Corrective Measures Implementation Plan
SWMU 54 Benzene Plume

Naval Activity Puerto Rico
Ceiba, Puerto Rico

Revision No. 00

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Submitted to:

U.S. Naval Facilities
Engineering Command
Southeast

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March 2011

Certification Page
Corrective Measures Implementation Plan
SWMU 54 Benzene Plume

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Signature: _____

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Title: BRAC Environmental Coordinator

Date: March 14, 2011

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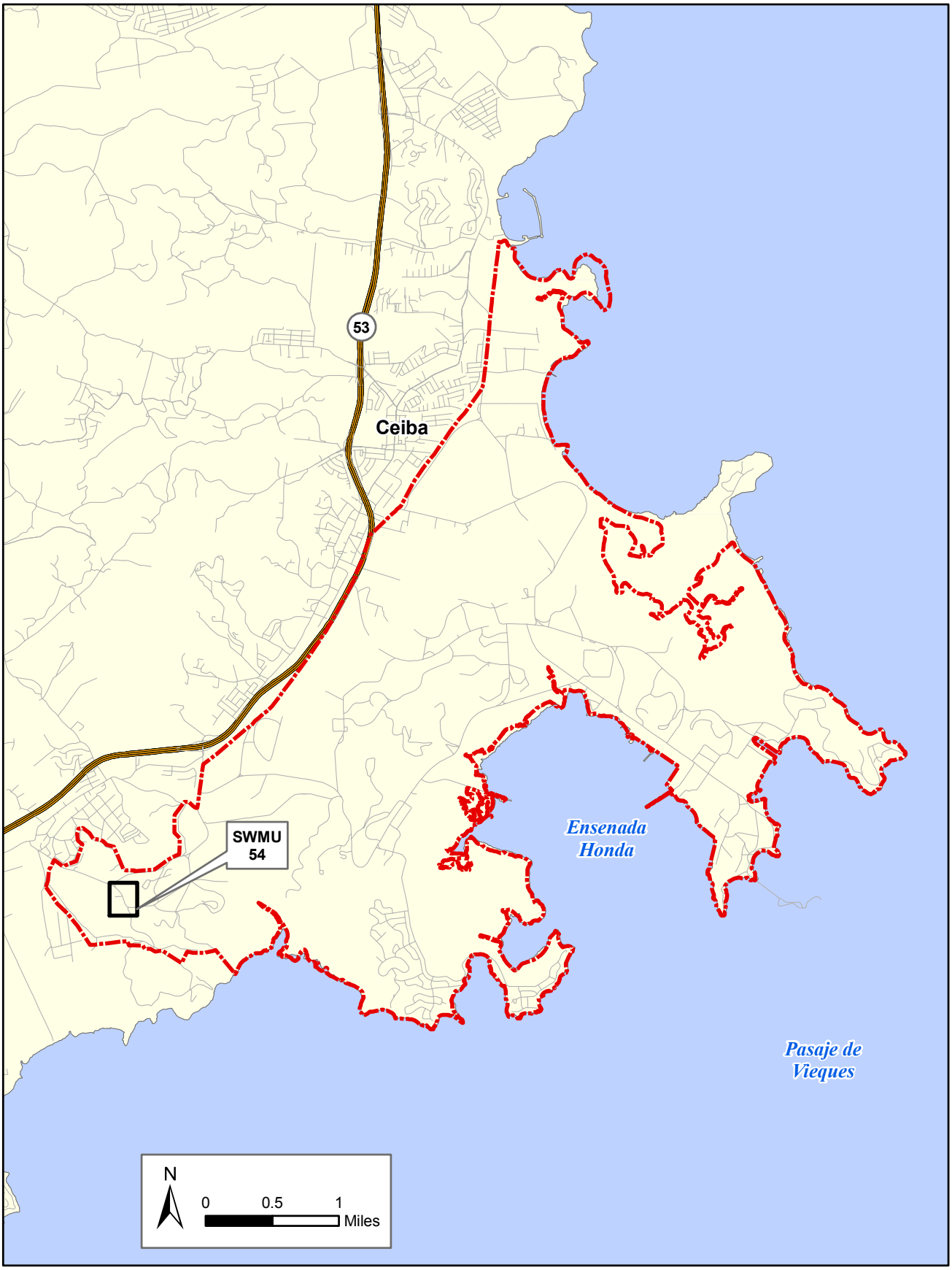
Acronyms and Abbreviations

AGVIQ-CH2M HILL	AGVIQ-CH2M HILL Constructors, Inc. Joint Venture III
CMI	Corrective Measures Implementation
DO	dissolved oxygen
HDPE	high density polyethylene
HSA	hollow stem auger
MNA	monitored natural attenuation
NAPR	Naval Activity Puerto Rico
NAVFAC SE	Naval Facilities Engineering Command Southeast
NSRR	Naval Station Roosevelt Roads
ORP	oxidation-reduction potential
PREQB	Puerto Rico Environmental Quality Board
PVC	polyvinyl chloride
SWMU	Solid Waste Management Unit

1.0 Introduction

AGVIQ-CH2M HILL Constructors, Inc. Joint Venture III (AGVIQ-CH2M HILL) has been retained by the Department of the Navy, Naval Facilities Engineering Command Southeast (NAVFAC SE) to prepare a Corrective Measures Implementation (CMI) Plan to address the cleanup of benzene in groundwater beneath Solid Waste Management Unit (SWMU) 54. SWMU 54 is located at Naval Activity Puerto Rico (NAPR), formerly known as Naval Station Roosevelt Roads (NSRR), in Ceiba, Puerto Rico (Figure 1-1). This CMI plan presents the remedial approach and technologies that will be implemented to reduce benzene concentrations in groundwater to the corrective action objective (CAO) of 550 micrograms per liter (µg/L).



Road

Expressway

Naval Station Roosevelt Roads Boundary

Originated By: Amanda Struse *Amanda Struse*
Checked By: Shruti Shah *Shruti Shah*
Checked By: Alicia Nobles *Alicia Nobles*

FIGURE 1-1
SWMU 54 Site Location
SWMU 54
Naval Activity Puerto Rico

CH2MHILL

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2.0 Background

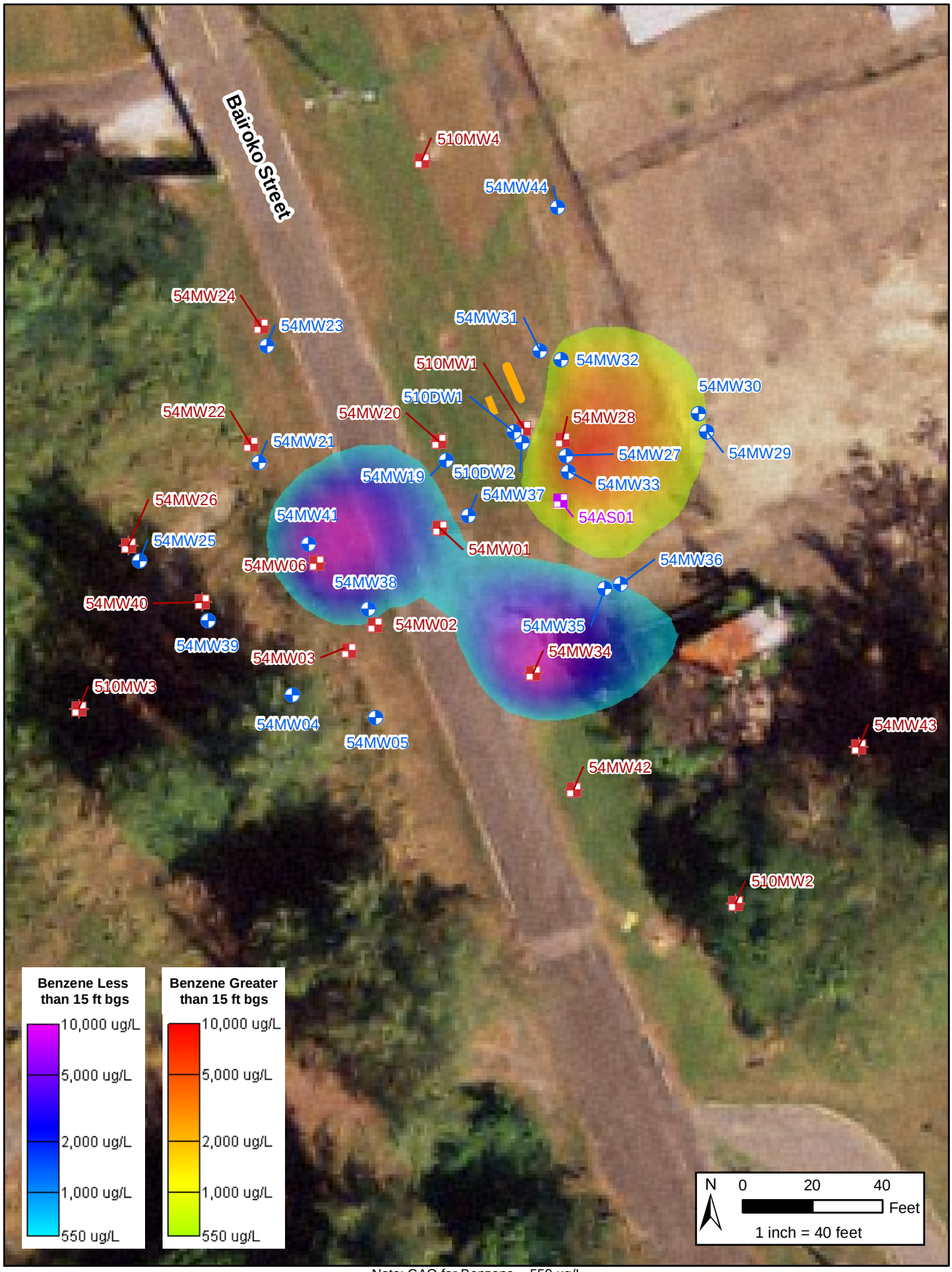
In 2005, Baker Environmental, Inc. (Baker), prepared a *Final Corrective Measures Study* [CMS] *Final Report* (hereinafter referred to as the CMS) for remedial actions at NAPR, including SWMU 54 (Baker, 2005). The CMS included human health and ecological risk assessments to develop CAOs for the cleanup of contaminants in groundwater. A CAO of 550 µg/L was calculated for benzene at SWMU 54, and the subsurface injection of oxygen-releasing compounds was proposed to achieve the CAO.

Subsequently, NAVFAC SE contracted AGVIQ-CH2M HILL, to review the CMS and optimize the remedial approach for the site. As part of the investigation work, 32 additional monitoring wells were installed to determine the horizontal and vertical extent of benzene in groundwater prior to implementing remedial actions (Figure 2-1). Findings obtained from the additional work indicated that the horizontal and vertical extent of the benzene was greater than described in the CMS, and benzene concentrations were higher than presented in the CMS (Baker, 2005). The additional investigation work performed to characterize the benzene plume is described in the CMS Addendum (AGVIQ-CH2M HILL, 2011a).

Because the magnitude and extent of the benzene plume are greater than presented in the CMS (Baker, 2005), AGVIQ-CH2M HILL determined that aerobic ISB via injection of oxygen-releasing compounds (slurry) would not adequately treat the benzene plume as it would be technologically difficult and costly to deliver the required volume of injectant. Therefore, a pilot-scale test was performed to evaluate the feasibility of injecting air into the aquifer to volatilize and biodegrade remaining benzene concentrations in groundwater to the CAO.

AS pilot-scale testing was performed in May 2010. During the test, air was injected into a single well (54AS01) at varying pressures and flows, and changes in water level, dissolved oxygen (DO), and oxidation-reduction potential (ORP) were monitored to evaluate air distribution. Details regarding the pilot-scale testing are provided in the CMS Addendum (AGVIQ-CH2M HILL, 2011a). Conclusions from the pilot-scale test results include the following:

- Air distribution in the subsurface at SWMU 54 is highly variable and is a function of the air injection rate and the heterogeneity of the formation.
- AS was effective in distributing air to the formation at SWMU 54 to promote volatization of benzene and increased DO to support aerobic biodegradation. Increases in DO and ORP concentrations were primarily observed in the deep monitoring wells (screened deeper than 15 feet below ground surface [bgs]) because of the placement of the injection well screen at approximately 24 to 26 feet bgs. Similar DO and ORP response is expected in shallow zone monitoring wells with the proper placement of the injection well screen at the base of the zone.



Monitoring Well Screened Primarily Less than 15 ft bgs

Monitoring Well Screened Primarily 15-25 ft bgs

Air Sparge Injection Well

Note: CAO for Benzene = 550 µg/L

Originated By: Kylie McCord *Kylie McCord*
Checked By: Tom Kessler *Tom Kessler*

FIGURE 2-1
Benzene Concentrations Exceeding Corrective Action Objectives
August 2009 Through October 2010
SWMU 54
Naval Activity Puerto Rico

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- DO response was observed as far away from the injection well as 40 feet; however, results were not consistent in all directions around the monitoring well. Based on a review of pilot-scale results, a conservative radius of influence for a single injection well is estimated to be approximately 15 feet at an injection flow rate of 4 standard cubic feet per minute (scfm). AS injection well spacing of 20 feet between wells is recommended for full-scale application to provide overlap of sparging influence and adequately distribute the air into the formation at a low injection flow rate.
- VOC concentrations observed at storm sewer monitoring location SS#3 (located approximately 65 feet south of the AS injection well) indicate that VOCs liberated from groundwater during the AS pilot-scale test may be traveling through the gravel backfill that surrounds the sewer pipe. Due to the highly variable nature of the distribution of air both horizontally and vertically, and the potential for VOC-laden air to migrate along the backfill of the utility corridors, the AS system should be designed with a maximum flow rate of 4 scfm per injection point to minimize effects of volatilization.
- Shallow injection wells installed to a depth of approximately 16 to 18 feet bgs should be utilized to address VOC concentrations in the shallow zone, while deeper injection wells installed to a depth of approximately 26 to 28 feet bgs should be installed to address intermediate zone impacts.
- AS wells should be individually plumbed from a common equipment manifold and operate on a pulsed frequency to minimize the size of the AS compressor required and to limit the potential for vapor migration along utility corridors or other preferential pathways.

Based on the favorable pilot-scale test results, NAVFAC SE proposes to amend the remedial approach using biosparging. Biosparge system details are described in Section 3.

3.0 System Description

The CMS (Baker, 2005) was amended (AGVIQ-CH2M HILL, 2011a) to recommend implementation of biosparge to address benzene in groundwater at SWMU 54. The biosparge technology is described in the CMS Addendum (AGVIQ CH2M HILL, 2011a). The fieldwork is summarized in the following subsections.

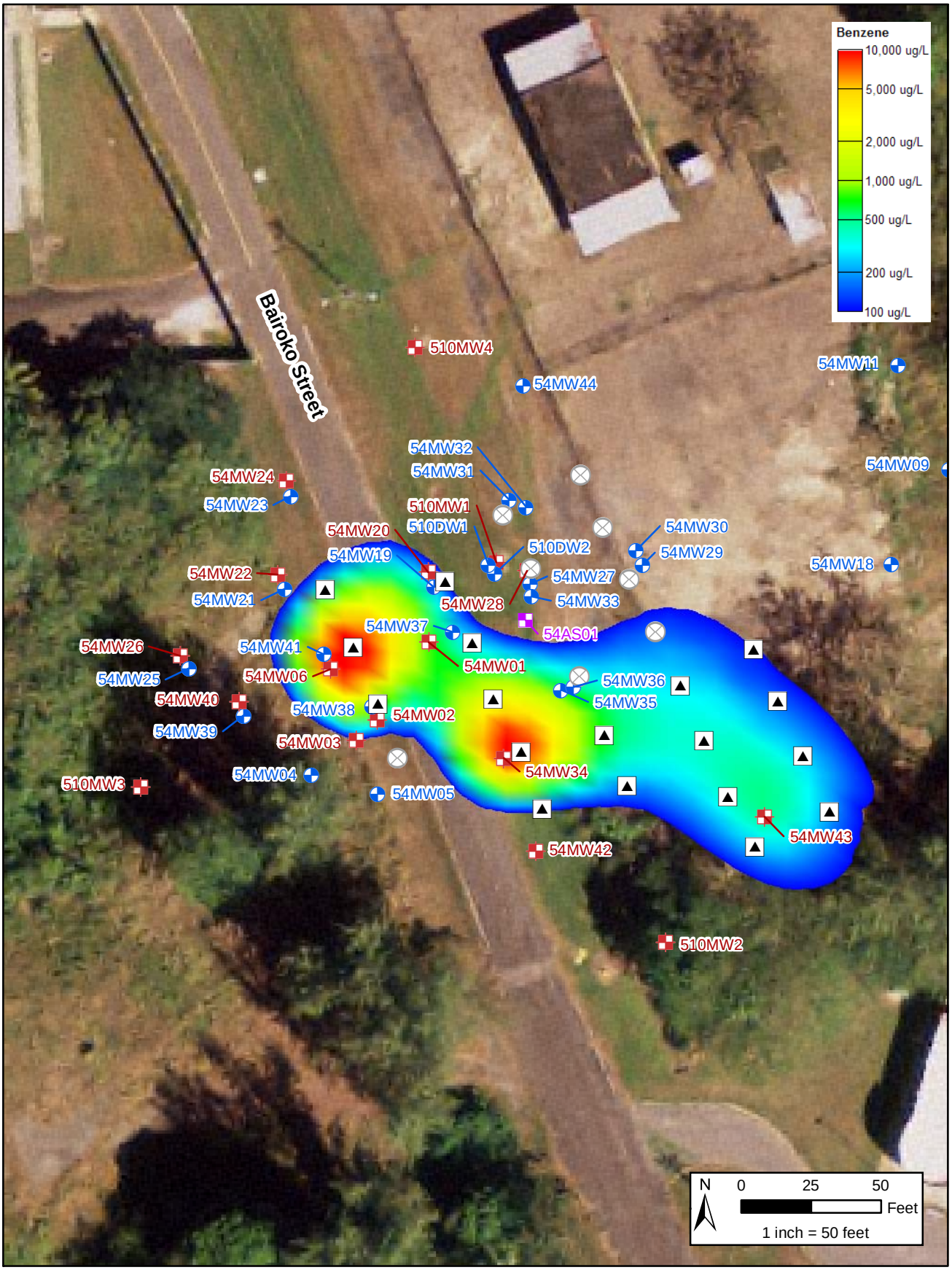
3.1 Site Preparation

According to the NAPR, no dig permit will be required for this project; however, utilities are known to exist in the area and a utility clearance will be conducted in work area prior to beginning intrusive activities.

3.2 Well Installation

Twenty-six vertical air injection wells will be installed within the benzene plume. Eighteen shallow injection wells will be installed to treat the upper portion of the benzene plume (top of water table to approximately 15 feet bgs), and 8 deep injection wells will be installed to treat the lower portion of the benzene plume (approximately 15 to 25 feet bgs). In addition, existing injection well 54AS01, installed as part of the May 2010 pilot-scale test, will also be used to treat the lower portion of the benzene plume. The proposed locations of the shallow and deep injection wells are depicted on Figures 3-1 and 3-2, respectively. The wells will be placed in rows oriented perpendicular to the direction of groundwater flow. As illustrated on Figures 3-1 and 3-2, five rows of shallow injection wells and three rows of deep injection wells will be installed. The wells will be spaced approximately 20 feet apart, though the final placement may be adjusted to avoid utilities. The wells will be installed using hollow-stem auger (HSA) drilling techniques. The well installation will be performed in accordance with the Sampling Analysis Plan (SAP) (AGVIQ-CH2M HILL, 2011b) and the general requirements of the U.S. Environmental Protection Agency (EPA) Environmental Services Division Environmental Investigations *Standard Operating Procedures and Quality Assurance Manual* (EPA, 2001). Well installation procedures and materials will also conform to the requirements of the Puerto Rico Standards and Regulations, including submittal of well construction permits prior to well installation, as required by the Puerto Rico Environmental Quality Board (PREQB).

Both the shallow and deep injection wells will be constructed using 2 feet of 2-inch inner diameter (ID) polyvinyl chloride (PVC) continuously wrapped well screen (0.020-inch slot size), and a variable amount of casing. The shallow injection wells will be screened from 16 to 18 feet bgs (Figure 3-1), and the deep injection wells will be screened from 26 to 28 feet bgs (Figure 3-2). At both the shallow and deep wells, sand pack will be placed around the well screen and brought to a height 2 feet above the top of the screen, followed by 2 feet of bentonite. The remainder of the annular space will be filled to within 1 foot of the ground surface using Portland cement grout slurry containing 3 to 5 percent bentonite. The injection wells will be developed after the grout has cured for a minimum of 24 hours.



Monitoring Well Screened Primarily Less than 15 ft bgs

Monitoring Well Screened Primarily Greater than 15 ft bgs

Shallow Biosparge Well

Deep Biosparge Well

Note: Corrective Action Objective (CAO) for Benzene = 550 µg/L

Originated By: Kylie McCord *Kylie McCord*

Checked By: Tom Kessler *Tom Kessler*

FIGURE 3-1
Proposed Shallow Biosparge Layout
SWMU 54
Naval Activity Puerto Rico

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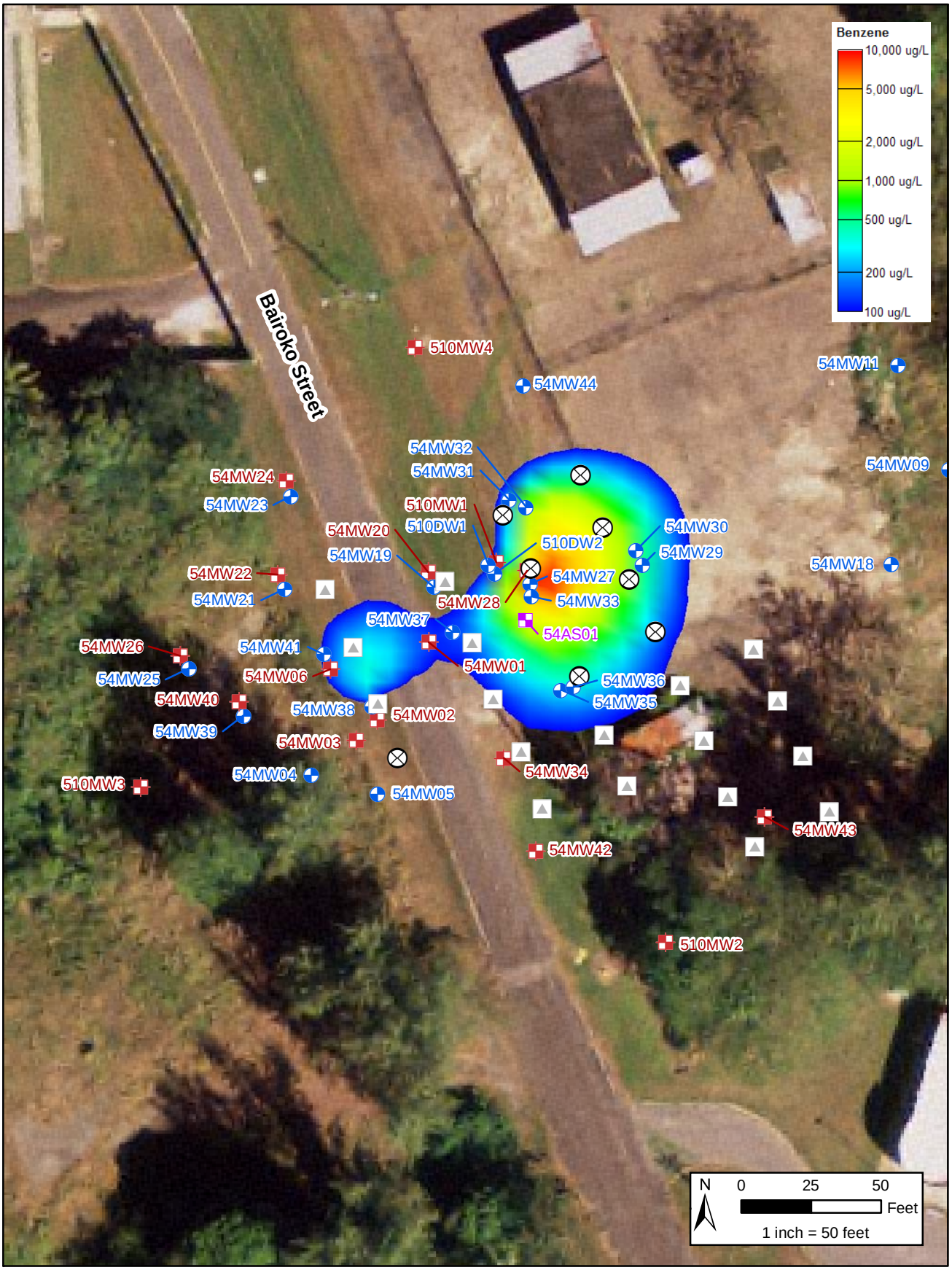

Monitoring Well Screened Primarily Less than 15 ft bgs

Monitoring Well Screened Primarily Greater than 15 ft bgs

Deep Biosparge Well

Shallow Biosparge Well

Note: Corrective Action Objective (CAO) for Benzene = 550 µg/L

Originated By: Kylie McCord *Kylie McCord*

Checked By: Tom Kessler *Tom Kessler*

FIGURE 3-2
Proposed Deep Biosparge Layout
SWMU 54
Naval Activity Puerto Rico

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Soil and liquids generated during the installation of the injection wells will be containerized and managed in accordance with the procedures outlined in the Waste Management Plan in the SWMU 54 Work Plan (AGVIQ-CH2M HILL, 2009).

The locations and elevations of the newly installed injection wells will be surveyed by a land surveyor registered in Puerto Rico. The wells will be surveyed relative to a previously established benchmark. The horizontal location will be surveyed to an accuracy of 0.1 foot, and the ground surface will be surveyed to an accuracy of 0.01 foot. Top of casing elevations for each biosparge well will not be surveyed because the wells will be buried during biosparge system trenching.

3.3 Biosparge Operations

Air will be injected into the AS wells at a flowrate of less than 4 scfm per injection well with the goal of sufficiently aerating the aquifer to increase oxygen levels in groundwater and stimulate aerobic biodegradation of benzene.

An air compressor will be used to deliver air to the formation. Air will be delivered from the compressor to each sparge well through a delivery manifold equipped with up to five separate zones for air delivery. Air will be delivered to each individual sparge well through buried high-density polyethylene (HDPE) pipe. The system will be programmed to pulse the injection of air to each zone to minimize channeling effects, minimize vapor migration potential, and increase system performance. The system will be equipped with a wireless telemetry unit to monitor system performance and notify the operator if a fault condition occurs. A Process and Instrumentation Diagram for the proposed biosparge system is provided in Appendix A.

3.4 Biosparge Operations Optimization and Exit Strategy

An observational approach to optimization will be used for the biosparge system. Baseline groundwater monitoring to assess benzene and DO concentrations will be completed before turning on the system. During the first week of operation, DO concentrations will be measured from the monitoring well network to evaluate DO distribution in the aquifer. After initial startup monitoring, quarterly monitoring events will be performed to evaluate system performance (discussed further in Section 4). If the monitoring data do not show decreasing trends in benzene concentrations, then optimization of the system will be evaluated. Table 3-1 summarizes the operational parameters that can be optimized and the expected impact of optimization.

TABLE 3-1
Optimization Guidance
SWMU 54, Naval Activity Puerto Rico, Ceiba, Puerto Rico

Parameter	Design	Impact
Flow Rate per Well	2 to 4 scfm	Increased air flow rate could expand oxygen influence /treatment zone.
Pulsed Cycles	Three to four cycles per day	Shortening the pulse cycle could allow each zone to receive air more frequently. This may be necessary to sustain oxygen if biodegradation rates are high.

TABLE 3-1
Optimization Guidance
SWMU 54, Naval Activity Puerto Rico, Ceiba, Puerto Rico

Parameter	Design	Impact
Nutrient Addition	None	The addition of a nitrogen/phosphorus/phosphate in a liquid injection could enhance the rate of aerobic biodegradation.
Radius of Influence	15 feet	The installation of additional biosparge wells could improve coverage of the plume if the estimated radius of influence is not achieved at all locations. The biosparge system will be sized to accommodate system expansion, if necessary.
Monitoring Frequency	Quarterly	Limited quarterly monitoring would allow for better system optimization and decrease costs. Not all wells require quarterly monitoring.

3.4.1 Exit Strategy

The biosparge system will be operated until one of the following conditions is met:

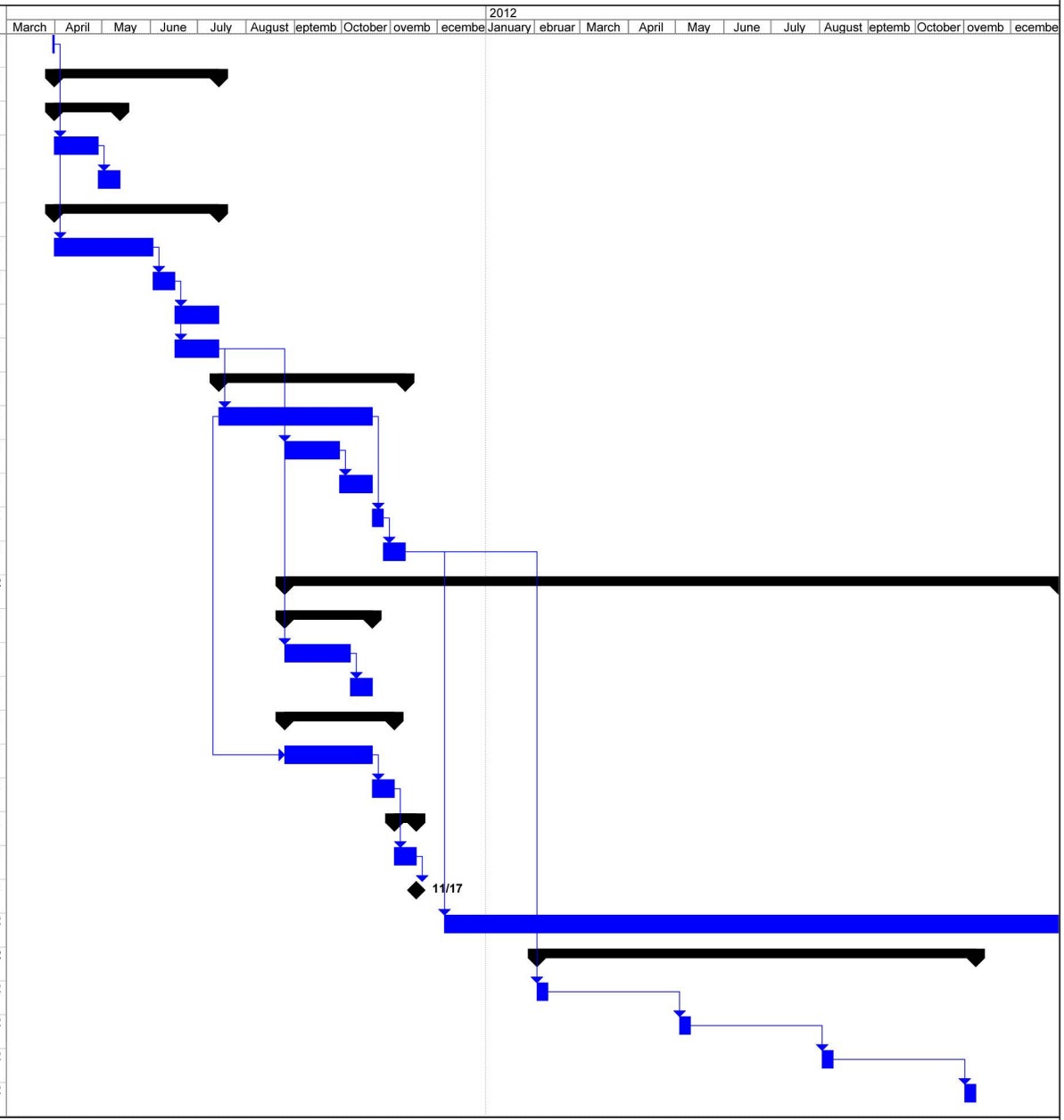
- Source area concentrations of benzene have been reduced by at least 95 percent or to the point where monitored natural attenuation can cost-effectively reach the site CAO for benzene (550 µg/L).
- Additional mass removal is determined to be technically or economically infeasible.

Once one of these conditions has been met, 1 year of post-operation quarterly groundwater monitoring data will be collected to determine if additional monitoring or corrective measures are required. If benzene concentrations do not exceed the CAO, NAVFAC SE will request no further action (NFA) for the site. However, if benzene concentrations exceed the CAO, one or more of the optimization steps discussed above will be implemented to enhance system performance.

3.5 Implementation Schedule

An implementation schedule is presented on Figure 3-3.

ID	Task Name	Duration	Start	Finish
1	Notice to Proceed	1 day	Thu 3/31/11	Thu 3/31/11
2	**Biosparge Design and Workplanning**	**75 days**	**Fri 4/1/11**	**Thu 7/14/11**
3	**Design Preparation**	**30 days**	**Fri 4/1/11**	**Thu 5/12/11**
4	60% Design	20 days	Fri 4/1/11	Thu 4/28/11
5	Final Design	10 days	Fri 4/29/11	Thu 5/12/11
6	**Work Plan for Field Implementation**	**75 days**	**Fri 4/1/11**	**Thu 7/14/11**
7	Work Plan Generation	45 days	Fri 4/1/11	Thu 6/2/11
8	Navy Review	10 days	Fri 6/3/11	Thu 6/16/11
9	EPA Review	20 days	Fri 6/17/11	Thu 7/14/11
10	UIC	20 days	Fri 6/17/11	Thu 7/14/11
11	**Field Implementation**	**85 days**	**Fri 7/15/11**	**Thu 11/10/11**
12	Equipment Fabrication	70 days	Fri 7/15/11	Thu 10/20/11
13	Biosparge Well Installation	25 days	Fri 8/26/11	Thu 9/29/11
14	Trenching	15 days	Fri 9/30/11	Thu 10/20/11
15	Electrical Installation	5 days	Fri 10/21/11	Thu 10/27/11
16	Startup/Shakedown Testing	10 days	Fri 10/28/11	Thu 11/10/11
17	**Biosparge Operations**	**352 days**	**Fri 8/26/11**	**Mon 12/31/12**
18	**O&M Plan**	**40 days**	**Fri 8/26/11**	**Thu 10/20/11**
19	Work Plan Generation	30 days	Fri 8/26/11	Thu 10/6/11
20	Navy Review	10 days	Fri 10/7/11	Thu 10/20/11
21	**O&M Manual**	**50 days**	**Fri 8/26/11**	**Thu 11/3/11**
22	Draft O&M Manual Prepartion	40 days	Fri 8/26/11	Thu 10/20/11
23	Navy Review	10 days	Fri 10/21/11	Thu 11/3/11
24	**Final O&M Manual**	**10 days**	**Fri 11/4/11**	**Thu 11/17/11**
25	Final O&M Manual Prepartion	10 days	Fri 11/4/11	Thu 11/17/11
26	Submittal to Navy	0 days	Thu 11/17/11	Thu 11/17/11
27	Operation and Maintenance	14 mons	Tue 12/6/11	Mon 12/31/12
28	**Monitoring**	**200 days**	**Fri 2/3/12**	**Thu 11/8/12**
29	YR 1 Q1	5 days	Fri 2/3/12	Thu 2/9/12
30	YR1 Q2	5 days	Fri 5/4/12	Thu 5/10/12
31	YR1 Q3	5 days	Fri 8/3/12	Thu 8/9/12
32	YR1 Q4	5 days	Fri 11/2/12	Thu 11/8/12



Project: Worksheet 16
Date: Thu 2/10/11

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

FIGURE 3-3
Biosparge Installation Schedule
SWMU 54
Naval Activity Puerto Rico

4.0 Monitoring and Reporting Requirements

4.1 System Monitoring

System monitoring will be performed to evaluate the effectiveness of biosparging to achieve the remedial objectives and determine when the system will be turned off. Additionally, system flow and pressure measurements will be recorded bi-weekly during the operations and maintenance (O&M) site visits. An O&M Plan will be developed and submitted under separate cover following system design. The proposed outline of the O&M Manual is as follows:

Executive Summary

1.0 Introduction

- Purpose and Scope
- Background Information

2.0 Equipment Description

3.0 O&M Procedures

- Startup Procedures
- Vapor Monitoring
- Routine Operations
- Shut Down Procedures
- Emergency Procedures

4.0 Data Collection Procedures

5.0 Appendices

- Process and Instrumentation Diagram
- Equipment Building Layout
- Electrical Drawings
- Equipment Cut Sheets and Manuals
- Startup Checklist
- Routine Operational Data Collection Form
- Shut Down Checklist

4.2 Performance Monitoring

Quarterly groundwater sampling events will be conducted beginning 90 days after the completion of system startup and shakedown testing. Quarterly monitoring will be conducted for one year to evaluate and optimize the biosparge system operations. Groundwater samples will be collected from monitoring wells 54MW01, 54MW02, 54MW06,

54MW27 through 54MW41, and 54MW43 to evaluate system effectiveness. The sample locations are shown on Figure 2-1. All sampling and analyses will be conducted in accordance with the SAP (AGVIQ-CH2MHILL, 2011b).

During purging field measurements of DO, turbidity, conductivity, pH, temperature, and ORP will be recorded during well purging. DO concentrations will be monitored with a goal of achieving greater than 2 milligrams per liter (mg/L) throughout the monitoring network. Following the collection of the field measurements, water quality samples will be collected from each well for the analysis of VOCs using EPA Method 8260B. Purge water generated during sampling will be managed in accordance with the procedures described in the Waste Management Plan (part of the SWMU 54 Work Plan [AGVIQ-CH2M HILL, 2009]).

TABLE 4-1
Performance Monitoring Summary
SWMU 54, Naval Activity Puerto Rico, Ceiba, Puerto Rico

Analysis	Method	Well Samples	Quality Assurance/ Control Samples	Total Samples
VOCs	SW8260B	19	2	21
DO, pH, ORP, Temperature, and Specific Conductance	Field	19	-	19

4.3 Vapor Monitoring

Monitoring will be performed to test for the presence of vapors in storm sewers, sanitary sewers, and water lines located within the area of sparge influence. Prior to system startup, a photo-ionization detector and explosimeter will be used to collect baseline hydrocarbon and methane readings in all nearby utility vaults and manholes. During the first week of system startup, vapor monitoring will be performed daily to monitor potential changes in vapor concentrations. If vapor concentrations increase, system operation will be modified (that is, decrease flow rates,) to minimize the buildup and/or migration of vapors.

4.4 Reporting

A summary of the SWMU 54 activities described in this CMI Plan, and the progress of each activity, will be presented in annual reports. The outline of the annual reports is as follows:

Executive Summary

1.0 Introduction

- Purpose and Scope
- Background Information

2.0 Summary of Field Activities

- Biosparge System Operations
- Well Gauging and Sampling Procedures

3.0 Discussion of Results

- Groundwater Flow
- Groundwater Monitoring Results
- Vapor Monitoring Results

4.0 Conclusions and Recommendations

5.0 References

5.0 References

AGVIQ-CH2M HILL 2009. *Work Plan, Pilot Test at SWMU 54 at Naval Activity Puerto Rico.* Prepared for Naval Facilities Engineering Command Southeast. March.

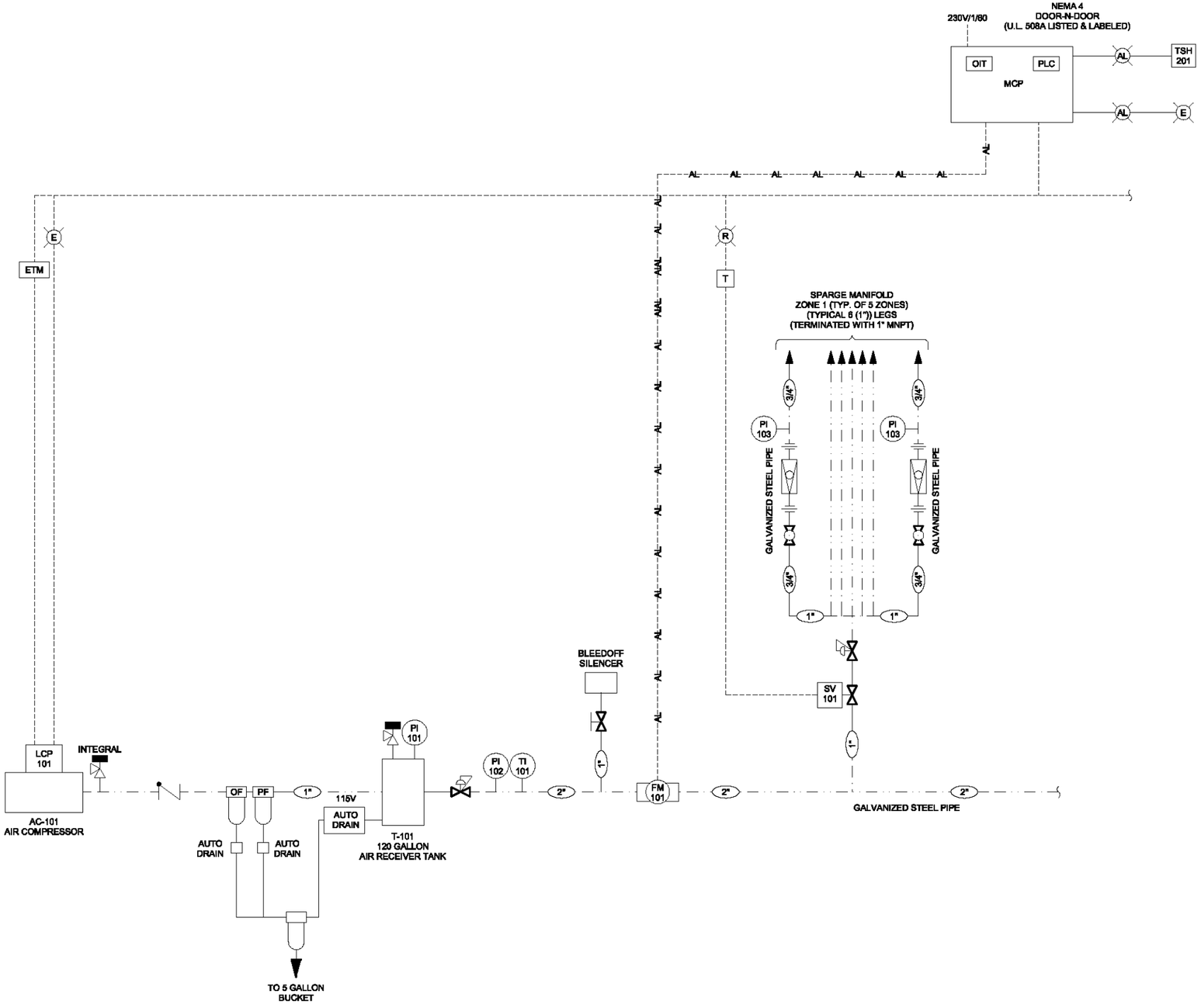
AGVIQ-CH2M HILL. 2011a. *Corrective Measures Study Addendum, SWMU 54, Naval Activity Puerto Rico.* Prepared for Naval Facilities Engineering Command Southeast. February.

AGVIQ-CH2M HILL. 2011b. *Amended Final Sampling and Analysis Plan, Pilot Test at Solid Waste Management Units 54 and 55 at Naval Activity Puerto Rico.* Prepared for Naval Facilities Engineering Command Southeast. January.

U.S. Environmental Protection Agency (EPA). 2001. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* EPA Region 4 Science and Ecosystem Support Division (SESD). November.

APPENDIX A

Process and Instrumentation Diagram for the Proposed Biosparge System



CF	CONDENSATE FILTER
ETM	ELAPSED TIME METER
FM	FLOWMETER
LCP	LOCAL CONTROL PANEL
MCP	MATER CONTROL PANEL
OF	OIL FILTER
OIT	OPERATOR INTERFACE TERMINAL
PF	PARTICULATE FILTER
PI	PRESSURE INDICATOR
PLC	PROGRAMMABLE LOGIC CONTROLLER
SV	SOLENOID VALVE
T	TIMER
TI	TEMPERATURE INDICATOR
TSH	TEMPERATURE SWITCH
	BALL VALVE
	CHECK VALVE
	GATE VALVE
	FLOWMETER
	RELIEF VALVE
	REGULATOR
	UNION
AL	ALARM LIGHT
R	RUN LIGHT
E	EMERGENCY STOP
	AIR LINE
	CONTROL LINE
	WATER LINE
AL	ANALOG LINE

DSGN K.McCORD						
DR D.T.HERR						
CHK T.KESSLER						
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NAVAL ACTIVITY PUERTO RICO
SWMU 54 BIOSPARGE SYSTEM

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DATE January 2011
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