-4) during Q2 2013 has increased slightly since the completion of Surfactant Enhanced In Situ Chemical Oxidation (S-ISCO) injection, which was initiated in Q2 2009 and completed in Q4 2009. The excavation of shallow soil impacts and backfill phase of the OU-4 Excavation IRM was performed in Q2 and Q3 2011. The excavations were performed “in the wet” (no dewatering). Temporary increases in groundwater concentrations have typically been observed in other areas of the site following similar source material excavations, as was the case in OU-4. Decreasing concentration trends are evident in recent sampling events in both the shallow and intermediate zones. No impacts have been present in the deep zone.

Future Plans

The GM and OM&M schedule will continue to be evaluated on a quarterly basis to keep the groundwater treatment systems operating as efficiently as possible. Rationale for sampling groundwater and soil vapor will also continue to be evaluated on a quarterly basis. Proposed modifications or plans to system OM&M and site monitoring are presented below.

Non-aqueous Phase Liquid (NAPL) Gauging and Recovery

- The frequency of monitoring and DNAPL recovery in OU-1 will be evaluated on a quarterly basis.

Ozone Groundwater Treatment System

- Develop a long-term sampling plan for groundwater, soil vapor and soil vapor extraction system effluent.

Current Oxygen Injection Systems

- The installation of two new oxygen injection systems and the modification of three others are currently underway to treat lingering impacts. The installations and modifications are scheduled to be complete in Q4 2013.

Short-term Groundwater Monitoring

- Continue evaluation of the groundwater impacts in OU-3, through monthly monitoring.
- Additional monitoring wells are planned for installation along the southern extent of the LIRR right-of-way (ROW). Installation is currently planned for Q4 2013.

Remedial Activity

Operable Unit 1

- The installation of one new oxygen injection system, located to the north of the LIRR ROW along the eastern portion of the operable unit, and the modification of the OU-1 Union Boulevard oxygen injection system to treat lingering impacts is currently underway. The installation and modifications are scheduled to be completed in early Q4 2013.
- The 60/66 North Clinton oxygen injection system is being relocated to the northern property boundary to facilitate potential redevelopment of the property. It is also being modified to treat groundwater impacts inside of the western portion of the subsurface barrier wall. The relocation and modification is scheduled to be completed in Q4 2013

Operable Unit 2

- The modification of two existing oxygen injection systems is currently underway and is scheduled to be completed in Q4 2013. The systems being modified include 33 North Clinton Avenue and Montauk Highway lines.

Operable Unit 3

- The installation of one additional oxygen injection system is currently underway as discussed above. An additional round of ORC-A injection was completed during Q3 2013 in the downgradient area of OU-3. The need for additional injection will be evaluated as needed.

Operable Unit 4

- None

Long-term Monitoring

- Continue following the approved long-term monitoring program.

1. Introduction

This report presents the 2012/2013 Annual groundwater monitoring (GM) and operations, maintenance and monitoring (OM&M) activities for the Bay Shore/Brightwaters former manufactured gas plant (MGP) site located in Bay Shore, Suffolk County, New York. The period for this report includes third quarter (Q3) 2012 through Q2 2013. This report has been prepared in accordance with the requirements of Section 6 of DER-10, Technical Guidance for Site Investigation and Remediation, and the Order on Consent, Index No. D1-0001-98-11 between National Grid Corporation and the New York State Department of Environmental Conservation (NYSDEC).

Quarterly monitoring reports for the site have been prepared and submitted to the agencies and provided to the public since the initial site remediation report was prepared in 2004 through Q2 2012. Modification of the reporting frequency from quarterly to annual was approved by the NYSDEC in their letter dated August 22, 2012. The GM and OM&M data continues to be evaluated and the data submitted to the agencies on a quarterly basis; however, the 2013 annual report represents the first reported interpretation of the data since the Q2 2012 quarterly report.

Along with the requested reduction to the reporting frequency for the site, reductions to the long term groundwater and soil vapor monitoring programs, as well as the establishment of remediation system shutdown criteria were also approved by NYSDEC. The specific objectives included:

- Criteria for future reductions in groundwater sampling based on analytical results,
- Analytical requirements for monitoring groundwater,
- Criteria for shut down and removal of groundwater treatment systems,
- Reduction of soil vapor sampling, and
- Reduction of the frequency of the quarterly operation, maintenance and monitoring (OM&M) reporting cycle to annual.

The NYSDEC approved criteria for the groundwater monitoring program for the Bay Shore/Brightwaters site is summarized as follows:

- Monitoring wells which meet ambient groundwater quality standards for Class GA groundwater for individual benzene, toluene, ethylbenzene and xylene (BTEX) and polycyclic aromatic hydrocarbons (PAHs) compounds for four consecutive quarters can be reduced to annual sampling.

- For compounds with standards less than the analytical detection limits, individual BTEX or PAH compound concentrations must be reduced below detection limits for four consecutive quarters before annual sampling can be instituted.
- Monitoring wells that meet the above criteria for two consecutive years of annual sampling will be removed from the monitoring network.
- Quarterly sampling will resume at any wells where concentrations greater than 50 µg/L of total BTEX or total PAHs are detected in annual sampling.
- Select monitoring wells associated with the ozone or oxygen injection treatment systems will continue to be monitored at least quarterly to evaluate system performance.
- A proposal to shut down an oxygen system may be considered when the groundwater quality of all monitoring wells located upgradient as far as the next treatment system and immediately downgradient of a treatment system meet the sample reduction criteria noted above.
- A treatment system will be placed back into operation if the total BTEX or total PAH concentrations found in either upgradient or downgradient wells exceed 50 µg/L during any of the four (4) quarterly sampling events.

Implementation of the monitoring reductions was initiated in Q4 2012. As a result of the reductions, approximately 55% of the wells on quarterly groundwater sampling list were initially changed to annual sampling and approximately 5% were eliminated from the sampling program. The sample list is re-evaluated quarterly following the receipt of the most recent analytical results. Annual sampling is conducted during the second quarter of each year. Excluding samples related to the operation and maintenance of the ozone injection system, soil vapor sampling was eliminated. A groundwater monitoring well tracking summary is provided in **Appendix A** for the quarterly sampling events included in this report (Q3 2012 through Q2 2013)

In 2003, the site was divided into four operable units (OUs) to more effectively manage investigation and remediation activities. The four OUs are shown on **Figure 1**. The groundwater monitoring results for all four OUs have been included in this report to present an overall picture of trends in groundwater quality. The groundwater trend analysis includes discussion of the effectiveness of the remedial activities which affect groundwater quality in the Upper Glacial aquifer.

GM and OM&M activities include monitoring groundwater, soil vapor, and ambient air, as well as maintenance and monitoring of the dense non-aqueous phase liquid (DNAPL) recovery and groundwater treatment systems. GM and OM&M results are presented in the following sections of the report:

- Section 2 – Remediation Systems
- Section 3 – Groundwater Flow

- Section 4 – Groundwater Quality
- Section 5 – Future Plans

1.1 Background

The former MGP operations began in the late 1880s and continued into the 1970s. Most of the MGP facilities were demolished in 1973. Various remedial investigation activities have been completed at the site. The results of the investigations and discussion of the site history are presented in the Remedial Investigation Report (RIR) (Dvirka and Bartilucci Consulting Engineers [D&B], 2002) and the Final Remedial Investigation Report (D&B, 2003).

A Final Remedial Action Plan (RAP) for OU-1 was approved by the NYSDEC on August 9, 2004. The remedy currently being implemented at OU-1 is detailed in a document titled "Final Remedial Action Plan, Bay Shore Former MGP Site – Operable Unit-1, Bay Shore, New York" (Final RAP) prepared by GEI Consultants, Inc., P.C. (GEI) and dated August 2004. In addition to the remedial activities specified in the Final RAP, several interim remedial measures (IRMs) have been conducted since 1999 in OU-1, OU-2, OU-3, and OU-4. A summary of remedial activities conducted in each OU is presented below. These activities are presented by operable unit on **Figure 2**.

1.1.1 Operable Unit 1 (OU-1)

OU-1 consists of the Bay Shore site, formerly the main operations area of the MGP, as well as properties immediately south of the site which are currently owned by National Grid. **Table 1a** summarizes the remedial actions, IRMs, and pilot studies that have been performed in OU-1.

Table 1a – Summary of OU-1 Remedial Activity

Date	OU-1 Remedial Activity	Comment
2004	In-Situ Chemical Oxidation (ISCO) Pilot Studies	Three pilot studies were conducted using Activated Persulfate, Modified Fenton's Reagent and Activated Fenton's Reagent (GEI, 2005).
2006-Present	DNAPL Recovery	A DNAPL recovery system was installed in the offsite area south of the Long Island Rail Road (LIRR) and was implemented as a portion of the Phase I Remedial Activities performed for implementation of the Final RAP (GEI, 2006b) and documented in the DNAPL Pump Test Letter Report (KeySpan, 2006).
2006	Surfactant-Enhanced In-Situ Chemical Oxidation (S-ISCO) Pilot Study	A pilot study was conducted using a surfactant to solubilize MGP-related impacts and Sodium Persulfate to oxidize those impacts (GEI, 2007a).
February-April 2007	OU-1 Southern Cell Excavation	The southern cell excavation was included in Phase I of the OU-1 remedy performed in accordance with the Final RAP. The results are provided in the Phase I and Phase II Remedial Activities, OU-1 Bay Shore Former MGP site, Final Completion Report (Paulus, Sokolowski and Sartor Engineering, PC [PS&S], 2009).
April 2007-May 2008	Subsurface Barrier Wall Installation	The barrier was installed as part of Phase I of the OU-1 remedy performed in accordance with the Final RAP. The final construction details are presented in the Final Completion Report (PS&S, 2009).

Date	OU-1 Remedial Activity	Comment
February 2008	Oxygen Injection System	An oxygen injection system was installed along the downgradient edge of OU-1 as an IRM to treat groundwater at the perforated portion of the subsurface barrier wall until startup of the full-scale groundwater treatment system was completed (KeySpan, 2007).
August 2007-August 2008	OU-1 Excavation North of the LIRR	The excavation north of the LIRR in OU-1 was performed as Phase II of the OU-1 remedy in accordance with the Final RAP. The final construction details are provided in the Final Completion Report (PS&S, 2009).
October 2009	Ozone Groundwater Treatment System	The installation of the ozone injection groundwater treatment system was performed as Phase IA of the OU-1 remedy (GEI, 2009b) in accordance with the Final RAP (GEI, 2004a).
March-April 2009	66 North Clinton Avenue Excavation	Shallow MGP-impacted soils located outside of the subsurface barrier wall in the western fringe area were removed to the approximately 10 feet (below ground surface) bgs as part of Phase IV of the OU-1 remedy (GEI, 2010a) in accordance with the Final RAP (GEI, 2004a).
January 2010	60/66 North Clinton Avenue Oxygen Injection System	The system was installed as part of Phase IV of the OU-1 remedy to treat groundwater west of the barrier wall (GEI, 2010a).
June 2011	OU-1 Oxygen Injection System Extension	The OU-1 Union Boulevard system was extended in accordance with the OU-2 Remedial Design Document (GEI, 2009a) to treat impacted groundwater east of the subsurface barrier wall.
August-2011	TarGOST® Study	This investigation was performed to delineate potential recoverable non-aqueous phase liquid (NAPL) in OU-1, North and South of the Long Island Rail Road (LIRR).in order to locate additional recovery wells.
October 2011	Recovery Well Installations (19 temporary & 1 permanent)	These wells were installed following the TarGOST study. Following DNAPL gauging, bailing and recovery rate testing of wells with measurable DNAPL, one additional permanent recovery well is planned.
February 2012	Temporary Recovery Well Abandonment and Recovery Well Installation	The temporary recovery wells with no measurable level of NAPL were abandoned and one permanent recovery well was installed

1.1.2 Operable Unit 2 (OU-2)

OU-2 consists of the groundwater plume which extends south/southeast from OU-1. The NYSDEC issued a Voluntary Cleanup Program Decision Document for OU-2 in July of 2008. This document specified the installation of a minimum of three oxygen injection systems as the selected remedy for OU-2. A summary of the system installation and IRMs completed in OU-2 is presented in **Table 1b**, below.

Table 1b – Summary of OU-2 Remedial Activity

Date	OU-2 Remedial Activity	Comment
December-2005	Oxygen Injection IRM	The Garner Lane system treats groundwater prior to discharge to Lawrence Creek. The system is comprised of two injection lines located along Montauk Highway and at the intersection of Manatuck Lane and Garner Lane (GEI, 2006).
May-July 2007	Hydrologic Study	An investigation to further evaluate groundwater conditions in the vicinity of the Garner Lane oxygen Injection system and to validate the observed decreases in MGP related contaminants in groundwater in the vicinity of the Montauk Highway and Manatuck Lane treatment lines (GEI, 2007b).
January-November-2009	Groundwater Treatment Remedy (Installation and operation of the 9 North Clinton Avenue, 33 North Clinton Avenue, 34 North Clinton Avenue, Plume Tail and Cooper Lane oxygen injection systems/treatment lines)	In accordance with the Voluntary Clean-up Program Decision Document (NYSDEC, 2008) and the OU-2 Remedial Design Document (GEI, 2009a), three additional groundwater treatment systems utilizing the oxygen injection technology were installed within the OU-2 groundwater plume (GEI, 2010d).
June 2011	Additional Oxygen Injection System Installation (29 Community Road Oxygen Injection System)	The 29 Community Road oxygen injection system treats impacted groundwater along the western extent of OU-2. The system was installed as an addendum to the OU-2 Remedial Design Document (GEI, 2009a).

1.1.3 Operable Unit 3 (OU-3)

OU-3 consists of the Brightwaters Yard, which is currently owned by National Grid, and the groundwater plume that extends south/southeast from the Brightwaters Yard. A summary of the IRMs completed in OU-3 is presented in **Table 1c**, below.

Table 1c – Summary of OU-3 Remedial Activity

Date	OU-3 Remedial Activity	Comment
2000	Groundwater Treatment IRM	An oxygen injection system was installed at the intersection of Union Boulevard and Lanier Lane to reduce the concentrations of MGP-related contaminants in groundwater prior to discharge into O-Co-Nee Pond (FW, 2000).
May 2001, September 2001,- October 2004	ISCO IRMs	Three rounds of ISCO by In-Situ Oxidative Technologies, Inc. (ISOTEC) were used to treat the Brightwaters Yard groundwater plume source area (FW, 2000).
May-July 2004	Excavation IRM	A source area excavation was effective in removing 1,500 tons of source contaminated soils (PS&S, 2005).
2004	Groundwater Treatment IRM	The Brightwaters Yard oxygen injection system was installed to reduce the concentrations of MGP-related contaminants in groundwater leaving the OU-3 site boundary (PS&S, 2004).
2008	Storm Sewer Rehabilitation IRM	Sections of the storm water collection network located within OU-3 were rehabilitated. This included the replacement of catch basins and the cured in-place lining of drainage piping (GEI, 2010b)
July 2009	Brightwaters Yard Oxygen Injection System Abandonment	The Brightwaters Yard system was abandoned in support of the LIRR Excavation IRM (National Grid, 2010).
February 2010 (Phase I completed) July 2010 (Phase II completed) September 2010 (Phase III completed)	LIRR Excavation/Temporary Track Relocation IRM	Source material was removed from the OU-3 Brightwaters Yard and under the adjacent LIRR property (GEI, 2009c).
April 2010	Community Road Oxygen Injection Line	This treatment line was installed to replace the OU-3 Union Boulevard oxygen injection system (GEI, 2010a).

Date	OU-3 Remedial Activity	Comment
July 2010	OU-3 Union Boulevard Oxygen Injection System Abandonment	The system was abandoned to limit the amount of remedial equipment within the community. The Community Road oxygen injection line was installed to replace this system (National Grid, 2010).
March 2012	OU-3 Community Road Oxygen Injection Line Reconfiguration	This treatment line was reconfigured to optimize the treatment of impacted groundwater in OU-3 (National Grid, 2011).
March 2013/August 2013	ORC-Advanced Injection Program	A targeted Oxygen Release Compound – Advanced (ORC-A) injection program was conducted to treat downgradient impacts (National Grid, 2013).

1.1.4 Operable Unit 4 (OU-4)

OU-4 consists of a former cesspool area, former pond area, and the headwaters of Watchogue Creek/Crum's Brook, located approximately 400 feet east of the Bay Shore site. A summary of the IRMs completed in OU-4 is presented in **Table 1d**, below.

Table 1d – Summary of OU-4 Remedial Activity

Date	OU-4 Remedial Activity	Comment
2000	Restoration of Watchogue Creek/Crum's Brook	Sediments were removed and the channel was restored (Foster Wheeler Environmental Corporation [FW], 2002).
November 2005	Cesspool Excavation IRM	The former cesspool shallow impacted soils (vadose zone soils) were removed and treated offsite as part of an IRM (GEI, 2010c).
April-December 2009	Surfactant Enhanced In-Situ Chemical Oxidation (S-ISCO) IRM	S-ISCO was implemented in accordance with the NYSDEC-approved OU-4 Cesspool Area S-ISCO Work Plan (VeruTEK, 2008) and associated addendums.
April 2011-August 2011	Cesspool Area and Pond Area Excavation IRM	Mobilization and initiation of the OU-4 Upgradient excavation was completed in Q1 2011, monitoring well abandonment and the Cesspool Area excavation were completed July 2011, Pond Area excavation completed August 2011.

2. Remediation Systems

Groundwater remedial systems in operation at the site include DNAPL recovery, a combined ozone injection and soil vapor extraction system, and eight oxygen injection systems. A description of each system, the quarter's monitoring activities, and operational data are presented in the sections below. The location of all remedial activities performed at the site is provided on **Figure 2**.

2.1 OU-1 DNAPL Recovery System and NAPL Monitoring

2.1.1 Program Scope and Purpose

A DNAPL recovery system was installed at recovery well BBRW-02 in January 2006. The location of BBRW-02 is shown on **Figure 1**. The DNAPL recovery system consists of a Blackhawk Electric Anchor Piston Pump which pumps DNAPL from BBRW-02 and discharges it to a United States Department of Transportation/United Nations approved 55-gallon steel drum. The DNAPL recovery system is operated approximately once every four weeks as of Q2 2011. A routine evaluation of DNAPL thicknesses and recovery volumes determined that recovery operations would shift from a three week schedule to a four week schedule in Q2 of 2011.

In addition to the NAPL Recovery operations, OU-1 monitoring and recovery wells are gauged quarterly for the presence of LNAPL and DNAPL.

2.1.2 OU-1 NAPL Monitoring Data

2.1.2.1 DNAPL Monitoring

DNAPL has historically been observed in OU-1 at wells BBRW-01R, BBRW-02, BBRW-06, BBRW-08, BBMW-05D, BBMW-22D, BBMW-34I2, BBMW-38I, BBMW-38I2, OZMW-21I, OZMW-21D, as well as in temporary recovery wells TG-29I2, TG-32I2, TG-32D and TG-44I2. Temporary recovery well TG-29I2 was damaged during Q2 2012 and is no longer part of the gauging program. Between Q3 2012 and Q2 2013, thicknesses of DNAPL in OU-1 wells have remained consistent with previous monitoring data as shown in **Table 2a**, below.

Table 2a – Summary of Measured DNAPL Thickness

Well ID	Screen Interval	Average DNAPL Thickness (feet)							
		Q3 11	Q4 11	Q1 12	Q2 12	Q3 12	Q4 12	Q1 13	Q2 13
BBRW-01R	30-60	0.4	0.5	0.3	0.6	0.5	0.6	1.1	0.4
BBRW-02	58.2-78.2	4.5	3.7	5.4	5.1	5.3	6.2	6.5	5.7
BBRW-06	25-55	0.9	0.7	1.6	1.2	1.1	1.4	0.4	0.5

Well ID	Screen Interval	Average DNAPL Thickness (feet)							
		Q3 11	Q4 11	Q1 12	Q2 12	Q3 12	Q4 12	Q1 13	Q2 13
BBRW-08	65-75	NI	2.4	3.2	2.9	2.8	NM	4.67	2.1
BBRW-09	66-76	NI	NI	NI	NI	NI	NI	Trace	Trace
BBMW-22D	64-74	6.5	4.7	4.5	4.1	4.8	4.5	4.8	4.4
BBMW-34I2	40-45	1.93	1.2	1.9	2.5	1.7	2.5	1.9	2.1
BBMW-38I	25-30	0.78	0.4	0.3	0.6	0.5	0.9	1.0	0.5
BBMW-38I2	40-45	1.4	1	0.8	1.1	0.9	1.2	1.5	1.1
OZMW-21I	20-30	1.5	0.9	1.8	1.7	1.4	1.7	1.1	1.5
OZMW-21D	55-60	0.4	0.6	0.8	1.3	1.5	1.4	1.5	1.4
TG-29I2	55-65	NI	NO	0.2	Trace	Trace	NM	NM	NM
TG-32I2	40-50	NI	0.25	0.4	1.1	1.2	NM	2.4	2.3
TG-32D	65-75	NI	0.78	1.3	1.5	1.7	NM	1.6	1.3
TG-44I2	55-60	NI	1.3	1.0	1.3	1.5	NM	0.8	1.5

Notes:

NI – Not Installed
NM – Not Measured
NO – Not Observed
Historically, DNAPL was observed at recovery well BBRW-01. This well has been abandoned.
BBMW-22D is located within 15 feet of BBRW-02. DNAPL thickness at this well is influenced by pumping operations at BBRW-02. DNAPL is not recovered at BBMW-22D.

2.1.2.2 LNAPL Monitoring

Historically, LNAPL has been observed in OU-1 in monitoring wells BBMW-34I and OZMW-25I. LNAPL has not been observed at BBMW-34I and OZMW-25I since Q3 2011. Recently LNAPL has been observed in OZMW-21S, as shown in **Table 2b**, below.

Table 2b – Summary of Measured LNAPL Thickness

Well ID	Screen Interval	Average LNAPL Thickness (feet)											
		Q3 10	Q4 10	Q1 11	Q2 11	Q3 11	Q4 11	Q1 12	Q2 12	Q3 12	Q4 12	Q1 13	Q2 13
BBMW-34I	25-30	NM	0.1	Trace	Trace	NO	NO	NO	NO	NO	NO	NO	NO
OZMW-21S	5-15	NM	NM	NM	NM	NM	NM	NM	NM	NM	0.2	0.1	0.1
OZMW-25I	20-30	0.04	2.1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Note:

NO – Not Observed

2.1.3 OU-1 DNAPL Recovery Data

2.1.3.1 DNAPL Recovery

Approximately 444 gallons of DNAPL have been recovered from BBRW-02 since the beginning of the recovery operations in Q1 2006. Approximately 27 gallons were removed between Q3 2012 and Q2 2013. A summary of the recovery operations are provided in **Table 2c**, below.

Table 2c – Summary of DNAPL Removal for Recovery Well BBRW-02

Time Period		Approximate DNAPL Thickness (feet)		Approximate DNAPL Removed
		Initial	Final	(Gallons)
Historical	Q1 2006 through Q2 2012	-	-	417.7
Q3 2012	7/9/2012	6	4.5	2.2
	8/9/2012	6.8	5.3	2.2
	9/4/2012	7	4.5	3.67
Q4 2012	10/5/2012	6.8	5	2.64
	11/5/2012	6.9	5	2.79
	12/5/2012	6.9	4.8	3.08
Q1 2013	1/3/2013	6.1	5.2	1.32
	1/28/2013	6.1	5	1.62
	3/6/2013	6.8	5.5	1.84
Q2 2013	4/5/2013	6.9	5.7	1.76
	5/3/2013	6.8	5.7	1.63
	6/1/2013	6.9	5.6	1.92
Totals	Q3 2012 - Q2 2013	-	-	26.67
	To Date	-	-	444.4

Notes:

NAPL measurements were made using a dedicated tape. The smear of DNAPL on the tape is measured to determine DNAPL thickness.

Total volume calculated by multiplying the thickness by the cross-sectional area of the well. This is an estimate of the minimum volume removed.

Historical trends of DNAPL recovery, initial DNAPL thickness (measured prior to operation), and final DNAPL thickness (measured post operation) are shown on **Figure 3**. Apparent trends, related to DNAPL recovery, for the past four quarters are:

- The initial DNAPL thickness was consistently observed between 6 and 7 feet between Q3 2012 and Q2 2013. This is generally consistent with recent historical DNAPL thickness measurements.
- The amount of DNAPL recovered during each pumping event increased from approximately 1.5 gallons to above 3.0 gallons after the operational schedule was

changed in Q2 2011 to operate once every four weeks. In the most recent 2 quarters, Q1 and Q2 2013, product recovery has decreased to approximately 1.5 gallons per pumping event.

2.2 OU-1 Ozone Groundwater Treatment System

2.2.1 Program Scope and Purpose

A groundwater treatment system was installed at the downgradient edge of OU-1 at 61 North Clinton Avenue. The treatment system consists of an ozone injection system and soil vapor extraction (SVE) system. The ozone injection system was installed to reduce concentrations of dissolved phase COCs prior to passing through the perforated section of the subsurface containment barrier wall. The barrier wall is located at the downgradient boundary of OU-1 and extends through the Upper Glacial aquifer to approximately 70 feet bgs. The 190-foot long perforated section is located parallel to Union Boulevard and extends from a depth of approximately 10 to 40 feet bgs. This perforated zone creates a window where groundwater is discharged from OU-1 to OU-2 after being treated by the ozone injection. The location of the groundwater treatment system and subsurface barrier wall are depicted on **Figure 1**.

The ozone injection system injects an air-ozone mixture at a maximum concentration of 3 percent ozone into the groundwater to destroy contaminants through in-situ chemical oxidation. The SVE system is designed to capture any potential ozone or volatile organic compounds (VOCs) that might migrate from the groundwater to the vadose zone.

The groundwater treatment building houses the equipment used to generate the ozone gas from fresh air as well as the SVE equipment, carbon vessels, and an ozone destruction unit. The treatment zone, located south of the groundwater treatment building, consists of 63 ozone injection wells that are screened at 2 foot intervals between 27 and 50 feet bgs, and 11 horizontal SVE laterals.

The treatment system began operation in October 2009. Between Q3 2012 and Q2 2013, the average ozone/air mixture injected was approximately 1.6 percent ozone and 98.4 percent air.

2.2.2 Current Monitoring Activities

The monitoring and operation activities performed during the past four quarters for the ozone groundwater treatment system are summarized in **Table 2d**, below.

Table 2d – Current Ozone System Site Activity

Activity	Task Description	Frequency	Location of Results
Ozone System Monitoring	Routine inspection and maintenance of the system components, monitoring of operational parameters, and recording/adjusting of the injected ozone concentrations.	Weekly	Details are recorded on field logs and are not provided in this report.
SVE System Monitoring	Inspection and maintenance of the system components, recording of operational parameters, and screening of the SVE effluent.	Weekly	Details are recorded on field logs and are not provided in this report.
	Sampling of the SVE effluent before, in the middle of, and after treatment.	Monthly	Appendix B
System Performance Monitoring	Monitoring BTEX and total PAH concentrations downgradient well clusters OZMW-23 and OZMW-24.	Monthly	Figure 4, Section 4, Table 4-1, Table 4-2
	Sampling soil vapor (SV-01, SV-02, SV-03) downgradient and site ambient air.	Monthly	Section 2.2.4, Table 2-1, Appendix C
	Sampling ambient air downgradient and upgradient of system.	Monthly	Section 2.2.4, Table 2-2

2.2.3 Ozone Injection System OM&M Data

2.2.3.1 Groundwater

The ozone injection system has been effective at reducing BTEX and total PAH concentrations in groundwater. The ozone injection system treats groundwater prior to passing through the perforated window of the subsurface barrier wall, 10 to 40 feet bgs. The reduction of BTEX and total PAH concentrations are shown in the shallow and intermediate zones of the time series graphs of OZMW-23 and OZMW-24 on **Figure 4**. These monitoring well clusters are located downgradient of the system and upgradient of the subsurface barrier wall. Total PAH concentrations have remained elevated at OZMW-24I2 and OZMW-24D. Groundwater passing through the perforated section of the subsurface barrier wall is also treated by the OU-1 Union Boulevard oxygen injection system. Groundwater quality trends are discussed further in Section 4.

2.2.3.2 Ozone Injection System

Approximately 11 pounds of ozone were injected each day between Q3 2012 and Q2 2013. The ozone groundwater treatment system was in operation for 338 out of 365 days (93%) in the past four quarters.

- Q3 2012 – The system was operational for 85 out of 92 possible days. The system was down for seven days due to power outages and A/C maintenance.
- Q4 2012 - The system was operational for 86 out of 92 possible days. The system was down for six days due to a power outage caused by Hurricane Sandy.
- Q1 2013 - The system was operational for 84 out of 90 possible days. The system was down for six days due to system malfunction and power outages.
- Q2 2013 - The system was operational for 83 out of 91 possible days. The system was down for eight days due to elevated ozone concentrations detected in the generation room and the remote outbuildings. The leaks were identified and fixed.

2.2.3.3 SVE System Effluent

Total VOC concentrations, measured after granular activated carbon treatment, ranged between 0.006 and 0.06 parts per million (ppm) during the past four quarters. **Appendix B** presents data collected from the SVE system effluent, before carbon treatment (OZ-PREGAC), in between carbon vessels (OZ-MGAC), and after carbon treatment (OZ-STACK).

2.2.4 Ozone Groundwater Treatment System Soil Vapor and Ambient Air Sampling

Three soil vapor points are located downgradient of the ozone groundwater treatment system. These points are sampled monthly to monitor potential influence of the ozone groundwater treatment system operation on soil vapor concentrations, downgradient of the barrier wall. Ambient air is monitored to determine the potential influence of the ozone groundwater treatment system on ambient air.

Soil vapor concentrations have remained generally consistent at the locations downgradient of the ozone groundwater treatment system (OZSV-01, OZSV-02, and OZSV-03). A majority of the compounds detected have varied within a range of 50 micrograms per cubic meter ($\mu g/m^3$) over the sampling history. Between Q3 2012 and Q2 2013, concentrations remained consistent with historical levels. Concentrations are depicted graphically in **Appendix B**. Analytical data are provided in **Table 2-1**.

Ambient air concentrations have remained mostly consistent since the startup of the ozone groundwater treatment system. Between Q3 2012 and Q2 2013, concentrations remained consistent with historical levels. Ambient air analytical data are provided in **Table 2-2**.

2.3 Oxygen Injection Systems

2.3.1 Program Scope and Purpose

Eight oxygen injection systems are currently in operation at the site. These systems generate and inject oxygen into the subsurface to create an aerobic environment which facilitates the bioremediation of the dissolved MGP-related contaminants. Oxygen injection is used to treat impacted groundwater within OU-1, OU-2 and OU-3. The system locations are shown on **Figure 1** and presented in **Table 2e,** below.

Table 2e – Oxygen Injection System Summary

Operable Unit	Oxygen Injection System Designation	Operation Start Date	System Description
OU-1	OU-1 Union Boulevard Oxygen Injection System	February 2008	Used to treat groundwater as it passes through the perforated portion of the subsurface barrier wall. Initially installed to provide temporary treatment during the construction and startup of the ozone injection system. NYSDEC has requested that the system remain online following the installation of the ozone injection system.
	OU-1 Union Boulevard Extension	June 16, 2011	Extension of the OU-1 Union Boulevard system installed to comply with the requirement of the OU-2 Remedial Decision Document issued by the NYSDEC in 2008. The system treats impacts east of the subsurface barrier wall.
	60/66 N. Clinton Ave Oxygen Injection System	January 27, 2010	Installed as part of the Phase 4 Remedial Action to treat impacted groundwater west of the barrier wall in OU-1.
OU-2	Garner Lane (Montauk Highway and Manatuck Lane) Oxygen Injection Lines	December 28, 2005	Installed as part of an Interim Remedial Measure in OU-2 to treat groundwater prior to discharge to Lawrence Creek. The system is comprised of two injection lines located along Montauk Highway and at the intersection of Manatuck Lane and Garner Lane.
	34 N. Clinton Ave Oxygen Injection Line	January 20, 2009	Installed to comply with the requirement of the OU-2 Remedial Decision Document issued by the NYSDEC in 2008. These systems treat groundwater at three transects in the middle of OU-2.
	9 N. Clinton Ave Oxygen Injection Line	February 16, 2009	
	33 N. Clinton Ave/Cooper Lane Oxygen Injection Line	March 31, 2009 November 16, 2009	
	29 Community Road	June 14, 2011	Installed to treat the western extent of the OU-2 groundwater plume that was delineated in the 2010 Pre-Design Investigation.
	Plume Tail Oxygen Injection System	August 17, 2009	Installed to treat groundwater prior to discharging into Lawrence Creek.
OU-3	Community Road Oxygen Injection Line	April 6, 2010	Installed to replace the former Union Boulevard and Brightwaters yard systems. This treatment line is supplied by the 60/66 North Clinton Avenue oxygen injection system located within OU-1. This system was reconfigured in March 2012 to more effectively distribute oxygen to impacted areas.

2.3.2 Current Monitoring Activities

The oxygen injection system monitoring activities are summarized in **Table 2f**, below.

Table 2f – Summary of Oxygen Injection System OM&M Activity

Current Activity	Description	Frequency	Location of Results
Oxygen System Monitoring	Routine inspection and maintenance of the system components, monitoring of operational parameters, and recording/adjusting of the injection flow rates.	Monthly	Appendix D, E
	Monitoring of oxygen purity.	Monthly	Appendix D, E
Performance Monitoring of Oxygen Injection Systems	Monitoring of BTEX and total PAH concentrations in groundwater at upgradient and downgradient wells.	Quarterly	Section 4, Figure 4, Table 4-3 and 4-4
	Monitoring of groundwater chemistry parameters.	Monthly	Appendix F

2.3.3 Oxygen Injection System OM&M Data

2.3.3.1 System Operational Data

Approximately 573,562 pounds of oxygen were injected into OU-1, OU-2, and OU-3 from Q3 2012 through Q2 2013. All of the oxygen injection systems experienced some downtime during the past four quarters. The oxygen systems went down mainly due to power loss during Hurricane Sandy and mechanical issues. Injected oxygen weights are calculated in **Appendix D** for OU-1 and OU-3 systems. Oxygen weights for OU-2 systems are calculated in **Appendix E**. Injected oxygen weight and system operational data are summarized in **Table 2g**, below.

Table 2g – Oxygen Injection Systems Operations Data

Operable Unit	Oxygen Injection System/Treatment Line	System Operational Time	Weight of Oxygen Injected (pounds)				Total Weight of Oxygen Injected Through Q2 2013 (Pounds)
			Q3 12	Q4 12	Q1 13	Q2 13	
OU-1	OU-1 Union Boulevard and Extension	93%	18,612	16,971	14,944	15,888	287,372
	60/66 N. Clinton (O_2 to OU-1)	88%	7,740	8,001	9,366	8,551	113,829
OU-2	Garner Lane	94%	27,582	17,269	18,583	24,965	737,513
	9 N. Clinton	98%	16,094	16,588	16,120	16,785	260,121
	34 N. Clinton	96%	18,514	15,645	20,832	17,621	318,437
OU-2	33 N. Clinton/Cooper Lane	94%	26,630	23,952	20,296	21,062	363,453
	Plume Tail	83%	9,120	2,763	10,019	8,370	109,891
	29 Community Road	96%	11,026	9,663	13,963	12,574	105,728
OU-3	Community Road (60/66 N. Clinton [O_2 to OU-3])	88%	15,275	19,521	22,257	20,400	174,731

2.3.3.2 Groundwater Parameters

The oxygen injection systems have significantly increased both Dissolved Oxygen (DO) concentrations and Oxidation Reduction Potential (ORP) in groundwater. Concentrations of DO are summarized in **Table 2h**. **Table 2i** summarizes ORP values. **Appendix F** contains historical groundwater parameters including DO, ORP, pH, conductivity, and temperature for site wells.

Table 2h – Summary of Dissolved Oxygen (DO) Concentrations

Operable Unit	Groundwater Interval	DO Concentrations (mg/L)			Downgradient Monitoring Wells
		Baseline Average	Historical Average	Q3 12 - Q2 13 Average	
OU-1	Shallow (0-10')	12.5	20.2	22.3	OZMW-16, OZMW-17, OZMW-18, OU2MW-50, OU2MW-57
	Intermediate (10-50')	7.0	10.1	10.5	
	Deep (50'+)	0.1	1.4	0.6	
OU-2	Shallow (0-10')	5.4	20.5	26.4	OU2MW-02, OU2MW-19, OU2MW-30, OU2MW-39, OU2MW-47, OU2MW-55
	Intermediate (10-50')	3.0	20.2	24.5	
	Deep (50'+)	5.0	14.9	15.9	
OU-3	Shallow (0-10')	10.1	4.5	9.2	OU3MW-02, 03, 04, 05, 07, IO-10, MW-34, MW-46WR, MW-70/70S
	Intermediate (10-50')	2.4	7.4	13.4	

Notes:
mg/L - milligrams per liter
'- feet

Table 2i – Summary of Oxidation Reduction Potential (ORP) Values

Operable Unit	Groundwater Interval	ORP Values (mV)			Downgradient Monitoring Wells
		Baseline Average	Historical Average	Q3 12 - Q2 13 Average	
OU-1	Shallow (0-10')	29	100	139	OZMW-16, OZMW-17, OZMW-18, OU2MW-50, OU2MW-57
	Intermediate (10-50')	63	122	151	
	Deep (50'+)	0	40	29	
OU-2	Shallow (0-10')	51	190	223	OU2MW-02, OU2MW-19, OU2MW-30, OU2MW-39, OU2MW-47, OU2MW-55
	Intermediate (10-50')	3	148	150	
	Deep (50'+)	50	148	176	
OU-3	Shallow (0-10')	-9	-16	23	OU3MW-02, 03, 04, 05, 07, IO-10, MW-34, MW-46WR, MW-70/70S
	Intermediate (10-50')	32	69	146	

Notes:
mV - millivolt
'- feet

Specific trends in DO and OPR values are presented below:

- DO concentrations and ORP values in OU-1 increased significantly from baseline values collected prior to system startup and remained elevated in the past four quarters.
- In OU-2, DO concentrations and ORP values increased significantly from baseline values collected prior to system startup and have remained elevated over the past four quarters. The baseline values for OU-2 showed measurable levels of DO. This is because actual baseline values did not exist for some wells that were installed after system startup or affected by an upgradient system.

- DO concentrations in OU-3 as a whole have continued to rebound during the past four quarters. Significant increases have been observed in monitoring well clusters OU3MW-02 and OU3MW-07 and monitoring wells IO-10 and MW-34I. National Grid reconfigured the OU-3 Community Road treatment line in Q1 2012 to direct more oxygen to the more impacted zones within OU-3. This has contributed to increase in DO concentrations.
- In OU-3, ORP values in shallow and intermediate groundwater have increased between Q3 2012 and Q2 2013. National Grid reconfigured the OU-3 Community Road treatment line in Q1 2012 to direct more oxygen to the more impacted zones within OU-3. This has contributed to the increase in ORP values.

2.3.3.3 BTEX and Total PAH Concentrations

Significant reductions in BTEX and total PAH concentrations have been observed since the startup of the oxygen injection systems. This is discussed in detail in Section 4. Reductions of BTEX and total PAH concentrations compared to DO concentrations at monitoring wells downgradient of each treatment area are depicted on **Figure 4**.

3. Groundwater Flow

This section presents a summary of the scope of work performed for the groundwater elevation monitoring program, the hydrogeologic setting, and the resultant groundwater elevation and groundwater flow direction data for each of the site's OUs.

3.1 Scope of Groundwater Level Monitoring Program

Groundwater level monitoring is conducted annually at the individual site OUs (OU-1, OU-2, OU-3 and OU-4) and offsite to determine the groundwater elevations and resultant groundwater flow regimes at these areas. This information aids in monitoring and evaluating the effectiveness of remedial activities and is used in remedy planning. The groundwater well locations and geographic boundaries of the OUs are depicted on **Figure 1**.

Depth to groundwater measurements were collected from a total of 360 wells, and five surface water measurements from gauging stations in Q2 2013. The distribution of these wells for each of the operable units consisted of 79, 142, 73 and 66 monitoring wells from within and in the vicinity of OU-1, OU-2, OU-3 and OU-4, respectively. The surface water elevations were obtained from surface water gauges located within OU-2 in Lawrence Lake (BBSW-07) and Lawrence Creek (OU2SW-01 and BBSW-06), in OU-3 from a surface water gauge located within the headwaters of O-Co-Nee Pond (BBSW-13), and in OU-4 from a surface water gauge located in Watchogue Creek (a.k.a., Crum's Brook) at Union Boulevard (BBSW-14). The depth to groundwater and surface water elevation measurements were collected from April 1 through April 4, 2013.

The depth to groundwater and groundwater elevation data for the site and offsite areas are provided in **Tables 3-1** through **3-8** and on **Figures 5** through **7**. The elevation data presented in the tables and figures is in reference to the North American Vertical Datum (NAVD) 88 datum. All historical groundwater elevation data, collected prior to November 2007, has been recalculated based on the November 2007, or subsequent survey data, and the NAVD 88 datum.

3.2 Hydrogeologic Setting

The Upper Glacial, Magothy and Lloyd represent Long Island's three major aquifers. The Upper Glacial aquifer is a water table aquifer and is the primary aquifer of concern at the site. The Upper Glacial aquifer occurs in moderate to highly permeable glacial outwash deposits consisting mainly of inter-bedded layers of permeable sand and gravel, and less permeable layers of silty sand. Low permeability zones define the boundary between the Upper Glacial and Magothy aquifers in the vicinity of the site. The Upper Glacial aquifer is approximately 70 feet at the site and the water table is present within the upper 10 feet of the aquifer. The Upper Glacial aquifer is not used as a source of potable water at or downgradient of the site.

3.3 Groundwater Elevation and Flow

As depicted on **Figures 5** through **7,** the groundwater flow direction throughout the site is generally towards the south/southeast. The data provided on **Figures 6** and **7** indicate that the shallow and deep groundwater elevations and groundwater flow directions are generally similar.

Figure 8 includes hydrographs depicting the historical groundwater elevations for the period beginning in Q2 2002 through the current monitoring period (Q2 2013). The groundwater elevations are presented for select site wide shallow, intermediate, and deep wells. Minimum and maximum historical values are summarized in the table below.

Table 3a – Summary of Historical Groundwater Elevations

Groundwater Depth Zone	Minimum Water Level Elevation			Maximum Water Level Elevation		
	Value	Monitoring Well	Date	Value	Monitoring Well	Date
Shallow	9.41	BBMW-24S	Q3 2007	18.00	MW-09S	Q2 2010
Intermediate	9.44	BBMW-24I	Q3 2007	18.02	MW-09I	Q2 2010
Deep	9.44	BBMW-24D	Q3 2007	16.40	BBMW-05D	Q2 2010

The hydrographs show regular seasonal variations in groundwater elevation throughout all screen intervals. Q2 2013 values are near the average values for the historical monitoring period, and are generally higher than the values for Q2 2011 and Q2 2012.

4. Groundwater Quality

As noted in Section 1.0, reductions to the long term groundwater monitoring program were approved by the NYSDEC. Implementation of the reduction program began in Fourth Quarter (Q4) 2012.

In general, the OU-1/OU-2 and OU-3 areas of MGP-impacted groundwater (concentrations of BTEX and total PAH equal to or greater than 100 micrograms per liter [µg/L]) have significantly been reduced in size and concentration since the implementation of remedial activities. These reductions have been occurring since the installation of the barrier wall, source area excavations, and the operation of the ozone and oxygen injection treatment systems. Following the startup of the remedial systems in 2009, the depiction of BTEX and total PAH impacts in groundwater on **Figures 9** through **14** have been significantly refined, particularly in OU-1 and OU-3, with the installation and sampling of new groundwater monitoring well clusters. Several areas, where elevated concentrations have persisted, are currently being addressed by the installation of additional oxygen injection systems, or the modification of current systems to focus treatment on the zones with residual impacts.

The IRMs conducted in OU-3 included the LIRR Excavation/Temporary Track Relocation IRM (Phases 1 and 2) and the LIRR Excavation IRM, Phase 3 (Brightwaters Yard), and supplemental remedial efforts as summarized in Section 1 of this report. It is expected that these remedial activities will result in continued decreasing constituent trends in groundwater throughout the impacted areas of OU-3. Although BTEX and total PAH concentrations continue to vary, the majority of the monitoring wells within the excavation area of the Brightwaters Yard and in the area immediately south of the LIRR tracks have decreasing concentrations, or have remained at or near, detection levels. Decreasing concentrations in intermediate monitoring wells in the area have become evident within the past year. However, elevated concentrations, particularly of BTEX, remain in the area immediately downgradient of the excavation IRM in shallow and intermediate wells. In order to address the residual impacts in the area immediately south of the LIRR track, an additional oxygen injection system is currently being installed with start-up planned for late Q3 or early Q4 2013.

In the downgradient portion of OU-3 (south of Union Boulevard), decreasing trends of BTEX and total PAHs in shallow and intermediate groundwater are evident (**Figures 9 through 12)**. Shallow BTEX and total PAH impacts above 100 µg/L are no longer present in the area downgradient of Union Boulevard. Intermediate impacts have also been reduced, but some still remain.

In order to address the downgradient impacts in OU-3, a groundwater investigation targeting shallow and intermediate zone impacts was conducted during early Q2 2013. Groundwater samples were collected from three 4-foot intervals extending from the water table to approximately 30 feet bgs, along several transects to better define the impacts in the area.

Following the groundwater investigations, a targeted ORC-A injection program was conducted to treat the identified impacts. Approximately 100 pounds of ORC-A was injected at 21 points located along four transects from 30 feet bgs to 10 feet bgs. Several new monitoring wells were installed in the area to monitor the groundwater quality and evaluate the effectiveness of the ORC-A injection program. Initial concentrations in two of these wells were above 100 µg/L; however, impacts were reduced below 100 µg/L in subsequent sampling events.

The reductions in these wells can likely be directly attributed to the effectiveness of the ORC-A injection program. A second round of injections targeted to treat lingering impacts, including those identified in area upgradient of the initial injection area was conducted during Q3 2013. It is anticipated that the injection program along with the installation of a new oxygen injection system upgradient and the continued operation of the reconfigured Community Road oxygen injection line will reduce impacts in this area in future sampling events.

The area of impacted groundwater in OU-4 during Q2 2013 has increased slightly since the completion of S-ISCO injection, which was initiated in Q2 2009 and completed in Q4 2009. Pre-injection conditions are depicted in the Q1 2009 plume, which is smaller than the current Q2 2013 plume (**Figure 1**). The majority of the OU-4 Excavation IRM consisted of shallow soil excavation (approximately 10 feet bgs) and was performed in Q2 and Q3 2011. The excavations were performed “in the wet” (no dewatering). Temporary increases in groundwater concentrations have typically been observed in other areas of the site following similar source material excavations, as was the case in OU-4. Decreasing concentration trends are now evident in the shallow and intermediate zones in recent sampling events. No impacts have been present in the deep zone.

In the sections below, descriptions are provided for Q2 2013 BTEX and total PAH groundwater impacts, as well as for the composite plumes for each of the OUs. The Q2 2013 plume is also compared to the Q2 2012 plume and the remedial baseline Q1 2009 plume for BTEX and total PAH for each of three groundwater horizons. The second quarter data set is chosen for comparison since the annual sampling round is conducted during that period each year. The annual sampling round consists of the largest number of wells and therefore, the most complete data set. These groundwater horizons include shallow (water table zone to approximately 10 feet bgs), intermediate (approximately 10 to 50 feet bgs), and deep (below approximately 50 feet bgs). In addition, any significant changes or impacts noted during the reduced sampling rounds conducted between the last complete sampling round (Q2 2012) and the current annual sampling round (Q2 2013) are discussed.

The data presented by the Q1 2009 iso-concentration lines in the plume iso-concentration maps in **Figures 9** through **14** (described below) represent the first full round of groundwater results of the current monitoring well network installed as part of the OU-2 Remedial Design. The Q1 2009 data represents the groundwater conditions prior to the start of the groundwater treatment systems in the mid-plume area. The oxygen injection lines located at 9 North Clinton Avenue, 33 North Clinton Avenue, and 34 North Clinton Avenue were started following Q1 2009. In addition, the OU-4 Cesspool Area S-ISCO IRM was initiated in Q2 2009. Therefore, this data set represents baseline conditions within OU-2 and OU-4 groundwater prior to treatment. As such, the Q1 2009 plume, throughout the remainder of this report, is referred to as the Baseline Q1 2009 Plume.

4.1 Groundwater Horizon Descriptions and Comparisons

The distribution of BTEX and total PAH concentrations within the Upper Glacial aquifer for Q2 2012 and Q2 2013 are presented in the iso-concentration maps on **Figures 9** through **14**. The iso-concentration figures for the sampling events conducted between the final quarterly GM and OM&M report (Q2 2012) and the first annual report (Q2 2013) are provided in **Appendix G**. As discussed in Section 1 of this report, reductions to the long term groundwater monitoring program were approved by NYSDEC in August 2012. As part of the approved reductions, criteria were established to reduce sampling frequency and eliminate monitoring wells from the program provided they meet the approved criteria. Monitoring wells which were not sampled due to implementation of the reduction criteria, having been below ambient groundwater quality standards (or below detection limits for compounds whose standards are below the detection limits) for four consecutive quarterly sampling events or two consecutive annual sampling events, were assumed to be non-detect for generation of the iso-concentrations figures.

The horizontal distribution of the constituent groups in each iso-concentration figure is depicted as lines of equal concentration (iso-concentration lines). The iso-concentration lines were generated using a combination of applied methods. Initially, the lines were created by direct graphical interpolation between concentrations. These lines were then modified to factor in groundwater flow, taking into account the southeasterly flow direction and the low transverse dispersion of the Upper Glacial aquifer, as well as other local hydraulic factors that might influence groundwater flow. For areas where the groundwater monitoring well density was low historically, water quality from existing wells and groundwater quality data from previous groundwater probes, as appropriate, were used. For the purpose of this report, the lateral extent of groundwater impacts (plume outline) in each groundwater horizon for BTEX and total PAH is defined by the 100 µg/L contour.

Beginning in Q3 2009 and continuing through Q3 2012 when monthly sampling was discontinued in OU-1, the concentrations used for the iso-concentration maps referenced below are the latest concentrations recorded (for wells that are sampled on multiple occasions) within the reporting quarter for each respective well (excluding OU-3). Monthly samples are currently collected from multiple wells within OU-3 and analyzed for BTEX only. The full round of quarterly samples for OU-3, which currently include analysis for BTEX and PAHs, are typically collected in the first month of the quarter. The BTEX results from the full round of quarterly samples for OU-3 are presented on the summary tables and figures. The other monthly BTEX groundwater data is included in the complete analytical tables for OU-3 (**Tables 4-11** through **4-13**).

In addition to the comparisons made between the iso-concentration maps, a comparison of concentration ranges and averages between the Baseline Q1 2009 Plume, the Q2 2012 plume and the current Q2 2013 plume is provided, where appropriate, for the impacted areas within each OU. For OU-1, the concentration comparison was conducted for the entire operable unit, as well as specifically for the wells located downgradient, or within the immediate vicinity, of the groundwater treatment systems located at the downgradient edge of the area. The downgradient wells serve to evaluate the effects of the groundwater treatment systems. Monitoring wells located on the eastern side of the upgradient area of OU-3 were not included in the concentration comparison, as the concentrations in these wells are typically low or non-detect and are not related to the impacts emanating from the central portion of OU-3.

Sulfate concentration data, as requested in a letter to NYSDEC titled “Revised – Additional Sampling Parameters for Quarterly Groundwater Monitoring – Sulfate Analysis in Select Monitoring Wells,” dated June 4, 2010, is presented in **Appendix I**. The additional sulfate analysis began in Q2 2010 and was initially planned to continue for a period of one year, ending in Q1 2011. The results of the initial investigation concluded that elevated sulfate concentrations in select monitoring wells exceeded the New York State Ambient Water Quality Standards (NYS AWQS) and Guidance Value for GA groundwater criteria. Based on these results, sulfate sampling has continued at monitoring wells that exceed the NYS AWQS criteria for GA groundwater, as well as at additional monitoring wells located downgradient of the monitoring wells with exceedances. Along with the approved reductions to the long term groundwater monitoring program, the frequency of sulfate sampling was reduced to annual. An evaluation of sulfate concentrations is provided in Section 4.4.

Routine monitoring well maintenance is conducted on a quarterly basis at the site. The groundwater sampling crews make any simple repairs identified during groundwater monitoring activities, while major repairs are performed by subcontractors on an as-needed basis.

4.2 Operable Unit 1/Operable Unit 2

The groundwater plume designated as OU-2 and the source area of the plume, OU-1, are presented and evaluated together in this section, because of their dependent relationship. The remedial actions, IRMs and pilot studies that have been performed in OU-1 and OU-2 are outlined in Section 1 of this report.

4.2.1 BTEX and Total PAH Composite Plume Comparison

Figure 1 includes the Q2 2013 outline of BTEX and total PAH impacted groundwater. This composite outline denotes the horizontal extent of BTEX and total PAH from the three groundwater horizons. Also included on **Figure 1** for comparison are the outlines of the historical 2004 remedial investigation (RI) plume and the Baseline Q1 2009 Plume.

The composite Q2 2013 plume is comprised of primarily of two areas, which have been divided and reduced in area from the single larger historical RI plume. These two areas are located in the central portion of the plume. Two additional very localized areas exist further downgradient and are defined by concentrations in a single well each. The main area of impacts begins in the upgradient portion of OU-1, and continues downgradient into the mid-plume area of OU-2. The second of the two larger impacted areas is present on the eastern side of the mid-plume area.

In comparison to the Baseline Q1 2009 Plume, the current composite Q2 2013 plume is significantly smaller in size (**Figure 1**). Significant changes to the overall outline of the composite plume from the pre-remediation depiction are summarized as follows:

- The plume is better defined throughout, particularly in OU-1, as a result of additional monitoring well installations.
- The Q2 2013 composite plume has been fragmented and is no longer continuous from OU-1 downgradient to the Manatuck Lane oxygen injection line.
- The plume has largely been eliminated in the downgradient areas.

The composite Q2 2012 plume is roughly similar in size as the corresponding Q2 2013 depiction (**Figure 1**), but is configured differently. The impacts in the upgradient to mid-plume areas are larger in Q2 2013, but the downgradient impacted areas are considerably smaller than those during Q2 2012.

4.2.2 Groundwater Quality Horizons and Comparisons

A description of the individual depth horizons for BTEX and total PAH, and comparisons between the baseline plume, the Q2 2012 plume and the current Q2 2013 plume are provided below. Historical BTEX and total PAH concentrations detected in each of the wells are presented in **Table 4-1** and **Table 4-2** for OU-1 and **Tables 4-4** through **Table 4-9** for OU-2. The complete analytical results for Q3 2012 through Q2 2013 for OU-1 are presented in **Table 4-3**. The complete analytical results for Q3 2012 through Q2 2013 for OU-2 are presented in **Table 4-10**.

4.2.2.1 Shallow Zone

In OU-1/OU-2, the highest concentrations of BTEX are generally present in the shallow portion of the aquifer. Total PAH concentrations in shallow groundwater in OU-1/OU-2 are generally lower than the corresponding BTEX concentrations. As shown in the water table iso-concentration map (**Figures 9 and 10**), these impacts mainly are present in the eastern and south-central portions of OU-1.

There are currently two shallow areas of BTEX and two shallow areas total PAH impacted groundwater in OU-1, including a section upgradient of the central portion of the barrier wall, and a section to the east of the barrier wall. BTEX impacts from the central section extend westward beyond the western edge of the wall and into OU-2, while the total PAH impacts are contained within the barrier wall on the western side. Impacts located east of the barrier wall or the capture zone of the barrier wall do, not currently extend beyond the operable unit boundary.

Impacted groundwater inside the barrier wall capture zone is treated by the ozone injection system before passing through the perforated section of the barrier wall. Groundwater is then treated immediately downgradient of the barrier wall by the Union Boulevard oxygen injection system. Neither BTEX nor total PAHs were detected in shallow monitoring wells located immediately downgradient of the ozone injection system and the perforated section of the barrier wall.

Shallow BTEX and total PAH concentrations to the east of the barrier wall and outside the capture zone, particularly in monitoring wells BBMW-39S and BBMW-40S, have varied, but generally remain elevated. Total PAH concentrations in BBMW-39S have been particularly varied, ranging from a high of 2,674 µg/L (Q1 2013) and to 34 µg/L during Q2 2013. BTEX and total PAH concentrations in BBMW-40S have increased in recent sampling events. The installation of an additional oxygen injection system, the OU-1 North oxygen injection line (see **Figure 2**) located to the north of the LIRR tracks, is currently being installed to treat the impacts identified in this area. Downgradient of this area in OU-1, the eastern edge of the plume has been further defined with the installation of new monitoring wells BBMW-42S and BBMW-43S in Q1 2013. Impacts remaining downgradient of the OU-1 North oxygen injection line will be treated by the Union Boulevard oxygen injection system as they migrate downgradient.

Within the plume section located generally upgradient of the central portion of the barrier wall, all of the monitoring wells with concentrations above 100 µg/L were located within the capture zone of the barrier wall excluding one well, BBMW-41S. BTEX and total PAH concentrations in BBMW-41S have generally increased in recent sampling events, typically remaining above 5,000 µg/L (BTEX) and 1,000 µg/L (total PAH). The depiction of the plume to the west of the capture zone of the barrier wall is determined by the concentration in monitoring well BBMW-41S, as well as downgradient well OZMW-22SR, as discussed below.

Detections of BTEX located farther downgradient and to the west of the barrier wall, specifically in monitoring well OZMW-22SR, have been somewhat varied in recent sampling events. BTEX concentrations in this well have generally been above 100 µg/L, as they were during Q2 2013, but remain well below the historical average. BTEX concentrations in monitoring well OU2MW-57S located downgradient of OZMW-22SR and the 60/66 North Clinton Avenue oxygen injection line, have remained below 100 µg/L for the past six sampling events. Total PAH concentrations in these wells have been below 100 µg/L over the past five sampling events excluding one detection in OZMW-22SR during Q3 2012.

Farther downgradient, BTEX concentrations in BBMW-23S, have remained elevated and increased during Q2 2013, but remain significantly below the historical average. The total PAH detection in BBMW-23S increased slightly during Q2 2013, but has remained relatively stable over the past nine sampling events. These impacts do not persist past the downgradient Cooper Lane oxygen injection system. Similar to recent sampling events, the detections of BTEX and total PAH in BBMW-23S were the only shallow detections above 100 µg/L in OU-2 during Q3 2012. Additional oxygen injection wells in the shallow zone as part of the Union Boulevard oxygen injection line are currently being installed to address lingering impacts in this area.

A summary of the two areas of impacted shallow groundwater in OU-1 during Q2 2013 is provided in the table below.

Table 4a – Summary of Q2 2013 Shallow Impacted Groundwater Areas in OU-1/OU-2

Impacted Groundwater Area		Maximum Concentration (µg/L)	No. of wells > 100 µg/L	Approximate Length (feet)	Average Width (feet)	Remedial System in Area
Eastern	BTEX	3,528	3	550	125	Union Boulevard Extension Oxygen Injection System*
	Total PAH	2,654	3	500	100	
Central/Western**	BTEX	8,730	9	900	200	Ozone Injection System, Union Boulevard Oxygen Injection System and 60/66 North Clinton Avenue Oxygen Injection System
	Total PAH	3,151	6	625	175	

Notes:
*: Additional oxygen injection system planned to treat upgradient impacts (OU-1 North)
**: Includes portion in OU-2

Differences for shallow impacted groundwater from Q1 2009 and Q2 2013 (**Figures 9 and 10**) are summarized as follows:

- Concentrations of BTEX and total PAHs have generally decreased throughout OU-1, with the decreases particularly evident in the area downgradient, or in the immediate vicinity of, the groundwater treatment systems present near the downgradient edge of OU-1.
- The shallow groundwater plume has largely been eliminated in OU-2, with only one detection currently above 100 µg/L.
- A section of the shallow plume is present in Q2 2013 to the east of the barrier wall, defined by concentrations in wells installed subsequent to the Baseline Q1 2009 sampling event.

A summary of the concentrations in OU-1/OU-2 between Q1 2009, Q2 2012, and Q3 2012 is provided in the tables below.

Table 4b – Comparison of BTEX Concentrations in Shallow Groundwater

Operable Unit	Shallow Zone BTEX Concentrations (µg/L)					
	Range			Average		
	Baseline Q1 2009	Q2 2012	Q2 2013	Baseline Q1 2009	Q2 2012	Q2 2013
OU-1 (Overall)	0 – 11,947	0 – 7,586	0 - 8,730	3,270	991	1,203
OU-1 (Downgradient)*	0 – 244	0	0	96	0	0
OU-2	0 – 11,860	0 – 3,718	0 - 5,214	304	65	91

Table 4c – Comparison of Total PAH Concentrations in Shallow Groundwater

Operable Unit	Shallow Zone Total PAH Concentrations (µg/L)					
	Range			Average		
	Baseline Q1 2009	Q2 2012	Q2 2013	Baseline Q1 2009	Q2 2012	Q2 2013
OU-1 (Overall)	0 – 1,850	0 – 4,167	0 - 3,151	457	430	506
OU-1 (Downgradient)*	0	0 - 1	0	0	1	0
OU-2	0 – 1,673	0 – 437	0 - 525	55	8	9

Note:

*: OU-1 downgradient wells include OZMW-16S, OZMW-17S and OZMW-18S.

Significant changes in shallow BTEX or PAH concentrations within the last year (since Q2 2012) are limited to increases outside the eastern edge of the capture zone of the barrier wall in OU-1. As mentioned above, lingering impacts in the area will be treated by the installation of the OU-1 North oxygen injection line, located to the north of the LIRR tracks. Installation is currently underway.

4.2.2.2 Intermediate Zone

Remedial activities, including operation of the oxygen injection systems, have divided and greatly reduced the BTEX and total PAH plumes in the intermediate zone of the aquifer into five and six areas, respectively. These areas, while not continuous, extend from OU-1 to the area downgradient of the Montauk Highway oxygen injection line (**Figures 11 and 12**).

Similar to the shallow zone, the intermediate plume in OU-1 is divided into two areas, a central area behind the barrier wall, and an area located outside the eastern edge of the barrier wall or the capture zone of the barrier wall. The central section of the plume begins in the central portion of OU-1 and extends downgradient, ending roughly at the barrier wall. Detections of BTEX and total PAHs above 100 µg/L in intermediate wells located immediately downgradient of the ozone injection system or the perforated section of the subsurface barrier wall were limited to two of the 10 monitoring wells (OZMW-16I2, and OZMW-24I2).

The impacted areas located to the east of the barrier wall or capture zone of the barrier wall, begin in the vicinity of the LIRR tracks and extend into OU-2, ending approximately 100 and 200 feet south of the OU-1/OU-2 boundary for BTEX and total PAH, respectively. Impacts in the eastern upgradient area have generally been low, but variable. Impacts near the downgradient edge of the plume in this area at monitoring well OZMW-16I2, have been varied, but generally remain elevated. Prior to the installation of the Union Boulevard oxygen injection system extension, the downgradient section of the plume had been continuous approximately to the 33 North Clinton Avenue oxygen injection line.

A summary of the Q2 2013 intermediate impacted areas in and emanating from OU-1 is provided below.

Table 4d – Summary of Q2 2013 Intermediate Impacted Groundwater Areas in OU-1

Impacted Groundwater Area		Maximum Concentration (µg/L)	No. of wells > 100 µg/L	Approximate Length (feet)	Average Width (feet)	Remedial System in Area
Eastern*	BTEX	778	8	450	125	Union Boulevard Extension and 33 North Clinton Avenue Oxygen Injection Systems**
	Total PAH	3,396	7	475	125	
Central	BTEX	1,081	6	425	125	Ozone Injection System and Union Boulevard Oxygen Injection System
	Total PAH	5,955	12	575	175	

Notes:
*: Includes portion extending into OU-2
**: Additional oxygen injection system planned to treat upgradient impacts (OU-1 North)

In OU-2, two areas of impacts for BTEX and total PAH are present downgradient of the 33 North Clinton oxygen injection line. The impacts present in this area are divided, with one located immediately downgradient of the oxygen injection line, consisting of one impacted monitoring well, and another located slightly farther downgradient. The downgradient section is defined by three wells and two wells for BTEX and total PAH, respectively, two of which are common to each area. Each of the impacted wells in the area are deeper intermediate wells screened from 45 to 50 feet bgs. Maximum concentrations in the area during Q2 2013 were 347 µg/L (BTEX) and 1,610 µg/L (total PAH) at monitoring well OU2MW-24I2. Impacts in this area have shifted slightly between the different well clusters in the area historically, but have persisted in the general area. In order to address lingering impacts to this zone, the oxygen injection system in the area is being modified with additional wells being installed to target the residual impacts in this zone. The installation is scheduled for late Q3 2013 with start-up in early Q4 2013.

BTEX impacts are present downgradient of the barrier wall as defined by the concentration in one well, BBMW-23I. The Q3 2013 BTEX concentration in this well (100 µg/L) is only the second detection at, or above 100 µg/L in this well during the historical monitoring period.

Other total PAH impacted areas in the intermediate zone of OU-2 include one in the upgradient area of OU-2, beginning downgradient of the barrier wall and extending roughly to the Cooper Lane and 33 North Clinton oxygen injection lines and one in the downgradient area of OU-2. Total PAH impacts in the upgradient area of OU-2 have been present historically; however, the extent of impacts in the area has not been as widespread since Q1 2011. Total PAH impacts in the downgradient area of OU-2 are defined by the concentration in one well, OU2MW-04I (102 µg/L), located downgradient of the Montauk Highway oxygen injection line. Historically, this section of the plume was much larger in extent and was characterized by higher concentrations. Decreasing trends for historically impacted monitoring wells in the area have been evident in recent sampling events.

A summary of the Q2 2013 intermediate zone impacted areas in OU-2 are provided below.

Table 4e – Summary of Q2 2013 Intermediate BTEX Impacted Groundwater Areas in OU-2

Impacted Groundwater Areas		Maximum Concentration (µg/L)	No. of Wells > 100 µg/L	Approximate Length (feet)	Average Width (feet)	Remedial System in Area
Upgradient	BTEX	100	1	100	75	Cooper Lane Oxygen Injection System
	Total PAH	1,349	3	375	200	Cooper Lane, 33 or 34 North Clinton Avenue Oxygen Injection Systems
Mid-plume (upper)	BTEX	137	1	100	75	9 North Clinton Avenue or Montauk Highway Oxygen Injection Systems
	Total PAH	853	1	175	100	
Mid-plume (lower)	BTEX	347	3	550	150	
	Total PAH	1,610	2	650	150	
Downgradient	Total PAH	102	1	100	75	Manatuck Lane Oxygen Injection Line

Differences for intermediate impacted groundwater from Q1 2009 (baseline) and Q2 2013 are summarized as follows (**Figures 11 and 12**):

- The Q2 2013 plume has been greatly fragmented and is no longer continuous from OU-1 downgradient to the Manatuck Lane oxygen injection line.
- The plume has been significantly narrowed in areas where the plume still exists. This narrowing is especially evident from the mid-plume to downgradient areas of the plume where much of the historical plume area is now characterized by concentrations below 100 µg/L.
- Concentrations have generally decreased throughout the plume (see tables below). The decreases are particularly evident in the areas downgradient, or in the immediate vicinity, of the groundwater treatment systems present at the downgradient edge of OU-1 and throughout the axis of the plume in OU-2.

Table 4f – Comparison of BTEX Concentrations in Intermediate Groundwater

Operable Unit	Intermediate Zone BTEX Concentrations (µg/L)					
	Range			Average		
	Baseline Q1 2009	Q2 2012	Q2 2013	Baseline Q1 2009	Q2 2012	Q2 2013
OU-1 (Overall)	0 - 607	0 -2,302	0 - 1,081	102	209	125
OU-1 (Downgradient)*	0 - 441	0 - 553	0 -166	139	119	28
OU-2	0 – 28,040	0 - 919	0 - 347	637	17	11

Table 4g – Comparison of Total PAH Concentrations in Intermediate Groundwater

Operable Unit	Intermediate Zone Total PAH Concentrations (µg/L)					
	Range			Average		
	Baseline Q1 2009	Q2 2012	Q2 2013	Baseline Q1 2009	Q2 2012	Q2 2013
OU-1 (Overall)	7,728	7,755	5,955	895	1,128	746
OU-1 (Downgradient)*	7,728	1,973	1,330	1,316	371	225
OU-2	7,147	1312	1,610	877	62	54

Note:
*: OU-1 downgradient wells include OZMW-16I, OZMW-16I2, OZMW-17I, OZMW-17I2, OZMW-18I and OZMW-18I2.

Significant changes in intermediate impacts within the last year (since Q2 2012) include an increase in the total PAH impacted area downgradient of the barrier wall and the reduction of impacts in the downgradient area of the plume. Significant variations in total PAH concentrations have historically occurred in monitoring well OZMW-18I2, located just downgradient of the barrier wall. However, these impacts, when present, have generally been confined to OZMW-18I2 since Q1 2011. Increases in additional wells in the area have been evident since that time. Concentrations in this area will be monitored to determine if additional remedial action is warranted. In the downgradient area of OU-2 significant reductions in total PAH concentrations and extent have occurred within the last year.

BTEX and total PAH concentrations in the area downgradient of the 33 North Clinton oxygen system have continued to vary over the past year resulting in changes to the configuration of the plume in the area. As stated above, the oxygen injection system in the area is being modified with additional wells being installed to target the lingering impacts in the area. The installation is planned for late Q3 2013 or early Q4 2013.

Additional detections of note within the past year include BTEX detections above 100 µg/L located just outside the historical plume area at monitoring well cluster OU2MW-14I in Q3 2012 and Q1 2013. The BTEX detection reached a maximum of 261 µg/L in Q3 2012 before decreasing to 194 µg/L in Q1 2013 and 13 µg/L in Q2 2013. Monitoring well OU2MW-14I was not sampled during Q4 2012 due to the established reduction criteria, but was added back to the quarterly program after the elevated detection was received. Concentrations in this well will be monitored in future sampling events.

4.2.2.3 Deep Zone

In the deep groundwater (below a depth of approximately 50 feet within the Upper Glacial aquifer) of OU-1/OU-2, BTEX and total PAH impacts above 100 µg/L are primarily present in the same general areas (**Figures 13** and **14**). The total PAH impacts are larger in size and generally characterized by higher concentrations than the corresponding BTEX impacted areas. These areas include behind the barrier wall in OU-1 and in the area immediately downgradient of the barrier wall. In the area immediately downgradient of the barrier wall, BTEX impacts are divided into two separate areas, while total PAH impacts are present in one continuous section, within the same area. Total PAH concentrations above 100 µg/L are also present in a small area located immediately upgradient of the Montauk Highway oxygen injection line, as defined by the concentrations in a single well.

Historically, the concentrations in monitoring well OZMW-18D represented the only consistently elevated (above 100 µg/L) concentrations in deep monitoring wells located downgradient of the barrier wall. However, in recent sampling events, increases in total PAHs and more recently, BTEX, in monitoring well OZMW-17D are also evident. Concentrations in these wells have been variable but generally elevated (above 100 µg/L BTEX and 1,000 µg/L total PAH) in recent sampling events. Based on groundwater modeling and the elevated concentrations at this location, there appears to be a stagnation point downgradient of the barrier wall. Additional deep injection wells are currently planned for installation in this area along the Union Boulevard oxygen injection line in late Q3 or early Q4 2013 to treat these impacts.

The increases in concentration in the area immediately downgradient of the barrier wall appear to have migrated downgradient, extending the plume in the area. As mentioned above, BTEX impacts in the area are divided, while the total PAH impacts are continuous from the area downgradient of the barrier wall to the area of the Cooper Lane and 33 North Clinton Avenue oxygen injection lines. Total PAH impacts near the Cooper Lane and 33 North Clinton oxygen injection lines have been present continuously since Q1 2011, while BTEX impacts became evident in the area Q3 2012. However, both BTEX and total PAH concentrations have been increasing in recent sampling events. The additional deep injection wells being installed along the Union Boulevard oxygen injection line in late Q3 or early Q4 2013 to address past lingering impacts in the area, are anticipated to affect groundwater concentrations in this area as they migrate downgradient with groundwater flow.

The further downgradient total PAH impacted section is defined by the concentration in monitoring well OU2MW-08I2. Total PAH concentrations in this well have been decreasing significantly in recent sampling events. A summary of the Q2 2013 deep zone total impacted areas in OU-1/OU-2 are provided below.

Table 4h – Summary of Q2 2013 Deep Impacted Groundwater Areas in OU-1/OU-2

Impacted Groundwater Area		Maximum Concentration (µg/L)	No. of wells > 100 µg/L	Approximate Length (feet)	Average Width (feet)	Remedial System in Area
OU-1	BTEX	1,271	3	300	100	Ozone Injection System and Union Boulevard Oxygen Injection System
	Total PAH	4,352	4	300	150	
Upgradient OU-2	BTEX	126	2	100	100	33 North Clinton Avenue or Cooper Lane Oxygen Injection Systems
Upgradient/Mid-plume OU-2	Total PAH	2,468	5	625	175	33 North Clinton Avenue, Cooper Lane or 34 North Clinton Avenue Oxygen Injection System
Mid-plume OU-2	BTEX	1,860	3	350	200	
Downgradient	Total PAH	171	1	100	75	Montauk Highway Oxygen Injection System

Differences for deep impacted groundwater from Q1 2009 and Q2 2013 are summarized as follows (**Figures 13** and **14**):

- The plume is no longer continuous and has been largely eliminated in OU-2.
- Concentrations have generally been decreasing throughout the plume as indicated below. Exceptions include the impacted areas noted above.

Table 4i – Comparison of BTEX Concentrations in Deep Groundwater

Operable Unit	Deep Zone BTEX Concentrations (µg/L)					
	Range			Average		
	Baseline Q1 2009	Q2 2012	Q2 2013	Baseline Q1 2009	Q2 2012	Q2 2013
OU-1 (Overall)	0 - 2,314	0 - 1,702	0 - 1,271	335	164	152
OU-1 (Downgradient)*	0 - 216	0 – 201	0 - 126	72	67	76
OU-2	0 - 569	0 – 129	0 - 1,860	59	6	58

Table 4j – Comparison of Total PAH Concentrations in Deep Groundwater

Operable Unit	Deep Zone Total PAH Concentrations (µg/L)					
	Range			Average		
	Baseline Q1 2009	Q2 2012	Q2 2013	Baseline Q1 2009	Q2 2012	Q2 2013
OU-1 (Overall)	0 – 5,140	0 – 6,319	0 - 4,352	707	580	519
OU-1 (Downgradient)*	0 - 435	3 – 1,536	0 - 1,361	146	524	766
OU-2	0 – 7,007	0 – 2,330	0 - 2,468	455	62	128

Notes:
*: OU-1 downgradient wells include OZMW-16D, OZMW-17D and OZMW-18D.

Significant changes in deep impacts within the last year (since Q2 2012) are limited to increases in monitoring wells downgradient of the barrier wall and those in the area of the Cooper Lane and 33 North Clinton oxygen injection lines, as discussed above. Lingering impacts in these areas are being addressed by the installation of additional deep injection wells along the Union Boulevard oxygen injection line in late Q3 or early Q4 2013. Further downgradient, these impacts are mitigated and no longer present downgradient of the 34 North Clinton oxygen injection system.

Changes to the groundwater concentrations for BTEX and total PAH in OU-1/OU-2 described above are supported in the graphical presentations. Time series plots display the graphical analytical results and are provided for wells located downgradient of the oxygen injection systems on **Figure 4**.

4.3 Operable Unit 3

A summary of the remedial activities conducted in OU-3 is provided in Sections 1 and 2 of this report. In addition to the ongoing oxygen injection groundwater treatment system IRMs discussed in Section 2.3, the OU-3 LIRR Excavation/Temporary Track Relocation IRM (Phases 1 and 2) was initiated in Q4 2009 and completed by Q2 2010. Additionally, the LIRR

Excavation IRM, Phase 3 (Brightwaters Yard) was conducted during Q3 2010 and completed in September 2010. These excavation activities involved the removal of approximately 13,825 tons of impacted material from the Brightwaters Yard and immediately downgradient in the LIRR Right-of-Way (ROW), to depths ranging from 8 to 12 feet bgs.

Soil and groundwater investigations in the Brightwaters Yard, as well as in the area immediately south of the LIRR tracks, were conducted in December 2010, June 2011 and February 2012 to evaluate the post excavation IRM groundwater conditions. Replacement groundwater monitoring wells along with several new monitoring wells have been installed to further and more accurately define the impacts in the area.

Monitoring wells in OU-3 with elevated BTEX concentrations typically have PAH concentrations detected at significantly lower levels, therefore, BTEX concentrations can be used as an indicator of impacted groundwater and are the focus of the discussions below. The PAH data is provided in the tables, figures and appendices as referenced below. Time series graphs for BTEX and PAH concentrations are provided in **Appendix H** for shallow and intermediate groundwater monitoring wells located upgradient in the Brightwaters Yard; immediately south of the Brightwaters Yard on the 83 and 87 Community Road properties; and downgradient of the Community Road oxygen injection system. The monitoring well locations are provided on **Figure 2** and the data is provided on **Tables 4-11** and **4-12**.

The time series graphs H1 and H2 illustrate concentrations of BTEX and total PAHs in shallow groundwater monitoring wells located in the Brightwaters Yard. These graphs illustrate that BTEX and PAH concentrations have decreased significantly since completion of source area excavation in the Brightwaters Yard and generally continued to decrease. The maximum BTEX concentrations in shallow groundwater in the Brightwaters Yard prior to excavation ranged from, greater than 100,000 µg/L in 2004 to 46,000 µg/Lin 2009 immediately prior to excavation. The highest BTEX and PAH concentrations in Q2 2013 were detected in OU3MW-08S and OU3MW-16S, 165 µg/L and 219 µg/L, respectively. These wells are located on the southwest portion of the site, west of the main source excavation area. A spot excavation was performed to remove the limited impacts in this area during the 2010 excavation IRM. The BTEX concentrations in these wells continue to fluctuate but are generally decreasing. There were no detections of BTEX or PAHs in the remaining shallow groundwater monitoring wells in the Brightwaters Yard in Q2 2013.

The time series graphs H3 and H4 illustrate concentrations of BTEX and total PAHs in intermediate groundwater monitoring wells located in the Brightwaters Yard. No significant BTEX or PAH impacts were detected in intermediate groundwater in the Brightwaters Yard prior to installation of the intermediate groundwater wells following source area excavation in Q4 2010. In Q2 2013 elevated concentrations of BTEX and total PAHs are present in two intermediate wells, OU3MW-09I (2,080 µg/L) and OU3MW-10 I (580 µg/L), located immediately upgradient of the LIRR excavations. Concentrations in monitoring well OU3MW-09I, have decreased significantly since the initial concentrations detected immediately follow source excavation (from 38,700 µg/L in Q4 2010) and have generally continued to decrease.

Concentrations in OU3MW-10I, while increasing slightly recently, remain within the historical concentration range. BTEX and total PAHs in the deeper intermediate well OU3MW-09I2, screened from 35 to 40 feet bgs, have remained below 100 µg/L.

The time series graphs H5 and H6 illustrate concentrations of BTEX and total PAHs in shallow groundwater monitoring wells located on the 83 and 87 Community Road properties immediately south of the LIRR tracks and downgradient of the excavated zones. Shallow BTEX concentrations, and to a lesser degree shallow total PAH concentrations have decreased following excavation of upgradient source material, but, while generally decreasing, remain elevated and extremely variable.

The time series graphs H7 and H8 illustrate concentrations of BTEX and total PAHs in intermediate groundwater monitoring wells located on the83 and 87 Community Road properties. Increasing concentrations of BTEX and total PAHs in intermediate zone wells were observed from approximately Q3 2010 through Q3 2012, following abandonment of the Brightwaters Yard oxygen injection system; however, decreasing trends have been evident in since Q3 2012. BTEX and total PAHs in the deeper intermediate wellSV-02I2, screened from 35 to 40 feet bgs have remained below 100 µg/L and were below detection limits in recent sampling events. The most recent phase of investigation performed to evaluate the post excavation IRM groundwater conditions in the Brightwaters Yard and immediately downgradient was completed in February 2012. The results of this and earlier investigations, including additional soil and groundwater sampling data and the recommended future actions for remaining impacts, was presented in a separate Post LIRR Excavation IRM Groundwater Evaluation Report in Q2 2012. As a result of these investigations, an additional oxygen injection system was recommended for installation in the area immediately south of the LIRR tracks. System installation is currently underway with start-up scheduled for late Q3 or early Q4 2013.

Time series graphs H9 and H10 illustrate the BTEX and PAH concentrations in shallow groundwater monitoring wells in the downgradient portion of OU-3, south of Union Boulevard. These graphs illustrate decreases in concentrations from 2004 through Q1 2010 following by increasing BTEX and PAH concentrations roughly coincident with relocation of the Union Boulevard oxygen injection system and following abandonment of the Brightwaters Yard oxygen injection system and source area excavation in late 2010. These concentrations have decreased significantly in shallow and intermediate wells following optimization of the Community Road oxygen injection system in March 2012. Time series graphs H11 and H12 illustrate BTEX and PAH concentrations from Q1 2010 through Q2 2013. Shallow BTEX and total PAH impacts above 100 µg/L are no longer present in the area downgradient of Union Boulevard.

Time series graphs H13 through H20 illustrate the BTEX and PAH concentrations in the intermediate wells. These graphs have been divided into intermediate zone impacts from 15 to 25 feet bgs (H13 through H16) and deep intermediate zone impacts from 25 feet to 46 feet bgs (H17 through H20) due to the number of intermediate zone well currently located downgradient. Similar to the shallow impacts, intermediate zone groundwater impacts increased in late 2010 and started decreasing following the Community Road oxygen injection system operation in March 2012. There have been some recent increases in intermediate zone impacts in 2013.

A Geoprobe groundwater investigation targeting shallow and intermediate zone impacts was conducted in the downgradient area of OU-3 during early Q2 2013. Groundwater samples were collected from three 4-foot intervals extending from the water tale to approximately 30 feet bgs, along several transects to better define the impacts in the area. Following the groundwater investigations, a targeted Oxygen Release Compound – Advanced (ORC-A) injection program was conducted to treat the identified impacts. Approximately 100 pounds of ORC-A was injected at 21 points located along four transects from 30 feet bgs to 10 feet bgs. Several new monitoring wells were installed in the area to monitor the groundwater quality and evaluate the effectiveness of the ORC-A injection program. The new monitoring wells were sampled weekly for a period of three weeks, and were then added to the monthly sampling program. Results from two of these monitoring wells (OU3MW-17I2 and OU3MW-18I) indicated impacts above 100 µg/L in several of the initial sampling events; however, impacts were reduced below 100 µg/L in both wells in the final monthly Q2 2013 monthly sampling event (June).

The reductions in these wells can likely be directly attributed to the effectiveness of the ORC-A injection program. A second round of injections targeted to treat lingering impacts, including those identified in area upgradient of the initial injection area was conducted during Q3 2013. It is anticipated that the injection program along with the installation of a new oxygen injection system upgradient and the continued operation of the reconfigured Community Road oxygen injection line will reduce impacts in this area in future sampling events.

4.3.1 BTEX and Total PAH Composite Plume

The composite Q2 2013 plume is present in three areas. The first section begins in the southern portion of the Brightwaters Yard and continues downgradient approximately 600 feet, terminating in the area of the Community Road oxygen injection line. The plume reaches a maximum width of approximately 500 feet at the downgradient edge of the Brightwaters Yard, before narrowing in the area south of the LIRR tracks (**Figure 1**). The second and third areas are present downgradient of Union Boulevard and are defined by concentrations in two intermediate zone wells.

Significant changes to the outline of the Q2 2013 composite plume as compared to the Q1 2009 composite plume are noted as follows:

- The area of impacted groundwater in the Brightwaters Yard north of the LIRR tracks in Q2 2013 appears larger in comparison to Q1 2009. This is a result of the detected concentrations in several of the new wells installed in the area in Q4 2010 and Q2 2011, which are located farther (laterally) from the center of impacts than the wells present in the area in Q1 2009.
- The historical area of impacted groundwater has been fragmented and is currently present in three areas.

- The impacts are present in monitoring wells located farther downgradient than those during Q1 2009.

In comparison to the Q2 2012 composite plume, the impacted area has been significantly reduced. During Q2 2012, the impacts extended from the Brightwaters Yard downgradient approximately 2,400 feet, terminating in the area of Cooper Lane.

4.3.2 Comparison of Current Plume to Baseline Q1 2009 and Q2 2012 Plume

A description of the current groundwater plume configuration and a comparison of BTEX in the groundwater depth zones between Q1 2009 and Q2 2013 are provided below. Also provided is a description of any major changes in the groundwater plumes for each depth horizon since the last GM and OM&M report was issued (Q2 2012). Monitoring wells in OU-3 with elevated BTEX concentrations typically have PAH concentrations detected at significantly lower levels, therefore, BTEX concentrations can be used as an indicator of impacted groundwater and are the focus of the discussions below. Due to the remedial activity conducted in OU-3 prior to and subsequent to the Baseline Q1 2009 sampling event, comparisons to more recent data were also conducted, as appropriate. To aid in these comparisons, BTEX data from monthly sampling conducted at select wells downgradient of the excavation areas were utilized.

The BTEX and total PAH concentrations detected in the quarterly sampling round from each of the wells through Q2 2013 are presented in **Table 4-11** and **Table 4-12**. The complete analytical results for Q3 2012 through Q2 2013 are presented in **Table 4-13**.

4.3.2.1 Shallow Zone

As depicted on **Figure 9,** the shallow BTEX impacts in Q2 2013 are confined to the areas adjacent to the LIRR tracks. A description of the BTEX impacted areas in Q2 2013 in the shallow zone is provided below.

Table 4k – Summary of Q2 2013 Shallow BTEX Impacted Groundwater Areas in OU-3

Impacted Area	Maximum Concentration (µg/L)	No. of wells > 100 µg/L	Approximate Length (feet)	Average Width (feet)	Remedial Action in Area
Northern section	19,600	12	175	200	Brightwaters Yard and LIRR Excavation IRM*

Note:

*: An additional oxygen injection system is currently being installed in the area immediately south of the LIRR tracks

In comparison to the Baseline Q1 2009 Plume, which was continuous from the Brightwaters Yard to the area south of Union Boulevard, the Q2 2013 plume has been reduced in size and is no longer present in the area south of Community Road.

The BTEX concentrations within the Brightwaters Yard are significantly lower in Q2 2013 than the concentrations detected in Q1 2009 (**Table 4l**). In comparison to Q1 2009, maximum and average concentrations in the Brightwaters Yard have decreased by two orders of magnitude.

BTEX concentrations in the area immediately south of the LIRR tracks are also lower in Q2 2013 than those detected in Q1 2009 **(Table 4l**). In Q1 2009, the maximum concentration detected in shallow wells in this area was 55,200 µg/L in monitoring well MW-80. In Q2 2013 the maximum BTEX concentration detected in this area was 19,600 µg/L in monitoring well OU3MW-14S. Concentrations in OU3MW-14S have been generally decreasing since its initial sampling event in Q3 2011. BTEX concentrations in other shallow monitoring wells located immediately south of the LIRR have varied significantly in recent sampling events but are generally decreasing. The variations noted in these wells have been significant, ranging up to two orders of magnitude. The concentration variations in monitoring wells located downgradient of the excavation IRM may be seasonal, related to the fluctuation in groundwater elevation in the area. An additional oxygen injection system is currently being installed in the area to treat lingering impacts with start-up scheduled for late Q3 or early Q4 2013.

Reductions are particularly evident in the area south of the Community Road oxygen injection line (**Table 4l**). Significant decreases have occurred since Q1 2009 and specifically within the last year. There have been no BTEX detections in the shallow zone above 100 µg/L in the past two sampling events in any of the wells south of the Community Road oxygen injection line. It is noted that the concentrations recorded in the monthly sampling events were not used to calculate the concentrations in **Table 4l**.

As mentioned above, BTEX concentration fluctuations in monitoring wells, particularly those in the area south of the LIRR tracks, have varied greatly partly as a function of the seasonal fluctuation of the water table. However, as further illustrated in the comparison of the BTEX concentrations in northern and southern areas of OU-3 provided below, shallow BTEX concentrations overall appear to be decreasing, especially within the excavated areas within the northern section and in the area to the south of the Community Road oxygen injection line.

Table 4l – Comparison of BTEX Concentrations in Shallow Groundwater in OU-3

OU-3 Impacted Groundwater Areas	Shallow Zone BTEX Concentrations (µg/L)											
	Maximum						Average					
	Q1 2009	Q2 2012	Q3 2012	Q4 2012	Q1 2013	Q2 2013	Q1 2009	Q2 2012	Q3 2012	Q4 2012	Q1 2013	Q2 2013
Northern section (Brightwaters Yard)	59,210	2,260	1,321	966	1,850	219	9,733	472	240	321	745	55
Northern Section (South of LIRR)	55,200	27,800	25,300	23,100	21,500	19,600	7,457	5,112	6,324	5,825	2,878	4,361
Southern section	4,210	5,794	1,735	428	48	80	578	457	135	37	3	3

Concentrations of total PAH above 100 µg/L during Q2 2013 in the shallow zone in OU-3 are located adjacent (north and south) of the LIRR tracks (**Figure 10**). The shallow total PAH plume is present in similar areas to the corresponding BTEX plume, but has been fragmented in the northern area and is generally less expansive with lower concentrations. Concentration trends of total PAH in the shallow zone are similar to the corresponding BTEX trends described above.

4.3.2.2 Intermediate Zone

The extent of BTEX and total PAH impacts (**Figures 11** and **12**) in the intermediate zone in Q2 2013 have increased relative to the Baseline Q1 2009 Plume, when no impacts were present in the area, but have decreased significantly from the Q2 2012 plume. BTEX and total PAH detections above 100 µg/L in the intermediate zone in Q2 2013 were observed in eight and six wells, respectively, with maximum detections of 2,472 µg/L (BTEX) and 611 µg/L (total PAH) in monitoring well OU3MW-03I. However, many of these concentrations were detected in monitoring wells installed subsequent to the Baseline Q1 2009 sampling event likely contributing to the apparent increase in impacted area. Nineteen intermediate monitoring wells were sampled in Q1 2009 compared with 42 intermediate monitoring wells in Q2 2013.

During Q2 2013, there were three areas of BTEX impacted groundwater in the intermediate zone. The first begins in the southern portion of Brightwaters Yard and extends roughly to the Community Road oxygen injection line, the second and third area, which are each defined by the concentration in one well and are located adjacent to each other, are present in the area south of Union Boulevard. A summary of the BTEX impacted areas in the intermediate zone is provided in **Table 4m** below.

Table 4m – Summary of Q2 2013 Intermediate BTEX Impacted Groundwater Areas in OU-3

Impacted Area	Maximum Concentration (µg/L)	No. of wells > 100 µg/L	Approximate Length (feet)	Average Width (feet)	Remedial Action in Area
Northern	2,080	6	300	175	Brightwaters Yard and LIRR Excavation IRM*
Southern**	2,472	2	225	100	Community Road Oxygen Injection Line

Notes:
*: An additional oxygen injection system to treat lingering impacts is currently being installed in the area south of the LIRR with start-up schedule for early Q4 2013
**: Area consists of two separate sections, measurements were from the larger of the two sections

Due to the lack of intermediate zone groundwater data in OU-3 in Q1 2009, the Q2 2013 groundwater data has been compared to the Q2 2012 groundwater data to evaluate recent trends. In general, intermediate BTEX concentrations overall appear to be decreasing throughout the area in recent sampling events, especially in the areas south of the LIRR tracks (**Table 4n**).

Table 4n – Comparison of BTEX Concentrations in Intermediate Groundwater in OU-3

OU-3 Impacted Groundwater Areas	Intermediate Zone BTEX Concentrations (µg/L)											
	Maximum						Average					
	Q1 2012	Q2 2012	Q3 2012	Q4 2012	Q1 2013	Q2 2013	Q1 2012	Q2 2012	Q3 2012	Q4 2012	Q1 2013	Q2 2013
Northern section (Brightwaters Yard)	5,920	1,948	2,441	3,497	915	2,080	769	401	538	1,276	467	455
Northern Section (South of LIRR)	20,409	12,929	25,962	25,765	2,447	1,906	5,112	4,117	6,141	5,899	967	573
Southern section	12,187	4,165	3,001	1,665	115	2,472	1,356	594	289	179	10	116

BTEX concentrations in intermediate zone Brightwaters Yard monitoring wells have decreased in recent sampling events. The highest BTEX detections in the intermediate zone have been detected in monitoring well OU3MW-09I. The BTEX concentrations in OU3MW-09I have decreased from the initial concentration of 38,700 µg/L BTEX in Q4 2010 immediately following source area excavation to greater than 20,000 µg/L for all 2011 sampling events, to a minimum concentration of 915 µg/L in Q1 2013. The BTEX concentration increased in Q2 2013 to 2,080 µg/L, however, this represents a significant reduction from initial values.

BTEX concentrations in intermediate zone monitoring wells located immediately downgradient of the LIRR ROW have decreased significantly in recent sampling events. As noted in **Table 4n** above, the average concentration in monitoring wells in this area has decreased an order of magnitude over the past year. The concentrations in the deeper intermediate wells (OU3MW-09I2 and SV-02I2) installed in either the Brightwaters Yard or the area immediately downgradient of the LIRR tracks have remained below 100 µg/L.

In the area downgradient of Union Boulevard, the area and magnitude of BTEX impacts in Q2 2013 has also decreased relative to recent sampling events. During Q2 2013 impacts above 100 µg/L were identified in two wells, OU3MW-03I and OU3MW-05I. BTEX concentrations in OU3MW-03I have varied greatly in recent sampling events from a low of non-detect (Q1 2013) to a high of 2,472 µg/L in Q2 2013. BTEX concentrations in OU3MW-05I have been increasing in recent sampling events to a high of 364 µg/L in Q2 2013. These values are significantly lower than BTEX values detected Q2 2012 in MW-34I, 11,070 µg/L and OU3MW-07I3 12,187 µg/L.

As mentioned above, a groundwater investigation targeting shallow and intermediate zone impacts was conducted in the downgradient area of OU-3 during early Q2 2013. Groundwater samples were collected from three intervals extending from the water tale to approximately 30 feet bgs, along several transects to better define the impacts in the area. Following the groundwater investigations, a targeted Oxygen Release Compound – Advanced (ORC-A) injection program was conducted to treat the identified impacts. Several new monitoring wells were installed in the area to monitor the groundwater quality and evaluate the effectiveness of the ORC-A injection program. The new monitoring wells were sampled weekly for a period of three weeks, and were then added to the monthly sampling program. Results from several of these monitoring wells (OU3MW-17I2 and OU3MW-18I) indicated impacts above 100 µg/L in several of the initial sampling events; however, impacts were reduced below 100 µg/L in both wells in the final monthly Q2 2013 monthly sampling event (June).

The reductions in these wells can likely be directly attributed to the effectiveness of the ORC-A injection program. A second round of injections targeted to treat lingering impacts, including those identified in area upgradient of the initial injection area was conducted during Q3 2013. It is anticipated that the injection program along with the installation of a new oxygen injection system upgradient and the continued operation of the reconfigured Community Road oxygen injection line will reduce impacts in this area in future sampling events.

Similar to BTEX impacts in the intermediate zone, the area of total PAH impacts in the intermediate zone has increased relative to the Baseline Q1 2009 Plume when no impacts were present. Total PAH concentrations above 100 µg/L during Q2 2013 in the intermediate zone are present in similar areas to the corresponding BTEX plume, but are generally less expansive with lower concentrations (**Figure 12**). Concentrations trends of total PAH in the intermediate zone are generally similar to the corresponding BTEX trends described above.

Many of the changes described above between the Baseline Q1 2009 plume and the current Q2 2013 plume are also evident when comparing the current impacts to those of a year ago (Q2 2012). These changes primarily include the elimination of shallow impacts and the significant reduction of intermediate zone impacts in the area south of Community Road.

Changes to the groundwater concentrations for BTEX and total PAH described above are supported in the graphical presentations. The time series plots display the graphical analytical results and are provided for wells located downgradient of the oxygen injection systems on **Figure 4**.

4.4 Operable Unit 4

The injection phase of the OU-4 Cesspool Area S-ISCO IRM was initiated in Q2 2009 (April 30, 2009) and was completed in Q4 2009 (December 3, 2009). Therefore, a comparison between the Q1 2009 and Q2 2013 data, provides a useful evaluation of the effectiveness of this remedy to date. Several wells in OU-4 (WCMW-11S, I, and D, WCMW-17S, I, and I2, and WCMW-18WT, S, I and I2) were not sampled in Q1 2009, but were sampled in April 2009, prior to the initiation of S-ISCO injection. For these wells, the April 2009 pre-S-ISCO data was used in the development of the Baseline Q1 2009 iso-concentration maps. In advance of, and during the OU-4 excavation IRM, which was initiated in earlyQ2 2011, numerous wells were abandoned. As a result, many of the wells sampled in the Baseline Q1 2009 event were not sampled in Q2 2013. The monitoring well network was re-evaluated upon the completion of the remedial work, with the re-installation and sampling of several monitoring wells conducted in Q1 2012. A summary of the remedial efforts for OU-4 is provided in Sections 1 and 2 of this report.

Time series graphs for BTEX and PAH concentrations are provided in **Appendix H** for shallow and intermediate groundwater monitoring wells located within and upgradient of the Cesspool Area; and within and downgradient of the Pond Area. Groundwater data from monitoring wells with BTEX or PAH impacts greater than 100 µg/L during any sampling event, were included on the OU-4 time series graphs included in Appendix H. Time series graphs H21 through H24 illustrate the PAH concentrations in shallow and intermediate groundwater wells in the Cesspool Area and upgradient. The time series graphs generally illustrate an increase in PAH concentrations in during S-ISCO application followed by a decrease in PAH impacts after excavation was complete. The exception to the trend is shallow groundwater monitoring well WCMW-29S which was installed after S-ISCO injection was complete and is located beneath the garage currently located on the 22 Oak Street property and therefore, these impacts were not excavated. The PAH concentration is this well has fluctuated between approximately 2,400 µg/L and 1,100 µg/L.

Time series graphs H25 and H28 illustrate the PAH concentrations in shallow and intermediate groundwater wells in the Pond Area and downgradient. The time series graphs for the Pond Area also show an increase in PAH concentrations following S-ISCO application and excavation followed by a recent decrease in concentrations in most wells. The total PAH concentration was below 100 µg/L in Q2 2013 in all wells on the Pond Area with the exception of WCMW-14I. Monitoring well WCMW-14I is located on the upgradient portion of the Pond Area, south of the LIRR.

4.4.1 BTEX and Total PAH Composite Plume

In comparison to the OU-4 composite Baseline Q1 2009 Plume, which was indicative of conditions prior to S-ISCO injection, the OU-4 composite Q2 2013 plume depiction is larger in size (**Figure 1**). In Q1 2009, the area of impacted groundwater was limited to the south-central portion of the Cesspool Area, while in Q2 2013, groundwater impacts extend from the upgradient Cesspool Area to the Pond Area. The increase in areal extent of impacts, particularly in the upgradient Cesspool Area is partly attributable to wells installed subsequent to the Baseline Q1 2009 sampling round.

The area of impacts in Q2 2013 is roughly similar in size to Q2 2012; however, an area of impacts located downgradient of the Pond Area during Q2 2012 was no longer present during Q2 2013.

4.4.2 Comparison of Current Plume to Baseline Q1 2009 and Q2 2012 Plume

As depicted on **Figures 9, 11** and **13**, there were no detections of BTEX above 100 µg/L in OU-4 during Q1 2009 or Q2 2012 and only one detection during above 100 µg/L Q2 2013. As a result of the limited detections of BTEX, the evaluation of groundwater quality for OU-4 will focus on PAHs as the primary COCs for OU-4. **Figures 10** and **12** illustrate that concentrations of PAHs above 100 µg/L are present in the shallow and intermediate groundwater zones. No PAHs above 100 µg/L were detected in the deep groundwater zone (**Figure 14**). A comparison of total PAH groundwater concentrations in the shallow and intermediate zones between Q1 2009 and Q2 2013 are provided below along with data from recent sampling events (**Table 4o**). The BTEX and total PAH concentrations detected in each of the wells through Q2 2013 are presented in **Table 4-14** and **Table 4-15**. The complete analytical results for Q3 2012 through Q2 2013 are presented in **Table 4-16**. The monitoring well locations are shown on **Figure 1**.

Table 4o – Summary of Total PAH Concentrations in OU-4

Depth Zone	Total PAH Concentrations (µg/L)											
	Maximum						Average					
	Baseline Q1 2009	Q3 2011*	2012		2013		Baseline Q1 2009	Q3 2011*	2012		2013	
			Q3	Q4	Q1	Q2			Q3	Q4	Q1	Q2
Shallow	243	1,773	1,986	141	2,123	1,615	29	334	229	48	293	163
Intermediate	170	778	654	585	373	602	19	134	83	137	108	73

Note:
*: Completion of excavation activity

As depicted on **Figure 10,** the area of total PAH concentrations greater than 100 µg/L in water table wells in Q2 2013 begins in the upgradient of the Cesspool Area and extends into the central portion of the Cesspool Area.

Comparison of the total PAH distribution in water table wells in Q1 2009 to Q2 2013 is difficult due to the different wells sampled in each of the sampling rounds (total of 14 wells sampled in Q1 2009 and 17 in Q2 2013, but only eight in common). Comparison of the total PAH distribution in water table wells in Q2 2012 to Q2 2013 indicates a reduction in plume extent to the south. There were no detections of PAHs in water table wells at concentrations greater than 100 µg/L in the southern portion of the Cesspool Area or south of the LIRR tracks in Q2 2013.

Figure 12 illustrates the total PAH concentrations greater than 100 µg/L present in intermediate zone wells in Q1 2009, Q2 2012 and Q2 2013. Relative to the Baseline Q1 2009 sampling event, increases in total PAH concentrations in wells in the intermediate zone were identified in Q2 2013 (**Table 4o**); however, concentrations have decreased slightly since the completion of excavation (Q3 2011). Total PAH impacts in the intermediate zone in Q2 2013 are present in the southern portion of the Cesspool Area north of the LIRR, roughly the same area as in Q1 2009. However, in Q2 2013 the intermediate PAH impacts are larger in extent in the Cesspool Area and extend across the LIRR ROW to the Pond Area at WCMW-14I. The extent of intermediate zone PAH impacts in groundwater in Q2 2013 is similar to the extent in Q3 2013.

In general, the concentration of impacted groundwater in OU-4 had slightly increased (through Q2 2011) since the completion of S-ISCO injection, which was initiated in Q2 2009 and completed in Q4 2009. However, groundwater concentrations in the impacted area increased further in Q3 2011. It is noted that the Q3 2011 sampling event was conducted during, and immediately following the completion of the OU-4 Cesspool Area and Pond Area Excavation IRM. As observed in other portions of the site, there is a typical "lag" period between the completion of excavation and groundwater contaminant concentration reduction following source material excavation. This "lag" period is further increased by the fact that the excavations were performed "in the wet" and although the source material was removed, impacted groundwater remains within the excavation area.

The increases identified in Q3 2011 have generally been followed by slightly decreasing trends; however, concentrations continue to vary. Concentrations in water table wells are now slightly lower than both pre-excavation levels (Q1 2011) and Q3 2011 levels, which were collected during, and immediately following the completion of excavation activities. Groundwater concentrations have remained higher than pre-SISCO levels (Q1 2009) in wells outside of the extent of excavation (WCMW-29S located beneath the 22 Oak Street garage and some intermediate wells located beneath the vertical extent of excavation (WCMW-04I, WCMW-05I, WCMW-05I2 and WCMW-30I). Intermediate zone concentrations are generally higher than pre-S-ISCO levels, but are below Q3 2011 levels.

Significant changes in total PAH concentrations in the shallow or intermediate zone identified within the last year (since Q2 2012) are limited to the elimination of the impacted area (above 100 µg/L) located downgradient of the Pond Area. Impacts had been present in this area at monitoring well WCMW-13S from Q1 through Q4 2012.

4.5 Analysis of Sulfate Concentrations

At the request of the NYSDEC, National Grid has been monitoring sulfate concentrations within OU-1, OU-2, and OU-4 in monitoring wells upgradient and downgradient of former ISCO IRM areas. Sampling for additional sulfate analysis began in Q2 2010 and was scheduled to continue for a period of one year, ending in Q1 2011. The purpose of the sulfate sampling program was to establish baseline sulfate concentrations in groundwater and to identify any potential trends associated with remedial activities conducted at the site. The results of this investigation were originally presented in the Q1 2011 GM and OM&M Report. This initial investigation concluded that elevated sulfate concentrations in select monitoring wells exceed the NYS AWQS criteria for GA groundwater. Based on these results, sulfate sampling has continued at monitoring wells that exceed the NYS AWQS criteria for GA groundwater, as well as downgradient monitoring wells. Following the approved reductions to the long term groundwater monitoring program, the frequency of sulfate sampling was reduced to annual. A discussion of the analytical results is presented below. This data is presented in **Appendix I**.

4.5.1 OU-1 and OU-2 Sulfate Concentrations Downgradient of the OU-1 ISCO Pilot Tests

Persulfate was injected during two pilot tests within OU-1, north of the LIRR. The first pilot test was completed in 2004 using activated persulfate. The second pilot test was completed in 2006 using activated sodium persulfate. Analytical testing for sulfate in downgradient monitoring wells began in 2007. The former pilot test areas are shown on **Figure 2**.

4.5.1.1 Background Sulfate Concentrations

Background sulfate concentrations have historically been within a range of approximately 5,000 to 43,000 µg/L. These values were determined based on sulfate concentrations within monitoring wells located upgradient of the ISCO pilot test treatment areas (MW-09S, 09I, 09I2, and 09D, and BBMW-38S, 38I, 38I2 and 38D). Sampling of these wells was discontinued after Q3 2011. These concentrations are depicted on **Graph I-1** of **Appendix I**. The monitoring well locations are shown on **Figure 1**.

4.5.1.2 OU-1/OU-2 Trends in Sulfate Concentration

Historically, sulfate concentrations have been observed above the background concentration range at multiple wells within OU-1 and OU-2. A majority of the concentrations at these wells do not exceed the NYS AWQS of 250,000 µg/L. Sulfate concentrations are depicted graphically for monitoring wells with concentrations of sulfate greater than the NYS AWQS value of 250,000 µg/L in **Appendix I, Graph I-2** for OU-1 monitoring wells and **Graph I-3** for OU-2 monitoring wells.

Since sampling began in 2007, samples from 21 monitoring wells have exceeded the NYS AWQS criteria for GA groundwater; nine monitoring wells in OU-1 (BBMW-05D, BBMW-06D, BBMW-18D, BBMW-19D, BBMW-22D, OZMW-17D, OZMW-18D, OZMW-23D, and OZMW-24D) and twelve in OU-2 (BBMW-24D, OU2MW-19D, OU2MW-24D, OU2MW-27D, OU2MW-30D2, OU2MW-35D, OU2MW-36D, OU2MW-37D, OU2MW-39D, OU2MW-42D, OU2MW-43I, and OU2MW-43D). Concentrations at these monitoring wells have ranged from 59,700 µg/L to 2,470,000 µg/L in OU-1 and between ND and 841,000 µg/L in OU-2.

Twenty of the 21 monitoring wells are screened to below 60 feet bgs in the deep zone. These monitoring wells are located within or downgradient of the former ISCO pilot test injection areas. The persulfate solutions injected during the pilot test were denser than water and therefore traveled vertically downward after injection. The density of the persulfate solution was modified during the pilot testing to attempt to reduce the vertical migration and increase the lateral migration of the injected persulfate. Monitoring wells with elevated sulfate concentrations are generally located within or downgradient of the In Situ Chemical Oxygen ISCO injection pilot test area.

Thirty-eight monitoring wells in OU-1 were sampled for sulfate in Q2 2012. Of the 38 wells only one well, OZMW-24D, exceeds the NYS AWQS of 250,000 µg/L. Sixty-nine monitoring wells in OU-2 were sampled for sulfate in Q2 2013. Of the 69 wells, six wells (BBMW-24D, OU2MW-24D, OU2MW-30D2, OU2MW-36D, OU2MW-42D, and OU2MW-43D) exceeded the NYS AWQS of 250,000 µg/L.

Graphical trends observed in **Graphs I-2** and **I-3** of **Appendix I** indicates that concentrations are declining in the wells located in OU-1 and the majority of wells in OU-2. The only increasing trend still apparent is in monitoring well OU2MW-30D2. The data indicates that sulfate is still present in the deep aquifer and may be migrating downgradient.

4.5.2 OU-4 Sulfate Concentrations

The injection phase of the OU-4 S-ISCO IRM was conducted from Q2 2009 through Q4 2009. The wells selected for sulfate analysis in Q2 2013 included wells within and immediately downgradient of the S-ISCO treatment area (WCMW-05S, 05I, 05I2; WCMW-11S, 11I, 11D; and WCMW-25I and 25D). The above wells specified for quarterly sampling in Q2 2013 differs from the wells sampled in Q2 2011 due to the abandonment of monitoring wells WCMW-01S, 01I, 01D; WCMW-03S, 03I, 03D; WCMW-16S, 16I, 16I2; WCMW-17S, 17I, and

17I2 to support the excavation IRM. The majority of the additional wells within and immediately downgradient of the S-ISCO treatment area were also sampled for sulfate once in Q2 2010. This data is provided in the table in **Appendix I** and in **Graphs I-4** through **I-6**. The well locations are provided on **Figure 1**.

4.5.2.1 Background Sulfate Concentrations

Background sulfate concentrations for OU-4 were determined based on sulfate concentrations within monitoring wells located upgradient of the S-ISCO treatment area (WCMW-19S, 19, and 19I2). The background sulfate concentrations ranged from approximately 11,000 µg/L to 40,000 µg/L. These concentrations are similar to the background concentrations observed for OU-1 and OU-2. The OU-4 sulfate background wells were sampled quarterly for sulfate from Q2 2010 through Q2 2011. The OU-4 background concentrations are depicted on **Graph I-4** of **Appendix I**. The monitoring well locations are shown on **Figure 1**.

4.5.2.2 Sulfate Concentrations Within and Immediately Downgradient of the S-ISCO Treatment Area

Sulfate concentrations are depicted graphically for monitoring wells within and immediately downgradient of the S-ISCO treatment area in **Appendix I, Graph I-5**. Historically, 10 monitoring wells had sulfate concentrations greater than the NYS AWQS value of 250,000 µg/L (WCMW-01S, WCMW-01D, WCMW-03S, WCMW-04S, WCMW-05S, WCMW-14D, WCMW-17S, WCMW-17I, WCMW-25I, and WCMW-25D). Five of these wells (WCMW-01S, WCMW-01D, WCMW-03S, WCMW-17S, and WCMW-17I) were decommissioned in support of the remedial excavation and were not sampled in Q2 2013. Sulfate sampling was discontinued at WCMW-04S and WCMW-14D following numerous detections below the NYS AWQS criteria. Eight monitoring wells were sampled for sulfate in OU-4 during Q2 2013. There were no sulfate concentrations in exceedances of the NYS AWQS criteria for GA groundwater detected in OU-4 in Q2 2013.

4.5.2.3 Sulfate Concentrations Greater than 200 Feet Downgradient of the S-ISCO Treatment Area

Historical sulfate concentrations are depicted graphically for monitoring wells greater than 200 feet downgradient of the S-ISCO treatment area in **Appendix I, Graph I-6**. Historically, the only sulfate exceedances detected greater than 200 feet downgradient of the S-ISCO treatment area was in WCMW-02I in Q4 2010. The sulfate concentrations were below the NYS AWQS value of 250,000 µg/L in Q1, Q2, and Q3 2011, after which sulfate sampling was discontinued in the area.

5. Future Plans

The OM&M schedule is evaluated on a quarterly basis to keep the remedial systems operating as efficiently as possible. Rationale for sampling groundwater and soil vapor is also evaluated on a quarterly basis. Recommendations for future system GM and OM&M, as well as recommendations and rationale for groundwater, soil vapor and ambient air monitoring are presented in the sections below.

5.1 Remedial Systems

5.1.1 NAPL Gauging & Recovery

- The frequency of NAPL gauging at BBMW-05D, BBMW-22D, BBRW-01R, BBRW-02, BBRW-05, and BBRW-06 will remain on a quarterly schedule, as approved by the NYSDEC. NAPL gauging at new recovery wells BBRW-08 and BBRW-09, as well as in the remaining temporary recovery wells (TG-32I2, TG-32D and TG-44I2) will also continue on a quarterly basis.
- DNAPL monitoring will continue on a quarterly basis for OU-1 monitoring wells BBMW-34I2, BBMW-38I, BBMW-38I2, OZMW-21I, and OZMW-21D. LNAPL has been observed, historically in monitoring wells BBMW-34I and OZMW-25I. NAPL thickness in these wells will continue to be monitored on a quarterly basis.
- The DNAPL recovery system operational schedule was changed in Q2 2011 so that DNAPL recovery was conducted once every four weeks. The increase in time between pumping events has allowed more DNAPL to enter the recovery well, increasing the amount of DNAPL recovered during each pumping event, and minimizing excess water purged during the recovery event. DNAPL will continue to be recovered once every four weeks.

5.1.2 Ozone Groundwater Treatment System

- Continue bi-weekly and monthly inspections.
- Continue monthly sampling of groundwater, soil vapor, and the SVE effluent.
- Continue monthly soil vapor and ambient air sampling at locations within OU-1 to monitor for potential influence to soil vapor from the ozone injection system.
- Conduct manufacturer recommended maintenance on the system components.

5.1.3 Current Oxygen Injection Systems

- The installation of two new oxygen injection systems and the modification of three others are currently underway to treat lingering impacts. The installations and modifications are scheduled to be complete in Q4 2013.

- Continue monthly system inspections and groundwater parameter monitoring.
- Continue quarterly groundwater monitoring.
- Continue weekly system inspections.
- Conduct manufacturer recommended maintenance on the systems.

5.2 Groundwater Monitoring

5.2.1 Operable Unit 3

- The groundwater monitoring network in the vicinity of the OU-3 LIRR Excavation IRM and downgradient of the upgraded Community Road oxygen injection line will continue to be monitored.
- Additional monitoring wells are planned for installation along the southern extent of the LIRR ROW. Installation is currently planned for Q4 2013.

5.2.2 Operable Unit 4

- Since there were no detections above NYS AWQS criteria for class GA groundwater for sulfate, sulfate sampling will be discontinued.

5.2.3 Sitewide

- Continue quarterly gauging and sampling of the groundwater monitoring well network in accordance with the approved long-term monitoring program.
- Continue to sample for sulfate at and downgradient of monitoring wells that exceed the NYS AWQS criteria for class GA groundwater.

5.3 Remedial Activity

5.3.1 Operable Unit 1

- The installation of one new oxygen injection system, located to the north of the LIRR ROW along the eastern portion of the Operable Unit, and the modification of the OU-1 Union Boulevard oxygen injection system to treat lingering impacts is currently underway. The installation and modifications are scheduled to be completed in early Q4 2013.
- The 60/66 North Clinton oxygen injection system is being relocated to the northern property boundary to facilitate potential redevelopment of the property. It is also being modified to treat groundwater impacts inside of the western portion of the subsurface barrier wall. The relocation and modification is scheduled to be completed in Q4 2013

5.3.2 Operable Unit 2

- The modification of two existing oxygen injection systems is currently underway and is scheduled to be completed in early Q4 2013. The systems being modified include 33 North Clinton Avenue and Montauk Highway lines.

5.3.3 Operable Unit 3

- The installation of one additional oxygen injection system on the property south of the LIRR and north of Community Road is currently being completed. An additional round of ORC-A injection was completed during Q3 2013 in the downgradient area of OU-3. .

5.3.4 Operable Unit 4

- None

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Tables (compact disk only)

Tables also available at www.bayshoreworksmgp.com

Figures

Appendices (compact disk only)