NAVAL FACILITIES ENGINEERING COMMAND
Washington, DC 20374-5065

# Site Specific Report
## SSR-2537-ENV

# EASTERN GROUNDWATER PLUME
# Naval Air Station Brunswick

# REMEDIAL ACTION OPERATION OPTIMIZATION CASE STUDY

January 2000

Prepared for
Department of the Navy RAO/LTM Optimization Working Group

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**FINAL**

# Eastern Groundwater Plume
# Naval Air Station Brunswick

# Remedial Action Operation (RAO) Optimization Case Study

Contract No. N47408-99-C-7017

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January 2000

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# LIST OF ACRONYMS

| | |
|---|---|
| ACL | Alternate Cleanup levels |
| ARAR | Applicable or relevant and appropriate requirements |
| AS | Air Stripper |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act |
| COC | Contaminant of Concern |
| CSM | Conceptual Site Model |
| DCA | 1,1-Dichloroethane |
| DCE | 1,1-Dichloroethene; 1,2-Dichloroethene |
| DO | Dissolved oxygen |
| DON | Department of the Navy |
| DRMO | Defense Reutilization and Marketing Office |
| EW | Extraction Well |
| FTA | Fire Training Area |
| GAC | Granular Activated Carbon |
| GIS | Geographic Information System |
| gpm | gallons per minute |
| GWTP | Groundwater Treatment Plant |
| lb(s) | pounds |
| LTM | Long-Term Monitoring |
| MCB | Marine Corps Base |
| MCL | Maximum Contaminant Levels |
| MEDEP | Maine Department of Environmental Protection |
| MEG | Maximum Exposure Guideline |
| Mgal | Million Gallons |
| MNA | Monitored Natural Attenuation |
| MW | Monitoring Well |
| NA | Not Applicable |
| NAS | Naval Air Station |
| NFA | No Further Action |
| NFESC | Naval Facilities Engineering Service Center |
| NORTHDIV | Northern Division |
| NPDES | National Pollution Discharge Elimination System |
| NPV | Net Present Valve |
| NTU | Nephelometric Torbidity Unit |
| O&M | Operation and Maintenance |

# LIST OF ACRONYMS (Continued)

| | |
|---|---|
| ODC | Other Direct Costs |
| ORP | Oxidation Reduction Potential |
| P&T | Pump and Treat |
| PCE | Tetrachloroethene |
| PLC | Programmable Logic Controller |
| ppb | parts per billion |
| RAO | Remedial Action Operation |
| Redox | Reduction Oxidation |
| ROD | Record of Decision |
| RW | Recovery Well |
| SCADA | Supervisory Control And Data Acquisition |
| TCA | 1,1,1-Trichloroethane |
| TCE | Trichloroethene |
| TOC | Total Organic Compound |
| USEPA | United States Environmental Protection Agency |
| USN | United States Navy |
| UST | Underground Storage Tank |
| UV-Ox | Ultraviolet Oxidation |
| VOC | Volatile Organic Compound |
| Y2K | Year 2000 |

# EXECUTIVE SUMMARY

## ES.1 Purpose of the Case Study Report

This case study report includes an effectiveness evaluation for the Eastern Groundwater Plume (Eastern Plume) pump and treat (P&T) system located at Naval Air Station (NAS) Brunswick, Maine. The primary purpose of the evaluation is to assess the ongoing remedial action operation (RAO) program for this system; and provide recommendations resulting in attainment of site remedial action objectives and ultimate closure for optimal life-cycle costs. For the purposes of this report, optimal is defined as the minimum cost without sacrificing data quality or decision-making. NAS Brunswick and Northern Division (NORTHDIV) view this independent confirmation of their optimization plan as an important, proactive step toward operating and maintaining a cost-effective and protective remedy.

This project was conducted for the Naval Facilities Engineering Service Center (NFESC) under a Broad Agency Announcement contract. NFESC is leading a Department of the Navy (DON) working group in developing guidance on optimizing monitoring and remedial action operations for Navy/Marine Corps activities. This working group is comprised of members from NFESC, NORTHDIV, other Engineering Field Divisions/Activities, Naval Facilities Engineering Command, and Chief of Naval Operations.

## ES.2 Optimization Approach

The approach employed in this RAO optimization project to achieve site closure for optimal life-cycle cost is outlined below:

- Gain a detailed understanding of the remedial decision-making framework, remedial action objectives, and site closure criteria for each site.
- Describe and understand past investigation and remedial actions taken to date, and how they have affected the current evolution and understanding of the conceptual site model.
- Describe the current conceptual site model, i.e., geology, pathways, receptors, and contaminants of concern (COCs).
- Gain an understanding of other remedial actions and associated data at NAS Brunswick having potential applicability at the Eastern Plume.
- Describe the system design basis and operational objectives for the P&T system, including extraction trench and well network.
- Baseline the past and current cost and operational data.

- Compare the cost and performance data with the system design basis.
- Assess the need for additional system operation.
- Provide the future decision strategy framework and prioritized recommendations to improve total system performance and achieve site remedial action objectives for optimal cost.

A site visit at NAS Brunswick was conducted from 20-21 July 1999 to gather the required information for this report.

## ES.3 Eastern Plume Remedial Action Overview

The Eastern Plume pump and treat (P&T) system was evaluated over an operating period of approximately 3 years (July 1996 to May 1999). The treatment system is comprised of a network of extraction wells (EWs) with treatment using ultraviolet oxidation (UV-Ox). The system was designed to accommodate influent flow rates up to 110 gallons per minute (gpm). The extraction system consists of 5 EWs. These extraction wells contain pumps rated at over 20 gpm.

Remedial action objectives for the system are covered under the United States Environmental Protection Agency (US EPA) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) program. A Record of Decision (ROD) for this site was signed in February 1998. The remedial action proposed included operation of a P&T system and long term monitoring. Groundwater cleanup levels are those listed in the State of Maine Maximum Exposure Guidelines (MEGs). Current total volatile organic compound (VOC) contaminant levels in the influent average 500 parts per billion (ppb).

## ES.4 Eastern Plume System Performance Summary

The performance of the Eastern Plume system from July 1996 to May 1999 has been fair, with increased performance following the addition of a new extraction well in July 1998. The overall performance is summarized below:

- Influent treatment plant flow rates are adequate, averaging 70 percent of design capacity.
- Total mass removal has been 536 pounds of VOCs in 3 years of operation at a cost of $3.4 million.
- The average mass removal rate of the system has been approximately 15 pounds per month.
- The average cost per pound of contaminant removed is approximately $7,800.

## ES.5 Eastern Plume System Recommendations

The primary recommendation of this case study is to implement four primary, strategic recommendations. These four parallel activities are as follows:

- As groundwater monitoring results indicate that the downgradient edge of the Eastern Plume has not changed position since 1995, focus future investigations on confirming that the plume is stable or receding, and begin a formal evaluation of Monitored Natural Attenuation (MNA);
- Pursue negotiations with the regulators to establish risk-based cleanup levels for the entire Eastern Plume, and Alternate Concentration Limits (ACLs) for any groundwater discharging to Mere Brook;
- Continue and enhance contaminant mass removal in the Eastern Plume; and
- Modify the aboveground treatment system to allow effluent discharge to surface water or to an infiltration gallery after confirming the most effective and efficient option based on a detailed technical review and life cycle cost analysis.

These four parallel activities will enable NAS Brunswick to prepare to work with regulators during any current and future performance evaluations. In addition, this discussion should be used to reach an agreement on how to implement required changes to the ROD, i.e., via explanation of significant difference (ESD), or a ROD amendment.

# 1.0 INTRODUCTION

The Department of the Navy (DON) formed a working group in April 1998 to provide guidance to the DON for optimizing Remedial Action Operation (RAO) and Long-Term Monitoring (LTM) programs at remediation sites. This Working Group, led by the Naval Facilities Engineering Service Center (NFESC), selected four pump and treat sites for detailed RAO evaluations. Three of these sites are at Marine Corps Base (MCB) Camp Lejeune, North Carolina, and the fourth is located at Naval Air Station (NAS) Brunswick, Maine. This case study report includes an evaluation of a groundwater pump and treat (P&T) system located at the Eastern Groundwater Plume (Eastern Plume) at NAS Brunswick. Separate reports are available for evaluations of P&T systems at Operable Units 1 and 2 at MCB Camp Lejeune, and the Campbell Street Fuel Farm at Marine Corps Air Station, New River (co-located at Camp Lejeune).

## 1.1 Purpose and Objectives

The primary purpose of this case study is to evaluate and assess the ongoing RAO program at the Eastern Plume system at NAS Brunswick, Maine; and provide recommendations resulting in attainment of site remedial action objectives and closure for optimal life-cycle costs.

Specific elements that were evaluated for the Eastern Plume P&T system include:

- Overall site remediation strategy and approach;
- Best operation and management practices already in place;
- Extraction system network, including all wells, screen intervals, and piping;
- Performance of treatment system components, including control systems;
- Operation, maintenance, and control for the treatment units;
- Treatment system data collection, analysis, and reporting;
- Effluent discharge options;
- Appropriate exit strategy for site closeout, including recommendations for the use of alternative technologies, as appropriate; and
- Total estimated cost avoidance/savings from optimized operations.

## 1.2 Optimization Approach

The overall goal of this case study report is to provide a decision framework and recommendations which will facilitate attainment of site remedial action objectives and closure for optimal life-cycle costs. For the purposes of this report, optimal is defined as

the minimum cost without sacrificing data quality or decision-making. The approach employed in this RAO optimization project to achieve this goal is outlined below:

- Gain a detailed understanding of the remedial decision-making framework, remedial action objectives, and site closure criteria for each site.
- Describe and understand past investigation and remedial actions taken to date, and how they have affected the current evolution and understanding of the conceptual site model.
- Describe the current conceptual site model, i.e., geology, pathways, receptors, and contaminants of concern (COCs).
- Gain an understanding of other remedial actions and associated data at NAS Brunswick having potential applicability at the Eastern Plume.
- Describe the system design basis and operational objectives for the P&T system, including extraction well network.
- Baseline the past and current cost and operational data for the system.
- Compare the cost and performance data with the system design basis.
- Assess the need for additional system operation.
- Provide the future decision strategy framework and prioritized recommendations to improve total system performance and achieve site remedial action objectives for optimal cost.

# 2.0 LOCATION AND PHYSICAL SETTING OF NAS BRUNSWICK

NAS Brunswick comprises 3,094 acres located south of the Androscoggin River between Brunswick and Bath, Maine, south of Route 1 and between Routes 24 and 123. The southern edge of the base borders the estuary of Harpswell Cove. NAS Brunswick is an active facility supporting the U.S. Navy's antisubmarine warfare operations in the Atlantic Ocean and Mediterranean Sea. The base's primary mission is to operate and maintain P-3 Orion aircraft. NAS Brunswick first became active in the 1940s during World War II, and underwent major expansion in the 1950s.

## 2.1 Location of NAS Brunswick and Case Study Site

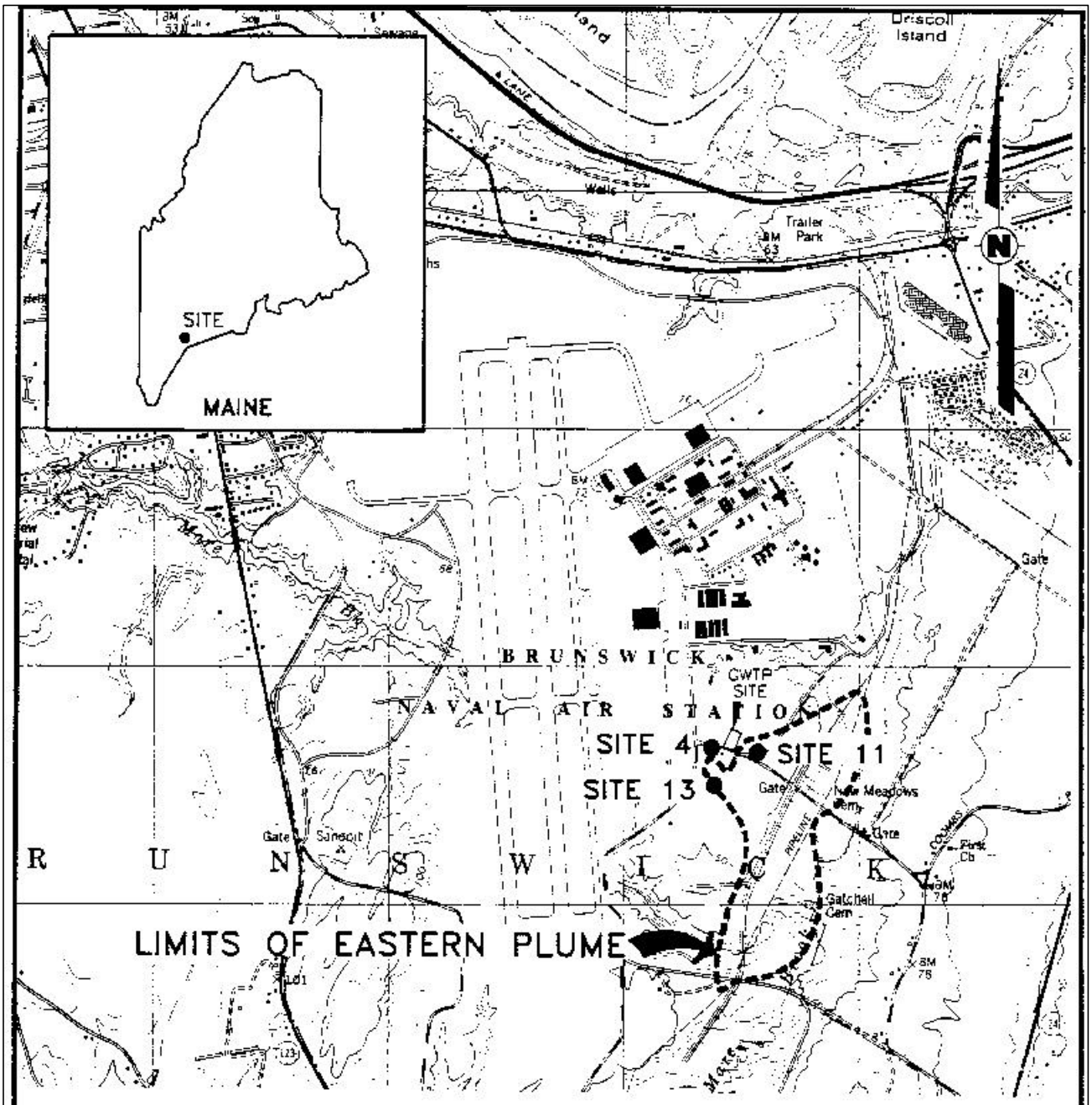
The locations of the Eastern Plume and the three contributing sites of contamination at NAS Brunswick are shown in Figure 2-1. Descriptions of the sites are provided in Section 3.0. The Eastern Plume is the result of contamination from three contributing sites:

- Site 4 - the Acid/Caustic Pit, under the eastern portion of Building 584
- Site 11 - the former Fire Training Area (FTA)
- Site 13 - the Defense Reutilization and Marketing Office (DRMO) Area immediately south of Building 584 and Site 4

## 2.2 Physical Setting

This section describes the geology, hydrogeology, and geography at NAS Brunswick. The information in this section is summarized from the *1995 Annual Report Monitoring Events 1 through 4, Sites 1 and 3 and Eastern Plume, NAS Brunswick, ME* (EA Engineering, July 1996).

**2.2.1 Geology—**In the shallow subsurface of the eastern portion of NAS Brunswick are sand, silt, and clay units overlying a moderately sloping bedrock surface. The main aquifer impacted by the COCs occurs within the unconsolidated deposits. Three major units have been identified in the unconsolidated deposits: sand, transition, and clay (E.C. Jordan, 1990). The sand unit consists of fine sand which readily transmits water, and ranges from 10 to 20 feet thick in the Eastern Plume area. The transition unit lies between the overlying sand and underlying clay, and is composed of interbedded sands, silts, and clays. The transition unit thickens from 5 to 80 feet from west to east across the




SCALE

0 2000 4000 feet

SOURCE: OHM 1996

REFERENCES:

1. BASE MAP PREPARED FROM 7.5 MIN U.S.G.S. TOPOGRAPHIC MAP OF BRUNSWICK, MAINE QUADRANGLE, DATED: 1980, SCALE: 1:24000.

2. LOCATION OF SITES 4, 11, 13 AND THE EASTERN PLUME OBTAINED FROM THE RECORD OF DECISION FOR AN INTERIM REMEDIAL ACTION AT THE EASTERN PLUME GROUNDWATER OPERABLE UNIT, FIGURE 2, PAGE 10, SCALE: 1" = 800'.

Figure 2–1. SITE LOCATION MAP

*EASTERN PLUME NAVAL AIR STATION, BRUNSWICK, MAINE*

| DRAWING NO. | CONTRACT NO. | DATE |
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Eastern Plume. The clay unit underlies the transition and overlies the bedrock surface in a nearly continuous layer. The clay has low permeability, and ranges from 15 feet thick in the northern portion of the Eastern Plume to an undetermined thickness in the south.

**2.2.2 Surface Water – Hydrology—**Most of NAS Brunswick lies within the Mere Brook watershed, and most of the runoff from the installation drains into Mere Brook or its largest tributary, Merriconeag Stream. The brook drains into the tidally-influenced Harpswell Cove on the Atlantic Ocean.

**2.2.3 Groundwater—**Groundwater flow at the site occurs within an unconfined to semi-confined aquifer system composed primarily of transitional, stratified, silty sands and coarse sands. These transitional soils overlay a glacio-marine clay considered to be an underlying aquitard to the shallow groundwater flow system. The clay unit ranges from 20 to 60 feet thick, and is found throughout most of the Eastern Plume area. The transitional soils are separated into an upper stratified sandy silt unit and a lower coarse sand unit. Groundwater flow is largely influenced by Mere Brook and Merriconeag Stream.

Average hydraulic conductivities at the site are 9.4 feet per day (ft/day) for the coarse sands, 0.5 ft/day in the stratified silts, and 0.11 ft/day for the stream bottom sediments. Groundwater seepage velocities range from 85 to 1,200 ft/yr. Downward vertical gradients exist in upland areas whereas upward gradients are generally present in stream valleys.

**2.2.4 Land Use—**Land use around NAS Brunswick includes residential, park, industrial, and commercial properties. On base, natural areas such as wetlands and wooded areas are interspersed with developed land that houses administrative and mission-related buildings and airfield facilities. It is not anticipated that land use, either on or off base, will change in the foreseeable future.

# 3.0 EASTERN PLUME REMEDIAL SYSTEM ASSESSMENT

## 3.1 Eastern Plume Background and Regulatory Framework

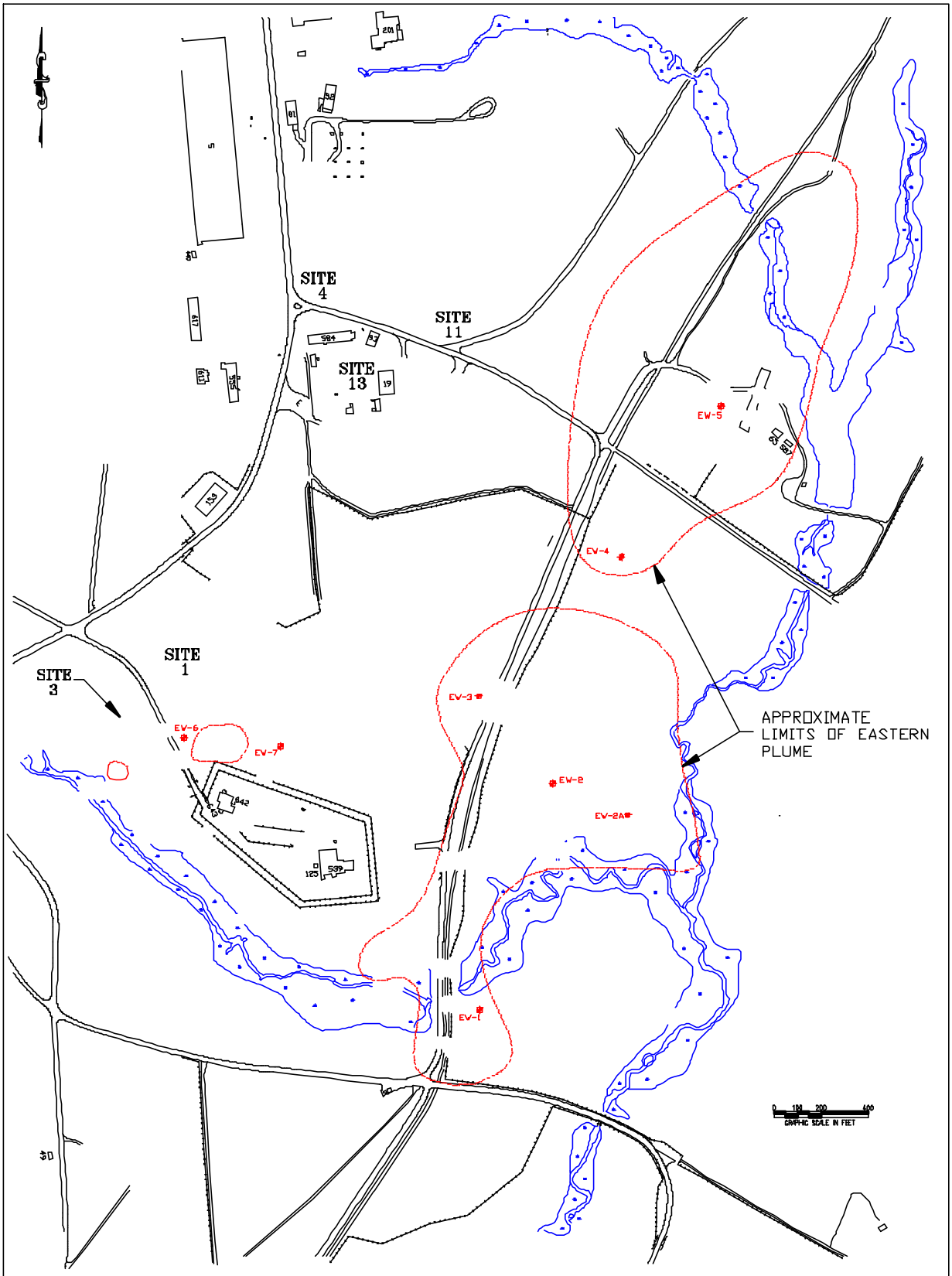
This section provides a description, regulatory information, and site activity status for the Eastern Plume and its contributing sites (Sites 4, 11, and 13) at NAS Brunswick. Figure 3-1 shows the location of the Eastern Plume. Tables 3-1 to 3-3 summarize the information for the sites.

**3.1.1 Description—**The Eastern Plume consists of contaminated groundwater located at the eastern edge of the installation. The Eastern Plume originated at three distinct sites located within several hundred feet of each other near Old Gurnet Road between the intersection of Orion Street and Sandy Road:

- Site 4: The Acid/Caustic Pit – Under the eastern portion of Building 584, this pit was used from 1969 to 1974 to dispose of acidic and caustic liquid wastes. The wastes were poured into the pit, which was approximately 4 feet square and 3 feet deep. In 1975, Building 584 was constructed on top of the pit. Investigations showed that subsurface soils around Site 4 were not contaminated and deemed suitable for no further action (NFA).
- Site 11: The former FTA – This area was used regularly over a 30-year period until it was closed in the fall of 1990. Waste liquids, including fuels, oils, and degreasing solvents, were used as fuel for the fire training exercises.
- Site 13: The DRMO Area – This area consisted of the former locations of three underground storage tanks (USTs) south of Site 4. One UST was used for diesel fuel; the other two tanks were reportedly used for storage of waste fuels, oils, and degreasing solvents. All three tanks were removed during the late 1980s.

**3.1.2 Regulatory Framework—**A Record of Decision (ROD) for the Eastern Plume was signed in February 1998. The ROD specified NFA for Sites 4, 11, and 13, and a final remedial action for the Eastern Plume. The associated cleanup levels and selected remedy components are summarized in Tables 3-2 and 3-3. As shown in the tables, the ROD specifies continuation of extraction, treatment, and discharge of contaminated groundwater; these were selected as actions in the Interim ROD signed in 1992. The LTM that began under the Interim ROD is also continued under the new ROD, with specifications to modify, if necessary, to ensure proper coverage of the Eastern Plume area. The monitoring status for the Eastern Plume is shown in Table 3-4.

For groundwater, ROD-specified cleanup levels are those listed in the MEG. The ROD states that the selected remedy will be operated until the cleanup levels for COCs have been met. In addition, Section X of the ROD contains language stating that although P&T is an effective method of reducing concentrations of highly contaminated groundwater, natural attenuation may be an important aspect in achieving the final increment of site cleanup.




LEGEND

EV-1 EXTRACTION WELL

APPROXIMATE LIMITS OF EASTERN PLUME

Source. EA Engineering, Science, and Technology, (22 July 1996)

NOTE:

1 SITE PLAN TAKEN FROM THE INTERGRAPH VERSION 5 BASE-WIDE PLAN PROVIDED BY NAS BRUNSWICK PUBLIC WORKS DEPARTMENT ON 13 OCTOBER 1995.

| | | | | |
|---|---|---|---|---|
| SCALE: AS SHOWN | DESIGNED BY | DATE | DRAWING TITLE: FIGURE 3-1 LOCATION OF EXTRACTION WELLS AND EASTERN PLUME | |
| CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF RADIAN INTERNATIONAL | DRAWN BY TSH | DATE 25AUG99 | | |
| | CHECKED BY | DATE | CAD DRAWING FILE | |
| | APPROVED BY | DATE | CONTRACT NO. 803016 0202 | DRAWING NO. EXTRACT | REV. 0 |

**Table 3-1. Description of Contaminated Sites for the Eastern Plume**

| Site | Description | Source of Release | Contaminated Media | Contaminants of Concern |
|---|---|---|---|---|
| 4 | Acid/ Caustic Pit | Liquid wastes | Groundwater and Soil | Chlorinated VOCs |
| 11 | FTA | Waste fuels, oils, degreasing solvents | Groundwater and Soil | Chlorinated VOCs |
| 13 | DRMO | Waste diesel, fuels, oils, degreasing solvents | Groundwater and Soil | Chlorinated VOCs |
| Eastern Plume | Eastern Groundwater Plume | Contributing contamination from Sites 4, 11, and 13 | Groundwater | Chlorinated VOCs |

Note:
VOC = Volatile Organic Compound

**Table 3-2. Groundwater Cleanup Levels Sites 4, 11, 13, and Eastern Plume ROD**

| Contaminant of Concern | Federal MCL (ppb) | Maine MEG (ppb) | Cleanup Level (ppb) |
|---|---|---|---|
| 1,1-dichloroethylene | 7 | 7 | 7 |
| 1,1-dichloroethane | - | 5 (70**) | 5 |
| 1,2-dichloroethane | 5 | 5 | 5 |
| cis-1,2-dichloroethylene | 70 | 70 | 70 |
| trans-1,2-dicholoroethylene | 100 | 70 | 70 |
| 1,1,1-trichloroethane | 200 | 200 | 200 |
| 1,1,2-trichloroethane | 5 | 3 | 3 |
| trichloroethylene | 5 | 5 | 5 |
| perchloroethylene | 5 | 5 | 3 |

Notes:
- = Not Available
MCL = Maximum Contaminant Level
MEG = Maximum Exposure Guideline
ppb = parts per billion
** = Revised MEG recommended by State of Maine on June 19, 1995

**Table 3-3. Summary of Regulatory Framework for Eastern Plume**

| Date of ROD | Site | Remedy Components | Cleanup Levels for Active Systems | Criteria to Stop Monitoring |
|---|---|---|---|---|
| February 1998 | Eastern Plume | Pump and treat contaminated groundwater from extraction wells installed within the Eastern Plume. Implement an LTM program. | State of Maine MEGs | LTM until deemed no longer necessary by the EPA and MEDEP. |

Notes:
MEG = Maximum Exposure Guideline
LTM = Long-Term Monitoring
MEDEP = Maine Department of Environmental Protection

**Table 3-4. Summary of Monitoring Status for Eastern Plume**

| Site | Status of Monitoring | Monitored Medium | Sampling Frequency | Current Number of Monitoring Points | Remedial Actions |
|---|---|---|---|---|---|
| Eastern Plume | Active; begun in 1995. | Groundwater | Required three times a year. | 34 wells | A single active pump and treat system. |

## 3.2 Current Eastern Plume Conceptual Model

This conceptual site model (CSM) is primarily an excerpt from the *Geostatistical Assessment of the Eastern Plume, Naval Air Station, Brunswick, Maine* (EA Engineering, Science, and Technology, 1998). As noted in that report, the CSM is based on a numerical model prepared by ABB Environmental Services, Inc. in 1993 and supplemented by data collected since long-term monitoring (LTM) commenced in March 1995.

The major elements of the CSM are:

- The Eastern Plume extends north to south along the eastern boundary of the Base as shown in Figure 3-1. The southern boundary of the Eastern Plume is located near New Gurnet Road.

- The COCs for the Eastern Plume are chlorinated volatile organic compounds (VOCs) including 1,1-dichloroethene (1,1-DCE), 1,1-dichloroethane (DCA), cis-1,2-dichloroethene (cis-1,2-DCE), 1,1,1-trichloloroethane (TCA), tetrachloroethene (PCE), and trichloroethene (TCE). Concentrations exceed state

maximum exposure guidelines (MEGs) and federal maximum contaminant levels (MCLs) in drinking water.

- The sources of dissolved-phase VOC in the Eastern Plume are considered to be Site 4 (Acid/Caustic Pit), Site 11 (former FTA), and Site 13 (DRMO area).

- The COCs are present in the unconsolidated aquifer system and have not impacted the bedrock aquifer.

- Based on the numerical model and measured potentiometric head changes with depth, groundwater in the Eastern Plume can be defined as a two-layer system. Unconfined groundwater occurs within the upper stratified sand/silt unit (referred to as Layer 1 in the numerical model and as the upper or shallow sand and transition unit in various reports). This upper sand/silt transition unit has a saturated thickness of approximately 20 to 30 feet. Semi-confined groundwater occurs within a lower coarse sand unit (referred to as Layer 2 in the numerical model and as the lower or deep sand in various reports). This lower coarse sand unit is considered semi-confined due to the presence of the transition unit above, and the Presumscot clay formation below.

- The Presumscot clay foundation is considered an impermeable base for the unconsolidated aquifer system due to the thickness of the clay (i.e., 20 to 60 feet) across most of the Eastern Plume, and its low hydraulic conductivity ($1x10^{-8}$ cm/sec).

- The confining clay formation is present over bedrock throughout most of the Eastern Plume. The surface of this clay formation forms troughs that influence the movement of groundwater and migration of COCs. The troughs present in the clay formation appear to be the focal point of the dissolved-phase VOCs.

- Groundwater flow at the Eastern Plume is interpreted to discharge to Merriconeag Stream, Mere Brook, Picnic Area Pond, and the Harpswell Cove watershed area.

- The Eastern Plume is recharged principally by infiltration of precipitation, and to a much lesser degree by upward groundwater flow. Measured potentiometric heads indicating an upward flow component from the lower sand unit to the upper sand/silt transition unit are commonly observed near Mere Brook and its major tributary, Merriconeag Stream. The upward flow gradients suggest that the Mere Brook drainage system is recharged by groundwater throughout its length in the vicinity of the Eastern Plume.

- Samples collected from wells located in the upper sand/silt transition unit (Layer 1) generally have non-detectable or less than cleanup level concentrations of COCs. Only one location in the upper sand/silt transition unit, at well MW-332, is known to exceed groundwater cleanup goals. The highest concentrations of COCs are reported in lower sand unit (Layer 2) wells screened within the clay troughs.

- Two areas of elevated VOC concentrations are observed in the lower coarse sand unit of the Eastern Plume: a northern lobe in the vicinity of extraction wells EW-4 and EW-5, and a southern lobe in the vicinity of extraction wells EW-1 through EW-3.

- Based on the results of LTM, the Eastern Plume is considered relatively stationary. The stability of the plume and the distribution of parent/daughter compounds in the plume suggest that natural attenuation processes are occurring in the Eastern Plume.

- Groundwater in the area of the plume is not currently used for drinking water or other purposes; therefore, there are no human receptors (ABB Environmental Services, Inc., 1993). Groundwater use on base can be prevented through the use of institutional controls; however, there is future potential exposure from ingestion for off base receptors if plume migration occurs (E. C. Jordan, 1990). Groundwater cleanup levels are based on applicable or relevant and appropriate requirements (ARARs), which include drinking water MCLs and the MEGs (OHM Remediation Services Corp., 1996).

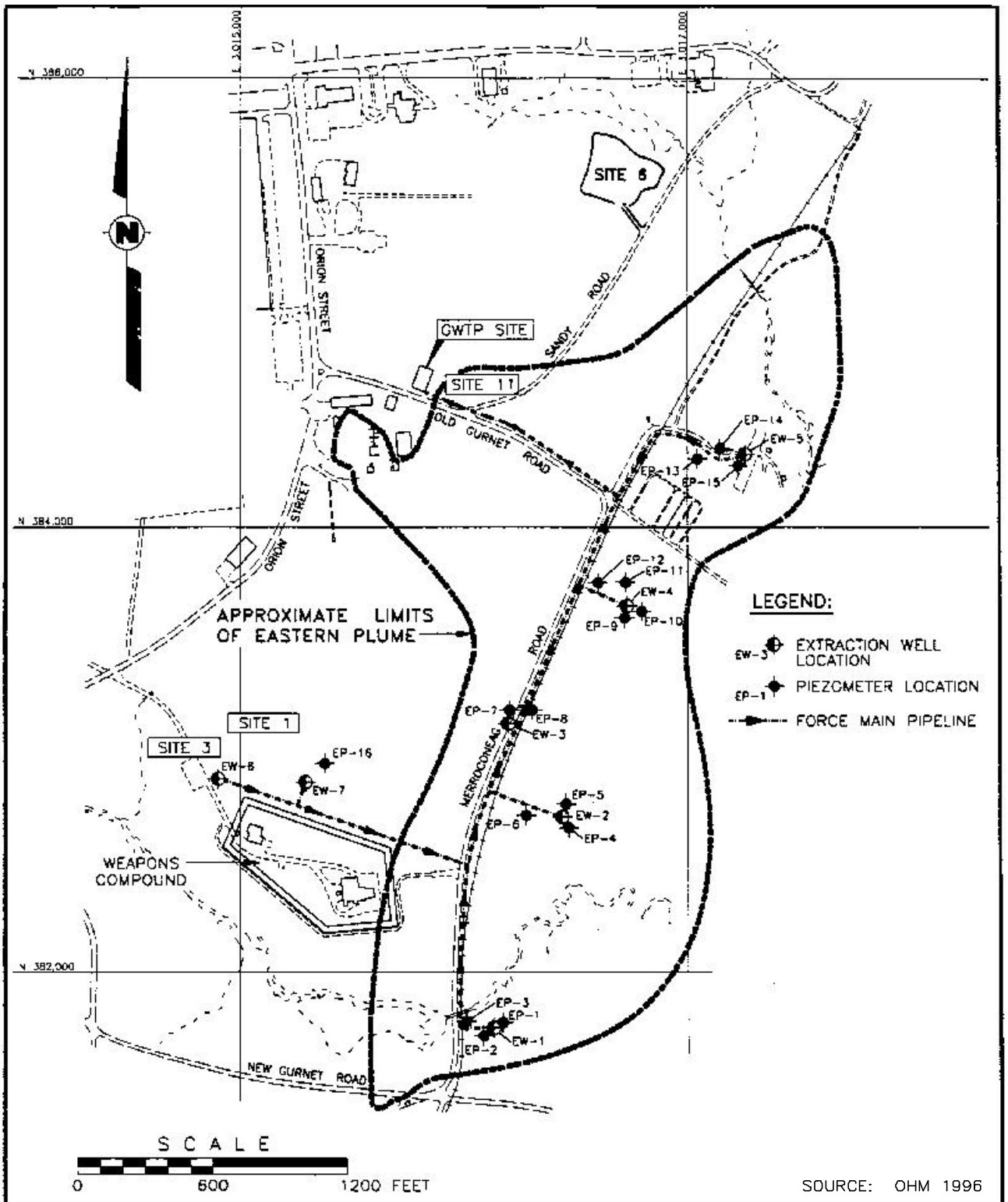
- In 1991, the Eastern Plume was predicted to discharge to Harpswell Cove in 5 years, potentially affecting ecological receptors; however, there is currently no evidence that the predicted discharge is occurring.

## 3.3 System Descriptions and Design Basis

The groundwater P&T system at the Eastern Plume has been in operation since May 1995. The system was designed to collect and treat contaminated groundwater from the Eastern Plume. Contaminated groundwater is extracted via a network of extraction wells and is then treated and discharged to the sanitary sewer. Figure 3-2 depicts a plan view of the extraction system.

The groundwater P&T system for the Eastern Plume is co-located in the same treatment building as the Landfill Sites 1 and 3 dewatering treatment system. The landfill dewatering system ceased operation in November 1997 because the system had effectively dewatered the landfill. This system may be restarted in the future if groundwater levels rise in the landfill area. The landfill dewatering system is not addressed in the report except as it relates to the Eastern Plume P&T system.

**3.3.1 Description of Extraction and Monitoring Well Network—**The groundwater P&T system was designed to collect landfill leachate and to dewater the waste buried at Sites 1 and 3; and, to contain and remove dissolved-phase VOCs from groundwater in the Eastern Plume (EA Engineering, Science, and Technology, 1999d). The P&T System utilizes a network of extraction wells to provide hydraulic control and remove contaminated water and a network of monitoring wells to measure system performance. The two well networks are described in the following sections.




SOURCE: OHM 1996

REFERENCES:

1. BASE MAP PREPARED FROM ABB ENVIRONMENTAL SERVICES, INC. DRAWINGS.
2. LOCATION OF SITES 4, 11, 13 AND THE EASTERN PLUME OBTAINED FROM THE RECORD OF DECISION FOR AN INTERIM REMEDIAL ACTION AT THE EASTERN PLUME GROUNDWATER OPERABLE UNIT, FIGURE 2, PAGE 10, SCALE: 1" = 800'.

Figure 3-2. GROUNDWATER PUMP AND TREAT SYSTEM

*EASTERN PLUME NAVAL AIR STATION, BRUNSWICK, MAINE*

| DRAWING NO. | CONTRACT NO. | DATE |
|---|---|---|
| brn99151.dwg | 803016.0202 | 08/20/99 |

*3.3.1.1 Extraction Well Network*

The original extraction well network, installed in 1995, included seven wells, EW-1 through EW-7. Well EW-2A was added in 1998. The network currently includes five pumping wells (EW-1, EW-2, EW-2A, EW-4, and EW-5) and three inactive wells (EW-3, EW-6, and EW-7). Extraction wells EW-1 through EW-5 are located at the Eastern Plume and wells EW-6 and EW-7 are located at Sites 1 and 3. Although connected to the same treatment system as the other wells, EW-6 and EW-7 were installed to dewater the landfill wastes at sites 1 and 3, and are not directly related with remediation of the Eastern Plume. Figure 3-2 shows the locations of the eight extraction wells and the approximate boundary of the Eastern Plume. The locations of wells EW-1 through EW-5 were selected based on groundwater modeling completed in 1993 that predicted hydraulic control of the Eastern Plume at a pumping rate of approximately 20 gallons per minute (gpm) per well (ABB Environmental Services, Inc., 1993).

Operation of the original seven wells began in May 1995 with the initiation of a 1-year system startup/prove-out period. In November 1997, pumping of EW-6 and EW-7 was terminated when groundwater levels had been lowered below the landfill waste. The wells remain on standby if needed in the future to dewater the waste. In June 1998, EW-2A was added to the extraction well network. It was installed downgradient of EW-2, near the Eastern Plume Boundary, to capture and remove a portion of the plume in which concentrations of VOCs exceed 5,000 micrograms per liter (µg/L). In December 1998, pumping at EW-3 was terminated due to the failure of the filter pack and well screen that allowed excessive amounts of silt and fine sand to enter the well (EA Engineering, Science, and Technology, 1999d). The well has been recommended for permanent abandonment.

Each extraction well is constructed with 6-inch diameter, stainless steel well casing and screen. Each well screen is surrounded by a sand pack. The seven original wells were installed with 6-inch diameter, stainless steel sumps of varying lengths below the screens; EW-2A was installed without a sump. Construction information for the individual wells installed at the Eastern Plume is summarized in Table 3-5. The table indicates that wells EW-1 to EW-5 are screened through both the sand/silt transition unit and the lower sand. Only well EW-2A is screened solely in the lower sand unit.

**Table 3-5. Summary of Installation Details for Extraction Wells in the Eastern Plume**

| | Well Component Interval (feet below ground surface) | | | | | |
|---|---|---|---|---|---|---|
| **Well Component** | **EW-1** | **EW-2** | **EW-2A** | **EW-3** | **EW-4** | **EW-5** |
| Upper Grout Seal | 0-13 | 0-9 | 0-44 | 0-11.5 | 0-6 | 0-14 |
| Bentonite Seal | NA | NA | 44-46 | NA | NA | NA |
| Sand Pack | 13-95 | 9-86 | 46-65 | 11.5-65 | 6-66 | 14-84 |
| Screen | 16-94 | 12-85 | 48-63 | 15-64 | 9-65 | 17-83 |
| Sump | 94-101 | 85-92 | NA | 64-71 | 65-72 | 83-90 |
| Lower Grout Seal | 95-101.5 | 86-94 | NA | 65-71 | 66-72 | 94-90 |

NA = Not Applicable

A stainless steel submersible pump is installed approximately 5 feet from the bottom of wells EW-1 through EW-5. At EW-2A, the pump is installed approximately 9 feet from the bottom of the well. The extraction system controls are designed to protect the pump from damage if the water level in the well is drawn down to a predetermined depth. In the event of a low water level condition, a capacitance probe in the well casing transmits a signal to the programmable logic controller (PLC), which instructs the motor control center to shut off the pump (Woodard & Curran, 1996).

Each extraction well is equipped with an in-line, magnetic flow meter that is used when adjusting the well's pumping rate. The meter measures flow at the well head only. It does not transmit flow data to the treatment facility and has no totalizing capability (Woodard & Curran, 1996).

The water level in each extraction well is measured in a piezometer located adjacent to the well. A transducer installed in the piezometer measures pressure and transmits the data to the PLC where the readings are converted to equivalent feet of water (Woodard & Curran, 1996).

*3.3.1.2 Monitoring Well Network*

The monitoring well network is a component of a LTM program that is designed to measure the effectiveness of remedial actions being conducted at Sites 1 and 3 and the Eastern Plume. Specifically, monitoring data from the Eastern Plume are being used (EA Engineering, Science, and Technology, 1999d):

- To assess the ambient water quality trends from analyses of well samples and the effectiveness of the P&T action;
- To evaluate the effectiveness of the groundwater extraction system by assessing trends in the concentration of VOCs in the Eastern Plume, and provide recommendations to improve system effectiveness; and,
- To analyze the effective capture zone of the groundwater extraction system to determine if hydraulic control of the plume is being maintained.

The well network includes the extraction wells and the monitoring wells listed in Table 3-6. As shown in the table, monitoring wells are assigned to one of three categories based on their location relative to the Eastern Plume (EA Engineering, Science, and Technology, 1999d). Each monitoring well is also classified as shallow or deep. Shallow wells are screened in the upper portion of the transition unit. Deep wells are screened in the lower portion of the transition unit and in the coarse (deep) sand unit above the clay aquitard. Water samples are collected and analyzed for VOCs from these wells in March, July, and November of each year. Figure 3-3 shows the locations of the sampling points.

The LTM program requires that water levels be measured in conjunction with groundwater sampling. In 1998, water levels were also measured in January, May, and September. Water levels are measured in each of the sampled wells and in other selected monitoring wells. Figure 3-4 shows the locations of the water level gauging points.

**Table 3-6. Summary of Sentinel, Perimeter, and Interior Plume Wells**

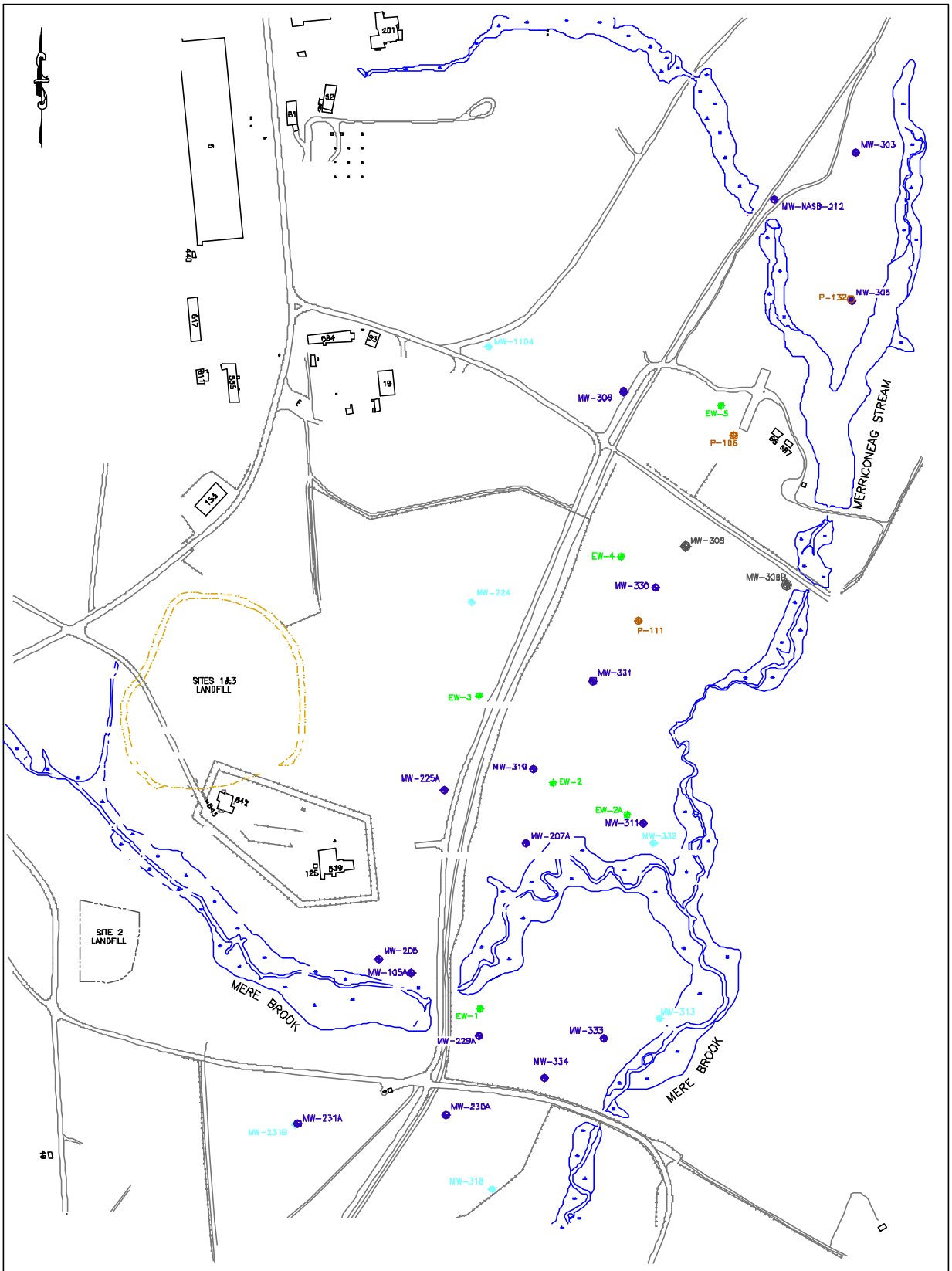
| Sentinel Wells | Perimeter Wells | Interior Plume Wells |
|---|---|---|
| MW-230A | MW-229A | MW-205 |
| MW-231A | MW-1104 | MW-207A |
| MW-231B | MW-105A | MW-311 |
| MW-313 | MW-225A | MW-319 |
| MW-318 | MW-306 | MW-331 |
| MW-333 | MW-NASB-212 | MW-332 |
| MW-334 | MW-224 | P-106 |
| MW-303 | MW-330 | EW-1 |
| MW-305 | P-111 | EW-2 |
| P-132 | | EW-2A |
| MW-308 | | EW-3 |
| MW-309B | | EW-4 |
| | | EW-5 |

Note: Only monitoring wells located within the Eastern Plume which are sampled under the draft LTM Plan have been assigned designations.

Definitions listed below were established during the 10 February 1999 Technical Restoration Advisory Board Meeting:

- Sentinel wells are located outside the area of known contamination to be used to warn of plume migration.
- Perimeter wells are located at the edge of the plume to monitor the plume boundary.
- Interior plume wells are located within the area of known contamination to monitor plume migration.

Source: 1998 Annual Report - Sites 1 and 3 and Eastern Plume Monitoring Events 11 through 13 (EA Engineering, Science, and Technology, 1999d).




LEGEND

- MW-311A — BEDROCK MONITORING WELL
- MW-231A — DEEP MONITORING WELL
- MW-231B — SHALLOW MONITORING WELL
- EW-3 — EXTRACTION WELL
- EP-1d — SHALLOW PIEZOMETER
- FENCE
- APPROXIMATE LIMITS OF SLURRY WALL
- APPROXIMATE LIMITS OF SITES 1 & 3
- APPROXIMATE BOUNDARY OF SITE 2 LANDFILL

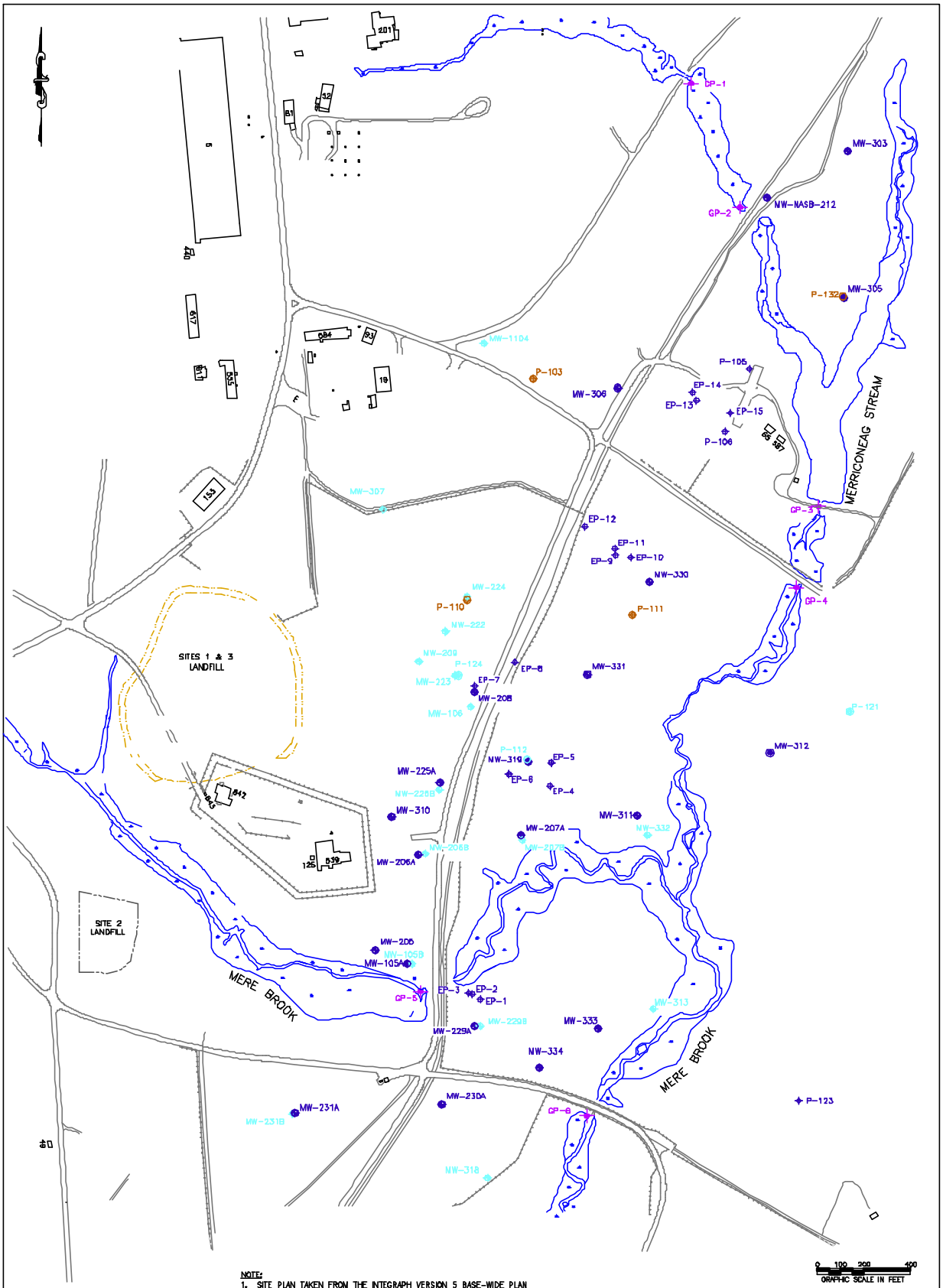
NOTE:
1. SITE PLAN TAKEN FROM THE INTERGRAPH VERSION 5 BASE-WIDE PLAN PROVIDED BY NAS BRUNSWICK PUBLIC WORKS DEPARTMENT ON 13 OCTOBER 1996

Source: EA Engineering, Science, and Technology, (10 January 1999)

| SCALE | DESIGNED BY | DATE | DRAWING TITLE |
|---|---|---|---|
| AS SHOWN | | | FIGURE 3-3. EASTERN PLUME LONG-TERM MONITORING SAMPLING POINTS |
| DRAWN BY TSH | DATE 25AUG99 | | |
| CHECKED BY | DATE | | |
| APPROVED BY | DATE | | |

RADIAN INTERNATIONAL

| CONTRACT NO. | DRAWING NO. | REV. |
|---|---|---|
| 803016.0202 | LTMSP | 0 |




NOTE:
1. SITE PLAN TAKEN FROM THE INTERGRAPH VERSION 5 BASE-WIDE PLAN PROVIDED BY NAS BRUNSWICK PUBLIC WORKS DEPARTMENT ON 13 OCTOBER 1996

LEGEND

- MW-311A — BEDROCK MONITORING WELL
- MW-331A — DEEP MONITORING WELL
- MW-331B — SHALLOW MONITORING WELL
- EP-11 — DEEP PIEZOMETER
- EP-16 — SHALLOW PIEZOMETER
- GP-4 — SURFACE WATER GAUGING POINT
- FENCE
- APPROXIMATE LIMITS OF SLURRY WALL
- APPROXIMATE LIMITS OF SITES 1 & 3
- APPROXIMATE BOUNDARY OF SITE 2 LANDFILL

Source: EA Engineering, Science, and Technology, (10 January 1999)

| SCALE | DESIGNED BY | DATE | DRAWING TITLE |
|---|---|---|---|
| AS SHOWN | | | FIGURE 3-4. EASTERN PLUME LONG-TERM MONITORING GAUGING LOCATIONS |
| RADIAN INTERNATIONAL | DRAWN BY TSH | DATE 25AUG99 | |
| | CHECKED BY | DATE | |
| | APPROVED BY | DATE | |

| CONTRACT NO. | DRAWING NO. | REV. |
|---|---|---|
| 803016.0202 | LTMGL | 0 |

Annual routine maintenance of the monitoring wells includes inspection and maintenance of identifying markings on each well; and inspection and replacement, as necessary, of caps, locks, seals, and grouting (ABB Environmental Services, Inc., 1994).

**3.3.2 Description of Aboveground Treatment Train for the Eastern Plume—**A schematic of the aboveground groundwater treatment plant for the Eastern Plume is presented in Figure 3-5. The aboveground treatment train for the Landfill Sites 1 and 3 dewatering system is also included in Figure 3-5 as it exists in the same treatment building. The following describes the treatment process for the Eastern Plume.

**Metals Precipitation**. Groundwater from the extraction wells is pumped directly to a 1,400-gallon equalization tank equipped with a mixer. Potassium permanganate may be added to the equalization tank to oxidize any iron and manganese present in the groundwater. The metals precipitation process is currently not in use, as the first O&M contractor felt it was not needed to meet effluent standards.

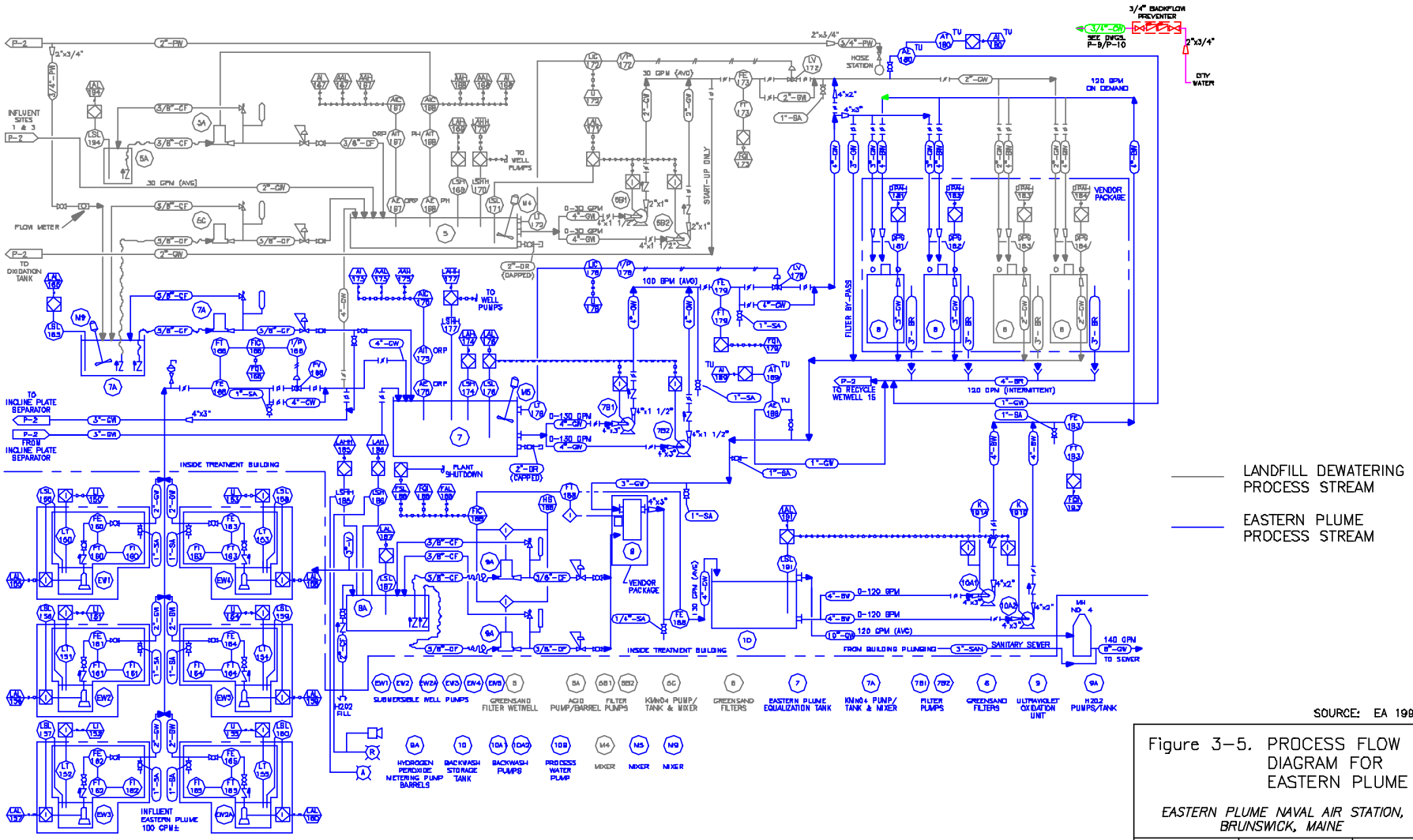
**Clarifier and Sand Filtration**. The water is then either pumped to a clarifier and/or four green sand filters to remove any precipitated metals or bypassed directly to the ultraviolet oxidation (UV-Ox) system. The filters are designed to treat a maximum flow of 110 gpm from the Eastern Plume and 20 gpm from landfill dewatering. The filters are equipped with a backwash system.

**Ultraviolet Oxidation (UV-Ox)**. Prior to entering the UV-Ox system, the Eastern Plume process stream is combined with the landfill process stream (if operational). Hydrogen peroxide is added to the combined process stream before it enters the UV-Ox system. In the UV-Ox unit, the groundwater is irradiated with ultraviolet light. In the presence of ultraviolet light, hydrogen peroxide forms hydroxyl radicals, which is a strong oxidizer that can oxidize organic and inorganic compounds. Once oxidized, organic molecules form various end products, such as carbon dioxide, water, and chloride.

**Treated Effluent Storage and Discharge**. From the UV-Ox system, the water is conveyed to the discharge holding tank. The discharge holding tank has a gravity outlet to the Brunswick District sewer system.

**Landfill Process Stream**. The landfill process stream (designed for 20 gpm) includes metal precipitation involving an oxidation tank, solids and metals removal, and filtration prior to being combined with the Eastern Plume process stream for treatment by UV-Ox. This system is currently idle.

**Instrumentation and Control System**. A PLC and a supervisory control and data acquisition (SCADA) system are used to control the treatment plant. Signals from various equipment transmit data such as flow, level, pH, turbidity, etc. The data is used to control the process, alert the operator of alarm conditions, and log historical data to the SCADA system. There are personal computers equipped with the SCADA package to control the treatment plant at the treatment plant building, the Base Fire Department, and the Public Works




NOTE: (1). EA ADAPTED FROM ABB ENVIRONMENTAL SERVICES ORIGINAL DESIGN DRAWINGS DATED 5/25/93

SOURCE: EA 1999

Figure 3-5. PROCESS FLOW DIAGRAM FOR EASTERN PLUME

*EASTERN PLUME NAVAL AIR STATION, BRUNSWICK, MAINE*

| DRAWING NO. | CONTRACT NO. | DATE |
|---|---|---|
| brn99158 dwg | 803016 0202 | 08/25/99 |

Building. Also, the operator may control the system via the phone lines with a portable computer equipped with the SCADA package. In the event of an alarm, the control system alerts the operator by pager via modem and through the SCADA systems. A summary of the data inputs of the instrumentation and control system (manual and/or controlled by the PLC) is provided in Table 3-7.

**Table 3-7. Summary of the Eastern Plume Groundwater Treatment Plant Data Input for Instrumentation and Control System**

| Process | Data Input |
|---|---|
| Trend Recorders | Two strip chart recorders are being used to monitor:<br>• Landfill Influent Flow (not operating)<br>• Eastern Plume Influent Flow<br>• Effluent Flow |
| Flow Meters | Fourteen flow meters are located at the two extraction and treatment facilities. However, the individual flow meters at the wells do not transmit to the control room. They are used for manually adjusting the flow at the well head. Six of these flow meters are located in the treatment plant and transmit flow data to the PLC. |
| pH and Oxidation Reduction Potential (ORP) Analyzers | Several ORP and pH analyzers are used to monitor flow, signal alarms, and control chemical feed pumps. |
| Pressure Transducers | Pressure transducers are used to control water levels in the equalization tank. This signal is sent to the PLC and is used to control the discharge pumps. |
| Level Switches | Each process and bulk chemical tank has one or more level switches that signal the PLC to control pumps or activate alarm conditions. |
| Turbidity Meters | In-line turbidity meters are installed to monitor turbidity and shut down the system when the turbidity is greater than 5 nephelometric turbidity units (NTU). The operator then manually diverts flow through the sand filters. If the flow is greater than 10 NTU the operator manually diverts flow to the clarifier. |

**3.3.3 Design Specifications and Parameters—**The remedial action objectives for the Eastern Plume P&T system are summarized below:

- Minimize further migration of the Eastern Plume;
- Minimize any future negative impact to the Harpswell Cove estuary resulting from discharge of contaminated groundwater;
- Reduce the potential risk associated with ingestion of contaminated groundwater to acceptable levels; and
- Reduce the time required for restoration of the aquifer.

The total system design flow for the Eastern Plume P&T system is 110 gpm from five extraction wells. The landfill dewatering treatment system is designed to treat an additional 20 gpm. The treatment plant is designed to remove VOC and metals to

concentrations below the Brunswick Sewer District limits for discharge to the sanitary sewer. These limits for discharge are shown in Table 3-8. To monitor the performance of the Eastern Plume treatment plant, samples are collected monthly as shown in Table 3-9.

**3.3.4 System Upgrades and Modifications—**At the Navy's request, the operations and maintenance (O&M) contractor has recommended upgrading the Eastern Plume treatment plant. Several upgrade options are presented in "Technical Engineering Evaluation Report for Groundwater Extraction and Treatment System NAS Brunswick" (EA Engineering, 1999c). The report recommends modifying the Eastern Plume treatment system by replacing the UV-Ox system with an air stripper followed by granular activated carbon (GAC) polishing. This report also documents the Navy's investigation which revealed that discharging to surface water and/or to groundwater via infiltration galleries may be a more cost-effective approach than the current discharge method to the sanitary sewer. Other major upgrades include addition of the SCADA systems in November 1997. The SCADA system was previously discussed in Section 3.3.2.

**3.3.5 Total Capital Costs—**The total capital cost of the combined Eastern Plume P&T system and the Landfill Sites 1 and 3 dewatering system was $4.25M. These costs are summarized in Table 3-10. Given an estimated operational life of 10 years, this capital cost translates to over $632,000 per year.

## 3.4 Best Practices Already in Place for the Eastern Plume

This section is intended to highlight good management practices that have been implemented by NAS Brunswick and its O&M contractors. The following are considered good O&M practices:

- Recently, the current O&M contractor verified that the treatment plant SCADA system was year 2000 (Y2K) compliant.
- From 1996 through 1999, the treatment plant operated at annual operating percentages ranging from 94 to 97 percent. These operating uptimes are considered above average.
- NAS Brunswick has implemented use of an interactive geographic information system (GIS). GIS, along with other graphic packages, help with the visual interpretation of large amounts of data and allows for data query to help easily track trends in plume and contaminant migration at the Eastern Plume.
- The addition of EW-2A increased mass removal. EW-2A now accounts for 85 percent of the mass removal at the Eastern Plume. This represents good optimization practice.
- NAS Brunswick successfully dewatered the waste in the landfill, thus eliminating direct contact of groundwater with contaminants. The landfill dewatering system was turned off after only 17 months of operation.

**Table 3-8. Effluent Standards for the Eastern Plume Treatment Plant**

| Groundwater Contaminant of Concern | Effluent Discharge Limits (µg/L except as noted) |
|---|---|
| Trichloroethene (TCE) | 5 |
| 1,1-Dichloroethane (DCA) | 94 |
| 1,1-Dichloroethene (1,1-DCE) | 7 |
| 1,2-Dichloroethene (1,2-DCE) total | 70 |
| Tetrachloroethene (PCE) | 5 |
| 1,1,1-Trichloroethane (TCA) | 750 |
| Methylene Chloride | 5 |
| Vinyl Chloride | 2 |
| Iron | 400 |
| Arsenic | 50 |
| Chromium | 10 |
| Cyanide | 34 |
| Lead | 15 |
| Nickel | 78 |
| Zinc | 200 |
| Manganese | 100 |
| PH (max) | 8 |
| PH (min) | 6 |
| Turbidity | 50 NTU |

Notes:
µg/L = micrograms per liter
NTU = Nephelometric Turbidity Unit

**Table 3-9. Performance Monitoring for Eastern Plume Groundwater Treatment Plant**

| Analytes | Eastern Plume Influent | UV-Ox Influent | Plant Effluent |
|---|---|---|---|
| VOCs | Monthly | Monthly | Bi-weekly |
| Iron and Manganese | Daily | Daily | Daily |
| Metals | | | Bi-weekly |
| pH and Turbidity | | Continuous | |
| Flow | Daily | Daily | Continuous |

Notes:
UV-Ox = Ultraviolet Oxidation
VOC = Volatile Organic Compounds

**Table 3-10. Capital Costs for the Eastern Plume and Landfill Treatment System**

| Description | Cost |
|---|---|
| Mobilization | $19,620 |
| Technical Plans | $93,835 |
| Site Preparation | $279,090 |
| Groundwater Extraction System | $932,560 |
| Utilities Groundwater Treatment Plant (GWTP) Building | $153,164 |
| GWTP Building | $1,737,100 |
| Groundwater Treatment - Process Equipment | $851,800 |
| Groundwater Treatment Plant Start-up | $89,250 |
| Groundwater Treatment Plant - Site Restoration | $80,200 |
| Demobilization | $9,700 |
| **Total** | **$4,246,319** |

Note: GWTP = Groundwater Treatment Plant

- Passive aqueous diffusion samplers were placed in the bed of Mere Brook to evaluate if contaminated groundwater discharge from the Eastern Plume measurably impacts Mere Brook. This is a proactive step in establishing the most appropriate cleanup requirements. Only toluene was detected in all samples, and it was determined to be a method contaminant.

## 3.5 Eastern Plume System Performance Baseline

**3.5.1 Eastern Plume Treatment System Cost and Performance Baseline—**Figures 3-6 through 3-9 are cost and performance plots for July 1996 through May 1999 for the Eastern Plume Treatment System. The dashed lines in each of the plots reflect the linear trend of the data. Taken collectively, these plots provide valuable information on the current and historical performance baseline for this system, and are discussed below:

- **Figure 3-6, "Influent VOC Concentrations vs. Time":** As shown in Figure 3-6, the monthly total VOC influent concentrations for the Eastern Plume have increased steadily since system start-up. The increase is indicative of the addition of extraction wells in contaminant hot spots to improve system performance, particularly the installation of EW-2A in July 1998.
- **Figure 3-7, "Cumulative Mass Recovered vs. Time":** The Eastern Plume system removed approximately 536 pounds of VOC during an operational period of July 1996 through May 1999. Mass removal from the Eastern Plume had begun to decrease prior to the installation of EW-2A. Mass removal averages 15 pounds per month.
- **Figure 3-8, "Cumulative Costs vs. Cumulative VOCs Recovered":** Figure 3-8 graphically displays the relatively stable cost effectiveness of the Eastern Plume treatment system; however, this figure also shows how expensive this operation has been during its lifetime. With capital costs included, it has cost almost $3.5 million (the amortized total cost increment) to remove approximately 536 pounds. So while the system has not experienced a significant decrease in mass removal efficiency, the price of operation has been high.

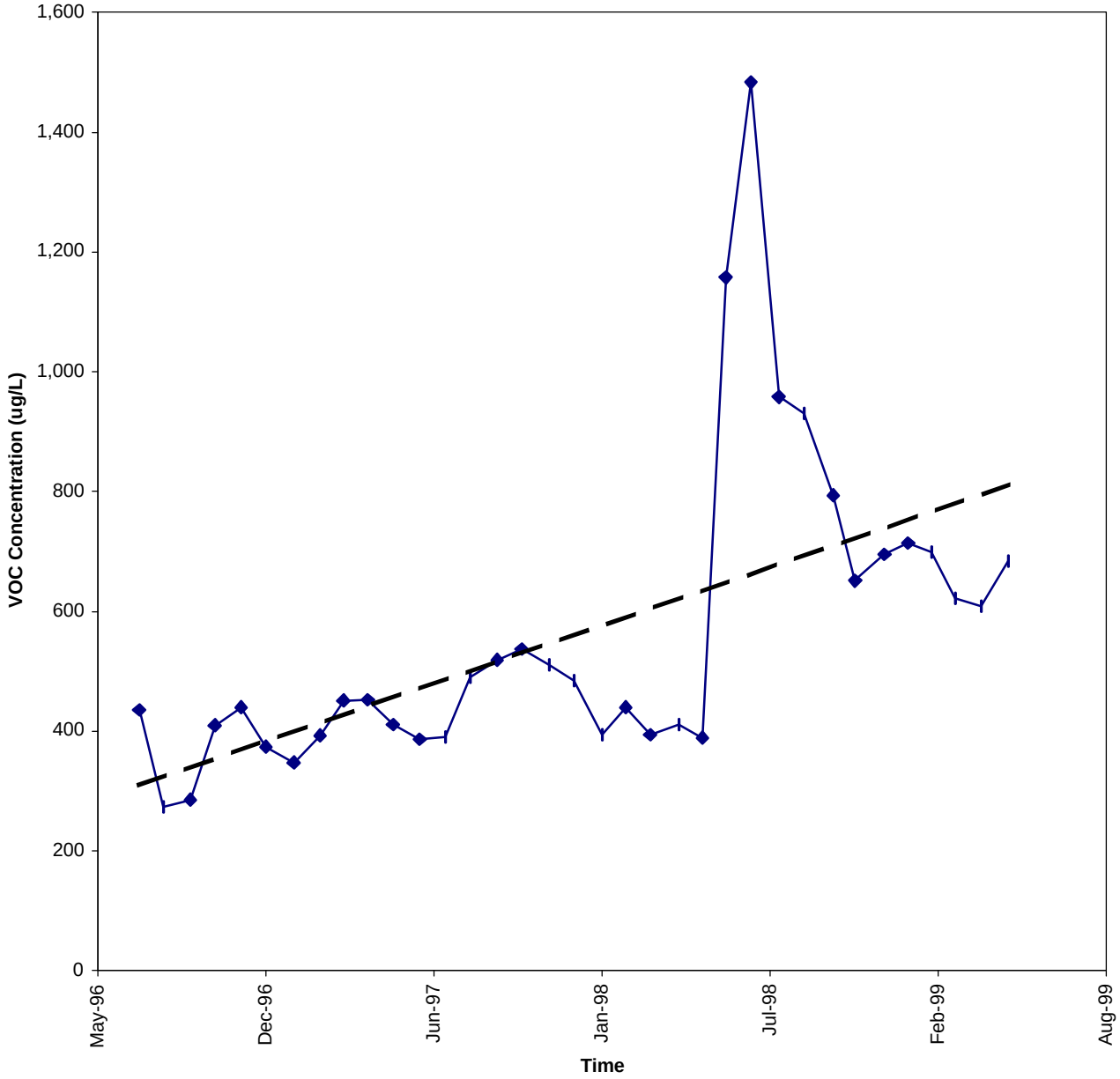



**Figure 3-6. Influent VOC Concentrations vs. Time**
**Eastern Groundwater Plume**
**NAS Brunswick**

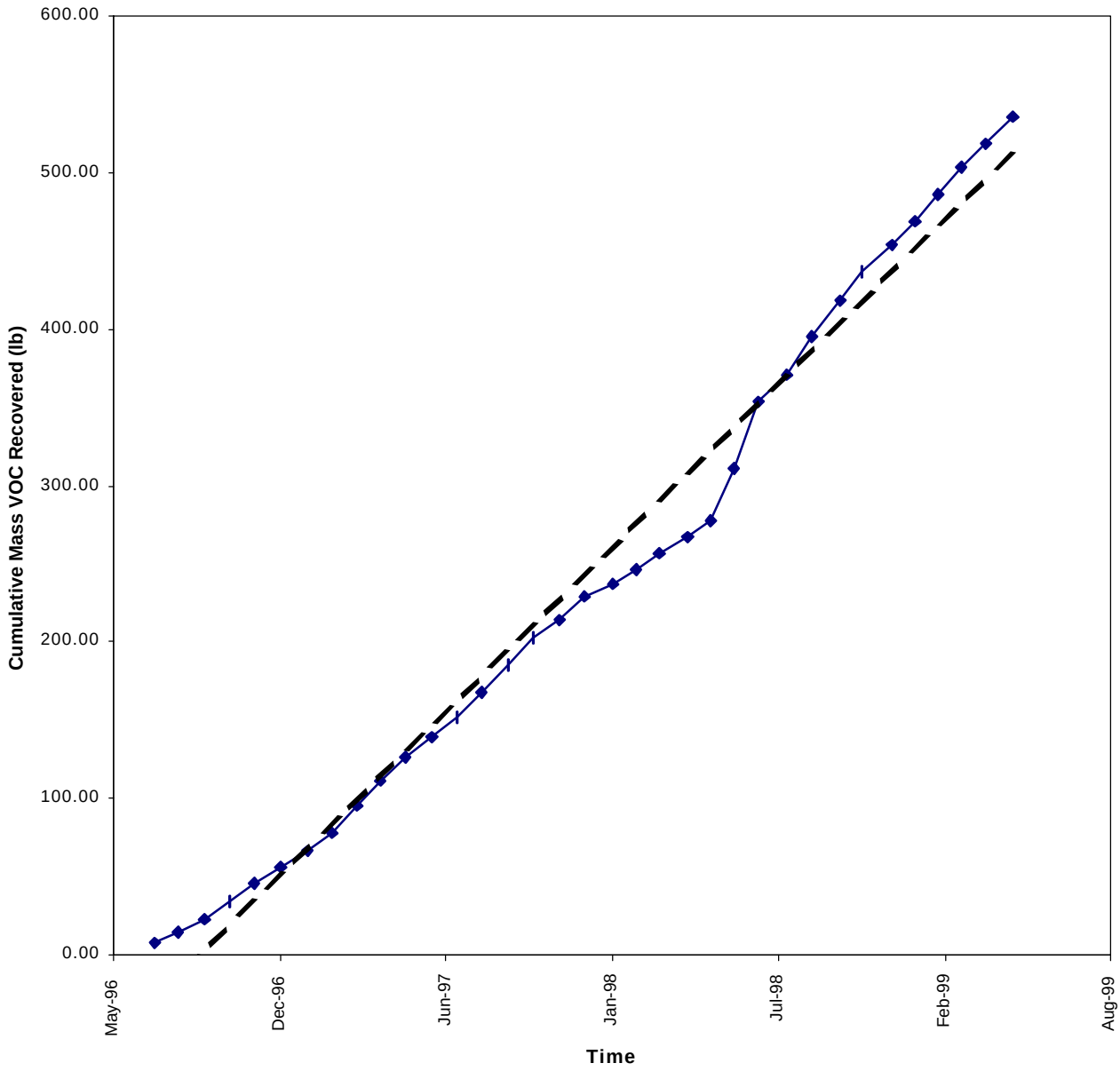



**Figure 3-7. Cumulative Mass Recovered vs. Time**
**Eastern Groundwater Plume**
**NAS Brunswick**

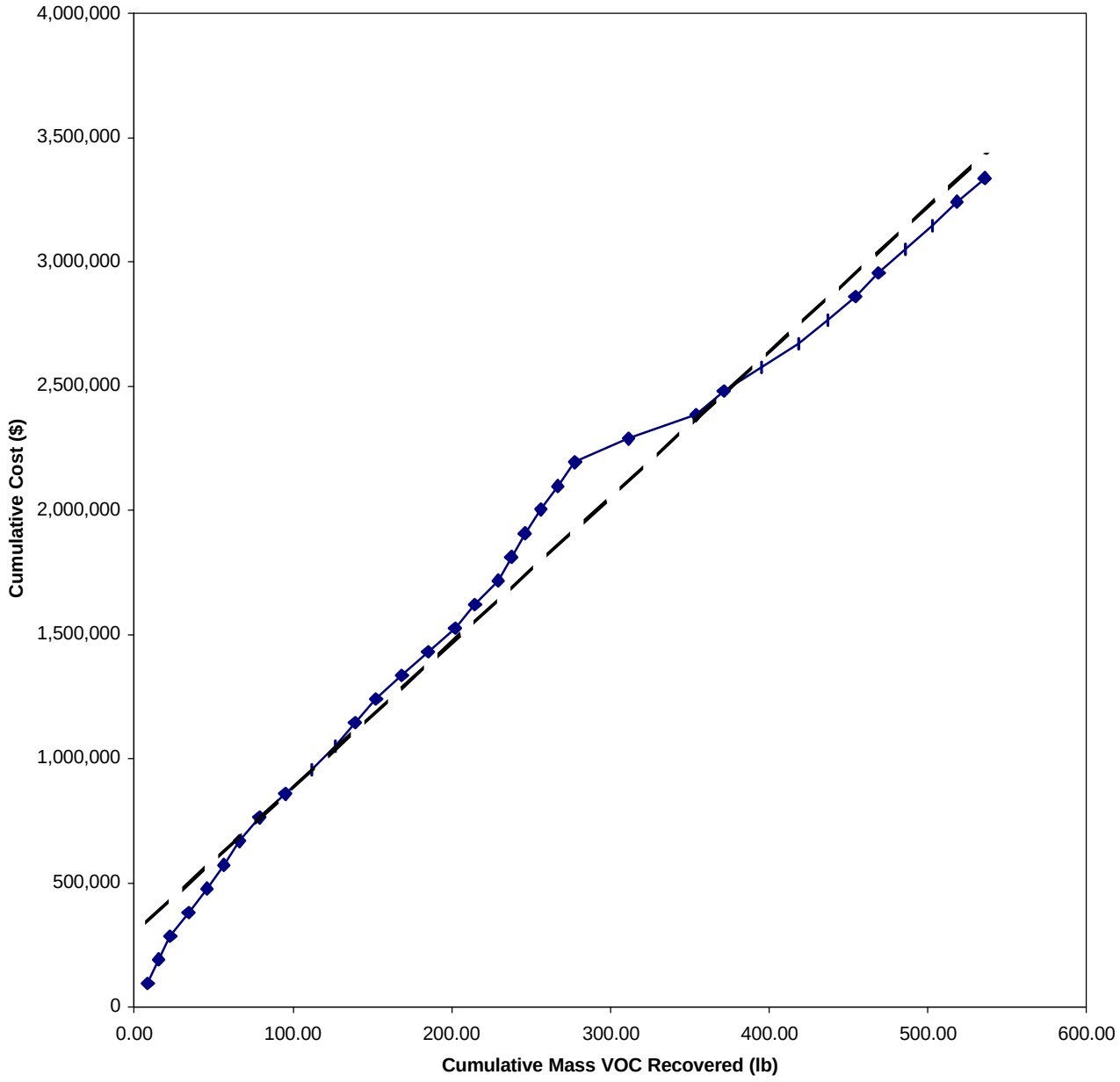



**Figure 3-8. Cumulative Costs vs. Cumulative VOCs Recovered**
**Eastern Groundwater Plume**
**NAS Brunswick**

- **Figure 3-9, "Average Cost Per Pound Recovered vs. Time":** As seen in Figure 3-9, the average cost per pound removed for the Eastern Plume system is trending steadily downward. Since a September 1996 high of approximately $11,000 per pound of VOC removed, the average cost per pound of VOC removed has decreased to approximately $6,200 for the most recent 8 months. This decrease in cost can be directly attributed to the installation of EW-2A, which has improved system performance. The Eastern Plume treatment plant was originally designed to handle not only the Eastern Plume, but also the landfill site, and was consequently overbuilt for the site. The inclusion of these capital costs significantly skews the average cost per pound recovered upward.

Table 3-11 summarizes selected performance parameters for the system.

**Table 3-11. Eastern Plume System Performance vs. Design Data**

| Parameter | Design | Actual Average[1] | Actual Median[1] |
|---|---|---|---|
| Aquifer Average Flow Rate (gpm) | 110 | 76.8 | 76.8 |
| Monthly Aquifer Volume (gallons) | 5,616,000 | 3,318,862 | 3,319,430 |
| Monthly Mass removed (lbs.) | - | 15.3 | 15.5 |
| Average cost per mass ($/lb.) | - | $7,781 | $7,742 |

[1]Based on performance data from July 1996-May 1999.
- = Not Available

**3.5.2 Extraction and Monitoring Well Network Performance**—This section discusses the performance of the extraction and monitoring well networks at the Eastern Plume. It also identifies data gaps that may preclude fully assessing system performance, groundwater conditions, or plume behavior.

*3.5.2.1 Extraction Well Network*

Mechanically, the operation of the Eastern Plume extraction well network in 1998 was acceptable. Annual "uptime" of the wells ranged from 64 percent for EW-5 to 100 percent for EW-2A, which began operating in June 1998. Most of the interruptions in the operation of the extraction wells were due to power fluctuations and turbid conditions in wells EW-1, EW-3, and EW-5 (EA Engineering, Science, and Technology, 1999d). Pumping at EW-3 was terminated in December due to the pumping of excessive sand and is not scheduled to resume. Pumping at EW-5 was suspended at the end of January until the well was redeveloped and restarted in June. Well EW-4 was removed from service in November due to pump motor problems and was not restarted until 1999. The operating statistics and the nature of the interruptions recorded in 1998 are typical of earlier years in the system's operating history. Turbid conditions and "sand pumping" are anticipated to be a recurring problem in those wells whose design and construction require that the pump be located in or near the screened, rather than the cased, portion of the well. Pump placement within the well screen increases water entrance velocities and contributes to higher rates of corrosion, incrustation, and sand pumping.

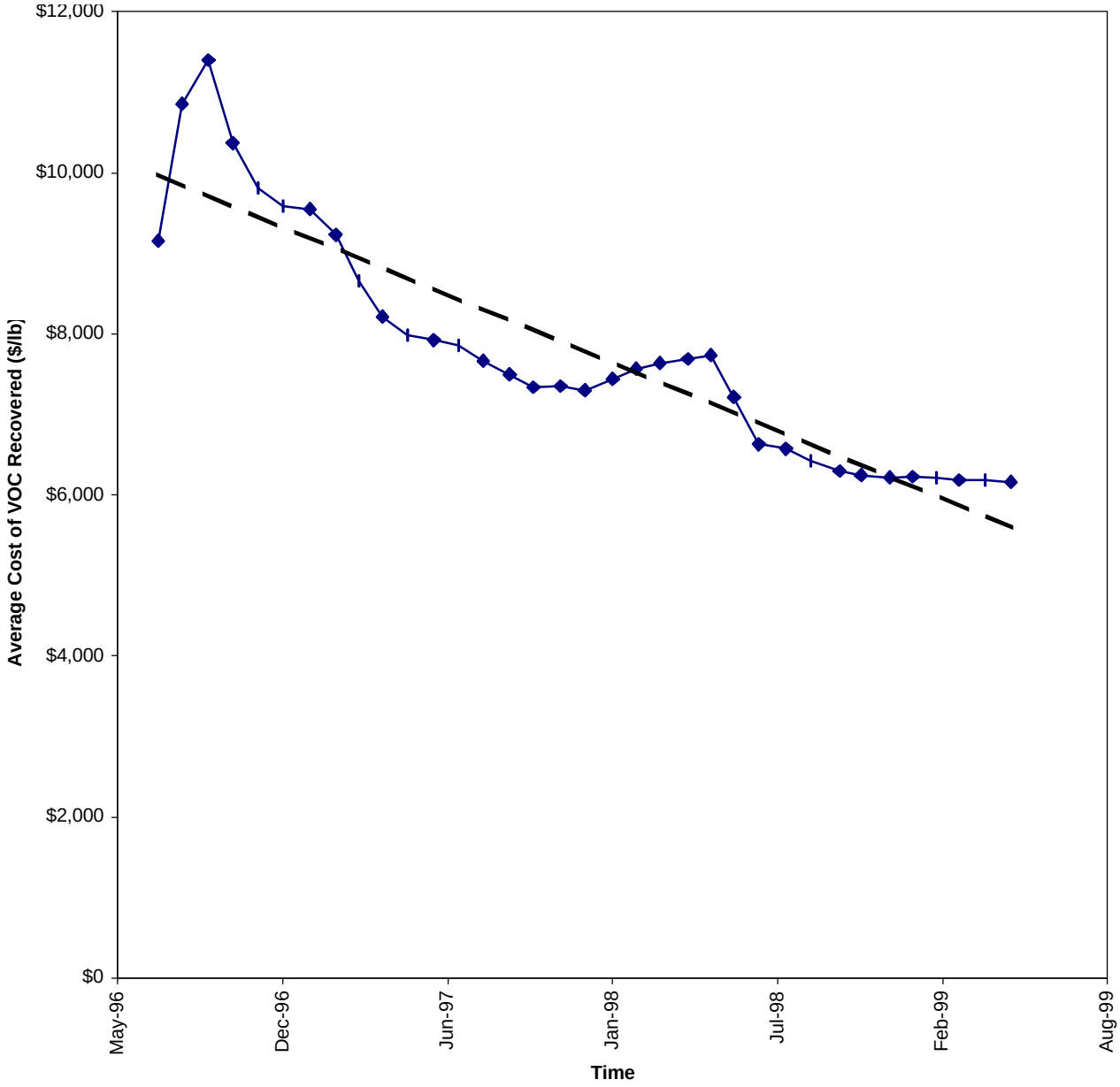



**Figure 3-9. Average Cost Per Pound Recovered vs. Time Eastern Groundwater Plume NAS Brunswick**

Despite acceptable mechanical operation, a fundamental flaw in the design of wells EW-1, EW-2, EW-3, EW-4, and EW-5 has resulted in sub-par system performance since operation began. Each of the five wells is screened throughout the entire unconsolidated aquifer system so that water is pumped not only from the contaminated lower sand unit, but also from the essentially uncontaminated upper sand/silt transition unit. As discussed below, the consequence of this well design will continue to negatively impact plume containment, contaminant mass removal, and operating cost.

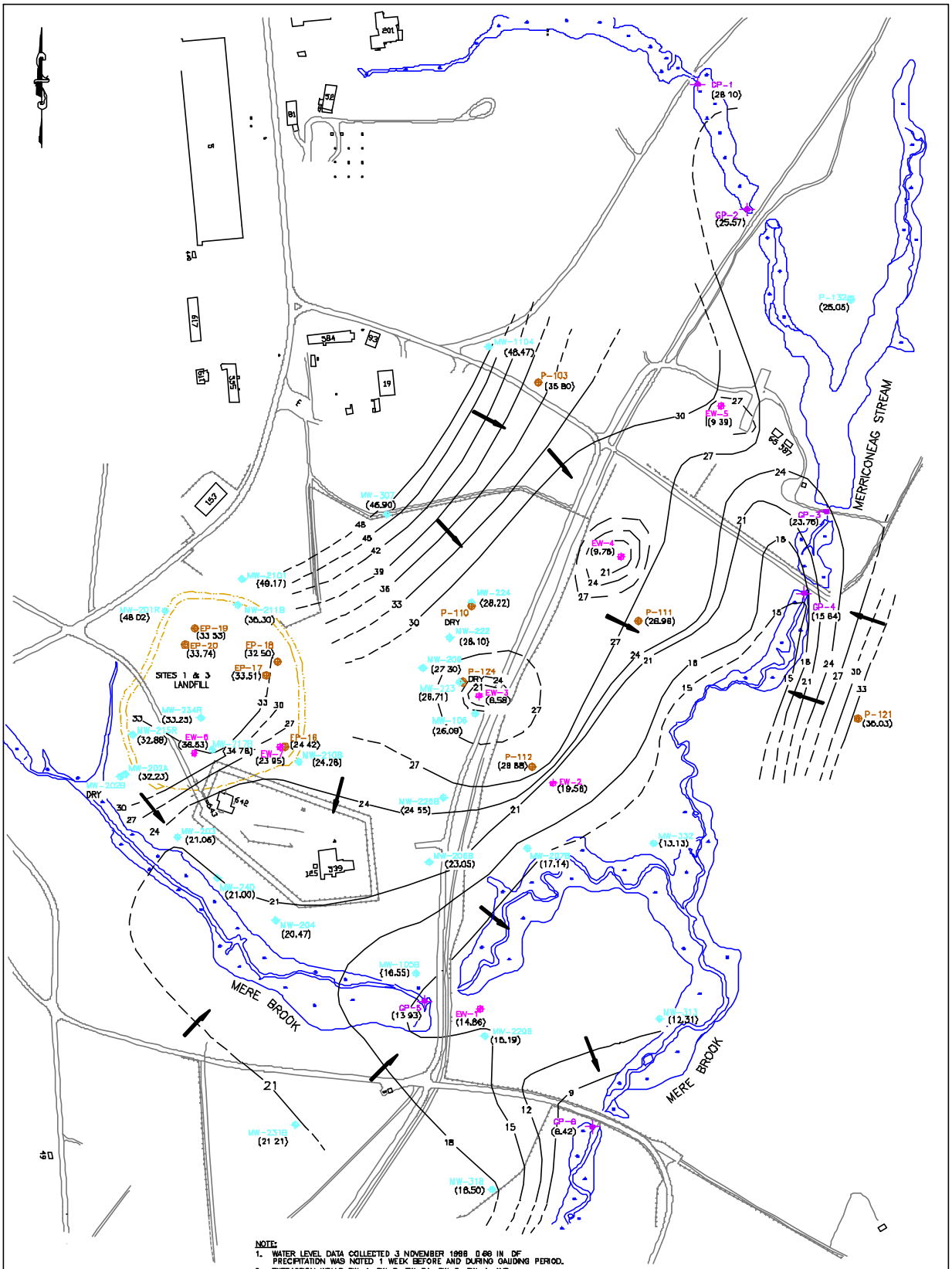
Hydraulic Head and Gradients

In the lower sand unit, where contaminant concentrations are highest, large areas of the Eastern Plume that are located between the individual extraction wells or downgradient of them are not hydraulically contained by the extraction well network. Capture zones measured in the lower sand unit extend only several tens-of-feet from EW-1, EW-2, EW-3, EW-4, and EW-5. In comparison, distances separating adjacent extraction wells range from approximately 350 to 1000 feet. Due to the use of wells with screen intervals that draw water from the entire unconsolidated aquifer system, capture zones have also been developed in the upper sand/silt transition unit, despite the nearly complete absence of COCs at concentrations above the cleanup levels in this unit.

Hydraulic head, represented by the water level measured in extraction and monitoring wells, is illustrated on potentiometric surface contour maps for the shallow and deep zones in Figures 3-10 and 3-11, respectively. The figures show that, although inward gradients have been established around each extraction well, the radius of influence extends only a short distance from the well. At EW-1, EW-2, EW-3, EW-4, and EW-5, which are screened through the entire unconsolidated aquifer system, the typical radius of influence in the lower sand (deep zone) is 25 feet or less, and the maximum radius of influence is about 70 feet at well EW-5. By comparison, the radius of influence at well EW-2A, which is screened in the lower sand unit only, is approximately 175 feet. The larger radius of influence measured at EW-2A demonstrates the advantage of screening extraction wells in the lower sand unit only. Although pumping at the same approximate rate as the fully screened wells, EW-2A is capturing a portion of the Eastern Plume that is nearly 50 times larger than that being captured by each of the other fully screened extraction wells.

Because the extraction wells, other than EW-2A, are fully screened, capture zones have also been developed in the upper portion of the sand/silt transition unit (shallow zone). The typical radius of influence in this unit is approximately 75 to 100 feet and the maximum radius of influence was about 200 feet at well EW-3, before the well failed and was abandoned. However, extracting groundwater from the upper sand/silt transition unit is not cost effective. Pumping and treating water that meets cleanup levels results in the use of system capacity and other resources managing water that need not be extracted.

Data regarding vertical gradients near the extraction wells is sparse, but not considered critical to evaluating plume containment, because downward migration of the Eastern Plume is precluded by the Presumscot clay layer.




NOTE:

1. WATER LEVEL DATA COLLECTED 3 NOVEMBER 1998 0.68 IN. OF PRECIPITATION WAS NOTED 1 WEEK BEFORE AND DURING GAUGING PERIOD.
2. EXTRACTION WELLS EW-1, EW-2, EW-2A, EW-3, EW-4, AND EW-5 WERE IN OPERATION DURING WELL GAUGING ACTIVITY.
3. CONTOUR INTERVAL = 3 FT.
4. THE CONTOURS FOR 18, 15, 12, AND 9 FT ENCOMPASS EW-3 ALTHOUGH THEY COULD NOT BE DISPLAYED DUE TO MAP SCALE.
5. THE CONTOURS FOR 18, 15, AND 12 FT ENCOMPASS EW-4 ALTHOUGH THEY COULD NOT BE DISPLAYED DUE TO MAP SCALE.
6. THE CONTOURS FOR 24, 21, 18, 15, AND 12 FT ENCOMPASS EW-5 ALTHOUGH THEY COULD NOT BE DISPLAYED DUE TO MAP SCALE.
7. SITE PLAN TAKEN FROM THE INTEGRAPH VERSION 5 BASE-WIDE PLAN PROVIDED BY NAS BRUNSWICK PUBLIC WORKS DEPARTMENT ON 13 OCTOBER 1995.
8. CONTOURS REPRESENT EVALUATION OF PROBABLE CONDITIONS BASED ON PRESENTLY AVAILABLE DATA. SOME VARIATION FROM THESE CONDITIONS MUST BE EXPECTED.

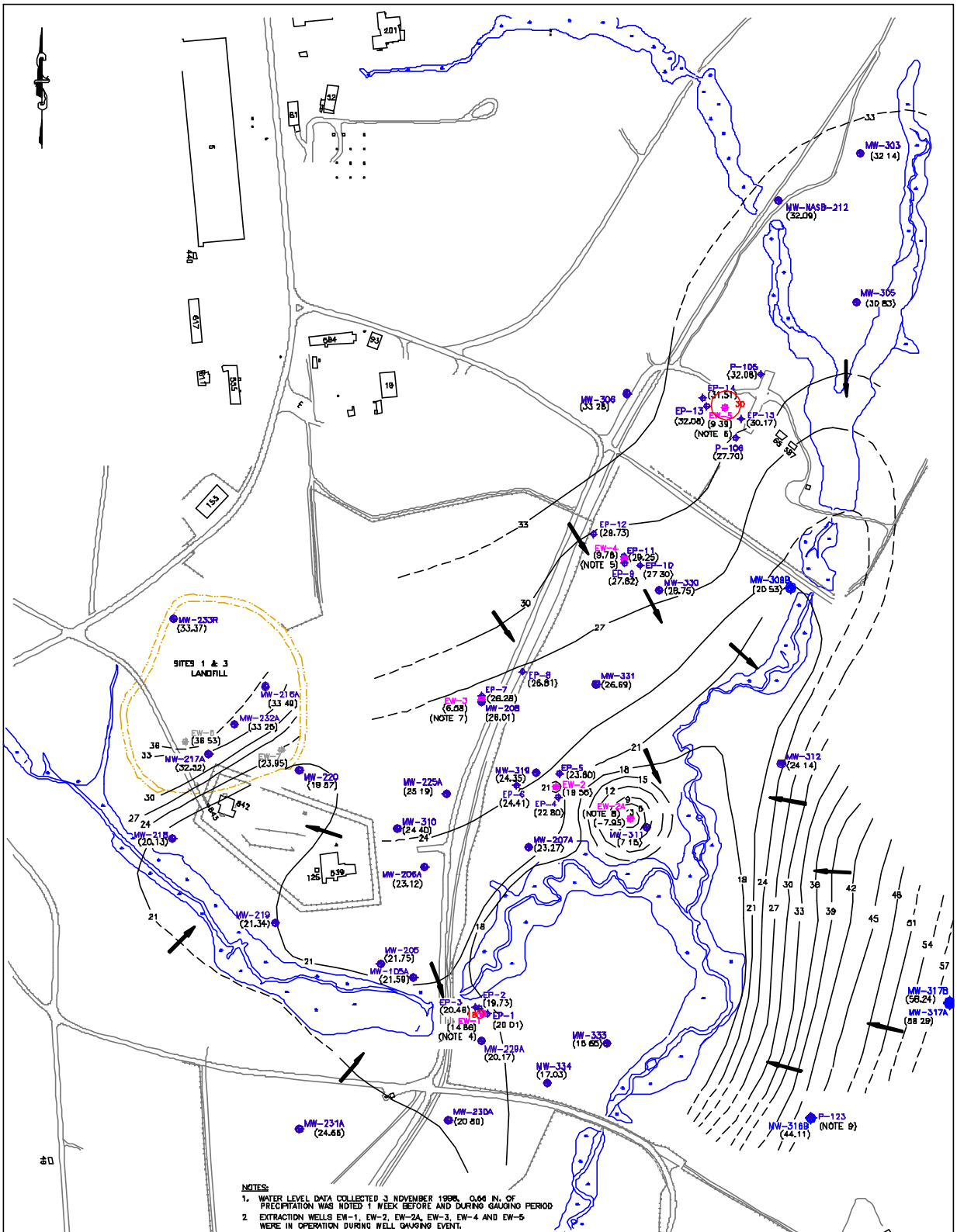
LEGEND

- MW-231B (21.21) — SHALLOW MONITORING WELL (POTENTIOMETRIC SURFACE ELEVATION, FT MSL)
- EW-1 (1.488) — EXTRACTION WELL (POTENTIOMETRIC SURFACE ELEVATION, FT MSL)
- EP-18 (34.43) — SHALLOW PIEZOMETER (POTENTIOMETRIC SURFACE ELEVATION, FT MSL)
- GP-6 (13.93) — SHALLOW PIEZOMETER (SURFACE WATER ELEVATION, FT MSL)
- FENCE
- APPROXIMATE LIMITS OF SLURRY WALL
- APPROXIMATE LIMITS OF SITES 1 & 3
- 27 — GROUND-WATER CONTOUR (FT MSL) (DASHED WHERE INFERRED)
- INFERRED GROUND-WATER FLOW DIRECTION
- BOXED AREAS ARE DETAILED ON FIGURE 3-11

0 100 200 400
GRAPHIC SCALE IN FEET

Source: EA Engineering, Science, and Technology, (10 January 1999)

| | | | |
|---|---|---|---|
| SCALE: AS SHOWN | DESIGNED BY / DATE | FIGURE 3-10. INTERPRETED SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR MAP 3 NOVEMBER, 1998 | |
| RADIAN INTERNATIONAL | DRAWN BY: TSH / DATE: 25AUG99 | | |
| | CHECKED BY / DATE | | |
| | APPROVED BY / DATE | CONTRACT NO. 803016.0202 | DRAWING NO. SHPOTNOV / REV. 0 |




NOTES:

1. WATER LEVEL DATA COLLECTED 3 NOVEMBER 1998. 0.66 IN. OF PRECIPITATION WAS NOTED 1 WEEK BEFORE AND DURING GAUGING PERIOD
2. EXTRACTION WELLS EW-1, EW-2, EW-2A, EW-3, EW-4 AND EW-5 WERE IN OPERATION DURING WELL GAUGING EVENT.
3. CONTOUR INTERVAL = 3 FT
4. THE 18 AND 15 FT CONTOURS ENCOMPASS EW-1 ALTHOUGH THEY COULD NOT BE DISPLAYED DUE TO MAP SCALE.
5. THE 27, 24, 21, 18, 15, AND 12 FT CONTOURS ENCOMPASS EW-4 ALTHOUGH THEY COULD NOT BE DISPLAYED DUE TO MAP SCALE.
6. THE 30, 27, 24, 21, 18, 15, AND 12 FT CONTOURS ENCOMPASS EW-5 ALTHOUGH THEY COULD NOT BE DISPLAYED DUE TO MAP SCALE.
7. THE 24, 21, 18, 15, 12, AND 9 FT CONTOURS ENCOMPASS EW-3 ALTHOUGH THEY COULD NOT BE DISPLAYED DUE TO MAP SCALE
8. THE 0, -3, AND -6 FT CONTOURS ENCOMPASS EW-2A ALTHOUGH THEY COULD NOT BE DISPLAYED DUE TO MAP SCALE
9. MONITORING WELL BLOCKED, UNABLE TO GAUGE
10. SITE PLAN TAKEN FROM THE INTERGRAPH VERSION 5 BASE-WIDE PLAN PROVIDED BY NAS BRUNSWICK PUBLIC WORKS DEPARTMENT ON 13 OCTOBER 1995.
11. CONTOURS REPRESENT EVALUATION OF PROBABLE CONDITIONS BASED ON PRESENTLY AVAILABLE DATA. SOME VARIATION FROM THESE CONDITIONS MUST BE EXPECTED

LEGEND

- MW-317B (56.24) BEDROCK MONITORING WELL (POTENTIOMETRIC SURFACE ELEVATION, FT MSL)
- MW-231A (24.66) DEEP MONITORING WELL (POTENTIOMETRIC SURFACE ELEVATION, FT MSL)
- EW-1 (14.88) EXTRACTION WELL (POTENTIOMETRIC SURFACE ELEVATION, FT MSL)
- EP-11 (29.25) DEEP PIEZOMETER (POTENTIOMETRIC SURFACE ELEVATION, FT MSL)
- FENCE
- APPROXIMATE LIMITS OF SLURRY WALL
- APPROXIMATE LIMITS OF SITES 1 & 3
- 27 GROUND-WATER CONTOUR (FT MSL) (DASHED WHERE INFERRED)
- INFERRED GROUND-WATER FLOW DIRECTION
- BOXED AREA IS DETAILED ON FIGURE 3-19

Source: EA Engineering, Science, and Technology, (11 March 1999)

| | | | |
|---|---|---|---|
| SCALE: AS SHOWN | DESIGNED BY | DATE | DRAWING TITLE: FIGURE 3-11 INTERPRETED DEEP GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR MAP 3 NOVEMBER 1998 |
| RADIAN INTERNATIONAL | DRAWN BY: TSH | DATE: 25AUG99 | |
| | CHECKED BY | DATE | |
| | APPROVED BY | DATE | CONTRACT NO.: 803016.0202 / DRAWING NO.: DPPOTNOV / REV.: 0 |

Pumping Rates

The extraction wells have not achieved the individual pumping rates specified in design documents (ABB Environmental Services, Inc., 1993) to prevent further migration of the Eastern Plume, nor is the combined pumping rate sufficient to ensure adequate flushing of the contaminant plume. In 1998, the average annual pumping rate of the individual extraction wells ranged from 8.0 gpm for EW-5 to 18.6 gpm for EW-4. The average pumping rates are less than the design rate of approximately 20 gpm estimated for each of the five original extraction wells by numerical modeling completed in 1993 (ABB Environmental Services, Inc., 1993). In 1998, the combined average pumping rate of the six extraction wells in the Eastern Plume including EW-2A, which was added in mid-year, was 85.8 gpm (EA Engineering, Science, and Technology, 1999d). Although the addition of EW-2A increased the combined pumping rate for the well network, the average pumping rate of well EW-2 dropped from about 25 gpm to 13.8 gpm after the addition. EA Engineering, Science, and Technology (1999d) attributed the reduced pumping rate to limits in the capacity of the piping that connects the two wells, not to limits in the aquifer yield.

The pore volume of the Eastern Plume's northern and southern lobes is roughly estimated at 45 million gallons (Mgal) each. Typically, extraction well systems should be designed and operated to extract between 0.3 and 2 pore volumes per year from the contaminant plume (Cohen, 1994). Based on 1998 pumping rates, less than 0.3 and 0.5 pore volumes were extracted from the northern and southern lobes of the Eastern Plume, respectively. These values are liberal estimates that overstate the actual number of pore volumes removed for several reasons. First, they assume 100 percent "uptime" for the system and, second, they assume that all of the water extracted was derived from the contaminated portion of the lower sand unit. Since neither of these conditions was met, removal from the two plume lobes may be as low as half the number of pore volumes estimated.

Extracted Water Quality

Trends in the chemical quality of the treatment system influent indicate that the extraction wells are removing contaminant mass, but are not doing so efficiently. In addition to extracting water from the contaminated lower sand unit, the fully screened wells are extracting uncontaminated water from the upper sand/silt transition unit. More efficient mass removal is evident in the performance of well EW-2A, which is screened only in the lower sand unit.

Prior to the addition of well EW-2A in June 1998, total VOC concentrations in the treatment system influent ranged from 274 μg/L to 537 μg/L with a median concentration of 411 μg/L. Since EW-2A was added, total VOC concentrations have ranged from 608 μg/L to 1483 μg/L with a 72 percent increase in the median concentration to 760 μg/L. Part of the increase in the median concentration is due to the installation of EW-2A within a "hotspot" in the plume. However, a second factor contributing to the increase is the design of EW-2A, which isolates the well screen in the

contaminated lower sand unit. Due to the well design, water extracted by EW-2A is not diluted by groundwater from the upper sand/silt transition unit.

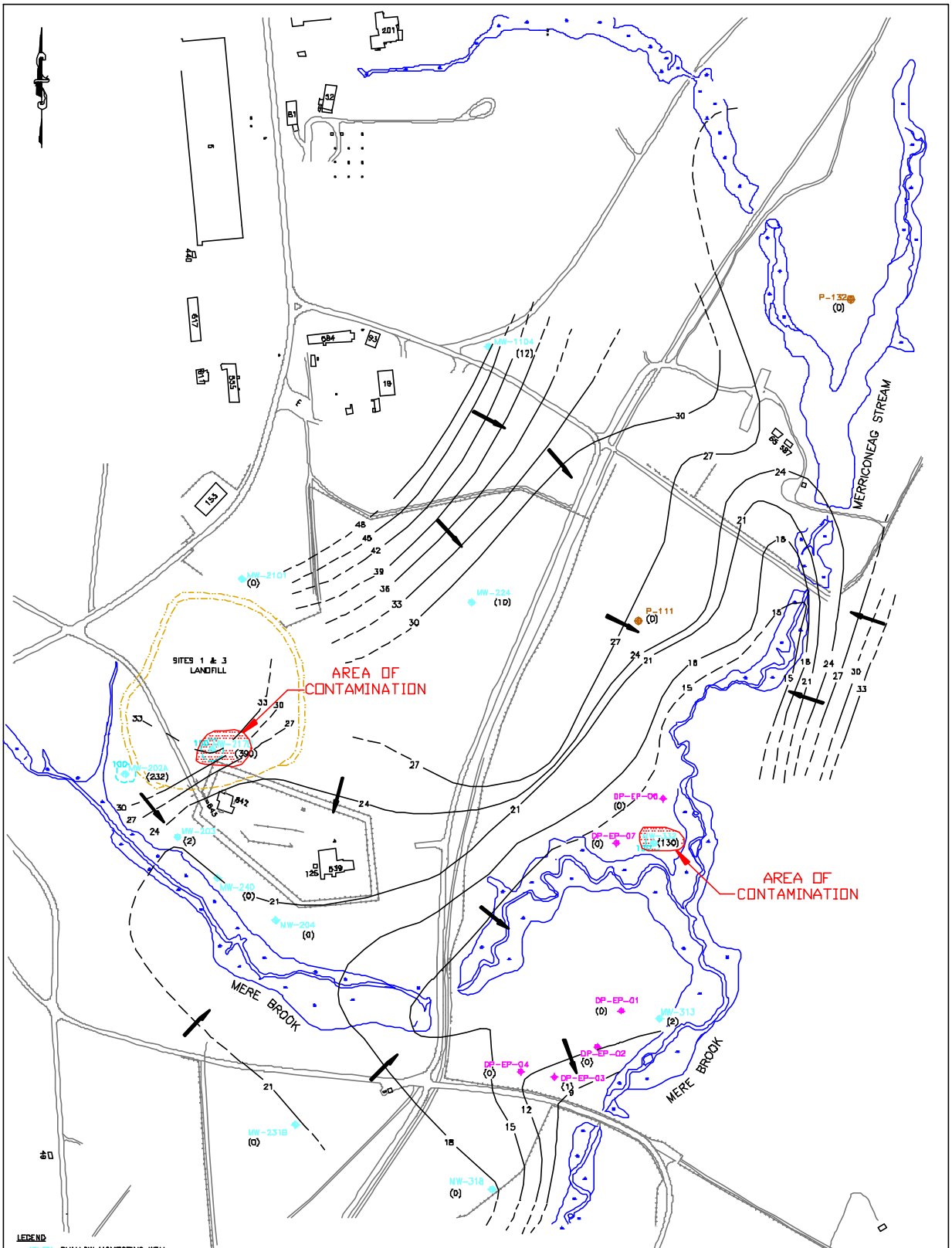
In contrast, an example of the dilution occurring in fully screened extraction wells is evident at EW-5, where monitoring points in the lower sand unit are located near the extraction well. Total VOC concentrations detected in groundwater samples from the deep monitoring points are an order-of-magnitude higher than total VOC concentration in water extracted from EW-5 (EA Engineering, Science, and Technology, 1999d). The development of capture zones in the upper sand/silt transition unit, discussed earlier, provides supporting evidence that dilution of the influent is occurring.

A similar trend is seen in the record of contaminant mass removed by the system. The mass of VOCs removed in 1998 totaled 240 pounds as compared to 112 pounds in 1997 (EA Engineering, Science, and Technology, 1999d). The highest mass removal rates in 1998 were experienced in June and July, shortly after EW-2A was put on-line. Over the remainder of the year, mass removal rates decreased, exhibiting an asymptotic “tailing” phenomenon that is typical in P&T systems. Nevertheless, at year’s end, the mass removal rate was approximately 60 percent above rates measured earlier in the year (EA Engineering, Science, and Technology, 1999d), justifying both the design and location of EW-2A.

Contaminant Concentration and Distribution

Contaminant distribution in the Eastern Plume has been consistent since LTM began in 1995. The distribution of VOCs within the Eastern Plume as determined by LTM suggests that no measurable migration of the plume has occurred. Trends in VOC concentrations in samples collected from monitoring and extraction wells over the same period have varied with location within the plume. VOC concentrations in perimeter monitoring wells generally exhibit a decreasing trend, whereas concentrations at interior monitoring wells appear stable. Total VOC concentration in samples from EW-1, EW-3, and EW-5 have decreased over time exhibiting a tailing phenomenon common to extraction. However, experience at other P&T systems indicates that concentrations may rebound if pumping is terminated.

Isoconcentration contour maps illustrated in Figures 3-12 and 3-13 estimate the areal extent of groundwater with VOCs exceeding cleanup levels in the shallow and deep zones of the Eastern Plume during November 1998. Figure 3-12 shows that MEGs or MCLs are exceeded in only three isolated areas within the upper sand/silt transition layer or shallow zone. Two of the areas are located near Sites 1 and 3 and the third area is near well MW-332. Geostatistical analysis, previously completed in early 1998, confirmed that the upper sand/silt transition is "relatively unaffected by volatile organic compounds" (EA Engineering, Science, and Technology, 1998b). Figure 3-13 shows that, within the lower sand unit or deep zone, two lobes of the Eastern Plume exhibit VOC concentrations that exceed the MCLs or MEGs. The separation of the Eastern Plume into two lobes is tentatively attributed to a bedrock formed ridge.




LEGEND

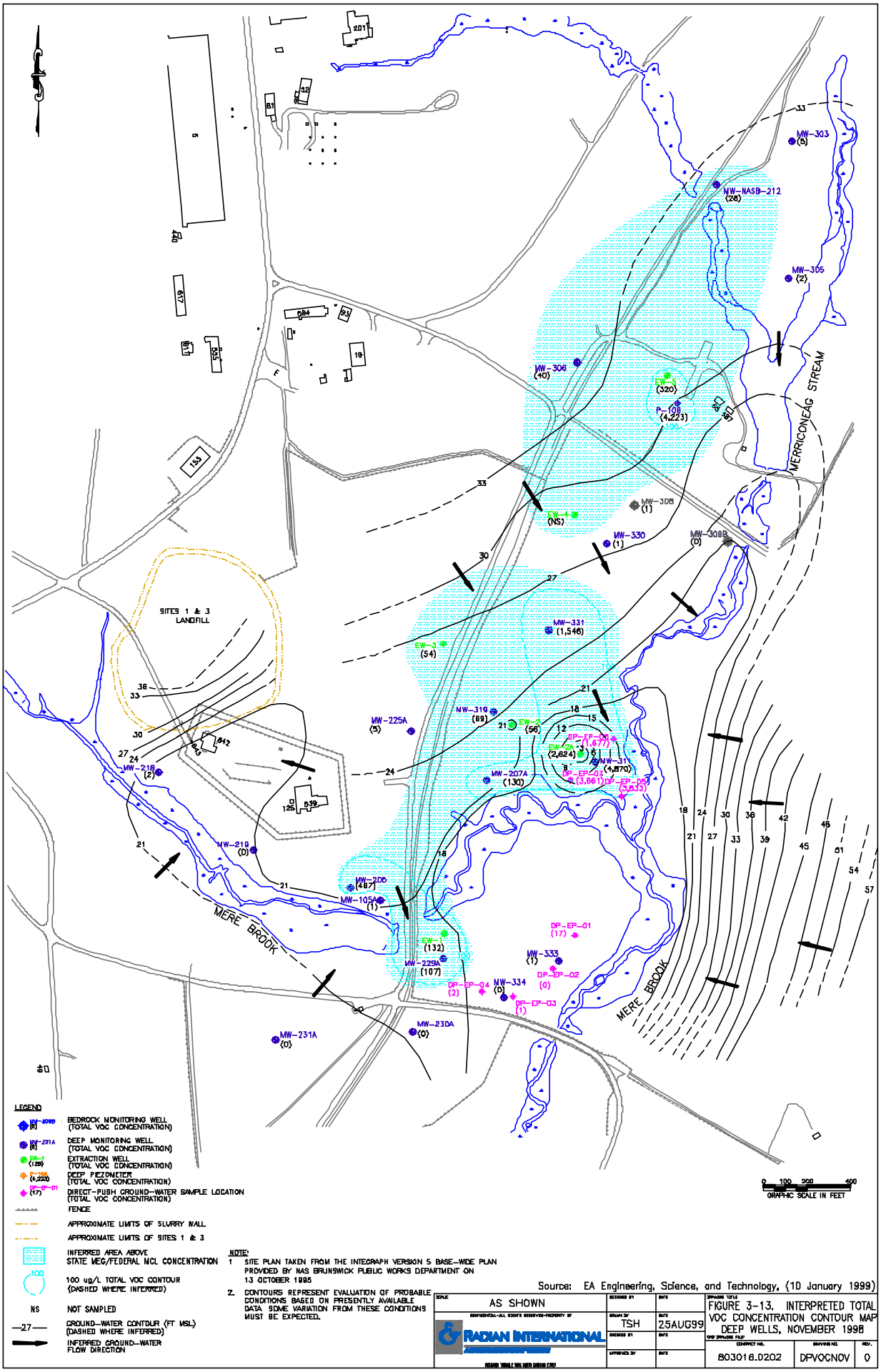
- SHALLOW MONITORING WELL (TOTAL VOC CONCENTRATION)
- DIRECT-PUSH GROUND-WATER SAMPLE LOCATION (TOTAL VOC CONCENTRATION)
- SHALLOW PIEZOMETER (TOTAL VOC CONCENTRATION)
- INFERRED AREA ABOVE STATE MEB/FEDERAL MCL CONCENTRATION
- 100 ug/L TOTAL VOC CONTOUR (DASHED WHERE INFERRED)
- FENCE
- APPROXIMATE LIMITS OF SLURRY WALL
- APPROXIMATE LIMITS OF SITES 1 & 3
- 27 GROUND-WATER CONTOUR (FT MSL) (DASHED WHERE INFERRED)
- INFERRED GROUND-WATER FLOW DIRECTION

NOTE:

1. SITE PLAN TAKEN FROM THE INTERGRAPH VERSION 5 BASE-WIDE PLAN PROVIDED BY NAS BRUNSWICK PUBLIC WORKS DEPARTMENT ON 13 OCTOBER 1996
2. CONTOURS REPRESENT EVALUATION OF PROBABLE CONDITIONS BASED ON PRESENTLY AVAILABLE DATA. SOME VARIATION FROM THESE CONDITIONS MUST BE EXPECTED.

Source: EA Engineering, Science, and Technology, (10 January 1999)

| | | | | |
|---|---|---|---|---|
| SCALE: AS SHOWN | DESIGNED BY | DATE | DRAWING TITLE: FIGURE 3-12. INTERPRETED TOTAL VOC CONCENTRATION CONTOUR MAP SHALLOW WELLS, NOVEMBER 1998 | |
| RADIAN INTERNATIONAL | DRAWN BY: TSH | DATE: 25AUG99 | | |
| | CHECKED BY | DATE | CONTRACT NO.: 803016.0202 | DRAWING NO.: SHVOCNOV / REV.: 0 |
| | APPROVED BY | DATE | | |




Source: EA Engineering, Science, and Technology, (10 January 1999)

| | | | |
|---|---|---|---|
| SCALE: AS SHOWN | DESIGNED BY | DATE | DRAWING TITLE: FIGURE 3-13. INTERPRETED TOTAL VOC CONCENTRATION CONTOUR MAP DEEP WELLS, NOVEMBER 1998 |
| RADIAN INTERNATIONAL | DRAWN BY: TSH | DATE: 25AUG99 | |
| | CHECKED BY | DATE | |
| | APPROVED BY | DATE | CONTRACT NO.: 803016.0202 · DRAWING NO.: DFVOCNOV · REV.: 0 |

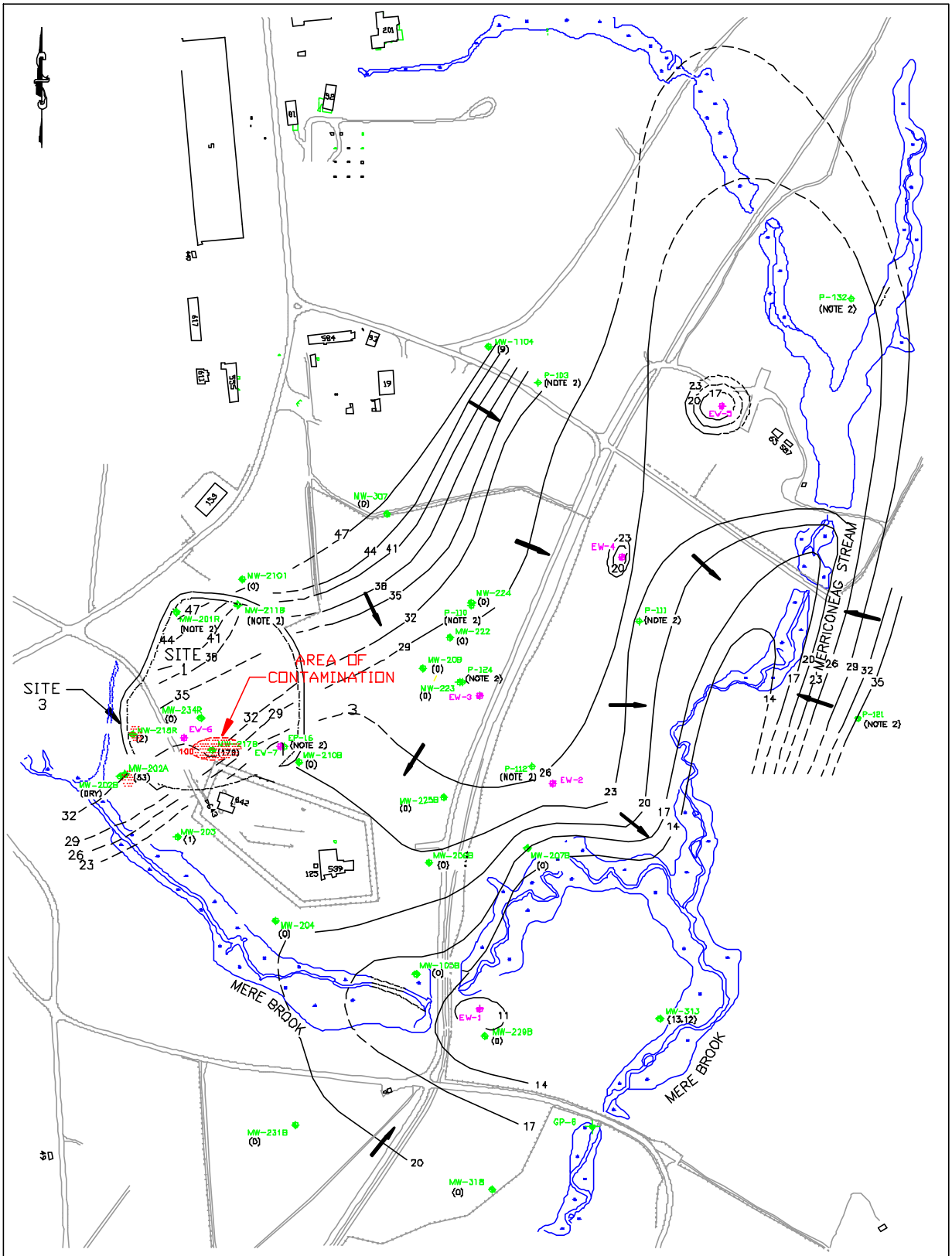
In comparison to these maps, Figures 3-14 and 3-15 show concentration contour maps for the shallow and deep zones in the Eastern Plume based on LTM monitoring results from March 1997. No changes are evident between the figures from 1997 and 1998 for the shallow zone, whereas the western, or upgradient extent of the southern lobe in the deep zone, between well MW-225A and Mere Brook, appears to have migrated eastward several tens-of-feet over the period of 20 months. During the same period however, the figures indicate no apparent change in the downgradient position of the Eastern Plume. The size of the southern lobe within the deep zone appears to have increased since 1997, but the apparent growth is due to the availability of new data from additional monitoring wells, rather than from a physical change. Geostatistical analysis also determined that the distribution of concentrations within the lower sand during March 1997 had not changed significantly from concentrations measured 22 months earlier in May 1995, and concluded that "the Eastern Plume is stationary" (EA Engineering, Science, and Technology, 1998b). Therefore, LTM results for the entire period of record suggest that except for a minor shift in the position of the southern lobe's upgradient boundary, the extent and position of the plume is unchanged since at least 1995.

Because large areas of the plume are not captured by the extraction wells, the apparently unchanging position of the plume is due to one or more other factors. One possible explanation, supported by the potentiometric surface data, is that contaminated groundwater is discharging into the Mere Brook drainage system. Figures 3-10 and 3-11 show that groundwater flows under natural gradients toward Mere Brook and Merriconeag Stream. The maps depict a groundwater drainage basin with concentrated discharge areas along Mere Brook and Merriconeag Stream. The gradients illustrated are characteristic of local groundwater flow systems that are common in areas with well-defined local relief. However, analysis of surface water samples collected from the drainage system detected COCs at only trace concentrations and the analysis of aqueous diffusion samplers placed in Mere Brook did not detect COCs. These results suggest that plume constituents may be degrading under natural remediation processes that are operating in wetland areas adjacent to the streams.

Another contributing factor may be the degradation of COCs through the process of reductive dechlorination. LTM results indicate the presence of PCE, TCE, and 1,2-DCE within the Eastern Plume. The results also indicate that a higher proportion of PCE occurs at interior monitoring wells with an increasing proportion of 1,2-DCE toward the perimeter of the plume. The presence and distribution of daughter products within the Eastern Plume indicates that reductive dechlorination is taking place. In 1998, the results of statistically analyzing the relative distribution of parent and daughter products in the Eastern Plume also suggested that "chemical transformation and/or bioremediation is occurring" (EA Engineering, Science, and Technology, 1998b).

*3.5.2.2 Monitoring Well Network*

The LTM program including the monitoring well network at the Eastern Plume is performing as designed. Gauging and sampling locations are adequate to interpret




LEGEND

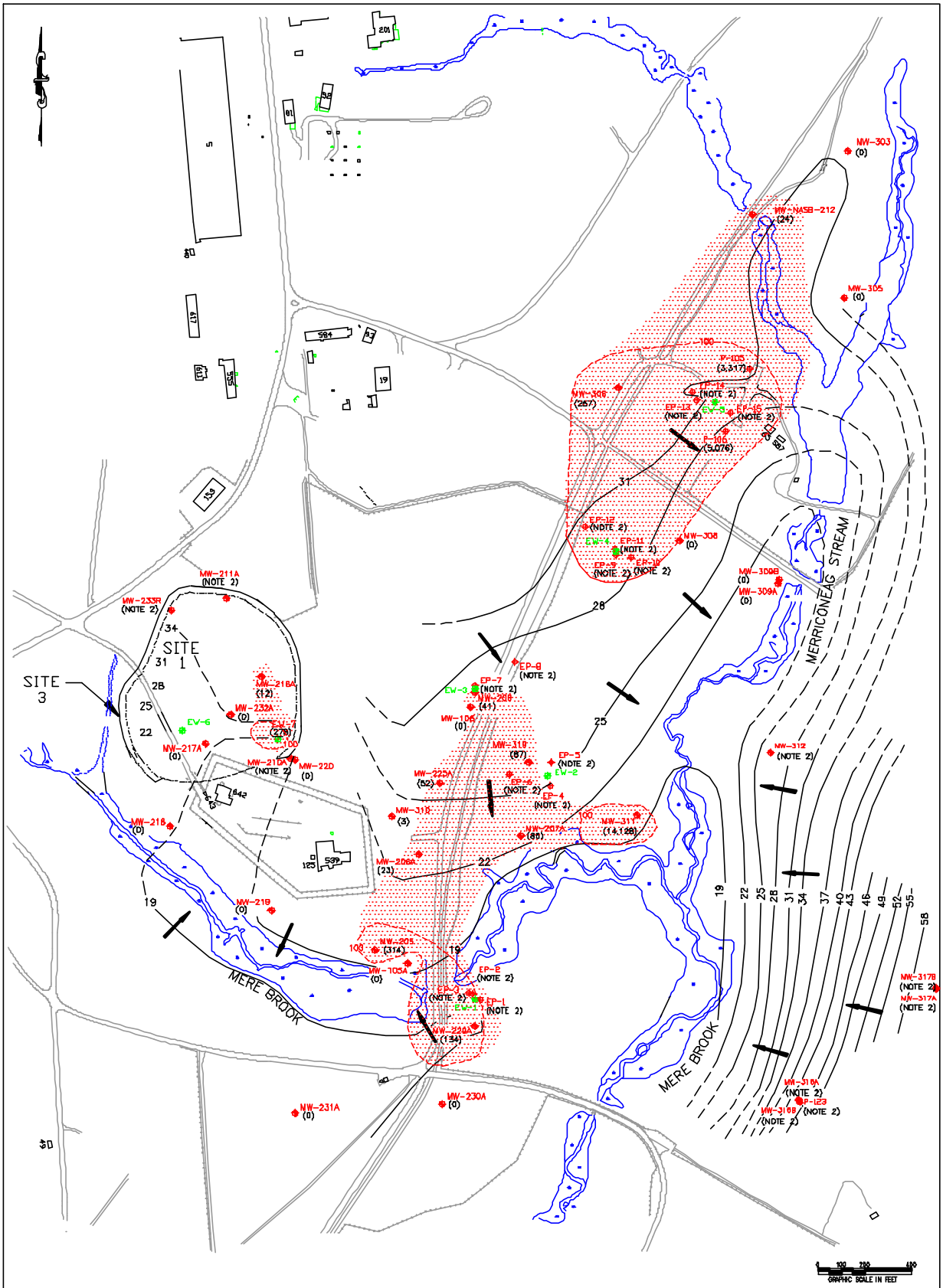
- MW-204 (0) — MONITORING WELL (TOTAL VOC CONCENTRATION, ug/L)
- (NA) — NOT AVAILABLE, RISER BLOCKED
- EW-1 — EXTRACTION WELL
- PZ-1L (NS) — PIEZOMETER (TOTAL VOC CONCENTRATION, ug/L)
- —28— — GROUND-WATER CONTOUR (FT MSL) (DASHED WHERE INFERRED)
- INFERRED GROUND-WATER FLOW DIRECTION
- ------ APPROXIMATE LIMITS OF SLURRY WALL
- -·-·- APPROXIMATE LIMITS OF SITES 1 & 3
- INFERRED AREA ABOVE STATE MEG/FEDERAL MCL CONCENTRATION
- 100 — 100 ug/L TOTAL VOC CONTOUR (DASHED WHERE INFERRED)

NOTE

1. GROUND-WATER SAMPLES COLLECTED FROM 9 APRIL 1997
2. NOT SAMPLED AS PART OF LTMP, ONLY WATER LEVEL DATA COLLECTED.

Source. EA Engineering, Science, and Technology, (01 April 1998)

| | | | |
|---|---|---|---|
| SCALE: AS SHOWN | DESIGNED BY | DATE | DRAWING TITLE: FIGURE 3-14. INTERPRETED TOTAL VOC CONCENTRATION CONTOUR MAP SHALLOW WELLS, MARCH 1997 |
| CONFIDENTIAL—ALL RIGHTS RESERVED—PROPERTY OF RADIAN INTERNATIONAL | DRAWN BY: TSH | DATE: 30AUG99 | |
| | CHECKED BY | DATE | CONTRACT NO.: 803016 0202 |
| | APPROVED BY | DATE | DRAWING NO.: SHALLEV8 REV.: 0 |




LEGEND

- MW-22A (9) MONITORING WELL (TOTAL VOC CONCENTRATION; ug/L)
- EW-L EXTRACTION WELL
- EP-LL PIEZOMETER
- NS NOT SAMPLED
- INFERRED GROUND-WATER FLOW DIRECTION
- APPROXIMATE LIMITS OF EASTERN PLUME
- APPROXIMATE LIMITS OF SLURRY WALL
- APPROXIMATE LIMITS OF SITES 1 & 3
- —26— GROUND-WATER CONTOUR (FT MSL) (DASHED WHERE INFERRED)
- INFERRED AREA ABOVE STATE MCL/FEDERAL MCL CONCENTRATION
- 100 100 ug/L TOTAL VOC CONTOUR (DASHED WHERE INFERRED)

NOTE

1. GROUND-WATER SAMPLES COLLECTED FROM 8-21 NOVEMBER 1996.
2. NOT SAMPLED AS PART OF LTMP, ONLY WATER LEVEL DATA COLLECTED

Source: EA Engineering, Science, and Technology, (19 May 1997)

| | | | |
|---|---|---|---|
| SCALE: AS SHOWN | DESIGNED BY / DATE | DRAWING TITLE: FIGURE 3-15. INTERPRETED TOTAL VOC CONCENTRATION CONTOUR MAP DEEP WELLS, MARCH 1997 | |
| RADIAN INTERNATIONAL | DRAWN BY: TSH / DATE: 30AUG99 | | |
| | CHECKED BY / DATE | CONTRACT NO.: 803016 0202 | DRAWING NO.: DEEPEVB / REV.: 0 |
| | APPROVED BY / DATE | | |

groundwater flow and to assess contaminant distribution. Interior plume wells monitor the impacts of the extraction system and perimeter and sentinel wells assess potential contaminant migration. Monitoring results are evaluated regularly, possible trends are identified, and the LTM program is re-assessed and modified, as necessary. However, two elements of the monitoring network and LTM program can be optimized.

First, piezometers currently in the monitoring well network are not adequate to measure the development of capture zones in the lower sand unit. However, this failure is due as much to the small radius of influence established around each extraction well as it is due to the number and location of the piezometers. Nevertheless, except at EW-2A, additional piezometers should not be installed until properly screened extraction wells are installed and operating.

Second, the practice of illustrating total VOC concentrations on the groundwater isoconcentration contour maps, particularly the 100 µg/L contour concentration curve, can be misleading. Plotting total VOC concentration provides a general perspective of the plume, but does not provide a comparison with cleanup levels, which are specific to individual COCs.

**3.5.3 Aboveground Treatment Train Performance—**Since operation began in 1995, the aboveground treatment train for the Eastern Plume has been performing at a level that meets requirements of the design basis. From 1996 through April 1999, the plant has operated at an average flow rate of 76 gpm, approximately 70 percent of its design flow of 110 gpm for the Eastern Plume. Most of the equipment at the plant is functioning as designed.

From 1996 through 1999, the treatment plant operated at annual operating percentages ranging from 94 to 97 percent. These operating uptimes are considered above average. One primary cause of system downtime that has not been remedied is plant shut down due to fluctuations in turbidity. Currently the plant is set to shut down when the turbidity exceeds 5 NTU. The operator then manually switches the flow through the sand filters prior to treatment by UV-Ox. When turbidity is greater than 10 NTU, the plant automatically shuts down and the operator manually switches the flow through the clarifier prior to treatment by UV-Ox.

Exceedance of the Brunswick Sewer District Discharge requirements for VOCs have occurred twice since 1996. In December 1998, concentrations of 1,1-DCE slightly exceeded the discharge limit of 7 ppb. This was attributed to high turbidity, causing inefficiencies in the UV-Ox system. In June 1998, due to the addition of extraction well EW-2A, a discharge exceedance TCA occurred. Corrective action was taken to optimize the hydrogen peroxide rate and UV-Ox process to ensure additional exceedances would not occur.

Since 1996, only one exceedance of pH over the maximum effluent requirement (pH of 8) occurred. This pH exceedance occurred in June 1996.

The groundwater treatment plant (GWTP) for the Eastern Plume has consistently exceeded the discharge requirements of 100 ug/l for manganese. Manganese concentrations are recorded daily. A few days of each of the following months were in exceedance of the discharge requirements up to concentrations of 300 ug/L: Aug 96, Dec 96, June 97, Aug 97, Sept 97, Oct 97, Nov 97, Dec 97, Jan 98, May 98, Aug 98, Dec 98, Jan 99, Feb 99, and June 99. In addition, most days in the months of March 99 and May 99 exceeded the effluent discharge requirements for manganese. Note that the precipitation process previously described is not currently in use at the Eastern Plume treatment plant.

A review of the existing sampling and analysis plan for the Eastern Plume indicates that the individual effluent from each well is not analyzed separately. In addition, the effluent samples from the treatment plant are collected on a bi-weekly basis as prescribed by the National Pollutant Discharge Elimination System (NPDES) permit. This frequency is considered high as many GWTP NPDES permits only require monthly effluent sampling. Also, because the landfill dewatering system is not active, the Eastern Plume influent sample and the UV-Ox influent sample are considered redundant, as there is no treatment occurring to the process stream between the sample points.

The annual O&M costs for the Eastern Plume Groundwater P&T system are provided in Table 3-12. The most costly O&M item for the Eastern Plume is the sanitary sewer discharge fee of $0.03 per cubic foot for treated water discharge, or approximately $158,000 annually. The sewer fee is considered extremely high in comparison to other P&T systems around the country. Currently, NAS Brunswick is considering other discharge options mentioned in Section 3.3.4 and/or renegotiating with the Brunswick Sewer District. The second most costly O&M item is the labor (operator and support) at a total of $180,000 annually. This equates to more than two full time personnel to run the Eastern Plume Treatment Plant. These labor hours are considered excessive in light of the activities performed. NAS Brunswick is currently renegotiating the O&M contract to include one part time operator with reduced support.

**Table 3-12. Annual Operation and Maintenance Costs for the Eastern Plume Groundwater Treatment System**

| Description | Cost |
|---|---|
| Amortized Capital Cost (10 years) | $632,826.75 |
| Sewage Discharge Fees | $158,000.00 |
| Replacement of UV Lamps | $18,000.00 |
| UV Replacement Parts | $4,200.00 |
| On-site Service | $7,200.00 |
| Chemical Usage (50% Hydrogen Peroxide) | $8,500.00 |
| Electrical Usage | $47,304.00 |
| Laboratory Analysis | $29,700.00 |
| Reporting | $12,000.00 |
| Labor (Grade 1 Phy/Chem Treatment Plant Operator) | $110,000.00 |
| Support Labor | $70,000.00 |
| ODCs | $46,300.00 |
| **Total Annual Cost** | **$1,144,030.75** |
| **Average Monthly Cost** | **$95,335.90** |

# 4.0 CONCLUSIONS AND RECOMMENDATIONS FOR THE EASTERN PLUME SYSTEM

Based on the information reviewed and presented in Section 3.0, five primary recommendations are presented below for the Eastern Plume P&T system. The resulting data and information will form the basis for any current and future performance evaluations discussed in recommendation V. In addition, current and future operational recommendations to optimize the Eastern Plume P&T system are summarized in Table 4-2 and discussed in Sections 4.2 and 4.3.

## 4.1 Primary Recommendations for Eastern Plume

I. *Begin a formal evaluation for Monitored Natural Attenuation (MNA) for the Eastern Plume.* In particular, determine whether natural wetland biodegradation and/or natural attenuation processes are occurring at acceptable rates in the aquifer zone and at Mere Brook, as discussed in section 4.1.1. Groundwater monitoring results indicate that the downgradient extent of the plume has not changed since at least 1995. Verify, through continued monitoring, that the Eastern Plume is not migrating and identify the mechanisms (e.g., discharge to surface waters, natural attenuation) by which this is occurring. It may be necessary to suspend operation of the remediation system in order to monitor natural attenuation processes.

II. *Pursue negotiations with the regulatory agencies to establish risk-based cleanup levels for the entire Eastern Plume, and Alternate Concentration Limits (ACLs) for any groundwater discharging to Mere Brook.* Groundwater at the Eastern Plume is not a drinking water source, thus cleanup to MCLs or State of Maine standards is not necessary for the remedy to remain protective of human health. In addition, per SARA Section 121(d), ACLs may be established if groundwater is shown to discharge to Mere Brook without measurably degrading the water quality of the brook as discussed in Section 4.1.2.

III. *Continue and enhance contaminant mass removal in the Eastern Plume.* As recommended in Section 4.2.1, mass removal should be enhanced by replacing existing extraction wells EW-4 and EW-5 with wells that are screened solely in the lower sand unit “hotspots”. In order to ensure appropriate piping size and treatment system capacity, determine groundwater flowrates and mass removal from these new extraction wells prior to making any modifications to the aboveground treatment system.

IV. *Modify the aboveground treatment system to allow effluent discharge to surface water or to an infiltration gallery after confirming the most effective and efficient option based on a detailed technical review and life cycle cost analysis.*

V. *Utilize the data and trend analysis resulting from recommendations I through IV to prepare for any current and future performance evaluations.* In particular, begin discussions with the regulatory agencies to establish definitive criteria for discontinuing active pump and treat (P&T) as the final remedy. As an example, "discontinue pump and treat operations for the Eastern Plume if MNA is demonstrated to occur at acceptable rates, and when mass removal from extraction wells EW-4, EW-5, and EW-2A reach asymptotic levels." Also, reach agreement with the agencies on the criteria and process for implementing required changes to the ROD, i.e., explanation of significant difference (ESD) or a ROD amendment.

**4.1.1 Implementation of an MNA Program—**Evidence should be gathered to evaluate the downgradient wetlands of the Eastern Plume as a viable, passive, biodegradation treatment option. In addition, the groundwater at the Eastern Plume should be screened to determine if natural attenuation processes are occurring. The parent products that have been released to the aquifer appear to be TCA, PCE, and potentially TCE. The presence of 1,2-DCE, a daughter product of TCE, indicates that reductive dechlorination may be occurring in the aquifer. Furthermore, in addition to being a parent compound, TCE can also occur as a daughter product from reductive dechlorination processes. As a first step, the following parameters should be collected to screen for natural attenuation:

- Aromatic and chlorinated hydrocarbons (parent and daughter products)- full suite SW8260, including the existing NAS Brunswick SW8260 analyte list, plus the addition of the following daughter products: cis-1,2-DCE, trans-1,2-DCE, vinyl chloride (VC), and chloroethane in all appropriate wells;
- Methane, ethane, and ethene;
- Dissolved oxygen (DO);
- Total organic carbon (TOC);
- Reduction oxidation (Redox) potential; and
- Water quality parameters.

To perform a complete natural attenuation study, Table 4-1 summarizes the natural attenuation sampling parameters to be measured and the data use for each parameter as requested by NAS Brunswick. It is recommended that all samples be collected using low flow techniques and a flow-through sample collection cell. For more information on natural attenuation, refer to the "*Technical Guidelines for Evaluating Monitored Natural Attenuation at Naval and Marine Corps Facilities*" (Department of the Navy, 1998).

**4.1.2 Establishment of Alternate Concentration Limits (ACLs)—**It is recommended that NAS Brunswick pursue discussions with the regulatory agencies to establish less stringent groundwater cleanup criteria known as ACLs. Per SARA Section 121(d), ACLs can be established when it can be shown that groundwater discharging to a surface water

## Table 4-1. Natural Attenuation Sampling Parameters

| Analyses | Method/Reference | Data Use |
|---|---|---|
| **WATER ANALYSES** | | |
| Aromatic and Chlorinated hydrocarbons - Full Suite including existing SW8260 analyte list, plus the addition of cis-1,2-DCE, trans-1,2-DCE, VC, and chloroethane | SW8260 (full suite) | Used to identify the primary target analytes and their daughter products. The presence of daughter products is a good indicator of dechlorination. |
| Methane, Ethene and Ethane | SW3810M or Microseeps | The presence of ethane and ethene suggests biological transformation of chlorinated solvents. The presence of methane may suggest degradation through methanogenesis. |
| Dissolved Oxygen (option to field analysis) | Microseeps | Concentrations less than 1 mg/l indicate an anaerobic condition. |
| Nitrate, Sulfate, Chloride | E300.0 | Nitrate and sulfate are the substrate for anaerobic microbial respiration. Chloride is the final product of chlorinated solvent reduction. |
| Nitrite | E354.1 | Reduced form of nitrate, indicates reductive chlorination. |
| Alkalinity | E310.1 | General water quality parameter used to measure the buffering capacity of groundwater. May also be used to indicate dissolved inorganic carbon, which is a byproduct of organic carbon oxidation. |
| Ferrous Iron – 10% laboratory QC (confirmation for field analysis) | E310 | Used to confirm ferrous iron field measurements. Reduced form of ferric iron, indicates reductive chlorination. |
| Total Iron and Manganese | SW6010 | Used to determine Ferric iron [Iron (III)] and Mn (IV) concentrations as they are the substrate for anaerobic microbial respiration. |
| TOC | SW9060 | TOC used to determine if cometabolism is possible. |
| **FIELD ANALYSES** | | |
| Ferrous Iron [Iron (II)] | Colorimetric HACH 8146 | Reduced form of Iron (III), may indicate reductive chlorination. |
| Manganese [Mn (II)] | Colorimetric HACH | Reduced form of Mn (IV), may indicate reductive chlorination. |
| $H_2S$ | Colorimetric HACH 2238-01 | The presence of H2S suggests degradation via sulfate reduction. |
| Dissolved Oxygen (DO) | Direct-reading meter | Concentrations less than 1 mg/l indicate an anaerobic condition. Anaerobic conditions are required for reductive dechlorination. |
| Redox Potential | Direct-reading meter (A258OB) | Indicates the biological degradation of contaminants and the relative oxidizing or reducing nature of the aquifer. |
| pH | E150.1 Direct Reading Meter | Standard water quality parameter measured during well sampling to indicate sample is representative of the aquifer. Also anaerobic processes are sensitive to pH. |
| Temperature | E170.1 Direct Reading Meter | Standard water quality parameter measured during well sampling to indicate sample is representative of the aquifer. |
| Conductivity | E120.1 Direct Reading Meter | Standard water quality parameter measured during well sampling to indicate sample is representative of the aquifer. |

mg/L = milligrams per liter
pH = Hydrogen Ion Concentration
QC = Quality Control
TOC = Total Organic Carbon
$H_2S$ = Hydrogen Sulfide
Redox = Reduction Oxidation
DCE = Dichloroethene
VC = Vinyl Chloride

body does not measurably degrade the surface water body; and, there are no known points of human exposure to the contaminated groundwater prior to it reaching the surface water body.

This appears to be the case for the Eastern Plume. In this instance, the allowable ACL for the plume is the maximum groundwater contaminant concentration which can discharge to Mere Brook without measurably degrading its water quality. It is expected that this allowable concentration would be significantly higher than MCLs and/or current State of Maine standards.

Typically, supporting data requirements to establish ACLs include simple mixing zone model results and/or sampling results from the interface of the groundwater and surface water bodies. The samples previously collected using vapor passive diffusion samplers in the bed of Mere Brook can serve as direct supporting evidence for this evaluation.

## 4.2 Eastern Plume Extraction and Monitoring Network Recommendations

This section provides specific recommendations for improving the performance of the extraction well network at the Eastern Plume; and for enhancing monitoring capabilities under the LTM program. These recommendations are summarized in Table 4-2.

**4.2.1 Extraction Well Network—**The steps outlined below should be implemented to enhance contaminant mass removal from the lower sand unit and to improve overall system performance and efficiency:

- The use of all current extraction wells, except EW-1 and EW-2A, should be discontinued and the wells should be properly abandoned. The existing wells cannot be modified to isolate their production intervals in the contaminated lower sand unit.
- The abandoned wells should be selectively replaced by properly designed, constructed, and developed extraction wells that are screened solely in the lower sand unit. In general, the new extraction wells should be located in the areas of greatest known contamination to reduce the flow path and travel time of contaminants to the extraction wells. Specifically, new wells should be installed near current wells EW-4 and EW-5. No replacements are recommended for EW-2 and EW-3 because total VOC concentrations at these locations are insufficient to justify a focused mass removal approach.
- Well EW-1 should continue to be operated. Replacement of EW-1 is not recommended because analytical results from recent LTM events indicate similar VOC concentrations in samples collected from EW-1 and deep monitoring well MW-229A. Therefore, a new extraction well screened only in the lower sand unit may not enhance contaminant mass removal at this location. Additional LTM data from future sampling events, particularly concentrations of individual COCs, should be evaluated to confirm this conclusion.

**Table 4-2. Eastern Plume Evaluation and Optimization Recommendations Summary**

| System Component | Consideration | Cost Impacts | Effectiveness Impacts |
|---|---|---|---|
| Eastern Plume Extraction Well Network | Discontinue use of all EW's except EW-1 and EW-2A. | • Unknown | • Eliminates ineffective wells that cannot be modified to improve performance. |
| Eastern Plume Extraction Well Network | Position pumps in EW-2A and all new wells so that intakes are not in well screen. | • Unknown | • Decrease in pump corrosion, incrustation, and sand pumping. |
| Eastern Plume Extraction Well Network | Size and configure EW distribution piping to handle pumping rates of individual wells. | • Unknown | • Increased mass removal. |
| Eastern Plume Extraction Well Network | Install piezometers in the lower sand unit at each new EW. | • $20,000 | • Allows monitoring of EW capture zones. |
| Eastern Plume Extraction Well Network | Install extraction wells screened solely in the contaminated lower sand unit. Install at "hotspots" in the Eastern Plume, specifically near current EW-4 and EW-5. | • $15,000 to $20,000 per well, exclusive of distribution piping. | • Increase contaminant mass removal.<br>• Enlarge capture zones in the lower sand unit.<br>• Optimize well locations.<br>• Eliminate the extraction and subsequent treatment of uncontaminated water from the upper sand/silt transition zone. |
| Eastern Plume Aboveground Treatment Plant | If the UV-Ox system operates for at least two more years, install motorized valves to control flow to proper turbidity treatment systems. | • Increase in one time cost of approximately $4,500. | • Reduce system down time due to changes in turbidity. |
| Eastern Plume Aboveground Treatment Plant | Utilize existing precipitation system (not in use) to remove manganese from process stream. | • Increase potassium permanganate cost of $700 to $1000/year. | • Reduce effluent concentrations of manganese to meet effluent requirements. |

**Table 4-2. Eastern Plume Evaluation and Optimization Recommendations Summary (Continued)**

| System Component | Consideration | Cost Impacts | Effectiveness Impacts |
|---|---|---|---|
| Eastern Plume Aboveground Treatment Plant | Sample influent from individual wells for VOCs once a quarter. | • Increase analytical costs by $2,640/year. | • Determine the effectiveness of each individual well for removal of contaminants from the subsurface. |
| Eastern Plume Aboveground Treatment Plant | Negotiate a new NPDES permit to reduce effluent sampling from bi-weekly to monthly sampling. | • Decrease analytical costs by $1,800/year. | • None |
| Eastern Plume Aboveground Treatment Plant | Discontinue VOC analysis of UV-Ox influent sample when landfill dewatering system is not in operation, due to redundancy. | • Decrease analytical costs by $1,300/year when the landfill de-watering system is idle. | • None |
| Eastern Plume Aboveground Treatment Plant | Renegotiate with the Brunswick sewer district to lower the $158,000 annual sewer discharge fee. | • Unknown (up to $158,000/year) | • None |
| Eastern Plume Aboveground Treatment Plant | Reduce current 2 person operating team to a part-time operator. | • Decrease in labor cost of $90,00 to $110,000/year. | • None |
| Eastern Plume Aboveground Treatment Plant | Combine the landfill dewatering treatment system with the Eastern Plume groundwater treatment system. | • Increase cost for adding potassium permanganate of $3,000 to $6,000/year, when landfill dewatering is active.<br>• Costs savings from salvage or resale of idle equipment. | • Increase in metals treatment required. |
| Eastern Plume Aboveground Treatment Plant | Consider connecting the well head flow meters to the SCADA system. | • One time implementation cost (unknown). | • Provides accurate extraction well flow rates. |

- Pumps in existing well EW-2A and in all new extraction wells should be positioned so that the intakes are located above the well screen in order to minimize water entrance velocity contributing to corrosion, incrustation, and sand pumping.
- The capacity of distribution piping from the extraction wells should be sized and configured to adequately handle the pumping rate of the individual wells.

Replacing the original extraction wells with wells screened only in the lower sand unit will cost up to eighty thousand dollars. However, the performance of EW-2A is evidence of the improvement in capture and mass removal that can be expected when wells are installed in hot spots within the lower sand unit. While pumping at the same approximate rate as each original extraction well, EW-2A has established a radius of influence that is seven times greater than that measured at the original wells. Also, well EW-2A is currently contributing 85 percent of the contaminant mass now being extracted by the P&T system. By isolating the extraction well network to the contaminated lower sand unit, performance of the P&T system will improve significantly and shorten the time to clean up or initiate of passive remedies.

**4.2.2 Monitoring Well Network—**The steps outlined below should be implemented to improve monitoring of the P&T system performance:

- Piezometers should be installed in the lower sand unit around the new extraction wells to monitor the capture zones established by them.
- At least one piezometer installed at each extraction well should monitor the upper sand/silt transition zone to assess the degree of leakage due to extraction well pumping.

## 4.3 Eastern Plume Aboveground Treatment Train Recommendations

The current O&M contractor recently recommended modifying the Eastern Plume treatment system by replacing the UV-Ox system with an air stripper followed by GAC polishing. The O&M contractor also suggested that discharge to surface water and/or to groundwater via infiltration galleries appears to be a more cost-effective approach than the current discharge method to the sanitary sewer. NAS Brunswick has indicated that these modifications will be implemented.

Additional recommendations on the proposed and existing treatment systems are organized in the following subsections.

**4.3.1 Recommendations for Groundwater Treatment at the Eastern Plume—**The following are recommendations for the Eastern Plume aboveground treatment train as it exists now or following any future modifications. These recommendations may be

implemented regardless of any changes to the treatment system. These recommendations are also summarized in Table 4-2.

- Sample the influent for VOCs from individual wells, once a quarter concurrent with the groundwater monitoring program, to determine the removal effectiveness of each well. This recommendation represents an annual cost increase of $2,640.
- Renegotiate a new NPDES permit that allows for effluent samples to be collected on a monthly basis during long-term operation. The past 4 years of data may be used to argue that the effluent data is consistent and the need for bi-weekly sampling is not warranted. This recommendation represents an annual cost savings of $1,800. Note that system changes to the treatment train may require more frequent sampling during prove out.
- Currently, the treatment plant that processes dewatering flow from landfill sites 1 and 3 is idle. If the groundwater level in the landfill rises in the future, dewatering will need to occur. Currently, there is excess capacity (35 gpm) of the Eastern Plume treatment plant. Any future flow from dewatering the landfill is expected to be small (2 to 6 gpm) and can be redirected to the Eastern Plume treatment plant. We recommend combining these two process streams and selling or reusing the landfill sites 1 and 3 treatment plant equipment. This equipment is in very good condition and may be sold or salvaged to other Department of Defense facilities. However, due to the high metals content expected in any future landfill process stream, additional potassium permanganate will be required to precipitate metals (i.e., arsenic, iron, manganese, and lead) out of the process stream to meet effluent requirements. Approximately 2 to 5 pounds of potassium permanganate per day would be needed when landfill dewatering is occurring. Based on effluent discharge requirements, when the landfill is being dewatered, metals must be removed from the process stream regardless of whether the process stream is discharged to the sanitary sewer, groundwater, or surface water. (Refer to Table 4-3 for more information.) Approximate costs for adding potassium permanganate are $3,000 to $6,000 per year when the landfill dewatering system is running. However, these costs may be offset by the operations costs of the current landfill dewatering treatment system and any costs recovered during salvage or resale of the idle equipment.
- It is recommended that the extraction well head flow meters be connected to the SCADA system. Actual implementation cost would be dependent upon the transmitting capability of the existing flow meters and the SCADA system's availability of inputs. Cost data on this recommendation is not currently available.

**4.3.2 Considerations for Proposed Modifications of the Existing Treatment Train**—The recommendation to replace the UV-Ox system with an air stripper (AS) and to select an alternative discharge method is appropriate. In addition, the following comments should be considered when evaluating these proposed modifications:

**Table 4-3. Treatment Required for Proposed Eastern Plume Effluent Discharge Options**

| Discharge | UV-Oxidation | | Air Stripper | |
|---|---|---|---|---|
| | Eastern Plume Influent only | Eastern Plume and Landfill Influent | Eastern Plume Influent only | Eastern Plume and Landfill Influent |
| Sewer Discharge | 1) Occasional metals treatment required to meet discharge requirements<br>2) Meets VOC discharge requirements | 1) Metals treatment required to meet discharge requirements<br>2) Meets VOCs discharge limits | 1) Occasional metals treatment required to meet sewer discharge requirements<br>2) Meets VOCs discharge limits | 1) Metals treatment required to meet sewer discharge requirements<br>2) Meets VOCs discharge limits<br>3) No iron fouling expected from combined flow. |
| Infiltration to Groundwater | Does not meet VOC discharge requirements | Does not meet VOC discharge requirements | 1) Meets VOC discharge requirements<br>2) Meets Federal MCL and State MEG metals requirements. | 1) Meets VOC discharge requirements<br>2) Occasional metals treatment (for manganese) may be required if effluent must meet Federal MCLs<br>3) No iron fouling expected from combined flow. |
| Surface Discharge | Does not meet VOC discharge requirements | Does not meet VOC discharge requirements | 1) Meets VOC discharge requirements, may need GAC polishing to meet state human health criteria.<br>2) Occasional metals treatment (for manganese and lead) may be required if effluent must meet Federal MCLs and State Human Health Criteria Aquatic Life Criteria | 1) Meets VOC discharge requirements, may need GAC polishing to meet state human health criteria.<br>2) Metals treatment (for arsenic, iron, manganese, and lead) may be required if effluent must meet Federal MCLs, State Aquatic Criteria and State Human Health Criteria<br>3) No iron fouling expected from combined flow. |

- Total labor costs of $180,000 for all options presented in the Evaluation Report appear excessive.

  1. Recommend reducing the greater than full time (48 hours per week) operator to a part time operator with the appropriate number of hours reflected in the cost estimate for each type of remedial equipment being considered. Each system will have different labor needs.
  2. Reevaluate the estimate for support labor (20-30/week) for all of the treatment systems; reduce and modify to make system specific.
  3. Recommend defining support labor.

- The Maine Department of Environmental Protection (DEP) only requires air permitting and best available control technologies (BACT) where VOC emissions would exceed 10 pounds/hour or 100 pounds/day. If vapor GAC is required, re-evaluate the need for a second blower prior to vapor GAC as shown in Figure 2-2 of the Evaluation Report.
- Based on the potential for fouling and the high turbidity water as mentioned in the report, recommend installing filters prior to liquid GAC to remove fines <10 microns to avoid clogging liquid GAC.
- Cost of replacing filters may range from $5,000 to $25,000 annually depending on presence of fines, biofouling, and flow rates. Recommend adding to life cycle and capital costs.
- Recommend considering choosing the AS only option versus AS with liquid GAC (AS/GAC) if the groundwater infiltration or sewer discharge options are chosen. For mean concentrations at the higher flow rates, the total costs (life cycle + capital) are lower for the AS than the AS/GAC. At lower flow rates the AS/GAC is only $7,000 (total cost) lower than AS. With the addition of $5,000 to $25,000 per year (not amortized) for filter replacement and the cost of a plant operator for carbon change out, the AS/GAC exceeds the cost for AS under all flow and discharge scenarios.
- If AS/GAC is chosen, take note to monitor air stripper effluent as remediation continues. If the air stripper effluent decreases to below effluent standards, bypass liquid GAC to save expenses.
- Metals treatment may be required to meet surface discharge requirements and should be addressed in the Evaluation Report. Refer to Section 4.4 for more information.

**4.3.3 Recommendations for Operation Using the Existing Treatment Train—**The following are recommendations for the existing Eastern Plume aboveground treatment train. These recommendations are provided in the event that the proposed modifications above are delayed or not implemented. These recommendations are also summarized in Table 4-2.

- If the UV-Ox systems will remain in place for at least 2 more years, recommend installing approximately five motorized valves controlled by the PLC and SCADA system to direct flow: (1) directly to the UV-Ox unit, (2) through the sand filters, or (3) to the clarifier depending on the turbidity. This will reduce system downtime. This will represent a one time cost increase of $4,500.
- The effluent from the treatment plant has consistently exceeded the effluent requirements for manganese. Recommend using the existing Eastern Plume precipitation system (currently not in use) to reduce metal concentrations in the process stream. Approximately 0.6 pounds of potassium permanganate per day is needed when influent concentrations of manganese exceed 100 ug/L. Approximate costs for adding potassium permanganate is $700 to $1,000 per year.
- The Eastern Plume influent sample and the UV-Ox influent sample are considered redundant when the Landfill dewatering system is idle. Recommend discontinuing VOC analysis of the UV-Ox influent sample when the Landfill dewatering system is not operating. This recommendation represents an annual cost savings of $1,300.
- The sewer discharge cost of approximately $158,000 annually is considered excessive. The sewer discharge fee should be renegotiated based on the following:
    1. Discharge fees charged by other local districts
    2. Discharge fees for other NAS Brunswick sewer discharges
    3. Discharge fees for other Brunswick Sewer District customers
- Currently, there are two full-time people supporting the operation of the groundwater treatment plant. Renegotiate the contract to a part-time operator with some support. Reducing the labor costs will represent an annual cost savings of $90,000 to $110,000.

## 4.4 Additional Considerations for Groundwater Discharge

Three discharge options are being considered for discharge of the Eastern Plume treatment plant effluent. These include: sanitary sewer (current discharge method), infiltration to groundwater, and surface discharge to a ditch. Possible discharge requirements for each of these options may include the following:

- **Sewer:** Brunswick Sewer District Discharge Limits
- **Infiltration to groundwater**: Federal MCLs and State MEGs
- **Discharge to surface water**: State Aquatic Life Criteria, State Human Health Criteria, Federal MCLs, and State MEGs

We have reviewed historical influent and effluent concentrations and possible discharge requirements for several of the proposed process stream treatment scenarios. Note that by combining the landfill influent and Eastern Plume influent, several metals such as zinc and nickel are diluted to below all discharge requirements. Table 4-3 summarizes the additional treatment that may be required for each of the discharge options being considered.

In general, surface water discharge is considered more favorable than infiltration for several reasons. Infiltration systems may often lose their infiltration capacity, clog due to fouling, are more difficult to maintain, and are dependent on the infiltration capacity of the subsurface. However, a cost analysis, a watershed study, an infiltration study, and a detailed review of the regulatory requirements must be performed prior to a final discharge decision. Also note that the discharge requirements for surface water are much more stringent than infiltration and sewer discharge.

## 4.5 Eastern Plume Recommendations Life-Cycle Costs

A life cycle cost analysis was conducted for each of the RAO optimization recommendations for the Eastern Plume system. In addition, the costs of continuing operation “as is” and system shutdown leading to MNA are presented for respective comparison. The life cycle cost analysis provides a net present value (NPV) for costs or savings incurred over the life of the operation. The NPV was calculated for operations of 5, 10, and 15 years, assuming a 6 percent interest rate. Results of the life cycle cost analysis are presented in Table 4-4.

## Table 4-4. Life Cycle Cost Analysis for Eastern Plume System Recommendations

| Recommendations | Annual Costs | | | | Net Present Value | | |
|---|---|---|---|---|---|---|---|
| | Material | Labor | Analytical | Total | 5 years | 10 years | 15 years |
| Continued operation of existing P&T as is | | | | $1.14M | $4.8M | $8.4M | $11.1M |
| Implement MNA | $10,000 | $30,000 | $10,000 | $50,000 | $210,618 | $368,000 | $485,612 |
| Install motorized valves on UV-Ox system to control flow to proper turbidity treatment systems | $4,500 | | | $4,500 | One time cost - no recurring impacts. | | |
| Use existing precipitation system to remove manganese from process stream | $300 | | | $300 | $1,264 | $2,208 | $2,914 |
| Sample influent from individual wells for VOCs quarterly | | | $2,640 | $2,640 | $11,121 | $19,431 | $25,640 |
| Negotiate a new NPDES permit to reduce effluent sampling from bi-weekly to monthly sampling. | | | ($1,800) | ($1,800) | ($7,582) | ($13,248) | ($17,482) |
| Discontinue VOC analysis of UV-Ox influent sample when landfill dewatering system is not in operation, due to redundancy. | | | ($1,300) | ($1,300) | ($5,476) | ($9,568) | ($12,626) |
| Renegotiate with the Brunswick sewer district to lower the $158,000 annual discharge fee. | Unknown - up to $158,000/yr. | | | | | | |
| Reduce current two person operating team to a part-time operator | | ($90,000) | | ($90,000) | ($379,113) | ($662,408) | ($874,102) |
| Combine landfill dewatering treatment system with Eastern Plume treatment system* | ($3,000) | | | ($3,000) | $12,637 | $22,080 | $29,137 |
| Install two new extraction wells with three piezometers | One time installation cost of $100,000, recurring annual costs difficult to quantify. | | | | | | |

(Figures in parenthesis indicate cost savings)
*Annual cost of landfill dewatering treatment system unavailable; therefore, life-cycle costs only reflect annual increase in potassium permanganate costs. Recommendation would also result in a net decrease of the operating cost and some salvage value.

# 5.0 DATA ANALYSIS, TREND EVALUATION AND REPORTING

A review of the existing monitoring reports for the Eastern Plume P&T system indicates that several steps may be taken to optimize the data analysis, trend evaluation, and reporting for the P&T system. The following recommendations will help improve understanding, decision making, and help optimize these remedial actions. Each of the following items should be included in quarterly operations reports and/or included in the annual monitoring reports.

## 5.1 Performance Plots

It is recommended to plot the monthly operation and cost data on performance plots similar to those found in Section 3.0 (i.e., Figures 3-6 to 3-9). These plots will help visualize the cost and performance trends for each system as well as help in making appropriate optimizations and remedial strategy decisions. More explanation of these plots as they relate to the past performance at the Eastern Plume is included in Section 3.5. The recommended performance plots are:

- Influent VOC Concentrations vs. Time
- Cumulative Mass Recovered vs. Time
- Cumulative Costs vs. Cumulative VOCs Recovered
- Average Cost Per Pound Recovered vs. Time

## 5.2 Contaminant Tracking

By periodically tracking the migration of contaminants, the performance of the Eastern Plume remedial action may be assessed. In addition, optimization decisions may be made as the plume changes shape or stabilizes. GIS, along with other graphics packages, will increase the visual impact of large amounts of data and will allow for data query to help easily track trends in plume and contaminant migration.

Secondly, plot contaminant plume contours for individual COCs. These plots will allow NAS Brunswick to assess how well the remedial action is addressing each contaminant compared to their individual cleanup levels. These plots will allow NAS Brunswick to target and optimize the remedial systems based on the most problematic COCs.

## 5.3 Operational and Performance Reporting

Currently, the monthly operations reports for the Eastern Plume contain the following operation and performance related items:

- A short summary of operations;
- A discussion and analysis of whether the effluent is meeting discharge requirements (iron and manganese are not currently included);
- A table of performance monitoring analytical results;
- A table with daily flow, iron, manganese, pH, and turbidity measurements;
- A table summarizing the system downtime/repair actions; and
- A table with flow and operation time information.

Manganese and iron should be included when comparing the effluent results to effluent standards in the monthly operations reports. In addition to the information already provided in the monthly reports, the following information should be included in quarterly operation reports:

- Performance plots as mentioned above;
- Summary of operations and maintenance costs including maintenance, repairs, capital improvements, and utility costs;
- Detailed operations and maintenance logs as an appendix;
- Discussion and analysis of system, plant, and extraction well performance; and
- Recommendations for system, plant, and extraction well optimization.

Presentation of this information will allow the NAS Brunswick team members to have a better understanding of the performance of the P&T system. It will also help in identifying problematic operation and encourage optimization.

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# APPENDIX A

# EASTERN GROUNDWATER PLUME
# NAS BRUNSWICK RAO OPTIMIZATION CASE STUDY
# PORE VOLUME AND EXTRACTION RATE CALCULATIONS

Pore Volume Estimate

The volume of groundwater within a contaminant plume is the pore volume (PV) and is approximated by

$$PV = BnA$$

where B is the average thickness of the plume (assume 15 feet in the lower sand unit), n is the porosity of the formation (assume 33% for the lower sand unit), and A is the area of the plume at each lobe.

The number of pore volumes (NPV) extracted per year is approximated by

$$NPV = Q/PV$$

where Q is the total annual pumping rate.

Northern Lobe

$$PV = 15ft \times 0.33 \times 1{,}225{,}000ft^2 \times 7.48gal/ft^3 = \sim 45 \text{ million gallons}$$

Wells EW-4 and EW-5 were pumped at 26.6 gallons per minute in 1998. Therefore, Q = 13,980,960 gallons per year (gpy)

$$NPV = 13{,}980{,}960 \text{ gpy}/\sim 45{,}000{,}000 \text{ gallons} = \sim 0.3$$

Southern Lobe

$$PV = 15ft \times 0.33 \times 1{,}218{,}750ft^2 \times 7.48gal/ft^3 = \sim 45 \text{ million gallons}$$

Wells EW-1, EW-2, and EW-2A were pumped at 44.6 gallons per minute in 1998. Therefore, Q = 23,441,760 gpy

$$NPV = 23{,}441{,}760 \text{ gpy}/\sim 45{,}000{,}000 \text{ gallons} = \sim 0.5$$