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Site Specific Report
SSR-2538-ENV

MARINE CORPS BASE CAMP LEJEUNE
Campbell Street Fuel Farm

REMEDIAL ACTION OPERATION OPTIMIZATION CASE STUDY

January 2000

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

FINAL

Marine Corps Base Camp Lejeune
Campbell Street Fuel Farm

Remedial Action Operation (RAO) Optimization Case Studies

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LIST OF ACRONYMS

AFVR	Aggressive Fluid Vapor Recovery
AST	Aboveground Storage Tank
AVGAS	Aviation Gasoline
bgs	below ground surface
bls	below land surface
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CAP	Corrective Action Plan
COC	Contaminants of Concern
CSFF	Campbell Street Fuel Farm
CSM	Conceptual Site Model
CST	Campbell Street
DON	Department of the Navy
EDB	Ethylene Dibromide
GAC	Granular Activated Carbon
GIS	Geographic Information System
gpm	gallons per minute
JP-5	Jet Petroleum Grade No.5
LANTDIV	Atlantic Division of Naval Facilities Engineering Command
lb(s)	pounds
LNAPL	Light Non-Aqueous Phase Liquids
LTM	Long-term Monitoring
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	Maximum Contaminant Levels
MNA	Monitored Natural Attenuation
MTBE	Methyl Tertiary Butyl Ether
NA	Not Analyzed
NAS	Naval Air Station
NCDWQ	North Carolina Department of Water Quality
ND	Non-detect
NFESC	Naval Facilities Engineering Service Center
NPDES	National Pollution Discharge Elimination System
NPV	Net present value
ODC	Other Direct Costs
O&M	Operation and Maintenance

LIST OF ACRONYMS (continued)

P&T	Pump and Treat
PAH	Polyaromatic Hydrocarbon
ppb	parts per billion
ppm	parts per million
PQL	Practical Quantitation Limit
PVC	Polyvinylchloride
RAO	Remedial Action Operation
RW	Recovery Wells
SVOC	Semivolatile Organic Compound
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
TPH	Total Petroleum Hydrocarbons
USMC	United States Marine Corps
UST	Underground Storage Tank
VACs	Volatile Aromatic Compounds
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

ES.1 Purpose of the Case Study Report

This case study report includes an effectiveness evaluation for the Campbell Street Fuel Farm (CSFF) groundwater pump and treat (P&T) system located at Marine Corps Air Station (MCAS) New River, which is co-located with Marine Corps Base (MCB) Camp Lejeune, North Carolina. 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 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.

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, Atlantic Division (LANTDIV), and other Engineering Field Divisions/Activities.

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 evolution and understanding of the conceptual site model (CSM).
- 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 MCB Camp Lejeune having potential applicability at CSFF.
- Describe the system design basis and operational objectives for the P&T system, including the 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 MCB Camp Lejeune was conducted from 27-30 April 1999 to gather the required information for this report.

ES.3 Campbell Street Fuel Farm (CSFF) System Description

The CSFF P&T system was evaluated over an operating period of approximately 2.5 years (July 1996 to March 1999). The system was installed to remove fuel-related contaminants from the groundwater. The treatment system is a skid-mounted package unit and includes oil/water separation, followed by air stripping, granular activated carbon (GAC), and discharge to a surface drainage ditch (See Figure 3-6). The system was designed to accommodate influent flow rates up to 30 gallons per minute (gpm).

The extraction system consists of a single recovery trench at each of the three contaminated sites: Campbell Street Fuel Farm, AS-143, and AS-4151. Four recovery wells (RWs) were recently installed (two RWs at AS-143, one RW at each of the other sites) to address hot spot contamination and improve contaminant recovery. These extraction wells contain pneumatic submersible pumps rated at 1 gpm.

Remedial action objectives for this system are regulated under the State of North Carolina underground storage tank (UST) program. Corrective Action Plans addressing each of the three contaminated sites were submitted in 1994. The proposed corrective actions included soil removal, free product recovery, operation of a P&T system, and long-term monitoring. Groundwater cleanup standards are those listed in the State of North Carolina Groundwater Standards.

ES.4 CSFF System Performance Summary

The technical performance and cost effectiveness of the CSFF system for the period from July 1996 to March 1999 has been poor. The overall performance for the system is summarized as follows:

- The monitoring well network is inadequate to define the plume capture zones; however, it appears the plumes are stable due to natural attenuation processes.
- Influent treatment plant flow rates are less than 10% of design capacity.
- Cumulative mass removal for the system has been limited to approximately 3.5 pounds in more than 2.5 years of operation.
- Total volatile organic compound (VOC) contaminant levels in the influent are now 440 parts per billion (ppb) in the AS-143 recovery trench and non-detect (ND) in the AS-4151 and Campbell Street recovery trenches.

- The AS-4151 recovery trench has shown consistent non-detect VOC contaminant levels for 20 months. Additionally, the Campbell Street recovery trench has hovered around non-detect for the last 12 months. This asymptotic performance supports discontinuing active remediation in favor of monitored natural attenuation (MNA).
- The cost per pound of contaminant removed has averaged $95,000.
- There is little evidence to suggest that the active pumping has had any significant impact in achieving site-specific cleanup objectives.

ES.5 CSFF System Recommendations

Recommendations for the CSFF System should be implemented in a phased approach. The AS-4151 and Campbell Street trenches should be shut down immediately, having reached asymptotic ND levels of contaminants. Based on contaminant spikes at the AS-143 site, hot spot removal should continue on an interim basis. If the newly installed recovery wells prove to be of limited benefit, Aggressive Fluid Vapor Recovery (AFVR) should be considered as a more cost effective means of addressing further hot spots. Finally, MNA data should be gathered to confirm the potential of a passive remedial approach for AS-143 once the remaining hot spots have been removed.

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 NAS Brunswick, Maine. This case study report includes an evaluation of a groundwater pump and treat (P&T) system located at the Campbell Street Fuel Farm (CSFF) at Marine Corps Air Station (MCAS) New River, a tenant of MCB Camp Lejeune. Separate reports are available for evaluations of P&T systems at the Operable Units 1 and 2 at MCB Camp Lejeune, and the Eastern Groundwater Plume at Naval Air Station (NAS) Brunswick.

1.1 Purpose and Objectives

The primary purpose of this case study is to evaluate and assess the ongoing RAO program at the CSFF system at MCB Camp Lejeune, North Carolina; and provide recommendations resulting in attainment of site remedial action objectives and closure for optimal life cycle costs.

Specific elements to be evaluated for each site and its associated P&T system include:

- Overall site remediation strategy and approach;
- Best operation and management practices already in place;
- Extraction system network, including all trenches, 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 goal of this case study report is to provide a decision framework and associated 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 reducing sound decision-making. The approach employed in this RAO optimization project to achieve this goal is outlined by the steps 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 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 MCB Camp Lejeune having potential applicability at CSFF.
- Describe the system design basis and operational objectives for the P&T system, including the 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 MCB CAMP LEJEUNE

MCB Camp Lejeune is a 236-square mile (153,439-acre) training base for the United States Marine Corps (USMC). The installation is located in Onslow County, North Carolina, and has 14 miles of coastline on the Atlantic Ocean.

2.1 Location of MCB Camp Lejeune and Case Study Sites

Figure 2-1 shows the general location of the base. The Campbell Street Fuel Farm (CSFF) is located on MCAS, New River (which is co-located with MCB Camp Lejeune) at the intersection of Campbell Street and White Street. Three distinct sites of contamination are in the near vicinity of the CSFF treatment system, they are:

- Campbell Street Site
- AS-143 Site
- AS-4151 Site

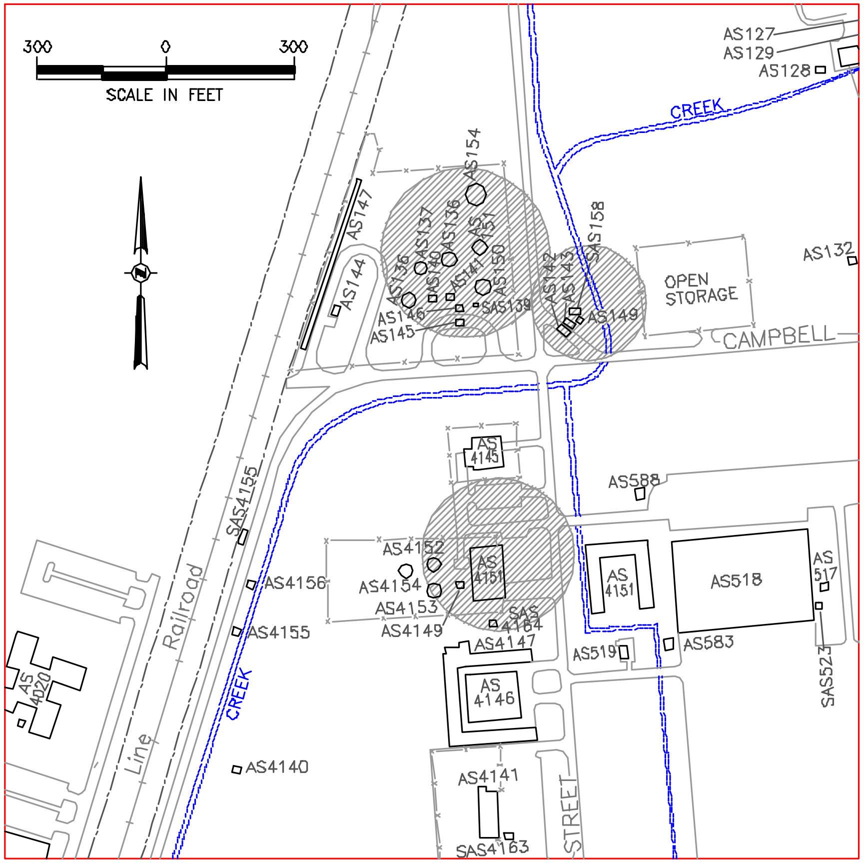
The locations of the Campbell Street Fuel Farm and the three sites of contamination at MCAS, New River are shown in Figure 2-1. Descriptions of the sites are provided in Section 3.0.

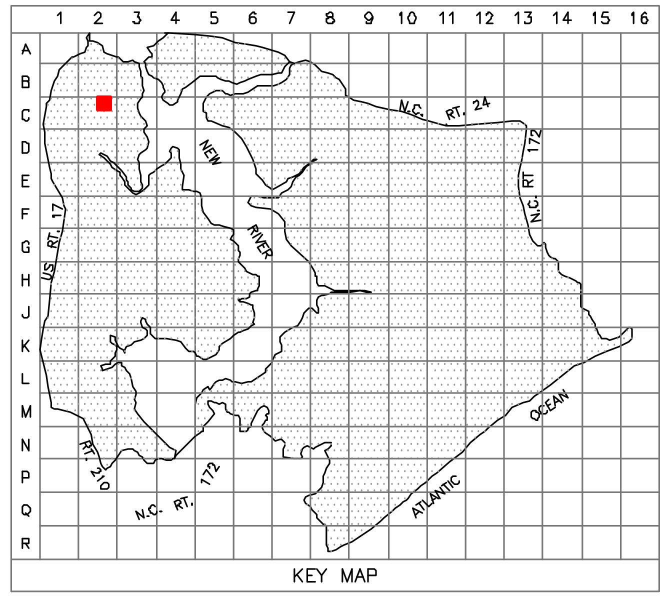
2.2 Physical Setting

Geology, hydrogeology, and geography in this section are summarized from the *Basewide Remediation Assessment Groundwater Study* (Baker Environmental, April 1998).

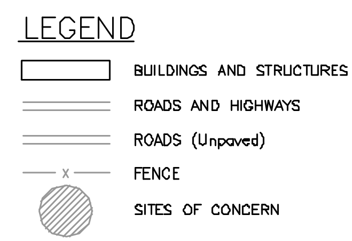
2.2.1 Geology – MCB Camp Lejeune is located in the Atlantic Coastal Plain geologic province. The Atlantic Coastal Plain consists of unconsolidated sediments consisting of rock grains eroded from the Appalachian and Piedmont geologic provinces to the west. They were transported by fluvial processes and deposited in alluvial fans and as tidal marine muds during advance and retreat of the ocean. These sediments overlie the Precambrian igneous and metamorphic bedrock in this area.

2.2.2 Surface Water – The majority of MCB Camp Lejeune drains into the New River, which bisects the Base. In the vicinity of Camp Lejeune, the New River flows to the south, through a wide estuary, and into the Atlantic Ocean via the New River Inlet. Several other small coastal creeks also drain parts of Camp Lejeune. These drain into the Intercoastal Waterway and eventually into the Atlantic Ocean via a series of inlets.





KEY MAP



AS SHOWN	TSH	27AUG99	Figure 2–1. Site Location Plot Plan Campbell Street Fuel Farm
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2.2.3 Groundwater – Unnamed surficial sediments are the shallowest water-bearing deposits underlying Camp Lejeune. The thickness of the surficial deposits ranges from zero to approximately 100 feet. The next water-bearing unit is the Castle Hayne Aquifer, which consists primarily of fine sand, shell, and limestone. The Castle Hayne confining unit, composed of clay and sandy clay, separates the Castle Hayne aquifer from the surficial unit. In the area of Camp Lejeune, the confining unit averages 9 feet thick, except near the New River and some of its larger tributaries where there is full communication between the surficial unit and the Castle Hayne Aquifer. The Castle Hayne Aquifer is used for domestic water supply at MCB Camp Lejeune.

There are five more aquifers that underlie Camp Lejeune. These are the Beaufort, the Peedee, the Black Creek, and the Upper and Lower Cape Fear aquifers. All of these aquifers are over 400 feet deep and are isolated from the shallower units by the Beaufort confining layer.

Groundwater monitoring and aquifer testing studies at MCB Camp Lejeune have focused on the surficial deposits and the Castle Hayne aquifer. This is because contamination from installation activities is limited to these two water-bearing units and is prevented from migration to deeper aquifers by the Beaufort confining layer.

Groundwater discharge areas on Camp Lejeune include the New River, its tributaries, and other surface water bodies such as wetlands.

2.2.4 Geography – Construction of MCB Camp Lejeune was initiated in 1941. Today, more than 40,000 military, civilian, and contract personnel work at Camp Lejeune. The nearest community to the installation is the City of Jacksonville, North Carolina, with a population of approximately 75,000.

Land use around MCB Camp Lejeune 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 offbase, will change in the foreseeable future.

3.0 CSFF REMEDIAL SYSTEM ASSESSMENT

3.1 CSFF, AS-143, and AS-4151 Background and Regulatory Framework

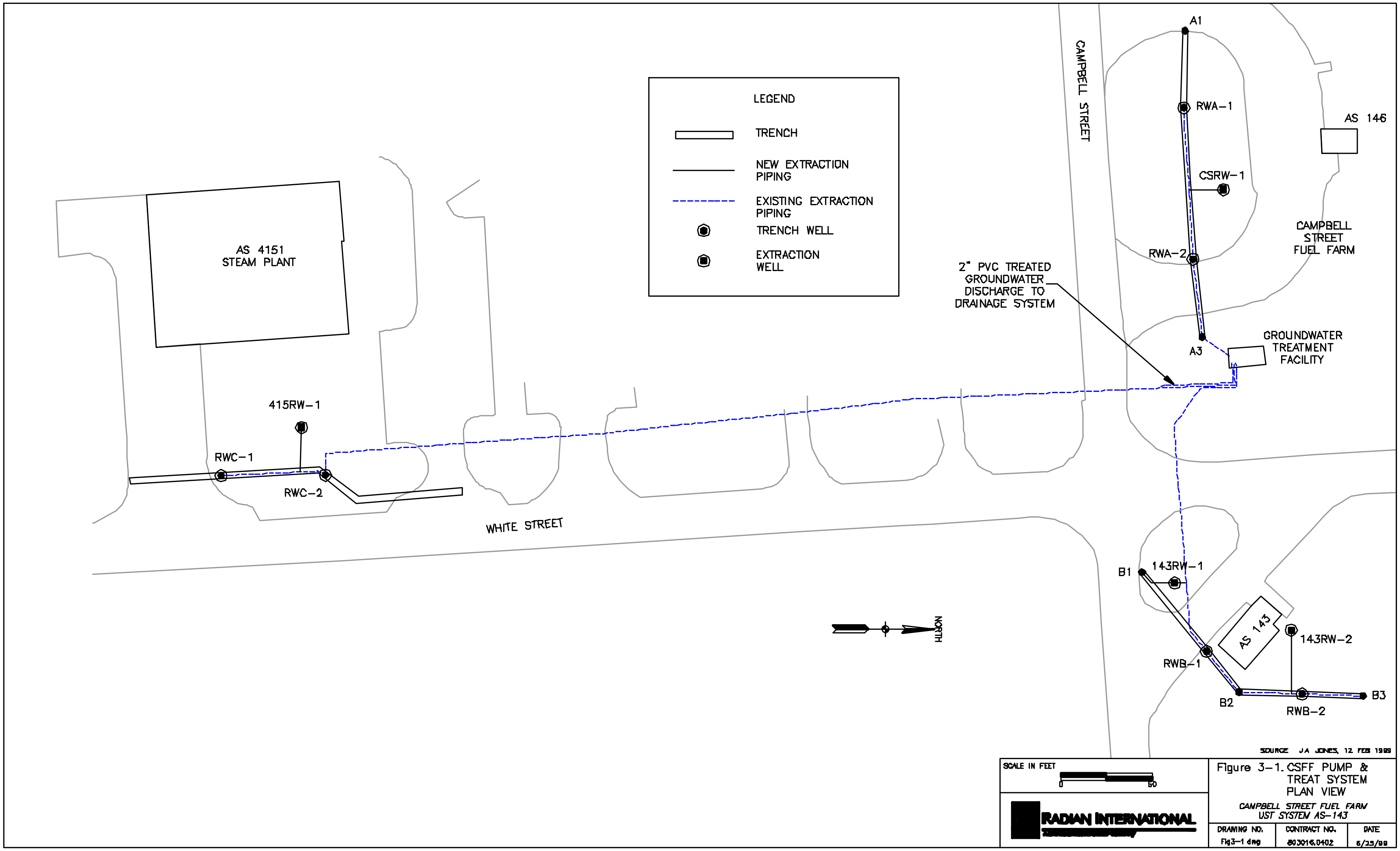
This section provides a description, regulatory information, and site activity status for the CSFF, Building AS-143, and Building AS-4151 at MCAS New River. Figure 3-1 shows the locations of the sites. Tables 3-1 to 3-3 summarize the information for each site.

3.1.1 Description - The CSFF is an active fuel storage facility located on the northwest corner of Campbell and White Streets. The CSFF stores JP-5 in four aboveground storage tanks (ASTs). Previously, JP-5 and aviation gasoline were stored in eight underground storage tanks (USTs). The USTs were replaced with the ASTs in 1985. Following replacement, seven of the USTs, the associated piping, and contaminated soil were excavated and removed from the site. One UST was filled with sand and left in place.

Building AS-143 is an active gasoline fueling station that services only government-owned vehicles. It is located directly across from the CSFF on the northeast corner of Campbell and White Streets. The fueling station stores unleaded gasoline in an UST that was installed in June 1994. The existing UST replaced a 10,000-gallon, steel UST that was installed immediately west of Building AS-143 in 1961. The existing UST is scheduled for replacement with an AST in mid-December 1999.

Building AS-4151 is a steam-generating plant located on the west side of White Street approximately 500 feet south of Campbell Street. Two underground pipelines cross the eastern edge of the site parallel to White Street. One pipeline carries JP-5 from the CSFF to the flight line. The other pipeline previously performed this function, but has been inactive since 1985. The inactive pipeline was allowed to drain and was abandoned in place in 1985 (Baker Environmental, 1994).

3.1.2 Regulatory Framework - The site is subject to rules in title 15A North Carolina Administrative Code (NCAC) Subchapter 2L and, specifically, Section .0106, also known as the corrective action rule. Section .0106 requires completion of a comprehensive site assessment and specifies the components required for the Site Assessment Report. Following assessment, the rule requires preparation of a Correction Action Plan (CAP) and its subsequent implementation. CAPs may propose active remediation of groundwater quality to the standards, or to alternate cleanup levels that are demonstrated to be protective of human health and the environment. CAPs may also propose natural attenuation provided its effectiveness at the site can be demonstrated. A Site Assessment Report for Building AS-4151 (Baker, 1992) was submitted in 1992 and a Site Assessment Report for the CSFF and Building AS-143 (Baker, 1994) was submitted in 1994. CAPs (Baker, 1994a and 1994b) addressing the three sites were submitted in 1994. Corrective action proposed for the sites included soil removal, free product recovery, operation of P&T systems, and long-term monitoring. The selected corrective action components and associated cleanup criteria are summarized in Table 3-2.



SOURCE: J.A. JONES, 12 FEB 1999

Figure 3-1. CSFF PUMP & TREAT SYSTEM PLAN VIEW

CAMPBELL STREET FUEL FARM UST SYSTEM AS-143

DRAWING NO.	CONTRACT NO.	DATE
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Table 3-1. Summary of Site Information

Site	Description	Source of Release	Contaminated Media	Contaminants of Concern
CSFF	JP-5 Fuel Farm	JP-5 and AVGAS USTs	Groundwater and Soil	BTEX and SVOCs
Building AS-143	Vehicle Fueling Station	Gasoline UST	Groundwater and Soil	BTEX and SVOCs
Building AS-4151	Steam Plant	Underground JP-5 Pipeline	Groundwater and Soil	BTEX and SVOCs

NOTES:

AVGAS = Aviation gasoline
BTEX = Benzene, toluene, ethylbenzene, and xylenes
CSFF = Campbell Street Fuel Farm
JP-5 = Jet petroleum grade No. 5
SVOC = Semivolatile organic compound
UST = Underground Storage Tank

Table 3-2. Summary of Regulatory Framework

Site	Remedy Components	Cleanup Criteria	Criteria to Stop Active Remediation
CSFF	• Remove approximately 1450 cubic yards of soil. • Remove measurable free product. • Pump and treat contaminated groundwater from interceptor trench installed at the downgradient edge of the plume. • Implement an LTM program.	Soil: Allowable TPH levels calculated by the Site Sensitivity Evaluation method. Groundwater: State groundwater standards or attainment of asymptotic conditions. Absence of measurable free product (<0.01 feet).	Suspend P&T and begin non-operational monitoring when the groundwater standards are not exceeded over four consecutive quarters. Terminate P&T and continue LTM when the reduction in COC concentrations reaches asymptotic levels (slope less than 1:40) in monitoring wells. Terminate P&T and LTM when the groundwater standards are not exceeded over four consecutive quarters of post-operational monitoring.
Building AS-143	• Remove UST and adjoining soil. • Remove measurable free product. • Pump and treat contaminated groundwater from interceptor trench installed at the downgradient edge of the plume. • Implement an LTM program.		
Building AS-4151	• Remove approximately 230 cubic yards of soil. • Remove measurable free product. • Pump and treat contaminated groundwater from interceptor trench installed at the downgradient edge of the plume. • Implement an LTM program.		

NOTES:

COC = Contaminants of concern
CSFF = Campbell Street Fuel Farm
LTM = Long-term monitoring
UST = Underground Storage Tank
TPH = Total petroleum hydrocarbons
P&T = Pump and treat

Table 3-3. Summary of Monitoring Status

Site	Status of Monitoring	Monitored Medium	Monitoring Frequency: Sampling/ Measurement	Current Number of Monitoring Points	Corrective Action
CSFF	Active; begun in 1996	Groundwater	Quarterly/ Monthly	9 wells sampled 13 wells measured	Pump and Treat System
Building AS-143	Active; begun in 1996	Groundwater	Quarterly/ Monthly	Monitored in conjunction with CSFF	Pump and Treat System
Building AS-4151	Active; begun in 1996.	Groundwater	Quarterly/ Monthly	7 wells sampled 11 wells measured	Pump and Treat System

NOTES:

CSFF = Campbell Street Fuel Farm

3.1.3 Activity Status - Contaminated soil was excavated from the center of the CSFF and from the area south of the tanker loading area in 1996. Contaminated soil was also excavated from Building AS-143 in conjunction with UST removal and from areas along the abandoned pipeline at Building AS-4151. Excavation targeted soil containing free product and soil exhibiting the highest concentrations of total petroleum hydrocarbons (TPH); however, not all soil exceeding allowable TPH concentrations was removed.

A P&T system incorporating an interceptor trench was installed downgradient of the contaminant plume at each site. The trenches began operating in 1996. The trenches at CSFF and Building AS-143 continue to operate; however, pumping at the AS-4151 trench was recently terminated in early 1999. Also, in early 1999, one extraction well was added to the extraction systems at both the CSFF and Building AS-4151 to enhance contaminant mass removal from a hot spot within each plume. Two extraction wells were also added to the extraction system at Building AS-143 to enhance contaminant removal from hot spots within the plume.

Groundwater monitoring began in 1996. Groundwater levels are measured monthly and samples are collected quarterly. All groundwater samples are analyzed for volatile aromatic compounds. In addition, two samples from the CSFF and Building AS-143 are also analyzed for polynuclear aromatic hydrocarbons and two samples from Building AS-4151 are also analyzed for semivolatile organic compounds.

3.2 Current Conceptual Site Model

The topography near the CSFF and Buildings AS-143 and AS-4151 is generally flat. Runoff is controlled by a network of storm drains and ditches that drain eastward (Baker, 1995). Local land use near the site is related to Base operations and is classified as commercial, light industrial, and military (Baker, 1994).

The geology of the site is typical of the Atlantic Coastal Plain which is characterized by interlayered beds and lenses of sand, silt, clay, shell, and limestone.

Surficial deposits are comprised of undifferentiated layers of sand, silt, and clay that extend to approximately 40 feet below land surface (bls). From land surface to depths between 12 and 17 feet, deposits beneath the site consist predominantly of silt and soft-to-stiff clay (Baker, 1994a and 1994b). In the area near Building AS-4151, the silt and clay may be overlain by two to three feet of sand (Baker, 1994b). The silt and clay deposits are underlain at a depth of approximately 22 feet by silty sand that grades to fine sand. The sand layer extends to approximately 40 feet below land surface (bls) where fine gravel, limey clay, and shell fragments, characteristic of the top of the Castle Hayne formation, are encountered (Baker, 1994b).

The hydraulic conductivity of the upper portion of the surficial deposits range from 0.14 feet/day (Baker, 1994b) to 0.46 feet/day (Baker, 1994a).

The water table is 6 to 7 feet below ground surface (bgs) at the CSFF and Building AS-143, and 3 to 4 feet bgs at Building AS-4151. In general, groundwater flow is toward natural and artificially developed discharge areas (Baker, 1994b). Groundwater flows predominantly toward the south at the CSFF, toward the east at Building AS-143, and toward the south and southeast at Building AS-4151 (Baker, 1995).

Former operations at the CSFF and Buildings AS-143 and AS-4151 have resulted in the contamination of soil and groundwater by gasoline and JP-5 aviation fuel (Baker, 1995). Site assessment results for all three locations indicated that the concentration of TPH in soil exceeded State allowable levels, that measurable free product was present in isolated areas, and that the concentrations of petroleum constituents dissolved in groundwater exceeded State standards. The allowable concentrations of purgeable TPH in soil at Building AS-4151 and at the CSFF, and Building AS-143 are 40 mg/kg and 180 mg/kg, respectively. Allowable concentrations of COCs in groundwater are summarized in Table 3-4. At Building AS-4151, contaminants in groundwater are present throughout the surficial deposits (Baker, 1992) and at the CSFF and at Building AS-143, dissolved contaminants are limited to the upper portion of the surficial deposits (Baker, 1994). Figures 3-2 and 3-3 generally show the horizontal extent of selected petroleum constituents measured in groundwater at the CSFF and Building AS-143, and at Building AS-4151, respectively. The distribution of constituents in the figures is inferred due to limitations in the groundwater monitoring well network.

Table 3-4. Summary of Groundwater Cleanup Goals and Maximum COC Concentration Detected

Constituent of Concern	**Cleanup Goal (ug/L)**	**Maximum Concentration Detected (ug/l)***		
		CSFF	**Building AS-143**	**Building AS-4151**
Benzene	1	**28.2**	**2545**	**8.2**
Ethlbenzene	29	11.1	**1383**	9.9
Toluene	1,000	ND	**3050**	4.9
Xylenes	400	47.9	**5214**	10.2
1,4-Dichlorobenzene	1.8	ND	ND	ND
Ethylene dibromide	0.0004	**3.5**	ND	ND
Acenaphthene	80	18	ND	ND
Acenphthylene	210	ND	ND	ND
Fluorene	280	15	ND	ND
1-Methylnapthalene	PQL	NA	NA	**41**
2-Methylnapthalene	28	NA	NA	**42**
Napthalene	21	ND	ND	**2960**

* Between December 1996 and March 1999

Bold values exceed cleanup goals
NA = Not analyzed
ND = Not detected
PQL = Practical quantitation limit

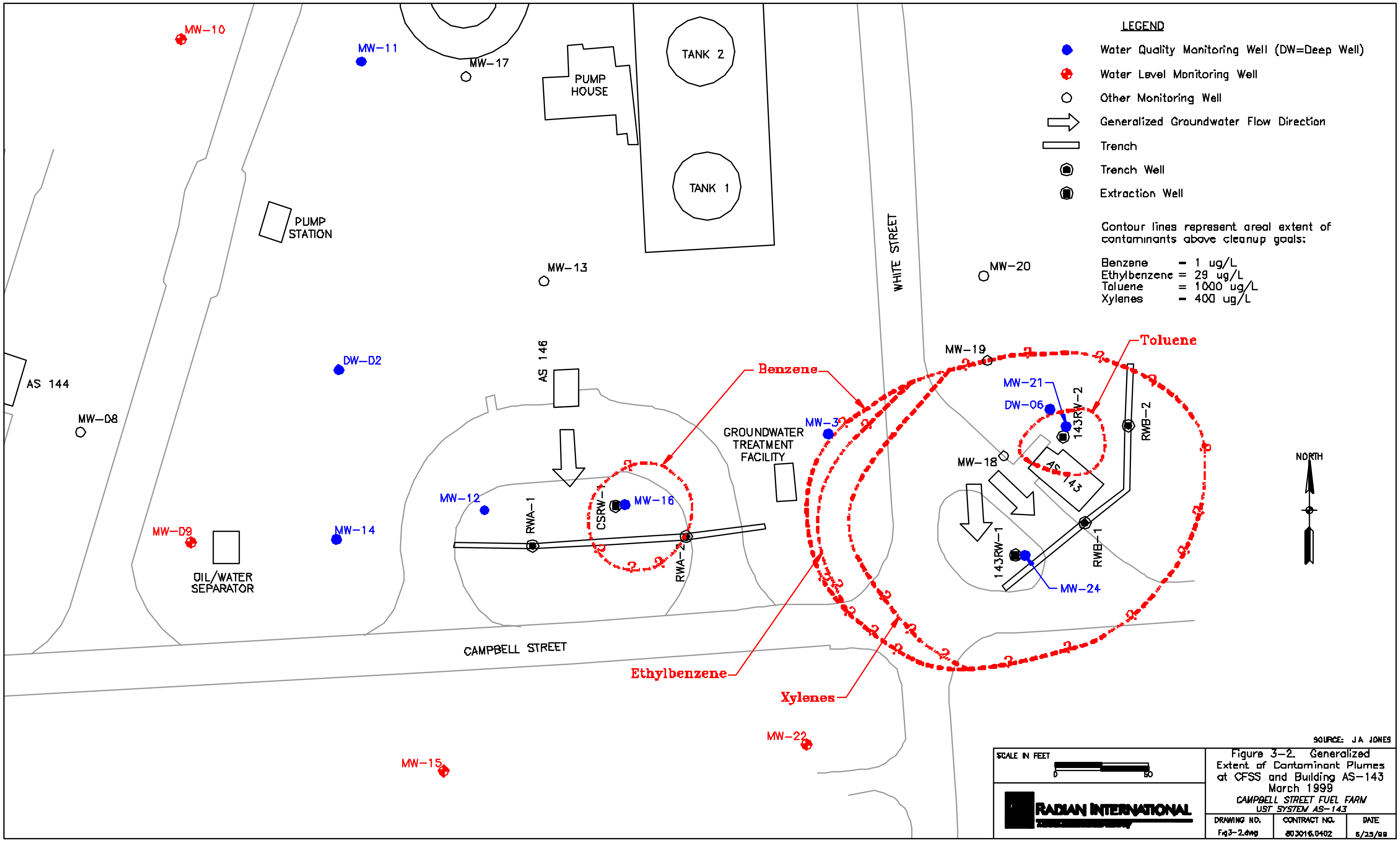

Figure 3-2. Generalized Extent of Contaminant Plumes at CFSS and Building AS-143 March 1999

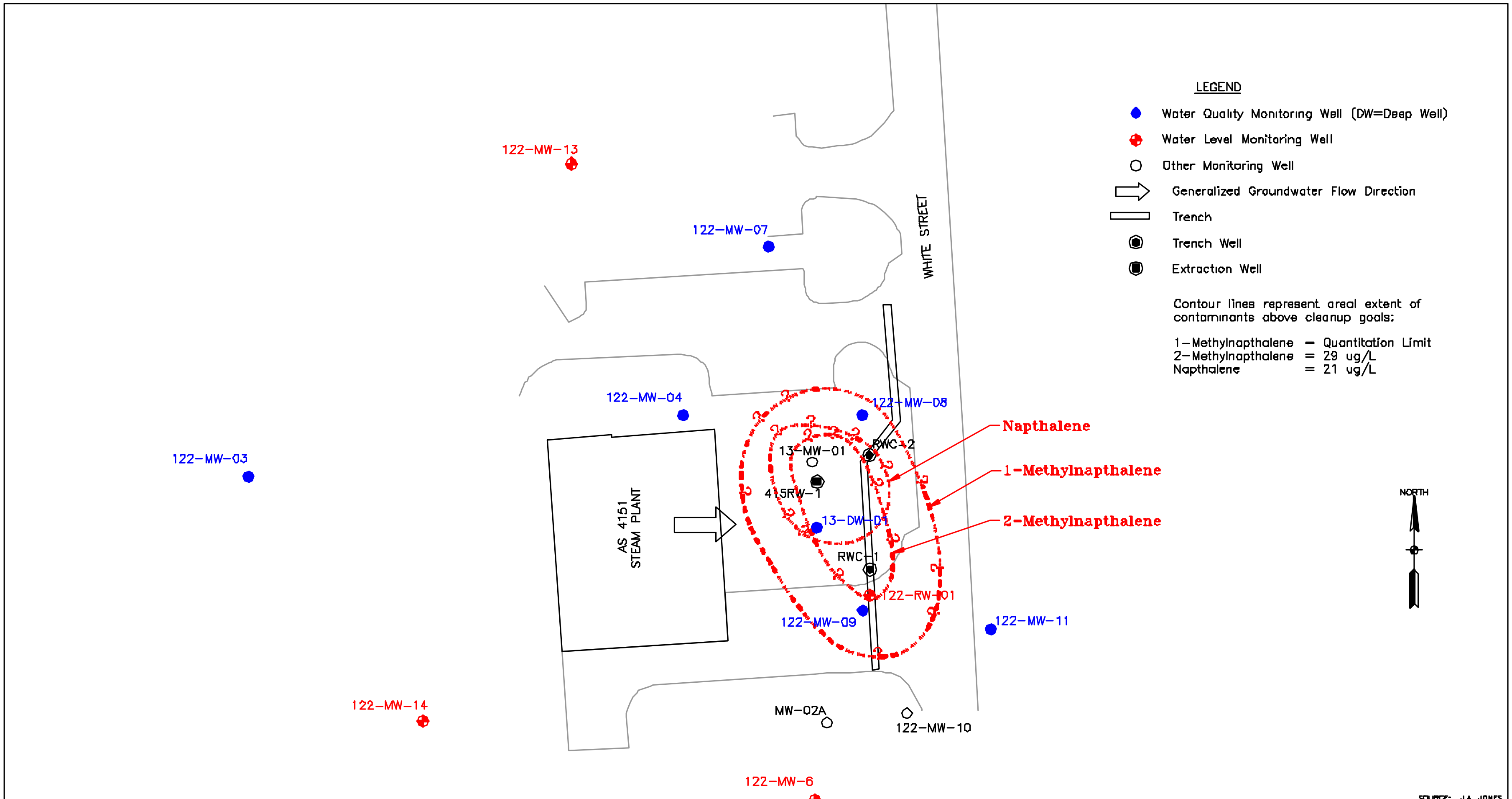

Figure 3-3 Generalized Extent of Contaminant Plumes Building AS-4151, March 1999

CAMPBELL STREET FUEL FARM
UST SYSTEM AS-143

DRAWING NO.	CONTRACT NO.	DATE
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Baker (1994) indicated that no actual or potential human receptors to the contaminated media were identified, except workers facing potential occupational exposure to soil during site remediation. Baker concluded that the contaminants at the CSFF and Buildings AS-143 and AS-4151 do not appear to represent a public health risk as no other direct exposure pathways exist.

3.3 CSFF System Description and Design Basis

The groundwater P&T system at the CSFF has been in operation since July 1996. The entire system was designed to remediate groundwater contaminated by previous releases of petroleum hydrocarbon fuels from USTs at the CSFF sites. Contaminated groundwater is extracted via a network of recovery trenches and wells and is then treated and discharged to a surface drainage ditch.

3.3.1 Description of Extraction Systems and Monitoring Well Networks – The groundwater P&T system is designed to contain and remediate contaminated groundwater at the CSFF and Buildings AS-143 and AS-4151. The P&T system began operating in 1996 and was predicted to meet the cleanup criteria in one to two years (Baker, 1994a and 1994b). The P&T system includes a separate extraction system and monitoring well network at each of the three sites. They are described in the following sections.

3.3.1.1 CSFF Extraction System and Monitoring Well Network

The extraction system at the CSFF includes the original interceptor trench, the Campbell Street (CST) trench and one extraction well (CSRW-1) that was installed in early 1999. The locations of the trench and extraction well are shown in Figure 3-1.

The trench was installed downgradient of the contaminant plume to intercept and extract groundwater from the upper portion of the surficial deposits as the plume migrates in the direction of groundwater flow. The trench is approximately 12 feet deep, 3 feet wide, 170 feet long, and filled with gravel. An impermeable, geomembrane liner is fitted to the bottom and downgradient side of the trench to act as a physical barrier to plume migration. The bottom of the trench slopes at a minimum grade toward two sumps that are installed approximately 45 feet from each end of the trench. Each sump contains a well having 10-slot, Schedule 40, polyvinylchloride (PVC) screen over the entire depth interval of the trench.

Extraction well CSRW-1 was installed in a hot spot within the plume to increase the extraction of dissolved contaminant mass. The well, located approximately 20 feet upgradient of the interceptor trench, is screened in the upper portion of the surficial aquifer. The well is constructed with six-inch diameter, Schedule 40, PVC casing and slotted screen. It is 15.5 feet deep with 13 feet of 10-slot screen surrounded by a No. 2 Grade silica sand pack.

Both trench sumps and the extraction well are equipped with three-inch diameter, pneumatic submersible pumps. The pumps have a top inlet and a maximum pumping rate of 6 gpm. Flow rates from the individual trenches are not currently measured, but each trench was estimated to yield 1 gpm during system design (Baker, 1995). Combined flow to the treatment system from the three trenches averages only 2 gpm (Jones, 1999). The pumping rate of extraction well CSRW-1 has been estimated at 0.5 to 1 gpm.

The monitoring well network for the CSFF includes nine wells used to monitor the quality of groundwater underlying both the fuel farm and the area near Building AS-143. Five shallow monitoring wells and one deep monitoring well are located at the fuel farm; two shallow wells and one deep well are located near Building AS-143. The wells are sampled each quarter. Each month, water levels are measured in these wells and in four additional monitoring wells. The locations of monitoring wells used for sampling and water level measurement are illustrated on Figure 3-4.

3.3.1.2 AS-143 Extraction System and Monitoring Well Network

The extraction system at Building AS-143 includes the original interceptor trench, (the AS-143 trench) and two extraction wells (143RW-1 and -2) that were installed in early 1999. The locations of the trench and extraction wells are shown in Figure 3-1.

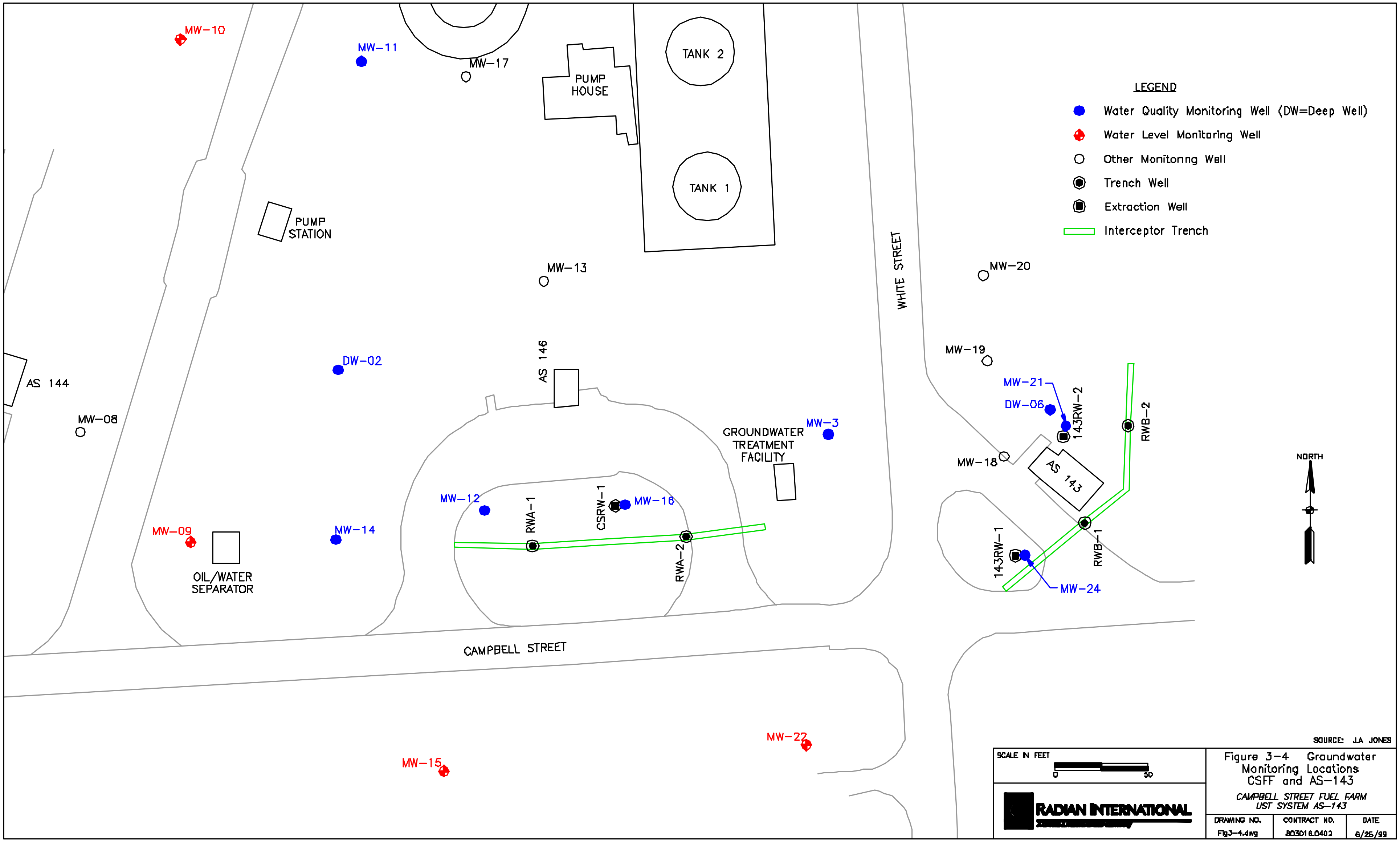
The interceptor trench was installed downgradient of the contaminant plume. The trench is comprised of two legs that are joined forming an angle of approximately 130 degrees. One leg is approximately 85 feet long with a sump located about 55 feet from the end of the leg. The other leg is approximately 70 feet long with a sump located near the midpoint. Otherwise, the trench construction is similar to the CST trench.

Extraction wells 143RW-1 and -2 were installed in two hot spots within the plume to increase the extraction of dissolved contaminant mass. Well 143RW-1 is located approximately 10 feet upgradient of the south leg and well 143RW-2 is located approximately 35 feet upgradient of the east leg. Both wells are screened in the upper portion of the surficial aquifer and construction is identical to CSRW-1.

Pumps used in the trench sumps and in the extraction wells are similar to those used at CSFF, as are the estimated pumping rates. The monitoring well network for Building AS-143 is the same as described for the CSFF.

3.3.1.3 AS-4151 Extraction System and Monitoring Well Network

The extraction system at Building AS-4151 includes the original interceptor trench (the AS-4151 trench) and one extraction well (4151RW-1) that was installed in early 1999. The locations of the trench and the extraction well are shown in Figure 3-1.


LEGEND
Water Quality Monitoring Well (DW=Deep Well)
Water Level Monitoring Well
Other Monitoring Well
Trench Well
Extraction Well
Interceptor Trench
MW-10
MW-11
MW-17
PUMP HOUSE
TANK 2
TANK 1
PUMP STATION
MW-13
WHITE STREET
MW-20
MW-19
MW-21
DW-06
143RW-2
RWB-2
DW-02
AS 146
AS 144
MW-08
MW-3
GROUNDWATER TREATMENT FACILITY
MW-18
AS 143
MW-12
RWA-1
CSRW-1
MW-16
MW-09
MW-14
RWA-2
143RW-1
RWB-1
MW-24
OIL/WATER SEPARATOR
CAMPBELL STREET
NORTH
MW-22
MW-15
SOURCE: J.A. JONES
SCALE IN FEET
0
50
RADIAN INTERNATIONAL
Figure 3-4 Groundwater Monitoring Locations CSFF and AS-143
CAMPBELL STREET FUEL FARM
UST SYSTEM AS-143
DRAWING NO.
Fig3-4.dwg
CONTRACT NO.
803016.0402
DATE
6/25/99

The interceptor trench was installed downgradient of the contaminant plume. The trench is approximately 185 feet long with two sumps located about 50 feet and 75 feet from the ends of the trench. Otherwise, the trench construction is similar to the CST trench.

Extraction well 4151RW-1 was installed in a hot spot within the plume to increase the extraction of dissolved contaminant mass. The well is located approximately 25 feet upgradient of the interceptor trench and screened in the upper portion of the surficial aquifer. The well is constructed with six-inch diameter, Schedule 40, PVC casing and slotted screen. It is 28.5 feet deep with 26 feet of 10-slot screen surrounded by a No. 2 Grade silica sand pack.

Pumps used in the trench sumps and in the extraction well are similar to those used at CSFF, as are the estimated pumping rates.

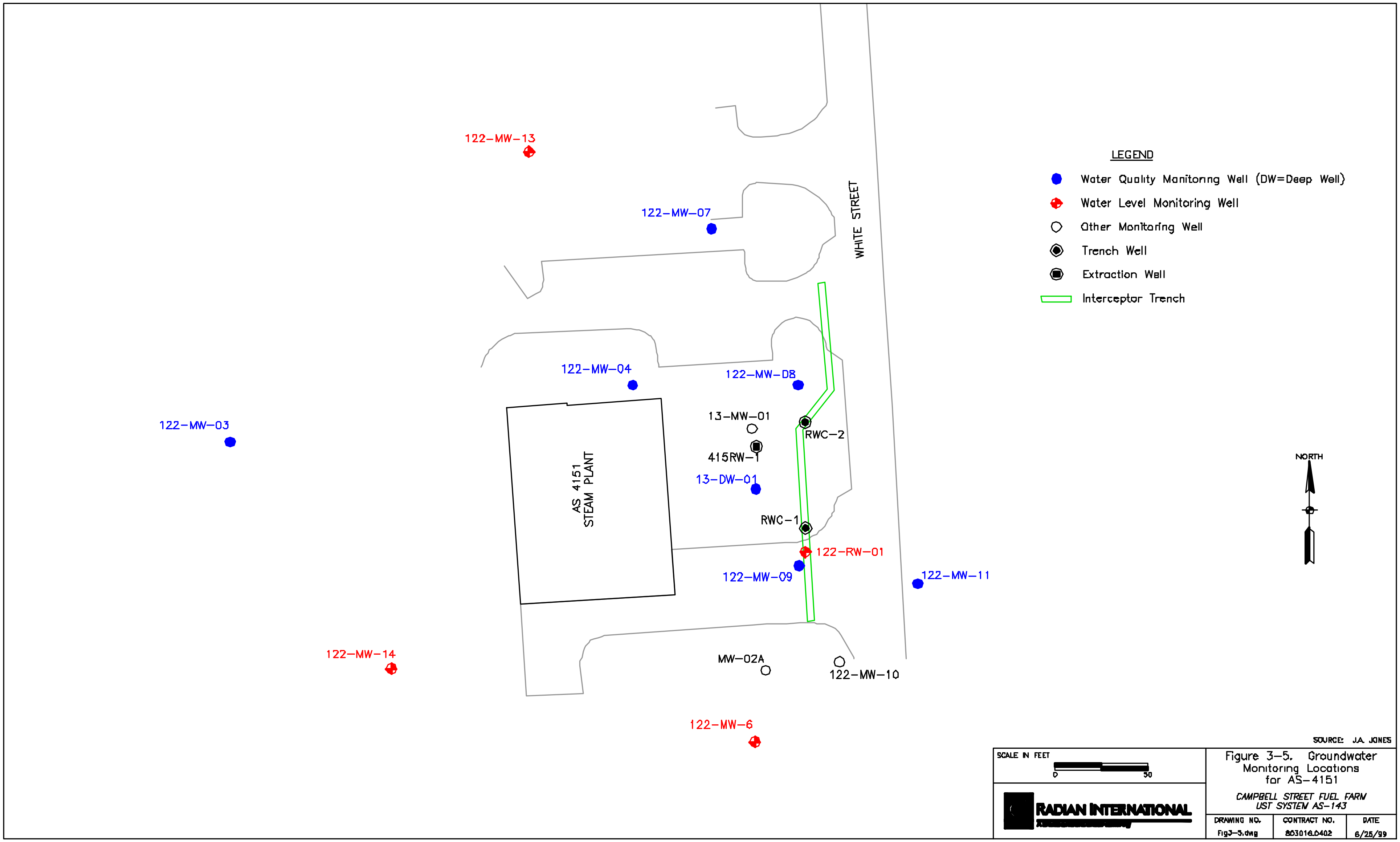
The monitoring well network for Building AS-4151 includes six shallow wells and one deep well. The wells are sampled each quarter. Each month, water levels are measured in these wells and in four additional monitoring wells: 122-RW-1, 122-MW-6, 122-MW-13, and 122-MW-14. The locations of monitoring wells used for sampling and water level measurement are illustrated in Figure 3-5.

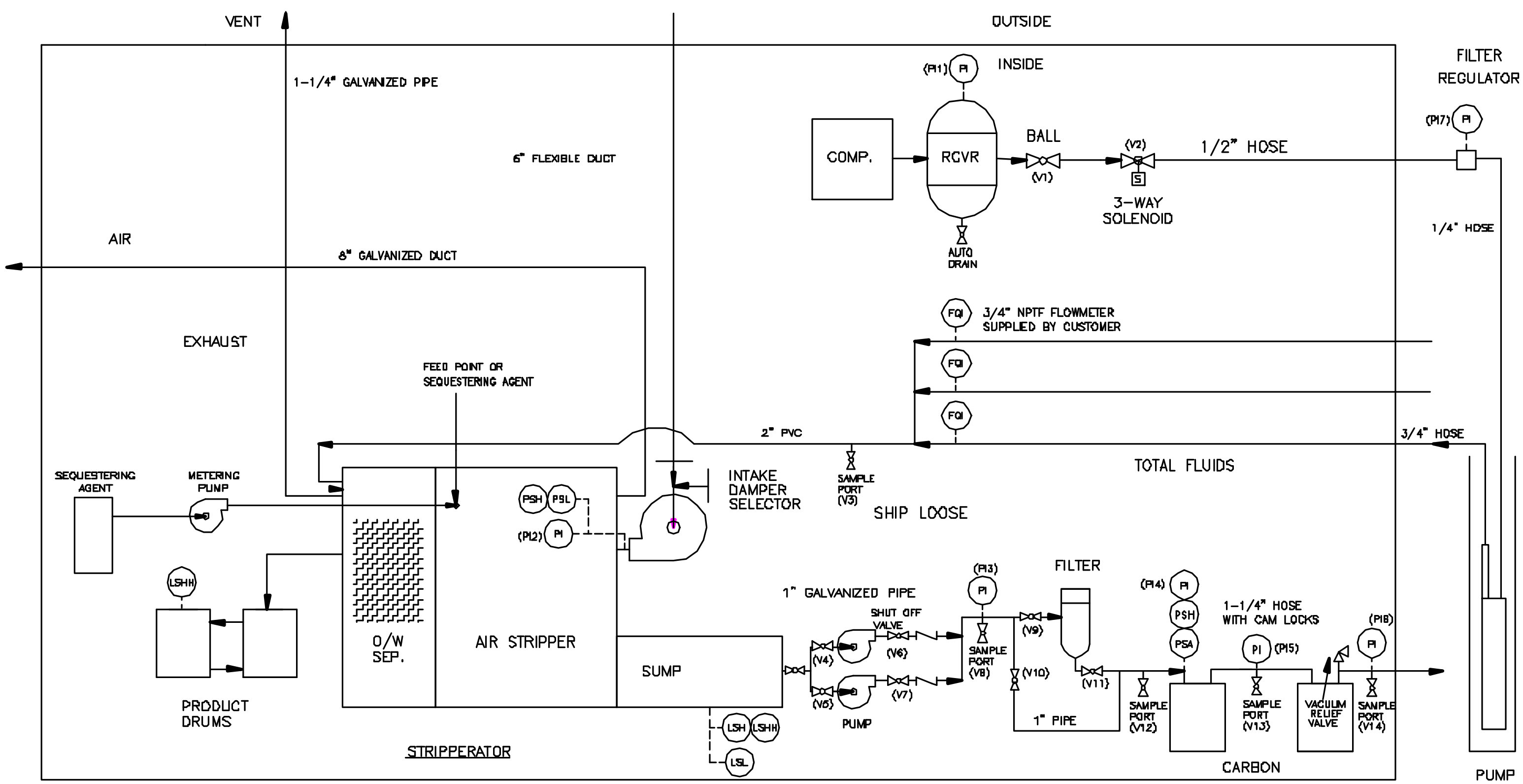
3.3.2 Description of Aboveground Treatment Train – A schematic of the aboveground groundwater treatment plant at the CSFF is presented in Figure 3-6. This treatment plant is a pre-assembled, containerized, and enclosed treatment system. It is mounted on a steel I-beam platform, so that it may be shipped, loaded, and unloaded by a crane or forklift without damaging the equipment, inter-connecting piping, or electrical conduit. The following describes the treatment process:

<u>Compressed Air System.</u> A 7.5-horsepower air compressor supplies compressed air for operation of the pneumatic well pumps.

<u>Sequestering Agent.</u> A sequestering agent (Aqua-Mag) is injected into the groundwater treatment influent prior to the oil/water separator. The sequestering agent helps maintain iron in solution to minimize potential iron fouling problems. The sequestering agent is introduced into the influent stream by a metering pump.

<u>Stripperator©</u>. Groundwater from the wells and trenches is pumped to the Stripperator©. The Stripperator© is a combination oil/water separator and an air stripping unit. The oil/water separator separates light non-aqueous phase liquids (LNAPL) from the groundwater. The LNAPL is transferred to two 55-gallon product drums for storage. Water from the oil/water separator then flows through a tray air stripper to remove VOCs. The stripper vapor is discharged directly to the atmosphere.


LEGEND
Water Quality Monitoring Well (DW=Deep Well)
Water Level Monitoring Well
Other Monitoring Well
Trench Well
Extraction Well
Interceptor Trench
NORTH
WHITE STREET
AS 4151
STEAM PLANT
122-MW-13
122-MW-07
122-MW-04
122-MW-D8
122-MW-03
13-MW-01
RWC-2
415RW-1
13-DW-01
RWC-1
122-RW-01
122-MW-09
122-MW-11
122-MW-14
MW-02A
122-MW-10
122-MW-6
SOURCE: J.A. JONES
SCALE IN FEET
0
50
RADIAN INTERNATIONAL
Figure 3-5. Groundwater Monitoring Locations for AS-4151
CAMPBELL STREET FUEL FARM
UST SYSTEM AS-143
DRAWING NO.
Fig3-5.dwg
CONTRACT NO.
803016.0402
DATE
6/25/99



SOURCE: J.A. JONES, 11 APRIL 1996

NOT TO SCALE	Figure 3-6. PROCESS FLOW DIAGRAM		
RADIAN INTERNATIONAL	CSFF GROUNDWATER TREATMENT PLANT		
	DRAWING NO.	CONTRACT NO.	DATE
	1aj99087 dwg	803018 0402	05/23/99

Filtration and Granular Activated Carbon (GAC) Adsorption. The water effluent from the air stripper is pumped by two transfer pumps through a bag filter to remove fines greater than 25 microns. Following filtration, the water is sent through two 800-pound granular activated carbon (GAC) units for polishing.

Treated Effluent Discharge**.** The treated water is discharged to nearby surface drainage.

Instrumentation and Control System. The system is designed with a telemetry system that monitors four dry contact input channels. The telemetry system will activate if one of the following "fail safe" conditions occur:

- High water level in air stripper sump;
- High pressure at GAC;
- High level in free product storage tanks; and
- Low pressure at air stripper blower.

If one of these conditions is met, the solenoid valve will close and the system will temporarily shut down. The telemetry system is capable of dialing four telephone numbers with message acknowledgement.

3.3.3 Design Specifications and Parameters – The entire system was designed to remediate groundwater contaminated by releases of product from the USTs at the sites. The system was designed to collect and treat contaminated groundwater and to mitigate the potential for offsite contaminant migration. The remedial objective for this system as stated in the CAP is to reduce groundwater contaminant concentrations at the CSFF to North Carolina Water Quality Standards and remove measurable free product from the water table at the CSFF. If it is determined that attaining the standards is not practical, remediation activities will continue until contaminant concentrations are reduced to asymptotic conditions.

The remediation end point for free product is less that 0.01 feet of free product present on the water table (Baker, 1994). The design flow for the treatment plant is 15 gpm, however the Stripperator© has a maximum capacity of 30 gpm and each recovery pump has a maximum capacity of 6 gpm. The treatment plant is designed to remove free product, fuel, and VOC concentrations to below the North Carolina Water Quality Standards and meet the National Pollution Discharge Elimination System (NPDES) requirements for discharge into the surface drainage system. The standards for each COC are listed in Table 3-5.

To monitor the performance of the CSFF treatment plant, the Operations and Maintenance (O&M) Manual (J.A. Jones, 1996) indicates that treatment samples are collected monthly as shown in Table 3-6. In addition to the analyses described in the O&M manual and Table 3-6, samples are also analyzed for total hardness.

Table 3-5. Effluent Standards for the CSFF Treatment Plant

Contaminant of Concern	NPDES Permit Requirements (ug/l)		North Carolina* Water Quality Standard (µg/L)
	Monthly Average	Daily Maximum	
MBTE			200
Benzene	71.4	142.8	1
Toluene	11	22	1000
Ethylbenzene			29
Xylenes			400
EDB			0.0005
1,4-Dichlorobenzene			1.8
1,2-Dichlorobenzene			620
Naphthalene			21
Arsenic			0.05
Barium			2.0
Cadmium			0.005
Chromium			0.05
Iron			0.3
Manganese			0.05
Lead			0.015
Selenium			0.05
TDS			500

*From NC Administrative Code 15A NCAC 2B.0200

Notes: MTBE = Methyl Tertiary Butyl Ether
EDB = Ethylene Dibromide

Table 3-6 Monthly Performance Monitoring for the CSFF Groundwater Treatment Plant

Analytes	EPA Analytical Method	Recovery Trench Effluent (each trench)	Air Stripper Influent	Air Stripper Effluent	1st GAC Effluent	2nd GAC (final) Effluent
VACs	602	x	x	x	x	x
Metals	6010	x	x	x	x	x
PAH	610	x				x
TDS	160.1	x	x	x	x	x
TSS	160.2	x	x	x	x	x

VACs = volatile aromatic compounds
TDS = total dissolved solids
TSS = total suspended solids
PAH = Polyaromatic compounds

3.3.4 System Upgrades and Modifications – Since initial operation, no major upgrades or modifications have been performed to the treatment plant. However, four groundwater recovery wells were installed to expedite the recovery and treatment of the dissolved contaminant plume. No treatment plant modifications were required for addition of these wells.

3.4 Best Practices Already in Place for CSFF

This section is intended to highlight good management practices that have been implemented at Camp Lejeune by its O&M contractors. The use of a modular/mobile design of the treatment equipment is considered a good O&M practice. This modular/mobile design allows for potential beneficial reuse of this equipment at other contaminated sites.

3.5 CSFF Treatment System Performance Baseline

The technical performance and cost effectiveness of the CSFF treatment system in comparison to its design and remedial action objectives is poor. As described in the following section, the plant and extraction system has demonstrated the following characteristics:

- Influent flow rates of less than 10% of design capacity;
- Low contaminant mass removal, i.e., less than 3.5 pounds of cumulative mass removed over 2.5 years of system operation;
- Poor cost effectiveness, evident in the average cost per pound of contaminant removed of $95,000; and,
- Little evidence that the system is significantly contributing to the restoration of the aquifer to the North Carolina Department of Water Quality (NCDWQ) cleanup standards. No contaminant mass is being removed by two of the three recovery trenches (AS-4151 and Campbell Street trenches).

3.5.1 CSFF Treatment System Cost and Performance Baseline – Figures 3-7 through 3-12 are cost and performance plots for the period of July 1996 through March 1999 for the CSFF 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:

- **Figures 3-7 through 3-9, "Combined Trench Influent VOC Concentrations vs. Time":** As shown in Figures 3-7 through 3-9, the monthly total VOC influent concentrations for the Campbell Street and AS-4151 trenches have achieved asymptotic conditions in recent months. For the Campbell Street trench (Figure 3-7), with the exception of two spikes, the total VOC concentration has been below 15 ppb since December 1996. For the AS-4151 trench (Figure 3-8), the total VOC concentration has been at zero

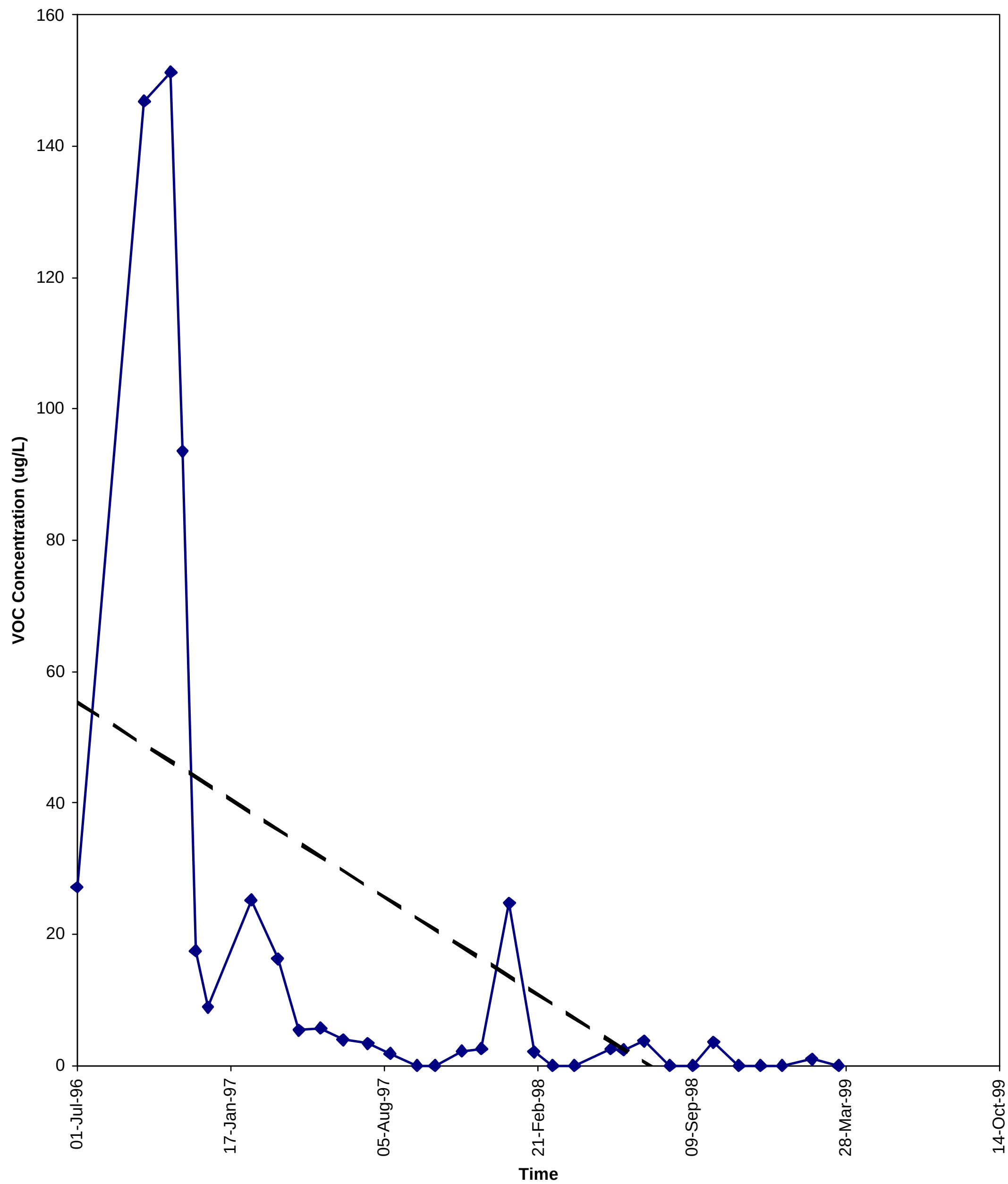


Figure 3-7. Influent VOC Concentrations vs. Time
Campbell Street Fuel Farm
CST Trench

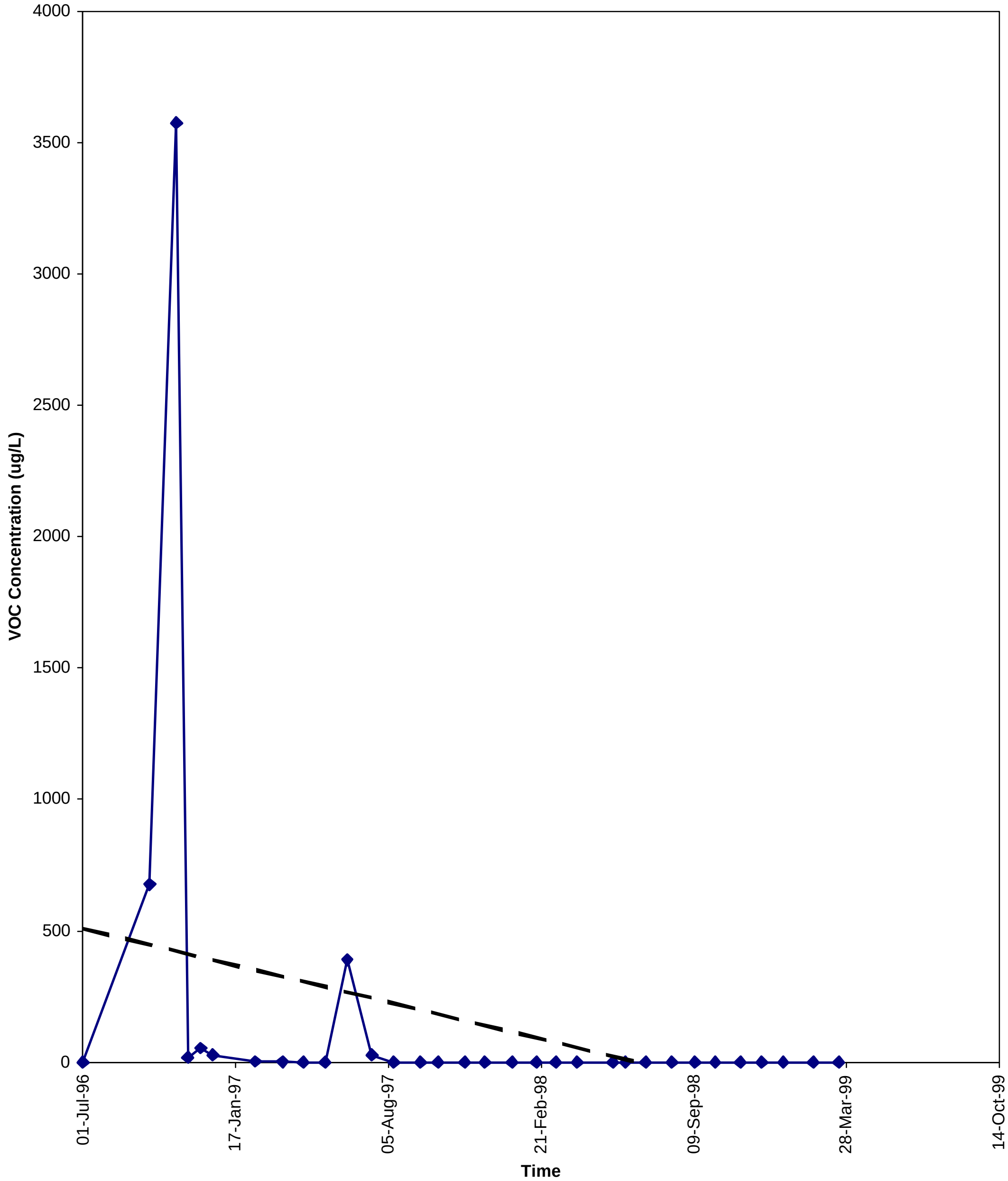


Figure 3-8. Influent VOC Concentrations vs. Time
Campbell Street Fuel Farm
AS-4151 Trench

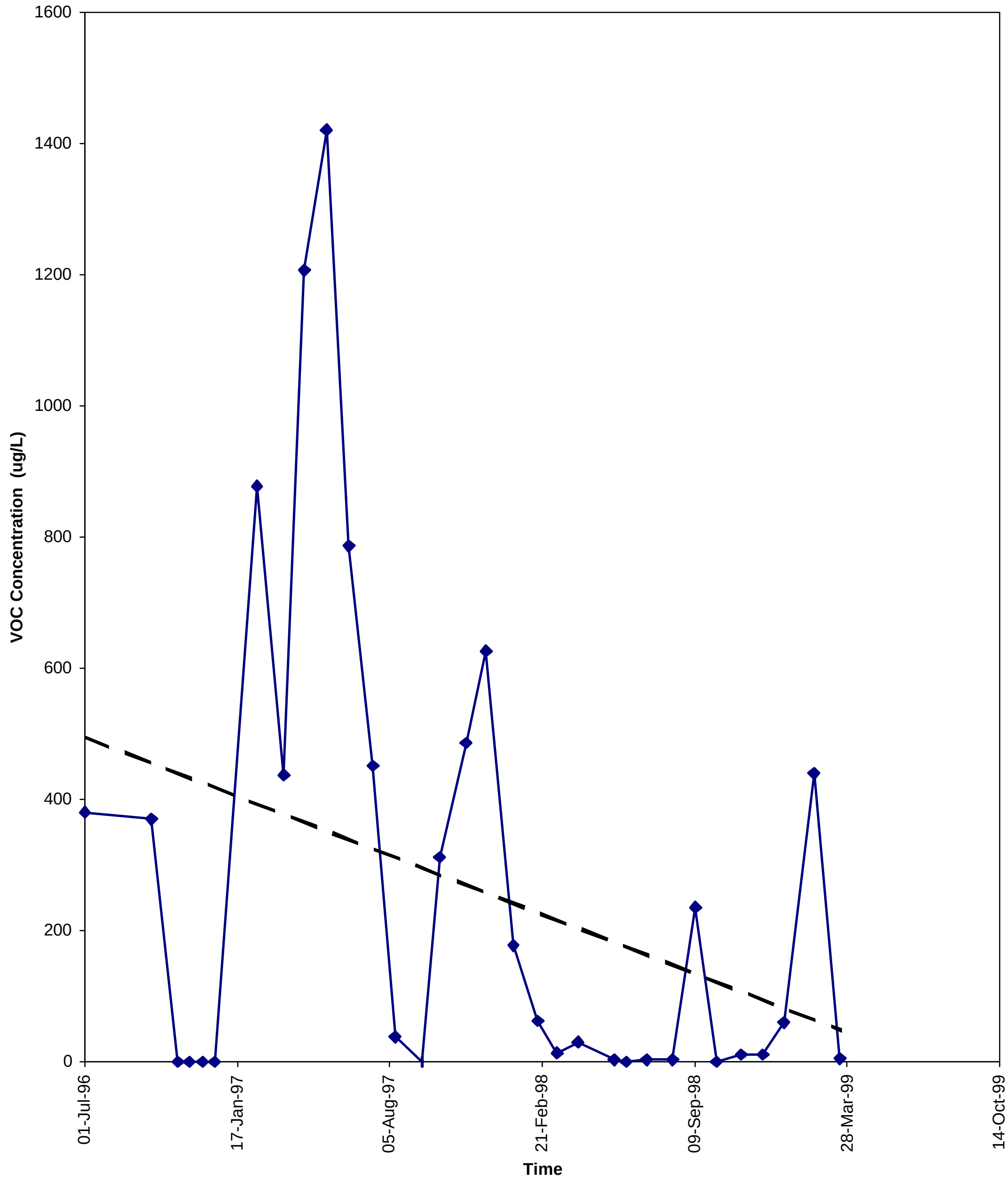


Figure 3-9. Influent VOC Concentrations vs. Time
Campbell Street Fuel Farm
AS-143 Trench

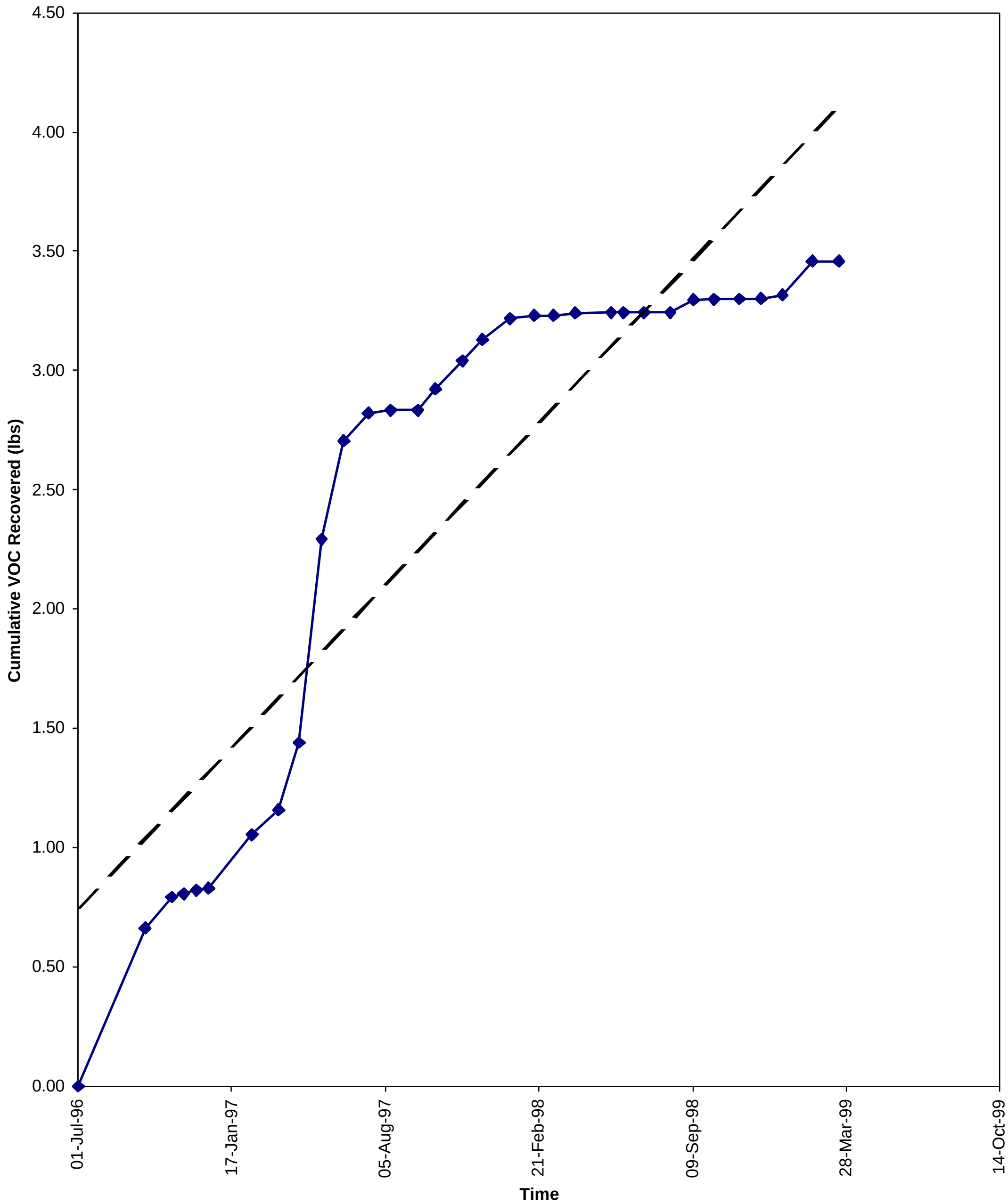


Figure 3-10. Cumulative Mass Recovered vs. Time
Campbell Street Fuel Farm

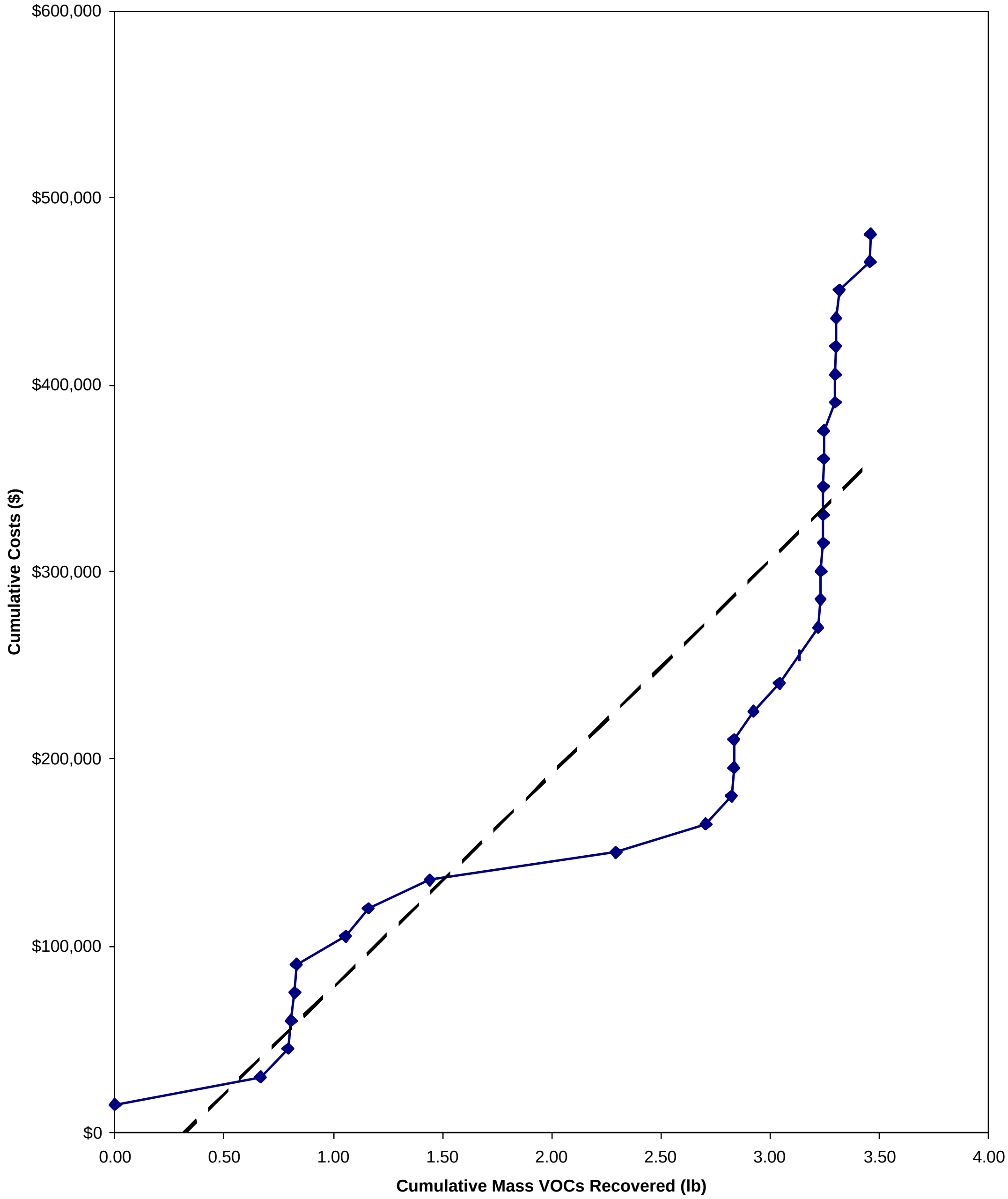


Figure 3-11. Cumulative Costs vs. Cumulative VOCs Recovered Campbell Street Fuel Farm

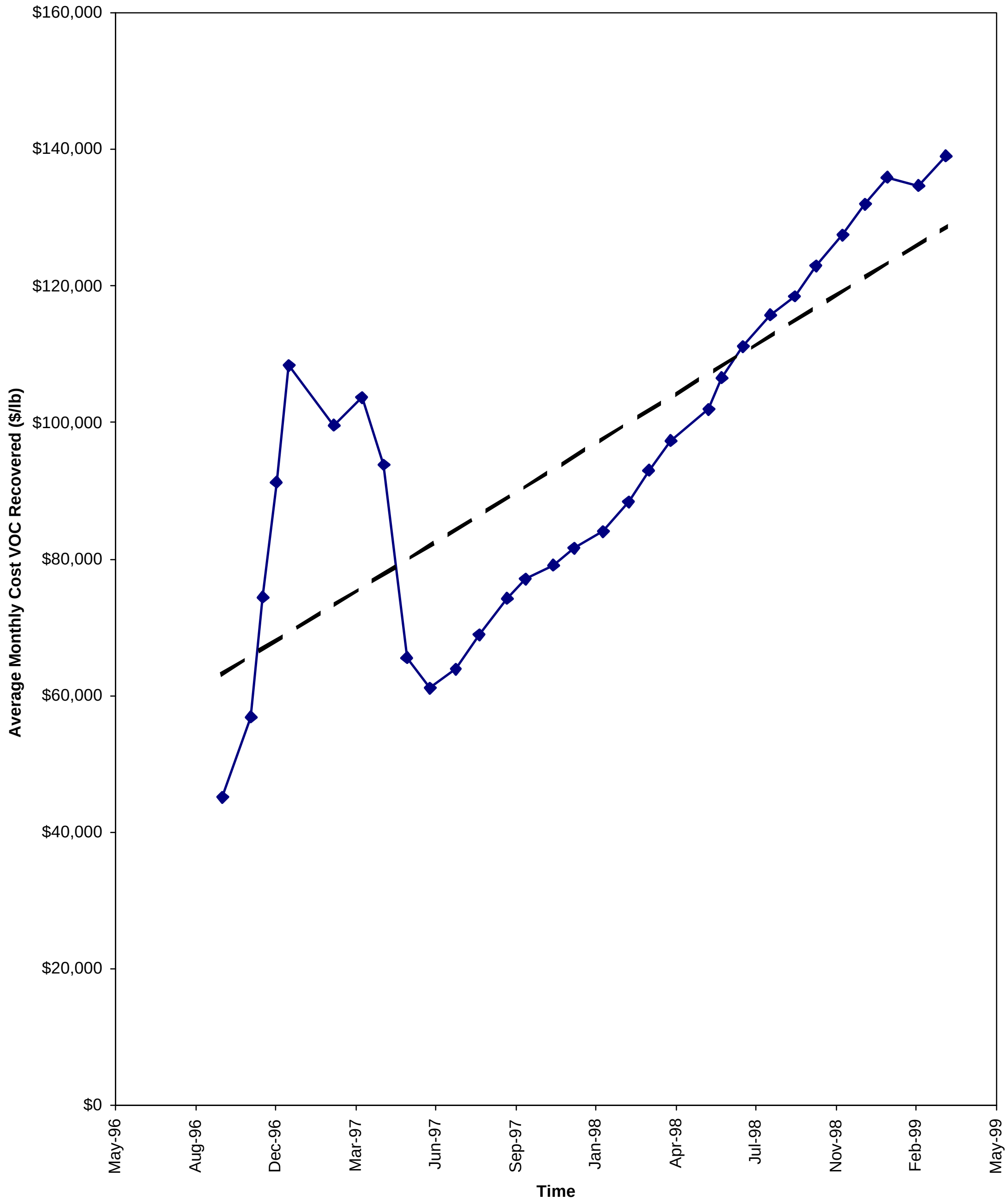


Figure 3-12. Average Cost Per Pound Recovered vs. Time
Campbell Street Fuel Farm

since August of 1997. The AS-143 trench (Figure 3-9) continues to show some contamination, as a mass spike of 440 ppb was reported in February 1999, but the trend overall has been one of decreasing concentrations.

- **Figure 3-10, "Cumulative Mass Recovered vs. Time":** The CSFF system removed just 3.46 pounds of VOC during an operational period of July 1996 through March 1999. Less than 0.5 pounds of VOC have been removed since December 1997, which is reflective of the asymptotic conditions in two of the three trenches. An extraction well has been installed at each of the trenches recently (April 1999) which should improve performance, but overall mass recovery has been minimal.
- **Figure 3-11 "Cumulative Costs vs. Cumulative VOCs Recovered":** Figure 3-11 graphically displays the cost ineffectiveness of the Campbell Street treatment system. Approximately $175,000 was spent to remove 3 pounds of VOCs, with $325,000 of additional expenditure to remove an additional 0.5 pounds of VOCs.
- **Figure 3-12, "Average Cost Per Pound Recovered vs. Time":** As seen in Figure 3-12, the average cost per pound removed for the Campbell Street system is trending sharply upward. Since June 1997, the average cost per pound of VOC removed has increased from $60,000 to almost $140,000.

Table 3-7 summarizes performance parameters for the CSFF system.

Table 3-7. CSFF System Design Versus Performance Data

Parameter	Design	Actual Average[1]	Actual Median[1]
Combined Trench Average Flow Rate (gpm)	15	2.00	1.91
Monthly Combined Trench Volume (gallons)	648,000	86,272	82,380
Combined Trench Monthly Mass removed (lbs.)	N/A	0.11	0.02
Average cost per mass ($/lb.)	N/A	$95,279	$93,851

[1]Based on performance data from July 1996-March 1999.

NOTES: gpm = gallons per minute
lb(s) = pounds

3.5.2 Extraction System and Monitoring Well Network – The CAPs for the CSFF and Building AS-143 (Baker, 1994a) and Building AS-4151 (Baker, 1994b) specify that the pump and treat system will operate until groundwater quality is restored to the level of the specified cleanup goals or until asymptotic levels of contaminants are documented. As previously discussed, the extraction systems at the CSFF and at Building AS-4151 are no longer removing contaminant mass and thus are extremely unproductive. At Building AS-143, the quality of extracted water and samples from on-site monitoring wells support the presence of a contaminant plume that continues to migrate toward the AS-143 trench. Therefore, the following sections address the performance of only the extraction system at Building AS-143. However, data gaps that affect the ability of the monitoring programs to assess plume behavior and/or extent at any of the three sites are identified.

3.5.2.1 Hydraulic Head and Gradients

The number and location of monitoring wells for water level measurement are inadequate to calculate hydraulic gradients and demonstrate whether or not the contaminant plume at Building AS-143 is contained both horizontally and vertically. Water levels are routinely measured in only two wells on-site. In addition, no monitoring wells are located in areas downgradient of the AS-143 trench to assess groundwater flow direction immediately off-site.

3.5.2.2 Pumping Rates

The interceptor trenches installed to extract groundwater at the three sites represent the least aggressive P&T option available. At a design flow rate of only 1 gpm (Baker, 1995) and an actual pumping rate of between 0.5 and 1 gpm, the interceptor trenches appear unable to facilitate groundwater restoration any faster than natural degradation processes.

3.5.2.3 Extracted Water Quality

In 1996, during the initial months of P&T system operation, maximum concentrations of VOCs in groundwater extracted from the CST trench and the AS-4151 trench were 181 and 9,829 micrograms per liter, respectively. However, since August 1997, the concentrations of VOCs measured in groundwater extracted from the CST trench and the AS-4151 trench indicate that no mass removal is occurring at either site (i.e., VOC concentrations are below detection limits). During the past 20 months, through March 1999, the mean concentration of VOCs in groundwater extracted from the CST trench was less than 1 microgram per liter. During the same period, no VOCs were detected in groundwater extracted from the AS-4151 trench. These results suggest that contaminants originally present in groundwater adjacent to the interceptor trenches have been removed and the remaining plume hot spots at upgradient locations are stationary or possibly receding.

During the initial months of system operation at the AS-143 trench, the mean concentration of VOCs in groundwater extracted was 832 micrograms per liter. The mean concentration has since decreased to 22 micrograms per liter for the 20-month period between August 1997 and March 1999. However, variations in VOC concentration, ranging from ND concentrations up to 440 micrograms per liter, have been recorded over the last six months of record. The sporadic peaks in the VOC concentration represent hot spots within the contaminant plume that continue to migrate toward the interceptor trench under the influence of natural groundwater flow.

3.5.2.4 Contaminant Concentration and Distribution

Assumptions regarding the migration of the contaminant plumes at the three sites are based primarily on the quality of water extracted from the interceptor trenches. Dependence on extracted water quality data is due to the inadequacy of the monitoring well to determine the extent of contamination, the rate of contaminant plumes migration, confirmation of hydraulic containment, or the rate of natural attenuation processes. The inadequacy of the well networks is notable in several respects.

First, no monitoring wells are located downgradient of the interceptor trenches or, in the case of the CST trench, existing downgradient wells are not sampled. Second, at Building AS-4151, only one well (13DW-1) is screened in the lower portion of the surficial deposits to monitor COCs that are present at concentrations exceeding the groundwater standards. Consequently, the areal extent of contamination depicted on isoconcentration contour maps (see Figures 3-2 and 3-3) is grossly inferred and reflects the limitations of the well networks for evaluating system performance and assessing plume extent or migration.

In addition, at Building AS-4151, the monitoring program does not include adequate sampling and analysis for relevant COCs. Polyaromatic hydrocarbons (PAHs) have been detected at concentrations above the standards in several wells located upgradient of the AS-4151 trench. More PAHs exceed their respective standards than VOCs. Also, the concentrations of PAHs are typically higher relative to the standards than is the case for VOCs. Therefore, accurate assessment of PAHs is considered important because their concentration and distribution in groundwater may be more significant than that of the VOC concentrations in formulating a closure strategy at this site. However, the current monitoring program requires that samples collected from only shallow well 122MW-9 and deep well 13DW-1 be analyzed for PAHs.

3.5.3 Aboveground Treatment Train Performance – Since operation began in July 1996, the equipment in the aboveground treatment train for the plant at the CSFF has been performing at a level that meets requirements of the design basis. However, from September 1996 to March 1999, the plant has operated at an average flow rate of 2 gpm, which is less than 15% of the total design flow rate of 15 gpm because of the low groundwater extraction rate from the aquifer. Based on records beginning in September 1996 through July 1997, the treatment plant operated approximately 255 days, achieving an uptime percentage of 80%. The most common reason for downtime was a problem associated with clogged bag filters and backwashing of GAC due to high solids content. According to the equipment operator, the GAC is changed out every 6 months due to fouling and channelization through the carbon. Equipment operators visit the site approximately 3 times a week to fill up the sequestering agent tank and change out bag filters. The bag filters are typically changed out approximately 2 times per week. The operator also mentioned that the individual influent flow meters tended to fail and are inaccurate.

From July 1996 to March 1999, the treatment plant effluent has continuously exceeded groundwater discharge limits for total metals such as iron and manganese and total dissolved solids (TDS). On 11 occasions the lead effluent limit was also exceeded. If this system continues to operate, the metals and TDS levels must be reduced during the treatment through a metals removal process to meet effluent requirements.

During this same time period, no dichlorobenzene (Method 602) has been detected in any of the performance samples. Based on these results, the need to report and evaluate this analyte as part of the performance monitoring program is unwarranted.

From July 1996 to March 1999, no VOCs have been detected in the air stripper effluent. This period of time is adequate to prove that the air stripper has an adequate removal efficiency to meet VOC effluent standards and that GAC polishing is not needed.

A review of the existing sampling and analysis plan for the CSFF indicates that analysis for metals, TDS, and total suspended solids (TSS) of the performance sample collected between the GAC units is not warranted, as GAC is designed to target removal of VOCs.

The capital and operations and maintenance (O&M) costs for the CSFF P&T system are provided in Table 3-8. The capital costs to construct the CSFF system and prove out were $507,395. Amortized over 10 years, the capital costs are approximately $69,000 per year. The average annual O&M costs are $111,000 for a total annual cost of $180,000. Almost one-third of the annual O&M budget is labor costs, which is considered excessive for an automatic package plant like the CSFF system.

Table 3-8. Capital and Operation and Maintenance Costs for the CSFF Groundwater P&T System

Cost Item	Total Project Costs as of 5/31/99 (Capital, Proveout and O&M costs)	Total Project Costs as of 9/30/96 (Capital and Proveout Costs)	O&M Costs from 9/30/96 to 5/31/99	Average Monthly O&M Costs	Average Annual O&M Costs
Professional labor	$133,385	$85,831	$47,554	$1,486	$17,833
SCA labor	$12,772	$4,899	$7,873	$246	$2,953
Craft labor	$59,766	$27,386	$32,380	$1,012	$12,142
Materials	$107,967	$78,869	$29,097	$909	$10,911
Small tools	$1,262	$530	$732	$23	$275
Consumables	$1,767	$742	$1,025	$32	$384
Fixed price subs	$220,053	$190,207	$29,846	$933	$11,192
ODC's (including analytical)	$210,418	$82,623	$127,795	$3,994	$47,923
Travel	$15,860	$10,094	$5,766	$180	$2,162
Per diem	$11,548	$8,107	$3,441	$108	$1,290
Co-owned equipment	$14,905	$5,997	$8,908	$278	$3,340
3rd party equipment	$14,653	$12,109	$2,543	$79	$954
Totals	**$804,356**	**$507,395**	**$296,961**	**$9,280**	**$111,360**
Amortized Capital Costs (10 years)		$68,939		$5,745	$68,939
Total Capital and O&M Cost				**$15,025**	**$180,299**

ODC = Other Direct Costs

4.0 CONCLUSIONS AND RECOMMENDATIONS FOR CSFF P&T SYSTEM

In light of the poor performance of the existing P&T system and asymptotic contaminant conditions in two of three interceptor trenches, it is recommended that active treatment be discontinued at CSFF except for possible hot spot removal at AS-143. Two of the three recovery trenches feeding the CSFF P&T are virtually inactive. The AS-4151 trench has operated for 20 continuous months without removing any VOCs. Following confirmation that no source material remains at the abandoned Campbell Street JP-5 pipeline, active remediation should be discontinued at the CSFF and AS-4151.

The AS-143 recovery trench produces negligible quantities of contaminants and should be abandoned as soon as possible. The addition of extraction wells at the AS-143 hot spots are expected to be effective, but another more aggressive technique, such as AFVR, could be more efficient and cost-effective. AFVR uses a high vacuum and flowrate to rapidly remove hydrocarbons from groundwater and capillary fringe. AFVR removes vapors, free product, and groundwater simultaneously. A mobile AFVR unit could be used strategically to remediate hot spot contamination without the use of the existing system, and would allow for the shutdown of the entire CSFF P&T system.

A sampling program to measure parameters that indicate if site conditions are favorable for monitoring natural attenuation (MNA) should be implemented as soon as possible. The corrective action rule allows MNA as the selected remedy for the site provided evidence demonstrates that conditions are conducive to natural remediation processes and natural attenuation is occurring. Specifically, data should show that: free product and contaminant sources have been removed or controlled; contaminants have the capacity to degrade or attentuate under site conditions; contaminant migration can be predicted; and, contaminants are not calculated to migrate to a receptor at concentrations exceeding applicable standards. Groundwater parameters that will be measured to evaluate natural attenuation at the site include COC concentrations, pH, conductivity, temperature, oxidation-reduction potential, chloride, electron acceptors (dissolved oxygen, nitrate, and sulfate), and metabolic byproducts (ferrous iron and bicarbonate). Additionally, to discontinue active remediation at CSFF and transition to a passive remedy, several data gaps in the characterization of the site must be addressed. The lateral and vertical extents of contamination are not currently well defined. The extent to which (if at all) the plume has migrated has not been investigated; and a study of nearby water wells should be conducted to ensure that there are no active water supply wells within 1,500 feet of the site. Requirements for information regarding the identification of water supply wells and other receptors located within 1500 feet of a release is specified in *North Carolina Administrative Code Title 15A Subchapter 2L Section .0115* and in *Groundwater Section Guidelines for the Investigation and Remediation of Soil and Groundwater, Volume II* (NC Department of Natural and Environmental Resources, 1998).

4.1 CSFF Optimization Recommendations

4.1.1 Extraction Systems and Monitoring Well Networks – The following recommendations are provided for the CSFF extraction systems and monitoring well networks:

4.1.1.1 Extraction Systems

Given the principal recommendation to terminate operation of the P&T system as soon as possible, no modifications to any of the three extraction systems are recommended.

4.1.1.2 Monitoring Well Networks

The groundwater monitoring program should be modified to improve the current understanding of contaminant extent, plume behavior, and potential for natural attenuation at each of the sites. The modifications should include changes in the number and location of the monitoring wells used for water level measurement and water sample collection.

New wells may need to be installed to provide information at locations and from depths where information is lacking. Modifications to the groundwater monitoring program should also include changes in analyte lists to assess site-specific COCs and to develop evidence of natural attenuation on a site-by-site basis. General and site-specific recommendations are outlined below:

General Recommendations

- Measure water levels in all wells at the three sites. The cost of measuring additional wells as part of the existing LTM program is insignificant. Also, add water level measuring points in adjacent ditches if they are groundwater discharge areas.

- To the extent possible, the monitoring program should be complementary between sites. For example, groundwater quality data pertaining to the CSFF should serve as upgradient data for Building AS-4151. Similarly, water level measurements from all sites should be considered when interpreting groundwater gradients and flow directions.

- Develop and implement a sampling program to evaluate and document conditions in groundwater favoring natural attenuation at the sites. Supplement site-specific COCs on the current analyte list with appropriate electron acceptors, metabolic byproducts, and geochemical parameters that influence biological and chemical reactions in the degradation process. EPA guidance on MNA is available in EPA directive 9200.4-17P, "Use of MNA at Superfund, RCRA Corrective Action, and UST Sites", April 21, 1999. Navy guidance on MNA is available in "Technical Guidelines for Evaluating MNA of Petroleum Hydrocarbons and Chlorinated Solvents in Groundwater at Naval and Marine Corps Facilities," September 1998. The State of North Carolina has codified its MNA guidance in 15A NCAC 2L.0106(l).

CSFF

- Reschedule sampling deep well DW-2 from quarterly to annually. Since 1996, only three COCs have been detected on a single occasion in samples from this well. Reported concentrations ranged from four to 18 times less than their respective groundwater standards.

- Remove well MW-14 from the groundwater quality monitoring network. No COC has been detected in samples from this well for the period of record beginning in 1996.

- Substitute well MW-13 for MW-11. No COCs have been detected in samples from MW-11 for the period of record beginning in 1996. Well MW-13 is also upgradient of the plume, but is located closer to the apparent plume boundary.

- Install a monitoring well downgradient of the site between wells MW-15 and MW-22. Add both existing wells and the new well to the LTM program.

Building AS-143

- Based on a comparison of water level measurements in the ditch and in adjacent monitoring wells, assess the possibility that the drainage ditch located approximately 15 feet east of AS-143 is a discharge point for groundwater from the site. If so, consider collecting water samples from the ditch using conventional sampling techniques or passive diffusion samplers and analyzing for benzene, toluene, ethylbenzene, and xylenes (BTEX).

- Initially, sample and analyze all monitoring wells at the site for BTEX to assess their approximate distribution across the site. Based on the results, identify areas (i.e. downgradient) where installation and sampling of additional wells will be necessary to eliminate data gaps. At a minimum, wells will be necessary south and east of the site. Also, eliminate from future sampling events, any wells that do not provide data critical to the interpretation of BTEX distribution.

Building AS-4151

- Add PAHs to the analyte list for all groundwater samples collected at Building AS-4151.

- Initially, sample and analyze all monitoring wells at the site for PAHs to assess their approximate extent. Based on the results, identify areas (i.e. down-gradient) where installation and sampling of additional wells will be necessary to eliminate data gaps. Also, eliminate from future sampling events, any wells that do not provide data critical to the interpretation of PAH distribution.

4.1.2 Aboveground Treatment Train Recommendations – If interim operation of the CSFF P&T system is required by regulators, the following are recommendations for the CSFF aboveground treatment train. These recommendations are also summarized in Table 4-1.

- According to the equipment operator, the individual influent flow meters tend to fail and are inaccurate. Recommend replacing and/or repairing influent flow meters to obtain consistent and accurate influent flow rates. Magnetic flow meters may be used as they are more resistant to clogging problems. Three magnetic flow meters will cost approximately $3,000.
- Based on the air stripper and GAC effluent performance discussed in Section 3.0, we recommend requesting that NPDES requirements be modified to allow for discharge to the surface drainage and to eliminate carbon polishing.
- In addition, the GAC and cartridge filters should be bypassed during normal operation. This change will require discussions with regulators to modify the NPDES permit. The GAC will be readily accessible if effluent sampling indicates that GAC is needed to reduce effluent concentrations. This recommendation will save labor and cost by reducing the amount of back flushing and eliminating the need for filter bag and GAC replacement. It is estimated that the annual replacement cost of cartridge filters is $400 and the annual replacement cost of GAC is $4,000. A decrease in labor (approximately 100 hours) to change filters, backwash carbon and manage sludge generated by back washing will represent annual cost savings of $4,000.

  This recommendation will also reduce the analytical cost by removing the monthly performance monitoring analyses of the 1st and 2nd GAC effluent for annual savings of $4,800. This will eliminate the problem with channeling and clogging of the GAC units, and will also eliminate the most prevalent cause for system shutdown, clogging of the filters and backwashing the GAC.
- Until the GAC units may be bypassed and the GAC performance samples can be eliminated, recommend discontinuing analysis for metals, TDS, and TSS after the air stripper and between GAC units as these analytes are not treated by GAC or the air stripper. This would result in a cost savings of $175 per month.
- Recommend eliminating dichlorobenzene analytes from the Method 602 analysis for performance sampling as no dichlorobenzene has been detected in any of the performance samples. A small cost savings may be realized by shortening the analyte list for Method 602, but this will be dependent on the contract with the laboratory.
- Recommend replacing the sequestering agent with an iron/metals removal system to help meet the effluent standards for metals and TDS. An ion exchange unit or other metals removal system may be used to remove iron and metals prior to the air stripper. This would be performed instead of keeping the metals in solution. This would help reduce the amount of fouling and help meet effluent standards. The costs for an ion exchange unit ranges between $0.30 to $0.80 per 1,000 gallons treated (FRTR, 1999). At a flowrate of 15 gpm (design flow), the ion exchange unit will have an annual operating costs between $2,500 to $6,250. At a flowrate of 3 gpm annual operating cost are expected to be $500 to $1,250.

Table 4-1. CSFF Evaluation and Optimization Summary

System Component	Consideration	Cost Impacts	Effectiveness Impacts
Monitoring Network	Modify water level monitoring network	• No cost increase.	• Integrate data from multiple sites. • Increase confidence in data interpretation.
Monitoring Network	Develop and implement an MNA sampling program.	• Cost contingent on the complexity of the work plan developed.	• Justify permanent termination of active corrective action.
Monitoring Network	Modify water quality monitoring network at CSFF.	• No net change in cost.	• Add downgradient monitoring points for plume delineation. • Eliminates unnecessary monitoring points.
Monitoring Network	Modify water quality monitoring network at AS-143.	• Initial evaluation cost of $1,000. • Modification cost contingent on number and depth of additional wells needed.	• Add monitoring points necessary for plume delineation.
Monitoring Network	Modify water quality monitoring network at AS-4151.	• Initial evaluation cost of $2,500. • Modification cost contingent on number and depth of additional wells needed.	• Add COCs and monitoring points necessary for plume delineation.
CSFF Aboveground Treatment Plant	Repair or replace influent flow meters	• Maintenance cost to repair flow meters or costs to purchase new meters at $3,000.	• Increase in accuracy of influent flowrate measurement.
CSFF Aboveground Treatment Plant	Modify NPDES permits to allow GAC bypass for normal operation.	• Decrease filter cartridge replacement cost of $400/year. • Decrease in GAC replacement cost of $4,000/year. • Decrease in labor cost of $4,000/year. • Decrease in analytical costs by $4,800/year.	• Air stripper effluent samples will need to be monitored closely to ensure that effluent discharge standards are met. • Decrease costs associated with back washing, GAC replacement, and filter replacement. • The bypass will eliminate the need for performance monitoring analysis at two points in the process stream. • Reduce amount of system down time.

Table 4-1. CSFF Evaluation and Optimization Summary (Continued)

System Component	Consideration	Cost Impacts	Effectiveness Impacts
CSFF Aboveground Treatment Plant	Until GAC may be bypassed, discontinue analysis for metals, TDS, and TSS after air stripper and between GAC.	• Decrease in analytical costs by $175/month.	• No impact
CSFF Aboveground Treatment Plant	Eliminate dichlorobenzene analytes from Method 602 analysis.	• A small cost savings may be realized by shortening the analyte list, depending on the contract with the laboratory	• No impact
CSFF Aboveground Treatment Plant	Replace sequestering agent with an iron/metals removal system such as an ion exchange unit.	• Increase in annual cost of $1,200.	• Meet discharge requirements for TDS and metals. • Reduce biofouling

4.1.3 CSFF Recommendations Life Cycle Costs - A life cycle cost analysis was conducted for each of the RAO optimization recommendations for the CSFF Treatment System. 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% interest rate. Results of the life cycle cost analysis are presented in Table 4-2.

Table 4-2. Life Cycle Cost Analysis for CSFF 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"				$180,300	$759,489	$1.33M	$1.75M
Implementation of MNA[1]	$5,000	$20,000	$10,000	$35,000	$147,434	$257,603	$339,929
Repair or replace influent flow meters	No quantifiable annual cost benefit.						
Modify NPDES permits to allow GAC bypass for normal operation	($4,400)	($4,000)	($4,800)	($13,200)	($55,603)	($97,153)	($128,202)
Until GAC is bypassed, discontinue analysis for metals, TDS, and TSS after air stripper and between GAC			($2,100)	($2,100)	($8,846)	($15,456)	($20,396)
Eliminate dichlorobenzene analytes from Method 602 analysis			($200)	($200)	($842)	($1,472)	($1,942)
Replace sequestering agent with iron/metals removal system, such as ion exchange unit	$1,800	$1,800		$3,600	$15,165	$26,496	$34,964
Use AFVR on AS-143 hot spots[2]		$3,000		$3,000	One time cost – no recurring impacts.		
Perform MNA screening		$6,000	$6,000	$12,000	One time cost – no recurring impacts.		
Sample for PAH's at AS-4151		$1,500	$1,000	$2,500	One time cost – no recurring impacts.		

(Figures in parenthesis indicate cost savings)

[1] Additional monitoring wells and/or characterization may be required. These costs are unknown until screening has been performed.

[2] More than one AFVR event may be required. The cost presented in Table 4-2 is per event.

5.0 DATA ANALYSIS, TREND EVALUATION AND REPORTING

A review of the existing monitoring reports for the CSFF P&T system indicates that several steps may be taken to optimize the data analysis, trend evaluation, and reporting for this P&T system. The following recommendations will help improve understanding, decision making, and help optimize this remedial action. Each of the following items should be included in the semi-annual monitoring reports:

5.1 Performance Plots

We recommend plotting the monthly operation and cost data on performance plots similar to those found in Section 3.0 of this report (i.e., Figures 3-7 to 3-12). These plots will help visualize the cost and performance trends for the P&T 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 CSFF system is included in Section 3.4. The recommended performance plots are:

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

5.2 Contaminant Tracking

We recommend two methods to optimize plume and contaminant tracking at the CSFF site. By continuously tracking contaminants, the performance of the CSFF remedial actions may be assessed. In addition optimization decisions may be made as the plumes change or stabilize. We first recommend use of an interactive geographic information system (GIS). GIS along with other graphic 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. Currently, the analytical database at Camp Lejeune is in the process of being linked to a GIS package so that data can be spatially displayed and analyzed. A more detailed discussion of GIS as it relates to Camp Lejeune is presented in the *Marine Corps Base Camp Lejeune Long-Term Monitoring Optimization Case Study* (NAVFAC, 1999).

Secondly, we recommend plotting contaminant plumes for the individual COCs. This will allow Camp Lejeune to assess how well the remedial action is addressing each contaminant compared to their individual cleanup goals. These plots will also allow

Camp Lejeune to target and optimize the remedial systems based on the most problematic COCs.

5.3 Operational and Performance Reporting

Currently, the semi-annual monitoring reports for CSFF contain the following operation and performance related items: a short summary of operations, a table of performance monitoring analytical results, and a table with flow and operation time information. In addition to the information already provided, we recommend that the following information be included in the semi-annual monitoring report:

- Performance plots as mentioned above;
- Summary of operations and maintenance costs including maintenance, repairs, capital improvements, and utility costs;
- A more detailed summary of system downtime/repair actions;
- Discussion and analysis of system, plant, and extraction well performance;
- Discussion and analysis of whether effluent is meeting discharge requirements; and,
- Detailed maintenance logs included as an Appendix.

Presentation of this information will allow the Camp Lejeune 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.

6.0 REFERENCES

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