Final

Five-Year Review Report
Installation Restoration Sites
1, 22, 26, and 28

Former Naval Air Station Moffett Field
Moffett Field, California

February 12, 2010

Prepared for:
Base Realignment and Closure
Program Management Office West
San Diego, California

Prepared by:
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Contract Task Order 0059

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Final

Five-Year Review Report for Installation Restoration Sites 1, 22, 26, and 28
Former Naval Air Station Moffett Field
Moffett Field, California

Contract Task Order 0059

PREPARED FOR:

DEPARTMENT OF THE NAVY

REVIEW AND APPROVAL

KA Stewart — 2/12/2010

Kathryn Stewart,
BRAC Environmental Coordinator
by direction of the Director

Date

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ACRONYMS AND ABBREVIATIONS

µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
§	Section
Air Force	U.S. Air Force
AOP	Advanced oxidation process
ARAR	Applicable or relevant and appropriate requirement
Army	U.S. Department of the Army
AWQC	Ambient water quality criteria
bgs	Below ground surface
Basin Plan	San Francisco Bay Water Basin Plan
BRAC	Base Realignment and Closure
CAMU	Corrective action management unit
CCL	Calculated concentration limit
CCR	*California Code of Regulations*
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CIWMB	California Integrated Waste Management Board
COC	Chemical of concern
COPC	Chemical of potential concern
CQC	Contractor Quality Control
CTR	California Toxics Rule
DCA	Dichloroethane
DCB	1,2-dichlorobenzene
1,2-DCE	1,2-Dichloroethene
DEH	Santa Clara County Department of Environmental Health
DNAPL	Dense nonaqueous phase liquid
DTSC	Department of Toxic Substances Control
EATS	East-side Aquifer Treatment System
EC	Engineering control
EE/CA	Engineering Evaluation / Cost Analysis
EHC	A proprietary substrate consisting of plant material and zero-valent iron
EIMP	Environmental Issues Management Plan

EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Earth Sciences Associates, Inc.
ESD	Explanation of Significant Differences
FFA	Federal Facility Agreement
FFS	Focused feasibility study
FS	Feasibility Study
FWEC	Foster Wheeler Environmental Corporation, Inc.
GAC	Granular activated carbon
gpm	Gallons per minute
HAWP	Habitat alteration work plan
HHRA	Human health risk assessment
HLA	Harding Lawson Associates
HRC	Hydrogen Release Compound
IAS	Initial Assessment Study
IC	Institutional control
Insight	Insight Environmental, Engineering and Construction, Inc.
IR	Installation Restoration
ITC	International Technology Corporation
JMM	James M. Montgomery, Consulting Engineers, Inc.
LFL	Lower foundation layer
MCL	Maximum Contaminant Level
MEW	Middlefield-Ellis-Whisman
mg/L	Milligrams per liter
MOA	Memorandum of Agreement
Moffett Field	Former Naval Air Station Moffett Field
MP	Monitoring Parameter
msl	Mean sea level
na	Not applicable
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration

NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NEX	Naval Exchange
NFA	No Further Action
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRP	NASA Research Park
O&M	Operations and maintenance
OMMP	Operations, Maintenance, and Monitoring Plan
OU	Operational Unit
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethene
PMO	Program Management Office
PP	Proposed Plan
ppb	Parts per billion
PRC	PRC Environmental Management, Inc.
PRG	Preliminary Remediation Goals
RAB	Restoration Advisory Board
RACR	Remedial Action Completion Report
RAO	Remedial Action Objective
RGRP	Regional Groundwater Remediation Program
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
SARA	Superfund Amendments and Reauthorization Act
SDA	Storm drain action
SVOC	Semi-volatile organic compound
SWAT	Solid waste assessment test
SWRCB	California State Water Resources Control Board
TBC	To be considered
TCE	Trichloroethene
TDS	Total dissolved solids

TN&A	T N & Associates, Inc.
TPH	Total petroleum hydrocarbons
TPH-e	Total petroleum hydrocarbons-extractable
TtEC	Tetra Tech EC, Inc.
TtEMI	Tetra Tech EM Inc.
TtFW	Tetra Tech FW, Inc.
USFWS	U.S. Fish and Wildlife Service
UST	Underground storage tank
UXO	Unexploded ordnance
VI	Vapor intrusion
VOC	Volatile organic compound
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region
WATS	West-Side Aquifers Treatment System

EXECUTIVE SUMMARY

This report presents the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five-Year Review of the remedies implemented at Installation Restoration (IR) Sites 1, 22, 26, and 28 at former Naval Air Station (NAS) Moffett Field (Moffett Field), near Mountain View, California. This is the first Five-Year Review that encompasses all CERCLA sites at Moffett Field currently subject to the Five-Year Review requirement.

This review was performed by the Department of the Navy (Navy) in accordance with Executive Order 12580, CERCLA Section (§) 121(c), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) at 40 *Code of Federal Regulations* (CFR) §300.430(f)(4)(ii). The report was conducted following guidance contained in the *Navy and Marine Corps Policy for Conducting CERCLA Statutory Five-Year Reviews* (Department of the Navy [Navy] 2004) and the U.S. Environmental Protection Agency's (EPA) *Comprehensive Five-Year Review Guidance* (EPA 2001).

The purpose of this Five-Year Review is to evaluate the implementation and performance of the selected remedies at Sites 1, 22, 26, and 28, including whether the selected remedies remain protective of human health and the environment. This Five-Year Review is required for Sites 1 and 22 because hazardous substances, pollutants, or contaminants remain at the sites above levels that allow for unlimited use and unrestricted exposure, and their records of decision (ROD) were signed after October 17, 1986. This Five-Year Review is being conducted for Sites 26 and 28 because achieving the remedial action objectives and remediation goals has taken longer than five years.

This is the second Five-Year Review for Sites 22, 26, and 28, and the third Five-Year Review for Site 1. The signature date on the first Five-Year Review for Site 26 (February 14, 2005) was used as the trigger date for this Five-Year Review because it is the earliest trigger date of all the sites subject to the Five-Year Review requirement. The Five-Year Review schedules for Sites 1, 22, and 28 were advanced in accordance with the May 2004 update to the *Navy and Marine Corps Policy for Conducting CERCLA Statutory Five-Year Reviews* so that all four sites would be on the same Five-Year Review cycle. This review included document and data review, site inspections, personnel interviews, and regulatory agency comments. The methods, findings, conclusions, and recommendations identified during the review are presented in this report.

Site 1 (Operable Unit 1)

Operable Unit (OU) 1 consists of two inactive landfills, Sites 1 and 2. In 1997, the Navy and regulatory agencies signed the *Record of Decision* (ROD) *for Operable Unit 1* (Navy 1997). The remedy selected in the ROD included the following:

- Consolidating wastes from Site 2 into the Site 1 Landfill and designating the Site 1 Landfill as a corrective action management unit (CAMU).
- Backfilling the former site of the Site 2 Landfill with clean soil.
- Capping the Site 1 Landfill with a multi-layer cover.
- Conducting groundwater and landfill gas monitoring at the Site 1 Landfill.
- Conducting groundwater monitoring at the Site 2 Former Landfill for a minimum of 3 years after relocating the Site 2 Former Landfill waste to ensure groundwater at the Site 2 Former Landfill was not adversely affected.
- Installing a subsurface groundwater collection trench along the northern border of the Site 1 Landfill to intercept the potential future migration of leachate before it reaches surface water.
- Conducting post-closure maintenance activities at the Site 1 Landfill.
- Installing a passive gas-venting trench along the western boundary of the Site 1 Landfill to prevent potential off-site, subsurface migration of landfill gases.
- Implementing institutional controls (IC) and engineering controls (EC) to maintain the integrity of the landfill cover and to prevent disturbances or excavation of waste materials.

Except for permanent IC implementation, the components of the remedy have been completed in accordance with the requirements of the ROD. The Site 2 Landfill was excavated in 1997, and approximately 23,000 cubic yards of refuse was transferred and consolidated within the Site 1 Landfill. The excavation was backfilled with overburden soil removed during clearing and grubbing of the landfill surface. Clean imported soil was graded and hydroseeded following the excavation activities. Three years of post-excavation monitoring showed that groundwater had not been adversely affected by former activities at Site 2, and groundwater monitoring was discontinued with concurrence from EPA and State of California Regional Water Quality Control Board, San Francisco Bay Region (Water Board). No further action is required at Site 2. The Site 1 landfill cover was completed in 1998, is functioning as designed, and prevents human and animal exposure to landfill contaminants.

The Navy conducts internal site visits and quarterly inspections as part of IC implementation measures. To meet the annual reporting requirement to EPA, the Navy provides annual reports that detail the effectiveness of IC monitoring and implementation. IC implementation at Site 1 has not been completed because the National Aeronautics and Space Administration (NASA) has not placed permanent ICs into its land use planning documents.

Groundwater sample testing results from Site 1 indicate that volatile organic compounds (VOC), semivolatile organic compounds (SVOC), polychlorinated biphenyls (PCB), and pesticides at

Site 1 do not appear to be affecting the shallow aquifer based on the infrequent, low, and trace concentrations detected. Landfill gas monitoring at Site 1 has shown that landfill gas is not migrating off-site from the landfill. Required maintenance of the landfill cover includes backfilling shallow, small-diameter holes made by burrowing mammals. The Navy implemented a burrowing mammal trapping plan in 2009 (abatement plan) that focuses on removing burrowing mammals from Site 1.

This Five-Year Review found that the remedy for Site 1 is currently protective of human health and the environment because potential exposure pathways are incomplete, groundwater contaminant concentrations are stable, landfill gas is not migrating from the landfill, and the landfill cover is functioning as intended. To ensure long-term protectiveness of the remedy, the following actions must be taken:

- Incorporate ICs into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of ICs.

- Evaluate the effectiveness of the current abatement plan.

Site 22

Site 22 is an inactive landfill currently covered by the Moffett Field golf course. In 2002, the Navy and regulatory agencies signed the ROD for the Site 22 Landfill (Navy 2002a), which selected the following remedy:

- Installing a biotic barrier to prevent burrowing animals from disturbing the subsurface contamination.

- Managing surface water flow across the site to prevent ponding of water on the Site 22 landfill and to improve precipitation runoff in order to reduce water infiltration into the subsurface.

- Implementing ICs to maintain the integrity of the biotic barrier and to prevent disturbances or excavation of waste materials.

- Monitoring groundwater and landfill gas in the vicinity of the site.

Except for permanent IC implementation, the components of the remedy have been completed in accordance with the requirements of the ROD. The Site 22 biotic barrier was constructed in 2003, is functioning as designed, and prevents human and animal exposure to landfill contaminants. While not specified as ECs in the ROD, the biotic barrier and landfill regrading activities to prevent ponding of water are ECs at Site 22.

Since the last Five-Year Review, a memorandum of agreement (MOA) was executed in September 2008 by the Navy and NASA to formally establish each party's roles and responsibilities in ensuring protectiveness of the remedy for the Site 22 landfill. The Navy conducts internal site visits and quarterly inspections as part of IC implementation measures. To meet the annual reporting requirement to EPA, the Navy provides annual reports that detail the effectiveness of IC monitoring and implementation. IC implementation at Site 22 has not been completed because NASA has not placed permanent ICs into its land use planning documents.

Groundwater monitoring at Site 22 has indicated that pesticides, SVOCs, and VOCs do not appear to be adversely affecting the shallow aquifer based on the infrequent, low, and trace concentrations detected. Landfill gas monitoring at Site 22 has shown that landfill gas is not migrating off-site from the landfill. Required maintenance of the landfill cover includes backfilling shallow, small-diameter holes made by burrowing animals.

This Five-Year Review found that the remedy for Site 22 is currently protective of human health and the environment because potential exposure pathways are incomplete, groundwater contaminant concentrations are stable, landfill gas is not migrating from the landfill, and the biotic barrier is functioning as intended. To ensure long-term protectiveness of the remedy, the following actions must be taken:

- Incorporate ICs into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of ICs.

Site 26

Site 26 consists of chlorinated VOC groundwater plumes located east of the Moffett Field runways. In 1996, the Navy signed the ROD for Site 26 (OU5) (Navy 1996). The ROD divided Site 26 into southern and northern groundwater contaminant plumes. The remedy selected for the southern plume at Site 26 includes:

- Extracting and treating groundwater so that concentrations of chemicals of concern (COC) are reduced to drinking-water, maximum contaminant levels (MCL) by the East-side Aquifer Treatment System (EATS).
- Conducting groundwater monitoring.
- Implementing ICs to prevent human exposure to or ingestion of contaminated groundwater.

EATS is a pump and treat system used on the southern plume only; EATS does not treat groundwater from the northern plume. Groundwater monitoring was the only action required for the northern plume because the groundwater is not a current or potential source of drinking water, and does not pose an unacceptable risk to human health or the environment (Navy 1996).

COCs identified in the ROD include trichloroethene (TCE), 1,2-dichloroethene (1,2-DCE), tetrachloroethene (PCE), vinyl chloride, 1,1-DCE, and 1,2-dichloroethane (1,2-DCA).

To extract and treat groundwater, the Navy began construction of EATS in 1997. In January 1999, construction was completed and EATS began operating.

EATS operated until July 2003 when it was turned off and pilot testing of an alternative treatment option was conducted at Site 26. When operating, EATS extracts groundwater from five wells completed in the upper portion of the A aquifer. Groundwater is treated using a combination of an air stripper and granular activated carbon (GAC). Between January 1999 and July 2003, EATS processed 67,050,786 gallons of extracted groundwater and removed 23.65 pounds of VOCs. The Navy is currently conducting a second pilot test at Site 26 to evaluate the effectiveness of a combined in-situ, biotic and abiotic treatment using EHC (a proprietary substrate consisting of plant material and zero-valent iron). Completion of the pilot test is anticipated in 2010.

The 2008 southern COC plume dimensions were determined to be stable based on a comparison to previous years. This comparison indicates the plume boundaries have not significantly migrated or changed shape. Overall, COC concentrations are stable or decreasing.

IC implementation at Site 26 has not been completed because NASA has not placed restrictions on domestic use of groundwater in its land use planning documents. At the Navy's request, NASA is in the process of adding groundwater restrictions to its Master Plan. Currently, groundwater use is prohibited at Site 26 by language contained in NASA's *Comprehensive Use Plan* that restricts access and development because of safety considerations related to munitions storage and runway/air operations.

This Five-Year Review found that the remedy at Site 26 is currently protective of human health and the environment because groundwater contaminant plumes are stable or decreasing and potential exposure pathways are incomplete. To ensure long-term protectiveness of the remedy, the following actions must be taken:

- Continue implementing the pilot test and determine the next course of action based on the results.
- Incorporate ICs into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of ICs.

Site 28

Historically, VOCs were released to the environment by the Middlefield-Ellis-Whisman (MEW) companies, the Navy, and NASA at or near Moffett Field (EPA 1989). The releases have commingled in a regional plume that migrates downgradient into Moffett Field west of the

runways. Site 28 consists of chlorinated VOC groundwater plumes attributable to Navy sources located west of the Moffett Field runways. In a December 1993 amendment to the Federal Facility Agreement (FFA) (EPA 1993), the Navy agreed to adopt the May 1989 MEW ROD. The remedy selected in the MEW ROD includes:

- Extracting and treating contaminated groundwater from the regional plume so that COC concentrations would be reduced to drinking water MCLs.
- Treating contaminated, unsaturated soil by in-situ vapor extraction or excavation and aeration so that COC concentrations were no more than 100 times the groundwater remediation goals.

There have been two Explanations of Significant Differences (ESD) for the MEW ROD. The September 1990 ESD (EPA 1990) clarified that the cleanup goals constituted final cleanup standards and the April 1996 ESD (EPA 1996) clarified the groundwater remedy.

Several COCs were identified in the MEW ROD. The most frequently occurring VOCs detected in groundwater are the chlorinated solvents TCE and *cis*-1,2-DCE, with lesser amounts of PCE and vinyl chloride. However, the MEW ROD selected TCE as the indicator chemical for cleanup goals because of the assumption that achieving the cleanup goal for TCE (5 micrograms per liter [µg/L]) would result in cleanup of the other site chemicals.

The West-side Aquifers Treatment System (WATS) is located west of the runways, near Hanger 1 at Site 28. WATS was installed by the Navy to clean up VOC contamination in the upper and lower portions of the A aquifer. WATS extracts groundwater from the upper portion of the A aquifer with six shallow-screened extraction wells and from the lower portion of the A aquifer with three deeper-screened extraction wells. Extracted groundwater is treated using an advanced oxidation process (AOP) and GAC. WATS also treats contaminated water collected in two on-site sumps near Hangar 1. To eliminate discharge of VOCs to the air, the WATS air stripper was removed from the treatment train on May 8, 2003.

WATS has operated consistently since November 1998. As of December 30, 2008, WATS had treated approximately 340,413,017 gallons of groundwater, removing approximately 4,362 pounds of VOCs.

Though the extent of the VOC plumes generally have not changed since the startup of WATS, the contaminant concentrations generally have remained the same or decreased. Capture zone analysis indicates that the target capture zone has been maintained throughout the review period. Decreasing or stable contaminant concentrations in downgradient wells, combined with capture zone analysis results, supports the conclusion that WATS is achieving complete hydraulic containment of the target contaminant capture zone.

The remedy was constructed in accordance with the requirements of the MEW ROD and the subsequent ESDs (EPA 1989, 1990, and 1996). Although WATS is functioning as intended,

dissolved VOCs in the regional plume continue to migrate north into Site 28 with groundwater underflow from off-site areas. As long as contaminants continue to migrate into Site 28 from an upgradient source, the remedial objective will not be achieved. The Navy is currently working with the MEW companies and NASA to develop a common strategy to remediate the regional plume to standards specified in the ROD.

During the review period, it was discovered that a potential source of PCE contamination to groundwater may be present beneath the former Building 88 footprint and the adjacent Traffic Island Area. The source consists of PCE in saturated soil potentially as a dense nonaqueous phase liquid (DNAPL), and is the result of historical activities at the former Building 88 dry cleaning facility. In an effort to optimize the remedy and address this potential source of groundwater contamination, the Navy will conduct a pilot test in 2010 to evaluate alternative treatment technologies. In the interim, on-site groundwater plumes of PCE and any daughter products are fully contained and the groundwater is being treated by the combined regional plume treatment systems (WATS and MEW).

The Navy has met cleanup goals for unsaturated soils at Site 28. In 1994 and 1995, Building 88, sump 91, and tank 68 were demolished and removed. Soil was excavated down to groundwater level and treated through ex-situ aeration. Confirmation samples from the excavation and the treated soil indicated that there was no contamination in unsaturated soils above remediation goals. The area was backfilled with clean materials and restored to preconstruction elevations. The Navy has fulfilled its obligations to remediate unsaturated soils as specified in the MEW ROD and no further action is required.

Although not a component of the remedy at Site 28, ICs and ECs have been implemented at Site 28 to prevent human exposure to, or ingestion of, contaminated groundwater. Additionally, in 2005, NASA issued the *NASA Research Park Environmental Issues Management Plan (EIMP)*, which places restrictions on groundwater use on the portion of Site 28 within the boundary of the Research Park.

This Five-Year Review found that the remedy for Site 28 is currently protective of human health and the environment because on-site contaminant plumes are stable or decreasing, contaminated groundwater is being treated by WATS, and potential exposure pathways that could result in unacceptable risks are being controlled. EPA has determined that there are no short-term health risks from exposure to vapor intrusion, and NASA has taken measures to mitigate known and potential future threats from the vapor intrusion pathway. To ensure long-term protectiveness of the remedy, the following actions must be taken:

- Update NASA’s internal directive on environment and incorporate ICs related to vapor intrusion.
- Follow EPA's Vapor Intrusion Pathway study and incorporate relevant measures into Ames construction permits normally required of permittees and lessees when redeveloping or remodeling structures and sites at NASA Ames.

- Continue implementing the pilot test and determine the next course of action based on the results.

- Continue to participate in a regional strategy to address groundwater contamination, and document the strategy in a Feasibility Study (FS) report.

- Evaluate need for ICs in Site-wide Groundwater FS for the MEW Study Area.

The following EPA Five-Year Review Summary Forms provide additional information on the review assessment results and the future effectiveness of the remedies implemented at Sites 1, 22, 26, and 28.

ChaduxTt JV
Consulting Engineers and Scientists

FIVE-YEAR REVIEW SUMMARY FORM

SITE IDENTIFICATION		
Former NAS Moffett Field, Site 1		
EPA ID: CA2-1-70090078		
Region: IX	**State:** CA	**City/County:** Moffett Field / Santa Clara County

SITE STATUS			
NPL status: ☒ Final	☐ Deleted	☐ Other (specify):	
Remediation status *(choose all that apply):*	☐ Under Construction	☒ Operating	☐ Complete
Multiple OUs? ☐ Yes ☒ No	**Construction completion date:** 11/16/1998		
Has site been put into reuse? ☐ Yes ☒ No			

REVIEW STATUS			
Reviewing Agency ☐ EPA	☐ State	☐ Tribe	☒ Other Federal Agency – Navy
Author name: Kathryn Stewart			
Author title: BRAC Environmental Coordinator	**Author affiliation:** BRAC PMO		
Review period: 5/31/2007 to 1/29/2010			
Date(s) of site inspection: 05/14/2009			

Type of review:
☒ Post-SARA ☐ Pre-SARA ☐ NPL-Removal only
☒ NPL Remedial Action Site ☐ NPL State/Tribe-lead
☐ Regional Discretion

Review number: ☐ 1 (first) ☐ 2 (second) ☒ 3 (third) ☐ Other (specify) _____

Triggering action:
☐ Actual RA Onsite Construction at OU#_____ ☐ Actual RA Start at OU#_____
☐ Construction Completion ☐ Previous Five-Year Review Report
☒ Other *(specify)* Signature date of 2/14/2005 for first Five-Year Review of Site 26

Triggering action date: 2/14/2005

Due date (*five years after triggering action date*): 2/14/2010

FIVE-YEAR REVIEW SUMMARY FORM

ISSUES

Summarize Issues:

1) Land use restrictions have not been documented in the NASA Environmental Resources Document as specified in Memorandum of Agreement (11/15/1999).

2) Ground squirrels and gophers continue to burrow within the landfill boundary.

RECOMMENDATIONS AND FOLLOW-UP ACTIONS:

Summarize recommendations and follow-up actions:

1) Incorporate institutional controls (IC) into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of ICs.

2) Evaluate effectiveness of current burrowing mammal abatement plan.

PROTECTIVENESS STATEMENT(S)

The remedy for Site 1 is currently protective of human health and the environment because potential exposure pathways are incomplete, groundwater contaminant concentrations are stable, landfill gas is not migrating from the landfill, and the landfill cover is functioning as intended. To ensure long-term protectiveness of the remedy, the recommendations and follow-up actions listed above must be taken.

ChaduxTt JV
Consulting Engineers and Scientists

FIVE-YEAR REVIEW SUMMARY FORM

SITE IDENTIFICATION		
Former NAS Moffett Field, Site 22		
EPA ID: CA2-1-70090078		
Region: IX	**State:** CA	**City/County:** Moffett Field / Santa Clara County

SITE STATUS			
NPL status: ☒ Final	☐ Deleted	☐ Other (specify):	
Remediation status *(choose all that apply):*	☐ Under Construction	☒ Operating	☐ Complete
Multiple OUs? ☐ Yes ☒ No	**Construction completion date:** 8/3/2003		
Has site been put into reuse? ☒ Yes ☐ No			

REVIEW STATUS			
Lead Agency ☐ EPA ☐ State	☐ Tribe	☒ Other Federal Agency – Navy	
Author name: Kathryn Stewart			
Author title: BRAC Environmental Coordinator	**Author affiliation:** BRAC PMO		
Review period: 11/14/2007 to 1/29/2010			
Date(s) of site inspection: 05/14/2009			

Type of review:
☒ Post-SARA ☐ Pre-SARA ☐ NPL-Removal only
☒ NPL Remedial Action Site ☐ NPL State/Tribe-lead
☐ Regional Discretion

Review number: ☐ 1 (first) ☒ 2 (second) ☐ 3 (third) ☐ Other (specify) _____

Triggering action:
☐ Actual RA Onsite Construction at OU#_____ ☐ Actual RA Start at OU#_____
☐ Construction Completion ☐ Previous Five-Year Review Report
☒ Other *(specify)* Signature date of 2/14/2005 for first Five-Year Review of Site 26

Triggering action date: 2/14/2005

Due date (*five years after triggering action date*): 2/14/2010

FIVE-YEAR REVIEW SUMMARY FORM

ISSUES

Summarize Issues:

1) Land use restrictions have not been incorporated into NASA's land use planning documents as specified in the Memorandum of Agreement (9/17/2008).

RECOMMENDATIONS AND FOLLOW-UP ACTIONS:

Summarize recommendations and follow-up actions:

1) Incorporate institutional controls (IC) into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of ICs.

PROTECTIVENESS STATEMENT(S)

The remedy for Site 22 is currently protective of human health and the environment because potential exposure pathways are incomplete, groundwater contaminant concentrations are stable, landfill gas is not migrating from the landfill, and the biotic barrier is functioning as intended. To ensure long-term protectiveness of the remedy, the recommendation and follow-up action listed above must be taken.

ChaduxTt JV
Consulting Engineers and Scientists

FIVE-YEAR REVIEW SUMMARY FORM

SITE IDENTIFICATION		
Former NAS Moffett Field, Site 26		
EPA ID: CA2-1-70090078		
Region: IX	**State:** CA	**City/County:** Moffett Field / Santa Clara County

SITE STATUS	
NPL status: ☒ Final ☐ Deleted ☐ Other (specify):	
Remediation status *(choose all that apply):* ☐ Under Construction ☒ Operating ☐ Complete	
Multiple OUs? ☐ Yes ☒ No	**Construction completion date:** 1/26/1999
Has site been put into reuse? ☐ Yes ☒ No, however, land over a portion of Site 26 is now a golf course.	

REVIEW STATUS	
Lead Agency ☐ EPA ☐ State ☐ Tribe ☒ Other Federal Agency – Navy	
Author name: Kathryn Stewart	
Author title: BRAC Environmental Coordinator	**Author affiliation:** BRAC PMO
Review period: 01/2003 to 1/29/2010	
Date(s) of site inspection: 05/14/2009	

Type of review:
☒ Post-SARA ☐ Pre-SARA ☐ NPL-Removal only
☒ NPL Remedial Action Site ☐ NPL State/Tribe-lead
☐ Regional Discretion

Review number: ☐ 1 (first) ☒ 2 (second) ☐ 3 (third) ☐ Other (specify) _____

Triggering action:
☐ Actual RA Onsite Construction at OU#_____ ☐ Actual RA Start at OU#_____
☐ Construction Completion ☒ Previous Five-Year Review Report
☐ Other *(specify)*

Triggering action date: 2/14/2005

Due date (*five years after triggering action date*): 2/14/2010

FIVE-YEAR REVIEW SUMMARY FORM

ISSUES

1) The *Final Site 26 EATS Evaluation Report* determined that the EATS groundwater extraction and treatment remedy is an inefficient and ineffective method to address groundwater contamination at Site 26.

2) NASA has not restricted groundwater use in its land use planning documents for the EATS area as required in the Record of Decision.

RECOMMENDATIONS AND FOLLOW-UP ACTIONS:

Summarize recommendations and follow-up actions:

1) Continue implementing the pilot test and determine the next course of action based on the results**.**

2) Incorporate institutional controls (IC) into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of ICs.

PROTECTIVENESS STATEMENT(S)

The remedy for Site 26 is currently protective of human health and the environment because groundwater contaminant plumes are stable or decreasing and potential exposure pathways are incomplete. To ensure long-term protectiveness of the remedy, the recommendations and follow-up actions listed above must be taken.

ChaduxTt JV
Consulting Engineers and Scientists

FIVE-YEAR REVIEW SUMMARY FORM

SITE IDENTIFICATION		
Former NAS Moffett Field, Site 28		
EPA ID: CA2-1-70090078		
Region: IX	**State:** CA	**City/County:** Moffett Field / Santa Clara County

SITE STATUS			
NPL status: ☒ Final	☐ Deleted	☐ Other (specify):	
Remediation status *(choose all that apply):*	☐ Under Construction	☒ Operating	☐ Complete
Multiple OUs? ☐ Yes ☒ No	**Construction completion date:** 11/26/1998		
Has site been put into reuse? ☐ Yes ☒ No			

REVIEW STATUS			
Lead Agency ☐ EPA ☐ State	☐ Tribe	☒ Other Federal Agency – Navy	
Author name: Kathryn Stewart			
Author title: BRAC Environmental Coordinator	**Author affiliation:** BRAC PMO		
Review period: 11/2002 to 1/29/2010			
Date(s) of site inspection: 05/7/2009			

Type of review:
☒ Post-SARA ☐ Pre-SARA ☐ NPL-Removal only
☒ NPL Remedial Action Site ☐ NPL State/Tribe-lead
☐ Regional Discretion

Review number: ☐ 1 (first) ☒ 2 (second) ☐ 3 (third) ☐ Other (specify) _____

Triggering action:
☐ Actual RA Onsite Construction at OU#_____ ☐ Actual RA Start at OU#_____
☐ Construction Completion ☐ Previous Five-Year Review Report
☒ Other *(specify)* Signature date of 2/14/2005 for first Five-Year Review of Site 26

Triggering action date: 2/14/2005

Due date (*five years after triggering action date*): 2/14/2010

FIVE-YEAR REVIEW SUMMARY FORM

ISSUES

Summarize Issues:

1) Potential actions need to be taken to ensure long term protectiveness from vapor intrusion (VI).

2) Potential contaminant sources exist in the former Building 88 area, associated sewer lines, and the Traffic Island Area.

3) The West-Side Aquifers Treatment System (WATS) is functioning as intended; however, dissolved VOCs in the regional plume continue to migrate into Site 28 with groundwater underflow from upgradient source areas. The upgradient source is contributing contaminants at concentrations greater than cleanup standards. As long as contaminants migrate into Site 28, remediation goals are unlikely to be met.

4) No institutional controls (IC) exist for groundwater.

RECOMMENDATIONS AND FOLLOW-UP ACTIONS:

Summarize recommendations and follow-up actions:

1) Update NASA's internal directive on environment and incorporate ICs related to VI.

2) Follow EPA's VI Pathway Study and incorporate relevant measures into Ames construction permits normally required of permittees and lessees when redeveloping or remodeling structures and sites at Ames.

3) Continue implementing the pilot test and determine the next course of action based on the results.

4) Continue to participate in a regional strategy to address groundwater contamination, and document the strategy in a Feasibility Study (FS) report.

5) Evaluate the need for institutional controls in Site-wide Groundwater FS for the MEW Study Area.

PROTECTIVENESS STATEMENT(S)

The remedy for Site 28 is currently protective of human health and the environment because on-site contaminant plumes are stable or decreasing, contaminated groundwater is being treated by WATS, and potential exposure pathways that could result in unacceptable risks are being controlled. EPA has determined that there are no short-term health risks from exposure to vapor intrusion, and NASA has taken measures to mitigate known and potential future threats from the VI pathway. To ensure long-term protectiveness of the remedy, the recommendations and follow-up actions listed above must be taken.

1.0 INTRODUCTION

The Department of the Navy (Navy) has conducted a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five-Year Review for Installation Restoration (IR) Sites 1, 22, 26, and 28 at Former Naval Air Station (NAS) Moffett Field (Moffett Field) in California. This report documents the results of the Five-Year Review. This Five-Year Review encompasses all CERCLA sites at Moffett Field currently subject to Five-Year Review requirements. This review was conducted in accordance with the following guidance documents:

- *Navy and Marine Corps Policy for Conducting Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Statutory Five-Year Reviews* (Navy 2004).
- U.S. Environmental Protection Agency (EPA) *Comprehensive Five-Year Review Guidance* (EPA 2001).

1.1 PURPOSE

The purpose of this Five-Year Review is to evaluate the in-place remedies at the sites and verify that they remain protective of human health and the environment. The review is not intended to reconsider decisions made during selection of the remedies, but rather to evaluate implementation and performance of the selected remedies only. The methods, findings, and conclusions identified during the review are presented in this Five-Year Review report. In addition, this report will identify issues and offer recommendations to address them.

Consistent with Executive Order 12580, the Secretary of Defense is responsible for ensuring that Five-Year Reviews are conducted at all qualifying U.S. Department of Defense cleanup sites. The Navy is authorized to conduct the Five-Year Review for Sites 1, 22, 26, and 28 in accordance with CERCLA Section (§) 121 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). CERCLA §121 states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

The NCP at title 40 *Code of Federal Regulations* (CFR) § 300.430(f)(4)(ii) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

The process of composing this report began in April 2009; however, the time period covered by the review varies for each site, starting at the end of the review period from each of their respective last Five-Year Reviews through January 29, 2010. The review period began in May 2007 for Site 1, November 2007 for Site 22, January 2003 for Site 26, and November 2002 for Site 28. The Navy is working in cooperation with the EPA and the California Regional Water Quality Control Board, San Francisco Bay Region (Water Board), in the production of this Five-Year Review.

This is the second Five-Year Review for Sites 22, 26, and 28, and the third Five-Year Review for Site 1. A statutory Five-Year Review is required for Sites 1 and 22 because (1) ongoing and completed remedial actions will leave contaminants in place above concentrations that allow unlimited use and unrestricted exposure of the land, and (2) the Records of Decision (ROD) were signed on or after October 17, 1986 (the effective date of the Superfund Amendments and Reauthorization Act [SARA]). The Five-Year Review for Sites 26 and 28 is conducted as a matter of policy because (1) at the conclusion of remedial actions for those sites, contaminant concentrations are expected to be reduced to levels that allow unlimited use and unrestricted exposure, and (2) it will take more than five years to complete remedial actions.

The signature date on the first Five-Year Review for Site 26 (February 14, 2005) was used as the trigger date for this Five-Year Review because it is the earliest trigger date of all the sites currently subject to the Five-Year Review requirement. Previous Five-Year Reviews for Sites 1, 22, and 28 were signed on September 28, 2007, February 11, 2008, and February 28, 2005, respectively. The Five-Year Review schedules for sites 1, 22, and 28 were advanced in accordance with the May 2004 update to the *Navy and Marine Corps Policy for Conducting CERCLA Statutory Five-Year Reviews* so that all four sites would be on the same Five-Year Review cycle.

1.2 IR SITES AND CURRENT STATUS

The purpose of the Navy's IR Program at Moffett Field is to identify, assess, characterize, and clean up or control contamination from past hazardous material spills and waste disposal. The status of the 29 IR Sites at Moffett Field are presented in Table 1 at the end of this report and are summarized below. Site locations within Moffett Field are shown on Figure 2.

Sites 5, 8 (petroleum contamination), 9, 12, 14, 15, 16, 17, 18, 19, 20, and 24 are petroleum IR sites and are not addressed under CERCLA. Thus they are not discussed further in this report

unless relevant to remedial actions at Sites 1, 22, 26, and 28. Sites 1, 3, 4, 6, 7, 8 (CERCLA contamination), 10, 11, 13, 21, 22, 23, 25, 26, 27, and 28 are CERCLA sites.

Sites 1, 22, 26, and 28 are the subject of this Five-Year Review and are addressed in this report. Sites 3, 4, 6, 7, 10, 11, and 13 are part of the October 1994 *Final OU2-East ROD* in which no action was selected (Navy 1994). Site 23 is included in the August 2002 *Stationwide No Action Sites Record of Decision* (Navy 2002b). Site 2 is part of Operable Unit (OU) 1 and the OU 1 ROD (Navy 1997); however, all waste at Site 2 was removed and consolidated into the Site 1 landfill, groundwater monitoring was discontinued with regulatory agency concurrence in 2003, and no further action is required. Site 2 is discussed further in this report as it relates to remedial actions at OU1 (Sites 1 and 2).

The petroleum portion of Site 8 has been closed under the petroleum program. The investigation of polychlorinated biphenyls (PCB) at Site 8 was completed under a CERCLA Action Memorandum (May 1991) and received closure. A National Aeronautics and Space Administration (NASA) contractor (on behalf of the Navy) is currently developing a work plan for a PCB soil removal action in a drainage swale (adjacent to Site 8, which is closed) for 2010.

The Navy issued a proposed plan for Site 25 in January 2009 that recommended a remedy consisting of excavating contaminated sediment, treating certain lead- and zinc-contaminated sediment, disposing of the sediment off-site, and restoring portions of the site. A final ROD was signed in January 2010.

A final ROD for Site 27 was signed in 2005 that selected a remedy consisting of excavating contaminated sediment in the channel and ditches and restoring portions of the site. Excavation of contaminated sediment and soil was completed in January 2007. The Navy is in the process of finalizing a work plan to perform site restoration activities at Site 27, and anticipates an NFA Remedial Action Completion Report in 2010. Site 21 soils were removed in January 2007 as part of Site 27 soils removal.

The Navy issued an action memorandum for Site 29 in December 2008 selecting a non-time-critical removal action to remove PBC-contaminated siding and then to apply an epoxy coating to the structural steel frame. The Navy anticipates it will take 30 months to complete this removal action.

The Orion Park housing area was transferred to the U.S. Air Force (Air Force) in 1994, and from the Air Force to the Department of the Army (Army) in 2000. In accordance with Department of Defense policy, the Army is responsible for the environmental condition of the Orion Park Housing Area. As a result, the Orion Park Housing Area is not discussed further in this report.

2.0 CHRONOLOGY OF SITES

This section summarizes events in the history of contaminant detection, characterization, and remediation for Sites 1, 22, 26, and 28 in chronological order. Key events are briefly discussed below. Site histories are discussed further in Sections 3 and 4. Tables 2 through 5, presented at the end of this report, give detailed site history.

Chronology of Significant Events for Operational Unit (OU) 1 (Sites 1 and 2)

The Site 2 Landfill was operational from the 1940s to 1952. The Site 1 landfill was operational from 1963 until the 1970s. In 1987, Moffett Field was placed on the EPA's National Priorities List (NPL). During the early 1990s, site characterization activities were conducted. The Navy signed the ROD for OU1 in August 1997, after which Site 2 wastes were excavated and transferred to Site 1; waste transfer was completed by November 1998. In November 1999, the Navy and NASA signed a memorandum of agreement (MOA) for institutional controls (IC). The Navy signed the first and second five year reviews for OU1 in September 2002 and 2007, respectively. The history of environmental remediation of OU1 is outlined in detail in Table 2 at the end of the report.

Chronology of Significant Events for Site 22

The Site 22 Landfill was operational from 1950 to 1967. In 1973, Site 22 was covered by holes 6 and 7 of the Moffett Field golf course. Site characterization activities were conducted between 1994 and 1997. The Navy signed the ROD for Site 22 in June 2002, and remedy implementation began in January 2003. The first Five-Year Review was completed in February 2008. In September 2008, the Navy and NASA signed an MOA for ICs. The history of environmental remediation of Site 22 is outlined in detail in Table 3 at the end of the report.

Chronology of Significant Events for Site 26

Contamination was first discovered and documented at Site 26 in an initial assessment study in March 1984. The Navy signed the ROD for Site 26 in June 1996. In January 1999, the East-side Aquifer Treatment System (EATS) was completed and began extracting and treating contaminated groundwater. The Navy and NASA signed an MOA for ICs in November 1999. In July 2003, EATS was turned off so that the Navy could explore alternative treatment methods. The Navy signed the first Five-Year Review in February 2005. The history of environmental remediation of Site 26 is outlined in detail in Table 4 at the end of the report.

Chronology of Significant Events for Site 28

Contamination was first discovered and documented at Site 28 in an initial assessment study in March 1984. The Navy adopted the 1989 Middlefield-Ellis-Whisman (MEW) ROD in a 1993 amendment to the Federal Facility Agreement (FFA). In March 1993, site characterization

studies for west-side groundwater were completed. In November 1998, the Navy completed and began operating the West-side Aquifers Treatment System (WATS) to extract and treat contaminated groundwater. The Navy signed the first Five-Year Review in February 2005. The history of environmental remediation of Site 28 is outlined in detail in Table 5 at the end of the report.

3.0 BACKGROUND

This section identifies threats posed to the public and environment when the RODs for Sites 1, 22, 26, and 28 were developed. General site conditions and all major activities for each site before its ROD was signed are discussed in this section, including physical characteristics, land and resource use, history of contamination, initial responses, and basis for taking action. Because the sites are located in the same general vicinity, the sites share the same general physical characteristics and area land uses that are discussed below.

Moffett Field is located near the south end of San Francisco Bay in California, 3 miles north of downtown Mountain View (see Figure 1). Moffett Field was originally established as a military facility in 1931, when the U.S. government acquired 1,000 acres from the neighboring cities of Sunnyvale and Mountain View.

The original purpose of the base was to provide a home base for the airship USS Macon. Between 1935 and 1941, the Navy transferred operations of Moffett Field to the War Department, and the installation was under the control of the U.S. Army Air Corps. In 1941, control of the facility was returned to the Navy. From the end of World War II until its closure, Moffett Field hosted development and use of several generations of land-based, anti-submarine warfare and maritime patrol aircraft. In 1987, Moffett Field was placed on the EPA's National Priorities List (NPL). Post-Cold War defense cutbacks and related Base Realignment and Closure (BRAC) actions in the 1990s identified Moffett Field for closure. On July 1, 1994, Moffett Field was closed as an NAS and turned over to NASA Ames Research Center. NASA Ames now operates the facility as Moffett Federal Airfield.

Moffett Field is bounded by United States Fish and Wildlife Service (USFWS) property (former salt evaporation ponds) to the north, Lockheed Martin Aerospace Facility to the east, U.S. Highway 101 and residential areas to the south, and Stevens Creek to the west (see Figure 2).

Moffett Field is relatively flat, ranging from 2 feet below to 36 feet above mean sea level (msl). A sizeable portion of Moffett Field is situated on previously submerged land or marshlands that have been filled to existing elevations with backfill material. Wetlands located in the northern portion of Moffett Field are the only natural surface water. Surface drainage near Moffett Field includes Stevens Creek to the west and Coyote Creek and Guadalupe Slough to the east (Foster Wheeler Environmental Corporation, Inc. [FWEC] 2002a).

The San Francisco Bay Water Quality Control Plan (Basin Plan) of 2007 (Water Board 2007) identifies potential and beneficial uses of groundwater in the region. Moffett Field is located at the northern end of the Santa Clara Basin. For the Santa Clara Basin, all four beneficial uses of groundwater (municipal and domestic, industrial process, industrial service, and agricultural water supply) are listed in the Basin Plan as existing uses.

Regionally, the Santa Clara Valley contains interbedded alluvial, fluvial, and estuarine deposits to a maximum depth of 1,500 feet (Iwamura 1980). Locally, these sediments consist of varying

combinations of clay, silt, sand, and gravel that represent the interfingering of estuarine and alluvial depositional environments during the late Pleistocene and Holocene epochs. The fluvial sediments were derived from the Santa Cruz highlands west of the basin and deposited on an alluvial plain bounded by alluvial fan deposits to the west and baylands to the northeast (Iwamura 1980). Heterogeneity of channel and interchannel sediments deposited in the fluvial depositional environment has been evident in subsurface explorations at Moffett Field. These sediments most likely were deposited during the Holocene period when the worldwide sea level was rising toward its present elevation (Navy 2002a).

The subsurface sediments were initially divided into upper and lower aquifers by Iwamura (1980) based on hydrogeologic characteristics. An investigation conducted by Harding Lawson Associates (HLA) (1988) classified these aquifers as the A, B, and C aquifers. The A and B aquifers correspond to Iwamura's upper aquifer, and the C aquifer corresponds to Iwamura's lower aquifer. HLA further subdivided the B aquifer into three subunits (B1, B2, and B3 aquifer zones). During a subsequent investigation, International Technology Corporation (ITC) reclassified the B1 sediments as the A2 aquifer zone based on lithologic and sedimentologic similarities between the A and B1 sediments (ITC 1991). However, further research by the Navy (Tetra Tech FW, Inc. [TtFW] 2005c and 2005d) indicated that the A1 and A2 aquifer zones are hydraulically interconnected, and these zones were reclassified as the upper and lower portion of the A aquifer.

This report uses the Navy nomenclature (upper and lower portion of the A aquifer, B aquifer, and C aquifer). The A, B, and C aquifers overlie what has been identified as the Deep aquifers. The aquifer and aquitard descriptions are based on existing data and lithologic interpretation of soil borings. The aquifer zones and their approximate depths are presented below (Tetra Tech EC, Inc. [TtEC] 2008c).

Aquifer	Aquifer Zone	Approximate Depth (feet bgs)
A	Upper portion of A aquifer (A1 aquifer zone)	0 to 35
	Lower portion of A aquifer (A2 or B1 aquifer zone)	35 to 55
B	B2 aquifer zone	55 to 100
	B3 aquifer zone	100 to 160
C	Aquifer zone breakdown, if any, unknown or undefined in the aquifer at this time	160 to 240
Deep	Aquifer zone breakdown, if any, unknown or undefined in the aquifer at this time	Generally deeper than 240

Note:

bgs Below ground surface

3.1 SITE 1

This section discusses the site characteristics and history of Site 1 prior to the signing of the ROD for OU1. Site 2 will be discussed in this section because remedial actions at Site 2 impacted Site 1.

3.1.1 Physical Characteristics

Sites 1 and 2 are located in the northern portion of Moffett Field and make up OU1 (see Figure 2). The Site 2 Landfill is now referred to as the Site 2 Former Landfill because the waste material was removed and transferred to Site 1 as part of remedy implementation. Site 2 was closed with NFA status in 2003. Remedy implementation is discussed further in Section 4.2.1.

Site 1, also referred to as the Runway Landfill, is located in the northernmost portion of Moffett Field and encompasses approximately 12 acres (see Figure 3). The adjacent properties include USFWS property and Former Jagel Slough to the east, North Perimeter Road and Moffett Field runways to the south, undeveloped land to the southwest, and the NASA Stormwater Retention Pond (Northeast Basin) to the northwest. The landfill is surrounded by a fence, except for the northwest side, which is bordered by the Stormwater Retention Pond. The landfill is flat on the west side (the Western Depression area) with an elevation of approximately 7 feet above msl. It is mounded on the eastern side (the Upper Waste Consolidation area) where the elevation is approximately 23 feet above msl at the apex. Two culverts drain surface water from the site toward the south and west.

The Site 2 Former Landfill (formerly the Golf Course Landfill) consists of a fenced area encompassing approximately 6 acres. The land surface is relatively flat with a surface drain that extends around the east, south, and west sides of the site before terminating in a subsurface storm drain. The site is fenced and secured by two locking gates. It is bordered to the north by North Patrol Road, to the east by Building 561, to the south by Macon Road, and to the west by North Perimeter Road (see Figure 2).

A silty clay aquitard several feet thick exists below the Site 1 Landfill and above the uppermost aquifer zone. The thickness of this aquitard varies and it is not known conclusively whether this aquitard is continuous beneath the landfill. The stratigraphy beneath the aquitard consists of silty sand or sand and gravel deposits separated by low-permeability silts and clays. Since the Site 1 landfill is relatively isolated from surrounding water bodies by low-permeability barriers, elevated water levels are maintained. Potential for flow from the landfill to the other bodies exists, but actual flow is limited or constrained by these barriers (Navy 1997).

Based on data obtained during the review period, depth to groundwater at Site 1 is between approximately 2.5 feet below msl in the northern portion of the landfill to approximately 3.5 feet below msl in the southern portion of the landfill. In general, groundwater in the upper portion of the A aquifer zone beneath the Site 1 Landfill flows north to south; however, the regional gradient is south to north toward San Francisco Bay. The southward gradient at Site 1 is

opposite from the regional gradient because of pumping of the storm drainage system associated with Building 191 (located south of Site 1 and just north of Site 2) (TN & Associates, Inc. [TN&A] 2007c). The pump station influences groundwater gradients because the drainage system that feeds the pump station is below the water table in some areas. Should pumping at Building 191 cease, the northern area of Moffett Federal Airfield, including Sites 1 and 2, may be prone to flooding (Navy 1997).

Similar to Site 1 soils, test results indicated low hydraulic conductivity for soils below and surrounding Site 2 (Navy 1997).

3.1.2 Land and Resource Use

Land use at Sites 1 and 2 is specified in the *Moffett Field Comprehensive Use Plan* prepared by NASA (1994). The plan states that the primary uses for this area are an airfield clearance zone and open space. The plan further states that access should be limited and the area preserved in its natural state because of safety interests. No plans currently exist for this property to change ownership. The nearest residential area is located over 1½ miles to the south-southwest (upgradient).

The Water Board defines the criteria for drinking water sources as groundwater with total dissolved solids (TDS) lower than 3,000 milligrams per liter (mg/L), and that can support a pumping yield of at least 200 gallons per day (California State Water Resources Control Board [SWRCB] 2006). Groundwater at Sites 1 and 2 is not currently used as a drinking water supply and it is not reasonably expected to be a drinking water supply in the future because it does not meet the state standards. Additionally, groundwater surrounding Sites 1 and 2 will not likely be extracted for future beneficial use because of problems (saltwater intrusion and land subsidence) that occurred while pumping groundwater in the past. No drinking water or production wells are in the area. None of the beneficial uses of groundwater (municipal or domestic, industrial process, industrial, and agricultural water supply) is identified in the Basin Plan of 2007 as an existing use at Sites 1 and 2 (Navy 1997).

3.1.3 History of Contamination

Site 1 was operated as a landfill from the mid-1960s until the late 1970s. Subsequently, the site was used as a pistol range. Detailed operation records for Site 1 were not maintained, but a solid-waste facility permit was obtained from Santa Clara County in 1979. This permit states that the landfill operated as a sanitary landfill and that it received wastes such as cardboard, lawn cuttings, prunings, wood waste, and asbestos insulation wrapped in double-plastic bags. According to civilian and military personnel interviews, the landfill received domestic refuse, as well as waste from maintenance and military operations. Maintenance and military operations waste included scrap equipment, paint and paint thinners, solvents, lacquer, ash, asbestos, jet fuels, waste oil, fuel filters (containing fuel sludge, lead compounds, and rust), transformer oil and filters, and PCB-contaminated sawdust. However, data obtained during field investigations

support the information found in the permit and indicate that Site 1 was operated much like a solid waste landfill (Navy 1997).

According to sources identified in the Remedial Investigation (RI) Report, refuse at Site 1 was placed in an excavation that ranged in depth from 2 to 21 feet below msl, but typically ranged from 8 to 12 feet below msl (ITC 1993a). The refuse material was covered with 0.5 to 7 feet of gravelly sand. At times, the refuse was placed above the land surface to an elevation of up to 10 feet above msl. Although no disposal records for the landfill exist and the extent of refuse has not been fully determined, a conservative estimate of the total refuse volume at Site 1 at the time was 423,000 cubic yards (Navy 1997).

At Site 2, records of landfill operation were not maintained, but the landfill operated from the 1940s until approximately 1952 (ITC 1993a). The landfill reportedly received domestic refuse, as well as wastes from maintenance and military operations, such as scrap equipment, paint and paint thinners, solvents, lacquer, oil, fuel filters, and sawdust contaminated with PCBs. Although no disposal records for the landfill exist, the feasibility study (FS) conservatively estimated that the total maximum volume of refuse at the Site 2 Former Landfill was approximately 169,400 cubic yards (Navy 1997).

3.1.4 Initial Response

Site characterization at Sites 1 and 2 consisted of an initial assessment study (IAS), confirmation study, solid waste assessment test (SWAT), air SWAT, RI, FS, and post-remedial investigations (Tetra Tech EM Inc.[TtEMI] 2001a).

Low contaminant concentrations found in samples of leachate, surface debris, and boreholes at both sites supported use of the EPA presumptive remedy (containment) for landfills (Navy 1997). The EPA established that engineered containment would be used at landfills where the wastes posed a relatively low long-term threat and treatment would be impracticable (40 CFR 300.430[a][l][iii][B]). As a result, complete characterization of the landfill refuse was not necessary because containment does not require such information. OU1 field investigations during the RI (ITC 1993a) and FS (PRC Environmental Management, Inc. [PRC] 1995a) incorporated this presumptive remedy approach and focused on hydrogeology, groundwater chemistry, and landfill gas composition to evaluate whether contamination from the landfills was migrating past landfill boundaries into the surroundings. Additional groundwater investigations at Site 1 and radiological surveys at Sites 1 and 2 were conducted in September 1996 (Navy 1997).

3.1.5 Basis for Taking Action

Chemical data from groundwater samples collected in association with the RI and FS reports at the landfill perimeter indicated that the Site 1 Landfill was not significantly impacting groundwater. Some chemicals had been detected infrequently and at low concentrations in samples collected from surrounding groundwater monitoring wells (PRC 1995a). However, the

data did not show any consistent patterns or trends that would indicate the presence of any leachate plumes emanating from the landfill. No contaminants had been detected during consecutive monitoring events from the same wells, except acetone and carbon disulfide. Furthermore, no compounds were consecutively detected above detection limits in any one well or in any two consecutive monitoring events. The low hydraulic conductivity, high organic content associated with clays surrounding the landfill, and low contaminant source concentrations combined to restrict flow and limit contaminant migration (Navy 1997).

Chemicals from leachate had been detected infrequently and at low concentrations in samples from groundwater monitoring wells downgradient of the Site 2 Former Landfill (PRC 1995a). However, the data did not indicate consistent patterns or trends for any organic contaminant plumes emanating from the landfill. The low-level detections were random. No compounds were detected above detection limits in any one well in any two consecutive rounds. Plumes of leachate were not migrating past Site 2 boundaries even though it did not have a documented, engineered barrier between the landfill and surrounding groundwater. Low source contaminant concentrations and low hydraulic conductivity soils surrounding the landfill were reasons for the absence of migrating contaminants (Navy 1997).

The radiological survey did not detect radioactive materials above background concentrations. The additional groundwater investigation at Site 1 did not indicate conditions significantly different than those reported in the OU1 RI and FS reports (Navy 1997).

Post-RI activities were performed at Site 2 to define the extent of buried material prior to its relocation in the Site 1 Landfill. Trenching was conducted in April 1996, September 1996, and July 1997. The results of the trenching indicated that the extent of area used for waste disposal was less than one acre, and waste depth appeared to be less than 10 feet at most locations (Navy 1997).

A human health risk assessment (HHRA) was conducted for OU1 as part of the RI even though quantified risk assessment results have limited use for landfills (ITC 1993a). Qualitatively however, the following exposure pathways are associated with constituents in refuse and landfill gas and the remedial alternatives were developed considering these exposure pathways: ingestion of and dermal contact with surface soils, inhalation of particulate matter from wind-eroded surface soils, and inhalation or explosion of landfill gas. For groundwater, exposure pathways associated with human health are incomplete because the groundwater is not a current drinking water supply and it is not reasonably expected to be a drinking water supply in the future (Navy 1997). The complete HHRA is discussed in the OU1 RI report (ITC 1993a).

An ecological assessment conducted for OU1 determined that exposure pathways for ecological receptors were incomplete based on previous groundwater analysis and containment of OU1 wastes through use of the EPA's presumptive remedy for landfills. Therefore ecological risks from refuse were not quantified and the ecological assessment for OU1 was streamlined. During the streamlined ecological assessment, field survey results found that no threatened and endangered species or special status species were known to inhabit Sites 1 and 2. The Navy prepared a replacement plan to address habitat of threatened and endangered species that were

potentially located on adjacent property that would be lost during consolidation and capping activities.

According to the OU1 ROD, the proposed landfill capping would also affect potential wetlands in the vicinity of Site 1. However, the Navy and regulatory agencies determined that a landfill cap was a necessary component of the remedy. Filling small areas of potential wetlands was required to cap the Site 1 landfill. Therefore, as part of the remedial design, the Navy met the substantive requirements of Nationwide Permit 38 through the U.S. Army Corps of Engineers. This decision allowed for fill to be placed in wetlands if filling was associated with the remediation of hazardous and toxic waste. The agencies concurred with the OU1 ROD in 1997 (Navy 1997).

3.2 SITE 22

This section discusses the site characteristics and history of Site 22 prior to the signing of the ROD.

3.2.1 Physical Characteristics

Site 22 is located in the northeastern corner of Moffett Field (see Figure 2). Site 22 covers approximately 9.4 acres and contains an estimated total refuse (waste) volume of 92,000 cubic yards. The refuse is believed to consist of primarily domestic waste, as confirmed through exploratory trenching (Navy 2002a). Site 22 now underlies the putting greens and fairways of holes 6 and 7 of the golf course, which is operated by NASA.

Adjacent properties include North Patrol Road bordered by USFWS property to the north, East Patrol Road bordered by Lockheed Martin to the east, and the remainder of the golf course to the south and west (see Figure 4). A channel on the northern edge of the landfill (Site 27), beyond North Patrol Road, drains surface water to the east.

The stratigraphy in the area of the Site 22 Landfill consists predominantly of clay and silty clay with discontinuous sand and silt intervals. Because of the discontinuous sand and silt intervals, communication between groundwater and surface water is limited. There appears to be only limited communication between groundwater and North Patrol Road channel. Hydraulic communication between groundwater and the channel is impeded by the relatively low hydraulic conductivity of clay/silty clay. Physical and chemical data indicate that communication between the perched landfill leachate and shallow groundwater is also limited due to the predominance of clay and clayey silt beneath and around the landfill (Navy 2002a).

Regional groundwater flow in the vicinity of Site 22 is to the north toward San Francisco Bay. However, groundwater flow beneath Site 22 differs from the regional flow because pumping activities associated with Building 191 lower the water table west of the site as described in Section 3.1.1. As a result, groundwater flow from Site 22 Landfill is generally to the west

toward Building 191 (FWEC 2003a). Based on data obtained during the review period, depth to groundwater at Site 22 ranges between approximately 2 and 4 feet below msl.

3.2.2 Land and Resource Use

Land use at Site 22 is specified in the *Moffett Field Comprehensive Use Plan* prepared by NASA (1994). Site 22 now underlies the putting greens and fairways of holes 6 and 7 of the golf course, which is operated by the NASA Ames Research Center at Moffett Field (FWEC 2003a). The rough for golf course holes 6 and 7, containing trees, is on the sloped portion of the landfill. Before completion of the remedy, observations associated with soil borings and trenching indicated that most of the landfill is covered by approximately 1.5 feet of soil; however, soil thickness in a few areas was less than 1 foot. The golf course has been maintained and operated for over 30 years, and no plans currently exist to change the land use of this area. Therefore, Site 22 likely will remain part of the golf course. The nearest residential area is located over 1½ miles to the southwest (upgradient).

Groundwater at Site 22 is not considered potable for human or animal consumption because it does not meet state standards for drinking water (Navy 2002a). No local wells or known natural seeps or springs where water could be withdrawn for local consumption are present, and the shallow aquifer underlying Site 22 does not supply water to local or municipal wells. Groundwater at Site 22 is not and will not likely be used as a source of drinking water or for other beneficial use in the future (TtEC 2005).

3.2.3 History of Contamination

Site 22 was used as an active landfill from 1950 through 1967. Because operating records do not exist for Site 22, the history of the landfill was compiled by studying aerial photographs and historical maps of the area and by interviewing base personnel. Base personnel reported that Site 22 was used as a municipal landfill after the landfill at Site 2 had been closed. Visual characterization of waste excavated at Site 2 confirmed that Site 2 contained primarily domestic waste; therefore, it was expected (and later confirmed) that Site 22 also contained domestic waste. When the landfill was covered with soil, it was not intended as the "cap" that is required by current regulations, but was placed to allow the area to be landscaped and converted to a golf course. In 1973, Site 22 was converted into holes 6 and 7 of the Moffett Field Golf Course (Navy 2002a).

3.2.4 Initial Response

The Site 22 Landfill was characterized in the *Final Station-wide RI Report* (PRC 1996a) and the *Additional Sites Investigation Phase II Draft Final Report* (PRC 1995d). In April 1998, an additional investigation was initiated to provide supplemental information about Site 22 and its surrounding area. Investigative activities conducted at the Site 22 Landfill in 1994, 1995, and 1998 included soil sampling, groundwater sampling, a landfill gas survey, exploratory trenching, and aquifer testing (slug tests) (Navy 2002a).

Low contaminant concentrations found in samples of leachate, groundwater, soil, and landfill gas at Site 22 supported use of the EPA presumptive remedy (containment) for landfills (Navy 2002a). The EPA established that engineered containment would be used at landfills where the wastes posed a relatively low long-term threat and treatment would be impracticable (40 CFR 300.430[a][l][iii][B]). As a result, complete characterization of the landfill refuse was not necessary because containment does not require such information. Site 22 RI/FS field investigations incorporated this presumptive remedy approach and focused on hydrogeology, groundwater chemistry, soil chemistry, and landfill gas composition to evaluate whether contamination from the landfills was migrating past landfill boundaries (Navy 2002a).

Soil and groundwater samples were analyzed for VOCs, SVOCs, pesticides, PCBs, total petroleum hydrocarbons (TPH), and metals. Additionally, soil samples were analyzed for radioactivity. A landfill gas survey was conducted to determine if landfill gas was escaping through the existing soil cover or migrating off-site (Navy 2002a).

3.2.5 Basis for Taking Action

The soil investigation revealed that the concentrations of contaminants detected in soil samples from boreholes within the landfill material were greater than concentrations detected in soil samples collected outside the landfill material. VOCs, in particular 2-butanone and acetone, were widely distributed within the soil samples collected from the landfill. A range of SVOCs, TPH, and pesticides were consistently detected in soil samples collected from boreholes within the landfill. Three PCBs, Aroclor 1242, Aroclor 1254, and Aroclor 1260, were repeatedly detected at various depths within the landfill soil samples. Inorganic constituents within the landfill were frequently detected at higher concentrations than in perimeter soil boring samples. Contaminant detections in soil samples from boreholes outside of the landfill were low level and sporadic. Analysis of soil samples for radioactivity revealed insignificant results (Navy 2002a).

VOCs that were regularly detected in the groundwater from landfill leachate wells included chlorobenzene, benzene, ethylbenzene, and xylene. Only chlorobenzene was detected at concentrations above ambient water quality criteria (AWQC). One SVOC, diethylphthalate, was detected above AWQC in the leachate samples. Other SVOCs detected frequently in the landfill leachate include 1,4-dichlorobenzene, 2-methylnaphthalene, and naphthalene. Two pesticides detected in landfill leachate sample were detected infrequently and at low concentrations (Navy 2002a).

Chemical analyses of groundwater samples from wells surrounding the landfill indicate sporadic detections of organic constituents in perimeter wells; these may have originated from the landfill due to the presence of groundwater within the refuse. TPH constituents were not detected more than one time, and neither VOCs nor SVOCs were detected at concentrations significantly above AWQC. Results from the analysis of groundwater samples did not indicate significant or consistent chemical releases from the landfill (Navy 2002a).

Nickel, lead, and zinc constituents were detected in both samples of landfill leachate and surrounding groundwater. The metals detected in some perimeter groundwater wells exceeded AWQC, but the results were not significantly different than background concentrations (Navy 2002a).

The landfill gas survey found no indications of off-site migration of landfill gases, no detectable concentrations of non-methane hydrocarbons migrating to the atmosphere from the landfill, and no significant subsurface gas migration beyond the perimeter of the landfill (Navy 2002a).

As part of the additional investigation, exploratory trenches were excavated to further evaluate the vertical and horizontal extent of refuse within the landfill. The exploratory trenching uncovered municipal wastes such as old tires, newspapers, vacuum tubes, and shampoo bottles. Based on the results of the trenching, the estimated extent of the landfill was approximately 9.4 acres and the estimated refuse volume was approximately 92,000 cubic yards (Navy 2002a).

An HHRA was conducted as part of the RI. The evaluation of risk was limited to ingestion or dermal contact with soils, inhalation of wind-eroded surface soils, and inhalation or explosion of landfill gas because groundwater was unlikely to be used as a drinking water source or for any other beneficial uses in the future (Navy 2002a).

The HHRA indicated that total carcinogenic risks and noncarcinogenic hazard indices for recreational and occupational exposures were within EPA target risk levels. Risks associated with soil gas exposure or methane hazards were not found (Navy 2002a).

An ecological risk assessment selected the burrowing owl as an indicator species, a representative measurement endpoint receptor. It concluded that chemical concentrations at the Site 22 Landfill did not appear to adversely affect the burrowing owl community, and risks to ecological receptors were not identified (Navy 2002a).

3.3 SITE 26

This section discusses the site characteristics and history of Site 26 prior to the signing of the ROD.

3.3.1 Physical Characteristics

Site 26 consists of northern and southern chlorinated VOC groundwater plumes that are located east of the Moffett Field runways and impact the upper portion of the A aquifer. The VOC plumes are made up primarily of tetrachloroethene (PCE) and trichloroethene (TCE), and their daughter products *cis*-1,2-DCE and vinyl chloride (Navy 1996).

Site 26 originates near the northeastern corner of Hangar 3 and continues northward into the Moffett Field golf course. The topography above Site 26 is relatively flat (Navy 1996).

The stratigraphy at Site 26 is composed primarily of interbedded silt, silty clay, and silty sand, with some sand and gravel channels of limited extent. At Site 26, the A aquifer is generally semi-confined to confined and the B aquifer is confined (Navy 1996).

Groundwater flow in the area of Site 26 is to the north. Water levels and groundwater flow in the A aquifer zone were influenced locally by the EATS extraction wells while it was operating. In addition, the Building 191 lift station and its associated drainage network influence groundwater flow in the A aquifer zone (Navy 2005a).

3.3.2 Land and Resource Use

Land use is specified in the *Moffett Field Comprehensive Use Plan* (NASA 1994), which restricts access and development in the Site 26 area because of safety considerations related to munitions storage, and runway and air operations, and indicates a change in land use is not planned. The closest residential area is approximately 1 mile southwest (upgradient of) Site 26 (Navy 1996). There are no buildings located over the northern or southern Site 26 plumes (FWEC 2003b).

Groundwater in the Site 26 southern plume meets the state criteria for potable use, so is considered a potential drinking water source. However, no drinking water wells are located in the Site 26 area and future use of groundwater as a drinking water supply is unlikely. The groundwater would have to be treated prior to any future use for drinking water supply because ambient concentrations of metals, which are naturally occurring, exceed drinking water standards (Navy 1996). Because TDS levels in groundwater within the upper portion of the A aquifer at the northern end of Moffett Field exceed the limit, including the area of the Site 26 northern plume, groundwater in this area is not considered a potential drinking water source.

3.3.3 History of Contamination

Aquifer contamination at Site 26 is a result of historical military uses dating back to the 1930s. Chemicals of potential concern (COPC) were generated at Moffett Field from refueling operations, maintenance, and firefighting training. Historical contaminants included jet fuel, waste oils, solvents, paints, asbestos, battery acids, and PCBs. These contaminants were disposed of in unlined landfills, drainage ditches, and unlined storage ponds at Moffett Field. In addition, some underground storage tanks (UST) and sumps were found to have leaked petroleum hydrocarbons and fuels, and lesser amounts of waste oils and solvents. 24 IRP sites were initially identified as potential sources of contamination, 14 of which overlie Site 26 groundwater (Navy 1996).

3.3.4 Initial Response

Site 26 contamination was characterized during the station-wide, 1984 IAS (Naval Energy and Environmental Support Activity [NEESA] 1984), confirmation study (Earth Sciences Associates, Inc. [ESA] and James M. Montgomery, Consulting Engineers, Inc. [JMM 1986]), and Phase I RI

(ITC 1991). Interpretation of the nature and extent of groundwater contamination at Site 26 is based on the Phase I and Phase II data compiled and presented in the OU5 RI report (ITC 1993b). Phase I and II OU5 RI groundwater samples were collected from the A, B, and C aquifers. The OU5 RI report was released in August 1993 (ITC 1993b) and the OU5 FS report was released in August 1995 (PRC 1995b). Groundwater samples were analyzed for COPCs during site characterization investigations.

3.3.5 Basis for Taking Action

Contaminants identified in the RI as having been detected in the OU5 aquifers include chlorinated VOCs, nonchlorinated VOCs, petroleum hydrocarbons, SVOCs, and metals (Navy 1996). These included low concentrations of the VOCs TCE and PCE. These two solvents are reported to have been used at Hangars 2 and 3. They may have been discharged with wastewater to the former flux ponds, which were located at the present EATS treatment pad, as well as to various USTs on the eastern side of Moffett Field (TtEMI 2001b). Low concentrations of other VOCs, primarily *cis*-1,2-DCE and vinyl chloride, were found commingled with TCE and PCE and were likely reductive dechlorination products from natural degradation.

Based on the RI data, a preliminary chemical of concern (COC) list was established and presented in the OU5 HHRA. Human health risks were based on domestic use of groundwater from the upper portion of the A aquifer. This conservative assumption was made even though shallow groundwater is not used as a drinking water source and residential development at Moffett Field is not anticipated. Residential exposure pathways included groundwater ingestion, inhalation of volatilized chemicals, and ingestion of irrigated produce (Navy 1996).

The HHRA indicated all potential residential exposure pathways associated with groundwater exposure at Site 26 are incomplete and that occupational exposure is the most likely exposure scenario. This risk assessment used conservative assumptions, including workers onsite for 8 hours a day for 25 years and exposed to VOCs through the inhalation pathway (PRC 1995b). The risk assessment found that occupational exposure to groundwater did not present significant risks to site workers and therefore a potential future residential use scenario was used to select COCs and remediation goals (Navy 1996).

The preliminary list was later refined based on additional groundwater data. The modified COC list consists of TCE, 1,2-DCE, PCE, 1,2-dichloroethane (1,2-DCA), 1,1-DCE, and vinyl chloride. Between 1989 and the when the ROD was signed in 1996, COCs were detected at the following maximum concentrations in Site 26 groundwater samples (Navy 1996):

- TCE – 140 micrograms per liter (µg/L)
- PCE – 260 µg/L
- 1,1-DCE – 16 µg/L
- 1,2-DCE – 90 µg/L
- 1,2-DCA – 14 µg/L
- Vinyl chloride – 89 µg/L

The COCs are vertically distributed in permeable deposits throughout the upper portion of the A aquifer to a depth of about 35 feet. Only sporadic and estimated quantities of the COCs were measured in the lower portion of the A aquifer. Site 26 COCs were not detected in the B and the C aquifers (Navy 1996).

An ecological risk assessment was also conducted. As a conservative measure, the maximum concentrations of COCs detected in groundwater between 1989 and 1996 were compared to ecological benchmarks. Results of the risk assessment demonstrated that even if the highest levels of COCs detected in the groundwater were to reach ecological receptors, there would be no adverse effects that would change the decision making process for remediation (Navy 1996).

3.4 SITE 28

This section discusses the site characteristics and history of Site 28 prior to the signing of the ROD.

3.4.1 Physical Characteristics

Site 28 consists of chlorinated VOC groundwater plumes that impact the upper and lower portions of the A aquifer west of the Moffett Field runways. The most frequently occurring VOCs detected in the groundwater are the chlorinated solvents TCE and *cis*-1,2-DCE, with lesser amounts of PCE and vinyl chloride (Navy 2005b).

The stratigraphy at Site 28 consists of discontinuous sand and gravel channels and discontinuous clay layers surrounded by silty sands, sandy silts, and silts. There is a hydraulic connection between the upper and lower portions of the A aquifer, and locally there is not a continuous aquitard that separates them. The hydraulic connection between the upper and lower portions of the A aquifers has an impact on capture zones, chemical transport and the interpretation of plumes (TtFW 2005d).

Groundwater flows generally to the north-northeast in the upper and lower portions of the A aquifer west of the runways at Moffett (SES-Tech 2009). Navy and MEW extraction wells influence local groundwater levels, flow directions, and hydraulic gradients (Navy 2005b).

3.4.2 Land and Resource Use

Land use in the vicinity of Site 28 area is specified in the NASA Ames *Moffett Field Comprehensive Use Plan* and includes airfield operations, administrative offices, and various storage buildings (NASA 1994).

Site 28 is located within NASA's redevelopment area. Future land use is described in the *NASA Ames Development Plan Final Programmatic Environmental Impact Statement* (EIS) (NASA 2002a). Site 28 is within portions of two planning areas: the NASA Research Park (NRP) and

the Ames Campus. New educational, office, research and development, museum, conference center, housing, and retail space is planned for NRP, and plans include demolition of non-historic structures. Residential development is not planned over areas of the regional plume with high concentrations of contaminants. High-density office, research, and development space is planned for the Ames Campus. There are currently no plans for this land to change ownership (NASA 2002a).

Groundwater at Site 28 meets the state criteria for potable use, so it is considered a potential drinking water source. However, there are no drinking water wells at Site 28. NASA controls future potential consumption of groundwater in the redevelopment areas through clauses in tenant leases prohibiting potable uses of the groundwater (NASA 2002b).

3.4.3 History of Contamination

Four areas within the area of Site 28 have been identified as potential sources of VOC or fuel-related groundwater contamination: Building 29, Building 31, former Building 88, and the Hangar 1 former aircraft wash rack (see Figure 5) (TtEMI 2001c).

Fuel-related contaminants are attributed to a number of petroleum sites, including USTs and sumps. The primary petroleum site in the area was Site 9, which includes buildings 29 and 31. Building 29 was part of the old fuel farm. The old fuel farm was used from the 1940s until 1964 (ESA and JMM 1986). The Building 29 area contained 13 USTs and one aboveground storage tank, all of which were removed in July 1993 (TtEMI 2001c). These tanks contained aviation gasoline, fuel and lubrication oils, and jet fuels that were used in operation of the old fuel farm. Building 31 was part of the former Naval Exchange gasoline station. The Building 31 area contained four USTs (three gasoline storage tanks and one waste oil tank), which were removed in October 1990 (TtEMI 2001c).

Former Building 88 and the Hangar 1 former aircraft wash rack are suspected sources of VOC contamination in the upper and lower portions of the A aquifer (TtEMI 2001c). Former Building 88 was located southwest of Hangar 1. Before it was closed in 1987, Building 88 served as Moffett Field's laundry and dry cleaning facility, which used PCE. Building 88 was demolished in June 1994 as part of Navy source control activities, in conjunction with removal of an associated tank (Tank 68) and sump (Sump 91). Another associated sump (Sump 66) was removed in May 1990 (TtEMI 2001c).

The former aircraft wash rack area is approximately 250 feet south of Hangar 1. The former wash rack was used to clean aircraft and consisted of a 90-foot by 100-foot section of pavement that was sloped to central catchment basin 297A. Effluent from the catchment basin was routed under Cody Road to the Sump 25 oil-water separator which, in turn, discharged to the sanitary sewer system. Sump 25 was a 2,000-gallon concrete, dual-chamber oil-water separator that used an oil skimmer system for oil recovery. Sump 25 was removed in May 1994 (PRC 1996b). The Navy is currently assessing Sump 25 as a petroleum site.

3.4.4 Initial Response

The initial response at Site 28 included site characterization, consisting of the facility-wide IAS (NEESA 1984), confirmation study (ESA and JMM 1986), and Phase I RI (ITC 1991). The old fuel farm, one of the potential sources within Site 28, was identified during the 1984 IAS and investigated during the confirmation study (ESA and JMM 1986). During 1988 and 1989, Phase I RI field activities were conducted at additional potential source sites within Site 28 (ITC 1991). Potential VOC impacts have been difficult to evaluate because these potential Navy sources lie within the area of the MEW regional VOC plume.

3.4.5 Basis for Taking Action

Site characterization indicated that VOCs are found in the upper and lower portions of the A aquifer to maximum depths of about 35 and 77 feet, respectively. The most frequently occurring VOCs detected in the groundwater within Site 28 are the chlorinated solvents TCE and *cis*-1,2-DCE, with lesser amounts of PCE and vinyl chloride. *Cis*-1,2-DCE and vinyl chloride are found commingled with TCE and PCE and are likely reductive dechlorination products from natural degradation. In addition to the on-site sources discussed above, VOCs have historically migrated into Site 28 area from upgradient MEW sources, and current data indicate migration continues (SES-Tech 2009). The MEW companies, the Navy, and NASA released VOCs that have commingled to form a regional plume (see Figure 6).

In October 1992, EPA determined that the west-side aquifers were affected by the MEW regional VOC plume. As a result, the Navy agreed to adopt the MEW ROD in a December 1993 amendment to the FFA. Because the Navy adopted the MEW ROD, a RI/FS and associated risk assessments specific to Site 28 were not completed (TtEMI 2001c).

An Endangerment Assessment prepared by EPA as part of the MEW RI/FS was used to evaluate threats to human health and the environment. The RI/FS stated that the bulk of the contamination is present in groundwater and subsurface soils and selected the following VOCs as COPCs: TCE, 1,1,1-trichloroethane, vinyl chloride, 1,1,-DCA, 1-,1-DCE, 1,2-DCE, dichlorobenzene (DCB), chloroform, Freon 113, PCE, and phenol. Metals were detected infrequently and determined to be less concern at the site that the VOCs. Several of the VOCs (TCE, chloroform, DCB, PCE) are known carcinogens in animals and possible or probable human carcinogens. Vinyl chloride is a known human carcinogen. The other contaminants have been shown to cause systemic toxicity under certain exposure conditions (EPA 1989).

The Endangerment Assessment concluded that exposure to contaminated groundwater poses the greatest public health concern. Contaminants are not present at elevated levels in exposed surface soils. The Endangerment Assessment also found that exposure to chemicals to flora and fauna at the MEW site was negligible (EPA 1989).

4.0 REMEDIAL/REMOVAL ACTIONS

This section discusses the initial plans, implementation history, status of the remedies, and relevant site activities since the RODs were signed to the present. Remedy selection, remedy implementation, remedy performance, operations and maintenance (O&M), and any changes to, or problems with the components of the remedy will be discussed.

4.1 REMEDY SELECTION

This section describes the remedial action objectives (RAO) and the remedies selected for each site. RAOs were established to allow selection of remedies that achieve protection of human health and the environment and are consistent with continued use according to the NASA Ames *Moffett Field Comprehensive Use Plan* (NASA 1994).

4.1.1 Site 1

The ROD did not identify RAOs, rather, it stated that the remedy selected for OU1 (Sites 1 and 2) met the statutory requirements of § 121 of CERCLA (Navy 1997). The statute requires that remedial actions:

- Protect human health and the environment.
- Comply with applicable or relevant and appropriate requirements (ARAR), unless a statutory waiver is justified.
- Be cost effective.
- Use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practical.
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element, or provide an explanation as to why this preference cannot be satisfied.

The ROD was signed by the Navy, EPA, the California Department of Toxic Substances Control (DTSC), and Water Board in August 1997 (Navy 1997). The following summary from the ROD describes the selected remedy:

- Consolidate wastes from Site 2 into Site 1.
- Place a cap and cover over Site 1.
- Perform groundwater monitoring at Sites 1 and 2.

- Install a subsurface groundwater collection trench along the northern border of Site 1 to intercept potential future leachate migration before it reaches surface water.

- Perform landfill gas monitoring at Site 1.

- Install a passive gas-venting trench along the western boundary of Site 1 to prevent potential off-site, subsurface migration of landfill gases.

- Conduct post-closure maintenance activities at Site 1.

- Implement ICs and ECs – fencing, signs, (assigning responsibility for) O&M of Building 191 pump station and drain and sub-drain system, and restrictions on cover disturbances.

4.1.2 Site 22

The RAO identified in the ROD was to protect human health by preventing contact with landfill refuse. The ROD for Site 22 was signed in 2002 by the Navy, EPA, and Water Board (Navy 2002a). The major components of the selected response action are summarized below:

- Install a biotic barrier to prevent burrowing animals from uncovering the subsurface contamination.

- Manage surface water flow across the site to prevent ponding of water on the landfill cover and to improve precipitation runoff in order to reduce water infiltration into the subsurface.

- Implement ICs to maintain the integrity of the barrier and to prevent disturbances or excavation of waste materials.

- Monitor groundwater and gas in the vicinity of the site.

For IC implementation, the ROD documents commitment to the following requirements as elements of the selected response action for the Site 22 landfill (Navy 2002):

- Protection of the structural aspects of the landfill cap (biotic barrier).

- Prohibition of alterations of the drainage patterns or modification of surface contours.

- Establishment of specific boundaries for the extent of the landfill.

- Prohibition of extraction of groundwater from the site.

- Prohibition of residential land use.
- Requirement of regulatory approval for consideration of alternative land uses.
- Indication of parties responsible for ongoing operations, maintenance, and monitoring activities for the site.
- Requirement of annual reporting to EPA regarding the implementation, monitoring, and efficacy of the ICs.
- Reference to how the MOA will be enforced with NASA and with its site-specific tenants.
- Requirement that transfer of the site to a non-federal entity includes a restrictive covenant conveying the property with ICs (as specified in the MOA) in place.

4.1.3 Site 26

The RAOs for Site 26 are to prevent unacceptable exposure to contaminated groundwater and to maintain current and future beneficial use of groundwater. The ROD (Navy 1996) was signed by the Navy, EPA, DTSC, and Water Board in June 1996 and addresses groundwater contamination, specifically the southern plume. Drinking water is considered to be the highest beneficial use and affords the greatest level of protection and cleanup. Because the southern plume is in an area of potential drinking water use, the ROD specifies maximum contaminant levels (MCL) as cleanup goals (Navy 1996). The more stringent of the federal or state standard was selected. The COCs and associated MCLs are as follows:

- 1,2-DCA – 0.5 µg/L
- 1,2-DCE – 6 µg/L
- 1,1-DCE – 6 µg/L
- PCE – 5 µg/L
- TCE – 5 µg/L
- Vinyl chloride – 0.5 µg/L.

The major components of the remedy for Site 26 follow (Navy 1996):

- Extraction and treatment of groundwater using an air stripping system for the southern plume (“pump and treat”).

- ICs to restrict domestic use of Site 26 groundwater.
- Groundwater monitoring.

The ROD specified that no action except for groundwater monitoring is required for the Site 26 northern plume since high concentrations of TDS render it unusable as a source of drinking water (Navy 1996).

The continued operation of the Building 191 pump station is necessary for successful implementation of Site 26 cleanup. Without its operation, flooding of the northern end of the runways and surrounding areas, including portions of the golf course which overlie the Site 26 east side aquifers, would occur during the rainy season. Therefore, the Building 191 pump station is a component of the groundwater remedy and must remain operational (Navy 1996).

The ROD estimated that the selected pump and treat remedy would take at least 50 years to reach cleanup standards; however, due to the lithology, achieving the groundwater cleanup standards may not be technically or economically feasible. It further stated that the Navy would monitor the performance of the system to assess its effectiveness, and that the selected remedy could be reevaluated as appropriate (Navy 1996).

4.1.4 Site 28

No RAOs are expressly stated in the MEW ROD, rather remedial goals are presented. The cleanup of groundwater and soil at the site is driven by current and future beneficial use of local groundwater (EPA 1989). In a December 1993 amendment to the FFA (EPA 1993), the Navy agreed to adopt the May 1989 MEW ROD (EPA 1989). This FFA amendment specifies that the Navy "agrees to adopt the MEW ROD and to remediate the source control removal areas of FFA Attachments 4 and 5 in accordance with the MEW ROD for contamination attributable to the Navy sources" (EPA 1993).

For the shallow aquifers, which include the contaminated media (upper and lower portion of the A aquifers) at Site 28, the MEW ROD states:

> Although the shallow aquifers are not currently used for drinking water, they are a potential source for drinking water and therefore a 5 parts per billion (ppb) TCE cleanup goal has been established which corresponds to between a 10^{-4} and 10^{-5} excess cancer risk, which is within EPA's acceptable risk range. Cancer risks have been screened for all aquifers, and the chemical ratio of TCE to other chemicals found at the site is such that achieving the cleanup goal for TCE will result in cleanup of the other site chemicals to at least their respective maximum contaminant levels (MCL) (EPA 1989).

The ROD also states that the federal and State of California drinking water standards are chemical-specific ARARs that are relevant and appropriate at the site. Therefore, should the ROD assumption (that remediating to the TCE MCL of 5 ppb will leave other COCs at or below their MCLs) prove false, the other COCs are to be remediated so that their respective concentration levels are at or below MCLs. The EPA has noted that additional investigation conducted by the MEW companies indicated antimony, lead, arsenic, cadmium, and phenol are no longer primary COCs. The ROD lists COCs and the lowest of the federal or state MCLs as follows (EPA 1989):

- Chloroform – 100 µg/L
- 1,2-Dichlorobenzene – no MCL listed in ROD
- 1,1-DCA – no MCL listed in ROD
- 1,1-DCE – 6 µg/L
- 1,2-DCE – no MCL listed in ROD
- Freon-113 – no MCL listed in ROD
- PCE – no MCL listed in ROD
- 1,1,1-Trichloroethane – 200 µg/L
- TCE – 5 µg/L
- Vinyl chloride – 0.5 µg/L

Since the signing of the ROD, the following MCLs (lower of federal or state) have been established for COCs detected at Site 28 for which no MCL existed at the time (CDPH 2008):

- 1,2-Dichlorobenzene – 600 µg/L
- 1,1-DCA – 5 µg/L
- 1,2-DCE – 6 µg/L
- Freon-113 – 1200 µg/L
- PCE – 5 µg/L

For unsaturated soils (those soils above the groundwater table), the MEW ROD selected two alternatives for remedy implementation, in-situ vapor extraction with treatment by vapor phase granular activated carbon (GAC) or excavation with treatment by aeration. Soil excavation and treatment by aeration would most likely be suitable for small, localized areas of contamination.

The cleanup goal applicable to Moffett Field is 500 µg/kg TCE for unsaturated soils. The soil remediation goal is based on the amount of contamination that can remain in the soil, leach into the groundwater, and still achieve the groundwater remediation goal in the shallow aquifers. For the remaining COCs, the soil remediation goals were 100 times the groundwater goals (EPA 1989).

There have been two ESDs for the MEW ROD (September 1990 and April 1996). The September 1990 ESD (EPA 1990) clarified that the cleanup goals constituted final cleanup standards that the remedial activity must meet. The April 1996 ESD (EPA 1996) clarified the groundwater remedy, with an additional rationale for use of liquid phase GAC for treatment.

The major components of the groundwater remedy originally consisted of extraction and treatment of groundwater using an air stripping system, followed by discharge and groundwater monitoring (EPA 1989). The MEW ROD states that the groundwater remedy for the shallow aquifers may be in operation for as long as 46 years or into the indefinite future because of the physical and chemical nature of the aquifers (EPA 1989). The ROD specifies that achieving the groundwater cleanup standard may not be technically and economically feasible due to the lithology.

4.2 REMEDY IMPLEMENTATION

The main goals of the remedies were to clean up COCs to levels specified in RODs and prevent human and ecological exposure to contamination. The following sections discuss the steps taken following the finalization of each ROD through the present, to implement the remedies for Sites 1, 22, 26, and 28.

4.2.1 Site 1

Construction of the remedy began in July 1997 and was completed in November 1998. Details regarding implementation of the selected remedy are documented in the *Draft Final Interim Remedial Action Report, Site 1 and Site 2 Landfill Closures* (TtEMI 2001a) and the *As-Built Report and Remedial Action Completion Report, Site I and Site 2 Landfill Closures* (ITC 2000a).

Landfill Activity

The excavation and transfer of wastes from Site 2 to Site 1 began on July 28, 1997, commencing the remedial action. Approximately 23,000 cubic yards of wastes were transferred from Site 2 to Site 1 from July to August 1997. Soil confirmation samples were collected at the Site 2 Former Landfill following the excavation activities. A total of 37 soil confirmation samples were collected from the bottom and sidewalls of the excavation. The analytical results of confirmation samples were compared to the EPA Region 9 industrial preliminary remediation goals (PRG). The excavation at the Site 2 Former Landfill continued until the confirmation sample results met the EPA Region 9 PRGs. The excavation was backfilled with soil overburden removed during

clearing and grubbing of the landfill surface, and additional, clean, imported soil. Following excavation activities, surface soil was graded and hydroseeded (TtEMI 2001a).

After contamination had been removed and confirmatory testing demonstrated that groundwater had not been impacted from landfill contents, groundwater monitoring was discontinued in 2003 with concurrence from EPA and the Water Board. Site 2 is available for unrestricted use. Copies of the EPA and Water Board concurrence letters are presented in Appendix A.

The waste from Site 2 was transferred to a pre-constructed lower foundation layer (LFL) in Site 1. The waste was spread, graded, and compacted onto the LFL. Portions of Site 1 were moved to construct the design contours of the LFL. The former pistol range located at Site 1 and other areas within the site were regraded. The Site 1 Landfill cover consists of a 1-foot-thick LFL (bottom), a 1-foot-thick upper foundation layer, a 1-foot-thick low-permeability clay layer, a geotextile biotic barrier layer, and a 1-foot-thick vegetative soil layer (top) (see Figure 7).

A groundwater collection trench was constructed across the northern boundary of the landfill as a contingency measure intended to act as a control system should the need arise to manage contaminated groundwater migrating off site (see Figure 3). The collection trench is approximately 5.5 feet deep (elevation of -5.0 feet msl) and is lined with geosynthetic material as described in the *As-Built Report and Remedial Action Completion Report, Site 1 and Site 2 Landfill Closures* (ITC 2000a). Depth to groundwater beneath Site 1 is approximately 2.5 to 3.5 feet below msl. Based on the drawings in the as-built report, the geosynthetic liner extends from the surface of the landfill over the top of the collection trench and continues into the north side of the collection trench. This effectively forms an impermeable barrier between the collection trench and the stormwater retention pond north of the landfill, and would intercept the potential future migration of leachate before it reaches surface water. Two wells (collection trench wells WI-22 and WI-23) are screened within the backfill material of the collection trench. Groundwater monitoring wells were installed along the landfill perimeter (TtFW 2004c).

A gas-venting trench was installed across the western boundary of the landfill to allow potential landfill gas to vent to the atmosphere (see Figure 3). The bottom of the gas-venting trench is approximately 4.0 feet bgs (elevation of -2.3 feet msl) and lined with geosynthetic membranes. A four inch perforated pipe was laid in the gas-venting trench before backfilling with drain rock (ITC 2000a). Several gas-venting wells were installed within the landfill to allow landfill gas to vent to atmosphere (see Figure 3).

Groundwater Monitoring

To comply with the remedy as specified in the ROD (Navy 1997), a long-term groundwater monitoring plan was developed. Groundwater sampling was performed on a quarterly basis at Site 1 from January 2002 to November 2004 in accordance with Appendix E of the *Site 1 Landfill Final Closure Plan and Post-Closure Maintenance Plan* (TtEMI 1998a). Beginning in January 2005, the groundwater monitoring schedule was amended to semiannual in accordance with the *Final Site 1 Landfill Post-Closure Long-Term Monitoring Plan* (TtFW 2005a).

Groundwater sampling at Site 2 was performed on a quarterly basis from August 1999 through October 2002. Groundwater sampling was discontinued in 2003 after concurrence from EPA and the Water Board because analytical data demonstrated that former activities at Site 2 had not impacted groundwater. Groundwater samples are collected using micropurge sampling methodology (flow rates less than 500 milliliters per minute) with a low-flow pump and disposable tubing. Field quality control samples are collected in accordance the *Final Sampling and Analysis Plan Addendum for Post-Closure Monitoring (Site 1) and Groundwater Monitoring (Site 2)* (FWEC 2001a) and the *Final Site 1 Landfill Post-Closure Long-Term Monitoring Plan* (TtFW 2005a). The samples are analyzed by the following methods:

- Dissolved metals by EPA Method 200.8/6010B/7742.
- Dissolved mercury by EPA Method 7470A.
- Total metals by EPA Method 200.8/6010B/7742 (until March 2004).
- Total mercury by EPA Method 7470A (until March 2004).
- VOCs by EPA Method 8260B.
- SVOCs by EPA Method 8270C.
- Pesticides by EPA Method 8081A.
- PCBs by EPA Method 8082 (until October 2005).

Target analytes at Site 1 are identified in the *Final Technical Memorandum, Site 1 Groundwater Evaluation Process* (TtFW 2004c) and are composed of COCs and monitoring parameters (MP). Based on the available historical information of site operations, potential and known waste materials received, potential degradation products, and groundwater sampling results, the COCs at the Site 1 Landfill include dissolved metals, PCBs, pesticides, VOCs, and SVOCs.

MPs include physical and analytical parameters that are subsets of the COCs. The analytical MPs were selected based on *California Code of Regulations* (CCR) Title 27 criteria, including frequency of detections, mobility and persistence in the environment, potential degradation products, toxicity to potential aquatic receptors, and reported operational history of the landfill. The analytical MPs include selected metals, VOCs, pesticides, and SVOCs. The objective was to select a subset of the COCs which, if a release from the landfill occurred, would be representative and detected in the groundwater monitoring wells (TtFW 2004c).

Sampling of groundwater for the complete list of COCs was conducted in May and November 2004. Groundwater sampling for the complete list of COCs occurs once every five years (TtFW 2004c). Groundwater sampling for MPs occurs semiannually. COC and MP concentrations are compared to their respective calculated concentration limits (CCL), which were derived and

presented in the *Final Technical Memorandum, Site 1 Groundwater Evaluation Process* (TtFW 2004c). COCs, MPs, and their respective CCLs are listed in Tables 6 and 7.

CCLs were developed based on ecological screening criteria and site-specific attenuation factors for groundwater. CCLs are used as initial screening criteria in the groundwater evaluation. If analytical results are less than the CCLs, no release from the landfill is presumed and no additional evaluation is required. If CCLs are exceeded, additional evaluation of upgradient and downgradient data is necessary to evaluate whether there has been a release from the landfill. If upgradient concentrations are higher than downgradient concentrations, most likely there was no release from the landfill. If downgradient concentrations are higher than upgradient concentrations, additional sampling events will be performed and results will be evaluated to assess whether there has been a release from the landfill (TtFW 2004c).

The following groundwater monitoring wells and collection trench wells are sampled during each event (see Figure 3): W1-1R, W1-5, W1-8, W1-12R, W1-14, W1-15, W1-16, W1-19, W1-22 (collection trench well), W1-23 (collection trench well), and W1-24. Based on the groundwater flow direction, wells WI-5, WI-8, and WI-12R are classified as upgradient or background wells and are not influenced by the Site 1 Landfill. The remaining wells, with the exception of the collection trench wells, have been classified as downgradient. The collection trench wells are included in the sampling program, as required by the OUI ROD; however, they are not considered to be representative of actual groundwater conditions at Site 1 (TtFW 2004c). Analytical data from the collection trench wells are removed from consideration in the Five-Year Review.

According to the *Final Site 1 Landfill Post-Closure Long-Term Monitoring Plan* (TtFW 2005a), wells W1-7, W1-20, and W1-6 are not sampled because they are either screened in the lower portion of the A aquifer or are not applicable based on location. Only wells screened in the upper portion of the A aquifer are sampled at Site 1. After review of screening depths and well locations, it appears well W1-7 is not sampled because it is screened in the lower portion of the A aquifer. W1-20 is not sampled based on location because it is located near well W1-15, which is already included in the sampling program. W1-6 is not sampled based on a combination of screening depth and location. W1-6 is screened in both the upper and lower portions of the A aquifer, and it is located near well W1-15.

Landfill Gas Monitoring

Landfill gas (methane) monitoring is performed in accordance with the *Site 1 Landfill Final Closure Plan and Post-Closure Maintenance Plan* (TtEMI 1998a), the *Post-Closure Monitoring (Site 1) and Groundwater Monitoring (Site 2) Sampling and Analysis Plan* (ITC 2000b), *Final Sampling and Analysis Plan Addendum* (FWEC 2001a), and the *Final Site 1 Landfill Post-Closure Long-Term Monitoring Plan* (TtFW 2005a).

The Site 1 gas monitoring network consists of 19 gas vents (GV-1 through GV-19), four landfill gas monitoring wells (LGMW1-1 through LGMW1-4), and 21 monitoring locations located

around the perimeter of the site (P-1 through P-21). Figure 3 shows the locations of the Site 1 Landfill gas monitoring locations (TtFW 2005a).

Landfill gas is monitored to confirm that concentrations remain below 5 percent by volume in air at the site boundary. An exceedance of the criterion will be considered verified if concentrations for an individual landfill gas monitoring well, a gas vent, or a perimeter surface monitoring location, are above this concentration for any two out of three consecutive quarters. If methane concentrations are confirmed, EPA, the Water Board, and the Santa Clara County Department of Environmental Health (DEH) will be notified.

Institutional Controls

ICs are non-engineered controls such as administrative and legal controls. ICs in conjunction with monitoring, maintenance, and inspection of the ECs are designed to help minimize impacts to the remedy and protect the integrity of the remedy.

An MOA between the Navy and NASA Ames Research Center was required by the ROD to establish ICs for Site 1. In November 1999, the MOA was executed and formally established the roles and responsibilities of the Navy and NASA with regard to the ICs in ensuring protectiveness of the remedy. However, for the remedy to be fully protective of human health and the environment, NASA must incorporate ICs required by the ROD and MOA into its planning documents and provide documentation and a reporting schedule to EPA and the Water Board.

The Navy conducts internal site visits and quarterly inspections as part of IC implementation measures. To meet the annual reporting requirement to EPA, the Navy provides annual reports that detail the effectiveness of IC monitoring and implementation. This MOA covered OUs 1 and 5 and is discussed more fully in Section 4.2.3. A copy of the MOA is presented in Appendix B.

NASA Ames agreed to incorporate remedy protection measures for the landfill remedy in its land use and operation plans. As part of the Ames Procedural Requirements, the Environmental Division maintains copies of environmental records, including those of the Site 1 landfill remedy. The Environmental Division reviews plans from personnel, tenants, and contractors for proposed field activities with the intent of preventing disturbances to the landfill remedy. NASA Ames is responsible for contamination or disturbances from its operations. The Navy and the NASA Ames Research Center Environmental Division coordinate on a regular basis.

NASA Ames continues to maintain and operate the Building 191 pumping station as part of its stormwater drainage and conveyance system. Operation of the pump station prevents major flooding at the landfill during storm events. The pump station also influences groundwater flow at the landfill.

NASA's Facilities Group is currently revising its Master Plan with input from the Environmental Division to ensure inclusion of language regarding NASA's continued and future operation of the Building 191 pump station. Revisions to the Master Plan will also incorporate ICs, as specified in the MOA, into NASA's land use planning documents. The Navy will continue to work with NASA to incorporate these changes into NASA's Master Plan (NASA 2010).

The Site 1 landfill is not planned for property transfer. Monitoring and inspection of the engineered controls allows the effectiveness of institutional controls to be evaluated. The ICs are effective overall. Additional information on ICs is provided in the *Draft Final Interim Remedial Action Report, Site 1 and Site 2 Landfill Closure* (TtEMI 2001a).

4.2.2 Site 22

Construction of the remedy began in January 2003 and was completed August 2003. Details regarding the implementation of the selected remedy are documented in the *Final Remedial Action Report for Installation Restoration Site 22 Landfill* (TtFW 2004a).

Landfill Cover

While not specifically referred to as an EC in the ROD, installation of the Site 22 Landfill cover is an EC because the intent was to construct a barrier that prevents human exposure to landfill contents. After the landfill was regraded to maintain a positive flow, the Site 22 Landfill cover was installed. Positive flow refers to contouring the surface of the landfill so that runoff flows off of the landfill. The cover consists (from bottom to top) of a 6-inch foundation layer, a biotic barrier composed of a 12-inch layer of 4- to 8-inch cobblestone capped with a concrete and sand slurry mix, a 6-inch coarse granular 3/8-inch pea gravel drainage layer, an 8-ounce geotextile fabric layer, and an 8-inch topsoil layer capped with a 4-inch layer of sand (see Figure 8) (FWEC 2003a).

Tree wells were installed following the placement of the biotic barrier and prior to the placement of the irrigation system. Tree wells consist of a 6-foot diameter plastic liner extending from the final ground surface into the foundation layer. They were installed to allow trees to be planted at the golf course without jeopardizing the integrity of the biotic barrier (TtFW 2004a).

A subsurface drainage system was installed above the biotic barrier to redirect water that infiltrates the upper layers toward the northern and southern boundaries of the Site 22 Landfill. On the north side of the site, surface runoff and subsurface water discharge to the new drainage swale, which ultimately flows into the North Patrol Road ditch through two 1-foot-diameter culverts. On the south side of the site, surface runoff and subsurface water is directed to existing water hazards outside of the landfill limits. Completed topography directs sheet-flow water in the same directions, and toward the east (FWEC 2003a).

Groundwater Monitoring

To comply with the remedy as specified in the ROD (Navy 2002a), a long-term groundwater monitoring plan was developed. Groundwater sampling and water level monitoring are performed on a quarterly basis at Site 22 in accordance with the *Final Post-Construction Operations, Maintenance, and Monitoring Plan* (OMMP) (FWEC 2003a) and the OMMP Addendum (TtEC 2007). The groundwater monitoring network consists of 10 wells screened in the upper portion of the A aquifer and located upgradient and downgradient of the landfill (see Figure 4). Samples are collected using low-flow sampling methodology (flow rates less than 500 milliliters per minute) with a low-flow pump and disposable tubing. The samples are analyzed for the following parameters:

- VOCs by EPA Method 8260B
- SVOCs by EPA Method 8270C
- Pesticides by EPA Method 8081A (TtEC 2007)

The ROD identified COCs (VOCs, SVOCs, and pesticides) and required development of CCLs for COCs as part of the groundwater monitoring program (Navy 2002a). Analytical MPs are a subset of the COCs at Site 22. The MPs are *cis*-1,2-DCE, chloroform, TCE, and xylenes. The VOCs selected as MPs were based on the frequency of detection and/or properties of each compound, with those selected that would most likely be present in the groundwater (TtEC 2007).

The CCLs were proposed in the OMMP Addendum (TtEC 2007) based on exposure pathways and potential groundwater use at the site, and were developed using AWQC and other appropriate surface water screening criteria to be protective of aquatic organisms. The CCLs are used in the evaluation of groundwater data collected from the monitoring wells at Site 22. Site 22 COCs, MPs, and their respective CCLs are presented in Table 8.

The data evaluation process follows the requirements of the ROD and the ARARs identified in the ROD. Regularly scheduled groundwater sampling data of the MPs will be compared to the respective CCLs to assess whether there is an exceedance. If downgradient analytical data are lower than or equal to the respective CCLs, no further action will be necessary. If concentration of a downgradient analyte is greater than its CCL, a statistical evaluation will be required to assess if a release has occurred. The evaluation process is described further in the OMMP Addendum (TtEC 2007).

According to the OMMP Addendum, monitoring wells WGC2-8, WGC2-9, WGC2-10, and WGC2-11 are downgradient wells; WGC2-4 and WGC2-13 are upgradient wells; and WGC2-6 and WGC2-12 are the reference wells. Reference wells are useful for assessing groundwater conditions relative to the site, but do not contain groundwater that will flow under the landfill. Wells WGC2-1 and WGC2-5 are crossgradient wells and may receive groundwater from off site. The groundwater from these monitoring wells does not impact groundwater under the landfill;

nor does the landfill impact groundwater within these wells. The OMMP Addendum stated that these wells would not be monitored for water quality. Thus, even though they are sampled, they are not useful for determining if a release from the landfill has occurred (TtEC 2007).

Landfill Gas Monitoring

Methane monitoring at Site 22 is conducted in accordance with the OMMP (FWEC 2003a) and the OMMP Addendum (TtEC 2007) to provide for the protection of public health and safety, and the environment by demonstrating that methane migration is not occurring in the vadose zone. The Site 22 methane monitoring network consists of four landfill gas monitoring wells (LGMW-1, LGMW-2, LGMW-3, and LGMW-4), 15 tree wells methane monitoring points (TW-2, -5, -9, -13, -15, -19, -21, -26, -30, -38, -40, -42, -49, -52, and -54), and 13 monitoring locations around the perimeter of the site (P1 through P13) (see Figure 4) (TtFW 2004a).

Because no methane detections occurred during the first two rounds of measurements when all 56 tree wells within the cap area were evaluated, the tree wells selected for monitoring are located randomly throughout the landfill cap area. The perimeter monitoring locations are spaced about 250 feet apart along the boundary of the landfill cap (FWEC 2003a).

Methane will be monitored to confirm that concentrations remain below 5 percent by volume in air at the site boundary. An exceedance of the criterion will be considered verified if concentrations for an individual landfill gas monitoring well, a tree well located at the boundary (TW-2, TW-42, TW-49, or TW-54), or a perimeter surface monitoring station, are above this concentration for any two out of three consecutive quarters. If methane concentrations are confirmed, EPA, the Water Board, and the Santa Clara County DEH will be notified.

Institutional Controls

A MOA between the Navy and NASA Ames Research Center was required by the ROD to establish ICs for Site 22. In September 2008, the MOA was executed and formally established the roles and responsibilities of the Navy and NASA with regard to the ICs in ensuring protectiveness of the remedy. However, for the remedy to be fully protective of human health and the environment, NASA must incorporate ICs required by the ROD and MOA into its planning documents and provide documentation and a reporting schedule to EPA and the Water Board.

The Navy conducts internal site visits and quarterly inspections as part of IC implementation measures. To meet the annual reporting requirement to EPA, the Navy provides annual reports that detail the effectiveness of IC monitoring and implementation. The monitoring strategy, which describes the required monitoring activities, schedules, and specific reporting requirements for Site 22, is addressed through the OMMP (FWEC 2003a), the OMMP Addendum (TtEC 2007), and the MOA (Navy 2008). A copy of the MOA is presented in Appendix B.

NASA Ames agreed to incorporate remedy protection measures for the landfill remedy in its land use and operation plans. As part of the Ames Procedural Requirements, the Environmental Division maintains copies of environmental records, including those of the Site 22 landfill remedy. The Environmental Division reviews plans from personnel, tenants, and contractors for proposed field activities with the intent of preventing disturbances to the landfill remedy. NASA Ames is responsible for contamination or disturbances from its operations. The Navy and the NASA Ames Research Center Environmental Division coordinate on a regular basis.

NASA Ames continues to maintain and operate the Building 191 pumping station as part of its stormwater drainage and conveyance system. Operation of the pump station prevents major flooding at the landfill during storm events. The pump station also influences groundwater flow at the landfill.

NASA's Facilities Group is currently revising its Master Plan with input from the Environmental Division to ensure inclusion of language regarding NASA's continued and future operation of the Building 191 pump station. Revisions to the Master Plan will also incorporate ICs, as specified in the MOA, into NASA's land use planning documents. The Navy will continue to work with NASA to incorporate these changes into NASA's Master Plan (NASA 2010).

The Site 22 landfill is not planned for property transfer. Monitoring and inspection of the engineered controls allows the effectiveness of institutional controls to be evaluated. The institutional controls are effective overall. Additional information on ICs is provided in the *Final Remedial Action Report for Installation Restoration Site 22 Landfill* (TtFW 2004a).

4.2.3 Site 26

The Navy began construction of the EATS groundwater pump and treat system in July 1997. In January 1999, construction was completed, and EATS began operating. Details regarding implementation of the selected remedy are found in the *Draft Final Interim Remedial Action Report, East-Side Aquifer Treatment System* (TtEMI 2001b).

EATS Overview

EATS consists of five extraction wells piped to a treatment system (see Figure 9). All of the extraction wells (EXW-1 through EXW-5) are completed in the upper portion of the A aquifer. EATS treats groundwater using an air stripper and liquid phase GAC vessels in series. The GAC units were added during the design phase as a safety factor for uncertainties and to polish treated groundwater from the air stripper. Based on operational data, the GAC units were determined to be redundant and not required to meet discharge requirements. The system was turned off in July 2003 so that the Navy could explore alternative treatment methods.

EATS was operated to meet MCLs. EATS treated about 30 gallons per minute of groundwater. This is consistent with the design specifications (TtEMI 2001b). Contaminated water was pumped from the extraction wells and treated to remove the contaminants to levels specified in

the National Pollutant Discharge Elimination System (NPDES) permit before being discharged. Because water could be reused, the treated water was discharged to the stormwater system in accordance with the NPDES general permit CAG912003, Order No. 99-051 and the ROD.

EATS began operating in January 1999. System functional checks were completed in April 1999, and the system was considered to be operating properly in May 1999 (TtEMI 2001b).

EATS operational data are provided in the *First*, *2001*, and *2002 Annual Groundwater Reports for WATS and EATS* (FWEC 2002a, 2003b; and TtFW 2004b). EATS processed 67,050,786 gallons of groundwater and removed 23.65 pounds of VOCs while in operation. The efficiency of EATS declined with time from 1999 to 2003. In 1999, the system removed 0.39 pounds of COCs per million gallons of groundwater treated; the rate of removal per million gallons of groundwater had decreased to 0.34 pounds by 2001 and remained at 0.34 pounds per million gallons of groundwater in 2002. The decrease in COC removal efficiency of EATS is believed due to a chemical tailing, or rebound effect. This generally is the case when COC concentrations are low (maximum COC concentration in 2002 was 51 µg/L of TCE) and COC removal rates decrease or remain stable.

On July 2, 2003, EATS was turned off and operations were secured in accordance with the agency approved *Final EATS Evaluation Work Plan* (FWEC 2003c). The system has remained off since the reporting period of the previous Five-Year Review (Navy 2005a). The Navy released the *Final Site 26 East-Side Aquifer Treatment System Evaluation Report* (TtEC 2008) on February 22, 2008, and is currently evaluating remedial alternatives described in that report. Specifically, the Navy is currently conducting a second pilot test to evaluate the effectiveness of combined biotic/abiotic treatment using EHC. In a letter dated October 24, 2008, EPA and Water Board concurred with the Navy's decision to keep EATS off while conducting the pilot test. A copy of the concurrence letter is presented in Appendix A. The pilot test should be complete in 2010.

Institutional/Engineering Controls

ICs and ECs specified in the ROD include fencing of the treatment system area, delegating responsibility to NASA for O&M of Building 191 and the stormwater drainage system, and domestic use restrictions on the groundwater at OU5 (Navy 1996).

ECs related to active extraction and treatment of the groundwater plume were implemented as part of the EATS remedial construction in 1997 and 1998.

Fencing of the treatment system area was specified in the ROD. The treatment system was fenced as part of the remedial construction of EATS. The fence is kept locked to maintain site security.

O&M of Building 191 and the storm drainage system were specified as ICs in the ROD. The OU5 ROD states that without continued operation of Building 191 (the pump station), flooding

of the northern end of the runways and surrounding areas, including the area overlying OU5, would occur during the rainy season.

Implementation of ECs and ICs is discussed in the MOA between the Navy and NASA signed in November 1999. This MOA addresses controls for OUs 1 and 5, and it is included in the *Draft Final Interim Remedial Action Report for Site 1 and Site 2 Landfill Closure*, dated September 25, 2001 (TtEMI 2001b). This MOA states that NASA agrees to maintain the Building 191 pump station and drain and subdrain system as long as it either owns the property or maintains operational control over the site. This MOA also states: "Furthermore, in the event of a future conveyance of the property, NASA will notify subsequent owners of this restriction by appropriate notices and land use restrictions." In a letter dated November 8, 2004, the Navy requested that NASA incorporate land use control language in the appropriate land use planning document(s), specifically to include access restrictions on the domestic use of the OU5 groundwater and notification to subsequent landowners of these restrictions by appropriate notices and implementation of appropriate land use restrictions. NASA's *Comprehensive Use Plan* (NASA 1994) currently contains language restricting access and development in the OU5 area because of safety considerations related to munitions storage and runway/air operations. There are no drinking water wells in the OU5 area, and NASA's Comprehensive Use Plan indicates no land use change is planned. However, for the remedy to be fully protective of human health and the environment, NASA must incorporate language restricting groundwater use into its planning documents and provide documentation to EPA and the Water Board.

NASA's Facilities Group is currently revising its Master Plan with input from the Environmental Division to ensure inclusion of language regarding NASA's continued and future operation of the Building 191 pump station. Revisions to the Master Plan will also place restrictions on groundwater use, as specified in the MOA, into NASA's planning documents. The Navy will continue to work with NASA to incorporate these changes into NASA's Master Plan (NASA 2010). A copy of the Navy's letter to NASA is presented in Appendix A and a copy of the MOA for OU5 is presented in Appendix B.

Groundwater Monitoring

To comply with the remedy as specified in the ROD (Navy 1996), a long-term groundwater monitoring plan was developed and issued in 1997 (PRC 1997). EATS startup began on January 26, 1999, (TtEMI 2001b) and long-term groundwater monitoring began in March 1999. The groundwater monitoring plan includes groundwater sampling and quarterly measurement of water levels at Site 26 groundwater monitoring wells. Groundwater sampling began on a quarterly basis and is currently conducted on an annual basis, in accordance with the *EATS Final Long-Term Groundwater Monitoring Plan* (PRC 1997). Groundwater monitoring has been conducted as specified in this plan or in accordance with deviations approved by EPA and the Water Board. Figure 9 presents locations of groundwater monitoring wells at Site 26 and Section 6.4.3.2 provides a detailed discussion of groundwater monitoring data.

4.2.4 Site 28

The Navy began construction of WATS in July 1997 and WATS began operating on November 26, 1998. Details regarding implementation of the selected remedy are found in the *Draft Final Interim Remedial Action Report, West-Side Aquifers Treatment System* (TtEMI 2001c). Prior to WATS, source control measures were implemented to treat contaminated groundwater.

Pre-WATS Source Control Measures

Source control measures were implemented in 1994 to provide hydraulic control and treatment of potential sources of contamination at Site 28 that were described in Section 3.4.3. Three systems were installed to extract and treat groundwater from three source areas: the former Building 88 dry cleaners, the Building 29 UST area, and the Building 31 UST area. Building 29 UST area and Building 31 UST area are separated from the former Building 88 dry cleaners and aircraft wash rack by approximately 1,000 feet. The Building 6 treatment system was located near the former Building 88 dry cleaning facility. It treated groundwater by using two GAC units in series. The Building 45 treatment system was located near the current WATS location and treated groundwater by air stripping, followed by two GAC units in series. The Building 45 treatment system extracted groundwater from the Building 29 UST area and the downgradient edge of the Building 88 plume. The Building 12 treatment system was located near the Building 31 UST area and treated groundwater using two GAC units in series. These systems operated until 1997 (TtEMI 2001c).

After unsaturated soils were remediated to soil cleanup levels, approximately 1 million gallons of groundwater contaminated with PCE and other VOCs were removed as a source control measure for former Building 88, significantly reducing groundwater contaminants. Approximately 1 million gallons of water containing fuel and chlorinated hydrocarbons was removed as a source control measure for the Building 29 UST area and approximately 2 million gallons of water containing fuel and chlorinated hydrocarbons was removed as a source control measure for the Building 31 UST area (TtEMI 2001c).

Following the source control measures that were conducted between 1994 and 1997, groundwater concentrations of PCE ranged from non-detect to 74 µg/L in samples collected in the upper portion of the A aquifer in May 1997 (FWEC 2002a). The maximum PCE concentration of 74 µg/L was detected in a groundwater sample from well W9SC-17, located adjacent to and downgradient from the former Building 88 location. In May 1999, PCE concentrations in a sample collected from the same well were less than 25 µg/L (FWEC 2002a). The Building 29 and 31 USTs were part of petroleum Site 9. The Navy received closure/no further action for these USTs from the Water Board.

According to the *Draft Wash Rack Area Investigation Technical Memorandum* (PRC 1996b), the soil surrounding Sump 25 was sampled for VOCs during its removal in May 1994. No VOCs were detected, although detection limits were elevated (1,000 micrograms per kilogram [µg/kg] for most compounds) based on high concentrations of petroleum constituents in the samples.

Soil and groundwater samples from the former aircraft wash rack area were collected and analyzed in October 1995 as part of the wash rack area investigation. The analytical results indicated that VOCs were present in groundwater in the wash rack area at elevated concentrations relative to the regional VOC plume, specifically near stormwater catchment basin 297A. TCE was detected in both the soil and groundwater in the wash rack area at concentrations indicating a potential source in the area. Consequently, the Navy proposed installing a groundwater extraction well in the upper portion of the A aquifer near the former aircraft wash rack area as a source control measure (PRC 1996b). EPA reviewed the draft technical memorandum and had no comment. A copy of EPA's no comment letter is included in Appendix A. The Navy later installed extraction well EA1-2 as a component of WATS to address contamination from the former aircraft wash rack.

WATS Overview

In accordance with the MEW ROD, the Navy installed and has been operating WATS since November 1998 as an integral component of the Regional Groundwater Remediation Program (RGRP).

WATS currently consists of advanced oxidation process (AOP) and liquid-phase GAC units (see Figure 10). The AOP unit destroys most influent VOCs. The liquid-phase GAC unit removes any remaining VOCs. To eliminate discharge of VOCs to the air, the WATS air stripper was removed from the treatment train on May 8, 2003 (SES-Tech 2009).

Groundwater is pumped from nine extraction wells to maintain a capture zone adequate to create hydraulic control of affected groundwater downgradient of Navy sources at Site 28. Six groundwater extraction wells (EA1-1 through EA1-6) are completed in the upper portion of the A aquifer (see Figure 11), and three extraction wells (EA2-1 through EA2-3) are completed in the lower portion of the A aquifer (see Figure 12) (SES-Tech 2009).

WATS also treats contaminated water collected in two on-site sumps near Hangar 1. The first sump, the Electrical Vault #5 sump, collects stormwater. The second sump, the Hangar 1 sump, collects groundwater that infiltrates into the Hangar 1 tunnel and flows into the sump. In addition, a small quantity of condensate from the steam trench collects in the Hangar 1 sump (SES-Tech 2009).

WATS treats between 70 and 80 gallons of groundwater per minute. This is consistent with the design specifications (TtEMI 2001c). Contaminated water is pumped from the extraction wells and treated to remove the contaminants to levels specified in the NPDES permit before being discharged. The treated water is discharged to the stormwater system in accordance with NPDES general permit CAG912003, Order No. 99-051 (SES-Tech 2009).

WATS is operated to maintain a capture zone that is adequate to create hydraulic control of affected groundwater downgradient of Site 28 and to extract and treat groundwater to meet

cleanup standards established by the MEW ROD and clarified in the September 1990 ESD and the April 1996 ESD (SES-Tech 2009).

Groundwater Monitoring

The ROD specifies groundwater monitoring as part of the selected remedy (EPA 1989). Groundwater monitoring has been instituted and is being performed as required by the ROD. A long-term groundwater monitoring plan was developed and issued in January 1998 (TtEMI 1998b). WATS began operating on November 26, 1998. Baseline groundwater monitoring was conducted in November 1998, and long-term groundwater monitoring began in March 1999 (TtEMI 2001c).

Groundwater monitoring for Site 28, including water level measurements, wells to be sampled and analyzed, and sampling frequency, is addressed in the *WATS Final Long-Term Groundwater Monitoring Plan* (TtEMI 1998b). Groundwater monitoring continues to be conducted annually as part of the O&M activities. Groundwater monitoring wells are screened in the upper portion of the A aquifer (see Figure 11) and the lower portion of the A aquifer (see Figure 12).

Recent groundwater sampling events have deviated from the *WATS Final Long-Term Groundwater Monitoring Plan* (TtEMI 1998b) as agreed upon or requested by EPA with concurrence from the Water Board. Deviations have primarily been related to sampling of additional wells to enable more complete evaluation of the eastern edge of the eastern lobe of the TCE plume (SES-Tech 2009).

Unsaturated Soils

The Navy has met cleanup goals defined in the MEW ROD for unsaturated soils at OU2 West (unsaturated soils overlying the regional plume). This was accomplished through efforts in 1994 and 1995 when Building 88 (the foundation, floor, floor drains, collection trenches, and subsurface piping), sump 91, and tank 68 were demolished and removed. Soil was excavated down to the groundwater table and treated through ex-situ aeration. Confirmation samples from the excavation and the treated soil indicated that there was no contamination above cleanup levels in unsaturated soils. The area was backfilled with clean materials and restored to preconstruction elevations. The Navy has remediated unsaturated soils as specified in the MEW ROD and no further action is required for OU2 West. This is documented in the *Final OU2 West (Building 88) Project Summary Report* (PRC 1995c).

Institutional/Engineering Controls

There are no ICs specified in the MEW ROD (EPA 1989). However, ECs and ICs have been implemented Site 28. The treatment system was fenced as part of the remedial construction of WATS. The fence is kept locked to maintain site security (Navy 2005b).

Site 28 is located within NASA's redevelopment area. Future land use is described in the *NASA Ames Development Plan Final Programmatic EIS* (NASA 2002a). This EIS states that residential development is not planned over areas of the regional plume with high concentrations of contaminants. This plan, in conjunction with the *Environmental Issues Management Plan* (EIMP) for the redevelopment projects, addresses controlling risks from soil or groundwater contaminants. The EIS specifies that procedures in the EIMP will be implemented "to ensure that none of the proposed construction, demolition, and infrastructure improvement projects would expose personnel to unacceptable levels of contaminated soil or groundwater." In addition, the EIS states that the EIMP will provide "construction techniques and minimum design requirements for new development located over the regional plume to reduce the potential for elevated toxic contaminant levels inside buildings."

NASA published the *Final EIMP, NASA Research Park* in March 2005 (NASA 2005). This plan places restrictions on groundwater use on the portion of Site 28 within the boundary of the Research Park. Additionally, NASA controls future potential consumption of groundwater in the redevelopment areas through clauses in tenant leases prohibiting potable uses of the groundwater (NASA 2002a).

No plans currently exist to change ownership of the land. However, in the event of a future conveyance of the property, NASA will notify subsequent landowners of this restriction by appropriate notices and will impose land use restrictions.

4.3 SYSTEMS OPERATIONS/O&M

This section discusses system operations, O&M requirements, activities to date, system problems, and costs.

4.3.1 Site 1

Since 2005, landfill inspections have been performed as prescribed by the *Site 1 Landfill Post-Closure Long-Term Monitoring Plan* (TtFW 2005a). Prior to 2005, inspections were performed in accordance with the *Final Site-Specific Contractor Quality Control Plan for Sites 1 and 2 Groundwater Monitoring and Maintenance* (FWEC 2001b). Maintenance activities are performed based on the findings of the inspections.

Landfill markers (LM-1 through LM-4) and settlement markers (SM-1 through SM-6) were added after remedial activities were completed at Site 1. The landfill and settlement markers were first surveyed in November 1998. Because of habitat alteration activities, SM-2 and SM-3 were destroyed. Therefore, replacement markers SM-2R and SM-3R were installed and resurveyed on October 22, 2003. Landfill survey monuments are surveyed by a licensed California surveyor every five years, in accordance with Title 27 CCR, Section 21090(e)(2). The last settlement marker survey was conducted in the first quarter of 2005, and the next settlement marker survey is scheduled for 2010 (Insight Environmental, Engineering and Construction, Inc. [Insight] 2009a).

Methane measurements, water level measurements, and groundwater samples have been collected at Site 1 on a quarterly basis from January 2002 to November 2004. Since January 2005, monitoring has been performed on a semiannual basis. Section 6.4.1 provides a technical assessment of the landfill gas, water level, and groundwater sampling results.

Annual reports are submitted to EPA and the Water Board. Each annual report summarizes Site 1 background information, maintenance activities, methods and procedures for monitoring and sampling; and gas sampling data, groundwater level data, groundwater analytical data, and references for Site 1.

The Santa Clara County DEH inspects Site 1 quarterly to check the integrity of the landfill cover and to measure landfill gas concentrations to assess whether landfill gas is migrating from the site. As indicated by DEH quarterly inspection reports, burrowing mammal activity is still a concern at Site 1. Raptor perches are present to encourage the presence of predatory species, and require maintenance. Flashing is installed around the perimeter of the landfill fence to deter burrowing mammals from entering the landfill. Ground squirrel and gopher burrowing mitigation currently involves collapsing and backfilling the burrows. The Navy has also implemented a burrowing mammal trapping plan (abatement plan). The Navy will continue to implement the abatement plan and evaluate the results, making adjustments as necessary.

Cracked-concrete well aprons on a number of vent wells were also noted as needing repair during the June 2008 inspection. The repair of concrete slabs was completed in August 2008 (Insight 2009a).

No other significant problems or deficiencies were noted. DEH Site Inspection Reports for June, September, and December 2008, and March, June, and September 2009 are presented in Appendix C.

Maintenance activities performed in conjunction with routine inspections at Site 1 are as follows:

- **Landfill Cover Integrity:** Activities include inspecting vegetation cover, animal burrowing, erosion, fissures, breaches, manmade disturbance, presence of new deep-rooted (shrubs and weeds) vegetation, and condition of existing deep-rooted vegetation.

- **Fencing Integrity:** Activities include checking for breaks in fabric, curled fabric at the ground surface, fabric detached from fence posts, loose barb wire at the fence top, and disturbed fence posts.

- **Signage Integrity:** Activities include checking for fallen or missing signs, legibility, and graffiti.

- **Drainage Systems Integrity:** Activities include checking for slumping and vegetation in drainage channels, vegetation and soil accumulation in drop-ins and pipe inlets, and existence of or damage to drop-in or pipe inlet guards.

- **Vegetation Monitor and Control:** Activities include mowing and related vegetation controls.

Operation and Maintenance Cost

O&M costs include cover, drainage structure, and road maintenance; water level measurements; groundwater sampling, analyses, and quarterly reporting; landfill gas monitoring; well and monument maintenance; settlement surveys; security fencing maintenance; and habitat alteration work plan (HAWP) development.

Reported costs of Site 1 O&M from 2007 and 2008, rounded to the nearest $1,000, are presented below:

Year	Annual O&M Cost for Site 1
2007	$72,000
2008	$75,000

4.3.2 Site 22

O&M activities at Site 22 are described and performed in accordance with the OMMP (FWEC 2003a) and the OMMP Addendum (TtEC 2007).

Landfill settlement markers SM-1 through SM-4 (see Figure 4) were installed in January 2004. Landfill settlement markers are surveyed annually by a land surveyor licensed in the State of California, in accordance with CCR, Title 27 (27 CCR), Section 21090(e)(2) to assess stability and movement. Landfill settlement markers were surveyed on February 3, 2004; November 15, 2006; and October 15, 2007. Surveying was not performed in 2005 due to Navy oversight. However, the 2004, 2006, and 2007 surveying results are consistent, which indicates that the surface is stable. Landfill settlement markers were not surveyed in 2008. Discussion of the 2009 survey will be included in the next Five-Year Review (Insight 2009b).

Groundwater sampling, water level monitoring, landfill gas monitoring, and landfill inspections are performed on a quarterly basis at Site 22. Section 6.4.2 provides a technical assessment of the sampling results.

Annual reports are submitted to EPA and the Water Board. Each annual report summarizes Site 22 background information, maintenance activities, methods and procedures for monitoring and sampling, gas sampling data, groundwater level data, and groundwater analytical data.

The Santa Clara County DEH inspects Site 22 quarterly to check the integrity of the landfill cover and to measure landfill gas concentrations to determine whether landfill gas is migrating from the site. The Site 22 General Inspection List was revised to include specific monitoring line items for geotextile material, hole diameters, and burrowing owl white wash and pellets. Evidence of potential small mammal burrowing requiring additional maintenance was noted during DEH inspections. Ground squirrel and gopher burrowing mitigation currently consists of collapsing and backfilling the burrows. By the March 2009 inspection, ground squirrel and gopher activity was deemed effectively under control by golf course maintenance. The June report states that "Sites 1 and 22 continue to have issues with gophers digging into the final cover." However, according to Navy personnel who attended the inspection, this was only applicable to Site 1. The September 2009 report states that "gopher activity appears minimal; golf course personnel are controlling gophers."

The inspections also noted inundation of landfill gas monitoring wells LGMW-1 and LGMW-4 from golf course irrigation systems during the September and December 2008 inspections. No monitoring was conducted on inundated wells. Repair of landfill gas monitoring wells LGMW-1 and LGMW-4 was completed in early 2009 (Insight 2009b). The wells now contain an air space that can be sampled.

No other significant problems or deficiencies were noted in DEH inspections. DEH Site Inspection Reports for June, September, and December 2008, and March, June, and September 2009 are presented in Appendix C.

Quarterly maintenance activities performed at Site 22 are as follows:

- **Landfill Cover Integrity:** Activities include inspecting vegetation cover, animal burrowing, erosion, fissures, breaches, manmade disturbance, presence of new deep-rooted (shrubs and trees) vegetation, and condition of existing deep-rooted vegetation.

- **Drainage Systems Integrity:** Activities include checking for slumping or vegetation in drainage channels, vegetation and soil accumulation in drop-ins and pipe inlets, and existence of or damage to drop-in or pipe inlet guards.

- **Vegetation Monitor and Control:** Activities include mowing and related vegetation controls. The vegetation at Site 22 is maintained by the golf course management. The Navy maintains vegetation along the golf course drainage channel on the south side of North Patrol Road.

Operation and Maintenance Cost

O&M costs include cover and drainage structure maintenance; water level measurements; groundwater sampling, analyses, and reporting; landfill gas monitoring; well and monument

maintenance; and settlement surveys. Reported costs of Site 22 O&M from 2007 and 2008, rounded to the nearest $1,000, are presented below:

Year	Annual O&M Cost for Site 22
2007	$72,000
2008	$75,000

4.3.3 Site 26

Prior to the system being turned off in July 2003, O&M activities included security of the treatment system, activities required to operate and maintain the system and extraction wells, groundwater monitoring, and NPDES compliance monitoring. The *EATS Final O&M Manual* (TtEMI, 2000a) and the *Final Site-Specific Contractor Quality Control Plan* (FWEC 2001b) address security and activities that were required to operate and maintain the system and the extraction wells. Groundwater monitoring is addressed in the *EATS Final Long-Term Groundwater Monitoring Plan* (PRC 1997).

Operation and Maintenance Cost

O&M costs include water level measurements; groundwater sampling, analysis, and reporting; well maintenance; and general housekeeping activities such as removing debris and pumping out sumps as they collect water. Reported costs of O&M from 2003 through 2008, rounded to the nearest $1,000, are presented below:

Year	Annual O&M Cost for Site 26
2003	$300,000
2004	$100,000
2005	$100,000
2006	$100,000
2007	$50,000
2008	$50,000

Annual O&M costs for Site 26 have declined since 2003, which is the year EATS was turned off.

4.3.4 Site 28

O&M activities began following system startup in November 1998 and are ongoing. O&M activities include security of the treatment system, activities required to operate and maintain the system, groundwater monitoring, and NPDES compliance monitoring. O&M activities are specified in the *WATS Final O&M Manual* (TtEMI 2000b), the *Final Site-Specific Contractor*

Quality Control Plan (FWEC 2001b), and the *Final WATS O&M Manual Addendum* (FWEC 2001c). Groundwater monitoring is addressed in the *WATS Final Long-Term Groundwater Monitoring Plan* (TtEMI 1998b). System and effluent monitoring is conducted in accordance with NPDES general permit CAG912003, Order No. 99-051.

WATS was fully operational on November 28, 1998. As of December 30, 2008, WATS had treated approximately 340,413,017 gallons of groundwater, removing approximately 4,362 pounds of VOCs (see Figure 13) (SES-Tech 2009). The system is functioning as intended. WATS operated approximately 88.7 percent of the time during 2003, 94.3 percent of the time during 2004, and between 97.9 to 99.4 percent of the time from 2005 through 2008. Down time was attributed primarily to routine maintenance (SES-Tech 2009 and TN&A 2007b).

The perimeter fence is kept locked to maintain site security. Maintenance and repairs are conducted as required to keep the system running. No problems have arisen in the implementation of system O&M. In 2001, WATS was upgraded to further polish the air stripper effluent through GAC vessels. O&M activities, NPDES sampling results, and operational data are presented in the quarterly and annual NPDES reports as well as annual groundwater reports. In addition, operational data are reported to EPA and the Water Board on a monthly basis through BRAC Closure Team meeting handouts.

There were no permit level exceedances during the 2003-2008 permit period. There were false positives, however, in 2003, 2005, and 2006. In addition, there were potential trigger level exceedances in 2005 and 2007.

In May 2003, modifications were made to WATS to bypass the air stripper. First and fifth day startup sampling was performed. First day startup sample results were non-detect for VOCs and TPH. Fifth day startup samples were collected on May 20, 2003. Analytical results for fifth day startup sampling showed potential exceedances for VOCs and TPH. The concentrations were noted to be atypical. Confirmation samples were collected on May 22, 2003, upon receipt of the fifth day startup sample results. Confirmation samples were non-detect for VOCs and TPH, with the exception of vinyl chloride. Additional samples along the treatment train were collected at the same time as the confirmation samples and vinyl chloride was not detected in these samples. Therefore, due to the atypical concentrations, confirmation sample results, and treatment train results, the detections were determined to be false positives. Based on the initial fifth day startup sample results and the potential for VOC breakthrough in the leaf GAC units, the carbon in the GAC units was replaced and startup monitoring was restarted. All effluent sample results were non-detect for VOCs and TPH in subsequent startup monitoring. WATS was returned to normal operation on June 13, 2003 (TtFW 2004d).

On August 21, 2003, the analytical results from the August monthly NPDES sample event were received. The results indicated a potential exceedance for total petroleum hydrocarbons-extractable (TPH-e) as diesel. Confirmation samples were collected on August 21, 2003. Two mid-point GAC samples were also collected from sample ports located immediately upstream of the effluent. The confirmation sample results for the effluent and mid-point GAC samples were not detected at the reporting limit (50 µg/L) for TPH-e as diesel (TtFW 2004d).

In a sample collected from the unit on April 5, 2005, diesel was potentially detected in the effluent stream in a concentration that exceeded the permit limit, and the Water Board was notified. This analytical result was considered a false positive as there was no diesel detected in the system influent. In addition, the laboratory qualified the effluent diesel analytical result as exhibiting a pattern that does not resemble the standard and exhibiting an unknown single peak or peaks. As a final check, the effluent stream was re-sampled within 24 hours for total extractable petroleum hydrocarbons. The effluent sample results were non-detect. The Water Board was notified on April 22, 2005, that the effluent analytical results were non-detect and there was no exceedance (TtFW 2006).

In September 2005, NPDES trigger compounds were detected in the effluent stream. The analytical results were considered false positives as the compounds were not detected in the system influent or at any other point of the treatment system. In accordance with NPDES permitting, additional sampling was conducted for 3 months, during which these compounds were reported as not detected. No further action was necessary (SES-Tech 2009).

In April 2006, TPH-e as diesel was detected in the effluent stream, but was considered to be a false positive as there was no TPH-e as diesel detected in the system influent. To confirm the suspect detection, the effluent stream was resampled within 24 hours for TPH-e. The effluent sample results reported TPH-e as not detected, thus confirming the false positive. The Water Board was notified on May 8, 2006 that the confirmation effluent analytical results were reported as not detected and there was no exceedance (SES-Tech 2009).

Zinc was detected above the NPDES trigger limit in December 2007; however, zinc is not a COC at Site 28. In accordance with the NPDES permit, three rounds of samples were subsequently collected and analyzed. Based on the results from these samples, it was determined that zinc detections were below the NPDES trigger limit and that the discharge load for zinc was below the permitted volume. No further action was warranted (SES-Tech 2009).

No other O&M difficulties have been reported (SES-Tech 2009). Analyses of monthly effluent samples have shown that the effluent has been in compliance with the NPDES discharge permit (SES-Tech 2009). The Navy submitted an application to renew the NDPES permit in January 2009. A copy of the NPDES permit compliance summary report for WATS over the period from 2003 through 2008 is presented in Appendix D.

Groundwater monitoring began in March 1999 and is ongoing. It includes groundwater sampling and quarterly measurement of water levels in Site 28 groundwater monitoring wells. Groundwater sampling is currently conducted annually, in accordance with the *WATS Final Long-Term Groundwater Monitoring Plan* (TtEMI 1998b). Groundwater monitoring has been conducted as specified in this plan or in accordance with variations approved by EPA and the Water Board.

Operations and Maintenance Cost

O&M costs include water level measurements; groundwater sampling, analysis, and reporting; well maintenance; monthly sampling of system water, influent, and effluent; maintenance of pumps and other system components; and regular replacement of filters and the GAC. Reported costs of O&M from 2003 through 2008, rounded to the nearest $1,000, are presented below:

Year	Annual O&M Cost for Site 28
2003	$506,000
2004	$428,000
2005	$308,000
2006	$753,000
2007	$761,000
2008	$761,000

The annual cost in 2003 was significantly higher than in 2002 ($295,000) because of air stripper bypass and system modification. Similarly, the annual cost was higher in 2004 than 2002 because the WATS ozone generator and electromagnetic flow meter were replaced. The higher annual costs in 2006 through 2008 reflect changes in project accounting practices and increases in utility and personnel rates. Higher operational costs do not indicate a potential problem with implementation of the remedy.

5.0 PROGRESS SINCE LAST REVIEW

This section summarizes progress of remedy implementation at Sites 1, 22, 26, and 28 since their respective previous Five-Year Review reports were prepared. The following sections discuss the status of recommendations and follow-up actions that previous Five-Year Review reports specified as necessary to maintain protectiveness of the remedy for the sites.

5.1 PROGRESS FOR SITE 1

The following presents the issues, recommendations, and follow-up actions as presented in the second Five-Year Review for OU1 (Sites 1 and 2), which was signed in September 2007. The last column was added for this report to indicate the status of recommendations and follow-up actions from the previous report. A text discussion follows to explain how that determination was made.

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes / No)		Status of Recommendations and Follow-up Actions from last Five-Year Review
					Current	Future	
Squirrels burrow on landfill slopes and area surrounding the landfill	Continue to monitor squirrel activity and fill holes as necessary	Navy	EPA, Water Board, Santa Clara County DEH	Ongoing	No	No	Issue addressed; abatement plan implemented. Landfill cover inspection and maintenance is part of maintenance plan
Cracked gas vent slabs	Repair cracked gas-vent slabs	Navy	EPA, Water Board, Santa Clara County DEH	December 2007	No	No	Completed
Verify landfill cover is not penetrated	Revise Site 1 General Inspection List to include monitoring line items for geotextile material, burrow diameters, and burrowing owl white wash and pellets	Navy	EPA, Water Board, Santa Clara County DEH	September 2007	No	No	Completed
Groundwater and landfill gas monitoring	Evaluate groundwater and landfill gas monitoring frequency	Navy	EPA, Water Board, Santa Clara County DEH	January 2008	No	No	Issue addressed; Annual Reports evaluate monitoring frequency as needed

Notes:

DEH	Department of Environmental Health
EPA	U.S. Environmental Protection Agency
Navy	Department of the Navy
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region

Recommendation: Continue to monitor squirrel activity and fill holes as necessary.

Monitoring for ground squirrels and other burrowing mammals is conducted as part of quarterly landfill inspections by Santa Clara County DEH and the Navy. Any holes that discovered are filled after inspections. The Navy implemented a burrowing mammal abatement plan in 2009 which focuses on trapping. The Navy will continue to evaluate the effectiveness of the abatement plan. DEH inspection reports are presented in Appendix C.

Recommendation: Repair cracked gas-vent slabs.

According to the Santa Clara County DEH inspection report dated June 13, 2008, ongoing repairs to cracked slabs are made as needed. The inspection report dated September 10, 2008 reported that slabs on vents 3, 6, 7, 8, and 11 had new concrete collars installed on August 18, 2008. These two inspection reports are presented in Appendix C.

Recommendation: Revise Site 1 General Inspection List to include monitoring line items for geotextile material, burrow diameters, and burrowing owl white wash and pellets.

The General Inspection List was revised on September 27, 2007 to include these three line items. They were checked during the November 14, 2007 inspection, which is presented in Appendix A of the *2007 Final Site 1 Landfill Annual Report.*

Recommendation: Evaluate groundwater and landfill gas monitoring frequency.

Groundwater and landfill gas monitoring are conducted semiannually. Assessments on monitoring frequency are made with each annual report. The *Draft Site 1 2008 Annual Report* recommended continuing semiannual monitoring.

There were no issues, recommendations, or follow-up actions for Site 2 because Site 2 is no longer subject to Five-Year Reviews; Site 2 is available for unlimited use and unrestricted exposure. Review of analytical results for groundwater samples from Site 2 showed that groundwater had not been adversely impacted by previous operations. EPA and the Water Board prepared closure letters for discontinuing groundwater monitoring at Site 2 on January 31, 2003, and February 25, 2003, respectively. Copies of these letters are presented in Appendix A.

5.2 PROGRESS FOR SITE 22

The following presents the issues, recommendations, and follow-up actions as presented in the first Five-Year Review for Site 22, which was signed in February 2008. The last column was added for this report to indicate the status of recommendations and follow-up actions from the previous report. A text discussion follows to explain how that determination was made.

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes / No)		Status of Recommendations and Follow-up Actions from last Five-Year Review
					Current	Future	
Perimeter gas monitoring values above 5 percent by volume at well LGMW-3	Continue to monitor landfill gas monitoring wells to determine if additional action is necessary Perform fingerprinting analysis of gas sample collected at LGMW-3 to evaluate source of methane gas as appropriate	Navy	EPA, Water Board, Santa Clara County DEH	January 15, 2009	No	No	Issue addressed; landfill gas concentration has been below five percent. Therefore, fingerprinting has not been necessary. Landfill gas monitoring is part of monitoring plan
Chloroform detections above the CCL of 3.5 µg/L at monitoring wells WGC2-8 and WGC2-9	Continue to monitor wells WGC2-8 and WGC2-9 to determine if additional action is necessary	Navy	EPA and Water Board	Ongoing	No	No	Issue addressed; chloroform concentrations have decreased in wells WGC2-8 and WGC2-9. Groundwater monitoring is part of monitoring plan.
Incomplete implementation of ICs due to lack of MOA between the Navy and NASA	Finalize MOA between the Navy and NASA to ensure implementation of ICs	Navy and NASA	EPA and Water Board	August 2008	No	Yes	MOA completed
Lack of land use controls monitoring plan and annual reporting on ICs to EPA	Appropriate land use controls monitoring plan and annual reporting to EPA on the implementation, monitoring, and efficacy of the ICs	Navy and NASA	EPA and Water Board	August 2008	No	Yes	Issue addressed; institutional controls are being reported in Annual Reports regarding the implementation, monitoring, and efficacy of ICs

Notes:

CCL	Calculated concentration limit	NASA	National Aeronautics and Space Administration
DEH	Department of Environmental Health	Navy	Department of the Navy
EPA	U.S. Environmental Protection Agency	OMMP	Post-Construction Operations, Maintenance, and Monitoring Plan
IC	Institutional control		
MOA	Memorandum of Agreement	Water Board	California Regional Water Quality Control Board, San Francisco Bay Region
N/A	Not applicable		

Recommendation: Continue to monitor landfill gas monitoring wells to determine if additional action is necessary. Perform fingerprinting analysis of gas sample collected at LGMW-3 to evaluate source of methane gas as appropriate.

The Santa Clara County DEH, in conjunction with the Navy, conducts quarterly landfill inspections that include monitoring for landfill gas and inspection of the wells.

Recommendations for additional action concerning the wells are made in the DEH reports as well as in annual reports. DEH inspection reports are presented in Appendix C.

If methane gas is measured at a concentration above 5 percent by volume at well LGMW-3 in any future two out of three consecutive monitoring events, fingerprinting analysis is required. However, methane concentrations at LGMW-3 were zero percent by volume for the last monitoring event in 2007 and all three consecutive monitoring events in 2008. This is documented in the annual reports for Site 22.

Recommendation: Continue to monitor wells WGC2-8 and WGC2-9 to determine if additional action is necessary.

These wells are included in the quarterly monitoring program at Site 22 and results are documented in annual reports. Groundwater monitoring data for Site 22 are discussed in Section 6.4.2.3.

Recommendation: Finalize MOA between the Navy and NASA to ensure implementation of ICs.

The MOA was executed in September 2008 and is presented in Appendix B.

Recommendation: Appropriate land use controls monitoring plan and annual reporting to EPA on the implementation, monitoring, and efficacy of the ICs.

Monitoring of land use controls is addressed in the MOA. The Navy reports annually on the status of ICs to EPA in annual reports. NASA is currently revising its Master Plan and will incorporate ICs for Site 22 into the Master Plan. NASA will also provide a schedule for future reporting on the status and efficacy of ICs.

5.3 PROGRESS FOR SITE 26

The following presents the issues, recommendations, and follow-up actions as presented in the first Five-Year Review for Site 26, which was signed in February 2005. The last column was added for this report to indicate the status of recommendations and follow-up actions from the previous report. A text discussion follows to explain how that determination was made.

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes / No)		Status of Recommendations and Follow-up Actions from last Five-Year Review
					Current	Future	
EATS may not be effective in cleaning up the low concentrations of VOCs in groundwater	Complete implementation of the EATS Evaluation Work Plan to collect field data for evaluation of the effectiveness and efficiency of EATS and applicability of other potential remedial options in achieving the groundwater cleanup standards specified in the ROD. Due to the low concentrations of extracted contaminants and low mass removal rates, opportunity exists to optimize and/or select more effective and economical remedies through implementation of the EATS Evaluation Work Plan.	Navy	Navy, EPA, Water Board	May 2003	No	No	Completed

Notes:

EATS	East-Side Aquifer Treatment System
EPA	U.S. Environmental Protection Agency
Navy	Department of the Navy
ROD	Record of Decision
VOC	Volatile organic compound
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region

Recommendation: Complete implementation of the *EATS Evaluation Work Plan* to collect field data for evaluation of the effectiveness and efficiency of EATS and applicability of other potential remedial options in achieving the groundwater cleanup standards specified in the ROD. Due to the low concentrations of extracted contaminants and low mass removal rates, opportunity exists to optimize and/or select more effective and economical remedies through implementation of the *EATS Evaluation Work Plan*.

The *Final EATS Evaluation Work Plan* was implemented in May 2003. Related monitoring activities and data evaluation are ongoing. The *Site 26 East-Side Aquifer Treatment System Evaluation Report* and the *Final Site 26 Technical Memorandum (Optimization Evaluation)* were finalized in 2008 and detail the results of the Work Plan. The Navy is currently conducting a

second pilot test to evaluate the effectiveness of combined biotic and abiotic treatment using EHC. The pilot test should be complete in 2010.

5.4 PROGRESS FOR SITE 28

This following presents the issues, recommendations, and follow-up actions as presented in the first Five-Year Review for Site 28, which was signed in February 2005. The last column was added for this report to indicate the status of recommendations and follow-up actions from the previous report. A text discussion follows to explain how that determination was made.

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes / No)		Status of Recommendations and Follow-up Actions from last Five-Year Review
					Current	Future	
WATS optimization and improved hydraulic control in the A2 aquifer (lower portion of the A aquifer) are needed	Complete implementation of the WATS Optimization Work Plan to collect field data needed to improve efficiency for long-term operation	Navy	Navy, EPA, Water Board	May 2003	No	No	Completed

Notes:

EPA	U.S. Environmental Protection Agency
Navy	Department of the Navy
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region
WATS	West-Side Aquifers Treatment System

Recommendation: Complete implementation of the WATS Optimization Work Plan to collect field data needed to improve efficiency for long-term operation.

As documented in the *2008 Annual Groundwater Report*, the WATS Optimization Work Plan has been implemented. Field data have been collected over the review period to evaluate opportunities to optimize. The *Draft WATS Site 28 Optimization Evaluation Report* was submitted to EPA on November 19, 2008 and included recommendations for system optimization.

6.0 FIVE-YEAR REVIEW PROCESS

This section provides a description of activities during the Five-Year Review process for Sites 1, 22, 26, and 28, and a summary of the findings of each step in the process where appropriate. The Five-Year Review was conducted between April 2009 and January 2010.

6.1 ADMINISTRATIVE COMPONENTS

Potentially interested parties were notified of the start of the Five-Year Review through a public notice published in local newspapers. The notice is discussed in Section 6.2.

The Navy conducted this Five-Year Review with technical assistance from a joint venture of St. George Chadux Corp. and Tetra Tech EM Inc. (ChaduxTt). Members of the review team included:

- Ms. Kathryn Stewart, BRAC Environmental Coordinator, Naval Facilities Engineering Command Southwest
- Ms. Angela Lind, Lead Remedial Project Manager, BRAC Program Management Office (PMO) West, Navy
- Mr. Wilson Doctor, Remedial Project Manager (RPM), BRAC PMO West, Navy
- Ms. Julie Crosby, RPM, BRAC PMO West, Navy
- Ms. Diane Macmillan, Project Manager, ChaduxTt
- Mr. Darren Knight, Program Manager, ChaduxTt
- Mr. Michael Anderson, Environmental Scientist, ChaduxTt
- Mr. Eric Rider, Environmental Scientist, ChaduxTt.

6.2 COMMUNITY NOTIFICATION AND INVOLVEMENT

The local community was informed of the start of the Five-Year Review for Sites 1, 22, 26, and 28 with a public notice that was published in the San Jose Mercury News, the Mountain View Voice, and the Palo Alto weekly on July 31, 2009. The notice stated the purpose of the Five-Year Review under CERCLA, identified the types of COPCs at Moffett Field, described the remedies selected to address contaminated soils and groundwater, and conveyed the status of remedy implementation for each site. A copy of the public notice is presented in Appendix E.

Upon completion of the Five-Year Review Report, a second public notice and fact sheet are planned to inform the community of the findings. In addition, the fact sheet will be sent to

current Restoration Advisory Board (RAB) members, regulatory agency personnel, and community representatives who indicated an interest in prior mailings concerning environmental restoration activities at Moffett Field. This Five-Year Review Report will be made available at the Mountain View Public Library, Government Publications Department, 585 Franklin Street, Mountain View, CA 94041. The Mountain View Public Library is the Information Repository for the Navy's Moffett Field IR Program.

The local community was not involved directly in the Five-Year Review process. The general public does not live adjacent to these sites and ICs are currently implemented to limit users of the land to the Navy, NASA, and their tenants. During earlier phases of the site RI and remedy selection and evaluation, interested community representatives had the opportunity to meet with and become members of the RAB, and the opportunity is still open for interested community members to join the RAB. This group was established to provide a forum for exchange of information and partnership among the community, the Navy, EPA, Water Board, DTSC, and NASA by reviewing and commenting on technical documents relating to the ongoing environmental cleanup at Moffett Field. The Navy put the draft version of this Five-Year Review as an agenda item for the January 2010 RAB meeting. In the July and September 2009 RAB meetings, attendees were given the opportunity to request the draft Five-Year Review and provide comments on the draft report.

6.3 DOCUMENT REVIEW

This Five-Year Review consists of a review of relevant documents including previous Five-Year Reviews, RODs, annual reports, groundwater reports, monitoring and maintenance plans, O&M records, remedial action reports, technical memorandums, optimization and evaluation reports, and NPDES reports. A complete list of documents reviewed is presented in Appendix F.

6.4 DATA REVIEW

Data over the Five-Year Review reporting period were reviewed for each site to determine relevant trends and whether or not compliance with RAOs was being met. Relevant trends and levels are discussed, and levels not currently compliant are noted. For instances of noncompliance, assessments are made on whether future compliance can be expected without additional action.

6.4.1 Site 1

Data reviewed for Site 1 from 2007 and 2008 included methane measurement data, water level measurement data, and groundwater sampling analytical data. Field activities occurred in April and October 2007 (TN&A 2008b) and June and October 2008 (Insight 2009a). Complete analytical results are included in the *2007 Annual Report, Site 1 Landfill* (TN&A 2008a) and *Draft 2008 Annual Report, Site 1 Landfill* (Insight 2009a). Each of these is discussed below.

Settlement markers are surveyed every five years, but were not surveyed during this review period. The next survey is scheduled for 2010.

6.4.1.1 Methane Measurement Data

As part of landfill maintenance activities, landfill gas measurements are routinely obtained from 19 passive gas vent wells within the landfill, four LGMWs on the perimeter of the landfill, and an additional 21 perimeter methane monitoring locations at approximately 150-foot intervals at the site boundary. Methane monitoring locations are shown on Figure 3.

Methane concentrations exceeded the limit of 5 percent by volume as specified in 27 CCR, Section 2092 1(a)(2) and in the ROD (Navy 1997) at three locations (GV-7, GV-8, and GV-11) during both sampling events in 2007, and at one location during the second sampling event in 2007 (GV-5). None of the GVs or other monitoring points had concentrations that exceeded the concentration limit in 2008.

6.4.1.2 Water Level Measurement Data

Water level measurements are routinely taken at 12 groundwater monitoring wells, two piezometers, and two collection trench wells at Site 1 (see Figure 3). Groundwater flow at the site is influenced by Building 191 pumping operations. Results indicate that groundwater flow was generally from north to south in 2007 (TN&A 2008a) and northeast to southwest in 2008 (Insight 2009a). Groundwater elevation exhibits seasonal trends, with the highest water levels occurring at the end of the wet season and the lowest levels occurring at the end of the dry season. Groundwater elevation, flow direction, and gradients have remained relatively consistent throughout the Five-Year Review period.

6.4.1.3 Groundwater Sampling Data

Groundwater samples are routinely collected from nine groundwater monitoring wells and two collection trench wells at Site 1 (see Figure 3).

Analytical results from 2007 were reported in the *Final 2007 Annual Report, Site 1 Landfill* (TN&A 2008a) and are summarized below:

- Arsenic and cobalt were detected at concentrations below their respective CCLs.
- Barium was detected above its CCL at all monitoring points.
- Copper exceeded its CCL in one sample (7.35 µg/L in W1-12R in April).
- No pesticides, VOCs, or SVOCs were detected.
- Analytical results indicated no release from the landfill to groundwater.

Analytical results from 2008 were reported in the *Draft 2008 Annual Report, Site 1 Landfill* (Insight 2009a) and are summarized below:

- Arsenic and cobalt were detected at several monitoring points; however, none of the concentrations exceeded its CCL.
- Barium was detected above its CCL at all monitoring points.
- Copper was detected in 5 of 11 monitoring points in June, and one detection exceeded the CCL (5.6 µg/L in W1-12R). Two of three copper detections in October exceeded the CCL (6.8 and 9.9 µg/L in W1-12R and W1-14, respectively).
- Carbon disulfide was detected at the detection limit of 0.5 µg/L in W1-23 in June. This exceeded the CCL of 0.21 µg/L.
- No SVOCs or pesticides were detected.

Barium consistently exceeded the CCL of 40 µg/L in all four monitoring events during 2007 and 2008 (TN&A 2008a; Insight 2009a). Barium in collection trench wells W1-22 and W1-23 is removed from further consideration because samples from collection trench wells are not considered to be representative of actual groundwater conditions at Site 1 (TtFW 2004c).

The maximum historical barium concentration from an upgradient monitoring well was 653 µg/L (well W1-5 in July 2003) (Insight 2009a). During the April 2007, June 2008, and October 2008 sampling events, the maximum reported barium concentrations were from upgradient well W1-5 (excluding data from the collection trench wells). In October 2007, the maximum barium concentration (excluding the collection trench wells) was 627 µg/L (well W1-24).

In accordance with the procedures for data evaluation presented in Appendix C, Section 3.0 of the Site 1 Long Term Monitoring Plan, the likelihood that the landfill is the source of barium is removed from further consideration because (1) the maximum exceedance from each sampling event was from an upgradient well (April 2007 and both 2008 events), or (2) if the maximum exceedance was not from an upgradient well, it was less than historical upgradient levels (October 2007) (TtFW 2005a).

Copper was detected above its CCL at a concentration of 9.9 µg/L in downgradient well W1-14 in October 2008. Copper was also detected above its CCL in upgradient well W1-12R at concentrations of 7.35 µg/L in April 2007, 5.6 µg/L in June 2008, and 6.8 µg/L in October 2008. The maximum historical copper concentration detected in an upgradient monitoring well at Site 1 was 19.3 µg/L (upgradient well W1-12R in October 2003).

In accordance with the procedures for data evaluation presented in Appendix C, Section 3.0 of the Site 1 Long Term Monitoring Plan, the likelihood that the landfill is the source of copper in well W1-12R in October 2008 is removed from further consideration because even though it is

an upgradient well, it was not the maximum exceedance during the sampling period but was less than historical upgradient concentrations. The likelihood that the landfill is the source of copper in downgradient well W1-14 in October 2008 is removed from further consideration because the concentration was less than historical upgradient concentrations. The likelihood that the landfill is the source of copper in well W1-12R in April 2007 and June 2008 is removed from further consideration because it was the maximum exceedance for the sampling event (excluding data from the collection trenches wells) and came from an upgradient well (TtFW 2005a).

Lack of detectable concentrations of VOCs, SVOCs, and pesticides in groundwater indicated that a release of those contaminants from the landfill to groundwater has not occurred.

6.4.2 Site 22

Data for Site 22 gathered since the last Five-Year Review reporting period was reviewed and included methane measurement data, water level measurement data, and groundwater sampling analytical data obtained in 2008. Maintenance and monitoring events occurred in June, August, and October 2008; maintenance and monitoring for the first quarter did not occur because of a transition in Navy contractors (Insight 2009b). Each of these is briefly discussed below. Complete analytical results are included in the *Draft 2008 Annual Report, Site 22 Landfill* (Insight 2009b).

No landfill settlement survey activities were conducted during this reporting period. The settlement survey for Site 22 that occurred in 2009 will be reported in the next Five-Year Review (Insight 2009b).

6.4.2.1 Methane Measurement Data

As part of landfill maintenance activities, landfill gas measurements are routinely obtained from 15 tree wells, four LGMWs on the perimeter of the landfill, and an additional 13 perimeter methane monitoring locations. Methane monitoring locations are shown on Figure 4. Methane readings were zero percent by volume at all monitoring points at Site 22 during 2008, indicating that migration of landfill gas is not occurring (Insight 2009b).

6.4.2.2 Water Level Measurement Data

Water level measurements are routinely recorded at 10 perimeter monitoring wells at Site 22 (see Figure 4). Groundwater flow at the site is influenced by Building 191 pumping operations. Groundwater flows essentially from east to west at Site 22 (Insight 2009b). A seasonal trend was observed during the quarterly events of 2008 in terms of elevation, and flow direction and rate. Groundwater elevation exhibits seasonal trends, with the highest water levels occurring at the end of the wet season and the lowest levels occurring at the end of the dry season. A groundwater high in the vicinity of WGC2-4 indicated a potential recharge zone. This area is also a topographic high of the site with regard to surface elevations (Insight 2009b).

Groundwater elevation trends at Site 22 have indicated that groundwater elevation, flow direction, and gradients have remained consistent.

6.4.2.3 Groundwater Sampling Data

Groundwater samples are routinely collected from 10 perimeter monitoring wells at Site 22 (see Figure 4). Analytical results are summarized below.

- Chloroform was detected at monitoring points WGC2-1 and WGC2-9 in June and August 2008. The August detection at WGC2-1 of 6.9 µg/L exceeded the CCL of 3.5 µg/L. Both detections at WGC2-9, as well as the June detection at WGC2-1, were below the CCL. Chloroform was not detected in these two or any other monitoring well in October.

- TCE was detected during all three monitoring events at wells WGC2-8 and WGC2-9 at the following concentrations: 2.5 and 1.1 µg/L, 3.0 and 0.9 µg/L, and 2.2 and 1.0 µg/L, respectively. None of these concentrations exceeded the CCL.

- No other VOCs were detected during the reporting period.

- Bis(2-Ethylhexyl)-phthalate was detected in the October sample collected from WGC2-5 at a concentration of 54 µg/L, which exceeded the CCL of 30 µg/L. Bis(2-ethylhexyl)-phthalate was not detected at this monitoring well in the other two monitoring events, nor in any other well other than WGC2-5 in any of the three monitoring events. As indicated in the OMMP Addendum (TtEC 2007), well WGC2-5 is not representative of Site 22 groundwater quality.

- Diethyl-phthalate was detected at WGC2-6 in October at a concentration of 12 µg/L, which was below the CCL. Diethyl-phthalate was not detected at this monitoring well in the other two monitoring events, nor in any other well other than WGC2-6 in any of the three monitoring events.

- No other SVOCs were detected during the reporting period.

- Organochlorine pesticides were not detected at any of the wells during the reporting period.

As stated in the previous Five-Year Review for Site 22, chloroform has been detected above its CCL in downgradient wells WGC2-8 and WGC2-9 in prior years. Statistical evaluations of chloroform detections associated with wells WGC2-8 and WGC2-9 were completed and documented in the *Final 2006 Annual Report Site 22 Landfill* (TN&A 2007a). The evaluations indicated a statistically measurably significant difference between well WGC2-9 and upgradient wells; however the concentration trend was decreasing, suggesting natural attenuation. For well WGC2-8, there was no statistically measurably significant difference from upgradient concentrations; thus it was removed from further consideration. Chloroform concentrations have

been below the CCL in well WGC2-8 since April 2007 and below the CCL in well WGC2-9 since April 2006.

In the current Five-Year Review reporting period, chloroform was reported at a concentration of 6.9 µg/L in the August 2008 sampling event, which is greater than the CCL of 3.5 µg/L. This sample came from crossgradient well WCG2-1. Except for this exceedance, chloroform was not detected above the CCL in this well or any other Site 22 well within the current Five-Year Review reporting period. The OMMP Addendum (TtEC 2007) indicated WGC2-1 may receive water from off site and was not useful as a water quality monitoring point. The OMMP Addendum for Site 22 recommended discontinuing monitoring at crossgradient wells WGC2-1 and WGC2-5 because they are not representative of Site 22 groundwater quality. In accordance with the OMMP Addendum, it appears that there have been no releases of chloroform from the Site 22 landfill since April 2006, when concentrations in well WGC2-9 dropped below the CCL.

6.4.3 Site 26

Water level measurement data and groundwater sampling analytical data for Site 26 were reviewed. Each of these is discussed in the sections that follow. Complete analytical results and groundwater plume depictions are included in the 2003 through 2008 annual groundwater reports (TtFW 2005b, 2005c; TtEC 2006; TN&A 2007b, 2008b; SES-Tech 2009).

6.4.3.1 Water Level Measurement Data

Seasonal groundwater elevation trends throughout the review period have remained consistent. Groundwater elevations fluctuate with precipitation levels and groundwater elevations in most monitoring wells continue to exhibit seasonal fluctuations. The highest groundwater elevations typically occur at the end of the wet season (March to April). The lowest groundwater elevations typically occur at the end of the dry season (October to November).

Because EATS has been off since July 2003, an analysis of hydraulic control and capture zones was not conducted for this review. Without the influence of EATS extraction wells on groundwater flow, the direction of groundwater flow in the upper portion of the A aquifer at Site 26 has been influenced by the groundwater depression associated with pumping at Building 191 and its associated network of ditches and drains. The direction of groundwater flow in the southern portion of the area is toward the north; in the northern portion of the area, groundwater flow is north-northwest, toward the groundwater depression near Building 191.

6.4.3.2 Groundwater Sampling Data – Southern Plume

Fourteen groundwater monitoring wells were selected to evaluate VOC concentration trends at Site 26 in accordance with the *Final East-Side Aquifer Treatment System Evaluation Work Plan* (FWEC 2003c). The 10 groundwater monitoring wells selected in the upper portion of the A aquifer were W4-3, W4-14, W4-15, W7-10, WSW-6, WU5-4, WU5-10, WU5-14, WU5-21, and WU5-25. The four wells selected in the lower portion of the A aquifer were W6-2, WU5-11,

WU5-12, and WU5-13. Data from these wells are considered representative of chemical concentrations at Site 26. The following sections present trends for Site 26 COCs in the upper portion of the A aquifer during the Five-Year Review reporting period. All COC concentrations in samples collected from wells completed in the lower portion of the A aquifer have been either not detected or detected below MCLs throughout the Five-Year Review period. Consequently, concentrations trends for the lower portion of the A aquifer are not discussed further because they are below cleanup goals.

Overall, COC concentrations at Site 26 have decreased or remained stable in the upper portion of the A aquifer since 2003. This is depicted in Figure 14, which shows a decrease in the extent of the TCE plume over the five year review period, as well as a general overall decrease in concentrations. TCE , cis-1,2-DCE, and PCE have historically made up approximately 95 percent of the contaminant mass at Site 26, with the majority being TCE.

TCE Evaluation and Trends

Although the EATS extraction wells have been off since July 2003, the location of the Site 26 TCE plume in the upper portion of the A aquifer has remained stable over the Five-Year Review period and the size has decreased. A side-by-side comparison of the 2003 and 2008 TCE plumes illustrates this trend (see Figure 14). The plume, extending downgradient from the northeast corner of Hangar 3, is generally centered east of the intersection of Marriage Road and Macon Road. Analytical results indicate that TCE concentrations are decreasing at Site 26.

- In 2008, the highest concentration of TCE in the upper portion of the A aquifer was reported as 22 µg/L. In 2003, the highest concentration was reported as 43 µg/L.
- Ten monitoring wells show a long-term trend of decreasing TCE concentrations; none of the data indicate increasing concentrations of TCE.
- The decreasing TCE concentration in samples collected from W7-10 and WU5-14 appears to be the result of adding HRC in the area during 2004.

***Cis*-1,2-DCE Evaluation and Trends**

The shape and location of the *cis*-1,2-DCE plume in the upper portion of the A aquifer have remained relatively stable over the review period (see Figure 15). One portion of the *cis*-1,2-DCE plume is adjacent to the intersection of Marriage Road and Macon Road and extends between extraction wells EXW-4 and EXW-5. Another portion of the plume extends downgradient from the northeastern corner of Hangar 3, in the area of extraction well EXW-1. A small plume is also around extraction well EXW-2. Analytical results indicate that *cis*-1,2-DCE concentrations are stable or decreasing at Site 26.

- In 2008, the highest concentration of *cis*-1,2-DCE in the upper portion of the A aquifer was reported as 39 µg/L. In 2003, the highest concentration was reported as 63 µg/L.

- *Cis*-1,2-DCE concentrations show a long-term decreasing trend in five wells, a stable trend in three wells, and an increasing trend in two wells.

- The increase in *cis*-1,2-DCE concentrations correlates with the decrease in TCE concentration in samples from monitoring wells W7-10 and WU5-14, and is likely due to dechlorination associated with the addition of HRC in the area during 2004.

PCE Evaluation and Trends

The shape and location of the PCE plume have remained relatively stable over the review period (see Figure 16). PCE concentrations in the upper portion of the A aquifer greater than the MCL of 5 µg/L have been limited to the northeast corner of Hangar 3 near extraction well EXW-1. Analytical results indicate that PCE concentrations are stable or decreasing at Site 26.

- In 2008, the highest PCE concentration detected in the upper portion of the A aquifer was reported as 57 µg/L. In 2003, the highest concentration was reported as 77 µg/L.

- PCE concentrations have been stable in five wells (remaining at or below 1 µg/L) and have shown long-term decreasing trends in the five other wells; none of the data indicate increasing PCE trends.

- A decrease in PCE concentration in samples collected from W7-10 was observed beginning in mid-2005. The decrease is likely due to the dechlorination effects associated with the addition of HRC in 2004.

Vinyl Chloride Evaluation and Trends

The shape and location of the vinyl chloride plume has remained stable over the review period (see Figure 17). The vinyl chloride plumes generally exist in the same area as the *cis*-1,2-DCE plumes, with a slight offset to the south. Analytical results indicate the following about vinyl chloride concentrations at Site 26:

- In 2008, the highest concentration of vinyl chloride in the upper portion of the A aquifer was reported as 17 µg/L; in 2003, the highest concentration was reported as 35 µg/L.

- Vinyl chloride concentrations have shown a long-term stable trend in six wells and increasing trends in four wells.

- Vinyl chloride concentrations began increasing in mid-2005 in three of the four wells with long-term increasing trends, whereas prior to 2005, they had been stable. Samples from the same wells exhibit a stable to decreasing trend in TCE and PCE concentrations. This appears to be result of dechlorination associated with the addition of HRC in the areas immediately upgradient of these wells during 2004.

1,1-DCE Evaluation and Trends

Concentrations of 1,1-DCE in samples collected from wells completed in the upper and lower portions of the A aquifer have been consistently below the MCL of 6 µg/L throughout the review period. Because concentrations have remained below the MCL, there are no groundwater plume maps for 1,1-DCE.

1,2-DCA Evaluation and Trends

Analytical results indicate that 1,2-DCA concentrations are low and stable at Site 26. Because of low and sporadic concentrations, there are no groundwater plume maps for 1,2-DCA.

- Concentrations of 1,2-DCA in samples collected from wells completed in the upper portion of the A aquifer have generally been below the MCL of 0.5 µg/L throughout the review period, except for samples from two wells each in 2003, 2004, and 2008; three wells in 2006; and one well in 2007.

- The exceedances were all reported at or below 1.0 µg/L.

- None of the samples from 2005 exceeded the MCL.

***Trans*-1,2-DCE Evaluation**

Analytical results indicate that *trans*-1,2-DCE concentrations are low and stable at Site26. Because of low and sporadic concentrations, there are no groundwater plume maps for *trans*-1,2-DCE.

- *Trans*-1,2-DCE concentrations in samples collected from wells completed in the upper portion of the A aquifer have generally been below the MCL of 6.0 µg/L throughout the review period, except for samples from one well each in 2004, 2005, 2007, and 2008; and samples from two wells in 2006.

- The exceedances were all reported at or below 13.0 µg/L, except for the samples from 2004 and 2007, which were reported at the MCL.

- None of the samples from 2003 exceeded the MCL.

6.4.3.3 Groundwater Sampling Data – Northern Plume

Groundwater monitoring wells WU5-8, WU5-9, and WU5-4 were selected in the *EATS Long-Term Groundwater Monitoring Plan* (PRC 1997) for monitoring COCs in the northern plume. From 2004 to 2008, concentrations of *cis*-1,2-DCE, PCE, vinyl chloride, 1,1-DCE, 1,2-DCA, and *trans*-1,2-DCE were less than laboratory reporting limits. No analytical data was presented for these wells in the 2003 annual groundwater report.

Between 2004 and 2008, TCE concentrations in northern plume groundwater monitoring wells WU5-8 and WU5-9 ranged from below detection limits to below the MCL of 5 µg/L. However, because the northern plume is located in an area that is not designated as a potential drinking water source, drinking water standards are not applicable. The OU5 ROD states that groundwater in the northern plume poses no unacceptable risk to human health or the environment.

TCE concentrations in monitoring well WU5-4 have decreased over the review period and were 11 µg/L in 2004, 7 µg/L in 2005, 6 µg/L in 2006, 5 µg/L in 2007, and 3.7 µg/L in 2008. Because samples from WU5-4 showed the only significant TCE concentrations in the northern plume, WU5-4 was determined to demarcate the extent of the northern TCE plume (TN&A 2008b). Thus, analytical data indicate a decreasing trend for TCE concentrations in the northern plume.

6.4.4 Site 28

Water level measurement data, hydraulic control and capture zone analysis, and groundwater sampling analytical data for Site 28 were reviewed. Each of these is discussed in the sections that follow. Complete analytical results and groundwater plume depictions are included in the 2003 through 2008 annual groundwater reports (TtFW 2005b, 2005c; TtEC 2006; TN&A 2007b, 2008b; SES-Tech 2009).

6.4.4.1 Water Level Measurement Data

Seasonal groundwater elevation trends appear consistent throughout the Five-Year Review reporting period. Though groundwater elevations in many monitoring wells have gradually decreased, most groundwater elevations continue to exhibit seasonal fluctuations. The highest groundwater elevations typically occur at the end of the wet season (March to April). The lowest groundwater elevations typically occur at the end of the dry season (October to November). The groundwater flow direction in the upper and lower portion of the A aquifer at Site 28 is generally to the north.

Groundwater elevations in monitoring wells completed in the upper and lower portions of the A aquifer near extraction wells have declined due to the start-up of the WATS extraction wells. The amount of groundwater elevation decline decreases with distance from the extraction wells. Groundwater elevations in monitoring wells at a distance from the extraction wells also show

declines in groundwater elevations, though less pronounced than those proximal to extraction wells.

6.4.4.2 Hydraulic Control and Capture Zone Analysis

WATS is operated to maintain a capture zone adequate to create hydraulic control of impacted groundwater and to restore groundwater quality to the cleanup standards established by the MEW ROD (EPA 1989). Hydraulic control of the contaminant plumes is accomplished by the cumulative effect of capture zones from nine Navy extraction wells working together with RGRP extraction wells.

WATS has achieved complete hydraulic containment of the target contaminant capture zone in the upper portion of the A aquifer throughout the reporting period, and in the lower portion of the A aquifer since extraction well EA2-3 came online in January 2004.

Prior to January 2004, data indicated that the extraction wells in the lower portion of the A aquifer may not have had complete capture of VOC plumes, primarily on the east side of WATS. In accordance with the *Final West-Side Aquifers Treatment System Optimization Work Plan* (FWEC 2003d), the Navy installed new extraction well EA2-3 and brought it online in January 2004 to improve the capture zone for VOCs in the lower portion of the A aquifer (TtFW 2005d).

The addition of EA2-3 and its lasting effects on WATS capture zones were first discussed in the *2004 Annual Groundwater Report for WATS and EATS* (TtFW 2005c). These are highlighted below:

- The combined pumping of EA2-2 and EA2-3 created a coalesced depression in the area, creating a single capture zone for the two extraction wells. The capture zone expanded to the east from previous estimates, outside of the WATS area.
- The capture zone in the upper portion of the A aquifer also extended 200 feet further to the east of the WATS area.
- The combined pumping of EA2-2 and EA2-3 was impacting the upper portion of the A aquifer by pulling groundwater down.

Consequently, it appeared that the extraction wells in the lower portion of the A aquifer were pumping at higher rates than necessary to capture the groundwater moving through the WATS area. The *Draft WATS Site 28 Optimization Evaluation Report* (SES-Tech 2008) concluded that pumping rates of extraction wells EA2-1, EA2-2, and EA2-3 could be reduced and still maintain capture. The report recommended decreasing the overall pumping rate of extraction wells in the lower portion of the A aquifer. EPA and the Water Board have reviewed the *Draft WATS Site 28 Optimization Evaluation Report* and, as agreed by the Navy, EPA, and the Water Board, comments are on hold until after the Navy completes its in situ remediation pilot testing at the site.

The efficacy of WATS and its resulting capture zones to ultimately achieve remedial objectives is demonstrated by declining TCE concentration trends. TCE concentration trends are stable or decreasing in groundwater in samples collected from monitoring wells completed within the upper and lower portion of the A aquifer wells located downgradient of the WATS extraction wells. However, as long as contaminant flow (exceeding cleanup standards) into Site 28 from a continuing upgradient source (south of U.S. Highway 101) continues, the remedial objective to restore groundwater quality to cleanup standards cannot be achieved (SES-Tech 2009).

6.4.4.3 Groundwater Plume Evaluation

The MEW ROD states that the ratio of TCE to other COCs is high enough that attainment of the TCE cleanup level will result in cleanup of the other COCs below their corresponding MCLs (EPA 1989). Because TCE was selected as the indicator chemical at Site 28, an evaluation of the TCE plume is representative of other Site 28 COCs. A graphical depiction comparing the TCE plume in 2003 to the plume in 2008 is included as Figure 18 and Figure 19. A discussion follows.

The regional TCE plume in the upper and lower portions of the A aquifer extends downgradient (north) from south of U.S. Highway 101 (see Figure 6). The regional plume has an axis that generally trends south to north, with at least two main lobes north of U.S. Highway 101: the eastern lobe through the WATS capture area and a smaller western lobe west of the WATS capture area. The plume is similar in shape and extent to the TCE plume maps prepared since 2003. However, the extent of the plume with TCE concentrations above 1000 µg/L in 2008 is significantly smaller than the same concentration area in 2003.

Differences in the shape and extent of the plume in 2003 compared to 2008 can be explained by the addition of monitoring wells added to the Navy and MEW sampling programs in 2008. A detailed analysis of the changes to the annual sampling programs and the resulting changes in the understanding of the extent of the plume is included in the *2008 Annual Groundwater Report for WATS and EATS* (SES-Tech 2009).

6.4.4.4 Groundwater Sampling Data

The following sections present trends for Site 28 COCs in the upper and lower portions of the A aquifer during the Five-Year Review reporting period. A subset of monitoring wells was selected to evaluate VOC concentration trends in accordance with the *Final West-Side Aquifers Treatment System Long-Term Groundwater Monitoring Plan* (TtFW 2004b). For the upper portion of the A aquifer, 26 monitoring wells were used to evaluate concentration trends: 14C33A, 14D05A, W9-2, W9-10, W9-18, W9-19, W9SC-1, W9-31, W9-37, W9-45, W9SC-7, W9SC-13, W9SC-14, W29-1, W29-3, W29-4, W56-2, WIC-1, WU4-8, WU4-10, WU4-14, WU4-17, WU4-21, WU4-25, WWR-1, and WWR-2. Ten wells were used to evaluate concentration trends in the lower portion of the A aquifer: 80B1, W9-9, W9-14, W9-20, W9-21, W9-34, W29-7, WU4-9, WU4-11, and WU4-15. Data from these wells are considered representative of COC concentrations at Site 28.

The deepest aquifer that the Navy monitors at Site 28 is the B2 aquifer. The Navy has monitored four wells in the B2 aquifer zone intermittently between 1992 and 1998, and annually from 2003 to 2008 (wells 45B2, W9-12, W9-15, and W9-40). Samples were also collected from B2 aquifer zone wells W9-3 and W9-5 in 2007. VOC contamination trends in the B2 and deeper aquifer zones are not discussed further in this report because (1) TCE concentrations in all B2 aquifer samples have been below the MCL of 5 µg/L, (2) there are no increasing trends, and (3) all recent samples either have been not detected or have been detected below 0.5 µg/L (SES-Tech 2009).

TCE Trends

Analytical results indicate that TCE concentrations show an overall decreasing trend at Site 28 (see Figure 18 and Figure 19). TCE concentrations are decreasing in monitoring wells located downgradient of WATS extraction wells.

- In the upper portion of the A aquifer, TCE concentrations showed a decreasing trend in 19 of 26 wells, relatively stable concentrations in 4 wells, and a long-term increasing trend in 3 wells (W29-4, WU4-14, and WU4-21). The highest TCE concentration over the reporting period was 3,000 µg/L in 2006. In 2008, the highest concentration was 2,000 µg/L.

- In the lower portion of the A aquifer, TCE concentrations showed a long-term decreasing trend in 9 of 10 wells, and a long-term increasing trend in one well (WU4-15). The highest TCE concentration over the reporting period was 7,100 µg/L in 2005. In 2008, the highest concentration was 4,700 µg/L.

***Cis*-1,2-DCE Trends**

Analytical results suggest that TCE is degrading to *cis*-1,2-DCE, and that overall, *cis*-1,2-DCE concentrations are stable or decreasing (see Figure 20 and Figure 21).

- In the upper portion of the A aquifer, *cis*-1,2-DCE concentrations showed a long-term decreasing trend in 10 of 26 wells, a stable trend in 14 wells, and a long-term increasing trend in 2 wells (W9-2 and W9SC-1). W9-2 and W9SC-1 exhibited increasing *cis*-1,2-DCE concentrations in conjunction with decreasing TCE concentrations, suggesting degradation of TCE to *cis*-1,2-DCE.

- In the lower portion of the A aquifer, *cis*-1,2-DCE concentrations showed a long-term decreasing trend in 5 of 10 wells, a stable trend in 3 wells, and a long-term increasing trend in 2 wells (W9-34 and WU4-15). W9-34 showed an increasing *cis*-1,2-DCE concentration trend in conjunction with a decreasing TCE concentration trend, suggesting degradation of TCE to *cis*-1,2- DCE.

PCE Trends

Analytical results suggest that PCE concentrations are stable or decreasing (see Figure 22 and Figure 23). There were no increasing trends for PCE.

- In the upper portion of the A aquifer, PCE concentrations showed a long-term decreasing trend in 8 of 26 wells and a stable trend in 18 wells. The highest PCE concentration over the reporting period was 350 µg/L in 2005. In 2008, the highest concentration was 11 µg/L.

- In the lower portion of the A aquifer, PCE concentrations showed a decreasing trend in 3 of 10 wells, while 7 wells had concentrations that were stable or below laboratory detection limits. The highest PCE concentration over the reporting period was 550 µg/L in 2005. In 2008, the highest concentration was 120 µg/L.

During the review period, it was discovered that a potential source of PCE to groundwater may be present in the former Building 88 footprint and the adjacent traffic island area. The source consists of PCE in saturated soils and potentially as DNAPL (TtEC 2008b). Monitoring well W9SC-15 is located approximately 50 feet downgradient of the former Building 88 area. PCE concentrations in this well over the review period have ranged from a low of 120 µg/L in 2007 and 2008 to a high of 220 µg/L in 2005.

Examination of groundwater plume maps over the review period indicates PCE plumes originating near the former Building 88 footprint and extending downgradient in both the upper and lower portions of the A aquifer, with higher concentrations in the lower portion of the A aquifer. The plumes in 2008 exhibit both decreasing size and concentrations when compared to the 2003 plumes (see Figure 22 and Figure 23). This data is consistent with the operating efficiency of WATS. The groundwater plumes of PCE and any daughter products are fully contained and groundwater is being treated by the combined regional plume treatment systems (WATS and MEW).

This potential source is discussed in more detail in Section 7.4.1.7.

Vinyl Chloride Trends

Analytical results indicate that overall, vinyl chloride concentrations are stable or increasing at Site 28, suggesting that PCE and TCE are undergoing reductive dechlorination and degrading to vinyl chloride (see Figure 24 and Figure 25).

- In the upper portion of the A aquifer, vinyl chloride concentrations showed a long-term decreasing trend in 7 of 26 wells, a stable trend in 11 wells, and a long-term increasing trend in 8 wells (W9-10, W9-18, W9-19, W9-45, W29-3, W56-2, WIC-1, and WU4-8). The increasing vinyl chloride concentration trend may be the result of TCE and PCE degradation. All of the monitoring wells with increasing vinyl chloride concentrations also have stable or decreasing TCE and PCE concentrations.

- In the lower portion of the A aquifer, vinyl chloride concentrations showed a long-term decreasing trend in 3 of 10 wells, while 2 wells had concentrations that were stable and below the laboratory detection limit. Five wells exhibited a long-term increasing vinyl chloride concentration trend (W9-9, W9-14, W9-34, W29-7, and WU4-15), which may be due to TCE and PCE degradation, as four of these wells also had stable or decreasing TCE and PCE concentrations.

6.4.4.5 Overall Trend Summary for WATS

Average influent VOC concentrations had declined during the period from system startup in November 1998 through late 2005. The average influent VOC concentrations increased in late 2006 followed by a decrease in late 2007. Average influent VOC concentrations increased slightly in 2008. Figure 26 presents a graphical display of PCE, TCE, *cis*-1,2-DCE, and vinyl chloride average influent concentrations and the sum of these average concentrations to WATS from 1999 through 2008 (SES-Tech 2009). Although there have been fluctuations, this data suggests that the average concentrations of VOCs entering WATS extraction wells have shown a slight overall decrease over the review period.

TCE and *cis*-1,2-DCE have made up between approximately 96 to 98 percent of the mass removed by WATS over the review period. Sampling analytical data from monitoring wells located in areas considered representative of WATS groundwater contamination exhibit long-term trends of decreasing or stable TCE concentrations (88 percent of evaluated wells in the upper portion of the A aquifer and 90 percent of evaluated wells in the lower portion of the A aquifer) (SES-Tech 2009).

6.5 SITE INSPECTIONS

ChaduxTt conducted inspections for this review on May 7 and May 14, 2009. The purpose of the site inspections was to review and document current site conditions and evaluate visual evidence regarding implementation of the remedial actions at each site. This effort included noting current land use, points of access, and access requirements for each site; presence and location of fencing; and locations and conditions of monitoring wells and other aspects of the remedies. EPA's *Comprehensive Five-Year Review Guidance* (EPA 2001) provides a site inspection checklist that was modified and used during the site inspections. The modified checklists filled out during the inspections are presented in Appendix G. Photographs selected to show the conditions noted during the site inspections are presented in Appendix H.

6.5.1 Site 1

Access to Site 1 is initially controlled by the main security checkpoint for Moffett Field and secondly by a security checkpoint located south of the runways that restricts access by unauthorized personnel to the east side of Moffett Field. Additionally, a locked gate at the landfill entrance prevents access specifically to the site.

Locations of all groundwater and landfill gas monitoring wells, gas vents, the gas venting trench, and the groundwater collection trench were confirmed during the site inspection (see Figure 3). Additionally, four raptor perches were observed on the northern and western portions of the site. Other than evidence of recent ground squirrel and gopher activity, all aspects of the remedy appeared to be functioning as intended.

Because Site 2 is closed with NFA status, it was not inspected. No activity that would be considered inconsistent with use as a closed landfill was noted at Site 1.

6.5.2 Site 22

Access to Site 22 is initially controlled by the main security checkpoint for Moffett Field and secondly by a security checkpoint located south of the runways that restricts access by unauthorized personnel to the east side of Moffett Field. Because of its use as a golf course, the site itself is unfenced.

Locations of all groundwater and landfill gas monitoring wells were confirmed during the site inspection (see Figure 4). Monitoring wells WGC2-4, WGC2-10, and WGC2-12 were missing bolts, allowing access to the well casing. WGC2-8 had a broken bolt head. The unbolted wells were not deemed a threat to the performance of the remedy because access into Moffett Field is strictly controlled. The Navy addresses monitoring well maintenance as part of routine maintenance activities during quarterly site inspections.

Burrowing animal holes have been noted at this site in the past, however, no evidence of burrowing was observed during the site inspection. According to Santa Clara DEH inspection checklists, the burrowing animal issue is being controlled by golf course maintenance staff.

No activity was noted at Site 22 that would be considered inconsistent with use as a closed landfill or golf course.

6.5.3 Site 26

Land use in the immediate vicinity of Site 26 consists of recreational facilities and airfield operations. Access to Site 26 is initially controlled by the main security checkpoint for Moffett Field and secondly by a security checkpoint located south of the runways that restricts access by unauthorized personnel to the east side of Moffett Field. The treatment facility was observed to

be off, completely fenced, and locked at the time of the site inspection. All monitoring wells and extraction wells were inspected during the site inspection (see Figure 9).

No activity that would be considered inconsistent with uses previously described in this report was noted, and no significant issues with regard to the integrity of the components of the remedy were identified.

6.5.4 Site 28

Current uses of the Site 28 area include airfield operations, administrative offices, and various buildings supporting daily operations at Moffett Field. Access to the site is initially controlled by the main security checkpoint for Moffett Field. The treatment facility is completely fenced and locked. Additionally, the treatment facility is manned during normal business hours during the week.

The site inspection consisted of a visual inspection of the components of the WATS treatment train, monitoring wells PZA2-2A and W29-2, and extraction well EA2-2, as well as a review of relevant on-site documents and inspection records. The on-site O&M manager reported that the wells that were inspected were representative of other monitoring and extraction wells at WATS. Site 28 monitoring and extraction well locations are presented in Figure 11 and Figure 12.

No activity that would be considered inconsistent with uses previously described in this report was noted, and no significant issues with regard to the integrity of the components of the remedy were identified.

6.6 INTERVIEWS

Interviews were conducted with personnel knowledgeable about remedial actions at Sites 1, 22, and 28. An interview was not necessary to acquire information about remedial actions at Site 26, such as the shutdown of EATS and the current pilot test, relevant to completing the Five-Year Review in accordance with EPA and Navy guidance documents. The full interviews are presented in Appendix I.

Mr. Duane Harrison, Treatment System Operator, and Mr. Gordon Jamison, Western Regional Science Manager, both with TtEC, provided a detailed response to the Five-Year Review questionnaire on April 23, 2009. In their response, they summarized WATS operations, efficiency, and analytical data for the period from 2003 through 2008.

Their overall impression with WATS is summarized below:

- WATS is functioning as intended.

- The system is intercepting groundwater contamination and properly treating and discharging the treated water.

- The system is dependable, operating at least 97 percent of the time.

Mr. Chris Rummel, inspector with the Santa Clara County DEH, was interviewed on July 8, 2009. Mr. Rummel inspects Sites 1 and 22 on a quarterly basis to assure that the landfills are maintained per requirements of Title 27 of CCR for closed landfills. He reports that both landfills have been well maintained. Mr. Rummel has not documented any deficiencies during quarterly inspections, except as summarized below:

- Ground squirrel and gopher burrowing at Site 1 requires routine mitigation.

- Elevated methane levels were detected near one of the landfill gas monitoring wells at Site 22, which has since naturally abated.

- Using raptor perches to attract birds of prey for rodent control at Site 1 is a potential collision hazard with Moffett Field aircraft.

- Current landfill monitoring is not consistent with expected gas ranges or California Air Board requirements. A lower detection range for landfill gas monitoring should be used. (The Navy began using a new field measurement instrument for landfill gas after the June 2009 quarterly inspection. The new device improves the accuracy of landfill gas measurements at Sites 1 and 22 by using a more sensitive scale.)

Mr. Don Chuck, Restoration Project Manager at NASA, was interviewed on January 13, 2010 regarding the status of IC implementation in NASA's Master Plan for Sites 1, 22, and 26; operation of Building 191 pump station; and vapor intrusion at Site 28. The interview is summarized below:

- NASA's Facilities Group is currently revising the Master Plan with input from the Environmental Department. NASA will incorporate ICs for Sites 1, 22, and 26, as well as language regarding NASA's continued and future operation of the Building 191 pump station, into the Master Plan.

- There are two pumps at the Building 191 station ─ the existing pump and an auxiliary pump that NASA added next to Building 191 after NASA took ownership. There are also two auxiliary pumps along the northern channel. All auxiliary pumps can be turned on for additional capacity during heavy rain events and provide backup should the main pump fail. However, the base does occasionally get flooded because of limitations on capacity and number of discharge points. NASA is looking for additional discharge points, potentially the USFWS ponds. The pumps can handle most rainfall events.

- During past heavy flood events, the landfills have been surrounded by water, but there have been no resulting issues, and the water dissipates soon thereafter.

- To address vapor intrusion risks in existing buildings in the EPA's Vapor Intrusion Study Area, NASA has adjusted heating, ventilation, and air conditioning systems to improve airflow through some of the buildings. NASA also periodically monitors some of the buildings for VI problems. NASA will begin sampling on a quarterly basis in March 2010, which will include indoor air sampling, soil gas measurements, and groundwater measurements to determine if NASA can get correlations in results from the three different sampling protocols.

- NASA does not plan to sample buildings that are unoccupied or that are only occupied occasionally. NASA will focus sampling efforts on buildings that are occupied most or all of the time. NASA's previous air sampling occurred in the WATS area, and new air sampling will continue in the WATS area.

- VI mitigation measures are required for all new construction at NASA. When NASA leases land for new construction, this requirement is included in tenant leases. The method selected to mitigate VI is up to the lessee, and must be reviewed and approved by NASA.

7.0 TECHNICAL ASSESSMENT

To determine whether the remedies for Sites 1, 22, 26, and 28 are protective of human health and the environment, three questions will be examined in the technical assessment:

Question A: Is the remedy functioning as intended by the decision documents?

EPA's guidance document for Five-Year Reviews identifies several areas that need to be considered in evaluating whether the remedy selected in the ROD is functioning as designed (EPA 2001). Areas of consideration include:

- Remedial Action Performance – Is the remedy operating as designed?
- System O&M – Will the system and current O&M activities maintain the effectiveness of the response actions?
- Cost of O&M – Are there large variances between current annual costs and costs for previous years that might indicate potential remedy problems?
- Implementation of Institutional Controls and Other Measures – Are these functioning as planned?
- Monitoring Activities – Do the current monitoring activities provide adequate information to determine the protectiveness and effectiveness of the remedy implemented?
- Optimization Opportunities – Are there any areas for improvement?
- Early Indications of Potential Issues – Are there problems that could lead to the remedy being not protective or suggest protectiveness is at risk unless changes are made?

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?

EPA's guidance document for Five-Year Reviews identifies several areas that need to be considered in evaluating whether the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection remain valid (EPA 2001). Areas of consideration include changes in standards and "to be considereds (TBC)," changes in exposure pathways, changes in toxicity and other contaminant characteristics, changes in risk assessment methods, and expected progress toward meeting RAOs.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

The final question in conducting a technical assessment of the selected remedy includes evaluation of any new information that could call into question its protectiveness. Examples of new information include newly exposed ecological risks, previously unconsidered unidentified risks from natural disasters (for example, flooding), or land use changes.

Each of these questions is addressed in the following subsections, building on the information and data summaries presented previously. The discussion presented here is a framework for the protectiveness determination that explains the conclusions of the review.

7.1 SITE 1 TECHNICAL ASSESSMENT

This section provides a technical assessment for Site 1 by discussing and answering each of the three questions used to determine protectiveness of the remedy. A summary is provided at the end of the section.

7.1.1 Question A

Is the remedy functioning as intended by the decision documents? Yes

7.1.1.1 Remedial Action Performance

The review of documents, ARARs, risk assumptions, and results of the site inspection indicate that the Site 1 cover is functioning as intended by the ROD (Navy 1997). The construction of a landfill cover, installation of the gas-venting trench and subsurface groundwater collection trench, groundwater and gas monitoring wells, use of ICs, and post-closure maintenance have met the statutory requirements of CERCLA § 121. The constructed landfill cover is an effective barrier that minimizes potential human and ecological exposure.

The gas vents installed at the site continue to provide for efficient and safe discharge of methane to the atmosphere. During quarterly monitoring, the concentration limit of 5 percent by volume was exceeded only four times during 2007 and was not exceeded in 2008. The results indicate that migration of landfill gas is not occurring. The remedy conforms with ARARs.

The groundwater collection trench on the north side of the landfill was installed to provide immediate protection to the adjacent stormwater retention pond (Navy 1997). Two collection wells are screened in the trench should it become necessary to pump water from the trench. Groundwater is monitored on a routine basis as previously discussed in Section 4.2.1.

7.1.1.2 System Operations and O&M

There are no continuous operating systems associated with Site 1. O&M activities are performed in accordance with the *Site 1 Landfill Final Closure Plan and Post-Closure Maintenance Plan* (TtEMI 1998a), the *Final Site-Specific Contractor Quality Control Plan for Sites 1 and 2*

Groundwater Monitoring and Maintenance (FWEC 2001b), and the *Final Site 1 Landfill Post-Closure Long-Term Maintenance Plan* (TtFW 2005a). The remedy is cost-effective and uses permanent solutions.

Ground squirrel and gopher control activities are performed according to the *Final California Ground Squirrel Management Plan for the Site 1 Landfill* and HAWP (FWEC 2002b). The mitigation activities include backfilling active burrows throughout the landfill and maintaining metallic and non-metallic flashing along the Site 1 barrier fence and swing gates. The metallic flashing is 3 feet tall, covers the bottom portion of the site security fencing (except for the swing gates), and was intended to form a barrier to burrowing mammals. Approximately 6 inches of the metallic flashing is buried below the ground surface. The swing gates have non-metallic flashing underneath the gates to cover the gap between the ground surface and the bottom of the swing gates. Additionally, because of the reflective properties of metallic flashing, non-metallic flashing is installed along the western perimeter fence to prevent interference with airfield operations.

Ground squirrels and gophers burrow into the first, vegetative layer of the landfill cover, which serves as a soil cap for plant growth. Deeper layers of the cover prevent contact with the waste, water infiltration into the waste, and escape of landfill gas. Observed burrow depths range from 3 to 10 inches bgs. These burrows ranged from 2 to 4 inches in outer diameter. The method used to assess burrowing animal impact(s) to the integrity of the landfill cover, including the geotextile fabrics, requires inspection personnel to diligently look for gravel, geotextile fabric, landfill waste, or other debris in the holes and on the ground surface adjacent to the holes. There is no evidence that burrowing mammals have penetrated deeper than the first vegetative layer. During documented inspections, personnel have not observed the following:

- Hole diameters exceeding 4 inches
- Evidence that holes have been enlarged at the surface
- Presence of gravel, geotextile fabric, landfill waste, and other debris in holes and on adjacent ground surfaces
- Burrowing owl white wash or pellets in holes and on adjacent ground surfaces.

Current O&M activities at Site 1 maintain the effectiveness of the response actions.

7.1.1.3 Costs of O&M

There were no large variances between current annual costs and costs for previous years. Nothing in the cost analysis indicates a potential remedy problem.

7.1.1.4 Engineering and Institutional Controls

Site 1 has a locked fence surrounding three sides of the landfill (the stormwater retention pond is on the northwest side of the site) for which the Navy controls access. ICs agreed to by the Navy and NASA are specified in the MOA signed on November 15, 1999. In the MOA, NASA agreed to continue O&M of the Building 191 pump station and associated drainage system. NASA also agreed not to undertake any activities that would compromise the integrity of the landfill cover. The Navy agreed to any required maintenance to maintain the integrity of the landfill cover. No plans currently exist for the Site 1 property to change ownership. The ECs and ICs are serving their intended purpose of limiting human and ecological exposure to landfill contaminants. The Navy meets its annual reporting requirements to EPA by conducting annual reports for the Site 22 Landfill. The annual reports address the effectiveness of monitoring and implementation of ICs. To ensure future protectiveness, NASA must incorporate the ICs required by the ROD and MOA into its Master Plan, and provide documentation and a reporting schedule to EPA and Water Board.

7.1.1.5 Monitoring Activities

Groundwater sampling was performed on a quarterly basis at Site 1 until 2005 in accordance with Appendix E of the *Site 1 Landfill Final Closure Plan and Post-Closure Maintenance Plan* (TtEMI 1998a). In 2005, the groundwater monitoring schedule was amended to semiannual in accordance with the *Site 1 Landfill Post-Closure Long-Term Monitoring Plan* (TtFW 2005b).

Landfill gas monitoring is conducted quarterly at Site 1 in accordance with the *Site 1 Landfill Final Closure Plan and Post-Closure Maintenance Plan* (TtEMI 1998a), the *Post-Closure Monitoring (Site 1) and Groundwater Monitoring (Site 2) Sampling and Analysis Plan* (ITC 2000b), *Final Sampling and Analysis Plan Addendum* (FWEC 2001a), and the *Final Site 1 Landfill Post- Closure Long-Term Monitoring Plan* (TtFW 2005a). After the June 2009 quarterly inspections, the Navy began using a landfill gas detection device recommended by the Santa Clara County DEH. The new detection device improves the accuracy of landfill gas measurements at Site 1 by using a more sensitive scale.

The monitoring program currently implemented is appropriate to determine the protectiveness and effectiveness of the remedy.

7.1.1.6 Optimization

Opportunities for optimization include devising an alternative to the current burrowing ground squirrel and gopher problem. Although ground squirrels and gophers have yet to transfer landfill material to the surface, a more permanent solution should be developed so that this potential exposure pathway is eliminated. The Navy has implemented a burrowing mammal abatement plan, which focuses on trapping, and will continue to evaluate the results.

Analysis has shown that landfill gas migration is not occurring and landfill contaminants are detected infrequently, sporadically, and in low and trace concentrations. As such, frequency of landfill gas and groundwater monitoring could be reduced from semiannually to annually.

7.1.1.7 Early Indicators of Potential Problems

There are no indicators of potential problems associated with the remedy selected and implemented for Site 1.

7.1.2 Question B

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid? Yes.

7.1.2.1 Changes in Standards and TBCs

No newly promulgated standards or TBCs, or changes to existing standards and TBCs, significantly impact the remedy selected.

7.1.2.2 Changes in Exposure Pathways

Since the issuance of the ROD, the understanding of the fate and transport of chemicals in the subsurface to indoor air has evolved. It is now understood that, under certain conditions, VOCs in soil and groundwater emit vapors that can migrate upward through subsurface soils and enter overlying buildings through cracks in floors or through piping conduits and other preferential pathways. However, since there are no buildings at Site 1, this exposure pathway is incomplete. Additionally, ICs and ECs protect against future exposure through this pathway with provisions to protect the integrity of the landfill cover, including prohibitions against building on the landfill.

Land use at Site 1 has not changed, nor is it expected to change in the near future. Land use at Moffett Field and in the immediate vicinity has not changed; nor is it expected to change in the near future.

No changes to physical site conditions that could affect exposure pathways or the protectiveness of the remedy have occurred. No new contaminants or contaminant sources originating from Site 1 have been identified or detected during monitoring. No toxic byproducts have been generated as a result of remedy implementation.

7.1.2.3 Changes in Toxicity and Other Contaminant Characteristics

Toxicity factors for COCs at Site 1 that could affect the protectiveness of the remedy have not changed. Contaminant characteristics have not changed in a way that could affect the protectiveness of the remedy.

7.1.2.4 Changes in Risk Assessment Methods

The assessment of risks to human health posed by Site 1 is limited to exposure to soil or soil gas because groundwater is not and will not likely be used as a source of drinking water or for other beneficial use in the future due to low yield and high TDS (Navy 1997). Therefore, the evaluation of risk was limited to ingestion or dermal contact with soils, inhalation of wind-eroded surface soils, and inhalation or explosion of landfill gas (Navy 1997). The landfill has been covered, thereby minimizing the human and ecological contact exposure pathway. Landfill gas has been detected at low quantities throughout the Five-Year Review reporting period. No changes in the risk assessment method were noted.

7.1.2.5 Expected Progress Toward Meeting RAOs

As discussed in Section 4.1.1, the ROD for OU1 did not list RAOs. However, numerical remedial goals were later developed as CCLs in the *Final Technical Memorandum, Site 1 Groundwater Evaluation Process* (TtFW 2004c). Site 1 CCLs are discussed in Section 4.2.1. Based on an analysis of the groundwater data in accordance with the *Final Technical Memorandum*, there have been no releases from the Site 1 landfill during the Five-Year Review reporting period.

7.1.3 Question C

Has any other information come to light that could call into question the protectiveness of the remedy? No.

All ecological risks have been adequately addressed. There have been no impacts from natural disasters over the review period. However, because of its low elevation and proximity to San Francisco Bay, sea level rise from global warming could have future impacts on the protectiveness of the remedy at Site 1.

There are many unknowns concerning sea level rise that could result from global warming, and the magnitude of the potential rise is unknown. If rising water level is indentified as an issue in future quarterly inspections and Five-Year Reviews, the Navy will take steps at that time to respond procedurally to ensure the protectiveness of the remedy before the landfill becomes completely surrounded by water. Additionally, water rise from onetime events such as the high tide five feet above mean sea level on February 3, 1998 caused by the El Niño that year (United States Geological Survey 2005) should be addressed as potential compromises to the remedy. Although the extent of sea level rise is uncertain, extreme high tides accompanied by wind

storms and heavy wave action are likely to occur over the life of the landfills. Wind and wave action from the combination of abnormally severe storms and increased static sea level could cause remedy failure and should be considered in future planning.

The Building 191 pump station currently provides flood protection for the entire northern portion of Moffett Field, with a main pump in Building 191 and three additional auxiliary pumps. NASA installed an auxiliary pump next to Building 191 after NASA took ownership of Moffett Field. There are two additional auxiliary pumps along the northern channel (one at end of Marriage Road Ditch and one at the end of East Patrol Road Ditch). NASA maintains the pumps on a regular schedule. These pumps can be turned on during heavy flood events to provide additional capacity and are able to address most flood events. Flooding occasionally occurs because of limitations on capacity and number of discharge points for floodwater. NASA is currently looking for additional discharge points to increase its ability to mitigate effects of flooding. According to the NASA Restoration Project Manager, the landfills have been surrounded by water during past flood events, but there have been no issues resulting from the flooding, and the water dissipates soon thereafter. The Navy is working with NASA to ensure that language regarding O&M of the Building 191 pump station is added to NASA's Master Plan (NASA 2010).

In accordance with the *Final Site 1 Landfill Post Closure Long Term Maintenance Plan* (TtFW 2005e), the Navy inspects the landfill cover for erosion semiannually. The maintenance plan also calls for inspection of the landfill cover "after significant events" to evaluate its integrity. The Santa Clara County DEH inspects the landfill cover for erosion during quarterly inspections.

Evaluation of implementation and performance of the selected remedy indicates that the landfill cover is functioning as intended and the remedy is currently protective of human health and the environment. Because of the design of the landfill cover, because the landfill cover is inspected quarterly by the Santa Clara DEH and semiannually by the Navy, and because the landfill is inspected after significant events such as flooding, flooding is not deemed a threat to future protectiveness of the remedy at this time. Land use of the site has not changed and no land use changes are currently being considered. The possibility exists for the adjacent property to become open to the public, at which time the issues of land use, security, access, and exposure will be addressed.

No additional information has been identified that suggests that the remedy for Site 1 may not be protective of human health and the environment.

7.1.4 Site 1 Technical Assessment Summary

According to the data reviewed and the site inspections, the cover at Site 1 is functioning as intended by the ROD (Navy 1997). There have been no changes in the physical conditions of the site that would affect the protectiveness of the remedy. ARARs cited in the ROD have been met (Navy 1997). To ensure future protectiveness, NASA must incorporate the ICs required by the ROD and MOA into its Master Plan, and provide documentation and a reporting schedule to

EPA and the Water Board. There is no other information that calls into question the protectiveness of the remedy.

7.2 SITE 22 TECHNICAL ASSESSMENT

This section provides a technical assessment for Site 22 by discussing and answering each of the three questions used to determine protectiveness of the remedy. A summary is provided at the end of the section.

7.2.1 Question A

Is the remedy functioning as intended by the decision documents? Yes

7.2.1.1 Remedial Action Performance

The review of documents, ARARs, risk assumptions, and the results of the site inspection indicated that the Site 22 cover is functioning as intended by the ROD (Navy 2002a). The construction of a biotic barrier, installation of groundwater and gas monitoring wells, use of ICs, and post-closure maintenance have met the statutory requirements of CERCLA § 121. The constructed biotic barrier is an effective barrier that minimizes potential human and ecological exposure.

7.2.1.2 System Operations and O&M

There are no continuous operating systems associated with Site 22. O&M activities are performed in accordance with the OMMP (FWEC 2003a) and Final OMMP Addendum (TtEC 2007). The remedy is cost-effective and uses permanent solutions.

No major problems have been documented during the reporting period except for ground squirrels and gophers burrowing into the landfill cover top soil. Observed burrow depths have ranged from 3 to 10 inches bgs, but have not penetrated into the debris. These burrows ranged from 2 to 4 inches in diameter. The method used to assess burrowing animal impacts to the integrity of the landfill cover, including the geotextile fabrics, requires inspection personnel to diligently look for gravel, geotextile fabric, landfill waste, or other debris in the holes and on the ground surface adjacent to the holes.

During documented inspections, personnel have not observed any of the following:

- Hole diameters exceeding 4 inches.
- Signs that holes have been enlarged at the surface.

- Presence of gravel, geotextile fabric, landfill waste, or other debris in holes or on adjacent ground surfaces.

- Burrowing owl white wash or pellets in holes or on adjacent ground surfaces.

During recent inspections by the Santa Clara DEH, it was reported that burrowing activity had become negligible because golf course maintenance crews were effectively controlling their activities.

Current O&M activities at Site 22 maintain the effectiveness of the response actions.

7.2.1.3 Costs of O&M

There were no large variances between current annual costs, as discussed in Section 4.3.2, and costs for previous years. Nothing in the cost analysis indicates a potential remedy problem.

7.2.1.4 Engineering and Institutional Controls

ICs and ECs for Site 22 are specified in the Site 22 ROD (Navy 2002a). Construction of the biotic barrier was completed in accordance with the *Appendix F, Final Post-Construction Operations, Maintenance, and Monitoring Plan for Installation Restoration Site 22 Landfill* (FWEC 2003a). The Navy conducts required maintenance activities to maintain the integrity of the landfill cover on an ongoing basis.

As discussed in Sections 4.1.2 and 4.2.2, Navy and NASA executed an MOA in September 2008 to establish each party's roles and responsibilities with regard to ICs as specified in the ROD (Navy 2002a). The MOA includes provisions designed to maintain the integrity of the landfill cap and prevent human and ecological exposure to landfill wastes. The Navy meets its annual reporting requirements to EPA by submitting annual reports for the Site 22 Landfill. The annual reports address the effectiveness of monitoring and implementation of ICs. The monitoring strategy, which describes the required monitoring activities, schedules, and specific reporting requirements for Site 22, is addressed through the OMMP (FWEC 2003a), the OMMP Addendum (TtEC 2007), and the MOA (Navy 2008). To ensure future protectiveness, NASA must incorporate the ICs required by the ROD and MOA into its Master Plan, and provide documentation and a reporting schedule to EPA and the Water Board.

7.2.1.5 Monitoring Activities

As discussed in Section 4.2.1, groundwater and landfill gas monitoring have been performed on a quarterly basis at Site 22 in accordance with the OMMP (FWEC 2003a) and Final OMMP Addendum (TtEC 2007). After the June 2009 quarterly landfill gas inspections, the Navy began using a landfill gas detection device recommended by the Santa Clara County DEH. The new detection device improves the accuracy of landfill gas measurements at Site 1 by using a more

sensitive scale. All monitoring activities are adequate to determine the protectiveness and effectiveness of the remedy.

7.2.1.6 Optimization

Analysis has shown that landfill gas migration is not occurring and that landfill contaminants are detected infrequently, sporadically, and in low and trace concentrations in groundwater. As such, the frequency of landfill gas and groundwater monitoring could be reduced from quarterly to semiannually. The Navy proposed revising the groundwater monitoring sampling frequency at Site 22 to a semiannual basis in the OMMP Addendum (TtEC 2007). This recommendation was based on historical trends in Site 22 water levels and the limited detections of COCs in groundwater samples collected from Site 22 monitoring wells. Additionally, as stated in the OMMP Addendum (TtEC 2007), because crossgradient wells WGC2-1 and WGC2-5 are not considered representative of groundwater quality at Site 22, groundwater monitoring could be discontinued in these wells. The Navy believes that reduction to semi-annual monitoring and elimination of the crossgradient wells from the monitoring program will be cost-effective and appropriate for determining if there is a release from the landfill.

7.2.1.7 Early Indicators of Potential Problems

There are no indicators of potential problems associated with the remedy selected and implemented for Site 22.

7.2.2 Question B

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid? Yes.

7.2.2.1 Changes in Standards and TBCs

No newly promulgated standards or TBCs, or changes to existing standards, significantly impact the remedy selected.

7.2.2.2 Changes in Exposure Pathways

Since the issuance of the ROD, the understanding of the fate and transport of chemicals in the subsurface to indoor air has evolved. It is now understood that, under certain conditions, VOCs in soil or groundwater emit vapors that can migrate upward through subsurface soils and enter overlying buildings through cracks in floors or through piping conduits and other preferential pathways. However, since there are no buildings at Site 22, this exposure pathway is incomplete. Additionally, ICs and ECs protect against future exposure through this pathway with provisions to protect the integrity of the landfill cover, including prohibitions against building on the landfill.

Land use at both Site 22 and Moffett Field has not changed; nor is it expected to change in the near future.

No changes to physical site conditions that could affect exposure pathways or the protectiveness of the remedy have occurred. No new contaminants or contaminant sources originating from Site 22 have been identified or detected during monitoring. No toxic byproducts have been generated as a result of remedy implementation.

7.2.2.3 Changes in Toxicity and Other Contaminant Characteristics

Toxicity factors for COCs at Site 22 that could affect the protectiveness of the remedy have not changed. Contaminant characteristics have not changed in a way that could affect the protectiveness of the remedy.

7.2.2.4 Changes in Risk Assessment Methods

The analysis of risks to human health posed by Site 22 is limited to exposure to soil or soil gas because groundwater is not and will not likely be used as a source of drinking water or for other beneficial use in the future due to high TDS content (TtEC 2005). Therefore, the evaluation of risk is limited to ingestion or dermal contact with soils, inhalation of wind-eroded surface soils, and inhalation or explosion of landfill gas (Navy 2002a). The landfill has been covered, thereby minimizing the human and ecological contact exposure pathway. Landfill gas has been detected at low quantities throughout the Five-Year Review reporting period. No changes in the risk assessment method were noted.

7.2.2.5 Expected Progress Toward Meeting RAOs

The primary RAO is to protect human health by preventing contact with landfill refuse. This RAO is currently being met, and it is anticipated that the RAO will continue to be met in the near future.

7.2.3 Question C

Has any other information come to light that could call into question the protectiveness of the remedy? No.

All ecological risks have been adequately addressed. There have been no impacts from natural disasters during the review period. However, because of its low elevation and proximity to San Francisco Bay, sea level rise from global warming could have future impacts on the protectiveness of the remedy at Site 22. This potential future issue is discussed in Section 7.1.3.

The land use of the site has not changed and no land use changes are being considered. No additional information suggests that the remedy for Site 22 may not be protective of human health and the environment.

7.2.4 Site 22 Technical Assessment Summary

The review of documents, ARARs, risk assumptions, and the results of the site inspection indicate that the Site 22 Landfill cover is an effective barrier in minimizing potential human and ecological exposure. No changes in the physical conditions of the sites would affect the protectiveness of the remedy. To ensure future protectiveness, NASA must incorporate the ICs required by the ROD and MOA into its Master Plan, and provide documentation and a reporting schedule to EPA and the Water Board. No other information calls into question the protectiveness of the remedy.

7.3 SITE 26 TECHNICAL ASSESSMENT

This section provides a technical assessment for Site 26 by discussing and answering each of the three questions used to determine protectiveness of the remedy. A summary is provided at the end of the section.

7.3.1 Question A

Is the remedy functioning as intended by the decision documents? No

7.3.1.1 Remedial Action Performance

Groundwater monitoring is currently conducted in accordance with the ROD; however, the groundwater treatment system is currently turned off. As discussed in Section 4.2.3, EATS was turned off in July 2003 in accordance with the agency approved *EATS Evaluation Work Plan* (FWEC 2003c). Analytical data from groundwater monitoring indicate that since EATS was turned off, COC plumes have not migrated and COC concentrations are generally stable or decreasing.

Recommendations for continued EATS system operation, modifications, and alternative long-term remedial strategies are summarized in the *Final Site 26, East-side Aquifer Treatment System Evaluation Report* (TtEC 2008a) and the *Final Site 26 Technical Memorandum (Optimization Evaluation)* (TtEC 2008c). In 2009, the Navy implemented a second pilot test consisting of biotic and abiotic treatment at Site 26 and is currently evaluating the results of that test (SES-Tech 2009). In a letter dated October 24, 2008, EPA and Water Board concurred with the Navy's decision to keep EATS off while conducting the pilot test. A copy of this letter is presented in Appendix A. Prior to this, EPA concurred with the EATS Evaluation Work Plan, which recommended turning EATS off to evaluate alternative treatment technologies.

7.3.1.2 System Operations and O&M

While operating, EATS functioned as designed. Since July 2003, the system has been off. Groundwater monitoring is the only O&M activity currently being conducted at the site. Although EATS remained off for most of the Five-Year Review reporting period, groundwater monitoring has demonstrated that the response action is functioning to protect human health and the environment.

7.3.1.3 Costs of O&M

O&M costs have steadily decreased over the review reporting period due to EATS being off. Nothing in the cost analysis indicates a potential remedy problem.

7.3.1.4 Engineering and Institutional Controls

ECs and ICs specified in the ROD include fencing of the treatment system area, O&M of the Building 191 pump station and the stormwater drainage system, and domestic use restrictions on the groundwater at Site 26 (Navy 1996). In the MOA between the Navy and NASA, NASA agreed to continue O&M of the Building 191 pump station and stormwater drainage system. Additionally, the treatment system is fenced and locked. However, NASA has not incorporated language restricting domestic use of groundwater at Site 26 into its land use planning documents as requested by the Navy in a letter dated November 8, 2004. A copy of the request letter is presented in Appendix A.

NASA's Comprehensive Use Plan (NASA 1994) currently contains language restricting access and development in the OU5 area because of safety considerations related to munitions storage and runway/air operations. There are no drinking water wells in the OU5 area, and the NASA Ames Development Plan indicates no land use change is planned. However, for the remedy to be fully protective of human health and the environment, NASA must incorporate language restricting groundwater use into its development plans. Long term protectiveness will be attained after NASA incorporates language restricting groundwater use in its planning documents. According to the NASA Restoration Project Manager, NASA's Facilities Group is currently revising its Master Plan with input from the Environmental Division. ICs for Site 26, including restrictions on domestic groundwater use, will be incorporated into the Master Plan (NASA 2010).

7.3.1.5 Monitoring Activities

Monitoring activities required to ensure the effectiveness of the remedy include groundwater monitoring and NPDES monitoring of treated effluent. As discussed in Section 4.2.3, groundwater monitoring is conducted annually at Site 26. On March 12, 2009, the Water Board rescinded the Navy's authorization to discharge treated groundwater from EATS. The original authorization was granted on September 9, 2004, however, the Navy has not conducted NPDES

monitoring since July 2003 and is not required to continue NPDES monitoring as long as EATS remains off. A copy of the rescission letter is presented in Appendix A.

Groundwater monitoring activities are adequate to evaluate the protectiveness and effectiveness of the remedy.

7.3.1.6 Optimization

The Navy is currently conducting a second pilot test at Site 26 consisting of biotic and abiotic treatment to determine if this technology can be used to optimize the remedy at Site 26.

No other optimization opportunities have been identified for Site 26.

7.3.1.7 Early Indicators of Potential Problems

As discussed in Sections 4.1.3 and 4.2.3, EATS had only removed 23.65 pounds of VOCs in 4.5 years, indicating that it was an ineffective and inefficient treatment method at Site 26.

There have been no other early indicators of potential problems associated with the remedy selected and implemented for Site 26.

7.3.2 Question B

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid? Yes.

7.3.2.1 Changes in Standards and TBCs

ARARs presented in the OU5 ROD (Navy 1996) were reviewed and evaluated to determine if any modifications had occurred that might affect the RAOs since the ROD was finalized. Cleanup standards identified in the ROD, which are MCLs, are still valid and afford the highest level of protectiveness.

7.3.2.2 Changes in Exposure Pathways

Since the issuance of the ROD, the understanding of the fate and transport of chemicals in the subsurface to indoor air has evolved. It is now understood that, under certain conditions, VOCs in soil and groundwater emit vapors that can migrate upward through subsurface soils and enter overlying buildings through cracks in floors or through piping conduits and other preferential pathways. However, since there are no buildings at Site 26, this exposure pathway is incomplete. Site 26 is expected to remain undeveloped in the near future because language in NASA's Comprehensive Use Plan (NASA 1994) restricts access and development in Site 26 area for safety considerations related to munitions storage and runway/air operations.

No changes to physical site conditions that could affect exposure pathways or the protectiveness of the remedy have occurred. No new contaminants or contaminant sources originating from Site 26 have been identified or detected during monitoring. No toxic byproducts have been generated as a result of remedy implementation.

7.3.2.3 Changes in Toxicity and Other Contaminant Characteristics

Toxicity factors for COCs at Site 26 that could affect the protectiveness of the remedy have not changed. Contaminant characteristics have not changed in a way that could affect the protectiveness of the remedy.

7.3.2.4 Changes in Risk Assessment Methods

Occupational exposure is the most likely exposure scenario for the OU5 aquifers and, therefore, an assessment of potential risks to workers was conducted during the RI for OU5. The assessment found that occupational exposure to groundwater did not present significant risks to workers. However, results of the assessment for the more conservative potential future residential use scenario were used to select COCs and remediation goals. These assumptions remain valid. No changes in the standardized risk assessment methodologies that could affect the protectiveness of the remedy were noted. The Site 26 risk assessment is discussed in Section 3.3.

7.3.2.5 Expected Progress Toward Meeting RAOs

The RAO for Site 26 is to reduce COCs in the southern plume to drinking water MCLs as described in the ROD (Navy 1996). The Navy is implementing a pilot test to evaluate alternative remedial strategies to attain the RAO at Site 26.

7.3.3 Question C

Has any other information come to light that could call into question the protectiveness of the remedy? No.

All ecological risks have been adequately addressed. Results of the ecological risk assessment demonstrated that even if the highest levels of COCs detected in the groundwater since 1989 were to migrate into the ditches, there would be no adverse ecological effects (Navy 1996).

There have been no impacts from natural disasters. Land use of the site has not changed; nor are any land use changes being considered.

No additional information suggests that the remedy for Site 26 may not be protective of human health and the environment.

7.3.4 Site 26 Technical Assessment Summary

According to the data reviewed and the site inspections, the remedy functioned as intended until EATS was turned off in July 2003. The Navy is researching methods to optimize the remedy to function more effectively and is currently conducting a second pilot test that consists of biotic and abiotic treatment of contaminated groundwater. As discussed in Section 7.3.1.1, the Navy received concurrence from EPA and the Water Board in 2008 to turn EATS off while conducting the second pilot test. Prior to concurrence in 2008, EPA concurred with the *EATS Evaluation Work Plan*, which recommended turning EATS off to evaluate alternative treatment technologies. Furthermore, according to the *Final Site 26 EATS Evaluation Report* (TtEC 2008a), during the period that EATS has been turned off, COC concentrations have remained stable or decreased, and COC plumes have not migrated.

NASA is in the process of adding restrictions on groundwater use into its Master Plan to ensure the long-term protectiveness of the remedy, and groundwater use is currently restricted by other means, which provides short-term protectiveness.

No changes in the physical conditions of the site have occurred that would affect the protectiveness of the remedy. No other information calls into question the protectiveness of the remedy.

7.4 SITE 28 TECHNICAL ASSESSMENT

This section provides a technical assessment for Site 28 by discussing and answering each of the three questions used to determine protectiveness of the remedy. A summary is provided at the end of the section.

7.4.1 Question A

Is the remedy functioning as intended by the decision documents? Yes.

7.4.1.1 Remedial Action Performance

The major components of the groundwater remedy specified in the MEW ROD, construction and operation of the groundwater treatment system and groundwater monitoring, are in place and functioning as intended. The current suite of monitoring parameters and the groundwater sampling frequency are adequate to evaluate the performance of the remedy.

The Navy has met cleanup goals defined in the MEW ROD for unsaturated soils (PRC 1995c). No further action is required for unsaturated soils at Site 28.

7.4.1.2 System Operations and O&M

O&M activities include security of the treatment system, activities required to operate and maintain the system and extraction wells, groundwater monitoring, and NPDES compliance monitoring. There have been no problems in the implementation of system O&M. O&M activities, NPDES sampling results, and operational data are presented in the quarterly and annual NPDES reports, and annual groundwater reports. Annual groundwater sampling and groundwater level measurements are presented in annual groundwater reports. WATS O&M activities are discussed in Section 4.3.4.

Per the design specifications (TtEMI 2001c), WATS continues to treat between 70 to 80 gallons of groundwater per minute. The *2008 Annual Groundwater Monitoring Report for WATS and EATS* (SES-Tech 2009) noted that pumping rates for extraction wells EA1-1, EA1-3, EA1-4, EA1-5, and EA1-6 had decreased over time. Because extraction well pumps are routinely replaced, the decrease in pumping rates was unlikely the result of deteriorating well pumps; it appeared that biofouling was the cause of the decrease in pumping rates. These wells were redeveloped and the pumps were replaced in 2009 (SES-Tech 2009).

As of December 30, 2008, WATS has treated approximately 340,413,017 gallons of groundwater, removing approximately 4,362 pounds of VOCs (SES-Tech 2009). WATS operated approximately 88.7 percent of the time during 2003, 94.3 percent of the time during 2004, and between 97.9 to 99.4 percent of the time from 2005 through 2008. Down time was attributed primarily to routine maintenance (SES-Tech 2009 and TN&A 2007b). Groundwater monitoring results have demonstrated that WATS continues to hydraulically contain the target contaminant capture zone. Discharge water from WATS has been below the NPDES permit limits. Long-term VOC concentration trends downgradient of the capture zone have either decreased or remained stable with time (SES-Tech 2009). Changes in the extent or shape of TCE, *cis*-1,2-DCE, PCE, and vinyl chloride plumes in the upper and lower portions of the A aquifer in 2008 compared to previous years were noted in the *2008 Annual Groundwater Monitoring Report for WATS and EATS* (SES-Tech 2009). These changes were attributed to the sampling of additional monitoring wells by the Navy and MEW companies in 2008.

7.4.1.3 Costs of O&M

O&M costs have increased over the review reporting period. Costs increased substantially beginning in 2006 and have continued to increase through 2008. The higher annual costs stemmed from changes in project accounting practices and increases in utility and personnel rates. Higher operational costs do not indicate a potential problem with the implementation of the remedy.

7.4.1.4 Engineering and Institutional Controls

No ICs are specified in the MEW ROD. However, ECs and ICs have been implemented at Site 28. The treatment system was fenced as part of the remedial construction of WATS. The fence is kept locked to maintain site security.

Site 28 is located within NASA's redevelopment area. NASA controls risk to workers and prevents current and future consumption of groundwater through provisions in various documents, as detailed in Section 4.2.4 of this report.

7.4.1.5 Monitoring Activities

As discussed in Section 4.2.4, groundwater monitoring is conducted annually at Site 28. All monitoring activities are adequate to determine the protectiveness and effectiveness of the remedy.

7.4.1.6 Optimization

Recommendations for continued WATS system operation, modifications, and alternative long-term remedial strategies are summarized in the *Draft West-Side Aquifers Treatment System Site 28 Optimization Evaluation Report* (SES-Tech 2008). To improve efficiency and reduce operating costs, the draft optimization evaluation report recommended the following modifications to WATS:

- Shut down extraction wells EA1-1 and EA1-6.
- Reduce the total pumping rate in the upper A aquifer extraction wells from 24.4 to 19.7 gallons per minute (gpm).
- Reduce the total pumping rate in the lower A aquifer extraction wells from 44.5 to 35.0 gpm.

Additionally, the draft optimization evaluation report recommended that pilot testing be considered in the WATS area, in coordination with pilot testing by the MEW companies and NASA. Table 6-2 from the optimization evaluation report presents a screening of several alternative groundwater remediation technologies considered for Site 28. These include biostimulation, bioaugmentation, combined abiotic/biotic treatment, in situ chemical oxidation, permeable reactive barrier, thermal treatment, pulsed extraction, multiphase extraction, alcohol or surfactant flushing, phytoremediation, and monitoring natural attenuation (SES-Tech 2008).

The Navy plans to conduct a pilot test in 2010 to evaluate a more effective remedial method to address groundwater contamination at Site 28. The pilot test will consist of a characterization stage in which the Navy will collect additional samples to help target higher concentration areas. The characterization stage will be followed by a treatment stage in which three different

substrates will be injected into three different areas of the regional plume (Building 88 area, Traffic Island area, well W9-18 area) to evaluate the potential for the in situ remedial technologies to achieve cleanup levels (Shaw Environmental, Inc. 2009).

7.4.1.7 Early Indicators of Potential Problems

During the review period, it was discovered that a potential source of PCE contamination to groundwater may be present in the former Building 88 footprint and the adjacent Traffic Island Area. The source consists of PCE in saturated soils and potentially as DNAPL. It appears that PCE contamination may have moved vertically downward into the lower portion of the A aquifer potentially as a combination of DNAPL and dissolved phase. Contamination is the result of historical activities at the former Building 88 dry cleaning facility. Specifically, PCE may have been released into the subsurface through cracks in wastewater collections trenches, floor drains, subsurface piping or sumps (TtEC 2008b).

Contamination of saturated soils has been identified in two areas: the former Building 88 area and the Traffic Island Area (the junction of Cummins Avenue, Wescoat Road, and Cody Road). Contamination in saturated soil appears to be contributing to groundwater contamination in the upper and lower portion of the A aquifer. PCE DNAPL may be present in both areas. PCE is likely biodegrading to daughter products (TCE, cis-1,2-DCE, and vinyl chloride), but contribution of these daughter products to the regional plume(s) cannot be determined due to upgradient sources of contamination migrating onto Moffett. A detailed analysis of this potential source of PCE contamination can be found in the *Final Former Building 88 Investigation Report* (TtEC 2008b).

In an effort to optimize the remedy, the Navy plans to conduct a pilot test in 2010 to address contamination resulting from the former Building 88 area, associated sewer lines, and Traffic Island Area. Additionally, a Site-Wide Focused Feasibility Study (FFS) is underway. The Navy plans on determining a path forward based on the conclusions and recommendations of the pilot test and the FFS. In the interim, groundwater plumes of PCE and any daughter products are fully contained and the groundwater is being treated by the combined regional plume treatment systems (WATS and MEW).

There are no other early indicators of potential problems associated with Site 28.

7.4.2 Question B

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid? No.

7.4.2.1 Changes in Standards and TBCs

ARARs provided in the May 1989 MEW ROD were reviewed and evaluated to determine if any modifications had affected the ROD's RAOs or operation of WATS since the ROD was

finalized. Based on the evaluation, none of the chemical-specific ARARs (for example, federal or state drinking water MCLs) originally cited in the ROD has changed. Cleanup standards identified in the ROD, which are the MCLs, are still valid. The ROD cleanup standard for TCE in the shallow aquifers is 5 ppb. In addition, the location-specific and action-specific ARARs cited in the ROD have not changed in a manner that affects the operation of WATS or effluent discharge limits.

One of the action-specific ARARs from the ROD cites NPDES discharge standards in accord with the Water Board's *Water Quality Control Plan, San Francisco Bay Basin (Region 2)* (Water Board 1995). The Basin Plan references standards that were adopted by the Water Board from EPA's AWQC in 1986. In 2000, however, EPA promulgated the California Toxics Rule (CTR), which provides updated and additional standards for discharges to surface waters. The CTR standards for VOCs are not lower than the pre-established discharge limits within the NPDES permit for WATS. The new CTR standards do not, therefore, affect the protectiveness of the remedy.

7.4.2.2 Changes in Exposure Pathways

Since the issuance of the ROD (EPA 1989), the understanding of the fate and transport of chemicals in the subsurface to indoor air has evolved. It is now understood that, under certain conditions, VOCs in soil or groundwater emit vapors that can migrate upward through subsurface soils and enter overlying buildings through cracks in floors or through piping conduits and other preferential pathways. This is called the VI pathway (EPA 2004).

Based on indoor air sampling conducted in 2003 and 2004 of both commercial and residential buildings in the MEW area, EPA confirmed the presence of the subsurface VI pathway into a number of structures overlying the shallow groundwater TCE plume (EPA 2004). The MEW ROD (EPA 1989) did not identify RAOs for mitigating the subsurface VI pathway. Accordingly, EPA recommended in the MEW Final First Five-Year Review that RAOs for the subsurface VI pathway be established for the MEW Site (EPA 2004).

To accomplish this, EPA established a VI Study Area, which is generally defined by the area where TCE concentrations in shallow groundwater are greater than 5 µg/L, plus a 100 foot buffer zone beyond the estimated 5 µg/L TCE plume boundary to account for the uncertainty of the depicted plume boundary. Site 28 is included in the VI Study Area (EPA 2009b).

EPA analyzed a number of indoor and outdoor samples in the VI Study Area between 2003 and 2008 and concluded that none of the indoor air breathing zone samples indicated any immediate or short-term health threat to building occupants from the VI pathway. Therefore, EPA's focus was whether TCE and other volatile COCs in indoor air pose an unacceptable risk of chronic health effects from long-term exposure (defined as 25 years for commercial, non-residential exposure and 30 years for residential exposure) (EPA 2009a and 2009b).

One of the RAOs to be addressed by the EPA VI remedy is to ensure that building occupants (workers and residents) in the VI Study Area are protected from contamination by preventing subsurface contaminants from migrating into indoor air or accumulating in enclosed building spaces at levels of concern (EPA 2009a and 2009b).

EPA evaluated alternatives to achieve the indoor air RAO in the *Final Supplemental Feasibility Study for Vapor Intrusion Pathway, Middlefield-Ellis-Whisman Study Area* (EPA 2009a) and presented them in the *Proposed Plan* (PP) *for the Vapor Intrusion Pathway, Middlefield-Ellis-Whisman Study Area* (EPA 2009b). The Supplemental FS found that TCE air concentrations were reduced after implementation of discrete mitigation measures (i.e., sealing conduits, enhanced ventilation, and air purification systems) (EPA 2009a). EPA's preferred remedy is building-specific and depends on four factors: (1) the building's location overlying the TCE contamination plume in shallow groundwater, (2) whether it is a residential or commercial building, (3) what the indoor sampling results are, and (4) whether any actions have already been implemented to reduce indoor air concentrations. Part of the PP process is to consider public opinion and modify the preferred remedy as applicable. The public comment period was July 10 through November 7, 2009. EPA will select the final remedy for VI after considering comments submitted during the public comment period and present that remedy in a ROD (EPA 2009b).

The Navy transferred ownership of Moffett Field to NASA in 1994, and no longer owns or operates Moffett Field and the buildings overlying the groundwater plume[1]. Therefore, the Navy does not have direct responsibility for implementing any response to address potential health risks from long-term exposure to TCE and other VOCs through the vapor intrusion pathway and implementing any new remedial measures specified in EPA's forthcoming ROD Amendment for vapor intrusion.

Because NASA is the federal facility property manager with responsibility for Moffett Field buildings, NASA has been sampling selected buildings for VI, retrofitting where necessary, and consistently resampling. Sampling by NASA has focused primarily on buildings located above the contaminated groundwater plume, as well as unoccupied historical buildings that are also located above the contaminated groundwater. Where elevated indoor air concentrations have been found, NASA has taken measures such as upgrading or replacing the heating, ventilation, and air conditioning systems, and making adjustments to air conditioning to bring concentrations within suggested levels. NASA then conducted follow-on sampling to ensure levels had been reduced, implementing consistent, recurring sampling protocols.

NASA has not sampled unoccupied buildings slated for demolition. NASA has also not sampled occupied buildings slated for demolition as part of the University Associates redevelopment, as this development is scheduled to occur within five years. Should this development be delayed, NASA plans to reexamine the need for sampling in those buildings. NASA states that sampling and follow-on actions have been conducted in cooperation with and to the satisfaction of EPA.

[1] Moffett Community Housing was transferred to the Air Force in 1994. Moffett Community Housing is not located at Site 28.

While the site is currently protective with respect to VI based on the actions NASA has taken to address the issue, additional measures may be necessary by NASA to ensure long-term protectiveness. NASA is currently updating its internal directive on environment and plans on incorporating ICs related to VI. NASA has also been following EPA's VI Pathway study and will incorporate relevant measures into Ames construction permits normally required of permittees and lessees when redeveloping or remodeling structures and sites at Ames.

Another RAO to be addressed by the VI remedy is to reduce or minimize the source of VI (i.e., contaminants in shallow groundwater) to levels that would be protective of current and future building occupants. This RAO will not be addressed by the forthcoming VI remedy; instead, it will be addressed by the current groundwater remedy, which is now being re-evaluated in a separate supplemental site-wide groundwater feasibility study for the regional plume (EPA 2009b). Since current RAOs are already at MCLs, any modifications to the remedy will likely involve treatments methods.

Based on indoor and outdoor air data sets that were collected, there does not appear to be an unacceptable short-term or long-term health risk to outdoor air through the VI pathway. TCE is not a banned consumer product and continues to be used in the San Francisco Bay Area and throughout the nation. As a result, outdoor air quality with respect to TCE in the vicinity of the MEW Site is generally similar to the outdoor air quality in other urban environments in the San Francisco Bay Area. Outdoor air quality in areas over the TCE groundwater plume area is generally consistent with outdoor air quality at reference locations outside the TCE groundwater plume area (EPA 2004).

No changes to physical site conditions that could affect exposure pathways or the protectiveness of the remedy have occurred. No new contaminants or contaminant sources originating from Site 28 have been identified or detected during monitoring. No toxic byproducts have been generated as a result of remedy implementation. Land use has not changed over the Five-Year Review period.

7.4.2.3 Changes in Toxicity and Other Contaminant Characteristics

Toxicity factors for COCs at Site 28 that could affect the protectiveness of the remedy have not changed. Contaminant characteristics have not changed in a way that could affect the protectiveness of the remedy.

7.4.2.4 Changes in Risk Assessment Methods

As discussed in Section 3.4, because the Navy adopted the MEW ROD, an RI/FS and associated risk assessments were not completed at that time (TtEMI 2001c). However, as discussed in Section 7.4.2.2, a risk assessment for VI has been evaluated for the MEW Study area and Moffett Field. A PP was presented for public comment and the final remedy will be presented in the forthcoming ROD.

7.4.2.5 Expected Progress Toward Meeting RAOs

As stated in the ROD and two ESDs (EPA 1989, 1990, and 1996), remedial goals at Site 28 are to reduce COCs in groundwater to MCLs. The remedial goals are driven by current and future beneficial use of local groundwater.

WATS is functioning as intended; however, dissolved VOCs in the regional plume continue to migrate into Site 28 with groundwater underflow from upgradient source areas (SES-Tech 2009). The upgradient source is contributing contaminants at concentrations greater than cleanup standards. As long as contaminant flow continues to migrate into Site 28 from an upgradient source, remediation goals will not be achieved (SES-Tech 2009).

The Navy participates in the RGRP, whose function is to address the regional VOC plume. It is recommended that the Navy continue to work with the other responsible parties to develop successful treatment methods for the regional groundwater plume so that the remediation goals can be met.

7.4.3 Question C

Has any other information come to light that could call into question the protectiveness of the remedy? No.

All ecological risks have been adequately addressed. There have been no impacts from natural disasters. No land use changes have occurred during the review period.

No additional information suggests that the remedy for Site 28 may not be protective of human health and the environment.

7.4.4 Site 28 Technical Assessment Summary

The review of documents, data, ARARs, risk assumptions, and results of the site inspection indicate that WATS is functioning as designed. No changes in the physical conditions of the sites would affect the protectiveness of the remedy. However, as long as COCs continue to migrate into Site 28, the RAO is unlikely to be met.

During the review period, it was discovered that a potential source of PCE contamination to groundwater may be present in the former Building 88 footprint, associated sewer lines, and the adjacent Traffic Island Area. The source consists of PCE in saturated soils and potentially as DNAPL. In an effort to optimize the remedy, the Navy plans to conduct a pilot test in 2010 to address contamination at the former Building 88, associated sewer lines, and Traffic Island Area. In the interim, groundwater plumes of PCE and any daughter products are fully contained and the groundwater is being treated by the combined regional plume treatment systems (WATS and MEW).

Additionally, during the Five-Year Review period, the VI exposure pathway has been presented as a potential threat to the health of occupants of existing and future residential and commercial buildings at Moffett Field. EPA is in the process of selecting a remedy to address the VI pathway in buildings. Because the Navy does not own the buildings that are located within the VI Study Area, they will not be responsible for implementing remedial actions that will be selected in EPA's forthcoming ROD Amendment for VI.

8.0 ISSUES, RECOMMENDATIONS, AND FOLLOW-UP ACTIONS

This section presents issues, recommendations, and follow-up actions for Sites 1, 22, 26, and 28 at Moffett Field.

8.1 SITE 1

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Completion Milestone Date	Affects Protectiveness (Yes / No)	
					Current	Future
Land use restrictions have not been documented in the NASA Environmental Resources Document as specified in Memorandum of Agreement (11/15/1999). [1]	Incorporate institutional controls into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of institutional controls.	Navy and NASA	EPA and Water Board	2010	No	Yes
Ground squirrels and gophers continue to burrow within the landfill boundary. [2]	Evaluate effectiveness of current abatement plan.	Navy	EPA and Water Board	2010	No	Yes

Notes:

EPA	U.S. Environmental Protection Agency
NASA	National Aeronautics and Space Administration
Navy	Department of the Navy
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region

Discussion: (1) Current protectiveness is not affected by the absence of land use restrictions in NASA's land use planning documents because potential exposure pathways are incomplete. Language specifically restricting land use must be integrated into an enforceable document to ensure future protectiveness. NASA is currently revising its Master Plan to include this language.

(2) Ground squirrel and gopher burrowing does not affect current protectiveness because burrowing has not exposed landfill waste. The landfill is inspected quarterly and any burrows that are discovered are backfilled. Future protectiveness could be affected if

gophers and ground squirrels continue to burrow into the landfill cover, penetrate deeper layers, and expose landfill waste. The current abatement plan focuses on removing the burrowing mammal population at Site 1.

8.2 SITE 22

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Completion Milestone Date	Affects Protectiveness (Yes / No)	
					Current	Future
Land use restrictions have not been incorporated into NASA's land use planning documents as specified in the Memorandum of Agreement (9/17/2008). [1]	Incorporate institutional controls into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of institutional controls.	Navy and NASA	EPA and Water Board	2010	No	Yes

Notes:

EPA	U.S. Environmental Protection Agency
NASA	National Aeronautics and Space Administration
Navy	Department of the Navy
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region

Discussion: (1) Current protectiveness is not affected by the absence of land use restrictions in NASA's land use planning documents because potential exposure pathways are incomplete. Language specifically restricting land use must be integrated into an enforceable document to ensure future protectiveness. NASA is currently revising its Master Plan to include this language.

8.3 SITE 26

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Completion Milestone Date	Affects Protectiveness (Yes / No)	
					Current	Future
The *Final Site 26 EATS Evaluation Report* determined that the EATS groundwater extraction and treatment remedy is an inefficient and ineffective method to address groundwater contamination at Site 26.[1]	Continue implementing the pilot test and determine the next course of action based on the results.	Navy	EPA and Water Board	2010	No	Yes
NASA has not restricted groundwater use in its land use planning documents for the EATS area as required in the Record of Decision.[2]	Incorporate institutional controls into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of institutional controls.	Navy and NASA	EPA and Water Board	2010	No	Yes

Notes:

EPA	U.S. Environmental Protection Agency
NASA	National Aeronautics and Space Administration
Navy	Department of the Navy
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region

Discussion: (1) Current protectiveness is not affected by the determination that EATS is an inefficient and ineffective method to address groundwater contamination because potential exposure pathways are incomplete. To ensure future protectiveness, continue conducting the second pilot test consisting of biotic and abiotic treatment to determine if this technology can be used to optimize the remedy.

(2) Current protectiveness is not affected by the absence of groundwater restrictions in NASA's land use planning documents because potential exposure pathways are incomplete. Language specifically restricting groundwater use must be integrated into an enforceable document to ensure future protectiveness. NASA is currently revising its Master Plan to include this language.

8.4 SITE 28

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Completion Milestone Date	Affects Protectiveness (Yes / No)	
					Current	Future
Potential actions need to be taken to ensure long-term protectiveness from vapor intrusion.[1]	Update NASA's internal directive on environment and incorporate institutional controls related to vapor intrusion.	NASA	EPA	2010	No	Yes
	Follow EPA's Vapor Intrusion Pathway Study and incorporate relevant measures into Ames construction permits normally required of permittees and lessees when redeveloping or remodeling structures and sites at Ames.	NASA	EPA	2010	No	Yes
Potential contaminant sources exist in the former Building 88 area, associated sewer lines, and the Traffic Island Area.[2]	Continue implementing the pilot test and determine the next course of action based on the results.	Navy	EPA and Water Board	2011	No	Yes

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Completion Milestone Date	Affects Protectiveness (Yes / No)	
					Current	Future
WATS is functioning as intended; however, dissolved VOCs in the regional plume continue to migrate into Site 28 with groundwater underflow from upgradient source areas. The upgradient sources are contributing contaminants at concentrations greater than cleanup standards. As long as contaminants migrate into Site 28, remediation goals are unlikely to be met.[3]	Continue to participate in a regional strategy to address groundwater contamination and document the strategy in a Feasibility Study report.	Navy	EPA and Water Board	2012	No	Yes
No institutional controls exist for groundwater.[4]	Evaluate need for institutional controls in Site-wide Groundwater Feasibility Study for the MEW Study Area.	Navy, NASA, and EPA	EPA	2010-2011	No	Yes

Notes:

EPA	U.S. Environmental Protection Agency
MEW	Middlefield-Ellis-Whisman
NASA	National Aeronautics and Space Administration
Navy	Department of the Navy
VOC	Volatile organic compound
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region

Discussion: (1) EPA has determined that there are no short-term health risks from indoor exposure to vapor intrusion in the EPA's Vapor Intrusion Study Area at Moffett Field, and NASA has taken measures to mitigate known and potential future threats from the vapor intrusion pathway. Therefore, current protectiveness is not affected. To ensure future protectiveness, NASA must take the recommendations and follow-up actions stated above.

(2) and (3) Current protectiveness is not affected because on-site contamination plumes are stable or decreasing, contaminated groundwater is being treated by WATS, and potential exposure pathways that could result in unacceptable risks are being controlled. To ensure future protectiveness, continue conducting the pilot test consisting of three different treatment options to evaluate whether the alternate technologies are effective in remediating contamination sources in the former Building 88 area, associated sewer lines, and Traffic Island Area. Results from the pilot test may be considered for addressing contamination in the regional plume. The Navy will continue to participate on a regional level to meet cleanup goals.

(4) Current protectiveness is not affected by the absence of institutional controls for groundwater because potential exposure pathways are being controlled and groundwater is not currently being used. If EPA determines that institutional controls are necessary, future protectiveness could be affected until language specifically restricting groundwater use is integrated into an enforceable document.

9.0 PROTECTIVENESS STATEMENTS

Site 1: The remedy for Site 1 is currently protective of human health and the environment because potential exposure pathways are incomplete, groundwater contaminant concentrations are stable, landfill gas is not migrating from the landfill, and the landfill cover is functioning as intended. To ensure long-term protectiveness of the remedy, the following actions must be taken:

- Incorporate ICs into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of ICs.
- Evaluate the effectiveness of the current burrowing mammal abatement plan.

Site 22: The remedy for Site 22 is currently protective of human health and the environment because potential exposure pathways are incomplete, groundwater contaminant concentrations are stable, landfill gas is not migrating from the landfill, and the biotic barrier is functioning as intended. To ensure long-term protectiveness of the remedy, the following actions must be taken:

- Incorporate ICs into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of ICs.

Site 26: The remedy for Site 26 is currently protective of human health and the environment because groundwater contaminant plumes are stable or decreasing and potential exposure pathways are incomplete. To ensure long-term protectiveness of the remedy, the following actions must be taken:

- Continue implementing the pilot test and determine the next course of action based on the results.
- Incorporate ICs into NASA's Master Plan. Report completion and documentation of this task to the Agencies. Provide a schedule for future reporting on the status and efficacy of ICs.

Site 28: The remedy for Site 28 is currently protective of human health and the environment because on-site contaminant plumes are stable or decreasing, contaminated groundwater is being treated by WATS, and potential exposure pathways that could result in unacceptable risks are being controlled. EPA has determined that there are no short-term health risks from exposure to VI, and NASA has taken measures to mitigate known and potential future threats from the VI pathway. To ensure long-term protectiveness of the remedy, the following actions must be taken:

- Update NASA’s internal directive on environment and incorporate ICs related to VI.

- Follow EPA's Vapor Intrusion Pathway study and incorporate relevant measures into Ames construction permits normally required of permittees and lessees when redeveloping or remodeling structures and sites at NASA Ames.

- Continue implementing the pilot test and determine the next course of action based on the results.

- Continue to participate in a regional strategy to address groundwater contamination and document the strategy in an FS report.

- Evaluate need for ICs in Site-wide Groundwater FS for the MEW Study Area.

10.0 NEXT REVIEW

The next Five-Year Review for Sites 1, 22, 26, and 28 at Moffett Field will be due five years from the date that this five year review is signed by the Navy. Consecutive Five-Year Reviews will be required for Sites 1, 22, 26, and 28 as long as contamination remains that does not allow for unlimited use and unrestricted exposure.

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