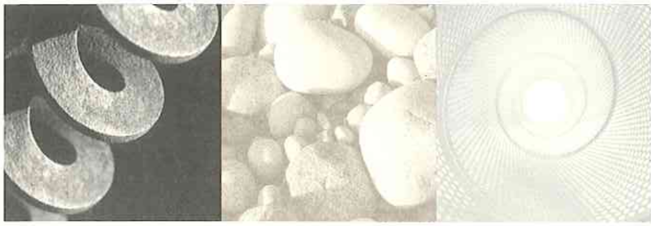

GEI Consultants

Geotechnical
Environmental and
Water Resources
Engineering

Quarterly Operations, Maintenance & Monitoring Report
First Quarter (Q1) 2009

Bay Shore/Brightwaters Former MGP Site

Town of Islip

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

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1. Introduction

This report presents the first quarter 2009 (Q1 2009) 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 (the Site). This report has been prepared in accordance with the requirements of Section 6 of DER-10, Technical Guidance for Site Investigation and Remediation, Order on Consent, Index No. D1-0001-98-11 signed by KeySpan Corporation (KeySpan) (currently know as National Grid) and the New York State Department of Environmental Conservation (NYSDEC), and the Operable Unit 2 Remedial Decision Document.

In 2003, the Site was divided into four operable units to more effectively manage investigation and remediation activities (**Figure 1**). The OM&M results of all four operable units have been combined in this report in order to present an overall picture of trends relating to effectiveness of the dense non-aqueous phase liquid (DNAPL) recovery, groundwater treatment systems operating at the Site, and remedial activities on groundwater quality in the upper glacial aquifer. The locations of the DNAPL recovery and groundwater treatment systems are presented on **Figure 1** and descriptions are presented in the applicable sections for each operable unit.

OM&M activities include maintenance and monitoring of the dense non-aqueous phase liquid (DNAPL) recovery and groundwater treatment systems, quarterly groundwater monitoring, and monitoring of soil vapor and ambient air. The OM&M results for each operable unit are presented in the following sections of the report: Section 2 - Operable Unit 1 (OU-1); Section 3 - Operable Unit 2 (OU-2); Section 4 - Operable Unit 3 (OU-3); and Section 6 - Operable Unit 4 (OU-4). In February 2009, NYSDEC approved the reconfiguration of the boundaries of OU-1 to include the portions of National Grid-owned properties north of Union Boulevard once designated as part of OU-2. This change was designed to refine the areas where OU-1 and OU-2 overlapped and designate areas involved with portions of the OU-1 remedy (i.e. subsurface barrier wall installation, in-situ chemical oxidation) as part of OU-1 and not OU-2. The soil vapor and ambient air results contain data for all operable units and are presented in Section 5.

Significant remedial activities conducted during Q1 2009 include installation and the startup of three additional oxygen injection systems within the OU-2 groundwater plume. Information pertaining to the operation and monitoring data from these systems is included in this report.

The graphical depiction and discussion of much of the data associated with the site operable units, especially for OU-2 and OU-3, provided in this Q1 2009 OM&M report, has been modified from previous reports with the intent of facilitating the interpretation and understanding of the data. These modified data and graphics presentations involved input from NYSDEC, and Bay Shore and Brightwaters community members, including their independent environmental consultant. The modifications primarily involve the graphical presentation of groundwater quality data using maps to depict the distribution of specific constituents, as well as trends of constituent concentrations (including both statistical trends and graphical trends). The details of these modifications are described in the appropriate sections of this report.

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 (Dvirka and Bartilucci Consulting Engineers [D&B], 2002) and the Final Remedial Investigation Report (D&B, 2003). Several Interim Remedial Measures (IRMs) have been conducted since 1999 in OU-2, OU-3, and OU-4. A brief description of each IRM is presented for each operable unit below.

OU-1 consists of the Bay Shore Site, formerly the main operations area of the MGP, which is currently owned by National Grid. The following remedial actions, IRM and pilot studies have been performed in OU-1:

- DNAPL Recovery IRM: A DNAPL recovery system was installed in the off-Site area south of the Long Island Railroad (LIRR) (GEI, 2006).
- In-Situ Chemical Oxidation (ISCO) Pilot Studies: Three pilot studies were conducted at the Site in 2004 utilizing Activated Persulfate, Modified Fenton's Reagent and Activated Fenton's Reagent (GEI, 2005).
- Surfactant-Enhanced In-Situ Chemical Oxidation (S-ISCO) Pilot Study: A pilot study was conducted in 2006 utilizing a surfactant to solubilize MGP-related impacts and Sodium Persulfate to oxidize those impacts (GEI, 2007a).
- OU-1 Southern Cell Excavation (February 2007 through April 2007). This excavation consisted of the removal of source material to a maximum depth of 25 feet below ground surface (bgs). The excavation was completed in support of the utility relocation in association with the excavation of source material in OU-1 located north of the LIRR tracks (GEI, 2004c).

- Subsurface Barrier Wall Installation (April 2007 through April 2008). The installation of the subsurface barrier wall commenced in April of 2007 and was completed in April 2008. The barrier was installed as part of the Remedial Action Plan (RAP) for OU-1 (GEI, 2004c).
- Oxygen Injection System: An oxygen injection system was installed along the downgradient edge of OU-1 in February 2008 as an interim remedial measure to treat groundwater at the perforated portion of the subsurface barrier wall until the full scale groundwater treatment system is complete.
- Groundwater Treatment System: The groundwater treatment building that will house the treatment system equipment began construction in February 2009. Construction of the ozone injection wells and soil vapor extraction laterals will begin in July 2009. The ozone injection system equipment has been constructed off-site and will be installed upon building completion.

OU-2 consists of the groundwater plume which extends south/southeast from OU-1. The following IRMs have been performed in OU-2:

- Oxygen Injection IRM: A groundwater treatment system utilizing oxygen injection technology was installed in Q4 2005 (GEI, 2006). The treatment system consists of two injection lines located along Montauk Highway and the intersection of Garner Lane and Manatuck Lane (**Figure 1**). The system injects oxygen into the upper glacial aquifer to increase aerobic biological activity and reduce the concentrations of MGP-related contaminants in groundwater prior to discharge into Lawrence Creek. MGP-related impacts are limited to the upper glacial aquifer. The underlying Magothy aquifer, which is the primary source of public water supply in Nassau and Suffolk Counties, is not impacted from former MGP operations.
- OU-2 Groundwater Treatment Remedy: In accordance with the OU-2 Remedial Decision Document (GEI, 2008), three additional groundwater treatment systems (**Figure 1**) utilizing oxygen injection technology were installed within the OU-2 groundwater plume. All three systems began operation during Q1 2009.

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. The following IRMs have been performed in OU-3:

- ISCO IRMs: Three rounds of ISCO by In-Situ Oxidative Technologies, Inc. (ISOTEC) were used to treat the Brightwaters Yard groundwater plume source area in May of 2001, September of 2001, and October of 2004. The treatment involved the injection of a chelated iron complex and stabilized hydrogen peroxide (H^2O^2) within the IRM area (Foster Wheeler Environmental Corporation [FW], 2000).

- Excavation IRM: A source area excavation was effective in removing 1,500 tons of source contaminated soils from May to July of 2004 (**Figure 1**) (Paulus, Sokolowski and Sartor Engineering, PC [PS&S], 2004).
- Oxygen Injection IRM: A groundwater treatment system utilizing oxygen injection technology was installed in Q3 2000 at the intersection of Union Boulevard and Lanier Lane (**Figure 1**). The treatment system consists of one injection line which injects oxygen into the upper glacial aquifer to increase aerobic biological activity and reduce the concentrations of MGP-related contaminants in groundwater prior to discharge into O-Co-Nee Pond. MGP-related impacts are limited to the upper glacial aquifer. The underlying Magothy aquifer, which is the primary source of public water supply in Nassau and Suffolk Counties, is not impacted from former MGP operations.

- Oxygen Injection IRM: A second groundwater treatment system utilizing oxygen injection technology was installed in Q4 2004 on the Brightwaters Yard adjacent to the LIRR (**Figure 1**). The treatment system consists of three injection lines which inject oxygen into the upper glacial aquifer to increase aerobic biological activity and reduce the concentrations of MGP-related contaminants in groundwater leaving the Site boundary (PS&S, 2004). MGP-related impacts are limited to the upper glacial aquifer. The underlying Magothy aquifer, which is the primary source of public water supply in Nassau and Suffolk Counties, is not impacted from former MGP operations.

- OU-3 Storm Sewer Rehabilitation IRM: Sections of the storm water collection network located within OU-3 were rehabilitated in Q4 2008. This included the replacement of catch basins and the cured in-place lining of drainage piping that is located within the OU-3 groundwater plume.

- OU-3 LIRR Excavation/Temporary Track Relocation IRM: Site preparation activities for the IRM were initiated in Q1 2009. Site preparation activities consisted of the relocation of high tension utility lines from the LIRR right-of-way to locations north of the proposed excavation area.

OU-4 consists of a former cesspool, former pond area, and the headwaters of Watchogue Creek (a.k.a., Crum's Brook), located approximately 400 feet east of the Bay Shore Site. The following IRMs have been, or will be, performed in OU-4:

- Sediments in Watchogue Creek/Crum's Brook were removed and the channel was restored as part of an IRM performed in 2000 (FW, 2002).

- The former cesspool was excavated and shallow impacted soils (vadose zone soils) were removed and treated off-Site as part of an IRM performed in Q4 2005 (**Figure 1**) (GEI, 2004a). The remaining impacted materials below the water table at the former cesspool area will be treated using in-situ treatment technologies. The NYSDEC-approved OU-4 Cesspool Area S-ISCO Work Plan (VeruTEK, 2008) was submitted on February 19, 2008. Site preparation work including installation of the S-ISCO injection wells, monitoring wells and injection lines and mobilization of S-ISCO injection equipment was initiated in Q1 2009. S-ISCO injection was initiated on April 28, 2009. The final report for the OU-4 cesspool IRM will be submitted at the completion of the ISCO portion of the former cesspool IRM.

- In the former pond area, shallow impacted soils will be removed and treated off-Site as part of an IRM that was approved by the NYSDEC in April 2006 (GEI, 2006a). Impacted soils below the water table will be treated using in-situ methods following the results of the S-ISCO implementation on OU-4 and/or through excavation.

2. Operable Unit 1 – Bay Shore Site, Bay Shore West Parcel and Adjacent Off-Site Areas

2.1 DNAPL Recovery System and NAPL Monitoring

2.1.1 Program Scope and Purpose

A DNAPL recovery system was installed in recovery well BBRW-02 in January 2006. The DNAPL recovery system consists of a Blackhawk Electric Anchor Piston Pump which recovers DNAPL from BBRW-02 and discharges to a United States Department of Transportation/United Nations (USDOT/UN) approved 55-gallon steel drum. The DNAPL system is currently operated approximately once every three weeks. Historically, the recovery system was operated once every two weeks. The DNAPL system operation schedule was revised in March 2008 due to decreasing DNAPL recovery observed in the well. Allowing more time in-between recovery operations enables the DNAPL to settle into a discrete layer which allows for more efficient recovery.

The presence and thickness of light non-aqueous phase liquids (LNAPL) and/or DNAPL is gauged in wells BBRW-02 through BBRW-05, BBMW-05D, and BBMW-22D on a weekly basis. BBMW-20D was damaged in Q1 2008 during construction activities on OU-1 and has not been gauged since. BBRW-01 was abandoned in support of the OU-1 Southern Cell Excavation in Q1 2007. These wells are located in OU-1 south of the LIRR (**Figure 1**).

2.1.2 Current Site Activity

The following DNAPL recovery and non-aqueous phase liquids (NAPL) monitoring events occurred during Q1 2009.

- **DNAPL Recovery:** The DNAPL recovery system in BBRW-02 was operated on the following dates:

- January 12, 2009 – DNAPL Recovery, Scheduled Operation 53
- February 2, 2009 – DNAPL Recovery, Scheduled Operation 54
- February 20, 2009 – DNAPL Recovery, Scheduled Operation 55
- March 13, 2009 – DNAPL Recovery, Scheduled Operation 56

- **NAPL Gauging:** Wells BBRW-02 through BBRW-05, BBMW-05D, and BBMW-22D were gauged for the presence of LNAPL and DNAPL on the following dates:

- January 9, 16, and 23, 2009
- February 2, 6, 13, 20, and 27, 2009
- March 6, 13, 19, and 27, 2009

2.1.3 DNAPL Recovery and NAPL Monitoring Data

The DNAPL recovery system and NAPL monitoring data are provided on the following tables and figure.

- **Table 2-1 Summary of DNAPL Removal for Recovery Well BBRW-02 –** provides DNAPL thickness prior to and after pumping events and volume of DNAPL recovered from BBRW-02. Approximately 12 gallons of DNAPL were recovered during Q1 2009. Approximately 281 gallons of DNAPL have been recovered since the beginning of DNAPL recovery operations.
- **Table 2-2 Summary of Measured DNAPL Thickness –** provides NAPL thickness in existing NAPL gauging wells BBRW-02 through BBRW-05, BBMW-05D, BBMW-20D, and BBMW-22D. Measured DNAPL thickness has remained consistent between Q4 2008 and Q1 2009.
- **Figure 2 DNAPL Recovery Data BBRW-02 –** Illustrates historical pre- and post-DNAPL recovery thickness and amount of DNAPL recovered from BBRW-02. The operational schedule of the DNAPL recovery system was changed from operating once every two weeks to approximately once every three weeks in Q2 2008 due to decreasing recovery. DNAPL recovery thickness and the amount of DNAPL recovered have been inconsistent since the change in operational schedule.

2.1.4 Future Plans

- The DNAPL recovery system will continue to be manually operated at a frequency of once every three weeks.
- The pumping interval will continue to be evaluated on a quarterly basis.
- The operational schedule will be adjusted if a significant change in the DNAPL recovery rate continues.
- The DNAPL/aqueous solution will be removed and disposed of by a licensed liquid hazardous waste transporter to a treatment, storage and disposal facility (TSDF) capable of

receiving the specific waste material. The schedule of removal will be established such that DNAPL storage time on-Site does not exceed 90 days from the start of accumulation in a drum.

- A permanent enclosure to house the pump, well, and control panel will be installed at the completion of the portion of the OU-1 remedy that will take place in this area.

2.2 Oxygen Injection System

2.2.1 Program Scope and Purpose

An oxygen injection system was installed downgradient of the perforated portion of the subsurface barrier wall at the downgradient edge of OU-1 in February 2008. This system is currently being used to treat groundwater at the perforated portion of the subsurface barrier wall until the full scale groundwater treatment system is complete. The location of the oxygen injection system is illustrated on **Figure 1**.

2.2.2 Current Site Activity

The following OU-1 oxygen injection system monitoring and system operation activities were performed in Q1 2009.

- **Monthly Groundwater Parameter Monitoring:** On a monthly basis, four monitoring wells downgradient of the oxygen injection line (OZMW-17S, OZMW-17I, OZMW-17I2, OZMW-17D) are monitored for Dissolved Oxygen Content (DO), Oxidation Reduction Potential (ORP), pH, Conductivity, and Temperature. Monthly Groundwater Parameter Monitoring was performed on the following dates:

  - January 29 and 30, 2009
  - February 26 and 27, 2009
  - March 26, 2009

1. **System Operation Monitoring:** The oxygen injection groundwater treatment system is monitored on a monthly basis to ensure effective continued operation. During each monitoring event, system parameters relating to system operational and equipment readiness are recorded and adjusted as necessary to optimize system performance. System Operation Monitoring was performed on the following dates:

   - January 12, 2009
   - February 20, 2009
   - March 10, 2009

- **Quarterly Groundwater Sampling:** Select monitoring wells upgradient and downgradient of the oxygen injection system located in OU-1 are sampled quarterly for volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs). Groundwater quality parameters (DO, pH, temperature, conductivity and ORP) are also recorded for each well during the quarterly sampling. Details on the groundwater sampling program are provided in Subsection 2.3 below.

2.2.3 Oxygen Injection System OM&M Data

The OM&M data collected for the OU-1 oxygen injection system is provided in the following table, figure and appendix:

- **Table 2-3 Summary of Groundwater Parameter Data – OU-1 Oxygen Injection System -** provides data gathered at downgradient monitoring well clusters OZMW-16, OZMW-17, and OZMW-18. Increases in DO have been observed at shallow and intermediate depths at all three monitoring well clusters. The data presented on this table indicate that for Q1 2009:

  - DO concentrations ranged between 0 and 44 milligrams per liter (mg/L) in all downgradient monitoring wells. DO concentrations decreased during the month of January but rebounded in February and March. The drop in DO concentrations can be attributed to a mechanical failure that is explained below.
  - ORP values were elevated in several downgradient monitoring wells. ORP values ranged between -132 and 121 millivolts (mV);
  - pH varied between 4.62 and 6.82 Standard Units (SU) in downgradient monitoring wells;
  - Conductivity in downgradient monitoring wells ranged between 0.350 and 2.1 milli-Siemen per centimeter (mS/cm); and
  - Temperature ranged between 10.6 and 13.7 degrees Celsius (deg C), typical for Q4 conditions.

1 **Figure 6 OU-1 Union Boulevard Oxygen Injection Line Groundwater Data –** provides a graphical depiction of DO levels, total benzene, toluene, ethylbenzene and xylenes (BTEX) and total polycyclic aromatic hydrocarbon (PAH) concentrations over time for wells located downgradient of the OU-1 oxygen injection line. **Figure 6** provides data for the monitoring well clusters OZMW-16, OZMW-17, and OZMW-18. Significant decreases of MGP-related contaminants have been observed downgradient of the OU-1 oxygen injection line at monitoring wells where effects of the oxygen injection system have been noted (OZMW-16S, OZMW-16I, OZMW17S,

OZMW-17I, OZMW-18S, OZMW-18I and OZMW-18I2). Further groundwater trend analysis is discussed in subsection 2.3.4.1.

1. **Appendix A OU-1 Oxygen Injection System OM&M Data –** provides data collected during system operation monitoring. The data provided in **Appendix A** indicate that:

- Approximately 298 lbs of oxygen have been injected during Q1 2009 and a total of 1,381 lbs of oxygen have been injected since the initial start-up period; and
- The OU-1 oxygen injection system operated for 88 out of a possible 90 days during Q1 2009. The oxygen injection system was shut down for two days for maintenance. The oxygen purity had decreased to ambient concentrations during January 2009. The sieve material within the oxygen generator was replaced in January and the system was brought back on-line. The system is currently generating oxygen with purity between 75 and 85%.

2.2.4 Future Plans

- Continue to conduct monthly system checks, groundwater parameter monitoring, and quarterly contaminants of concern (COC) sampling.
- Continue to conduct weekly system checks.
- Conduct labor intensive maintenance on the system.

2.3 Groundwater Monitoring

2.3.1 Program Scope and Purpose

Groundwater monitoring is conducted within OU-1 to aid in monitoring the groundwater plume (OU-2), and establishing baseline conditions against which the effectiveness of the planned ozone injection system and other remedial activities can be evaluated. Sixteen monitoring wells at four well cluster locations (OZMW-16S, I, I2, D; OZMW-17S, I, I2, D; OZMW-18S, I, I2, D and OZMW-22S, I, I2, D) were installed at the downgradient boundary of OU-1 in Q1 2008. The wells were installed to monitor the performance of the ozone injection system which will be installed at the perforated portion of the subsurface barrier wall. The wells are currently being used to monitor the performance of the oxygen injection system installed at this location. The well locations and geographic boundaries of OU-1 are illustrated on Figure 1. The wells sampled each quarter are selected based on previous analytical data and discussions with NYSDEC.

2.3.2 Current Site Activity

The following groundwater monitoring activities took place in OU-1 during Q1 2009.

- Depth to groundwater measurements were obtained on January 26 and 27, 2009 from 32 wells.
- Groundwater samples were collected from all of the 33 monitoring wells located in OU-1.
- Groundwater samples from 17 of the 33 wells were analyzed for BTEX and methyl tert-butyl ether (MTBE) by United States Environmental Protection Agency (EPA) Method 8260 and for PAHs by EPA Method 8270. Groundwater samples from the remaining 16 wells were analyzed for an expanded list of VOCs (EPA Method 8260) and PAHs (EPA Method 8270).

2.3.3 Groundwater Elevation Data

The depth to groundwater and groundwater elevation data for OU-1 are provided on the following tables and figures.

1. **Table 2-4 Water Level Measurements and Calculated Groundwater Elevations –** provides depth to water measurements and calculated groundwater elevation data for OU-1 wells measured in Q1 2009. The elevation data presented on this table is in reference to the NAVD88 datum.
2. **Table 2-5 Historic Calculated Groundwater Elevations –** provides historic groundwater elevations for existing OU-1 groundwater monitoring wells. All historic groundwater elevation data presented has been recalculated based on the November 2007 survey data and the NAVD88 datum.
3. **Figure 3 On-Site Shallow Groundwater Contour Map –** provides the Q1 2009 shallow groundwater elevation contours for OU-1 and OU-3.
4. **Figure 4 Shallow Groundwater Contour Map –** provides the Q1 2009 shallow groundwater elevation contours for OU-1, OU-2, OU-3 and OU-4.
5. **Figure 5 Deep Groundwater Contour Map –** provides the Q1 2009 deep groundwater elevation contours for OU-1, OU-2, OU-3 and OU-4.

The groundwater flow direction in OU-1 is towards the south/southeast. The shallow groundwater hydraulic gradient is approximately 0.0025 feet/foot and the deep groundwater hydraulic gradient is approximately 0.0026 feet/foot. The groundwater elevation in OU-1 monitoring wells during the Q1 2009 event were an average of approximately 0.10 feet higher than the Q4 2008 groundwater elevations and an average of approximately 0.30 feet higher than the Q1 2008 groundwater elevations.

2.3.4 Groundwater Analytical Data

The groundwater analytical results for groundwater monitoring wells located in OU-1 and sampled in Q1 2009 are provided on the following tables and appendix:

1. **Table 2-6 Summary of Historic Total BTEX Groundwater Analytical Results –** provides a summary of historical total BTEX results for existing OU-1 groundwater monitoring wells.
2. **Table 2-7 Summary of Historic Total PAH Groundwater Analytical Results –** provides a summary of historical total PAH results for existing OU-1 groundwater monitoring wells.
3. **Table 2-8 Summary of BTEX, MTBE and PAH Groundwater Analytical Results –** provides the Q1 2009 groundwater analytical results for monitoring wells located in OU-1 for each of the analyzed compounds detected in Q1 2009.
4. **Table 2-9 Summary of Expanded Groundwater Analytical Results –** provides the Q1 2009 groundwater analytical results for monitoring wells located in OU-1 that were analyzed for the expanded list of VOCs for each compound detected in Q4 2008.
5. **Table 2-10 Summary of Total BTEX Statistical Trends –** provides statistical trends of concentrations beginning when the upgradient oxygen injection system was installed or the subsurface barrier wall was completed, through Q1 2009.
6. **Table 2-11 Summary of Total PAH Statistical Trends –** provides statistical trends of concentrations beginning when the upgradient oxygen injection system was installed or the subsurface barrier wall was completed, through Q1 2009.
7. **Appendix E –** presents time series plots of groundwater monitoring well analytical data for total BTEX and total PAH.

2.3.4.1 Downgradient Groundwater Analytical Data Trend Analysis

Analysis of the trends of constituent concentrations for OU-1 groundwater monitoring wells were conducted on two levels: statistical and graphical. The focused period for these trends is the operational period of the OU-1 Union Boulevard oxygen injection line.

A statistical analysis typically used to assess trends in groundwater monitoring well concentration data is the Mann-Kendall method (Gilbert, 1987). This is a non-parametric statistical method that evaluates concentration trends over time, by comparing the relative difference in magnitude of data over time and assigning probability for the trends. One limitation of this statistical method exists for interpretation of remediation monitoring data sets of limited events.

The graphical trend analysis of groundwater monitoring well concentrations considers all of the concentrations for the same oxygen injection period as the statistical period.

The OU-1 Union Boulevard oxygen injection system began operation in February 2008. Considering a groundwater flow rate for the upper glacial aquifer of 1 to 2 feet per day, the trends of the wells immediate downgradient of the system, within the area where the oxygen front has passed through, were conservatively evaluated.

Three well clusters (OZMW-16 through OZMW-18) are located approximately 50 feet downgradient of the OU-1 Union Boulevard oxygen injection line. Groundwater monitoring wells OZMW-16S, OZMW-16I, OZMW-16I2, OZMW-16D, OZMW-17S, OZMW-17I, OZMW-17I2, OZMW-17D, OZMW-18S, OZMW-18I, OZMW-18I2, and OZMW-18D were installed immediately downgradient of the oxygen injection line located downgradient of the perforated portion of the subsurface barrier wall in OU-1. These wells were first sampled in Q1 2008, prior to operation of the oxygen injection system.

For perspective of the statistical trends discussion below, the highest historical median concentrations of wells located in the area of OU-1, during the operational period for the OU-1 Union Boulevard oxygen injection system, were 8,240 ug/l of total BTEX in BBMW-22S and 5,410.5 ug/l total PAH in BBMW-22D.

Statistical Trend Analysis

For the three downgradient well clusters located adjacent to the oxygen injection system, no statistical trends were identified. This lack of statistical trends did not factor in initial significant high pre-injection concentrations which ranged as high as 441 ug/l for total BTEX and 7,729 ug/l for total PAH.

At monitoring well cluster BBMW-01 (S, I, and D), located approximately 200 feet downgradient from the OZMW well clusters, the statistical trend for the intermediate and shallow zone of this cluster were decreasing.

Review of data and Mann-Kendall results for downgradient wells indicating no trend in total BTEX or total PAH concentrations identified that 17 of the 19 wells had a negative Mann-Kendall Statistic (S). This negative statistic parameter value indicates a decreasing trend to exist, even though it was not significant at a 95% confidence interval. Many wells indicated with no trend had a short duration of sampling (four or less sampling events) or high number of non-detect results.

Graphical Trend Analysis

A review of the groundwater quality data from these wells indicates that all of the elevated total BTEX and total PAH concentrations are located generally throughout the upper glacial aquifer (generally between 100 ug/l and 500 ug/l), with total PAH concentrations highest (up to 7,7,29 ug/l) in the intermediate depth zone of the aquifer.

For total BTEX, all of the wells described above had decreasing graphical trends, except for BBMW-01D, OZMW-16I2 and OZMW-18I2 (**Figure 6** and **Appendix E**). The decrease in concentrations ranged from a maximum of approximately 47,000 ug/l to minimum concentrations at least two orders-of-magnitude lower. The lack of graphical trends in wells identified above is because of either low concentrations or stable trends of total BTEX.

The graphical trends of total PAHs in the downgradient wells in the vicinity of the OU-1 Union Boulevard oxygen injection line are similar to those for total BTEX described above. One notable exception is the graphical trend for OU2MW-18-I, located approximately 300 feet downgradient of the injection line. Total PAH concentrations in this well averaged approximately 9,000 ug/l through the operational period of the oxygen injection system with no graphical trend. The lack of a significant decreasing trend at the OU2MW-18 cluster (**Figure 6**) likely indicates that the effects of the oxygen injection line (increased DO levels) may not yet be reaching the cluster. Impacted groundwater downgradient of the OU2MW-18 cluster will be additionally treated by the oxygen injection line installed downgradient at the 33 North Clinton Avenue property, which began operation in late Q1 2009.

2.3.5 Future Plans

- Continue annual and quarterly groundwater monitoring at selected wells.
- Begin construction of the ozone injection remedial system in July 2009.

2.4 Institutional Controls/Engineering Controls (IC/EC)

There has been no activity this quarter.

3. Operable Unit 2 – Bay Shore Groundwater Plume

3.1 Oxygen Injection Systems

3.1.1 Program Scope and Purpose

Four oxygen injection groundwater treatment systems have been installed within OU-2 to mitigate dissolved-phase groundwater impacts migrating from OU-1. The first oxygen injection groundwater treatment system, comprised of two injection lines located along Montauk Highway, and at the intersection of Manatuck and Garner Lanes, was installed in November of 2005. Three supplemental oxygen injection systems were installed in 2008/2009 in compliance with the requirement of the OU-2 Remedial Decision Document. These systems affect multiple portions of the OU-2 groundwater plume at 33 North Clinton Avenue, 34 North Clinton Avenue, and 9 North Clinton Avenue (**Figure 1**). All three systems were brought on-line in Q1 2009. The oxygen injection systems inject oxygen into the upper glacial aquifer to increase dissolved oxygen (DO) concentrations in groundwater and enhance biological breakdown of dissolved constituents in the groundwater plume in OU-2.

3.1.2 Current Site Activity

The following OU-2 oxygen injection system monitoring and system operation activities were performed in Q1 2009.

1. **Monthly Groundwater Parameter Monitoring:** On a monthly basis, seven monitoring wells downgradient of the Montauk Highway and Manatuck Lane oxygen injection lines (OU2MW-06, OU2MW-07, BBMW-25S, BBMW-25I, OU2MW-01S, OU2MW-01I, and OU2MW-01I2) are monitored for DO, ORP, pH, conductivity, and temperature. Monthly Groundwater Parameter Monitoring was performed on the following dates:
   - January 19, 20, 21, and 23, 2009
   - February 26 and 27, 2009
   - March 3, 27, 30, and 31, 2009
2. **System Operation Monitoring:** The groundwater treatment systems are monitored on a monthly basis to ensure effective continued operation. During each monitoring event, system parameters relating to system operational and equipment readiness are recorded and adjusted as necessary to optimize system performance. System Operation Monitoring was performed on the following dates:

- January 13 and 30, 2009
- February 3 and 26, 2009
- March 4, 9, and 24, 2009

1. **Quarterly Groundwater Sampling:** Select monitoring wells upgradient and downgradient of the oxygen injection systems located in OU-2 are sampled quarterly for VOCs, and SVOCs. Groundwater quality parameters (DO, pH, temperature, conductivity and ORP) are also recorded for each well during the quarterly sampling. Details on the groundwater sampling program are provided in Subsection 3.2.

3.1.3 Oxygen Injection System OM&M Data

The OU-2 Oxygen Injection System OM&M data are provided on the following tables and appendix.

2 **Table 3-1 Summary of Groundwater Parameter Data – Montauk Highway Oxygen Injection Line –** provides the historical conductivity, DO, ORP, pH and temperature data for monitoring wells downgradient of the Montauk Highway oxygen injection line. The data presented on this table indicate that for Q1 2009:

- DO concentrations remained elevated in downgradient monitoring wells. DO concentrations ranged between 0 and 39 mg/L;
- ORP remained elevated in select downgradient monitoring wells. ORP ranged between -142 and 235 mV;
- pH remained consistent. pH varied between 4.63 and 6.48 SU in downgradient monitoring wells;
- Conductivity in downgradient monitoring wells remained consistent and has ranged between 0.046 and 1.57 mS/cm; and
- Temperature ranged between 1.7 and 15.5 deg C, typical for Q1 conditions.

3 **Table 3-2 Summary Groundwater Parameter Data – Manatuck Lane Oxygen Injection Line –** provides the historic conductivity, DO, ORP, pH and temperature data for wells downgradient of the Manatuck Lane oxygen injection line. The data presented in this table indicate that for Q1 2009:

- DO concentrations remained elevated in downgradient monitoring wells. DO concentrations ranged between 13.2 and 39 mg/L;
- ORP remained elevated in a limited number of downgradient monitoring wells. ORP ranged between 85 and 253 mV;

- pH remained consistent. pH varied between 5.73 and 6.87 SU in downgradient monitoring wells;
- Conductivity in downgradient monitoring wells remained consistent. Conductivity ranged between 0.216 and 0.702 mS/cm; and
- Temperature ranged between 1.8 and 17.8 deg C, typical for Q1 conditions.

4 **Table 3-3 Summary Groundwater Parameter Data – Targeted Monitoring Wells for Supplemental Oxygen Injection Systems –** provides the system start-up conductivity, DO, ORP, pH and temperature data for wells downgradient of the 33 North Clinton Avenue, 34 North Clinton Avenue, and 9 North Clinton Avenue oxygen injection lines. All three systems were brought online in Q1 2009. In a short period of time, DO concentrations have increased in monitoring well clusters downgradient of both the 34 North Clinton Avenue (OU2MW-45, OU2MW-46 and OU2MW-47) and the 9 North Clinton Avenue (OU2MW-28, OU2MW-29, OU2MW-30, OU2MW-31, and OU2MW-32) oxygen injection systems. The 33 North Clinton Avenue system was started at the end of the quarter and no monitoring data was recorded in Q1 2009. System start-up dates are presented below.

- 34 North Clinton Avenue – January 20, 2009
- 9 North Clinton Avenue – February 16, 2009
- 33 North Clinton Avenue – March 31, 2009

On a monthly basis, targeted monitoring wells located downgradient of the supplemental oxygen injection systems are sampled during the first year of start-up. Total BTEX and total PAH analytical results are presented on **Tables 3-12** and **3-13** respectively.

- **Table 3-4 Summary of Heterotrophic Plate Count Results –** provides a summary of heterotrophic plate count (HPC) results for select wells located downgradient of the OU-2 oxygen injection systems. HPC results varied between 4 and 120,000 colony forming units per milliliter (cru/ml).

8. **Appendix B OU-2 Oxygen Injection Systems OM&M Data –** provides data collected during system operation monitoring. **Table B-1** provides the Garner Lane oxygen injection line operational data, **Table B-2** provides the 34 North Clinton Avenue oxygen injection system operational data, and **Table B-3** provides the 9 North Clinton Avenue oxygen injection system operational data. The operational data for the 33 North Clinton Avenue oxygen injection system will be presented in Q2 2009.

The results provided in **Table B-1** for the injection system located at the corner of Garner Lane and Montauk Highway (which feeds the Montauk Highway and Manatuck Lane injection lines) indicate:

- Approximately 1,000 lbs of oxygen have been injected during Q1 2009 and a total of 9,972 lbs of oxygen have been injected since the initial start-up period; and
- The OU-2 oxygen injection system operated for 89 out of a possible 90 days during Q1 2009. The system went down for one day in March of 2009. A problem was encountered with the air dryer. An internal line froze and restricted air flow to the system. The line was thawed and the system was brought back on-line.

The results provided in **Table B-2** for the 9 North Clinton Avenue system (which feeds the 9 North Clinton Avenue Injection Line) indicate:

- Approximately 272 lbs of oxygen were injected during Q1 2009.
- During Q1 2009, the system operated for all 42 days after initial start-up on February 16, 2009 during.

The results provided in **Table B-3** for the 34 North Clinton Avenue system (which feeds the 34 North Clinton Avenue Injection Line) indicate:

- Approximately 595 lbs of oxygen were injected during Q1 2009.
- During Q1 2009, the system operated for all 69 days after initial start-up on January 20, 2009.

5 **Figure 7 Montauk Highway Oxygen Injection Line Groundwater Data –** provides a graphical depiction of DO levels, total BTEX and total PAH concentrations over time for wells located downgradient of the Montauk Highway oxygen injection line. **Figure 7** provides data for the monitoring well clusters BBMW-25, OU2MW-01, OU2MW-02, OU2MW-03, OU2MW-04 and OU2MW-08. DO concentrations have remained elevated in several downgradient monitoring wells. Significant decreases of MGP-related contaminants have been observed in monitoring wells located downgradient of the Montauk Highway injection line at wells where effects of the oxygen injection system have been noted (BBMW-25S, BBMW-25I, OU2MW-01S, OU2MW-01I, OU2MW-01I2, OU2MW-02S, OU2MW-02I, and OU2MW-04I). Further groundwater trend analysis is discussed in Subsection 3.2.4.2.

6 **Figure 8 Manatuck Lane Oxygen Injection Line Groundwater Data –** provides graphical depiction of DO levels, total BTEX and total PAH concentrations over time for monitoring wells located downgradient of the Manatuck Lane oxygen injection line. Significant decreases of MGP-related contaminants have been observed in monitoring

wells located downgradient of the Manatuck Lane injection line at wells where effects of the oxygen injection system have been noted (OU2MW-06, OU2MW-07, GMP-02 and GMP-04). Further groundwater trend analysis is discussed in subsection 3.2.4.2.

3.1.4 Future Plans

- Continue monthly system checks, groundwater monitoring, and quarterly COC sampling.
- Continue sampling of permanent soil vapor points.
- Continue weekly system checks.
- Conduct labor intensive maintenance on the system.

3.2 Groundwater Monitoring

3.2.1 Program Scope and Purpose

Groundwater monitoring is conducted within OU-2 to aid in monitoring the groundwater plume, the effectiveness of remedial activities, the effectiveness of the oxygen injection systems, and to aid in remedy planning. The well locations and geographic boundaries of OU-2 are illustrated on **Figure 1**. The majority of OU-2 monitoring wells are sampled quarterly with the exception of groundwater monitoring wells BBMW-01S, I, and D and BBMW-23S, I, D and D2, which have been sampled on a monthly basis since Q2 2007 and wells installed to monitor new oxygen injection systems which are sampled monthly. BBMW-01S, I, and D and BBMW-23S, I, D, and D2 are located approximately 100 to 200 feet downgradient of OU-1 and will continue to be monitored on a monthly basis to measure the influence of the OU-1 excavations and subsurface barrier wall installation on the OU-2 groundwater plume. The wells sampled each quarter are determined based on previous analytical data and discussions with NYSDEC.

3.2.2 Current Site Activity

The following groundwater monitoring activities took place in OU-2 during Q1 2009.

- Depth to groundwater measurements were obtained on January 26 and 27, 2009 from 107 monitoring wells located within, sidegradient and downgradient of OU-2.
- Surface water elevations were obtained on January 27, 2009 from surface water gauges located within Lawrence Lake (BBSW-07) and Lawrence Creek (OU2SW-01 and BBSW-06).
- Groundwater samples were collected from 191 monitoring wells located within OU-2. 223 groundwater samples from all of the 191 wells were analyzed for expanded VOCs (EPA Method 8260) and PAHs (EPA Method 8270).

3.2.3 Groundwater Elevation Data

The depth to groundwater, groundwater elevation and surface water elevation data for OU-2 are provided on the following tables and figures.

- **Table 3-5 Water Level Measurements and Calculated Groundwater Elevations** – provides depth to water measurements and calculated groundwater and surface water elevation data for OU-2 wells and surface water bodies measured in Q1 2009.
- **Table 3-6 Historic Calculated Groundwater Elevations –** provides historic groundwater elevations for existing OU-2 groundwater monitoring wells.
- **Figure 4 – Shallow Groundwater Contour Map –** provides the Q1 2009 shallow groundwater elevation contours for OU-1, OU-2, OU-3 and OU-4.
- **Figure 5 – Deep Groundwater Contour Map –** provides the Q1 2009 deep groundwater elevation contours for OU-1, OU-2, OU-3 and OU-4.

The groundwater flow direction in OU-2 is toward the south/southeast. The shallow groundwater hydraulic gradient ranges from approximately 0.0031 feet/foot in the upgradient portion of the plume to approximately 0.0045 feet/foot in the downgradient portion of the plume. The deep groundwater hydraulic gradient ranges from approximately 0.0032 feet/foot to 0.0043 feet/foot. The groundwater elevation in OU-2 monitoring wells during the Q1 2009 event were an approximate average of 0.3 feet higher than the Q4 2008 groundwater elevations and an approximate average of 0.2 feet higher than the Q1 2008 groundwater elevations.

3.2.4 Groundwater Analytical Data

The OU-2 groundwater analytical data are presented on the following tables, figures and appendix.

- **Table 3-7 Summary of Historic Total BTEX Groundwater Analytical Results – Upgradient of Montauk Highway Oxygen Injection Line –** presents a summary of historical total BTEX results for existing OU-2 groundwater monitoring wells upgradient of the Montauk Highway Oxygen Injection Line.
- **Table 3-8 Summary of Historic Total PAH Groundwater Analytical Results – Upgradient of the Montauk Highway Oxygen Injection Line –** presents a summary of historical total PAH results for existing OU-2 groundwater monitoring wells upgradient of the Montauk Highway Oxygen Injection Line.
- **Table 3-9 Summary of Historic Total BTEX Groundwater Analytical Results – Downgradient of Montauk Highway Oxygen Injection Line –** presents a

summary of historical total BTEX results for existing OU-2 groundwater monitoring wells downgradient of the Montauk Highway Oxygen Injection Line.

- **Table 3-10 Summary of Historic Total PAH Groundwater Analytical Results – Downgradient of the Montauk Highway Oxygen Injection Line –** presents a summary of historical total PAH results for existing OU-2 groundwater monitoring wells downgradient of the Montauk Highway Oxygen Injection Line.
- **Table 3-11 Summary of Historic Total BTEX Groundwater Analytical Results – Downgradient of Manatuck Lane Oxygen Injection Line –** presents a summary of historical total BTEX results for existing OU-2 groundwater monitoring wells downgradient of the Manatuck Lane Oxygen Injection Line.
- **Table 3-12 Summary of Historic Total PAH Groundwater Analytical Results – Downgradient of the Manatuck Lane Oxygen Injection Line –** presents a summary of historical total PAH results for existing OU-2 groundwater monitoring wells downgradient of the Manatuck Lane Oxygen Injection Line.
- **Table 3-13 Summary of Monthly Total BTEX Groundwater Analytical Results – Targeted Monitoring Wells for Supplemental Oxygen Injection Systems –** presents monthly downgradient analytical results for total BTEX.
- **Table 3-14 Summary of Monthly Total PAH Groundwater Analytical Results – Targeted Monitoring Wells for Supplemental Oxygen Injection Systems –** presents monthly downgradient analytical results for total PAH.
- **Table 3-15 Summary of Expanded Groundwater Analytical Results –** provides the Q1 2009 groundwater analytical results for monitoring wells located in OU-2 for each compound detected during the Q1 2009 sampling event.
- **Table 3-16 Summary of Total BTEX Statistical Trends –** provides statistical trends of concentrations beginning near the date when the nearest upgradient oxygen injection system was installed, through Q1 2009. The table is set up to include wells for all of the existing oxygen injection systems; however, many of the wells installed to monitor the new systems do not have sufficient data to evaluate concentration trends. Future quarterly OM&M reports will evaluate the trends for these wells.
- **Table 3-17 Summary of Total PAH Statistical Trends –** provides statistical trends of concentrations beginning near the date when the nearest upgradient oxygen injection system was installed, through Q1 2009. The table is set up to include wells for all of the existing oxygen injection systems; however, many of the wells installed to monitor the new systems do not have sufficient data to evaluate concentration trends. Future quarterly OM&M reports will evaluate the trends for these wells.

- **Figure 9 Water Table Groundwater Total BTEX Iso-Concentration Map – Q1 2009 Data –** depicts the horizontal extent of total BTEX in the water table portion of the upper glacial aquifer for OU-1.
- **Figure 10 Intermediate Groundwater Total BTEX Iso-Concentration Map 10 to 50-Foot Depth – Q1 2009 Data –** depicts the horizontal extent of total BTEX in the 10 to 50 depth zone of the upper glacial aquifer for OU-1.
- **Figure 11 Deep Groundwater Total BTEX Iso-Concentration Map Below 50-Foot Depth – Q1 2009 Data** – depicts the horizontal extent of total BTEX in the deeper than 50-foot depth zone of the upper glacial aquifer for OU-1.
- **Figure 12 Water Table Groundwater Total PAH Iso-Concentration Map – Q1 2009 Data –** depicts the horizontal extent of total PAH in the water table portion of the upper glacial aquifer for OU-1.
- **Figure 13 Intermediate Groundwater Total PAH Iso-Concentration Map 10 to 50-Foot Depth – Q1 2009 Data –** depicts the horizontal extent of total PAH in the 10 to 50 depth zone of the upper glacial aquifer for OU-1.
- **Figure 14 Deep Groundwater Total PAH Iso-Concentration Map Below 50-Foot Depth – Q1 2009 Data** – depicts the horizontal extent of total PAH in the deeper than 50 feet within the upper glacial aquifer.

9. **Appendix E** – presents time series plots of historical concentrations in groundwater monitoring wells.

3.2.4.1 Distribution of Total BTEX and Total PAH in the Upper Glacial Aquifer

In previous OM&M reports, the horizontal extent of the OU-2 plume within the upper glacial aquifer, based on greater than 100 ug/l of total BTEX and greater than 100 ug/l total PAH, based on the results of the 2004 Remedial Investigation was depicted on the quarterly report figures. Starting with this Q1 2009 report, the horizontal extent of total BTEX and total PAH concentrations for quarterly monitoring events will be depicted using iso-concentration maps. The iso-concentration maps prepared for this Q1 2009 OM&M report also include the 2004 depiction of the plume extent for reference.

The overall outline of the groundwater BTEX/PAH plume has not changed significantly from the 2004 depiction. However, the internal configuration of the plume within the upper glacial aquifer has changed, primarily in response to the addition of a greater number of monitoring points within the plume limits and the ongoing remediation efforts at the site. This includes the installation of the oxygen injection system, the OU-1 excavation, and the installation of the subsurface barrier wall (**Figure 1**). The changes of the plume outline are summarized as follows:

- the downgradient edge of the plume does not extend to Lawrence Creek, and ends at the Manatuck Lane oxygen injection line
- the plume near the downgradient area of OU-1 is slightly narrower
- the plume is shallower adjacent to the downgradient side of the subsurface barrier wall
- the eastern edge of the central portion of the plume is slightly wider, primarily established by the installation of additional groundwater monitoring wells installed as part of injection system monitoring network for the 33 North Clinton Avenue property.

The distribution of total BTEX and total PAH for Q1 2009 within the upper glacial aquifer is depicted in **Figures 9 through 11** and **Figures 12 through 14**, respectively. The horizontal distribution of the constituent groups in each map 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. For areas where the groundwater monitoring well density was low, historical water quality from existing wells and groundwater quality data from previous groundwater probes were utilized.

The vertical distribution of the total BTEX and total PAH concentrations are depicted by the iso-concentration maps for three aquifer horizons: the water table zone (up to the approximate upper 5 feet of the upper glacial aquifer); an intermediate depth zone from approximately 10 to 50 feet below land surface; and a deep zone below 50 feet, to the top of the underlying low permeability surface unit of the Magothy aquifer.

Total BTEX

The depth series iso-concentration maps show that near the source area of OU-1, the total BTEX impacts are primarily shallow, with concentrations present above 10,000 ug/l (**Figure 9**). The contamination within this water table zone, above 100 ug/l, extends to approximately 1,500 feet downgradient of the OU-1 boundary. The width of the plume is fairly narrow, less than 200 feet.

With depth in the intermediate zone, similar maximum total BTEX concentrations in the water table zone are present in a localized area to the east of the shallow plume, in the vicinity of South Union Boulevard and Jan Court. A larger area of total BTEX concentrations, an order-of-magnitude lower than this eastern area, was present in the central portion of the downgradient area of OU-1 (**Figure 10**). The downgradient edge of this area is defined at the line of the oxygen injection line installed at Montauk Highway. Further downgradient of this area, the total BTEX plume concentrations decrease another order-of-magnitude, to concentrations of between 100 ug/l and 1,000 ug/l and extend to the oxygen injection line at

Manatuck Lane. Downgradient of this system and to Lawrence Creek, total BTEX concentrations are below 100 ug/l.

In the basal approximate 20 feet of the upper glacial aquifer zone, below a depth of approximately 50 feet, total BTEX concentrations between 100 ug/l and 1,000 ug/l are present in a narrow band (approximately 200 feet wide) from OU-1, and extending approximately 1,200 feet downgradient (**Figure 11**). No concentrations above 100 ug/l are present beyond the oxygen injection line located on Montauk Highway.

Total PAH

The vertical distribution of total PAH concentrations within the upper glacial aquifer is similar to that of total BTEX described above (**Figures 12 through 14**). The primary differences are:

- maximum concentrations were an order-of-magnitude lower than those of total BTEX concentrations
- downgradient of OU-1, the elevated concentrations were primarily present throughout the area to Montauk Highway.

Focused and Expedited Plume Remediation

The locations of the existing oxygen injection systems and planned systems depicted in **Figure 1** allows for the potential effective and comprehensive remediation of the plume. The figure illustrates that the entire width of the plume, and up to approximately 20 feet beyond, is being or will be remediated by oxygen injection lines. The figure also depicts that the remediation of the plume along its longitudinal, downgradient, axis isoccurring at several transects at various locations. The existing groundwater data shows that the existing oxygen injection systems have been successful in reducing concentrations of total BTEX and total PAH. The addition of the oxygen injection systems started during Q1 2009 enable the injection to occur at shorter distances along the plume axis, thereby, accelerating the remediation of the plume.

3.2.4.2 Groundwater Analytical Data Trend Analysis

The groundwater analytical data were reviewed to identify any trends in data, with the focus on data collected during the operational injection period of the various oxygen injection systems at the Site. The analysis of the data focuses on the downgradient areas of three oxygen injection systems installed within OU-2 and operating by early Q1 2009. These systems include the oxygen injection lines installed at Montauk Highway, Manatuck Lane and 34 North Clinton Avenue. The systems that were started late in Q1 2009 include 9 North Clinton Avenue and 33 North Clinton Avenue. The trend analysis presented below includes the previously existing systems in addition to the 34 North Clinton Avenue system since this system was started early in Q1 2009 (January 20) with sufficient post-startup groundwater quality data. For the 9 North Clinton Avenue and 33 North Clinton Avenue systems that began operation in the latter part of Q1 2009, the groundwater quality data indicates that the oxygen front has reached downgradient monitoring wells during Q1 2009.

Analysis of the trends of constituent concentrations for OU-2 groundwater monitoring wells were conducted on two levels: statistical and graphical. The period of these trends focus on the operational periods of each oxygen injection system or line with at least two quarterly sampling events.

A statistical analysis typically used to assess trends in groundwater monitoring well concentration data is the Mann-Kendall method (Gilbert, 1987). This method is a non-parametric statistical that evaluates concentration trends over time, by comparing the relative difference in magnitude of data over time and assigning probability for the trends. One limitation of this statistical method exists for interpretation of remediation monitoring data sets of limited events.

The graphical trend analysis of groundwater monitoring well concentrations considers all of the concentrations for the same oxygen injection period as the statistical period.

Downgradient of the 33 North Clinton Avenue Oxygen Injection Line

The 33 North Clinton Avenue oxygen injection system began operation on the last day of Q1 2009 (March 31, 2009). As a result, the system would not yet have the ability to affect groundwater quality downgradient at the time of sampling. A detailed analysis of groundwater trends downgradient of the system will be provided starting in the Q2 2009 OM&M report, when sufficient data is available.

Downgradient of 34 North Clinton Avenue Oxygen Injection Line

The total BTEX and total PAH concentrations in the groundwater immediately upgradient of the 34 North Clinton Avenue oxygen injection system were primarily present in the intermediate and deep upper glacial aquifer zones. The highest median concentrations, since the system was installed, in wells located immediately north of the 34 North Clinton Avenue system (OUMW-19 and OU2MW-20) were 1,957 ug/l total BTEX in well OU2MW-19I and 6,693 ug/l total PAH in monitoring well OU2MW-19I2. A discussion of the statistical and graphical concentration trends is presented below.

Statistical Trend Analysis

In the three well clusters located adjacent to, or immediately downgradient of, the oxygen injection line, OU2MW-45, OU2MW-46 and OU2MW-47, three statistical trends of total BTEX were identified; one significantly increasing trend in OU2MW-46I2 and significantly decreasing trends in OU2MW-47I2 and OU2MW-47S. The indication of no trend identified for most the adjacent downgradient wells of the oxygen injection system occurs for several reasons. The Mann-Kendall method may not utilize the initial high concentration, prior to oxygen injection remediation effects because it considers it anomalous to the subsequent significant consistent post-remediation concentration. Review of data and Mann-Kendall results for downgradient wells indicating no trend, identifies that 10 of the 17 wells had a negative Mann-Kendall Statistic (S). This negative statistic indicates a decreasing trend to exist, even though it was not significant at a 95% confidence interval. Many wells indicated with no trend had a short duration of sampling (four or less sampling events) or high number of non-detect results.

For total PAH concentration trends in these same adjacent downgradient wells, statistical decreasing trends were identified in OU2MW-45D, OU2WM-46 I, OU2MW-47D and OU2MW-47I2. Although trends were not identified in wells OU2WM-45I2, OU2WM-47I and OU2WM-47S, the associated statistical trends did not utilize the initial high concentration, prior to oxygen injection remediation effects, because they are considered anomalous to the subsequent significant consistent low post-remediation concentration.

Graphical Trend Analysis

For the time series plots (**Appendix A**) of the three well clusters located immediately downgradient of the oxygen injection system (OU2MW-45, OU2MW-46 and OU2MW-47), concentrations in the wells of cluster OU2MW-45 were below 100 ug/l. In wells OU2MW-46 and OU2MW-47, total BTEX concentrations significantly decreased several orders-of-magnitude from a high of 47,000 of ug/l during the system operational period, except in well OU2MW-46I2. In OU2MW-46I2 the total BTEX concentration increased from approximately 10 ug/l to 380 ug/l. Monitoring well cluster OU2MW-46 is located along the upgradient side of the injection line. Elevated system operational period concentrations of total PAH for the wells within these clusters significantly decreased from a high of approximately 6,200 ug/l in OU2MW-47I2 to near detection levels.

The above data indicate that there have been significant decreases of MGP-related contaminants in groundwater monitoring wells located downgradient of the 34 North Clinton Avenue oxygen injection system line.

Downgradient of Montauk Highway Oxygen Injection Line

The highest median concentrations of the oxygen injection system operational period in upgradient wells located closest to the Montauk Highway injection line (OU2MW-08, OU2MW-33 and OU2MW-41) were approximately 850 ug/l total BTEX in well OU2MW-08S and 7,376 ug/l total PAH in monitoring well OU2MW-8S.

For the groundwater entering the Montauk Highway oxygen injection system, the highest total BTEX concentrations are present in the intermediate depth zone of the upper glacial aquifer and the highest total PAH concentrations are present in the intermediate and deep aquifer zones.

Statistical Trend Analysis

In the three well clusters located immediately downgradient of the oxygen injection line, OU2MW-01, OU2MW-02 and BBMW-25, four statistical trends of total BTEX were identified and all four were decreasing. For total PAH concentration trends, statistical decreasing trends were identified in all five wells where trends were identified. Review of data and Mann-Kendall results for downgradient wells in these clusters indicating no trend, identifies that 3 of the 5 wells had a negative Mann-Kendall Statistic (S) indicating a decreasing trend, even though it was not significant at a 95% confidence level.

Graphical Trend Analysis

Significant decreases of MGP-related contaminants have been observed in monitoring wells located downgradient of the Montauk Highway injection line at wells where effects of the oxygen injection system have been noted. Plots of groundwater parameters and total BTEX, total PAH concentrations and DO over time are presented in **Figure 7** for wells located downgradient of the Montauk Highway injection line. The pre- and post-oxygen injection total BTEX and total PAH concentrations are presented in **Tables 3-6 and 3-7**, respectively.

Graphical trends of total BTEX and total PAH concentrations have decreased in 17 of the 48 wells sampled while one increasing trend (OU2MW-03I) was noted. The concentrations in 25 of the 48 wells remained at or near non-detect levels, and the remaining five wells exhibited no discernable trend.

Well clusters BBMW-25, OU2MW-01, OU2MW-02, OU2MW-03 and OU2MW-04 located immediately downgradient of the oxygen injection line are most likely to be affected by the remedial efforts. The zone currently exhibiting the greatest impacts in this area is the intermediate zone (between 10 to 50 feet below ground surface).

Significant historical elevated total BTEX and total PAH concentrations (>5 ug/l) were detected in monitoring wells BBMW-25I, OU2MW-01S, OU2MW-01I, OU2MW-02S, OU2MW-02I, OU2MW-02I2 (PAH only) OU2MW-03S, OU2MW-03I, OU2MW-04S, and OU2MW-04I.

Total BTEX concentration trends are decreasing in seven of the ten wells listed above. Concentrations in well BBMW-25I (469 ug/l in Q1 2009) have decreased from the pre-operational median of 1,106 ug/l to as low as non-detect in Q2 2006 and Q1 2007. Concentrations in well OU2MW-01I (2 ug/l in Q1 2009) have ranged from 885 ug/l in Q1 2007 to 1 ug/l in Q2 2008 and in OU2MW-01S (69 ug/l in Q1 2009) from 1,243 ug/l in the pre-operational sample (August 2005) to as low as 6 ug/l in Q2 2008. The concentrations in OU2MW-02S (5 ug/l in Q1 2009) have varied between 573 ug/l in Q4 2006 to as low as 1 ug/l in Q4 2007. The concentration ranges in the remaining wells are as follows: OU2MW-03S (30 ug/l), 1,103 ug/l in Q2 2007 to non-detect in Q1 2007; OU2MW-04S (841 ug/l), 3,130 ug/l pre-operational sample (August 2005) to 200 ug/l in Q2 & Q3 2008; and OU2MW-04 I (97 ug/l), 885 ug/l in Q1 2006 to non-detect in Q4 2006. No BTEX trend was found in monitoring well OU2MW-02I (370 ug/l in Q1 2009), where the post-operational concentrations have ranged between 64ug/l (Q1 2007) to 260 ug/l (Q2 2007).

The single increasing total BTEX trend was observed in OU2MW-03I. The concentration increased from non-detect in Q2 2008 to 85 ug/l in Q3 2008, rising again to 1,262 ug/l in Q4 2008 before decreasing to 366 ug/l in Q1 2009.

Total PAH concentration trends are decreasing in eight of the ten wells listed above. Concentrations in well BBMW-25I have decreased from the pre-operational median of 5,965 ug/l to as low as non-detect in Q2 2006. The non-detect PAH concentrations in wells OU2MW-01S and OU2MW-01I in Q1 2009 are the lowest value recorded during the monitoring period with values ranging up to 6,927 ug/l in the pre-operational sample (August 2005) and 8,222 ug/l in Q1 2006, respectively. The concentrations in OU2MW-02S (33 ug/l in Q1 2009) have varied between 424 ug/l in Q4 2006 to as low as non-detect in Q1 2007. The concentration ranges in the remaining wells are as follows: OU2MW-02I (2,129 ug/l), 5,251 ug/l in Q3 2006 to 43 ug/l in Q2 2008; OU2MW-03S (80 ug/l), 401 ug/l in the pre-operational sample (August 2005) to non-detect in Q1 2007; OU2MW-04S (641 ug/l), 12,611 ug/l in Q1 2006 to 334 ug/l in Q4 2008; and OU2MW-04 I (98 ug/l), 6,438 ug/l in Q1 2006 to non-detect in four sampling events.

No total BTEX trend was identified in monitoring well OU2MW-02I2 (6 ug/l in Q1 2009), where the post-operational concentrations have ranged between 30 ug/l (Q1 2008) to non-detect in six of the sampling events.

Similar to the total BTEX results, the single increasing total PAH trend was identified in OU2MW-03I where the concentration increased from non-detect in Q3 2008 to 95 ug/l in Q4 2008, and to 146 ug/l in Q1 2009. Prior to the Q4 2008 results, the concentration in well OU2MW-03I had been non-detect in nine of 11 post-operational sampling events. The results from future sampling events will be evaluated to determine if the recent increases represent an increasing trend.

The above data indicate that there have been significant decreases of MGP-related contaminants in groundwater monitoring wells located downgradient of the Montauk Highway oxygen injection line.

Downgradient of Manatuck Lane Oxygen Injection Line

Elevated total BTEX and total PAH concentrations downgradient of the Manatuck Lane oxygen injection line were only present in the intermediate depth zone of the upper glacial aquifer.

The highest median concentrations, since the system began operation in September 2005, in upgradient wells located closest to the Manatuck Highway oxygen injection line were 250 ug/l total BTEX and 3993 ug/l total PAH in monitoring well GMP-01.

Statistical Trend Analysis

Statistical trends were evaluated for wells located downgradient of the Manatuck Lane oxygen injection line with median operating period total BTEX and total PAH concentration above 100 ug/l.

One well, GMP-4 had an elevated median total BTEX concentration of 162.5 ug/l. The statistical trend for this well was decreasing. No other wells downgradient of the Manatuck Lane oxygen injection system had median system operational period concentrations over 100 ug/l.

Graphical Trend Analysis

Significant decreases of MGP-related contaminants have been observed in monitoring wells located downgradient of the Manatuck Lane injection line at wells where effects of the oxygen injection line have been noted. Plots of groundwater parameters, total BTEX and total PAH concentrations over time are presented in **Figure 8** for 13 selected wells located downgradient of the Manatuck Lane injection line. The pre- and post-oxygen injection total BTEX and total PAH concentrations are presented in **Tables 3-9 and 3-10**, respectively.

Statistically significant decreasing trends in total BTEX concentrations were noted in 4 of the 24 wells reviewed while decreasing total PAH trends were observed in 8 of the 24 wells. A significant increasing trend of total BTEX was observed in one well, OU2MW-10D; however, this trend was likely caused by potentially anomalous concentrations during Q1 2009 in the well. Additionally, one increasing trend of total PAHs at OU2MW-05S was observed. Review of data and Mann-Kendall results for downgradient wells in these clusters indicating no trend, identifies that 14 of the 21 wells had a negative Mann-Kendall Statistic (S). This negative statistic indicates a decreasing trend in total PAH and 11 of 19 wells had a negative statistic for total BTEX, even though it was not significant at a 95% confidence interval. Many wells indicated with no trend had a short duration of sampling (four or less sampling events) or a high number of non-detect results.

Well clusters OU2MW-06, OU2MW-07, OU2MW-10 and OU2MW-12 and monitoring wells GMP-02 and GMP-04 located immediately downgradient of the oxygen injection line are most likely to be affected by the remedial efforts. The zone extending from approximately 20 to 40 feet below ground surface is currently exhibiting the greatest impacts in this area. Wells that fall into this category among the clusters listed above with significant historical total BTEX and total PAH concentrations (>5 ug/l) include OU2MW-10I, OU2MW-10D (BTEX only), OU2MW-12I, and OU2MW-12I2.

Total BTEX concentration trends are decreasing in two of the four wells listed above. Total BTEX concentrations in well OU2MW-10I (76 ug/l in Q1 2009) have ranged from non-detect in Q3 2007 to 906 ug/l in Q1 2008 and in OU2MW-12I (107 ug/l in Q1 2009) from 62 ug/l in Q4 2008 to as high as 143 ug/l in Q3 2007. Total PAH concentrations in well OU2MW-10I (29 ug/l in Q1 2009) have ranged from non-detect in Q3 2007 and 2008 to 297 ug/l in Q4 2007. Total PAH concentrations in well OU2MW-12I (513 ug/l in Q1 2009) have ranged from 79 ug/l in Q4 2008 to 888 ug/l in Q3 2007.

Increasing trends were observed in two of the four wells listed above, OU2MW-10D (BTEX only) and OU2MW-12I2 (BTEX and PAH). As previously mentioned, the Q1 2009 total BTEX concentration in OU2MW-10D of 78 ug/l was lower than the value recorded in Q4 2008 (351 ug/l) and may be beginning to trend downward. Both the total BTEX and total PAH concentrations in OU2MW-12I2, 53 ug/l and 720 ug/l, respectively, represent the highest concentrations recorded in each well during the monitoring period and will be evaluated in subsequent sampling quarters to determine if they represent anomalously high results.

The above data indicate that there have been significant decreases of MGP-related contaminants in the majority of groundwater monitoring wells located downgradient of the Manatuck Lane oxygen injection line.

3.2.5 Future Plans

- Continue annual and quarterly groundwater monitoring at selected wells.

4. Operable Unit 3 – Brightwaters Yard & Groundwater Plume

4.1 Oxygen Injection Systems

4.1.1 Program Scope and Purpose

Two oxygen injection groundwater treatment systems have been installed at the Site to mitigate dissolved-phase groundwater impacts migrating from the OU-3 Brightwaters Yard to O-Co-Nee Pond. The first system was installed in Q3 2000, as part of an IRM at the intersection of Union Boulevard and Lanier Lane. This treatment system consists of one injection line intended to reduce the concentrations of MGP-related contaminants in groundwater prior to discharge to O-Co-Nee Pond. A second oxygen injection groundwater treatment system was installed in Q4 2004, as part of an IRM on the Brightwaters Yard. This treatment system consists of three injection lines intended to reduce the concentrations of MGP-related contaminants in groundwater leaving the Site boundary.

4.1.2 Current Site Activity

The following OU-3 oxygen injection system monitoring and system operation activities were performed in Q1 2009.

- **Monthly Groundwater Parameter Monitoring:** On a monthly basis, ten groundwater monitoring wells downgradient of the oxygen injection systems (MW-65, MW-75, MW-82, PDMW-01, IO-10, MW-34S, MW34I, MW-34D, MW-46WR, and MW-70/70S) are monitored for DO, ORP, pH, Conductivity, and Temperature. Monthly Groundwater Parameter Monitoring was completed at these wells on the following dates:
    - January 28 and 29, 2009
    - February 24 through 27, 2009
    - March 19, 26, and 31, 2009

- **System Operation Monitoring:** The groundwater treatment systems are monitored on a monthly basis to ensure effective continued operation. During each monitoring event, system parameters relating to system operational and equipment readiness are recorded and adjusted as necessary to optimize system performance. System Operation Monitoring was completed for the Brightwaters Yard System and the Union Boulevard System on the following dates:

  - January 12, and 13, 2009
  - February 4, and 20, 2009
  - March 3 and 10, 2009

- **Quarterly Groundwater Sampling:** Select monitoring wells upgradient and downgradient of the oxygen injection system located in OU-3 are sampled quarterly for VOCs, and SVOCs. Groundwater quality parameters (DO, pH, temperature, conductivity and ORP) are also recorded for each well during the quarterly sampling. Details on the groundwater sampling program are provided in subsection 4.2 below.

4.1.3 Oxygen Injection System OM&M Data

The OU-3 Oxygen Injection System OM&M data are provided on the following tables, figures and appendix.

- **Table 4-1 Summary Groundwater Parameter Data – Union Boulevard Oxygen Injection System –** provides the historical conductivity, DO, ORP, pH and temperature data for wells downgradient of the Union Boulevard oxygen injection system. The data provided on this table indicate that for Q1 2009:

  - DO concentrations remained elevated in downgradient monitoring wells IO-10, MW-46/WR, and MW-70/70S. DO concentrations ranged between 23 and 35 mg/L at these locations;
  - ORP remained elevated in downgradient monitoring wells IO-10, MW-46/WR, and MW-70/70S. ORP ranged between -28 and 104 mV at these locations;
  - pH ranged between 5.48 and 6.56 SU in downgradient monitoring wells;
  - Conductivity in downgradient monitoring wells remained consistent. Conductivity ranged between 0.272 and 3.720 mS/cm; and
  - Temperature ranged between 6.7 and 13.8 deg C, typical for Q1 conditions.

- **Table 4-2 Summary Groundwater Parameter Data – Brightwaters Yard Oxygen Injection System –** provides the historical conductivity, DO, ORP, pH and temperature data for wells downgradient of the Brightwaters Yard oxygen injection system. The data provided on this table indicate that for Q1 2009:

  - DO concentrations were elevated at monitoring wells MW-65, MW-79, MW-81, MW-82, MW-83, SV-02, and PDMW-01. DO concentrations ranged between 6.1 and 31 mg/L at these locations.
  - ORP remained elevated in select downgradient monitoring wells. ORP ranged between -164 and 107 mV;
  - pH remained consistent, pH ranged between 5.21and 6.28 SU in downgradient monitoring wells;

- Conductivity in downgradient monitoring wells remained consistent. Conductivity ranged between 0.24 and 3.41 mS/cm; and
- Temperature ranged between 5.2 and 13.2 deg C, typical for Q1 conditions.

6. **Table 4-3 Summary of Heterotrophic Plate Count Results –** provides a summary of heterotrophic plate count (HPC) results for select wells located downgradient of the OU-3 oxygen injection systems. HPC results varied between 100 and 4,300 colony forming units per milliliter (cru/ml).

Figure 15 OU3 Union Boulevard Oxygen Injection System Groundwater Data – provides graphical depiction of DO measurements, total BTEX and total PAH concentrations over time for wells located downgradient of the Union Boulevard oxygen injection system. Decreases in total BTEX and total PAH concentrations are evident historically in monitoring wells (MW-46WR, IO-10, and MW-34I) in the vicinity of the Union Boulevard injection system. Further groundwater trend analysis is discussed in subsection 4.2.4.2. .

10. **Figure 16 Brightwaters Yard Oxygen Injection System Groundwater Data –** provides graphical depiction of DO measurements, total BTEX and total PAH concentrations over time for monitoring wells located downgradient of the Brightwaters Yard oxygen injection system. Potential impacts on the Long Island Railroad (LIRR) property make it difficult to evaluate the effectiveness of the Brightwaters Yard oxygen injection system. However, decreases in total BTEX concentrations are graphical at monitoring wells (SV-03, MW-73, MW-75, and MW-79). Further groundwater trend analysis is discussed in subsection 4.2.4.2.

11. **Appendix C OU-3 Oxygen Injection System OM&M Data –** provides data collected during system operation monitoring. Table C-1 provides the Union Boulevard oxygen injection system operational data and Table C-2 provides the Brightwaters Yard oxygen injection system operational data.

    The results provided in Table C-1 for the Union Boulevard system indicate:

    - Approximately 366 lbs of oxygen were injected during Q1 2009.
    - A total of 4,432 lbs of oxygen have been injected since the initial start-up period.
    - The system operated for all 90 days during Q1 2009.

    The results provided in Table C-2 for the Brightwaters Yard system indicate:

    - Approximately 459 lbs of oxygen were injected during Q1 2009.
    - A total of 6,904 lbs of oxygen have been injected since the initial start-up period.
    - The system operated for all 90 days during Q1 2009.

4.1.4 Future Plans

- Continue monthly system checks, groundwater monitoring and quarterly COC sampling.
- Continue weekly system checks.
- Conduct labor intensive maintenance on the systems.

4.2 Groundwater Monitoring

4.2.1 Program Scope and Purpose

Groundwater monitoring is conducted within OU-3 to monitor the groundwater plume, to evaluate the effectiveness of remedial activities and the effectiveness of the oxygen injection systems, and to aid in remedy planning. There are currently approximately 70 monitoring wells located on OU-3. The well locations and geographic boundaries of OU-3 are depicted on **Figure 1**. The number of wells sampled each quarter is determined based on previous analytical data and discussions with NYSDEC.

4.2.2 Current Site Activity

The following groundwater monitoring activities took place in OU-3 during Q1 2009:

3. Depth to groundwater measurements were obtained on January 26, 2009 from 38 monitoring wells located within and sidegradient of OU-3.
4. The surface water elevation was obtained January 26, 2009 from a surface water gauge located within the headwaters of O-Co-Nee Pond (BBSW-13).
    2. Groundwater samples were collected from 63 of the 67 monitoring wells located within OU-3. 39 of the groundwater samples were analyzed for BTEX and MTBE via EPA method 8260 and PAHs via EPA Method 8270, and 24 of the groundwater samples were analyzed for an expanded list of VOCs (EPA Method 8260) and PAHs (EPA Method 8270).

4.2.3 Groundwater Elevation Data

The depth to groundwater, groundwater elevation and surface water elevation data for OU-3 are provided on the following tables and figures.

2. **Table 4-4 Water Level Measurements and Calculated Groundwater Elevations** – provides depth to water measurements and calculated groundwater and surface water elevation data for OU-3 wells measured in Q1 2009.

3. **Table 4-5 Historic Calculated Groundwater Elevations –** provides historic groundwater elevations for OU-3 for existing groundwater wells.
4. **Figure 4 Shallow Groundwater Contour Map –** provides the Q1 2009 shallow groundwater elevation contours for OU-1, OU-2, OU-3 and OU-4.
5. **Figure 5 Deep Groundwater Contour Map –** provides the Q1 2009 deep groundwater elevation contours for OU-1, OU-2, OU-3 and OU-4.

The groundwater flow direction in OU-3 is toward the south/southeast. The shallow groundwater hydraulic gradient in OU-3 is approximately 0.003 feet/foot. The deep groundwater hydraulic gradient is approximately 0.003 feet/foot. The groundwater elevation in OU-3 monitoring wells during the Q1 2009 event were similar to Q4 2008 groundwater elevations and an approximate average of 0.1 feet higher than the Q1 2008 groundwater elevations.

4.2.4 Groundwater Analytical Data

The OU-3 groundwater analytical data is presented in the following tables, figures and appendix.

- **Table 4-6 Summary of Historic Total BTEX Groundwater Analytical Results -** presents a summary of historical total BTEX results for existing OU-3 groundwater monitoring wells.
- **Table 4-7 Summary of Historic Total PAH Groundwater Analytical Results** – presents a summary of historical total PAH results for existing OU-3 groundwater monitoring wells.
- **Table 4-8 Summary of BTEX, MTBE and PAH Groundwater Analytical Results –** provides the Q1 2009 groundwater analytical results for monitoring wells located in OU-3 for each compound detected during the Q1 2009 sampling event.
- **Table 4-9 Summary of Expanded Groundwater Analytical Results –** provides the Q1 2009 groundwater analytical results for monitoring wells located in OU-3 for each compound detected during the Q1 2009 sampling event.
- **Table 4-10 Summary of Total BTEX Statistical Trends –** provides statistical trends of concentrations beginning near the date when the nearest upgradient oxygen injection system began operation, through Q1 2009. The table is set up to include wells for all of the existing oxygen injection systems, however, the systems for which the nearest downgradient groundwater monitoring wells have sufficient sampling data to evaluate concentration trends are discussed. Future quarterly OM&M reports will evaluate the trends for these wells.
- **Table 4-11 Summary of Total PAH Statistical Trends –** provides statistical trends of concentrations beginning near the date when the nearest upgradient oxygen injection system began operation, through Q1 2009. The table is set up to include wells for all of

the existing oxygen injection systems, however, the systems for which the nearest downgradient groundwater monitoring wells have sufficient sampling data to evaluate concentration trends are discussed. Future quarterly OM&M reports will evaluate the trends for these wells.

- **Figure 9 Water Table Groundwater Total BTEX Iso-Concentration Map - Q1 2009 Data –** depicts the horizontal extent of Total BTEX in the water table portion of the upper glacial aquifer for OU-4.
- **Figure 12 Water Table Groundwater Total BTEX Iso-Concentration Map - Q1 2009 Data –** depicts the horizontal extent of Total PAH in the water table portion of the upper glacial aquifer for OU-4.
- **Appendix E –** presents time series plots of the groundwater monitoring wells.

4.2.4.1 Distribution of Total BTEX and Total PAH in the Upper Glacial Aquifer

The distribution of total BTEX and total PAH for Q1 2009 within the upper glacial aquifer is depicted in **Figures 9 through 11**, and **Figures 12 through 14**, respectively. The horizontal distribution in each map 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 the southeasterly flow direction and the low transverse dispersion of the upper glacial aquifer. For areas where the groundwater monitoring well density was low, historical water quality from existing wells and groundwater quality data from previous groundwater probes were utilized.

The vertical distribution of the total BTEX and total PAH concentrations are depicted by iso-concentration maps for three aquifer horizons: the water table zone (to approximate upper 5 feet of the upper glacial aquifer); an intermediate depth zone from approximately 10 to 50 feet below land surface; and a deep zone below 50 feet to the top of the underlying low permeability surface unit of the Magothy aquifer.

For OU-3, total BTEX and total PAH concentrations in groundwater above 100 ug/l were only detected in the water table zone of the upper glacial aquifer. The distribution of these constituent groups is presented below.

<u>Total BTEX</u>

As depicted in **Figure 9**, a plume of total BTEX concentrations above 100 ug/l for Q1 2009 is present in the southern area of the Brightwaters Yard, just north of the LIRR tracks. The plume extends downgradient (southeastward) approximately 100 feet beyond Union Boulevard and the oxygen injection line located along its downgradient edge. The plume is comprised of a northern lobe in the downgradient Brightwaters Yard and a southern lobe in the vicinity of the Union Boulevard oxygen injection line.

The northern lobe has the highest total BTEX concentrations with a maximum value of 59,210 ug/l and the southern lobe has a maximum total BTEX concentration of 4,210 ug/l.

Total PAH

The total PAH plume (**Figure 12**) is less extensive and concentrated in OU-3 than the total BTEX plume. Elevated total PAH concentrations are limited to the downgradient edge of the Brightwaters Yard, with the maximum total PAH concentration of 2,100 ug/l.

4.2.4.2 Groundwater Analytical Data Trend Analysis

Analysis of data trends has been separated into three areas of OU-3: the Brightwaters East Parcel (former underground storage tank area); the area downgradient of the Brightwaters Yard oxygen injection system lines, and area downgradient of the Union Boulevard oxygen injection system.

Analysis of the trends of constituent concentrations for OU-3 groundwater wells were conducted on two levels: statistical and graphical. The periods of these trends focus on the operation periods of each oxygen injection system.

A statistical analysis typically used to assess trends in groundwater monitoring well concentration data is the Mann-Kendall method (Gilbert, 1987). This method is a non-parametric statistical that evaluates concentration trends over time, by comparing the relative difference in magnitude of data over time and assigning probability for the trends. One limitation of this statistical method exists for interpretation of remediation monitoring data sets of limited events.

The graphical trend analysis of groundwater monitoring well concentrations considers all of the concentrations for the same oxygen injection period as the statistical period.

Brightwaters East Parcel (Former UST Area)

Statistical trends identified for total BTEX and total PAH concentrations for the six wells located on the Brightwaters East Parcel (Former UST Area) were identified as “No Trend” (**Tables 4-10** and **4-11**). Median historical total BTEX and total PAH concentrations in these wells were below 14 ug/l. The concentrations of the wells were not significantly elevated to present any remedial concerns so a discussion of their trends is not warranted.

Downgradient of the Brightwaters Yard Oxygen Injection System

The highest historical median concentrations in wells in the vicinity of the Brightwaters Yard oxygen injection system during the operational period were 2,416 ug/l of total BTEX and 68,020 ug/l total PAH in PDMW-02.

The oxygen injection system on the Brightwaters Yard site consists of three injection lines installed parallel to the LIRR property. As discussed in Subsection 4.1.3, the oxygen injection system has significantly affected groundwater concentrations downgradient of the injection lines. However, impacted material beneath the LIRR property is contributing to groundwater impacts downgradient of the treatment system making evaluation of the system effectiveness difficult. Excavation of these impacts is being coordinated with LIRR and is planned to begin in Q3 2009. The groundwater analytical trends as they relate to observed groundwater quality parameters and system effectiveness are discussed in Subsection 4.1.3. An analysis of overall groundwater quality trends downgradient of this treatment system is provided below.

<u>Statistical Trend Analysis</u>

The statistical trends of total BTEX for wells at the area of the oxygen injection lines in the Brightwaters Yard identify significant decreasing trends in most wells; MW-64, MW-73, MW-78, MW-79, MW-80, and MW-82.

The statistical trends of total PAH for wells within the area identify significant decreasing trends in MW-64, MW-73, and MW-78. In one well (MW-80) with elevated total PAH concentrations, no statistical trend was identified.

All downgradient wells other than PDMW-01 (total BTEX and total PAH both positive with a statistic), and PDMW-03 (BTEX positive Mann-Kendall Statistic [S]) had a negative statistic. This negative statistic indicates a decreasing trend for total BTEX and total PAH concentrations, even though it was not significant at a 95% confidence interval. PDMW-01 has a high level of non-detect results for both total BTEX and total PAH, while PDMW-03 has a limited sampling set of only three events.

<u>Graphical Trend Analysis</u>

Plots of groundwater parameters and total BTEX and total PAH concentrations over time are presented in **Figure 16** for wells located downgradient of the Brightwaters Yard injection system lines. The groundwater impacts at OU-3 are primarily BTEX. Significant decreasing trends in total BTEX were identified in 19 of the 22 wells reviewed. Concentrations as high as approximately 160,000 ug/l have decreased through Q1 2009 from two to five orders-of-magnitude.

Downgradient significantly elevated total PAH concentrations were identified in one well, MW-80, at 522 ug/l. The historical concentrations of total PAH in this well are highly variable.

The above analysis indicates that reductions in total BTEX and total PAH concentrations have been observed in wells affected by the oxygen injection systems. Total BTEX and total PAH concentrations have remained consistent in the majority of the remaining wells. The variations in total BTEX and total PAH concentrations are attributed to remaining source material located downgradient of the Brightwaters Yard oxygen injection system on the Brightwaters Yard property and within the LIRR right-of-way.

Downgradient of Union Boulevard Oxygen Injection System

The oxygen injection system located along Union Boulevard consists of one injection line installed on the downgradient, southern side of Union Boulevard (**Figure 1**). The oxygen injection system has affected groundwater concentrations downgradient of the injection line, but past system component failures have reduced the overall system efficiency. New OM&M procedures have increased system efficiency over the last eight quarters (since Q1 2007). The groundwater analytical trends as they relate to observed groundwater quality parameters and system effectiveness are discussed in Subsection 4.1.3 and presented on **Figure 15**.

Statistical Trend Analysis

In OU-3 wells located downgradient of the Union Boulevard oxygen injection system, statistical decreasing trends were identified in one well for total BTEX and two wells for total PAH (**Tables 4-10** and **4-11).** This applied to the downgradient well with the highest median operating period concentrations for total BTEX (MW32W/W-R). No statistical trends were identified in the remaining wells. Although no statistical trends were identified in the remaining wells, 10 of the 13 wells had a negative Mann-Kendall Statistic (S) for total PAH, and 7 of 13 wells, had a negative statistic for total BTEX. These negative statistics indicate decreasing trends even though they were not significant at a 95% confidence interval. Many wells indicated with no trend had a short duration of sampling (four or less sampling events) or high number of non-detect results.

Graphical Trend Analysis

The effectiveness of the Union Boulevard oxygen injection system was evaluated by examining the trends of the monitoring wells located downgradient of the Union Boulevard oxygen injection line. Decreasing trends in total BTEX and total PAH concentrations were noted in seven and six of the 13 wells reviewed, respectively. Total BTEX and PAH concentrations in those wells have remained at or near detection levels throughout the monitoring period (BBMW-

29, BBMW-31S, BBMW-31I, BBMW-31D, MW-12W, MW-34D and MW-30W/W-R [total PAH only]).

For the three wells with total BTEX operational period median concentrations above 100 ug/l, MW-32W/WR, MW34S and MW-70/70S, concentrations decreased from approximately 130 ug/l, 74,000 ug/l and 58,000 ug/l to near detection levels in wells MW-32WR and MW-70/70S. In well MW-34S, total BTEX concentrations have significantly varied, apparently dependent on seasonal water level fluctuations.

For the single well with a total PAH operational period median concentration above 100 ug/l (120 ug/l in MW-34S), the Q1 2009 concentration was near its detection level.

In addition to the wells listed above the concentrations in wells further downgradient in the vicinity of O-Co-Nee Pond were also reviewed. Total BTEX concentrations were below detection limits at MWBS-02I and MWBS-02D in Q1 2009. The total BTEX concentration in MWBS-02S was 98 ug/l in Q1 2009. The concentration was only the second value recorded above the detection levels in the last 15 quarters. Total BTEX was last detected in MWBS-02S at a concentration of 8 ug/l in Q4 2007. Total BTEX concentrations in MWBS-02I have been below detection units for 18 of the last 19 quarters. Total BTEX was previously detected in MWBS-02I at a concentration of 17 ug/l in Q3 2008. Total BTEX was not present above detection limits in MWBS-02D in eight of the last nine quarters. Total BTEX at a concentration of 17 ug/l was last detected in MWBS-02D in Q1 2008.

The total PAH concentrations in MWBS-02I and MWBS-02D wells have been below detection limits for eight consecutive quarters. PAH were last detected in Q1 2007 at a concentration of 10 ug/l in MWBS-02I and at 22 ug/l in MWBS-02D. Total PAH concentrations were below detection limits at MWBS-02S in Q1 2009 and have been below detection limits for 13 out of the last 14 quarters. Total PAH concentrations were last detected in MWBS-02S, at a concentration of 7 ug/l, in Q2 2008.

4.2.5 Future Plans

- Continue annual and quarterly groundwater monitoring at selected wells.
- Continue monthly performance monitoring at selected wells located downgradient of the Brightwaters Yard in proximity to the oxygen injection lines.
- Excavate source material under LIRR tracks.

4.3 Institutional Controls/Engineering Controls (IC/EC)

- There has been no activity this quarter.

5. Soil Vapor and Ambient Air Sampling

5.1 Program Scope and Purpose

National Grid has conducted quarterly and monthly soil vapor and ambient air sampling events to evaluate the potential contribution of contaminants of concern (COC) from the OU-2 dissolved phase groundwater plume to soil vapor. Sampling events have been completed between May 2005 and March 2008. The first five sampling events (Q2 2005 through Q3 2006) were conducted using temporary soil vapor drive points in accordance with the NYSDEC-approved *Soil Gas Sampling Work Plan for the OU-2 Treatment Area*, dated May 15, 2005. Based on the soil vapor and equipment blank analytical results presented in the Q3 2006 OM&M report, all future sampling events were conducted using permanent soil vapor points in accordance with the NYSDEC-approved *Permanent Soil Vapor Point Installation Final Work Plan, Operable Unit No. 2 (OU-2) and Operable Unit No. 3 (OU-3), Bay Shore/Brightwaters Former Manufactured Gas Plant Site,* dated January 31, 2007 (GEI, 2007b).

5.2 Current Site Activity

During Q1 2009, three additional injection lines were installed in OU-2 as required in the OU-2 Remedial Decision Document. Per the requirements of the January 2009 Remedial Design Document, a number of additional soil vapor points were installed downgradient of and adjacent to the new injection lines. A number of the points were sampled at varying frequencies from daily to weekly to monthly during Q1 2009. Four additional soil vapor points were installed in OU-4 to monitor soil vapor during the injection of the S-ISCO. The following soil vapor and ambient air sampling activities were conducted as part of the OM&M program in Q1 2009.

- 155 samples (including 11 duplicate samples) were collected from 46 soil vapor locations and 5 samples were collected from 5 ambient air locations in Q1 2009.
- The soil vapor and ambient air sample locations represent 14 distinct areas as described below.

Soil Vapor/Ambient Air Sample Areas	Soil Vapor/Ambient Sample IDs
Upgradient of Operable Unit No. 1	OU1SG06, OU1SG07, OU1SG08
Upgradient of OU-1 Oxygen Injection Line	OZSG04, OZSG05
Downgradient of OU-1 Oxygen Injection Line/ Upgradient of 33 N. Clinton/Cooper Lane Injection Line	OZSG01, OZSG02, OZSG03[1], OU2SG14, OU2SG15
Downgradient of 33 N. Clinton Avenue Injection Line/ Upgradient of 9 N. Clinton Avenue Injection Line	OU2SG32, OU2SG20, OU2SG31, OU2SG19, OU2SG28, OU2SG21
Upgradient of 34 N. Clinton Avenue Injection Line	OU2SG16, OU2SG17, OU2SG18,
Downgradient of 34 N. Clinton Avenue Injection Line/ Upgradient of 9 N. Clinton Avenue Injection Line	OU2SG12, OU2SG22, OU2SG23, OU2SG38, OU2SG39, Ambient Air OU2AA04
Downgradient of 9 N. Clinton Avenue Injection Line/ Upgradient of Montauk Highway Injection Line	OU2SG24, OU2SG25, OU2SG26, OU2SG7, OU2SG29, OU2SG30, OU2SG06, Ambient Air OU2AA05
Upgradient of the Montauk Highway Oxygen Injection Line	OU2SG24, OU2SG25, OU2SG26, OU2SG29, OU2SG30, OU2SG06, Ambient Air OU2AA05
Downgradient of the Montauk Highway Injection Line/ Upgradient of Manatuck Lane Injection Line	OU2SG03, OU2SG04, OU2SG05, OU2SG10, OU2SG01, OU2SG02, OU2SG07 Ambient Air OU2AA01 and OU2AA02
Downgradient of the Manatuck Lane Injection Line	OU2SG08, OU2SG09 Ambient Air OU2AA03
Sidegradient of the Manatuck Lane Injection Line along Garner Lane	OU2SG13[2]
Downgradient of the Brightwaters Yard Injection System and Upgradient of the Union Boulevard Oxygen Injection System	OU3SG01
Background Location West of Lawrence Lake and Outside the Influence of the OU-2 and OU-3 Groundwater Plumes	OU2SG11
Downgradient of OU-4 S-ISCO Injection	OU4SV-1, OU4SV-2, OU4SV-3, OU4SV-4

Notes:

1. OZSG01-OZSG05 were destroyed during the installation of the barrier wall on OU-1 and subsequent activities. The points have been collected as temporary points and will be replaced at the completion of construction activities.
2. OU2SG13 was damaged during Q2 2007 and was replaced prior to the Q3 2007 sampling event.

5.3 Soil Vapor and Ambient Air Sampling Data

The Q1 2009 soil vapor and ambient air data are provided on the following tables and appendix.

- **Table 5-1 Summary of Soil Vapor Results for OU-1, OU-2, OU-3, and OU-4 –** presents the historical soil vapor data from the 46 permanent soil vapor points and the soil vapor data from the 155 samples collected during Q1 2009.
- **Table 5-2 Ambient Air Analytical Data –** presents the historic and Q1 2009 ambient air data.
- **Appendix D, Soil Vapor Analytical Results –** contains historical graphs of the soil vapor concentrations of analytes detected at any soil vapor point, as well as BTEX and Naphthalene historical plots. The periods when a treatment system was in operation are identified on each graph.

Soil vapor concentrations have varied widely between 2005 and 2009 at all locations monitored. The variations in concentrations have occurred both before the systems were installed and after the systems were in operation. These fluctuations occurred in the areas downgradient of the oxygen injection lines, upgradient of the injection lines, and west of Lawrence Lake outside of the influence of the groundwater plume. During Q1 2009, the concentrations detected at each soil vapor point were generally consistent with previous sampling events with three exceptions.

- The concentration of BTEX increased slightly at monitoring point OU2SG-17 when compared to previous sampling events. This location is along Cooper Lane and upgradient of the oxygen injection systems.
- Trichlorofluoromethane was detected in samples collected from monitoring point OU2SG-12. Trichlorofluoromethane is not found in the groundwater plume associated with the former MGP site. It is used as a refrigerant and a propellant for pesticides/insecticides. This location is downgradient from an injection line and there are no corresponding increases in the other three soil vapor points located downgradient of or adjacent to this injection line.
- The concentration of ethanol increased slightly in one of the three samples collected from OU2SG-09 on March 31, 2009. The concentrations in the other two samples were consistent with previous sampling events.

Low concentrations of VOCs were detected in ambient air before and after start-up of the oxygen injection system. Ambient air concentrations have not varied significantly from quarter to quarter. Frequent detections (compounds detected in more than 30% of samples collected) have been limited to low concentrations of 23 VOCs: benzene, ethylbenzene, toluene, xylenes, acetaldehyde, acetone, butane, 2-butanone, carbon disulfide, carbon tetrachloride, chloromethane, n-decane, dichlorodifluoromethane, n-dodecane, ethanol, n-hexane, n-octane, pentane, 2-propanol, 1,1,2-trichloro-1,2,2-trifluoroethane, trichlorofluoromethane, 2,2,4-trimethylpentane (TMP), and n-undecane. Benzene was detected in all five ambient air samples in Q1 2009 at concentrations ranging between 0.38 micrograms per cubic meter (ug/m^3) at OU2AA02 located downgradient of Montauk Highway, and 0.89 ug/m^3 at OU2AA01 located downgradient of Montauk Highway. All benzene detections were below the NYSDOH 95th percentile of typical background values for outdoor air in the five ambient air samples (OU2AA01, OU2AA02, OU2AA03, OU2AA04, and OU2AA05).

5.3.1 Soil Vapor Fate and Transport

The fate and transport of soil vapor in the subsurface is dependent on various chemical and environmental conditions that directly affect the concentrations detected (United States Environmental Protection Agency, 1997). These include the vapor pressure and the Henry's law constant of the individual COC present, the temperature and barometric pressure at the surface, and the moisture content and porosity of the vadose zone soils. A description of each of these chemical and environmental conditions and their effects on soil vapor fate and transport have been presented in previous OM&M reports and are summarized below.

- The higher the vapor pressure of a COC, the more readily it evaporates into the vapor phase.
- COC with a greater tendency to exist in the vapor phase have a Henry's law constant greater than 1, and compounds with a greater tendency to exist in the dissolved phase have a Henry's law constant less than 1.
- Generally, the higher the pressure, the more COC would tend to remain in the dissolved phase and the lower the pressure, the more COC would tend to release to the vapor phase.
- The soil moisture decreases permeability because moisture trapped in the pore space of the soil matrix inhibits or blocks vapor flow.

In addition, several other soil factors can influence the distribution of COC in the soil vapor. Preferential pathways such as sub-surface utilities, tree roots, and backfilled areas can allow vapor migration away from a source area. Conversely, impervious zones or layers such as clay/peat/organic soil layers, foundations, buried structures, or perched groundwater can trap or inhibit the flow of soil vapors.

During the 2007 hydrologic study completed in OU-2, the sharp increases in groundwater elevations noted during the two rainfall events provide an approximate guideline for the effects of other rainfall events. Based on the timeframe and the magnitude of the rainfall events observed, significant precipitation events within the one-week preceding a soil vapor-sampling event were identified below. As discussed above, these are events that could significantly affect the concentrations of COC detected in soil vapor at the site.

Sample Date	Recent Precipitation Date	Magnitude of Precipitation (in./day)	Description of Significant Precipitation Events
5/5/05	4/30/05	1.12	April 2005 was a wetter than average month 4.87 in. recorded (normal 4.13 in.)
8/30/05	--	--	A four-month drought occurred in the summer of 2005
6/14/06	6/7/06	1.27	June 2006 was a wetter than average month 5.34 in. recorded (normal 3.71 in.)
9/7/06	8/25/06 8/27/06	1.58 2.19	August 2006 was a wetter than average month 5.58 in. recorded (normal 4.48 in.)
2/22/07	2/14/07	1.05	Winter snow storm
5/24/07	--	--	April 2007 was a wetter than average month 6.72 in. recorded (normal 4.13 in.)
7/25/07	7/18/07 7/22/07	3.34 0.92	Both events occurred during Week 2 of the Hydrologic Study
12/18-19/07	12/13/07 12/16/07	0.82 0.85	December 2007 was a wetter than average month 4.64 in. recorded (normal 4.13 in.)
2/6-7/08	2/6/08 2/7/08	0.07 0.14	February 2008 was a wetter than average month 6.21 in. recorded (normal 3.33 in.)
2/19/08	2/18/08	0.48	
3/17/08	3/15/08	0.25	March 2008 was a wetter than average month 5.89 in. recorded (normal 4.76 in.)
3/21/08	3/19/08 3/20/08	0.91 0.30	
3/26-27/08	--	--	
6/13/08	--	--	June 2008 was a dryer than average month 3.17 in. recorded (normal 3.71 in.)
6/18-20/08	8/16/08 8/18/08 8/20/08	0.16 0.15 0.12	
6/23-25/08	8/21/08 8/23/08	0.27 0.05	
8/13/08	8/11/08	0.42	August 2008 was a dryer than average month 3.2 in. recorded (normal 4.48 in.)
9/16-19/08	9/9/08 9/12/08	0.50 0.59	September 2008 was a wetter than average month 7.46 in. recorded (normal 3.39 in.)
9/22-24/08	--	--	
9/30/08	9/26/08 9/27/08 9/28/08 9/29/08	2.39 0.50 0.20 0.11	
12/23/08	12/21/2008	0.41	December 2008 was a wetter than average month 6.68 recorded (normal 4.13 in.)
12/29-31/08	12/31/08	0.17	

Sample Date	Recent Precipitation Date	Magnitude of Precipitation (in./day)	Description of Significant Precipitation Events
1/20-26/09	1/18/09 1/19/09	0.13 0.03	January 2009 as a dryer than average month 3.2 in. recorded (normal 4.27 in.)
1/30/09	1/28/09	1.12	
2/5/09	2/3/09	0.31	February 2009 as a dryer than average month 1.79 in. recorded (normal 3.33 in.)
2/13/09	2/12/09	0.19	
2/16-21/09	2/18/09 2/19/09	0.69 0.05	
2/23/09	2/22/09	0.31	
2/27/09	2/27/09	0.24	
3/5/09	--	--	March 2009 as a dryer than average month 2.44 in. recorded (normal 4.76 in.)
3/12-13/09	--	--	
3/16-19/09	--	--	
3/23-24/09	--	--	
3/26/09	--	--	
3/31/09	3/29/09	0.67	

5.4 Future Plans

- Continued quarterly soil vapor and ambient air sampling.
- Continued daily/weekly/monthly soil vapor sampling per OU-2 OM&M Plan.

6. Operable Unit 4 – Watchogue Creek/Crum's Brook

6.1 Groundwater Monitoring

Program Scope and Purpose: Groundwater monitoring is conducted within OU-4 to aid in monitoring groundwater contamination, to evaluate the effectiveness of remedial activities and to aid in remedy planning. There were approximately 40 monitoring wells located in OU-4 during the Q1 2009 sampling event. The well locations and geographic boundaries of OU-4 are illustrated on **Figure 1**. The number of wells sampled each quarter is determined based on previous analytical data and discussions with NYSDEC.

6.1.1 Current Site Activity

The following groundwater monitoring activities took place in OU-4 during Q1 2009.

- Depth to groundwater measurements were obtained on January 27, 2009 from 37 monitoring wells located within OU-4.
- The surface water elevation was obtained on January 27, 2009 from a surface water gauge located in Watchogue Creek/Crum's Brook at Union Boulevard.
- Groundwater samples were collected from 34 monitoring wells located within OU-4. The groundwater samples were analyzed for an expanded list of VOCs (EPA Method 8260) and PAHs (EPA Method 8270).

6.1.2 Groundwater Elevation Data

The depth to groundwater, groundwater elevation and surface water elevation data for OU-4 are provided on the following tables and figures.

- **Table 6-1 Water Level Measurements and Calculated Groundwater Elevations –** provides depth to water measurements and calculated groundwater and surface water elevation data for OU-4 wells measured in Q1 2009.
- **Table 6-2 Historic Calculated Groundwater Elevations –** provide historic groundwater elevations for OU-4 for existing groundwater wells.
- **Figure 4 Shallow Groundwater Contour Map –** provides the Q1 2009 shallow groundwater elevation contours for OU-1, OU-2, OU-3 and OU-4.
- **Figure 5 Deep Groundwater Contour Map –** provides the Q1 2009 deep groundwater elevation contours for OU-1, OU-2, OU-3 and OU-4.

The groundwater flow direction in OU-4 is towards the southeast. The shallow groundwater hydraulic gradient is approximately 0.003 feet/foot. The deep groundwater hydraulic gradient is approximately 0.0036 feet/foot. The groundwater elevation in OU-4 monitoring wells during the Q1 2009 gauging event was an approximate average of 0.1 foot higher than the Q4 2008 groundwater elevations and an approximate average of 0.3 feet higher than the Q1 2008 groundwater elevations.

6.1.3 Groundwater Analytical Data

The OU-4 groundwater analytical data are presented on the following tables.

- **Table 6-3 Summary of Historic Total BTEX Groundwater Analytical Results –** presents a summary of historical total BTEX results for existing OU-4 groundwater monitoring wells.
- **Table 6-4 Summary of Historic Total PAH Groundwater Analytical Results –** presents a summary of historical total PAH results for existing OU-4 groundwater monitoring wells.
- **Table 6-5 Summary of Expanded Groundwater Analytical Results –** provides the Q1 2009 groundwater analytical results for monitoring wells located in OU-4 for each compound detected.

6.1.4 Groundwater Analytical Data Trend Analysis

Analysis of the trends of constituent concentrations for OU-4 groundwater wells were conducted on two levels: statistical and graphical. The periods of these trends cover the available historical data for past groundwater sampling events.

A statistical analysis typically used to assess trends in groundwater monitoring well concentration data is the Mann-Kendall method (Gilbert, 1987). This method is a non-parametric statistical that evaluates concentration trends over time, by comparing the relative difference in magnitude of data over time and assigning probability for the trends. One limitation of this statistical method exists for interpretation of remediation monitoring data sets of limited events.

The graphical trend analysis of groundwater monitoring well concentrations considers all of the concentrations for the same oxygen injection period as for the statistical period.

The highest median concentrations over 100 ug/l in wells located within OU-4 occurred only for total PAH and ranged from 169.5 ug/l in WCMW-4S and 1,113.5 ug/l in WCMW-3I.

Statistical Trend Analysis

A statistical trend for total BTEX in wells located in OU-4 was identified for one well, WCMW-01S, as an increasing trend. The concentrations in this well ranged from non-detect to 23 ug/l.

Statistical trends for total PAH in wells located in OU-4 were identified as significant decreasing trends in WCMW-03I, WCMW-03I2, WCMW-03S, and WCMW-05I. Additionally 17 out of 43 wells had non-detect results for all sampling events. Many wells identified with no trend for total BTEX or total PAH had a short duration of sampling (four or less sampling events) or high number of non-detect results.

Graphical Trend Analysis

In the four wells with median historical total PAH concentrations above 100 ug/l for Q1 2009 (WCMW-3S, WCM-W3I, WCMW-4S and WCMW-11S), the following is noted. In well MWCM-3S, the Q1 2009 concentration of 243 ug/l is similar to the historic median and within an associated stable trend. For well WCMW-3I, the Q1 2009 concentration of 142 ug/l is below the historic median of 961 ug/l and exhibits a decreasing trend. In well WCMW-4S, the concentration of 43 ug/l is below the historic median of 242 ug/l and exhibits a decreasing trend. Well WCMW-11S has not been sampled since second quarter April 2008.

6.1.5 Future Plans

- Continue annual and quarterly groundwater monitoring at selected wells.

6.2 Institutional Controls/Engineering Controls (IC/EC)

- There has been no activity this quarter.

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Tables (electronic only)

Tables also available at www.bayshoreworksmgp.com

Figures

Appendices A, B, C D and E (electronic only)

Appendix A: OU-1 Oxygen Injection System OM&M Data

Appendix B: OU-2 Oxygen Injection System OM&M Data

Appendix C: OU-3 Oxygen Injection Systems OM&M Data

Appendix D: Soil Vapor Analytical Results

Appendix E: Time Series Plots of Analytical Results for Groundwater Monitoring Wells