Broome County, New York

REMEDIAL SYSTEM OPTIMIZATION REPORT

Colesville Landfill,

Broome County, New York

March 30, 2017

REMEDIAL SYSTEM OPTIMIZATION REPORT

For The Colesville Landfill, Broome County, New York

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ACRONYMS AND ABBREVIATIONS

AGC	Annual Guidance Concentration
ARARs	Applicable or Relevant and Appropriate Requirements
Arcadis	Arcadis of New York, Inc.
ARI	Automated Reagent Injection
BPJ	Best Professional Judgment
COC	Contaminants of Concern
CSM	Conceptual Site Model
ERD	Enhanced Reductive Dechlorination
ESD	Explanation of Significant Differences
ft/ft	Foot per Foot
FML	Flexible Membrane Liner
ft/day	Feet per Day
FYR	Five-Year Review
gpm	Gallons per Minute
IRZ	In-Situ Reactive Zone
MCL	Maximum Contaminant Levels
MNA	Monitoring and Natural Attenuation
NYSDEC	New York State Department of Environmental Conservation
PRP	Principal Responsible Parties
PT	Pump and Treat
RAO	Remedial Action Objective
RI	Remedial Investigation
ROD	Record of Decision
RSO	Remedial System Optimization
SGC	Short-Term Guidance Concentration
SMP	Site Management Plan
SW-SGVs	Ambient Water Quality Standards and Guidance Values
TOC	Total Organic Carbon
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

1 INTRODUCTION

Arcadis of New York, Inc., (Arcadis) on behalf of Broome County has prepared this Remedial System Optimization Report (RSO) for groundwater and associated affected media (i.e., spring water and surface water) at the Colesville Landfill site (Site), located in Broome County, New York. The purpose of this RSO report is to evaluate the effectiveness of the site-wide remedies relative to the remedial action objectives (RAOs) documented in the Record of Decision (ROD). As described in the ROD, "It may become apparent, during the operation of the groundwater extraction system that, at a certain point, contaminant levels have ceased to decline and are remaining constant at levels higher than the remediation goal. In such a case, the system performance standards and/or the remedy will be reevaluated". Based on the remedial status, the findings that were documented in the In-Situ Reactive Zone Discontinuation Pilot Test Report (Arcadis 2015), and the reevaluation mechanism outlined in the ROD, a reassessment of the current remedy and the RAOs is warranted.

1.1 Site Overview

landfill is situated is generally bounded by East Windsor Road to the west and by unnamed tributaries of the Susquehanna River to the north, west, and east. The tributary to the north (DEC Tributary 120) is commonly referred to as the North Stream. The property consists of approximately 113 acres, 35 of which, located in the northern and western areas, were utilized for landfill operations. A site plan is provided as Figure 1.

A complete description of the hydrogeologic and hydrologic setting is presented in Section 2.2 of the 1996 Revised Focused Feasibility Study (Geraghty & Miller 1996). Two aquifers have been identified in the vicinity of the Site: the glacial outwash aquifer and the bedrock aquifer. These aquifers are separated by low permeability glaciolacustrine silt and clays and glacial till. In this type of hydrogeologic setting, a very high percentage of the areal recharge to the glacial outwash aquifer moves horizontally because of the dense glaciolacustrine clay confining unit that underlies the glacial outwash aquifer. Water moving within the glacial outwash aquifer beneath the landfill is part of a shallow groundwater subsystem that contributes base flow to surface-water bodies. The direction of groundwater flow at the Site is toward the west and southwest, discharging to the North Stream and Susquehanna River. Although groundwater is present in the till and glaciolacustrine clay, the low permeabilities of these units limits their potential for groundwater flow.

Historical aquifer testing indicates that the glacial outwash aquifer in the area of interest has a low permeability (approximately 0.2 to 0.3 feet per day (ft/day) and poor ability to yield water (0.25 to 0.5 gallons per minute (gpm)). The historical horizontal groundwater gradient ranges from 0.05 to 0.07 foot per foot (ft/ft). Assuming a mobile porosity range of three (3) percent to seven (7) percent (which is typical for glacial tills (Driscoll 1986), the calculated advective groundwater velocity ranges from 0.3 ft/day to 0.5 ft/day at the Site.

1.2 Project Objectives and Scope of Work

The objectives of this evaluation are to:

- Describe the significant remedial progress that has been achieved through reductive dichlorination of volatile organic compounds (VOCs) via the anaerobic in-situ reactive zone (IRZ).
- Describe the site conditions that make the current remedy inefficient and unable to restore groundwater quality to the cleanup criteria in the ROD in a cost effective and timely manner.
- To recommend an alternative remedial approach and/or revised RAOs that are achievable, and will be protective of human health and the environment.

1.3 Report Overview

This remainder of this Remedial System Optimization Report is organized in three sections: Section 2, Remedial Action Description, provides a description of the Site's regulatory and remedial action history; Section 3, Findings and Observations, provides a summary of groundwater quality observations over time and treatment system performance; and Section 4, Recommendations, describes the recommended modified remedial approach.

2 REMEDIAL ACTION DESCRIPTION

This section provides a brief overview of the Site history, regulatory history and requirements, remedial goals and site closure criteria, and past and current remedial actions.

2.1 Site Location and History

Waste disposal operations were conducted at the Site from 1969 to 1984. The Town of Colesville owned and operated the Site from 1969 to 1971 and then was transferred to Broome County. Broome County operated the landfill from 1971 until it was closed in 1984 (Wehran 1988).

The landfill was primarily used for the disposal of municipal solid waste. However, between 1973 and 1975, industrial waste consisting primarily of drummed aqueous dye wastes, as well as organic and chemical solvent mixtures were also disposed at the landfill (Wehran 1988). The primary disposal practice utilized during the operational life of the landfill was the trench method. Approximately ninety-three (93) percent of the material disposed at the Site was disposed in this way. The remaining seven (7) percent was disposed by utilizing the area method (Wehran 1988). Further information regarding the landfill operation is presented in Section 1.2 of the Colesville Landfill Site Management Plan (SMP) (Arcadis 2015).

2.2 Regulatory History and Requirements

A Remedial Investigation (RI) was initiated in 1983 by Wehran Engineering to characterize the nature and extent of contamination at the Site with other confirmatory sampling and further evaluations culminating in the ROD in 1991. The results of the RI are described in detail in the following reports:

- Hydrogeologic Investigation, Colesville Landfill, Wehran Engineers, Sept. 1983
- Phase II Hydrogeologic Investigation and Remedial Alternative Evaluation, Volumes 1 & 2, Wehran Engineers, Nov. 1984

- Agency for Toxic Substances and Disease Registry, Public Health Assessment, Colesville Municipal Landfill, Colesville, Broome County, NY, 1984.
- Colesville Landfill Remedial Investigation Report, Wehran Engineers, Revised Sept. 1988
- Record of Decision, Colesville Landfill Site, Town of Colesville, Broome County, NY, issued in March 1991.

As part of the RI, monitor wells were installed and sampled; surface water and sediment samples were collected and area homeowner wells were also sampled. In addition, a multi-phase geophysical investigation was conducted to determine the location and extent of landfilled materials buried on site. The RI was completed in the spring of 1988. In 1990, confirmatory sampling was conducted by Wehran Engineering to verify conclusions of the RI.

Studies found that ground water beneath the landfill was being contaminated with VOCs from wastes disposed at the Site. The areas of highest ground water contamination occurred along the southern and western site boundaries. Contamination was primarily confined to the upper portions of the glacial outwash aquifer underlying the Site and ground water flow was in a southwesterly direction, towards the Susquehanna River. Based on the geology, groundwater flow, and sampling data; groundwater and private water supply wells to the south and southeast and near Doraville did not appear to be impacted by site contaminants.

In December 1990, Wehran completed the FS report which presented an analysis of the potential alternatives for the remediation of the contamination observed at the Site.

Following the RI/FS, the United States Environmental Protection Agency (USEPA) issued a ROD for the Site in 1991 (USEPA 1991), which included the selection of a remedial method. The ROD called for capping the landfill, installing a leachate collection system, collecting and treating contaminated groundwater, and constructing and operating a new water supply system for the affected residents. The Principal Responsible Parties (PRPs) developed an engineering design package for the capping of the landfill and wetlands restoration areas between 1991 and 1994. The capping of the landfill and wetlands restoration were completed in October 1995. The alternate water supply design (consisting of a series of deep wells) was approved by the State in 1995.

Based upon design-related aquifer tests conducted at the Site, it was determined that extracting contaminated groundwater, as called for in the ROD, would not likely be an effective means of remediating groundwater in a reasonable timeframe. This conclusion led to an evaluation of alternative groundwater remediation technologies. Based upon this evaluation and a pilot-scale study of anaerobic IRZ technology, it was concluded that this technology, in combination with the installation of downgradient extraction wells, offered a more technically feasible approach for achieving site cleanup goals. A final groundwater remediation design was approved by New York State Department of Environmental Conservation (NYSDEC) on August 24, 2000. The Explanation of Significant Differences (ESD) to modify the ROD remedy was issued in September 2000.

Further information regarding regulatory history and requirements is presented in the SMP (Arcadis 2015).

2.3 Clean-Up Goals and Site Closure Criteria

As defined in the ROD, remedial measures are based on attaining groundwater maximum contaminant levels (MCLs) while mitigating potential exceedances of NYSDEC Ambient Water Quality Standards and Guidance Values (SW-SGVs) in the North Stream, a Class C water body (NYSDEC 1998) and potential risks to human health or ecological receptors from direct contact exposure to spring water along the North Stream. As stated in the ROD, the RAOs are as follows:

Surface Water

- Prevent exceedances of SW-SGVs for Site-related VOCs in the North Stream.

Groundwater

- Attain groundwater MCLs for Site-related VOCs in the glacial outwash aquifer; and
- Protect human health and the environment from current and potential future migration of contaminants in groundwater.

The ROD also identified soil and sediments as media of concern at the Site. However, the ROD Remedy addressed the RAOs for soil through the installation of a landfill cap which was completed in November 1995 and addresses the RAOs for sediments through the SP-4 spring water remedy and use of existing engineering controls.

The ROD describes several factors that contribute to the potential inability to reach remedial goals. The large size of the landfill and the fact that there are no identified on-site hot spots that represent the major sources of contamination preclude a remedy in which contaminants could be excavated and treated efficiently. Furthermore, the ROD was prepared based on an incomplete understanding of Site conditions that limit remedy effectiveness. This provided for the opportunity to reevaluate the ROD remedy, over time, to ensure ROD remedial measures continue to be effective.

2.4 Previous Remedial Actions

Prior to the preparation of the ROD, no remedial actions were undertaken at the Site.

In 1991, the USEPA issued the ROD Remedy , which included: (1) installation of a landfill cap; (2) construction of a gas venting layer; (3) installation of groundwater extraction wells beneath and downgradient of the landfill; (4) ex-situ groundwater treatment; (5) surface-water discharge to either the Susquehanna River or to the North Stream, a tributary of the Susquehanna River; (6) fencing to restrict access to the Site; (7) imposition of property deed restrictions, if necessary; (8) development and construction of a new water supply system (which may include a new well or wells) for impacted residential wells in the area that remain in use, and (9) implementation of a monitoring program upon completion of closure activities to provide data to evaluate the effectiveness of the remedial effort over time.

As previously discussed, installation of the landfill cap was completed in November 1995, and an anaerobic IRZ remedial system, in combination with the installation of downgradient extraction wells, was implemented as the groundwater remedy.

2.5 Description of Existing Remedy

The section provides a summary of the remedial system objectives, components, and operations and maintenance procedures.

2.5.1 System Goals and Objectives

The remedial response objectives of the remedy that was implemented include the following:

- Protect human health and the environment from current and future migration of contaminants in groundwater; and
- Restore the onsite groundwater to levels consistent with federal and state groundwater standards.

In a September 2000 ESD, it was determined that extracting groundwater from beneath the landfill, as called for in the ROD, would not likely be an effective means of remediating the source in a reasonable time frame. Specifically, the low permeability of the aquifer would necessitate the installation of an inordinate number of extraction wells. The ESD called for a groundwater remediation design using molasses injections in combination with a downgradient extraction and treatment system, on the basis of a successful pilot study of molasses injection technology.

A 2004 ESD addressed the discovery of a contaminated spring along the stream bank of the North Stream and an additional low-lying wet area located approximately 375 feet to the south of the landfill that could potentially overflow during rainy conditions to a vegetated drainage swale that conveys water to the South Steam. The remedy at the contaminated spring along the North Stream, identified as the SP-4 Remedy, consists of the installation of a subsurface stone collection trench and drainage layer in the area of the spring to prevent the contaminated spring water from exfiltrating above the land surface. The remedy at the low-lying wet area south of the landfill, identified as the SP-5 Remedy, consists of a sand filter and a granular activated carbon unit that were placed in an existing concrete structure, and the installation of a riprap-lined outlet structure to prevent erosion at the discharge point of the drainage pipe. The spring water flows vertically upward through the filter materials in the concrete structure, and the treated water is discharged via a horizontal drainage pipe at the rip-rap lined discharge area.

As part of the revised ROD remedy, both the IRZ and pump and treat (PT) systems were implemented. The IRZ was historically the primary remedial component used to treat VOC mass, with the PT system proving not to be highly effective at removing VOC mass. Beyond the IRZ treatment zone, natural attenuation has also been a major component of the remedy in areas beyond the area of the IRZ. Therefore, natural attenuation processes have effectively treated VOC-impacted areas that are side-gradient or downgradient of the IRZ treatment zone during the period of active remediation at the site, and have been a significant factor in maintaining a stable to decreasing plume extent over that time period. A further description of mass transport and natural attenuation processes is provided in Section 4.1.3 Conceptual Site Model.

2.5.2 System Description

Remedial systems associated with the Site are shown on Figure 1 and include the following:

Landfill Cap

The landfill cap consists of a multimedia cap over the landfill material that attains the performance requirements for caps at hazardous waste landfills as specified in the Code of Federal Regulations (CFR) Part 264.310. It provides for long-term minimization of migration of liquids through the closed landfill by establishing proper slopes for drainage of precipitation, vegetated topsoil to promote evapotranspiration, and installation of a flexible membrane liner (FML) with a permeability of 1×10^{-12} centimeters per second. The objective of the landfill cap is to prevent stormwater infiltration into the landfill thereby eliminating further contaminant migration from vadose zone soils (e.g., contamination from buried waste) into groundwater.

Groundwater Recovery System

When it is in operation, the Groundwater Recovery System consists of three recovery wells (GMPW-3, GMPW-4, and GMPW-5) and associated pumps that extract groundwater at a combined flow rate of approximately 1 gallon per minute. The pneumatic pumps deliver the extracted groundwater to a treatment building, and into the top of a low-profile air stripper. The air stripper off-gas is discharged through a stack to the atmosphere. The treated groundwater is then pumped through two cartridge filter housings that remove iron and silicate particulates. The treated groundwater is then discharged to the swale that conveys water to the North Stream.

Enhanced Reductive Dechlorination Automated Reagent Injection System

An automated reagent injection (ARI) system was installed within the treatment building to serve as the means for delivering organic carbon to the subsurface to establish conditions conducive for enhanced reductive dechlorination (ERD) across the southwest boundary (the IRZ) of the landfill. The system accelerates the microbial degradation of VOCs. The ARI system consists of two raw molasses blend storage tanks, a temporary PT system effluent water holding tank, a cone-bottom mixing tank where the raw molasses and PT system effluent water are mixed prior to being pumped into 17 injection wells, mixer motor and impellor, transfer pumps, and an associated controls and instrumentation system to automate the injection process.

SP-5 Spring Water Remediation System

The SP-5 spring remedy consists of a spring water collection trench, a 350-pound LPGAC unit, a sand pre-filter, a lockable aluminium cover, a two-inch diameter discharge pipe, a riprap-lined infiltration bed, and engineering controls for erosion and sediment control. Spring water from the SP-5 spring area is first collected within the collection trench and/or the sand pre-filter prior to exfiltrating land surface. Spring water collected within the trench is conveyed to the bottom of the concrete structure by gravity. The collected spring water then travels up through the LPGAC unit. Treated effluent is conveyed into a below grade infiltration bed consisting of a riprap layer. A rip-rap lined outlet structure to prevent erosion was installed at the discharge point of the drainage pipe.

SP-4 Spring Water Remedy

The remedy for the spring at SP-4 consisted of the installation of a subsurface stone infiltration bed in the area of the spring to prevent the contaminated spring water from exfiltrating above the land surface. Large boulders were placed between the stream and the infiltration bed to protect the integrity of the infiltration bed during high water conditions. A heavy stone retaining wall was also installed along a larger stretch of the North Stream as an erosion control measure and the stream channel was realigned as part of this effort.

2.5.3 Operation and Maintenance Program

The following briefly describes the components of the long-term effectiveness and performance monitoring programs. A detailed description of the long-term monitoring programs is found in the "Long-Term Monitoring Plan" (Arcadis 2002) the Long-Term Monitoring Addendum for Spring Water Remediation Systems" (Arcadis 2003) and the SMP (Arcadis 2015).

Effectiveness Monitoring

The long-term effectiveness monitoring program at the Site includes: hydraulic monitoring (depth to groundwater measurements); groundwater quality monitoring (groundwater sampling); sampling at spring water locations along the North Stream that were identified during the remedial investigation; and sampling of downstream surface water in the North Stream. A total of 18 existing monitoring wells, four spring water sample locations, and one surface water sample location were included in the long-term monitoring program. The components of effectiveness monitoring are described below:

- Monitor groundwater flow patterns on-site
- Monitor VOC concentrations in groundwater, spring water (if present) located along the north stream, and surface water in the North Stream downstream of the existing springs
- Monitor key field and biochemical indicator parameters in the area immediately downgradient of the ERD injection wells and other select monitoring wells

Groundwater Remediation System Operational Performance Monitoring

PT system operational performance monitoring, when the system is operating, includes: routine visual inspection, recording system field parameters, maintenance on system equipment (as necessary) and collection of air and water compliance samples. PT system effluent water and air samples are compared to effluent emissions criteria in order to ensure compliance and monitor system performance. System operational parameters are compared to design criteria to ensure the system continues to operate in accordance with the Groundwater Remediation System Design Drawings and Technical Specifications.

ARI groundwater monitoring, when the system is operating, includes: sampling select injection wells for total organic carbon (TOC) and monitoring field parameters (i.e., oxidation-reduction potential, pH, specific conductance, temperature, dissolved oxygen, and sulfide). Results from the injection well sampling are used to adjust carbon loading and/or frequency of reagent injections, as necessary. In addition to groundwater monitoring conducted explicitly for the ARI system monitoring, field parameter and analytical results for select monitoring wells associated with the long-term effectiveness monitoring program are also used as needed, to evaluate performance of the ARI system.

SP-4 and SP-5 Spring Water Remediation System Performance Monitoring

Operational performance monitoring of the SP-4 spring remedy is conducted on a semi-annual basis and includes visual inspection of the SP-4 area to ensure that the spring water generally remains suppressed within the groundwater system and the collection of a sample from the intermittent spring and a mid-stream surface sample immediately downgradient of the former SP-4 spring area. Operational performance monitoring of the SP-5 spring remedy is conducted on a semi-annual basis and includes routine visual inspection, recording system field parameters, maintenance on system equipment (as necessary) and collection of influent and effluent water samples. System effluent spring water samples are compared to effluent criteria in order to ensure compliance with the Best Professional Judgment (BPJ) limits and monitor system performance.

Residential Supply Well Operational Performance Monitoring

Groundwater quality samples are collected from the residential water supply wells on a quarterly basis and analysed at a NYSDOH approved laboratory. The analytical list was taken from 6 NYCRR Part 360 Baseline Parameters List.

Further information regarding the current system operations and maintenance is provided in Section 4 of the SMP (Arcadis 2015).

2.5.4 Institutional Controls

Following issuance of the ROD, Broome County installed double-cased bedrock wells for the two residences on the Charles Scott parcel (referred to as the Charles Scott Sr. and River residences). The Charles Scott Sr. residence is occupied, and the River residence (Claude Scott) is currently vacant and abandoned. The bedrock wells were installed to provide the residents with a clean drinking water supply.

In addition, the NYSDEC and the USEPA approved the Broome County and GAF Corporation (i.e., PRPs) proposal to undertake a program of acquiring the residential properties where wells were impacted by VOCs (the contaminants of concern [COCs]) as an alternative to implementing the new water supply required by the ROD. The impacted residential properties are or were owned by the DeFreitas family, Harry Ray Scott (Riley), the Smith family, and Charles Scott. The DeFreitas and Smith properties have been purchased and have been vacated; negotiations to purchase the Harry Ray Scott and Charles Scott properties were not successful, and as previously mentioned the residences on the Charles Scott parcel were provided with bedrock wells. The Harry Ray Scott residence is abandoned and dilapidated. Moreover, deed restrictions on groundwater use were recorded for Broome County-owned properties, and the Harry Ray Scott property, now owned by Thomas Scott.

3 FINDINGS AND OBSERVATIONS

The areal extent and distribution of total chlorinated VOCs prior to remedial implementation is shown on Figure 2. The plume can be described as centered at the westernmost toe of the landfill and decreasing in concentration with increasing distance from the landfill. As depicted on Figure 3, groundwater quality in monitoring wells has exhibited a significant improvement as a result of groundwater remediation system operation.

For site-wide groundwater concentrations to continue to decrease and eventually decline to MCLs, the following conditions are needed:

- A decreasing concentration trend for groundwater migrating from underneath the landfill. The landfill cap continues to remain in place to ensure that concentrations decrease over time, and long-term monitoring data from landfill monitoring well GMMW-7 demonstrate this trend.
- Stable to decreasing VOC concentrations in groundwater downgradient of the landfill. The time-concentration graphs shown on Figure 3 indicate that between remedial system startup (September 2002) and implementation of the IRZ Discontinuation Pilot Test (May 2012), concentrations decreased to asymptotic low levels. Following discontinuation of anaerobic IRZ injections in May 2012, there has also been very little change in the VOC concentration trends, indicating that the treatment systems (i.e., groundwater extraction and anaerobic IRZ injections) have effectively removed VOC mass and are no longer a necessary component of removing the remaining low levels of persistent VOCs.

The fact that VOC concentrations continue to persist at low, asymptotic levels approximately five years following discontinuation of active remedial measures indicates that natural attenuation processes are an equivalent and effective means of remediating groundwater at this stage of the remedial life cycle. Therefore, a more optimized means of progressing toward the cost-effective attainment of MCLs is to utilize natural attenuation processes as the primary means to remediate groundwater.

As VOC concentrations in groundwater continue to improve over time through natural attenuation processes, spring water quality and surface water quality will also exhibit commensurate improvements as they are a reflection of downgradient groundwater quality.

3.1 Subsurface Performance

Overall, the data indicate that the plume extent is stable as a result of degradation processes primarily occurring in the strongly anaerobic portion of the site (i.e., approximate area of the former anaerobic IRZ). Enhanced and/or natural attenuation mechanisms (e.g., reductive dechlorination completed through a biologically mediated pathway) continue to degrade chlorinated VOCs within the former IRZ area despite the discontinuation of carbon injections, as evidenced by stable VOC concentrations. The data indicate that shutdown of the groundwater extraction and treatment and automated injection systems have not resulted in an adverse impact to groundwater quality. A representation of the current plume delineation is provided on Figure 3. Furthermore, the time-concentration graphs shown on Figure 3 indicate decreasing VOC concentrations over time, no adverse concentration trends following discontinuation of anerobic IRZ injections (May 2012), and VOC concentrations predominantly at low, asymptotic levels.

The PT system recovered an estimated 2.39 million gallons of groundwater and an estimated 3.8 lbs of VOCs between system startup in 2002 and the initiation of the discontinuation pilot test in 2012. The spring water remediation system has treated an estimated 5.3 million gallons of spring water and recovered an estimated 2.3 lbs of VOC since remedy implementation in October 2003.

3.2 Treatment System Performance

When it is in operation, the PT consisted of three recovery wells that extracted groundwater at a combined flow rate of approximately 1 gpm. After treatment, the extracted groundwater was either used onsite for injections or discharged to the North Stream.

During PT system operation, regular sampling included collection of individual recovery well samples, total influent, and total effluent after the cartridge filters. A PT system air stripper effluent sample was also collected. Historically, all groundwater VOCs were treated to below their respective BPJ limits via the low-profile air stripper. Based on the results of the air model, all VOCs in air stripper emissions were historically below their respective short-term guidance concentrations (SGCs) and annual guidance concentrations (AGCs). While the treatment system operated as designed, and effectively treated influent groundwater, it represented only a minor component of VOC-mass removal from the subsurface in comparison with degradation processes (i.e., reductive dichlorination with the former anaerobic IRZ and site-wide natural attenuation).

3.3 Regulatory Compliance

As described in the Operational Year 10 Annual Monitoring Report (Arcadis 2013) the PT system operated effectively through 2012 and treated influent VOCs and total iron to below their respective BPJ limits during each operational period prior to system shutdown.

Site-related COCs have historically been detected in spring water samples at low concentrations. Despite the presence of site-related COCs in spring water, non-detect to trace concentrations are present in the surface water of the North Stream, immediately downgradient of each respective spring. These data demonstrate that surface water quality is not being adversely impacted by the landfill and spring water.

Metals results for spring sediment samples greater than background concentrations have also been detected in two locations (SP-3 and SP-4), primarily related to dissolved metals within the spring water that flocculate on the sediment surface when oxidized. Overall, this area is relatively inaccessible due to rip-rap within the spring area.

The USEPA issued a Fourth Five-Year Review (FYR) report on May 26, 2015 which stated that the remedy protects human health and the environment in the short-term because unacceptable exposure to contaminated media has been interrupted by the implemented remedial actions, and all institutional controls are in place. In order to demonstrate long-term protectiveness, it needs to be demonstrated that natural attenuation is effectively addressing impacted media. Furthermore, North Stream sediment sampling and scraping needs to continue. This scraping has been documented to be effective through the collection of sediment samples both prior to and after completion of surficial sediment removal.

3.4 Major Cost Components of Processes

During two typical years of PT system operation (April 2010 to March 2011 and May 2011 to April 2012), the project cost between $220,000 and $295,000 annually. This included costs for project management, operation and maintenance, groundwater monitoring, reporting and engineering.

Since the shutdown of the PT system, costs have declined due to the elimination of operation and maintenance and extensive groundwater monitoring. The proposed monitoring and natural attenuation (MNA) sampling program, including an Annual Report, would cost an estimated $20,000 to $25,000 per year, which saves approximately $200,000 to $275,000 on an annual basis.

3.5 Safety Record

No safety issues have been identified or recorded at the Site.

4 REDOMMENDATIONS

Based on known information regarding the efficacy of the ROD remedy (as modified by ESDs) and groundwater quality observations and trends over time, a modified approach to achieve site closure is warranted.

4.1 Recommendations to Achieve or Accelerate Site Closure

This section describes the Conceptual Site Model (CSM) including the nature of historic site disposal activities, limitations on the feasibility of source reduction, and hydrogeologic factors that cause VOCs to persist in the subsurface.

4.1.1 Source Reduction/Treatment

The source of contamination is below the landfill cap. The landfill cap serves to isolate the source material and limit the spread of contamination by preventing infiltration. Due to the difficulty of locating and removing the source of contamination, natural degradation is the only available means of source reduction. Although the source VOC mass has been reduced over time, concentrations remain above applicable or relevant and appropriate requirements (ARARs) in groundwater migrating from beneath the landfill.

VOC concentrations have exhibited a declining trend over time in GMMW-7, in terms of total volatile organic compounds (TVOCs) as well as the five Site indicator chemicals (1,1-dichloroethene, trichloroethene, benzene, chlorobenzene, and 1,1-dichloroethane). GMMW-7 is located at the downgradient edge of the landfill. VOC concentrations have also declined over time in the monitoring wells installed beneath the landfill cap (see Figure 3). These results indicate that the landfill cap, in combination with natural degradation, is effectively controlling source migration to a degree that allows for VOC concentrations in groundwater downgradient of the landfill to attenuate to levels that are protective of human health and the environment.

4.1.2 Sampling

Please refer to Section 4.2.2 for information regarding the new monitoring schedule prepared for the SMP.

4.1.3 Conceptual Site Model (Risk Assessment)

For most sites, mass transport is primarily governed by diffusion and the complex interaction between aquifer mass storage zones (e.g., immobile porosity/secondary porosity and low aquifer hydraulic conductivity architecture) and aquifer mass transport zones (e.g., mobile porosity and high hydraulic conductivity architecture). The primary factors in mass transport or plume behavior are plume age, the variability in hydrogeologic architecture (i.e., number of transitions or lenses of high hydraulic conductivity to low hydraulic conductivity media within a vertical section of aquifer), and the ratio of total porosity to mobile porosity. These concepts are described in detail in *Remediation Hydraulics* (Payne et al., 2008). Ultimately, these concepts, as a general rule, explain why traditional site remedies such as groundwater extraction are extremely inefficient at mass removal and explain why the actual estimated remedial timeframes at most sites are much longer than initially anticipated or modeled. The concepts also reveal that the rate of mass transport is typically much lower using the new paradigm when compared to the previous standard transport models.

Performance monitoring data from the anaerobic IRZ provided invaluable insight into the mass transport behavior at the Site. Specifically, the monitoring of TOC introduced into the aquifer during anaerobic IRZ implementation and the monitoring of the inert tracer bromide as part of the Alternate Electron Donor Pilot Test (ARCADIS G&M, Inc. 2006) were used to estimate the rate of advective groundwater velocity and estimate the rate of overall mass transport. As a general rule, the initial observation of an injected solute at relatively low concentration at nearby downgradient monitoring locations corresponds to the advective groundwater velocity because the solute has not had an opportunity to transfer into mass storage zones. The long-term behavior of solute mass, or the time to reach the center of solute mass at a location downgradient from the injection point, represents the overall mass transport rate as it accounts for the processes that drive mass retardation. Ultimately, TOC and bromide monitoring data support an advective groundwater transport velocity in the range of 0.3 ft/day to 0.5 ft/day, which is consistent with previous hydrogeologic data. However, these data also support an average mass transport rate of approximately 0.03 ft/day to 0.05 ft/day. When compared to current literature, these data correlate well to the overall hydrogeologic setting at the Site and the complex hydrogeologic architecture comprised of significant variability in vertical strata with varying conductivities and a high proportion of immobile to mobile porosity. However, the data indicate that groundwater cleanup times will be significant and will be dictated by the rate of mass transfer from the mass storage zones to the mass transfer zones, irrespective of remedial technology implemented. The revised CSM provides a significant challenge to expediting groundwater remediation within a reasonable timeframe; however, it also supports the fact that groundwater mass transport rates are extremely low and easily tracked using a monitoring only or similar approach.

The revised CSM indicates that the active remedy components provide little additional benefit to the quantity of mass removed and to the overall remedial timeframe, and MNA will be the primary driver for achieving groundwater MCLs, regardless of whether operation of the ROD remedy is continued. Since implementation of the IRZ Discontinuation Pilot Test, groundwater quality data indicate that the areal extent of VOC-impacted groundwater in the glacial outwash aquifer is static and total VOC concentrations are generally stable to decreasing over time, as evidenced by historical analytical results from landfill interior, landfill perimeter, downgradient and plume boundary monitoring well data.

4.2 Recommendations to Improve Performance

The performance of the current remedy can be maintained through the implementation of an equivalent MNA remedy. The MNA remedy is more sustainable than the current remedy and will provide equal protection of human health and the environment.

4.2.1 Maintenance Improvements

No improvements to the current maintenance schedule are necessary. County personnel will continue conducting periodic site visits to scrape and remove the surface sediments in the SP-3 and SP-4 areas.

4.2.2 Monitoring Improvements

An updated monitoring schedule has been prepared for the SMP that includes periodic sampling of natural attenuation parameters.

4.2.3 Process Modifications

As discussed in Section 3, the recommended modified remedial approach is MNA. The associated process modifications are the discontinuation of the PT and IRZ, to be implemented as proposed in the Discontinuation Pilot Test Work Plan (Arcadis 2012).

4.3 Recommendations to Reduce Costs

As noted in Section 3.4, operation, maintenance and monitoring of the PT and ARI systems have been costly, compared to monitoring only. Natural attenuation provides an equivalent means of protecting human health and the environment at a reduced cost. As described in Section 3.4, MNA has the potential to reduce costs by eliminating operation and maintenance, project management and other costs associated with the PT system.

4.3.1 Supply Management

There are no recommendations for supply management that can have a material effect on the efficiency or cost of remedial operations at the Site.

4.3.2 Process Improvements or Changes

Please refer to section 4.2.3 for a description of the recommended process change. The recommended change to MNA from active treatment will result in reduced costs and greater sustainability due to decreased electricity usage and decreased use of resources for maintenance and monitoring activities.

4.3.3 Optimize Monitoring Program

The monitoring program will be reviewed on an annual basis and any recommended changes to the monitoring program over time will be submitted to NYSDEC for their approval.

4.3.4 Maintenance and Repairs

Maintenance and repair activities will continue in order to maintain the integrity of the Site remedy, and will include inspections and any necessary maintenance of the cap, perimeter fencing, and monitoring wells.

4.4 Recommendations for Implementation

In light of the success of the IRZ Discontinuation Pilot Test, demonstration of a stable to decreasing plume extent, and no deterioration in the quality of springs, sediment or surface water associated with the North Stream, a transition to MNA will be an effective alternative to the current remedy.

Furthermore, based on projections for continued improvement, and unfavorable costs with no significant remedial benefit associated with groundwater extraction and treatment and ARI system groundwater treatment, a transition to MNA is implementable and more favorable than the ROD remedy. An MNA remedy should be implemented at the Site upon approval by the NYSDEC.

4.5 References

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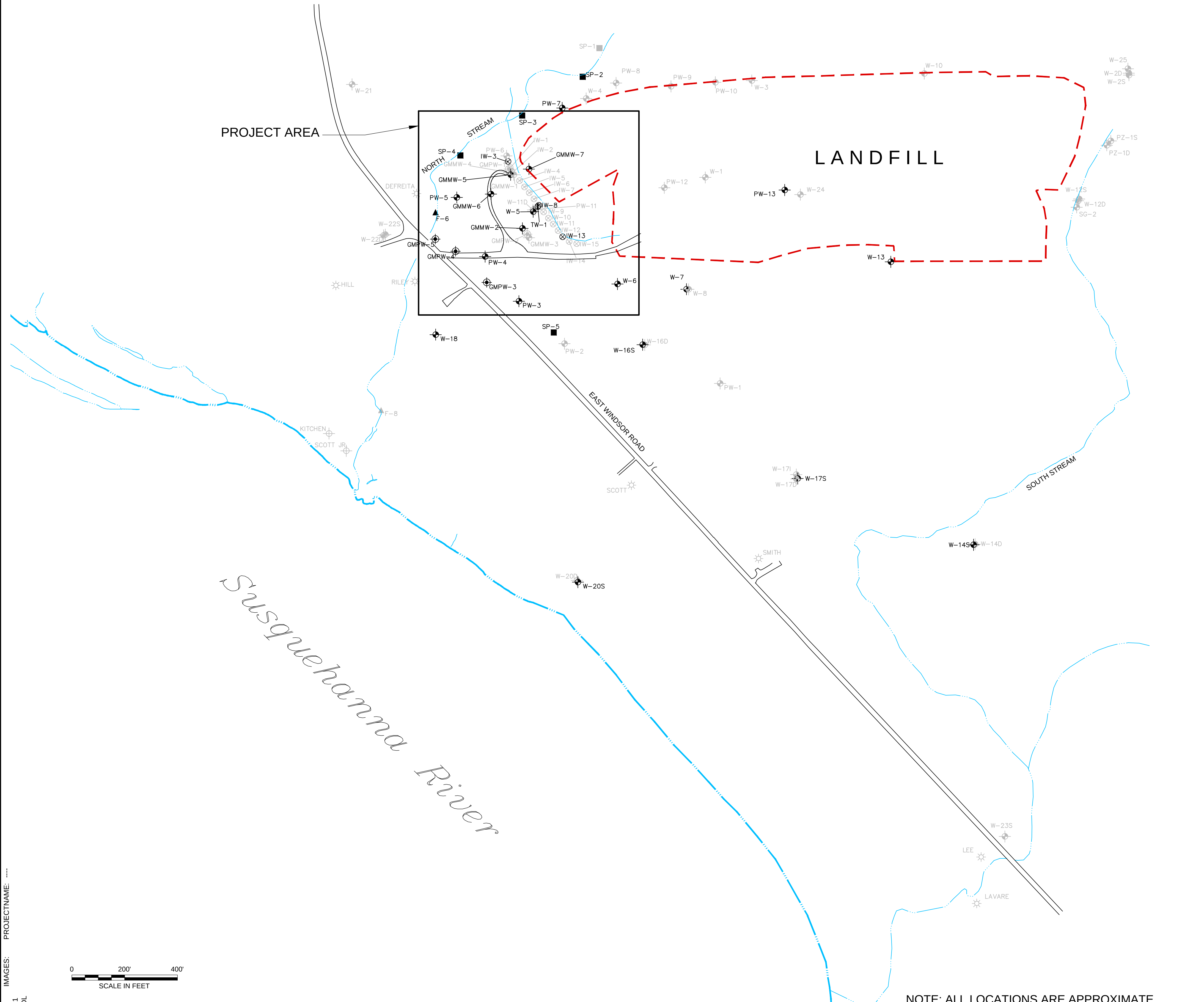
FIGURES



EXPLANATION

BOLD IN-SITU REACTIVE ZONE (IRZ) DISCONTINUATION PILOT TEST MONITORING WELL

W-24 / GMMW-7 LOCATION AND DESIGNATION OF MONITORING WELL

SCOTT LOCATION AND DESIGNATION OF EXISTING HOMEOWNER WELL

HILL LOCATION AND DESIGNATION OF FORMER HOMEOWNER WELL

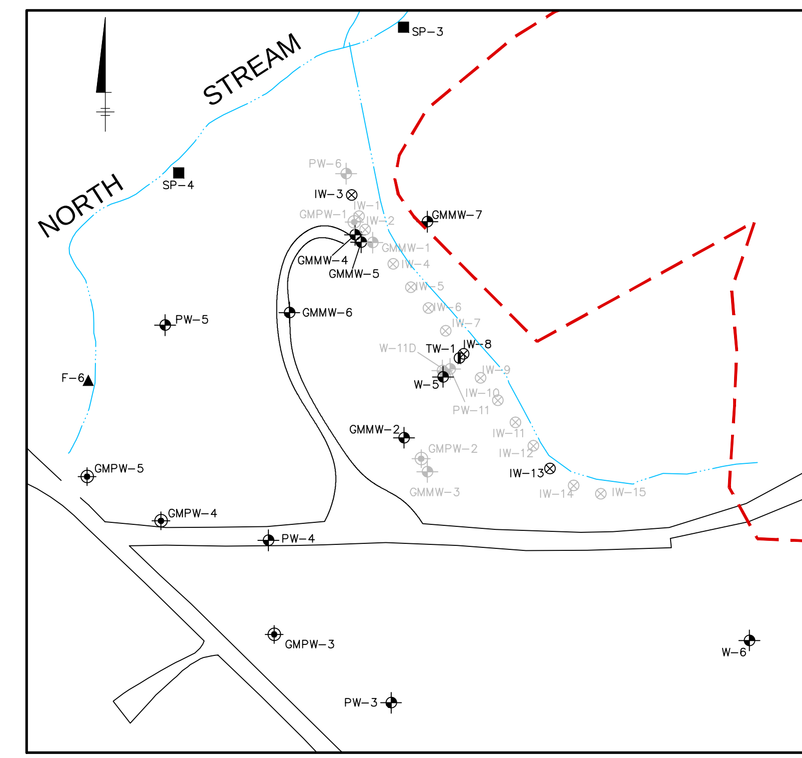
IW-2 LOCATION AND DESIGNATION OF INJECTION WELL

GMPW-3 LOCATION AND DESIGNATION OF PRODUCTION WELL

TW-1 LOCATION AND DESIGNATION OF TEST MONITORING WELL

F-6 LOCATION AND DESIGNATION OF SURFACE WATER SAMPLE

SP-2 LOCATION AND DESIGNATION OF SPRING SAMPLE AND CO-LOCATED SEDIMENT SAMPLE



SITE PLAN SHOWING PROJECT AREA

0 100' 200'
SCALE IN FEET

COLESVILLE LANDFILL
COLESVILLE, NEW YORK

SITE PLAN

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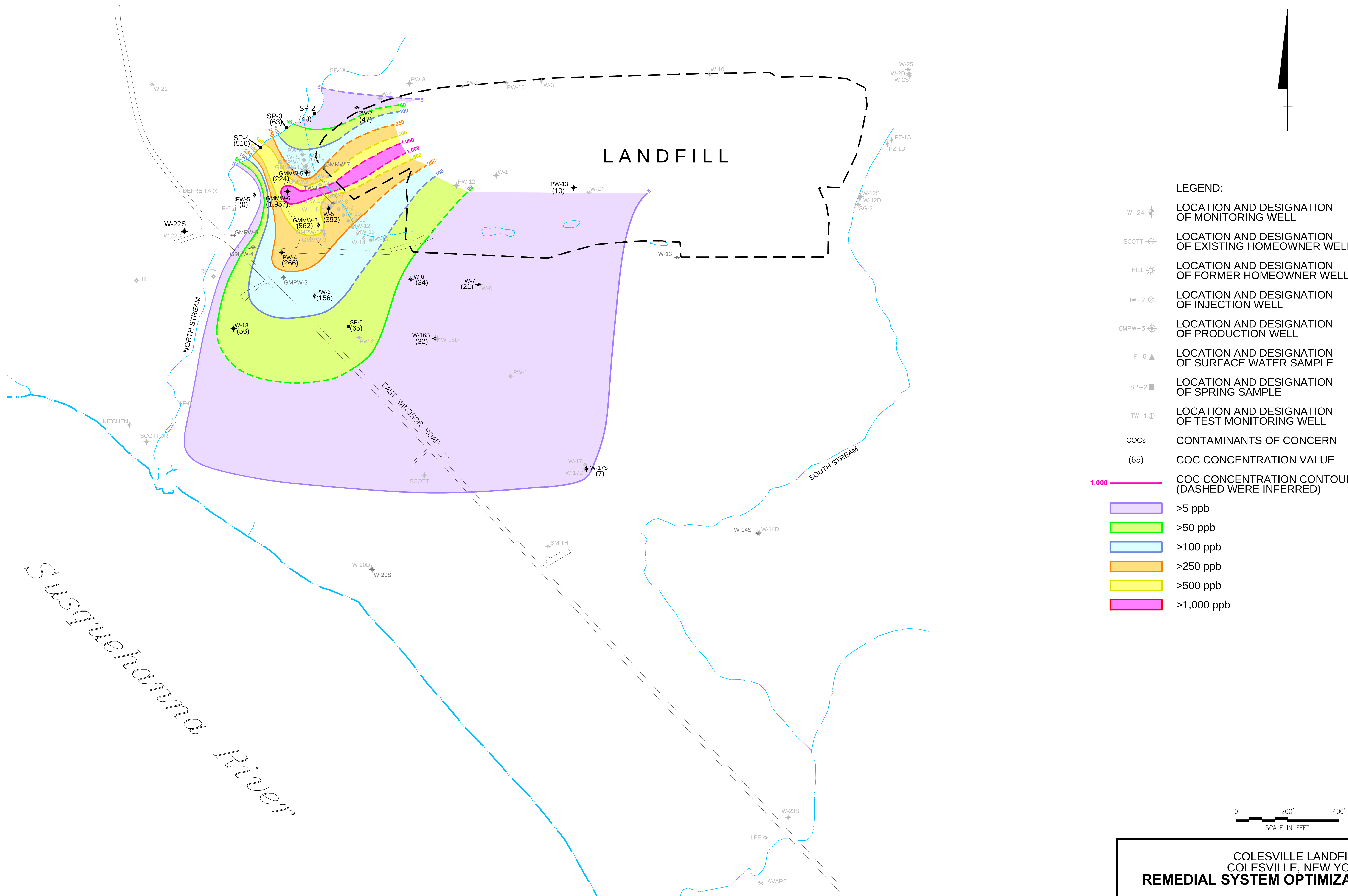
FIGURE 1



NOTES:

1. TOTAL CONTAMINANTS OF CONCERN (COCs) IS EQUAL TO THE SUM OF THE CONCENTRATIONS OF 1,1,1-TRICHLOROETHANE, 1,1,2-TRICHLOROETHANE, 1,1-DICHLOROETHANE, 1,1-DICHLOROETHENE, 1,2-DICHLOROETHANE, CHLOROETHANE, CIS-1,2-DICHLOROETHENE, TETRACHLOROETHENE, TRANS-1,2-DICHLOROETHENE, TRICHLOROETHANE, AND VINYL CHLORIDE.
2. ALL LOCATIONS ARE APPROXIMATE.

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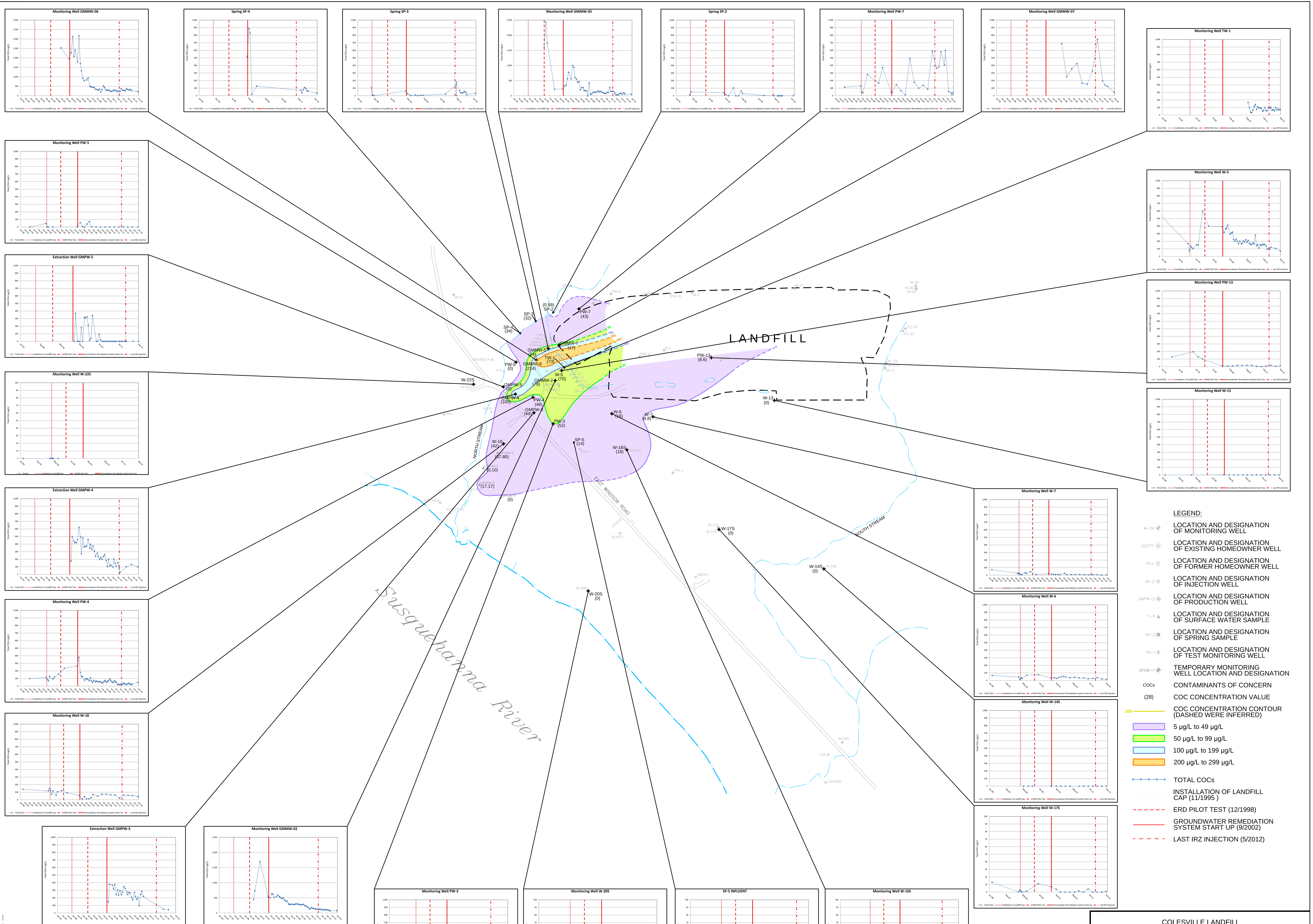
FIGURE
2



NOTES:

1. TOTAL CONTAMINANTS OF CONCERN (COCs) IS EQUAL TO THE SUM OF THE CONCENTRATIONS OF 1,1,1-TRICHLOROETHANE, 1,1,2-TRICHLOROETHANE, 1,1-DICHLOROETHANE, 1,1-DICHLOROETHENE, 1,2-DICHLOROETHANE, CHLOROETHANE, CIS-1,2-DICHLOROETHENE, TETRACHLOROETHENE, TRANS-1,2-DICHLOROETHENE, TRICHLOROETHENE, AND VINYL CHLORIDE.
2. GROUNDWATER REMEDIATION SYSTEM START-UP INCLUDES THE START-UP OF THE GROUNDWATER EXTRACTION SYSTEM AND ENHANCED REDUCTIVE DECHLORINATION (ERD) SYSTEM.
3. ALL LOCATIONS ARE APPROXIMATE.
4. LOCATIONS DPGW-1 TO DPGW-4 ARE TEMPORARY MONITORING POINTS SAMPLED IN JUNE 2011.

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FIGURE
3

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