SHEPLEY'S HILL LANDFILL
2013 ANNUAL REPORT

SHEPLEY'S HILL LANDFILL

FORMER FORT DEVENS ARMY INSTALLATION, DEVENS, MA

JUNE 2014

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Shepley's Hill Landfill
2013 Annual Report

Devens, Massachusetts

June 2014

CERTIFICATION:

I hereby certify that the enclosed Report, shown and marked in this submittal, is that proposed to be incorporated with Contract Number W912WJ-10-D-0003 DO#0002. This Document has been prepared in accordance with USACE Scope of Work and is hereby submitted for Government Approval.

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

Accutest	Accutest Laboratories
ADR	Automated Data Review
Alpha	Alpha Analytical Laboratories Inc.
AMEC	AMEC Environment & Infrastructure, Inc.
AOC	Area of Concern
AR	Annual Report
ATP	Arsenic Treatment Plant
bgs	Below Ground Surface
BCT	BRAC Closure Team
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIP	Clean-in-place
CMR	Code of Massachusetts Regulations
COC	Contaminant of Concern
CSA/CAAA	Comprehensive Site Assessment and Corrective Actions Alternatives Analysis
CSM	Conceptual Site Model
cy	cubic yard
DEM	Digital Elevation Model
DPT	Direct Push Technology
DQO	Data Quality Objective
DTW	Depth to Water
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
EW	Extraction Well
FBRO	Filtered bottom roll-off
FM	flux maintenance
FS	Feasibility Study
FYR	Five Year Review
Gatsby	Gatsby Grounds Co. Inc.
Gilbride	Gilbride Electric
Global	Global Remediation Services Inc.
gpm	gallons per minute
IC	Institutional Controls
IPC	Inclined Plate Clarifier
LEL	Lower Explosive Limit
LGP	Landfill Gas Probes
LTM	Long-Term Monitoring
LTMMP	Long Term Monitoring and Maintenance Plan
LUCs	Land Use Controls
LUCIP	Land Use Control Implementation Plan
MA	Massachusetts
MassDEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level

MCP	Massachusetts Contingency Plan
MF	Microfiltration
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NAVD	North American Vertical Datum
NIA	North Impact Area
NTCRA	Non-Time Critical Removal Action
O&M	Operations and Maintenance
ORP	Oxidation reduction potential
PCBs	Polychlorinated Biphenyls
PID	Photoionization detector
POTW	Publicly-Owned Treatment Works
ppm	parts per million
psi	pounds per square inch
PVC	Polyvinyl chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QSM	Quality Systems Manual
RAO	Remedial Action Objective
RI	Remedial Investigation
ROD	Record of Decision
RQD	Rock Quality Designation
SDG	Sample Delivery Group
SOP	Standard Operating Procedure
SHL	Shepley's Hill Landfill
SVOCs	Semivolatile Organic Compounds
SWET	Stone & Webster Environmental Technology & Services
TPH	Total Polyaromatic Hydrocarbons
TMP	Trans-Membrane Pressure
TTO	Total Toxic Organics
USACE-NAE	U. S. Army Corps of Engineers, New England District
μg/L	Micrograms per liter
V-3	Valve-3
VOCs	Volatile Organic Compounds

1.0 INTRODUCTION

This Annual Report (AR) was prepared by Sovereign Consulting Inc. (Sovereign) for the U. S. Army to meet the required reporting for the Shepley's Hill Landfill (SHL), located at the former Fort Devens, Massachusetts. This AR discusses the operation and maintenance (O&M) of the existing groundwater extraction, treatment and discharge system, landfill monitoring and maintenance, and groundwater monitoring for 2013. These activities were conducted as part of monitoring under the *Revised Long Term Maintenance and Monitoring Plan* (LTMMP) (CH2M HILL, 2007), which was further amended after the 2008 AR (ECC, 2009). In addition, this AR also provides a discussion and presents data collected as part of investigation activities completed in 2013 in the North Impact Area (NIA) as well as the barrier wall performance monitoring conducted in 2013 to document the groundwater hydraulics and hydraulic gradients on the east and west sides of the barrier wall.

1.1 Background

The former Fort Devens, Massachusetts (MA) is located approximately 35 miles northwest of the city of Boston, within the towns of Ayer, Shirley (Middlesex County), Harvard and Lancaster (Worcester County). The former Fort Devens was established in 1917 for military training and logistical support during World War I. Fort Devens became a permanent base in 1931, and continued service until its Base Realignment and Closure (BRAC) Committee closure in 1996. **Figure 1-1** depicts the area and topography of the former base and surrounding area.

SHL encompasses approximately 84 acres in the northeast corner of the main post of the former Fort Devens, as shown on **Figure 1-2**. The landfill is bordered to the northeast by Plow Shop Pond, to the west by Shepley's Hill, to the south by recent commercial development, and to the east by land formerly containing a railroad roundhouse. Nonacoicus Brook, which drains Plow Shop Pond, is located north of the landfill. The northern impacted area (NIA) is depicted on **Figure 1-3**.

SHL was reportedly operating by the early 1940s; however, evidence from test pits within the landfill suggests earlier usage, possibly as early as the mid-nineteenth century. The landfill contains a variety of waste materials including, but not limited to, incinerator ash, demolition debris, asbestos, sanitary wastes, and glass. The maximum depth of the refuse occurs in the central portion of the landfill and is estimated to extend about 40 feet below ground surface (bgs). The volume of waste in the landfill has been estimated at over 1.5 million cubic yards (cy), of which approximately 160,000 cys (11%) is below the water table. The saturated wastes appear to be emplaced in a wetland; at least two areas previously mapped as wetlands were filled (Harding ESE, 2002), and the waste has been found to be underlain by peat deposits (Sovereign, 2011).

The Massachusetts Department of Environmental Protection (MassDEP) approved the landfill closure plan in 1985. The landfill was closed in five phases between 1987 and 1993 in accordance with 310 Code of Massachusetts Regulations (CMR) 19.000. Closure consisted of capping the landfill with a 30 to 40-mil polyvinyl chloride (PVC) membrane, covering the cap with soil and vegetation, and installing gas vents. Closure also included installation of wells to monitor groundwater quality around the landfill and construction of drainage swales to control surface water runoff. MassDEP issued a Landfill Capping Compliance Letter approving the closure in February 1996.

Subsequent to closure of the landfill, remedial investigations (RIs) completed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) evaluated soil, sediment, surface water, and groundwater conditions at and in the immediate vicinity of the landfill. The results confirmed the presence of various contaminants, particularly certain inorganics, including arsenic and volatile organic compounds (VOCs), in groundwater, sediment, and surface water at and adjacent to SHL. A Feasibility Study (FS) and Record of Decision (ROD) resulted in a remedy that required long term monitoring including maintenance of the existing landfill cap and groundwater monitoring. **Table 1-1** lists the relevant contaminants of concern (COCs) and their target cleanup levels.

As described in the ROD (USAEC, 1995), the remedial response objectives are to:

- Protect potential residential receptors from exposure to impacted groundwater migrating from the landfill having chemicals in excess of maximum contaminant levels (MCLs); and,
- Prevent impacted groundwater from contributing to the contamination of Plow Shop Pond sediments in excess of human health and ecological risk-based concentrations.

The ROD required the Army to perform groundwater monitoring and five-year reviews to evaluate the effectiveness of the selected remedial action, which at the time relied heavily on the landfill cap to attain groundwater cleanup goals by 2008 and to reduce potential exposure risks. If groundwater contaminant concentrations, primarily arsenic, met risk-based performance standards (cleanup goals) over time, the ROD did not require further action; however, if cleanup goals were not met, the ROD required implementation of a groundwater extraction contingency remedy. Due to continued contaminant concentrations greater than MCLs, the Army installed and began operating a groundwater extraction and treatment system in March 2006 as a contingency remedy to address groundwater contamination emanating from the northern portion of the landfill (Sovereign, 2011a). Initially the system was operated at an extraction rate of 25 gallons per minute (gpm). In July 2007 the extraction rate was increased from 25 gpm to the full capacity of the plant. Since 2008, the system has been operated at full capacity and in 2013 achieved an average on-line extraction rate of 49.6 gpm.

In 2012, available data indicated that the landfill capping and groundwater extraction remedies did not eliminate groundwater flow and arsenic migration from SHL into Red Cove / Plow Shop Pond, identified as Area of Contamination (AOC) 72. The AOC 72 RI results suggested that groundwater discharge contributes arsenic to sediment that may accumulate to levels resulting in conditions that pose unacceptable risks, and therefore remedies that minimized arsenic-in-groundwater flux to Red Cove would be most protective (AMEC, 2011). Consequently, a low-permeability groundwater barrier wall was installed between the SHL and AOC 72 as part of a Non-Time Critical Removal Action (NTCRA) from August to September 2012 to mitigate arsenic flux to Red Cove/Plow Shop Pond by groundwater flow from the SHL. Documentation of the barrier wall installation was provided in the Removal Action Completion Report (Sovereign, 2013a).

1.2 5-Year Review Status

Stone & Webster Environmental Technology & Services (SWET) conducted the first two years of landfill post-closure monitoring in 1996 and 1997. These first two years of monitoring were included in the first *Five Year Review (FYR), Shepley's Hill Landfill, Long Term Monitoring* (SWET, 1998) which was issued five years after the final capping of the landfill in 1993. The United States Army Corps of Engineers, New England District (USACE-NAE) conducted the monitoring between 1998 and 2005. In 2000, a comprehensive review of all Former Fort Devens sites was performed and detailed in the *Five Year Review Report for Devens Reserve Forces Training Area, Devens, MA* (HLA, 2000) which included monitoring conducted for Shepley's Hill Landfill Operable Unit from 1996 through 1999. A second comprehensive FYR was completed in 2005 (Nobis, 2005) and included monitoring conducted from 1999 through 2004. In this review the Army and United States Environmental Protection Agency (EPA) deferred the protectiveness statement for the Shepley's Hill Landfill Operable Unit pending completion of landfill cap maintenance in 2009 to repair depressions in the cap and the *Comprehensive Site Assessment Corrective Actions Alternatives Analysis* (CSA/CAAA) which was replaced by the *Draft Final Supplemental Groundwater and Landfill Cap Assessment for Long-Term Monitoring and Maintenance* report issued in June 2009 (AMEC, 2009).

The third comprehensive FYR was completed in 2010 (HydroGeoLogic, 2010) and discusses the Contingency Remedy performance. With respect to the effectiveness of remedial measures, including landfill cap maintenance and the Contingency Remedy, the following conclusions were presented:

- The landfill cover is functioning as designed.
- The Arsenic Treatment Plant (ATP), as presently operated and maintained, consistently meets the effluent limit of 200 µg/L of arsenic in the discharged water, as well as all other requirements of the discharge permit.
- The 2009 hydraulic capture zone assessment indicates that, at the typical peak operating flow rate of 49 gpm, the extraction well field captures the majority of arsenic mass migrating northward from the landfill. In general, arsenic concentrations in the LTMMP wells remain relatively stable or, in some cases are decreasing, compared to historic levels.
- Even in the areas where the ATP is expected to provide the greatest decreases in contaminant levels, the levels may not meet remediation objectives if the strong reducing conditions that have been established in the aquifer continue to mobilize naturally-occurring arsenic.
- Overall, the Contingency Remedy, when coupled with the landfill capping system and Institutional Controls (ICs) that prevent use of the aquifer as source of drinking water, partially achieves the Remedial Action Objectives (RAOs) of the ROD.

Based on these conclusions and a technical assessment of onsite and offsite conditions the 2010 FYR made the following recommendations:

- The ROD does not include ICs prohibiting groundwater use in the impacted area, and therefore, the Army should prepare a ROD Amendment that will formally specify the ICs that prohibit the use of groundwater within the impacted area.
- The remedy may not achieve the groundwater cleanup goals for arsenic, and the ROD does not include specific RAOs for the restoration of groundwater within the "impacted area". Therefore, the Army should develop a remedial alternative that will effectively meet RAOs and cleanup goals established as part of an updated remedy that specifically addresses the current site conditions.
- Impacted groundwater is discharging to Plow Shop Pond, and therefore, the Army should develop a remedial alternative that will effectively meet RAOs and cleanup goals established as part of an updated remedy that addresses the groundwater discharge to Plow Shop Pond.

Lastly, with regard to the Protectiveness Statement, the 2010 FYR concluded the SHL remedy is considered protective in the short-term, because there is no evidence of current exposure. However, in order for the remedy to remain protective in the long-term, an updated SHL remedy must incorporate ICs that restrict the installation of private drinking water wells throughout the "Impacted Area" and effectively meet RAOs to address both groundwater restoration within the "Impacted Area" and groundwater discharging to Plow Shop Pond.

1.3 Remedy Updates and Assessments

In order to assess the adequacy of the landfill cap and the overall remedy at mitigating risks, a *Supplemental Groundwater Investigation and Landfill Cap Assessment* (AMEC, 2009) was initiated by the Army in 2005. The report confirmed potential risks related to arsenic in groundwater in the impacted area north of the capture zone of the groundwater treatment system as previously documented by the Army in the SHL *Record of Decision* (USAEC, 1995) and the SHL *Supplemental Groundwater Investigation* (Harding ESE, 2003). A *Supplemental Groundwater Investigation and Landfill Cap Assessment for Long-Term Monitoring and Maintenance – Addendum Report* (Sovereign, 2011a) addressed remaining uncertainties with respect to the extent of impacts in the NIA and long-term source persistence. The October 2013 Draft LTMMP (Sovereign, 2013b) also addresses continued efforts to monitor impacts in the NIA.

The Red Cove area of Plow Shop Pond was addressed as part of the RI for AOC 72 (AMEC, 2011). Based on the conclusions put forth in the *Statement of Army Position Following Withdrawal of the Draft Final Focused Feasibility Study for Shepley's Hill Landfill, Devens, MA* (US Army, 2012) and the *AOC 72 Engineering Evaluation/Cost Analysis* (Sovereign, 2011b), which examined long-term remedies for Red Cove sediments, the Army completed construction of a barrier wall in 2012 to mitigate arsenic flux to Red Cove following the completion of a *Final Engineering Evaluation/Cost Analysis, Shepley's Hill Landfill Barrier Wall, Former Fort Devens Army Installation, Devens, Massachusetts (*Sovereign, 2012a) and a *Final Action Memorandum, Shepley's Hill Landfill Barrier Wall, Former Fort Devens Army Installation, Devens, Massachusetts (*Sovereign, 2012b). Barrier wall construction details were presented in the *Final Removal Action Completion Report for Shepley's Hill Landfill Barrier Wall, Former Fort Devens Army Installation, Devens, Massachusetts (*Sovereign 2013a).

In December 2013, a final Explanation of Significant Differences (ESD) was submitted to outline the Land Use Controls (LUC) implemented to restrict groundwater use and protect potential residential receptors from exposure to impacted groundwater migrating from the landfill (Sovereign, 2013c). A Land Use Control Implementation Plan (LUCIP) will be prepared to describe the actions for all LUCs described in the ESD, including implementation, maintenance and periodic inspections. A draft LUCIP (Sovereign, 2014a) was submitted to BRAC Closure Team (BCT) for review and comment in February 2014.

1.4 Objectives

2013 was the sixth year of monitoring under the Revised LTMMP (CH2M HILL, 2007) and the eighth complete year of operation of the Contingency Remedy. The objectives of this Annual Report are as follows:

- Summarize landfill maintenance activities;
- Document landfill cap inspection to identify areas requiring future maintenance;
- Present landfill gas measurements at 18 gas vents and 26 permanent landfill perimeter gas monitoring wells to establish long-term trends with regard to gas production and venting;
- Summarize operations, maintenance, sampling, and reporting associated with the ATP and provide recommendations for any modifications;
- Present results of LTMMP groundwater hydraulic and analytical monitoring including COC concentrations, field parameters, and a complete well elevation survey; and
- Update the assessment of system hydraulic performance last presented in the 2012 AR based on data collected in 2013.

In addition to the recurring events detailed above, the AR also presents the results of any additional events performed throughout the year. In 2013, a groundwater investigation was conducted in the NIA to assess arsenic impacts in that area, and the results of this investigation are presented in this AR. In addition, a performance monitoring program was initiated in November 2012 and completed in April 2013 to document the groundwater hydraulics and hydraulic gradients on the east and west sides of the barrier wall. The results of this program are also presented in this AR.

1.5 Report Organization

Section 2 of this report documents the routine landfill maintenance and inspection activities, and also includes the results of gas monitoring in both gas vents and perimeter soil gas wells. **Section 3** of this report presents the ATP operations, maintenance, and monitoring. **Section 4** summarizes groundwater profiling activities conducted in the NIA and arsenic distribution findings. **Section 5** summarizes the LTMMP groundwater monitoring results including synoptic water levels, barrier wall hydraulic performance monitoring, arsenic concentrations and other water quality data. **Section 6** presents the latest system performance assessment. Finally, **Section 7** presents conclusions and recommendations for future system operations, monitoring, and assessments.

2.0 LANDFILL MAINTENANCE AND MONITORING

As required by the LTMMP (CH2M Hill, 2007), the SHL was inspected and routine maintenance performed in 2013. The annual inspection identifies and corrects any problems pertaining to the effectiveness of the cap system, erosion, and the conditions of vents and sampling points. A summary of the landfill cap maintenance, findings of the inspection, and results of landfill gas sampling are presented in the following sections. The landfill inspection checklist and supporting photographs are presented in **Appendix A**.

2.1 General Landfill Maintenance

The landfill was mowed on September 25 and 26, 2013 by Gatsby Grounds Co., Inc. of Lancaster, MA (Gatsby). The portions of the landfill in the vicinity of the barrier wall were not mowed during the annual mowing event as the vegetative growth is this area was less than six inches in height. Small shrub growth on the margins of the landfill was removed during the mowing event to maintain an effective cap system. Small shrub and tree growth was also removed from the rip-rap swales along the northern portions of the landfill in the vicinity of the ATP building. Small vegetative growth was also removed from the southern drainage swale. The eastern drainage swale was partially disturbed during Plow Shop Pond (Red Cove) construction activities and necessary repairs to the swale were completed following the completion of the construction activities in the area.

On September 25, 2013 during the first day of the mowing event, a clean-out for the ATP effluent line located on the landfill was struck and damaged by the mower. Due to the damage, the plant was shutdown until temporary repairs could be made on September 26, 2013. Permanent repairs which consisted of replacing the clean-out and its associated couplings and fittings were made on October 2, 2013. To prevent damage to the effluent line in the future, markers were placed periodically along the effluent line and specifically over all clean-out locations in October 2013.

In the 2012 SHL AR, it was recommended that all monitoring wells and piezometer locks be replaced by one standard master lock with one universal key to reduce costs associated with the long-term replacement of locks throughout the monitoring program. The replacement of all locks with one standard master lock and universal key was completed in June 2013. Additionally, the 2012 AR recommended that screens be installed on the gas vents located in the southern portion of the landfill to prevent any wildlife or debris from entering the vents. Consequently, screens were installed on gas vents in the southern portion of the landfill during June 2013.

As noted below in **Section 2.2**, the northern end of the landfill access road exhibited evidence of erosion during the annual landfill inspection. The erosion is assumed to be the cumulative result of heavy precipitation events. On November 26, 2013, Gatsby, under the direct supervision of Sovereign, completed repairs to the northern end of the landfill access road. Repair activities included the regrading of the eroded areas with existing material followed by application of ¾-inch stone to prevent future erosion. The access road repair activities were inspected by Sovereign during subsequent ATP O&M visits, including during times of heavy precipitation. Repairs and re-grading appeared be sufficient in preventing further erosion of the access road in this area.

2.2 Landfill Inspection

On October 4, 2013, Sovereign conducted an annual inspection of the Shepley's Hill Landfill as required by the LTTMP. Features of the landfill that were inspected included the cover system, drainage system, gas vent system, access road, monitoring wells and piezometers. Observations were made regarding the vegetative cover, vegetative types, erosion, settlement and general conditions. The overall condition of the landfill was satisfactory.

A summary of findings and observations are presented below and within the landfill inspection checklist included in **Appendix A** along with supporting photographs.

2.2.1 Cover Surface

There was no evidence of poor conditions affecting the cover surface. No new depressions were observed on the cover surface. No new tree or shrub growth was observed on the landfill surface, and observed growth in the drainage areas was removed during the September 2013 mowing event.

2.2.2 Vegetative Growth

The vegetative growth was normal and appeared to have no major stressed area. The landfill had been properly mowed during the September 2013 mowing event prior to the inspection. The portions of the landfill in the vicinity of the barrier wall were not mowed during the annual mowing event as the vegetative growth is this area was less than six inches in height. During the construction activities associated with the dredging of Plow Shop Pond (Red Cove), portions of the eastern edge of the landfill were disturbed. Upon completion of Red Cove construction activities, the area was re-graded and seeded to prevent erosion of the eastern slope.

2.2.3 Landfill Gas Vents and Gas Points

The landfill gas vents were observed to be in good condition. All pipes are functioning and screens are present on vents to prevent any wildlife or debris from entering the vents. Additionally, all landfill gas points were observed to be in good condition.

2.2.4 Monitoring Wells and Piezometers

All monitoring wells and piezometers currently part of the LTMMP network are all in good condition, with the exception of SHP-99-34A. SHP-99-34 is a stick-up piezometer located along the Molumco Road in which the steel casing of piezometer was observed to have been damaged to the extent the piezometer cannot be gauged or sampled. It was observed that the road boxes and concrete pads of flush-mounted wells SHM-05-41A through C have deteriorated to a condition in which the covers cannot be properly secured. Additionally, it was observed during the May 2013 site-wide gauging event that the standpipe caps of SHL-5, SHL-8S/D, SHL-15, SHL-18, SHL-19, SHL-21, and SHL-23, which are wells currently part of the LTMMP, are in need of repair in order to properly secure their respective caps with locks.

2.2.5 Drainage Swales

Most of the southern drainage swale exhibited vegetative growth. Large growth was removed during the September 2013 mowing activities. Small growth and wetland plant life were not disturbed, as they have become a natural retardant to erosive forces. The northern drainage swales in the vicinity of the ATP also exhibited vegetative growth. Large growth was removed from the drainage swales during the September 2013 mowing event, and only small growth remained during the October inspection.

2.2.6 Settlement

No new depressions were observed within the landfill.

2.2.7 Erosion

Due to Plow Shop Pond (Red Cove) construction activities, some erosion was observed along a portion of the eastern edge of the landfill. After Red Cove construction activities concluded, the disturbed eastern portions of the landfill were re-graded and seeded. It is anticipated that the vegetation will re-grow and prevent further erosion in the area. There were no other areas of concern with the cover system.

2.2.8 Access Roads

The southern portion of the access road was observed to be in good condition. The northern end of the landfill access road exhibited evidence of erosion assumed to be the cumulative result of heavy precipitation events. As noted in **Section 2.1**, repairs have been made to the northern end of the access road to prevent further erosion in the area.

2.2.9 Culverts and Catch Basins

Catch basins and culverts along the northern portion of the landfill were in good condition. Some growth was removed during the September 2013 mowing event along the entrance road to the ATP building to ensure proper use. The catch basins and culverts along the southern portion of the landfill were also in good condition.

2.2.10 Security/Fencing

There is no perimeter fencing along much of the wooded western boundary of the landfill (along Shepley's Hill); however, no roads have open access to the landfill. No breaches requiring repair were observed in the existing fence sections. Fence gates across roads that access the landfill are secured with chains and padlocks. A security fence surrounds the arsenic treatment plant. A portion of the perimeter fencing was removed in the vicinity of Red Cove during dredging activities. New fencing, including a gate, was installed in the area at the conclusion of construction activities in November 2013.

2.2.11 *Wetland Encroachment*

Wetland encroachment is taking place at several locations in and adjacent to drainage swales, but individual areas of encroachment are infrequent and small. Wetland encroachment is continually controlled by mowing the landfill surface and existing wetland species growth close to swales. This action will prevent the development and expansion of a wetland beyond the swale areas already invaded by the wetland species.

2.3 Recommendations

The following is a summary of recommendations following the annual inspection of Shepley's Hill Landfill. Further recommendations are detailed in the landfill inspection checklist included in **Appendix A.**

- The steel casing of piezometer SHP-99-34A was observed to have been damaged to the extent that gauging of the piezometer is no longer possible. SHP-99-34A was removed from the hydraulic monitoring program as part of the Draft *Long Term Monitoring and Maintenance Plan Update* (Sovereign, 2013b). It is recommended that this well is properly abandoned.
- Road boxes of flush-mounted wells SHM-05-41A through C have deteriorated to a condition in which the covers cannot be properly secured. It is recommended that the road boxes of flush-mounted wells SHM-05-41A through C be replaced. It is anticipated that these repairs will be conducted in summer 2014.
- The standpipe caps of the some wells currently in the LTMMP (SHL-5, SHL-18, SHL-21, and SHL-23) are in need of repair in order to properly secure the cover with a lock. It is recommended that repairs are made to the caps of those stick-up wells within that remain part of the long term monitoring (LTM) program following finalization the LTMMP Update anticipated in 2014. It is anticipated that this will occur in summer 2014.
- Swales should be monitored for expanded growth of wetland species and vegetative growth during each annual inspection.
- Mowing should be continued on an annual basis to maintain the effectiveness of the cover system.

2.4 Landfill Gas Monitoring

Annual sampling of landfill gas vents and landfill gas points (LGPs) was completed by Sovereign personnel on November 13, 2013. Sampling activities were conducted in accordance with procedures described in the MassDEP Landfill Technical Guidance Manual. Landfill gas sampling included the following parameters:

- VOCs concentration in parts per million (ppm);
- Percent oxygen (O_2) concentration in ppm;
- Hydrogen sulfide (H_2S) concentration in ppm;
- Percent lower explosive limit (LEL);
- Carbon monoxide (CO) concentration in ppm;

- Percent carbon dioxide (CO_2); and
- Percent methane (CH_4).

The landfill gas sampling was conducted using properly calibrated equipment. A LandTech Gem 5000 was used to measure CO_2 and CH_4, and a QRAE+ multi-meter was used to measure CO, H_2S, LEL and O_2. An Ion Science Tiger photoionization detector (PID) was used to measure total VOCs. Each gas sampling device was connected directly to the sampling port at the top of the probe/vent to measure initial levels of gas concentrations. After the initial measurements were recorded, two probe/vent volumes were purged from each probe/vent. Following purging, the gas sampling equipment was connected directly to the sampling port and post purge gas concentrations were measured and recorded. Refer to **Figure 2-1** for locations of landfill gas vents and LGPs. Results of the annual landfill gas monitoring are presented in **Table 2-1** and are discussed in the following sections. Refer to **Table 2-2** for landfill gas probe construction details.

2.4.1 Perimeter Gas Monitoring and Results

Annual LGP monitoring was performed by Sovereign personnel on November 13, 2013 during which barometric pressure ranged from 29.91 to 29.98 inches Hg. A rain storm had occurred on the previous day resulting in moist soil conditions. Elevated levels of methane/LEL were not detected in LGPs located in the northern end of the landfill. Elevated levels of methane/LEL were detected in three LGPs located on the southern perimeter of the landfill. Initially elevated levels of methane were detected in LGP-05-05X, LGP-09-05X, and LGP-09-08X, however; following purging, methane levels were not detected above instrument detection limits.

2.4.2 Landfill Gas Monitoring and Results

Annual landfill gas vent monitoring was performed by Sovereign personnel on November 13, 2013 in conjunction with the annual LGP sampling.

Overall, gas vents in the southern section of the landfill exhibited the highest levels of methane/LEL and CO_2. However, the 2013 gas monitoring results in the southern end of the landfill are lower than historical levels in this area. Post purge methane levels ranged from below instrument detection limits in gas vents GV-1 through GV-13, GV-16, and GV-17 to 18.9% in gas vent GV-18. Post purge CO_2 levels ranged from below instrument detection limits in gas vents GV-1 through GV-11 to 17.9% in gas vent GV-18. Post purge O_2 levels ranged from 3.2% in gas vent GV-18 to 20.9% in gas vents GV-1 through GV-6 and GV-9. Post purge VOCs levels ranged from below instrument detection limits in the majority of the gas vents to 0.3 ppm in gas vent GV-14. All of the landfill gas vents exhibited levels of CO below instrument detection limits. Levels of H_2S were below instrument detection limits in all of the landfill gas vents as well.

3.0 ARSENIC TREATMENT PLANT OPERATIONS, MAINTENANCE AND MONITORING

The Shepley's Hill Landfill ATP treated and discharged approximately 22.1 million gallons of groundwater between January 1 and December 31, 2013, bringing the cumulative discharge total to approximately 143.2 million gallons since system startup in 2006.

3.1 Operations

The operations, maintenance, and monitoring history for the ATP for the period from January 1 through December 31, 2013 is presented in the following sections.

3.1.1 System Description

The treatment system is designed to remove dissolved arsenic from extracted groundwater through co-precipitation with iron followed by microfiltration. The treatment system is housed in a 40-foot by 40-foot steel building and consists of the following components:

- Extraction system (two extraction wells);
- Chlorine dioxide (ClO_2) generation and addition;
- Coagulation via a contact tank with a direct drive batch tank mixer;
- Microfiltration (MF) of oxidized solids;
- Solids removal via an inclined plate clarifier (IPC);
- Bag filtration and discharge of the IPC decant water;
- Polymer aided flocculation of sludge using a filter bed roll-off (FBRO); and,
- Discharge to the Devens Publicly Owned Treatment Works (POTW).

The extraction system consists of two extraction wells (EW) located at the northwestern portion of the landfill cap. These extraction wells, EW-1 and EW-4, are capable of achieving the required combined extraction rate of 53 gpm by either operating simultaneously or independently of one another to maximize plant influent flow. Subsequently, groundwater enters the ATP influent stream and is dosed with chlorine dioxide which oxidizes and precipitates the inorganic metals, including arsenic, iron, and manganese. These precipitates are then filtered by the MF system and the effluent or treated water is discharged to the Devens POTW collection system. Every 15 minutes, the MF control unit conducts flux maintenance (FM), which backwashes the filtered precipitates from the membranes. These solids are fed to the IPC and allowed to settle out of suspension and form a residual sludge. The backwash effluent supernatant is fed through two bag filters configured in parallel and discharged to the plant effluent sump. The sludge is then pumped out of the IPC, dosed with polymer to increase flocculation, and carried over to the FBRO. The accumulated sludge is removed from the plant at least twice a month for disposal.

A summary of on-line hours, flow totals, and operating status for each month is shown in **Table 3-1**. Historical monthly treatment totals are shown in **Table 3-2**.

3.1.2 System Efficiency and Routine Maintenance

During 2013, the treatment plant was operational approximately 85% of the total available hours during the calendar year. A significant part of the non-operational time is due to routine plant maintenance and system repairs and performing clean-in-place (CIP) maintenance on the microfiltration skid. Additional downtime is associated with non-routine systems maintenance and repairs as noted below in **Section 3.2.** When online, the plant achieved an effective average extraction rate of 49.6 gpm which is an increase of 2.8 gpm from the average online extraction rate of 46.8 gpm in 2012.

The ATP system continues to generate a significant amount of sludge, requiring the FBRO to be emptied after treatment of approximately 1,000,000 gallons of groundwater. The primary cause of the high sludge generation is the high concentration of inorganics (primarily iron) in the influent. Influent arsenic concentrations have continued to decrease when compared to influent arsenic concentration at the time of startup of the ATP in 2006; however, the average annual combined inorganic concentrations (iron, arsenic, and manganese) remain high at approximately 61.2 parts per million (ppm). Influent inorganic loading is discussed in more detail in **Section 3.3.1.**

A subcontracted vendor, Global Remediation Services Inc. (Global), uses a vacuum truck to vacuum the dewatered sludge from the FBRO. The sludge is transported by Global under a Non-Hazardous Waste Manifest for disposal at Turnkey Landfill, which is operated by Waste Management in Rochester, New Hampshire. By coordinating FBRO pump-outs with Global before the container was full, Sovereign optimized the sludge removal process which resulted in zero downtime for the ATP in 2013 due to the FBRO operations. The FBRO pump-out history for 2013 is shown in **Table 3-3**.

The ATP microfiltration system continues to require periodic CIP procedures to prevent long-term fouling of the filter membranes. The CIP procedure is a multistep process that begins by flushing potable water though the MF skid after it is taken offline. Next, a 98% sulfuric acid (H_2SO_4) solution is cycled though the MF skid followed a flush of potable water, a cycle of a 25% sodium hydroxide (NaOH) solution and then another flush of potable water. Prior to restart, the MF skid is filled with potable water one last time. The acid and caustic solutions are cycled through the MF skid at approximately 90°F and allow for the dissolution of the iron and manganese precipitate that accumulate on the filter membranes during forward flow.

Modifications have been made to the CIP procedure since March 2009. Prior to March 2009, the CIP events were conducted for approximately 30 hours every two weeks. The Army has continued to optimize system operations, and currently CIP events are conducted approximately every 17 to 25 days. The optimization was accomplished by further modifying the CIP procedure in 2013 to include air scouring during acid and caustic circulation to facilitate the removal of precipitate. This modification appears to have increased the effectiveness of the CIP events, thereby increasing the time between CIPs and also resulting in a greater average extraction rate.

Optimizations to the CIP process have reduced the likelihood that an extended CIP (prolonged acid and caustic circulation times) or double CIP (acid solution recirculation/soak repeated after caustic solution recirculation) is conducted. Currently, extended CIPs are only conducted in situations where the level of MF fouling is greater than normal, most likely as a result of non-optimal dosage concentration of chlorine dioxide. The CIP process continues to be evaluated and refined to improve the process and minimize system non-pumping time. All system non-operational time associated with CIP procedures are detailed in **Table 3-1** for each month.

3.2 Non-Routine System Maintenance, Repairs, and Upgrades

This section details major system non-routine maintenance activities encountered or implemented, along with system upgrades completed during 2013. All shutdown and maintenance events along with associated system downtimes are included in **Table 3-1** for each month.

3.2.1 Chlorine Dioxide System Solenoid Valve Replacement

On January 24, 2013, following the restart of the system upon the completion of CIP activities, the solenoid valve on the ClO_2 generation system's potable water booster pump failed. A new solenoid valve was ordered and replaced on the booster pump on January 28, 2013.

3.2.2 Effluent Pump Motor Starter and Overload Replacement

On March 25, 2013, following effluent pump alarms and troubleshooting efforts, Sovereign provided oversight of Gilbride Electric of Chelmsford, Massachusetts (Gilbride) during repairs made to the system's two effluent pumps. Gilbride replaced the magnetic motor starters and electronic solid state relays on both pumps.

3.2.3 Microfiltration Air Header Replacement

During a regular O&M event on May 24, 2013, it was observed the pressure in the compressed air tank was only dropping approximately 15 psi during a MF backwash air scour. The compressed air tank should decrease in pressure by approximately 30 to 35 psi during each backwash air scour. The air header lines on the MF skid were inspected and found to be partially or fully obstructed with precipitate and deemed unfit for further use. Since the plant cannot operate without the backwash air scour, the plant remained offline until the appropriate replacement parts could be obtained. On May 28, 2013, parts to reconstruct the air header lines arrived, were assembled and installed. Replacing the MF skid air header lines allowed for greater air flow over the MF modules during backwash air scours thus increasing backwash efficiency. In turn, this allowed for more water to be treated between CIP events.

3.2.4 Chlorine Gas Regulator Replacement

During a routine chlorine gas cylinder swap on April 12, 2013, it was observed that one of two chlorine gas regulators was not sealing properly to any of the chlorine gas cylinders. The problematic regulator was removed from service for further inspection. The regulator's internal components were replaced where possible and the entire unit was cleaned of residual material build up. The regulator was returned to service on April 16, 2013.

During a regular O&M event on May 22, 2013, an inspection of both chlorine gas regulators revealed the potential for further operational issues. It was decided that replacement of both regulators was warranted because of the possibility of reduced performance as well as concerns regarding safety. Two new chlorine gas regulators were purchased and installed during scheduled chlorine swaps to minimize downtime. One was installed on June 28, 2013 while the second was installed on July 15, 2013.

3.2.5 Level Transducer Controller Reset

On September 11, 2013, the treatment system went offline due to a power failure caused by a tree that had fallen on Devens Electric power lines. During the restart attempt it was discovered that the water level transducer controller was not accurately reading the water level in the supernatant side of the inclined plate clarifier. Further investigation indicated that a power surge just before the power outage resulted in the level transducer controller to be reset to factory settings. In order to allow communication from the water level transducer controller to the recycle pump that empties the clarifier when full, the controller needed to be reprogrammed to detailed specifications. The remote required to reprogram the controller was ordered. This forced the plant to remain offline until the remote arrived. On September 16, 2013 the remote was received and the plant was restarted after the controller was reprogrammed.

3.2.6 Air Compressor Repairs

In October 2013, the treatment system went offline on multiple occasions due to MF skid low air pressure alarms caused by the air compressor's inability to keep up with demand. An investigation showed excess oil consumption to be the leading cause of the compressor's inefficiency. System operators made repairs to the extent of their ability though further troubleshooting required a service call to Atlas Copco, the manufacturer. On October 25, 2013, an Atlas Copco technician inspected and cleaned several of the compressor's internal components. Since then, the compressor has kept up with demand, and no major issues have occurred. Even though the air compressor is currently functioning, the service technician recommended replacement in the future because maintenance costs would soon result in greater cost than a new unit. The replacement of the air compressor is planned for 2014.

3.2.7 Influent Line Cleaning and Re-piping

On October 31, 2013, the treatment system went offline due a low chlorine dioxide flow alarm. Precipitate build up in the influent piping was found to have reduced inner pipe diameter by as much as 50% in some locations. This reduced the chlorine dioxide dosing rate to the point of an alarm forcing a shutdown. In early November 2013, the majority of the influent piping was inspected and cleaned over the course of multiple site visits. Additionally, several T-fittings and elbows that were no longer required for operation were removed and replaced with straight sections of pipe to reduce head loss and precipitate buildup. To minimize unscheduled downtime, the majority of this work was completed while the plant was offline for a scheduled CIP event. To prevent additional unscheduled downtime, the influent piping will be inspected annually and cleaned if necessary.

3.2.8 Microfiltration V-3 Actuator Replacement

Valve-3 (V-3) is a pneumatically controlled valve which controls the drain on the MF skid. Under normal operation, this valve automatically opens during the MF backwash process, which occurs after 15 minutes of forward flow. In November 2013, this valve was observed to be stuck in the closed position which could have caused high effluent pressure and the associated alarm would have shut the plant down. On November 23, 2013, the plant was shut down and V-3 was removed for inspection. It was observed that the internal moving parts and seals in the valve were exhausted and required replacement. V-3 was reinstalled and kept in operation until replacement parts could be obtained. Replacement parts were ordered and installed on December 9, 2013. V-3 was observed to be fully functional after the repair.

3.3 ATP Monitoring

The following sections detail ATP influent and effluent sampling for arsenic and other COCs conducted during 2013. The associated laboratory analytical reports are included as **Appendix B** and data validation is further discussed in **Section 5.6.4**.

3.3.1 ATP Influent Monitoring

3.3.1.1 Influent Inorganic Monitoring

Influent inorganic loading characteristics are assessed quarterly. Influent inorganic sampling is not required by either the ATP's MassDevelopement Landfill Discharge Permit or by the LTMMP but is monitored to gauge system loading and to ensure that a sufficient iron concentration is maintained to promote iron and arsenic precipitant coagulation. The original system design recommended a minimum iron concentration of 40 ppm. Current influent iron concentrations remain well above this level. As discussed below, the ATP was designed with a ferric chloride system with ability to add ferric chloride to the influent if deemed necessary based on results of influent organic sampling; however, due to influent iron concentrations, this system was never used. It has subsequently been decommissioned.

The total inorganic loading (iron, arsenic, and manganese) has declined since system start-up in 2006, but remains high enough for effective treatment, averaging 61.2 ppm for 2013. Individual average concentrations for iron, arsenic and manganese were 56.25, 2.89, and 2.08 ppm, respectively. Influent loading concentrations of iron, arsenic, and manganese are depicted in **Table 3-4** and graphically illustrated in **Figure 3-1**.

3.3.1.2 Influent Dissolved Gases and VOC Monitoring

As required by the LTMMP, annual ATP influent sampling was conducted for VOC and dissolved gas (methane and ethane) off-site analysis on September 10, 2013. Influent samples were collected by a Sovereign ATP operator and submitted to Alpha Analytical of Westboro, MA (Alpha) for analysis.

Results of the influent dissolved gas sampling indicated methane concentrations of 3,630 micrograms per liter (µg/L) and 1,550 µg/L in influent sampled from EW-01 and EW-04 respectively. Current methane concentrations are consistent with results of the 2012 sampling event which documented methane concentrations at 3,110 μg/L and 2,220 μg/L in influent sampled from EW-01 and EW-04, respectively. Ethane was detected at a concentration of 1.26 μg/L in influent sampled from EW-01. Ethane was not detected above laboratory detection limits in influent sampled from EW-04. Results of influent ethane concentrations sampling are consistent with 2012 sampling results.

Results of the influent VOC sampling indicated total VOC concentrations of 16.7 μg/L and 5.87 μg/L in influent sampled from EW-01 and EW-04 respectively. Detections of low concentrations of VOCs in ATP influent are consistent with historic sampling results.

Annual influent dissolved gas and VOC sampling results are detailed in **Table 3-5**.

3.3.2 ATP Landfill Discharge Permit and Effluent Monitoring

The USACE is authorized to discharge treated groundwater from the ATP to the Devens Municipal Sewerage System in accordance with Landfill Discharge Permit Number 020. The current permit was last amended on June 28, 2013 and is in effect until June 28, 2016. The discharge permit mandates effluent sampling for arsenic and other select parameters on a monthly, quarterly, and/or annual basis.

3.3.2.1 Permit Required Effluent Arsenic Monitoring

In accordance with the ATP's discharge permit, the collection of effluent samples for the off-site analysis of arsenic concentration is required on a monthly basis. The discharge permit contains a Special Condition which applies an effluent limitation of 75 μg/L of arsenic for each monthly sampling event. Effluent samples were collected by a Sovereign ATP operator each month throughout the year and submitted to Alpha for analysis.

Overall the plant has been effective at removing arsenic from the influent water stream, as designed. The average effluent arsenic concentration was 15.7 μg/L in 2013. Monthly effluent arsenic sampling results are detailed in **Table 3-6**.

3.3.2.2 Quarterly Permit Required Effluent Monitoring

The ATP's discharge permit requires quarterly sampling of plant effluent for metals (barium, manganese, and magnesium) and other select parameters (chloride, nitrate, and sulfate) for laboratory analysis. Quarterly effluent samples were collected by a Sovereign ATP operator on March 1, June 3, September 10, and December 9, 2013 and submitted to Alpha for analysis. Concentrations of all parameters sampled as part quarterly effluent monitoring were within permit defined discharge limitations. Quarterly effluent sampling results are included in **Table 3-7**.

3.3.2.3 Annual Permit Required Effluent Monitoring

The ATP's discharge permit requires annual sampling of plant effluent for select metals along with Total Toxic Organics (TTO) and Total Petroleum Hydrocarbons (TPH) for off-site analysis.

TTO is then determined by the summation of results of VOCs, semi-volatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs). Annual effluent samples were collected by the Sovereign ATP operator concurrent with the September 10, 2013 quarterly event and submitted to Alpha for analysis. Concentrations of all parameters sampled as part annual effluent monitoring were within permit defined discharge limitations. Annual effluent sampling results are shown in **Table 3-8**.

3.4 ATP Optimization

In 2013, the ATP was further optimized with the replacement of the air header lines on the MF skid. This upgrade allowed for more air to be delivered to the micro filters during the air scour portion of the backwash process. The increased airflow facilitates removal of precipitate that has built up on the micro filters during forward flow. The increased backwash efficiency has slowed the rate at which the micro filters foul directly leading to a decrease in the frequency of CIP events as well as an increase in the amount of water the MF modules can treat between CIP events. In addition, the concentration of precipitate within the MF skid backwash water has been regulated thereby increasing the efficiency of the ICP. In turn, the polymer dose applied to the precipitate stream before it enters the FBRO has also been regulated leading to optimal dewatering of the sludge that remains in the FBRO. This configuration allows for the greatest amount of sludge to accumulate in the FBRO between sludge removals.

Further, the replacement of the faulty effluent pump motor starter allows both pumps to operate in a lead-lag configuration where the pumps cycle between operating in the "lead" position as originally designed. The fifty percent reduction in workload borne by the by the pump that did not require a new motor starter greatly increases its potential lifespan. Proper lead-lag operation also decreases the likelihood of an emergency flooding situation due to pump failure.

3.5 Recommendations

The following recommendations are made with respect to the operation and maintenance of the ATP:

- Based on an inspection of the air compressor, it is recommended that it is replaced in the future. Consequently, a replacement air compressor was installed in April 2014.
- To increase safety and plant efficiency, it is recommended to manifold the piping system for the chlorine gas cylinders to allow three (3) cylinders to be connected via manifold rather than the existing two. This can be accomplished without any significant infrastructure changes or system downtime. Consequently, the chlorine gas manifold was installed in May 2014.
- To prevent the potential exposure of extraction well screens to air that is known to cause iron fouling and restricted flow/system down time, it is recommended that pressure level transducers are installed in each of the two active extraction wells (EW-1 and EW-4) to serve as a shut-off point to protect the extraction pumps in the event of a low water level condition. Additionally, this improvement will facilitate water level monitoring within the well at all times and allow the operators more control in optimizing flow rates. It is anticipated that this work will occur in summer 2014.

- To more accurately monitor and record the flow rate and total flow from each well, it is recommended that two local readout flowmeters with transmitters are installed prior to the extraction line manifold. In addition the use of the flowmeters will allow for an interlock to prevent extraction rates from exceeding the maximum treatment system flowrate and allow for the adjustment of flow from each of the extraction wells by adjusting the variable frequency drive output. It is anticipated that this work will occur in summer 2014.
- It is recommended that the Draft LTMMP Update be finalized in 2014 such that remedy performance metrics are clearly established based on the data quality objectives (DQOs) specified in the LTMMP. The LTMMP Update should consider the EPA's guidance on *Groundwater Remedy Completion Strategy (OSWER Directive 9200.2-144 May 2014).*

4.0 NORTH IMPACT AREA INVESTIGATION

At the request of USEPA and MassDEP to refine the understanding of the extent of both dissolved arsenic and chemically-reducing conditions in the NIA, a supplemental investigation was conducted in the spring of 2013 in the NIA.. The scope of this investigation was detailed in the May 2013 Final *Work Plan for Long-Term Monitoring and Maintenance Update* (Sovereign, 2013d). As part of this investigation, dissolved arsenic concentrations, oxidation-reduction potential (ORP), dissolved oxygen (DO), and other geochemical parameters were measured at select locations in the NIA. Components of this evaluation included the completion of vertical arsenic profiling, permanent monitoring well installation, and monitoring well sampling and analysis, as detailed in the sections below.

4.1 Access Arrangements and Boring Location Review

Prior to the implementation of the field program, the contact information of the property owners on whose property groundwater profiling locations were proposed was identified to obtain access. Work was not completed at a proposed exploration point until approval was received from the property owner. Access was obtained from the following property owners:

- Renald Meyers (161 West Main Street, Ayer MA)
- David Cibor (147 West Main Street, Ayer MA)
- Carol Anderer (139 West Main Street, Ayer MA)
- Town of Ayer (West Main Street and Shirley Street)

Dig Safe clearance was obtained prior to any groundbreaking activities in accordance with Massachusetts State Law. Areas on West Main Street and Shirley Street were pre-marked on March 29, 2013, and subsurface utilities were marked out by Dig Safe member utility companies.

During the review of proposed boring locations, two proposed locations, SHM-13-11 and SHM-13-13, were relocated from low-lying areas near Nonacoicus Brook to Old West Main Street due to accessibility and to further define the western edge of the core of arsenic impacted groundwater in the NIA. Additionally, it was determined that due to proximity of possible subsurface utilities, SHM-13-08 would be advanced to 10 feet below grade using vacuum excavation methods, as the majority of utilities are within 10 feet of ground surface.

4.2 Subsurface Exploration

The drilling services outlined under this section of the report were conducted in two separate phases – a direct push technology (DPT) phase and a rotosonic drill method phase. These services were conducted to evaluate conditions and fill spatial gaps in long term groundwater monitoring within the NIA.

The thirteen boring/profiling locations completed under this investigation are shown on **Figure 1-3**. The locations of the proposed exploration points were used to evaluate the following:

1. SHM-13-01 was located to evaluate any potential for westerly migration route of arsenic towards Nonacoicus Brook as had been previously predicted by model results and groundwater flow vector analysis;
2. SHM-13-02, -03, and -12 were located to evaluate the northwestern limit of the arsenic impacts in the area of Nonacoicus Brook and to evaluate any potential for a northwesterly migration route towards Nonacoicus Brook;
3. SHM-13-04 and -05 were located to evaluate the core of the arsenic impacted area in the NIA at an intermediate location between existing wells on Scully Road and West Main Street;
4. SHM-13-06 through -10 were located to evaluate contaminant and redox conditions along the West Main Street transect in the core of the arsenic impacted area; and
5. SHM-13-11 and -13 was located to evaluate the western edge of the core of the arsenic impacted area along West Main Street.

4.2.1 Direct Push Profiling

Between April 8 and May 9, 2013, DPT drilling methods were used to advance all proposed exploration points located within the NIA evaluation area. The borings were advanced with DPT groundwater sampling rods continuously, and vertical groundwater sampling was conducted at 10-foot intervals to assess groundwater chemistry and arsenic concentrations within the overburden aquifer. These points were used to characterize groundwater chemistry at downgradient points from the landfill and south of Nonacoicus Brook. A copy of the test boring logs/monitoring well construction reports are attached as **Appendix C**. No logs were prepared for the points identified as SHM-13-09 through SHM-13-13 since these points were used only to evaluate groundwater conditions.

4.2.2 Rotosonic Drilling Method and Monitoring Well Installation

From April to May 2013, rotosonic drilling methods were used to continue drilling operations at the exploration points identified as SHM-13-01 through SHM-13-06 and SHM-13-08, all of which were completed as groundwater monitoring wells. In addition, DPT was utilized to install a groundwater monitoring well at SHM-13-07 in October 2013.

With the exception of SHM-13-07, continuous soil samples were logged at each location, and soil was classified (based on Munsell Color System and grain size/type) and logged at ten foot intervals and at stratum changes from the ground surface extending vertically to the bedrock interface. A 5 to 10-foot core of the underlying bedrock was obtained at each of the completed borings, with the exception of SHM-13-07, to confirm bedrock depth corresponded with DPT refusal depth and the completeness of the previously collected groundwater profiling samples. No soil samples were submitted for laboratory analysis, and DPT refusal depth correlated with the depth of bedrock at each location within 2 feet of discrepancy as presented on **Table 4-1.**

As applicable, the open bedrock was then grouted, allowed to set, and covered with #2 Morie sand to the bottom of the designated screening depth. At each of the eight selected locations (SHM-13-01 through SHM-13-08), a 2-inch diameter permanent groundwater monitoring well was constructed. The screening interval at each well was based upon the laboratory arsenic profiling results obtained during groundwater profiling activities with the objective of monitoring zones of highest arsenic contamination. Prior to installation, groundwater profiling data and proposed well screen intervals were provided to the EPA and MassDEP for concurrence of screen placement. Upon receipt of EPA and MassDEP concurrence, each well was constructed with a 10-foot long PVC 10 slot (0.010-inch) screen located at the maximum depth explored (excluding bedrock coring exploration) or at a depth corresponding with the maximum arsenic concentration. Filter sand was placed around the PVC screen and extended 2 to 3 feet above the well point screen. Next, a two- to three-foot thick bentonite seal was installed. The remainder of the void around the PVC riser was filled with native drill cuttings or sand to approximately two feet below grade. At ground surface a protective casing (6-inch lockable stand pipe or 8-inch flush mounted road box) was installed with concrete to complete each location. Monitoring well construction information is summarized on the boring logs which are attached as **Appendix C**. Each of the wells was developed no sooner than 48 hours after installation in accordance in accordance with the procedures outlined within the October 2001 USEPA Monitor Well Development standard operating procedure (SOP #2044).

In general, soils encountered consisted of sand with varying percentages of silt and gravel with glacial till encountered above the bedrock in several locations. The bedrock encountered at each location was the Ayer Granodiorite, a coarse-grained, dark grey igneous rock with some white and light grey grains. The attached test boring/monitoring well logs in **Appendix C** contain complete soil sample logs and details on rock quality designation (RQD) of the bedrock coring.

4.3 Media Sampling

During this profiling investigation, select groundwater samples were collected and submitted for laboratory analysis. The limits of the testing or field screening program are outlined under the following subsections. Refer to **Table 4-1** for groundwater profiling results and **Section 4.5** for groundwater profiling results. The locations of these sampling points are presented on **Figure 1-3**.

4.3.1 Field Screening

Groundwater samples obtained during the profiling operations were field screened for groundwater chemistry parameters. During groundwater profiling, the samples were pumped through a YSI multi-meter with a flow-through cell, which was properly calibrated at the beginning of each day and post-calibrated at the end of the day. The YSI was used to monitor DO, pH, temperature, specific conductivity, and ORP. A separate turbidity meter was used to monitor turbidity. A summary of the monitoring parameters is provided in **Tables 4-1**, and the sampling logs along with calibration logs are attached as **Appendix D**.

4.3.2 Groundwater Profiling

Upon reaching the groundwater table, groundwater profiling samples were obtained at 10-foot sampling increments. At each profiling interval, water was purged through a YSI multi-meter and a turbidity meter to monitor groundwater chemistry parameters, and representative samples were collected after 45 minutes to 1 hour of purging as described in the May 2013 Final *Work Plan for Long-Term Monitoring and Maintenance Update* (Sovereign, 2013d). All samples were field filtered using a 0.45-µm filter and submitted for laboratory analysis of dissolved arsenic at Accutest Laboratories (Accutest) of Marlborough, MA. Quality Assurance/Quality Control (QA/QC) procedures included the use of duplicate samples, matrix spikes (MS), matrix spike duplicates (MSD), and rinsate blanks. The groundwater samples were collected in accordance with the USEPA Low Stress Purging and Sampling Procedures, Revision 3 (USEPA, 2010).

4.4 Quality Assurance / Quality Control Procedures

Field QC samples that were prepared and submitted to the laboratory for analyses during performance of this field effort consisted of equipment blanks (for all analyses), duplicate samples (for all analyses), and MS/MSD samples (for all analyses). Decontamination of equipment used during the investigation program was conducted as follows:

- All down-hole drilling equipment was decontaminated prior to initial use and between each borehole. Non-dedicated groundwater sampling devices (i.e., pumps, etc.) were decontaminated prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples. Equipment was decontaminated at the sample location, or at a pre-designated, controlled location. All equipment was decontaminated before leaving the site.

- Decontamination of drilling equipment included drill bits, drill-string tools, drill rods, tremie pipes, clamps, hand tools, steel cable, along with pump drop-lines and pumps. These items were cleaned, by the subcontractor, using a steam pressure washer.

- Sampling equipment that was decontaminated included the water level and water quality meters, pumps and pump equipment, and miscellaneous tools.

- Heavily soiled equipment was washed a second time using an aqueous non-phosphate detergent solution and using a portable, high presser steam cleaning equipment.

4.5 Groundwater Profiling Results

Samples obtained during groundwater profiling were field filtered and analyzed for dissolved arsenic. The concentration ranges were noted as follows:

Compound	Sampling Point	Concentration (µg/L)	
		Dissolved Arsenic	
		Minimum	Maximum
Arsenic	SHM-13-01	ND (<1.0)	ND (<1.3)
	SHM-13-02	0.82	1.2
	SHM-13-03	0.6	357
	SHM-13-04	3	3,510
	SHM-13-05	0.55	96.5
	SHM-13-06	ND (<1.0)	3,380
	SHM-13-07	ND (<1.8)	3,170
	SHM-13-08	1.5	1,080
	SHM-13-09	ND (<1.3)	165
	SHM-13-10	0.78	17.5
	SHM-13-11	ND (<1.0)	ND (<1.6)
	SHM-13-12	0.61	24.1
	SHM-13-13	0.61	0.83

Copies of the laboratory reports are attached as **Appendix B**, data validation is discussed in **Section 5.6.4**, and a summary of the testing results are provided in **Table 4-1**. Geological profiles depicting the concentration gradients of the results are discussed below in **Section 5.6**. These profiles show the spatial distribution of dissolved arsenic.

4.6 Arsenic Distribution

To aid in understanding the extent and path of impacted groundwater, cross section transects were prepared for areas primarily downgradient of the ATP. The vertical and horizontal distribution of arsenic in the northern portion of SHL and the NIA are presented as a series of geological transects constructed using the groundwater profile data conducted in 2001, 2007, 2010, and 2013. Only data points with dissolved arsenic data from depth profiles were utilized in this exercise. Depth profiles with only total arsenic data are not included as they are not considered representative of aquifer conditions and are biased due to turbidity in samples. The data were analyzed to identify arsenic distribution in the north end of impacted groundwater and along several transects from beneath the NIA. For the flow path analysis, the following well transects were analyzed. The transect plan is presented as **Figure 4-1** and the associated cross sections are presented as **Figures 4-2** through **4-5**.

a. **<u>Transect A-A'</u>**: South to North from the Landfill through the NIA: SHM-10-14, SHM-10-16, SHM-13-04, SHM-13-06, SHM-10-17, SHM-10-28, SHM-13-03, and SHM-10-04.

b. **<u>Transect B-B'</u>**: West to East from Sculley Road through Shirley Street: SB-07-01, SB-07-02, SHM-07-03, SHM-13-04, SHM-13-05, and SHM-10-05A.

c. **<u>Transect C-C'</u>**: West to East along West Main Street: SHM-13-11, SHX-01-11X, SHM-13-13, SHX-01-13X, SHM-13-06, SHX-01-10X, SHM-13-07, SHX-01-09X, SHM-13-08, SHX-01-12A/12E, SHM-13-09, SHX-01-14X. SHM-13-10, SHX-01-08X, SHX-01-07X, and SHX-01-06X.

d. **Transect D-D′**: West to East at the Wetland Boundary: SHM-13-01, SHM-10-09, SHM-13-12, SHM-13-02, SHM-10-22, SHM-10-10, SHM-10-21, SHM-10-20, SHM-13-03, SHM-10-24, SHM-10-23, and SHM-10-27.

4.6.1 Groundwater Profile Analysis – Transect A-A′

This transect is a south to north view of arsenic with depth from the north end of the landfill (SHM-10-14) through the center of the NIA (SHM-13-04, SHM-13-07 and SHM-10-17) and then to the northern side of Nonacoicus Brook (SHM-10-04) (**Figure 4-2**). This transect represents a two dimensional south to north slice through the apparent center of the highest arsenic concentration area in the NIA. The highest arsenic concentrations are found in groundwater beneath location SHM-13-06 where arsenic concentrations exceed 3,000 µg/L. The arsenic follows the bedrock surface to the north and arsenic in general is found to be highest at depths above the till layer. Proceeding north, there is a thinner profile of high arsenic at SHM-10-16 (about 500 µg/L) and then much lower arsenic concentrations at the Brook/wetlands boundary (<400 µg/L). It is important to note that based on existing data, the groundwater with elevated dissolved arsenic concentrations remains greater than at least 20 feet below the water table elevation approaching the brook.

4.6.2 Groundwater Profile Analysis – Transect B-B′

This transect is a west to east view of arsenic with depth from the west end of Sculley Road (SB-07-01, SB-07-02, and SHM-07-03) through the Shirley Street (SHM-13-04, SHM-13-05 and SHM-10-05A) (**Figure 4-3**). This transect represents a two dimensional west to east slice through the southern portion of the core arsenic impacted area in the NIA. The highest arsenic concentrations are found in groundwater beneath location SHM-13-04 where arsenic exceeds 3,000 µg/L, and arsenic concentration diminishes to less than 100 µg/L west and east of this location. This transect runs roughly parallel to Transects C-C′ and D-D′ and allows for a comparison of arsenic distribution perpendicular to the impact area.

4.6.3 Groundwater Profile Analysis – Transect C-C′

This transect is another west to east view of arsenic with depth along West Main Street from location SHM-13-11 to SHX-01-06X (**Figure 4-4**). This transect represents a two dimensional west to east slice through the core arsenic impacted area in the NIA. The highest arsenic concentrations are found in groundwater beneath locations SHM-13-06, SHX-01-10X, SHM-13-07, and SHX-01-09X where arsenic exceeds 3,000 µg/L, and arsenic concentration diminishes to less than 100 µg/L west and east of this area. This transect runs roughly parallel to Transects B-B′ and D-D′ and allows for a comparison of arsenic distribution through the NIA.

4.6.4 Groundwater Profile Analysis – Transect D-D′

This transect is also a west to east view of arsenic with depth along the wetland boundary south of Nonacoicus Brook from location SHM-13-01 to SHM-10-27 (**Figure 4-5**). This transect represents a two dimensional west to east slice through the area north of the core arsenic impacted area in the NIA. The highest arsenic concentrations are found in groundwater beneath locations SHM-10-23 and SHM-10-27 where arsenic exceeds 1,000 µg/L. Arsenic concentration diminishes to less than 100 µg/L west of these points. This transect runs roughly parallel to Transects B-B' and C-C'.

4.7 Spring 2013 Field Investigation Conclusions

The data collected during the 2013 field investigation is consistent with data collected historically throughout the NIA. Specifically, the data collected in 2013 from groundwater profiling locations along West Main Street correlates closely and is statistically consistent with the data collected from groundwater profiling locations in this area in 2001. This suggests the arsenic impact area in the NIA remains stable in terms of concentration and is bounded by SHM-07-03 to the southwest, SHM-13-10 and SHM-13-02 to the west, Nonacoicus Brook to the north, SHX-01-07X and SHM-10-05A to the east. Further, data collected from the western area of the NIA does not indicate that arsenic impacted groundwater extends west past the intersection of Old West Main Street and Shirley Street.

The consistency of the arsenic data at the transect along West Main Street between 2001 and 2013 is significant in that prior to 2006, the ATP had not yet been constructed. Therefore, these two overlapping transect data sets are reflective of both "pumping" and "non-pumping" conditions. The consistency of these data sets suggests that the ATP operation has little to no effect on the dissolved arsenic concentration in the NIA area along West Main Street and points north.

The results of these data define the downgradient extent of the arsenic impacted groundwater at Nonacoicus Brook in the vicinity of SHM-13-03 and at a depth of 50 feet below grade, or approximately 25-40 feet below the average water table elevation. As illustrated on Transect A-A' (**Figure 4-2**), arsenic impacted groundwater is located at approximately 25 feet below grade at SHM-13-04, at approximately 40 feet at SHM-13-06, and at approximately 50 feet below grade at SHM-13-03 and Nonacoicus Brook. In addition, the maximum concentration of arsenic decreases from 3,510 µg/L at SHM-13-04 to 357 µg/L at SHM-13-03 as it approaches the Brook. Based on the depth of arsenic impact below the water table elevation, the existing data set does not suggest that arsenic is discharging to the Brook at appreciable concentrations and continues to suggest that a redox area is present which naturally precipitates arsenic into iron solids near or beneath Nonacoicus Brook as the low-dissolved oxygen groundwater mixes with oxidized water from the north and beneath the Brook.

Additional data collection and profiling efforts as detailed within the Draft *Addendum to the Work Plan for LTMMP Update* (Sovereign, 2013e) were performed after the initial profiling event in Spring 2013 to ascertain if there is a localized discharge of arsenic to Nonacoicus Brook in the stream reach co-located with the highest dissolved arsenic concentrations (generally between profile point SHM-10-21 to the west and SHM-10-25 to the east). This scope resulted in the installation of one additional groundwater monitoring well (SHM-13-07) in October 2013 to avoid any data gaps, as discussed above in **Section 4.2.2**. At the request of the MassDEP, an additional groundwater profiling investigation at two locations in the wetland area north of SHM-10-25 and adjacent to Nonacoicus Brook occurred in January and February 2014. The resulting monitoring wells, SHM-13-14S, SHM-13-14D, and SHM-13-15, are shown on all site plans included with this report, and preliminary data from these locations are presented on

Table 4-2. Full details regarding the groundwater profiling investigation conducted in 2014 will be provided in the 2014 Annual Report.

5.0 GROUNDWATER AND HYDRAULIC MONITORING

Groundwater monitoring activities were conducted at SHL in accordance with the LTMMP (CH2M Hill 2007 as amended in December 2009) for the period of January 1, 2013 through December 31, 2013. At the request of the Army, a supplemental groundwater monitoring event was also conducted in November 2013 to begin integration of the proposed LTTMP monitoring network (Sovereign, 2013b) into the sampling plan. The results of these sampling events are presented in the following sections. This section also presents the installation of one new piezometer and three new staff gauges as detailed in the Draft *Addendum to the Work Plan for LTMMP Update* (Sovereign, 2013e) and the results of the site-wide survey that was conducted in June 2013.

5.1 Long Term Monitoring and Maintenance Plan Modifications

An update to the LTMMP was proposed in the Draft *Long Term Monitoring and Maintenance Plan Update* (Sovereign, 2013b) and is anticipated to be implemented in 2014. In 2013, the spring and fall monitoring events were conducted in accordance with the LTMMP submitted in 2007 and as amended in 2009. A supplemental sampling event was conducted in November 2013 to sample select wells from the proposed draft LTMMP update (Sovereign, 2013b). **Table 5-1** details all the monitoring wells/piezometers currently included in the LTM monitoring program as detailed in the 2009 amendment to the LTMMP. **Figure 5-1** displays all monitoring wells/piezometers locations along with 2009 LTM monitoring frequency. **Figure 5-2** depicts the proposed LTMMP monitoring network as presented in the 2013 draft LTMPP Update (Sovereign, 2013b).

5.2 Stream Gauging and Piezometer Hydraulics

To provide hydraulic interface elevation data between the groundwater and the Nonacoicus Brook, Sovereign installed one piezometer (SHP-13-03) in the Brook north of SHM-13-03 on May 14, 2013. The piezometer was constructed with a stainless steel drive screen and riser pipe advanced approximately 4 feet below the stream base. Sampling of this piezometer is scheduled for Spring 2014.

In addition, Sovereign installed three staff gauges (SHSG-13-01G through -03G), of which two were located in the area of SHP-07-03E and SHP-13-03. Each staff gauge was affixed to a standpipe (in the case of the stream gauges near SHP-07-03E and SHP-13-03, they were affixed to the standpipes for those piezometers) and driven at least 4 feet below the brook stream base. These new staff gauges were included in the hydraulic monitoring events in 2013.

5.3 Groundwater Elevation Monitoring

5.3.1 Barrier Wall Performance Monitoring

During the construction of the barrier wall in 2012, five (5) sets of overburden groundwater piezometers (PZ-12-01 through PZ-12-10) were installed along the barrier wall alignment, with one point per set located up-gradient of the barrier wall (westerly side) and the other down-gradient (easterly side) of the barrier wall, to provide hydraulic performance monitoring data for the barrier wall. The locations of the barrier wall piezometers are presented on **Figure 1-2**.

Weekly hydraulic monitoring events were conducted in November 2012 followed by monthly hydraulic monitoring events from December 2012 through April 2013. During each monitoring event, an electronic water level meter was used to measure depth to water (DTW) with an accuracy of ± 0.01 feet from the top of casing of each piezometer. Results of the monitoring events demonstrated a positive difference in hydraulic head at each piezometer couplet location along the barrier wall. The maximum hydraulic head differential observed in paired piezometers during the six month period was 1.83 ft. (PZ-12-09 and PZ-12-10), towards the southern end of the wall. The minimum head differential observed in paired piezometers was during the six month period was 0.27 ft. (PZ-12-01 and PZ-10-02) at the northern end of the wall. It is presumed that the greater head differential to the south is due to a combination of a less saturated thickness in the southern portion of the barrier wall as compared to the northern portion and the expected increase in velocity (and corresponding lowering of hydraulic head) of the groundwater as it flows north.

A summary of barrier wall piezometer hydraulic monitoring data collected from November 2012 to April 2013 is presented in **Table 5-2**, which provides detailed water table elevations measured at each piezometer pair during each monitoring event. Additionally, **Table 5-2** tallies the head differential between each pair along with the change in head differential from one monitoring event to the next. As presented on **Table 5-3,** continued hydraulic monitoring of the piezometers located along the barrier wall was conducted as part of the semiannual LTM gauging events.

5.3.2 Site-Wide Monitoring Events

Groundwater elevations at SHL monitoring wells and piezometers, including the barrier wall piezometers, were gauged as part of site-wide monitoring events on May 15, June 6, and October 21, 2013. The May and October hydraulic monitoring events were conducted as part of the LTM semi-annual monitoring. The June event was conducted after all new well installations were complete in the NIA (except SHM-13-07, which was installed in October) to update the groundwater flow model. During each event, an electronic water level meter was used to measure DTW with an accuracy of ± 0.01 feet from the top of casing of each monitoring well/piezometer. At staff gauges, the water level was read to the nearest 0.01 ft from the measurements on the staff. **Table 5-1** provides the relevant characteristics of the LTMMP monitoring wells/piezometers including the geological unit(s) the well is screened in and screen depths or elevations. Groundwater elevations for all monitoring events are listed in **Table 5-3**. Groundwater contour maps of water table elevations measured in May and October are presented in **Figures 5-3 and 5-4**, respectively.

Water level transducer data from May 15, 2013 for EPA piezometers EPA-PZ-1A/1B through EPA-PZ-4A/4B, EPA-PZ-5B, EPA-PZ-6A/6B, and EPA-PZ-7B was applied to updated survey data for these locations and is also displayed in **Table 5-3.** The EPA piezometer data was also utilized to generate **Figure 5-3.** No EPA transducer data was available during the October 2013 gauging event.

The results of each 2013 site-wide monitoring event illustrate a general groundwater flow from the southwest to the north towards Nonacoicus Brook with a deflection of groundwater flow to the north in the area west of the barrier wall. In May, the ATP was operating during the site-wide gauging event and the capture zone is visible in the contours. In October, the ATP was not operational the day before the site-wide gauging event and came online at 2:56 pm on the day of the gauging event. The contour map reflects this variation. A hydraulic capture assessment for SHL is described in detail in **Section 6.1**.

5.4 Site-Wide Certified Survey

Between June 17, 2013 and June 21, 2013, a land survey of the area was completed by a certified land surveyor. The survey included horizontal and vertical coordinates for the ground, rim, and casing of all monitoring wells, stream gauges, and piezometers at SHL and in the NIA to address vertical discrepancies noted from previous uncertified survey data. In addition, the horizontal and vertical coordinates were surveyed for the ground surface at the location of the soil borings which were performed in spring 2013. During surveying, all coordinates were cross-checked with existing survey data to ensure accuracy. The survey was conducted on the Massachusetts State Plane Coordinate System and vertically on North American Vertical Datum (NAVD) 1988 datum. The results of the survey are presented on **Table 5-4** and reference elevations for each well, piezometer, or staff gauge were used to calculate groundwater elevations as seen on **Table 5-3** and **Figures 5-3 and 5-4**.

A supplemental survey was conducted in early 2014 to capture monitoring wells installed since the previous certified survey, to fill in identified data gaps, and to integrate the EPA piezometers into the same datum for comparison of hydraulic data. Although this data was used to construct **Figures 5-3 and 5-4** and is displayed in **Table 5-4**, the survey event in early 2014 will be further discussed and presented in the 2014 AR.

5.5 Groundwater Sampling

As required by the LTMMP, Sovereign conducted semi-annual groundwater sampling events at SHL in the spring and fall of 2013, with an additional supplemental event conducted in November 2013 at the request of the Army.

Between May 20 and May 28, 2013, groundwater samples were obtained from a total of 55 monitoring wells including those designated for LTM semi-annual sampling, the additional wells outlined in the May 2013 Work Plan (Sovereign, 2013d), and the newly installed groundwater monitoring wells SHM-13-02 through SHM-13-06 and SHM-13-08. Because groundwater monitoring wells SHM-13-02 and SHM-13-06 through SHM-13-08 were not complete at the time of the May 2013 groundwater sampling event, these wells were sampled on June 13, 2013. However, a sample was not obtained from SHM-13-01 due to high water in Nonacoicus Brook that rendered the standpipe inaccessible.

Between October 22 and October 24, 2013, groundwater samples were obtained from 29 LTMMP wells designated for semi-annual or annual sampling. Four groundwater monitoring wells designated for annual sampling (SHL-4, SHP-01-36X, SHP-01-37X- and SHP-01-38A) were not sampled because of an insufficient water column due to low water level in Plow Shop Pond. Consequently, these wells were added to the supplemental sampling event in November 2013.

Between November 19 and November 21, 2013, the supplemental sampling of 19 groundwater monitoring wells was completed. This event consisted of sampling of 4 wells which were not sampled in October 2013 (discussed above) and 15 wells which were proposed for inclusion within future fall sampling events (SHM-10-06A, SHM-10-10 through SHM-10-12, SHM-10-15, SHM-10-16, SHM-11-02, SHM-11-06, SHM-13-01 through SHM-13-03, and SHM-13-05 through SHM-13-08) as presented within the Draft LTTMP Update (Sovereign, 2013b). Hydraulic monitoring was conducted at the 10 barrier wall piezometers during the November monitoring event as designated in the Draft LTTMP Update as well.

All groundwater samples were collected in accordance with the USEPA Low Stress Purging and Sampling Procedures, Revision 3 (USEPA, 2010) and were field filtered using a 0.45-µm filter. At each monitoring well, groundwater was purged using either a stainless steel bladder pump with a compressed nitrogen gas source or a peristaltic/inertial pump depending on the groundwater elevation within the monitoring well. At each groundwater monitoring well, groundwater was purged through a properly-calibrated YSI multi-meter and a turbidity meter to monitor groundwater chemistry parameters, and samples were collected upon achievement of field parameter stability. If the event field parameters did not stabilize within 2 hours, samples were collected at the 2 hour time mark, in accordance with the USEPA Standard Operation Procedure (SOP). All samples were submitted for off-site laboratory analysis at Accutest of dissolved (field filtered) arsenic, calcium, sulfate, total alkalinity, magnesium, manganese, sulfide, dissolved iron, sodium, ammonia, nitrate/nitrite, dissolved organic carbon, potassium, and chloride. As part of this sampling program, QA/QC procedures included the use of duplicate samples, MS/MSDs, and rinsate blanks.

A summary of 2013 groundwater sampling results are provided in **Table 5-5**. All groundwater monitoring field forms from each groundwater sampling event are provided in **Appendix E**.

5.6 Groundwater Sampling Results

5.6.1 Arsenic Concentration Results

Dissolved arsenic results from the sampling events conducted in 2013 are as follows:

- Results of the May 2013 groundwater sampling event documented concentrations of dissolved arsenic above the established cleanup level of 10 µg/L in groundwater sampled from 34 of the 55 monitoring wells/piezometers, with the highest concentration of 5,540 µg/L detected in SHM-10-14.

- Results of the October 2013 groundwater sampling event documented concentrations of dissolved arsenic above the established cleanup level of 10 µg/L in groundwater sampled from 25 of the 29 monitoring wells/piezometers, with the highest concentration of 3,100 µg/L detected in SHM-05-40X.

- Results of the November 2013 groundwater sampling event documented concentrations of dissolved arsenic above the established cleanup level of 10 µg/L in groundwater sampled from 11 of the 19 monitoring wells/piezometers, with the highest concentration of 5,740 µg/L detected in SHM-10-15.

Figure 5-4 presents dissolved arsenic concentration results for the 2013 sampling events. **Table 5-5** presents detailed results of the sampling events. A summary of historic arsenic concentration data through 2013 for selected monitoring wells/piezometers is provided in **Table 5-6**. Arsenic concentration data for select wells is plotted in chart format in **Appendix F**.

5.6.2 Other COC Results

The other COCs detected at concentrations above established cleanup levels in groundwater sampled from LTMMP network monitoring wells/piezometers during the 2013 groundwater sampling events included iron, manganese, and sodium. Concentrations of dissolved iron above the established cleanup level of 9,100 µg/l were detected in groundwater collected from 27 monitoring wells/piezometers during the May/June 2013 groundwater sampling event, 15 monitoring wells/piezometers during the October 2013 sampling event, and 10 monitoring wells during the November 2013 sampling event. The highest concentration of dissolved iron (107,000 µg/l) was detected in groundwater sampled from SHM-10-06 in May 2013.

Concentrations of dissolved manganese above the established cleanup level of 1,715 µg/l were detected in groundwater collected from 24 monitoring wells/piezometers during the May/June 2013 groundwater sampling event, 10 monitoring wells/piezometers during the October 2013 groundwater sampling event, and 12 monitoring wells/piezometers during the November 2013 groundwater sampling event. The highest concentration of dissolved manganese (26,400 µg/l) was detected in groundwater sampled from SHM-10-10 in May 2013.

Concentrations of dissolved sodium above the established cleanup level of 20,000 µg/l were detected in groundwater collected from 25 monitoring wells/piezometers during the May/June 2013 groundwater sampling event, 12 monitoring wells/piezometers during the October 2013 groundwater sampling event, and 12 monitoring wells/piezometers during the November groundwater sampling event. The highest concentration of dissolved sodium (432,000 µg/l) was detected in groundwater sampled from SHM-10-03 in May 2013. **Table 5-5** presents detailed results of the sampling events.

5.6.3 Groundwater Monitoring Field Parameters

During groundwater sampling, water was purged through a flow-through cell equipped with a YSI multi-meter and used to monitor parameters including pH, specific conductivity, DO, temperature, and ORP. ORP is a particularly significant field parameter at Shepley's Hill Landfill. Since arsenic and iron are mobilized under reducing conditions, be they landfill-induced or due to natural conditions, higher iron and arsenic concentrations are expected in locations where negative ORP values indicate reducing conditions. All monitoring wells/piezometers from which groundwater samples were collected contained dissolved arsenic concentrations above the established MCL of 10 µg/l also exhibited negative ORP values with the exception of SMH-05-41A, SHL-22, SHM-99-22B, and SHL-5 during the May 2013 event and SHP-99-31A and SHM-99-22B during October 2013 event.

Arsenic concentrations and associated field ORP measurements from April, October, and November 2013 groundwater sampling events are detailed in **Table 5-5** along with additional field parameter measurements collected during the 2013 sampling events.

5.6.4 Data Validation

Data validation was performed for each sample delivery group (SDG) from the groundwater profiling, the groundwater sampling events, and the ATP influent and effluent monitoring using the ADR.net (Automated Data Review) software along with a chemist review of the ADR results. The ADR output was adjusted by the chemist based on professional judgment to complete the validation process. The laboratory's analytical data packages were reviewed to assess adherence to acceptable laboratory practices and the data validation requirements specified in Massachusetts Department of Environmental Protection Massachusetts Contingency Plan (MCP) Compendium of Analytical Methods, EM-200-1-10, and the Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories, and applicable analytical methods. The level of data validation was performed with reference to the project Quality Assurance Project Plan (QAPP) and EPA Region I Tier II Guidance. For Tier II data review, data quality objectives were assessed by review of the Contract Laboratory Program-like summary forms, with no review of the associated raw data. Laboratory analytical reports are included as **Appendix B,** and data validation reports are included in **Appendix G**.

5.7 Proposed Monitoring Program Optimization

An update to the LTM well network was proposed in the Draft *Long Term Monitoring and Maintenance Plan Update* (Sovereign, 2013b) in October 2013. The proposed LTMMP groundwater monitoring wells were selected for assessment of remediation effectiveness from existing wells based on historical analytical results and both hydrologic and geochemical monitoring and modeling to provide representative samples in key sub-areas of the SHL remedy. The proposed LTM includes wells in the upgradient area to monitor levels of dissolved oxygen and dissolved arsenic entering the aquifer at the SHL; landfill area wells to monitor geochemical parameters within the landfill and track long term trends; barrier wall area wells to monitor performance of the barrier wall and hydraulics of groundwater entering Plow Shop Pond; nearfield area wells to evaluate hydraulic capture performance at the ATP; and NIA wells to monitor groundwater downgradient of the ATP and the effectiveness of the remedies in place.

The proposed LTM includes groundwater monitoring semi-annually at 12 wells, annually at 38 wells, and every 5 years at 11 wells. The plan also proposes hydraulics monitoring semi-annually at the 10 barrier wall piezometers and annually at 42 other wells. The proposed LTM network is displayed in **Figure 5-2**.

5.8 Groundwater Model Update

The SHL groundwater flow model was updated as part of the update to the LTMMP (Sovereign, 2013b). The update included a series of significant revisions as well as a thorough review and modification of various model parameters based upon available data where possible. The updated model was setup as a transient model capable of accepting real time adjustments based on the collection of future hydraulic data, and two versions of the model were developed (SHL200T1 and SHL200T2). Both were identical except one has the barrier wall included and the other does not. This was necessary because the barrier wall cannot be specified as absent and then present within a single model.

The results of the model indicated that the barrier wall is effective in mitigating the flow of water from beneath SHL to Plow Shop Pond and therefore will mitigate the arsenic flux levels into Red Cove. In addition, the model also indicated that the landfill extraction wells were effective at capturing water originating at the landfill and eastward to the barrier wall at present pumping rates. Further details regarding the update to the groundwater flow model are presented in the October 2013 Draft *Long Term Monitoring and Maintenance Plan Update* (Sovereign, 2013b).

6.0 SYSTEM PERFORMANCE METRICS AND ASSESSMENT

Annual performance assessments have been focused on system hydraulics and capture/control of groundwater at the north end of SHL. Consistent with EPA guidance including *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (USEPA, 2008), a multiple lines of evidence approach was taken with respect to performance assessment. The assessment components include the following:

- Hydraulic Capture Zone Analysis
  - Gradient Vector Analysis
  - Comparison to Numerical Model Results
  - Capture Zone Width Calculation
  - Drawdown Assessment

- Geochemical Monitoring
  - Advective Travel Time Analysis
  - Geochemical Assessment

Table 6-1 provides a description of each assessment component, its data requirements, and a brief summary of the results. Additional details are provided in the following sections.

6.1 Hydraulic Capture Assessment

Those components of the hydraulic capture assessment that have been updated for 2013 are presented in the following sections. The evaluation of capture continues using the same lines of evidence as have been evaluated in past Annual Reports as noted above.

The lines of evidence for capture for 2013 are strengthened by results from a USEPA Hydraulic Gradient Analysis (USEPA, 2014). This study involved installation of data loggers and the analysis of continuous (15-minute interval) water level data from 36 wells and piezometers in the landfill area. The locations instrumented included 14 piezometers installed between September 2012 and July 2013 by USEPA in the vicinity of extraction wells EW-01 and EW-04. The use of continuous water level data instead of single date and time measurements provides an enhanced gradient analysis, and the results are incorporated in the gradient vector analysis section below.

The capture zone analysis using the groundwater model has also been enhanced by a significant revision to the model. The model revision and capture simulation results are described further below.

Both the Gradient Vector Analysis and Numerical Model Results have been updated and are provided in the subsections below. Because these two lines of evidence provide the strongest indication of capture, the capture zone width calculation and drawdown assessment have not been updated, but are included in **Table 6-1**.

6.1.1 Gradient Vector Analysis

Gradient analyses presented in previous annual reports involved the calculation of gradient vectors for selected well triplets (3 adjacent wells with similar screened intervals) using data from synoptic water level surveys. The conclusion noted in the 2012 Annual Report was that gradient vectors in the near-field area are generally directed toward the extraction wells, while far-field wells exhibit an equal or greater apparent variation due to seasonal changes in water table elevation.

As noted above, a similar analysis was completed by the USEPA (USEPA, 2014). The USEPA analysis, however, used water level data collected by transducers and was able to calculate gradient vectors for each well triplet at 15-minute intervals. The resulting gradient vectors provide a continuous picture of hydrologic conditions allowing an enhanced analysis of seasonal and pumping impacts. Because the USEPA analysis provides a unique evaluation from what was done in the past, the results of their evaluation are presented in this section.

The USEPA analysis begins with an evaluation of temporal water level trends and vertical gradients, and the development of potentiometric maps. Conclusions from these analyses consisted of the following:

- Temporal groundwater fluctuations are in response to precipitation and significant changes in extraction rates;

- Vertical groundwater gradients are generally downward, with the magnitude varying spatially and temporally; and
- Potentiometric maps for the mid-deep overburden (where in general dissolved arsenic concentrations are greater than for the shallow portion of the aquifer) show groundwater flow is to the northwest except in the immediate vicinity of the extraction wells. The USEPA also concludes that *"The potentiometric surface in much of the area of elevated arsenic concentrations appears to indicate significant influence of the extraction system"* (USEPA, 2014).

For the gradient vector evaluation, 15 well triplets were defined, and for each triplet the magnitude and direction of the horizontal gradient were calculated for every time increment from the available data. The location and wells associated with select triplets are shown on **Figure 6-1**.

Key conclusions from the gradient vector evaluation include the following:

- Seasonal Shifts: Changes in vector direction over time at the well triplets were evaluated for seasonal influences to see if it indicated any major change in the effectiveness of the extraction system with respect to capture. No significant seasonal changes were observed. The data showed a small shift of up to 10 degrees in some places in the groundwater flow direction. While not conclusive evidence, these shifts could indicate small seasonal changes in the capture zone.

- Net/Average Hydraulic Gradient Vectors: The continuous gradient vectors were used to calculate net, or average, gradient vectors. It was noted that aquifer hydraulic conductivity limits groundwater flow, so although gradient vector direction may change rapidly, the net vector direction is a reasonable indicator of capture effectiveness.

  In the immediate vicinity of the extraction wells net gradient vectors are towards the extraction wells, indicating capture. In other areas the flow vectors do not definitively indicate flow toward the extraction wells, but it is noted that does not mean a lack of capture as flow can move beyond a pumping well before moving towards that well. One well triplet (EPA-PZ-2012-6B/4B/3B) was noted as an example where *"water that has migrated north of the extraction wells appears likely to be captured by the wells"* (USEPA, 2014).

  Periods of Extraction/No Extraction: The difference in gradient vectors when the extraction wells are pumping and when the system is shutdown from February 6-15, 2013 were evaluated. The gradient vectors show a shift in direction to the north when the extraction system is off. It is worth noting here that many of the areas of the USEPA analysis are outside of the design capture limits and are not intended to be captured by the system. In addition, the time period evaluated was an unusually long shutdown period and typically that duration is much shorter (24-48 hours), so the time shown can be considered a conservative scenario. Even under such a scenario, the gradient vectors within the designed capture limits of the ATP do not show a significant change. From the slight direction change, coupled with the fact groundwater movement is limited by aquifer properties, it can be assumed that loss of capture during system shutdown would be insignificant, especially during the much shorter shutdown durations.

In summary, the USEPA study provides a large dataset from which changes in water levels and gradient vectors can be analyzed in a variety of ways. The results of their evaluation suggest that seasonal changes in capture are likely to be small and that periods of system shutdown would also have a minimal effect on the capture effectiveness.

As noted in previous Annual Reports and as illustrated on **Figure 6-1**, gradient vectors for near-field monitoring wells close to the extraction wells and within the designed capture limits of the ATP are directed toward the extraction wells. Gradient vectors for far-field wells which are outside of the designed capture limits of the ATP exhibit an equal or greater apparent variation due to seasonal changes in water table elevation. While not definitive by itself, the gradient vector evaluation is a valuable line of evidence for capture effectiveness and provides a basis to compare numerical model results for consistency.

6.1.2 Comparison to Numerical Model Results

In 2013, the SHL groundwater flow numerical model (SHL-105) underwent a significant revision. Details of the model revision including rationale, source data, and calibration and sensitivity analysis are included in the draft *LTMMP Update* (Sovereign, 2013b). The updated LTMMP and revised numerical model are in draft form and undergoing review at the time of this annual report, but the key model revisions include:

- Domain: Extending the model domain to the east, south, and west to better include natural hydraulic boundaries;
- Grid Spacing: Revising the area of tighter grid spacing to cover both the barrier wall and extraction well areas;
- Model Layers: Adding a model layer in the overburden material to improve resolution and allow for future representation of vertical changes in material types if warranted;
- Recharge: Revising the recharge distribution to reflect current land use types;
- Layer Elevations: Updating surface elevation with digital elevation model (DEM) and Lidar coverages;
- Streams and Ponds: Specifying the representation of Plow Shop Pond and Grove Pond using bathymetry data, specifying stage for the ponds and other surface water bodies using available gaging data, and specifying different reaches to evaluate fluxes;
- Barrier Wall: Adding the barrier wall at the final constructed and surveyed location; and
- Simulation Mode: Changing the model to run in transient mode to be able to simulate seasonal changes in site conditions.

The resulting revised model is actually two models, referred to as SHL-200T1 and SHL-200T2. Both are identical with the exception that SHL-200T2 contains the barrier wall, while SHL-200T1 does not. Both models were used during the calibration and sensitivity phase with T1 being used to simulate conditions prior to the barrier wall installation and T2 used to simulate post-wall installation. Model SHL-200T2 is the version used for predictive simulations such as the capture zone evaluation presented below.

Because of the model revision, the Comparison to Numerical Model Results and Advective Travel Time Analysis components of the assessment have been updated using the latest model, referred to as SHL-200T2. Similar to what was done in the past, both reverse (backward in time) and forward (forward in time) particle tracking simulations were performed.

The model simulations presented use a combined pumping rate of 49 gpm, split between the two extraction wells with EW-04 pumping at 40% of the total and EW-01 at 60%. This total rate and proportion between the two wells is reflective of actual operating conditions, and is most representative for capture effectiveness because the system is only shutdown for very brief periods.

Results for a reverse particle tracking simulation using model SHL-200T2 are shown on **Figure 6-2**. For this simulation particles are released immediately around the screened intervals of the two extraction wells and allowed to move backwards in time. The endpoints of these flow paths indicate the source areas for the water being captured by the extraction wells (under current recharge conditions with the cap in place) are primarily Shepley's Hill which flows through the landfill area and eventually reaches the extraction wells. This figure indicates: 1) the predicted capture zone for the system as operated in 2013 effectively contains groundwater passing through the landfill footprint, and 2) the source areas for captured water correspond to the predicted source areas for arsenic impacted water downgradient. Therefore, the extraction system as currently being operated is considered sufficient to capture impacted groundwater passing beneath the landfill cap and migrating northward.

Forward particle tracking was also completed by releasing particles at well locations where arsenic exceedances have been observed. The results of this simulation are shown on **Figure 6-3**. The forward particle tracking results support the conclusion that the extraction system, as currently being operated, is considered sufficient to capture impacted groundwater passing beneath the landfill cap and migrating northward.

The particle paths shown on **Figure 6-3** also show that water originating at wells with arsenic exceedances in the vicinity of the barrier wall flow to the northwest and not towards Plow Shop Pond. Some of these particles migrate to Nonacoicus Brook (originating primarily east of the wall) while others are captured by the extraction wells (originating primarily west of the wall). This suggests that the barrier wall is effective in reducing groundwater flow into Plow Shop Pond from the landfill area.

6.2 Geochemical Monitoring Assessment

The 2013 aquifer geochemical and arsenic data are presented in **Section 5.6**. These data are discussed below in the context of advective travel times and prevailing geochemical conditions (redox) as they relate to remedy RAOs.

6.2.1 Advective Travel Time Analysis

The updated groundwater flow model provides a tool to calculate travel time relationships throughout the flow field. The forward particle tracking simulation shown on **Figure 6-3** includes model-predicted travel times using time markers, with arrows spaced at two (2) year intervals. This figure shows that groundwater downgradient of the landfill travels horizontally at an average velocity of approximately 1 ft/day, which represents a maximum for advective transport.

6.2.2 Geochemical Assessment

As presented in **Section 5.0** and based on available monitoring data, elevated metals concentrations and negative redox potential persist approximately 1,250 feet downgradient of the landfill toe. Maximum arsenic concentrations in this area are at ppm levels and impacted groundwater primarily occurs in the lower half of the overburden aquifer, where its vertical position as it extends downgradient is controlled by the elevation of the bedrock-overburden contact. Impacted groundwater also exists outside the landfill footprint in the vicinity of Red Cove. In contrast to the NIA, maximum arsenic concentrations near Red Cove are lower and, because the overburden aquifer is considerably thinner at this location, the magnitude of mass flux toward the pond historically has been much smaller (and appears to be restricted now that the barrier wall has been completed).

Arsenic concentrations in downgradient wells vary, but show no overall pattern of decline despite evidence of upgradient hydraulic capture of groundwater from the landfill and that the extraction system has been operating for over seven years. The extraction wells are preventing flow of groundwater from the landfill, yet the persistence of arsenic in wells downgradient of the extraction system indicates that other geochemical conditions in that area have a stronger impact on the mobilization of arsenic from naturally occurring sources and that it will take a considerable amount of time to reduce downgradient arsenic concentrations.

6.3 Performance Assessment Summary

Consistent with EPA guidance including *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (USEPA, 2008), a multiple lines of evidence approach was taken with respect to the performance assessment. The individual assessment components, their data requirements, and a brief summary of the results are provided in **Table 6-1**.

With respect to the hydraulic capture zone analysis, the lines of evidence evaluated above indicate correspondence to the expected aquifer response to pumping resulting in the capture of groundwater at the north end of SHL. Despite apparent minor seasonal fluctuations and brief system operational shutdowns, the extraction wells are effective in maintaining a capture zone across the toe of the landfill as designed.

With respect to the geochemical monitoring data, conditions in the downgradient aquifer including the ongoing arsenic mobilization in the NIA demonstrate that it will take 100s of years to 'flush' residual carbon and remobilized arsenic in groundwater from the area of attainment (Sovereign, 2011a). In addition, the consistency of the arsenic data at the transect along West Main Street between 2001 and 2013 suggests that the arsenic impacted area in the NIA remains stable and that the ATP operation has little to no effect on the dissolved arsenic concentration in the NIA along West Main Street and points north. While the existing hydraulic data shows the ATP is achieving capture of groundwater at the north end of SHL, the remedy is not capable of achieving MCLs throughout the area of attainment in a reasonable amount of time and, even if the system were capable, it would need to operate indefinitely to maintain any improvements in groundwater quality as the on-going presence of oxygen-depleted groundwater beneath the landfill will continue to mobilize arsenic in hydrated ferric oxide coated sands for the foreseeable future.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations resulting from the landfill monitoring and maintenance, remedy operations and performance, and long-term monitoring at the SHL during 2013 are summarized in the following sections.

7.1 Conclusions

7.1.1 Landfill Monitoring and Maintenance

- In order to maintain the effectiveness of the existing landfill cover system as a remedy component of the SHL, inspection, monitoring, and maintenance of the landfill and the cap system was completed during 2013, as detailed in **Section 2.0**.
- The landfill was mowed in September 2013. Small trees and shrub growth were removed in various areas during the mowing event to maintain an effective cap system. Upon completion of the Plow Shop Pond dredging project, site restoration activities were conducted in disturbed areas of the SHL. The disturbed areas were re-graded to allow for proper drainage off the landfill. Hydroseed was applied to all disturbed areas.
- Landfill gas vents results were generally consistent with historical results and indicate proper landfill gas venting.
- Two general maintenance tasks recommended in the 2012 AR – installing grates on the landfill gas vents to prevent animal intrusion and installing locks on all monitoring wells – was completed in 2013.

7.1.2 SHL Remedy Operations and Performance

- The overall condition of the landfill the cap system is satisfactory (per the conclusions of Section 7.1.1) and the cap continues to impede the infiltration of surface water to the underlying aquifer resulting in the diversion of groundwater flow to the north.
- The consistency of landfill gas vent results with historical data confirms that the cap continues to maintain an effective barrier to meteoric water infiltration to the landfill.
- The barrier wall has proven effective in mitigating flow to Red Cove/Plow Shop Pond as demonstrated through hydraulic monitoring. Results of the hydraulic monitoring events conducted in 2013 demonstrated a positive difference in hydraulic head at each piezometer couplet location along the barrier wall. With the barrier wall in place, flow patterns in the Red Cove area have changed permanently, with reduced gradient toward the pond east of the wall and greater gradient to the north on the west side of the wall.
- During 2013, the ATP was operational approximately 85% of the total available hours during the calendar year. The percentage of time the plant was operable increased since 2012 due to increased efficiency of CIP procedures and optimization of FBRO sludge vac outs. A significant part of the non-operational time is due to routine plant maintenance and CIPs.

- When online, the ATP achieved an effective average extraction rate of 49.6 gpm which is an increase of 2.8 gpm from the average online extraction rate of 46.8 gpm in 2012.
- An average effluent arsenic concentration of 15.7 µg/L was calculated for the ATP in 2013, which is below the Special Permit Condition discharge limitation of 75 µg/L.
- The hydraulic capture zone assessment indicates that the extraction well field is capturing the majority of groundwater migrating beneath the landfill northward to the landfill toe and extraction system. This was confirmed by EPA's evaluation of transducer data in the vicinity of the ATP.

7.1.3 Groundwater Monitoring

- The results of each 2013 site-wide monitoring event illustrate a general groundwater flow from the southwest to the north towards Nonacoicus Brook with a deflection of groundwater flow to the north in the area west of the barrier wall.
- Based on arsenic concentration data at wells on either side of the barrier wall, it appears that the wall is effective in reducing the flow of groundwater from the landfill to the east.
- The existing LTM well network does not include monitoring wells in the NIA to monitor the effectives of the remedies in place. Consequently, wells and piezometers located throughout the NIA were sampled as part of supplemental monitoring in 2013, and a select group of these wells were proposed for inclusion within a revised LTM well network as detailed in the October 2013 Draft LTMMP Update (Sovereign, 2013b).
- The consistency of the arsenic data at the transect along West Main Street between 2001 and 2013 suggests that the arsenic impacted area in the NIA remains stable and that the ATP operation has little to no effect on the dissolved arsenic concentration in the NIA along West Main Street and points north.
- Arsenic data from wells downgradient of the extraction well capture zone exhibit both increasing and decreasing arsenic concentrations. Given the fact that the extraction system has been operating for over seven years and there is no overall decline in arsenic concentrations, it can be concluded that the ATP remedy will not achieve the aquifer restoration goals within a reasonable timeframe and will be required to operate indefinitely.
- With respect to the geochemical monitoring data, conditions in the downgradient aquifer demonstrate that the ATP remedy is not capable of achieving MCLs throughout the area of attainment in a reasonable amount of time, and even if the system were capable, it would need to operate indefinitely to maintain any improvements in groundwater quality.

7.2 Recommendations

The following provides recommendations for landfill monitoring and maintenance, SHL remedy operations and performance, and groundwater monitoring. In addition to the individual recommendations detailed below, it is recommended that DQOs and performance monitoring objectives are formally established as part of an update to the existing LTMMP to monitor the performance and effectiveness of each remedy.

7.2.1 *Landfill Monitoring and Maintenance*

Based on the site inspection conducted on October 4, 2013 by Sovereign personnel the following recommendations are made with respect to landfill maintenance:

- The steel casing of piezometer SHP-99-34A was observed to have been damaged to the extent that gauging of the piezometer is no longer possible. SHP-99-34A was removed from the hydraulic monitoring program as part of the Draft *Long Term Monitoring and Maintenance Plan Update* (Sovereign, 2013b). It is recommended that this well is properly abandoned.
- The road boxes of flush-mounted wells SHM-05-41A through C have deteriorated to a condition in which the covers cannot be properly secured. It recommended that the road boxes of flush-mounted wells SHM-05-41A through C be replaced. It is anticipated that these repairs will be conducted in summer 2014.
- The standpipe caps of the some of the wells currently in the LTMMP (SHL-5, SHL-18, SHL-21, and SHL-23) are in need of repair in order to properly secure the cover with a lock. It is recommended that repairs are made to the caps of those stick-up wells that remain part of the LTM program following finalization the LTMMP Update anticipated in 2014. It is anticipated that this will occur in summer 2014.
- Swales should be monitored for expanded growth of wetland species and vegetative growth during each annual inspection.
- Mowing should be continued on an annual basis to maintain the effectiveness of the cover system.

7.2.2 *SHL Remedy Operations and Performance*

The following recommendations are made with respect to the operation and maintenance of the ATP:

- Based on an inspection of the air compressor, it is recommended that it is replaced in the future. Consequently, a replacement air compressor was installed in April 2014.
- To increase safety and plant efficiency, it is recommended to manifold the piping system for the chlorine gas cylinders to allow three (3) cylinders to be connected via manifold rather than the existing two. This can be accomplished without any significant infrastructure changes or system downtime. Consequently, the chlorine gas manifold was installed in May 2014.
- To prevent the potential exposure of extraction well screens to air that is known to cause iron fouling and restricted flow/system down time, it is recommended that pressure level transducers are installed in each of the two active extraction wells (EW-1 and EW-4) to serve as a shut-off point to protect the extraction pumps in the event of a low water level condition. Additionally, this improvement will facilitate water level monitoring within the well at all times and allow the operators more control in optimizing flow rates. It is anticipated that this work will occur in summer 2014.
- To more accurately monitor and record the flow rate and total flow from each well, it is recommended that two local readout flowmeters with transmitters are installed prior to the extraction line manifold. In addition the use of the flowmeters will allow for an interlock to prevent extraction rates from exceeding the maximum treatment system flowrate and allow for the adjustment of flow from each of the extraction wells by

adjusting the variable frequency drive output. It is anticipated that this work will occur in summer 2014.

- As stated above, it is recommended that the Draft LTMMP Update be finalized in 2014 such that remedy performance metrics are clearly established based on the DQOs specified in the LTMMP. The LTMMP Update should consider the EPA's guidance on *Groundwater Remedy Completion Strategy (OSWER Directive 9200.2-144 May 2014).*

7.2.3 Groundwater Monitoring

Based on the results of the groundwater monitoring program to date, the following recommendations are made with respect to groundwater monitoring:

- The updated LTMMP is expected to be implemented in late 2014. The proposed updated well network will monitor key areas in and around the landfill and NIA and will aid in informational modeling of impacts and assessment of remedies. Until the updated LTMMP is implemented, it is recommended that a hybrid of the current LTM and the updated LTM is implemented to collected groundwater samples at semi-annual and annual locations detailed in both versions of the LTMMP as applicable.

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FIGURES

TABLES

APPENDIX A

Landfill Inspection Report

APPENDIX B (ON CD)

Laboratory Analytical Reports

APPENDIX C

Boring Logs

APPENDIX D (ON CD)

Profiling Field Forms

APPENDIX E (ON CD)

Groundwater Monitoring Field Forms

APPENDIX F

Arsenic Concentration Charts

APPENDIX G (ON CD)

Data Validation Reports