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FINAL

INTERIM RECORD OF DECISION FOR THE OPERABLE UNIT 1 SOURCE AREA GROUNDWATER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JET PROPULSION LABORATORY
PASADENA, CALIFORNIA

EPA ID# CA9800013030

PREPARED FOR:

National Aeronautics and Space Administration
Management Office, Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91109

December 2006

Part I: DECLARATION

Site Name and Location

SITE NAME:	Jet Propulsion Laboratory (JPL)
EPA ID NUMBER:	CA9800013030; Federal Facility Agreement Docket Number 1998-27
LOCATION:	4800 Oak Grove, Pasadena, California
SITE TYPE:	Federal Facility; Government-owned, contractor-operated
LEAD AGENCY:	National Aeronautics and Space Administration (NASA)
SUPPORTING AGENCIES:	U.S. Environmental Protection Agency (U.S. EPA), Region 9; State of California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control (DTSC); and California Regional Water Quality Control Board (RWQCB), Los Angeles Region
OPERABLE UNIT:	Operable Unit 1 (OU-1), Source Area Groundwater

Statement of Basis and Purpose

This document is published as an Interim Record of Decision (ROD) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 United States Code (USC) § 9601 et seq. This decision document presents the response action selected by NASA and the supporting agencies (U.S. EPA, DTSC, and RWQCB) for the OU-1 source area at JPL. The response action was selected in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) 300.400 et seq. and California Health and Safety Code (HSC) § 25356.1. The response action was selected based upon information available in the Administrative Record.

The supporting agencies, consisting of U.S. EPA, DTSC, and the RWQCB, concur with the response action recommended in this ROD.

Assessment of the Site

The response action selected in this ROD is expected to achieve protection of human health and the environment from actual or threatened releases of hazardous substances into the environment.

Description of the Selected Remedy

In October 1992, JPL was placed on the National Priorities List (NPL) and, therefore, is subject to the provisions of CERCLA. The JPL site has been divided into three OUs. OU-1 is on-facility groundwater at JPL; OU-2 is on-facility vadose zone soil at JPL; and OU-3 is off-facility groundwater adjacent to the JPL property. This interim decision document addresses source area groundwater within OU-1. The ROD for OU-2 was signed in September 2002 and remedial action using soil vapor extraction (SVE) is underway (NASA, 2002). Another response action has been proposed by NASA for OU-3 to clean up the chemicals located adjacent to and in deep groundwater beneath JPL using wellhead treatment. NASA will conduct an integrated Feasibility Study in the future to evaluate the overall effectiveness of all the response actions for groundwater and to determine whether additional cleanup measures are required for on- and off-facility groundwater.

A human health baseline risk assessment and a preliminary assessment of ecological risk were conducted as part of the OU-1 and OU-3 Remedial Investigation (RI) to evaluate the potential risks associated with hypothetical exposure to chemicals in the untreated groundwater beneath the JPL facility. The baseline risk assessment identified eleven (11) chemicals as contributors to a cancer risk greater than 10^{-6} or a hazard index greater than 0.5 under a drinking water scenario. These chemicals included: arsenic, hexavalent chromium, nitrate, perchlorate, bromodichloro-methane, carbon tetrachloride, chloroform, 1,1-dichloroethene, 1,2-dichloroethane, tetrachloro-ethene, and trichloroethene (Foster Wheeler Environmental Corporation [FWEC], 1999a). It is important to note that because groundwater is in a deep aquifer and water purveyors treat groundwater before use, no complete pathway for exposure to these chemicals exists.

The highest concentrations of carbon tetrachloride and perchlorate at the JPL site are located in the north-central portion of the JPL facility, which is referred to as the "source area." The source area is the location where the majority of target chemicals are dissolved in the groundwater, and is defined as an 8-acre by 100-ft-thick portion of the aquifer. The response action for OU-1 consists of expansion of the existing source area demonstration study system which provides treatment and containment using groundwater extraction, aboveground treatment, and reinjection. This process will improve the effectiveness and efficiency of the OU-3 groundwater remedy by reducing chemical mass in groundwater that migrates off-facility. This action is part of a phased approach to characterization and cleanup of groundwater affected by chemicals originating from the JPL facility. A phased approach to cleanup is encouraged by Superfund Accelerated Cleanup Model (SACM) (U.S. EPA, 1992a), whereby characterization and performance data collected during initial phases are used to assess restoration potential. Groundwater restoration potential refers to the likelihood of achieving applicable or relevant and appropriate requirements (ARARs) throughout the facility.

A demonstration study system began operation in March 2005 to evaluate treatment effectiveness and has proven to be highly effective. This response action will expand the existing demonstration study treatment system associated with the source area beneath the JPL facility. Major components of the Interim Action include:

- groundwater extraction from the source area.
- aboveground groundwater treatment using liquid-phase granular activated carbon (LGAC) to remove volatile organic compounds (VOCs) and a fluidized-bed reactor (FBR) to remove perchlorate.
- reinjection of treated water.

The implementation of source treatment is consistent with the U.S. EPA's presumptive response strategy for sites requiring groundwater cleanup (U.S. EPA, 1996). Also, the U.S. EPA has identified presumptive technologies for treatment of extracted groundwater containing VOCs (U.S. EPA, 1996). The presumptive technologies include air stripping and LGAC. According to the U.S. EPA, these technologies are presumptive for treatment of VOCs in groundwater that has been extracted from the subsurface, and are expected to be used for this purpose at "all appropriate sites" (U.S. EPA, 1996). The benefits of presumptive technologies include: a simplified selection process, elimination of technology screening, and focusing resources on fundamental aspects of groundwater cleanup.

Statutory Determinations

This response action is protective of human health and the environment in the short term and is intended to provide adequate protection until a final ROD is signed; complies with those federal and state requirements that are applicable or relevant and appropriate for this limited-scope action; and is cost-effective. Although this response action is not intended to address fully the statutory mandate for permanence and treatment to the maximum extent practicable, this response action uses treatment and thus supports the statutory mandate. Because this action does not constitute the final remedy for OU-1, the statutory preference for remedies that employ treatment to reduce toxicity, mobility, or volume as a principal element, although partially addressed in this remedy, will be addressed by the final response action. Subsequent actions are planned, in a phased approach, to address fully the threats posed by conditions in groundwater at the JPL facility.

Because this response action may result in chemicals remaining in on-facility groundwater above health-based levels, a review will be conducted every five years to ensure that the remedy continues to provide adequate protection of human health and the environment. This first review is required five years after finalizing the first ROD for the site. The ROD for OU-2 was signed in September 2002 (See, 42 USC 9621(c)); therefore, the first five-year review will be conducted in 2007.

ROD Data Certification Checklist

The following information is included in Part II: Decision Summary of this ROD. Additional information can be found in the Administrative Record.

- Chemicals and their concentrations in source area groundwater, Section 5.0
- Baseline risk represented by the chemicals in on-facility groundwater, Section 7.0
- Interim action performance objectives for the chemicals in source area groundwater, Sections 8.0 and 11.0
- How chemicals in source area groundwater will be addressed, Section 11.0
- Current and reasonably anticipated future land use assumptions, Section 6.0
- Current and potential future beneficial uses of groundwater, Section 6.0
- Potential land and groundwater use that will be available as a result of the response action Section 11.0
- Estimated capital, annual operation and maintenance (O&M) and total present worth costs, Section 11.0
- Number of years that response action is expected to operate, Sections 9.0 and 11.0
- Key factors that lead to selecting the response action, Sections 9.0, 10.0, 11.0, and 12.0.

FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JET PROPULSION LABORATORY:

_______________________________ 12/07/06

Dr. Eugene Trinh, Director
NASA Management Office
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Date

FOR THE U.S. ENVIRONMENTAL PROTECTION AGENCY:

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Date

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Date

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ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement(s)
ATSDR	Agency for Toxic Substances and Disease Registry
BDAT	best demonstrated available technology
bgs	below ground surface
Cal/EPA	State of California, Environmental Protection Agency
Caltech	California Institute of Technology
CCl_4	carbon tetrachloride
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
COPC	chemical of potential concern
Cr^{+6}	hexavalent chromium
CSTR	Continuously Stirred Tank Reactor
CWC	California Water Code
DCA	dichloroethane
DCE	dichloroethene
DHS	(California) Department of Health Services
DTSC	Department of Toxic Substances Control
ERA	ecological risk assessment
EW	extraction well
FBR	fluidized-bed reactor
FFRDC	Federally-Funded Research and Development Center
FWEC	Foster Wheeler Environmental Corporation
gpm	gallons per minute
HI	hazard index
HHRA	human health risk assessment
HQ	hazard quotient
HSC	(California) Health and Safety Code
ISB	In Situ Bioremediation
IW	(re)injection well
JPL	Jet Propulsion Laboratory

ABBREVIATIONS AND ACRONYMS (Continued)

LDR	land disposal restriction
LGAC	liquid-phase granular activated carbon
MCL	maximum contaminant level
µg/L	microgram per liter
MW	monitoring well
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act of 1969
NFA	no further action
NL	notification level
NPL	National Priorities List
O&M	operation and maintenance
OU	operable unit
PBR	Packed Bed Reactors
PCE	tetrachloroethene
PHG	Public Health Goal
PNDM	nitrate catalytic destruction module
R&D	research and development
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RO	reverse osmosis
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
SACM	Superfund Accelerated Cleanup Model
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SVE	soil vapor extraction
SVOC	semivolatile organic compounds
TCE	trichloroethene
UCL	upper confidence level
USC	United States Code
U.S. EPA	United States Environmental Protection Agency

ABBREVIATIONS AND ACRONYMS (Continued)

VOC	volatile organic compound
WDR	waste discharge requirement

Part II: DECISION SUMMARY

1.0: SITE NAME, LOCATION, AND DESCRIPTION

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OPERABLE UNIT:	Operable Unit 1 (OU-1), Source Area Groundwater

NASA is the lead federal agency for selecting, implementing, and funding remedial activities at JPL, while U.S. EPA, DTSC, and RWQCB provide oversight and technical assistance.

The JPL is a federally-funded Research and Development Center (FFRDC) in Pasadena, California, currently operated under contract by the California Institute of Technology (Caltech) for NASA. JPL's primary activities include the exploration of the earth and solar system by automated spacecraft and the design and operation of the Global Deep Space Tracking Network.

Located in Los Angeles County, JPL adjoins the incorporated cities of La Cañada Flintridge and Pasadena, and is bordered on the east by the unincorporated community of Altadena. A NASA-owned facility, JPL encompasses approximately 176 acres of land and more than 150 buildings and other structures. Of the JPL Facility's 176 acres, approximately 156 acres are federally owned. The remaining land is leased for parking from the City of Pasadena and the Flintridge Riding Club. Development at JPL is primarily located on the southern half, in two regions, an early-developed northeastern area and a later-developed southwestern area. Figure 1-1 is a map showing the JPL facility and surrounding areas.

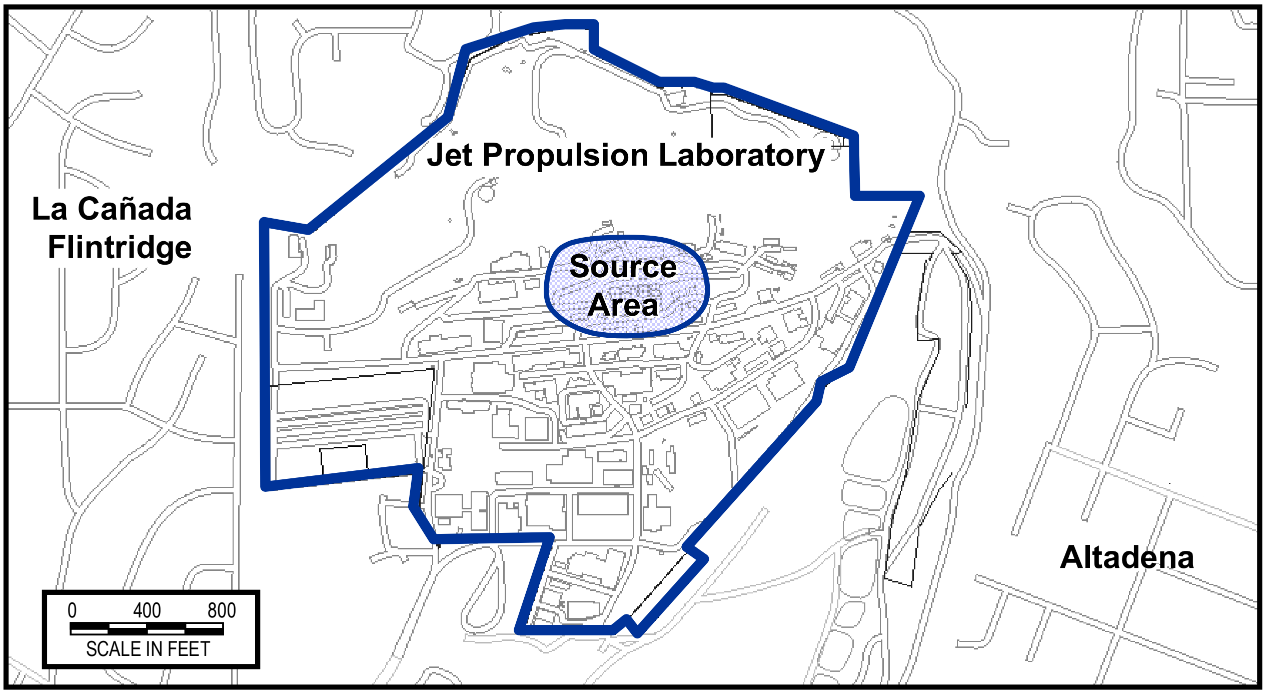


Figure 1-1. Map of JPL and the Surrounding Area

2.0: SITE HISTORY

During historic operations at JPL, various chemicals (including chlorinated solvents, solid rocket fuel propellants, cooling tower chemicals, sulfuric acid, Freon™, and mercury) and other materials were used at the JPL facility. During the 1940s and 1950s, many buildings at JPL maintained subsurface seepage pits for disposal of sanitary wastes and laboratory chemical wastes collected from drains and sinks within the buildings. The Remedial Investigation (RI) for OU-2 identified 40 seepage pits, five waste pits, and four discharge points at the facility that were used during historic operations (Foster Wheeler Environmental Corporation [FWEC], 1999b). Some of the seepage pits received volatile organic compounds (VOCs) and other waste materials which are currently found in groundwater beneath and adjacent to JPL. In the late 1950s and early 1960s, a sanitary sewer system was installed at JPL to handle sewage and wastewater, and the use of seepage pits for sanitary and chemical waste disposal was discontinued. Today, laboratory chemical wastes are either recycled or sent off-facility for treatment and disposal at regulated, Resource Conservation and Recovery Act (RCRA)-permitted hazardous waste facilities.

In 1980, the analyses of groundwater revealed the presence of VOCs in City of Pasadena water-supply wells located southeast of JPL in the Arroyo Seco. At about the same time, VOCs were detected in two water-supply wells used by the Lincoln Avenue Water Company, located east of the Arroyo Seco (FWEC, 1999a). As a result, NASA initiated investigation to evaluate VOCs originating from the JPL facility.

In 1988, a Preliminary Assessment/Site Inspection was completed at JPL, which indicated that further site characterization was warranted (Ebasco, 1988). Subsequent site investigations were conducted at JPL (Ebasco, 1990a; Ebasco, 1990b) and VOCs were detected in on-facility groundwater at levels above drinking water standards. In 1992, JPL was placed on the National Priorities List (NPL) of sites subject to regulation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (47180-47187 *Federal Register*, Vol. 57, No. 199 (1992)).

After being placed on the NPL, the nature and extent of chemicals in groundwater were investigated during the RI, which lasted from 1994 to 1998 (FWEC, 1999a; FWEC, 1999b). Additional groundwater data have been obtained from a long-term groundwater monitoring program in place at the facility since August 1996, which continues to be active. Based on the data collected during the RI and long-term groundwater monitoring, two VOCs (carbon tetra-chloride and trichloroethene [TCE]) and perchlorate have been detected consistently in the source area at concentrations significantly exceeding their respective state or federal maximum contaminant levels (MCLs) or California Department of Health Services (DHS) notification levels (NLs). The highest concentrations of carbon tetrachloride and perchlorate at the JPL site are located in the north-central portion of the JPL facility, which is referred to as the "source area." The source area is the location where the majority of chemicals is dissolved in the groundwater, and is defined as an 8-acre by 100-ft-thick portion of the aquifer.

In the late 1990s and early 2000, NASA conducted pilot testing of several technologies to address dissolved perchlorate in source area groundwater. The technologies tested included reverse osmosis, a fluidized bed reactor (FBR), packed bed reactors, in situ bioremediation, and ion exchange (FWEC, 2000; NASA, 2003a). Due to the depth and extent of the chemicals in groundwater, in situ (below ground) treatment is not cost-effective at the JPL facility; therefore, groundwater must be pumped from the ground, treated aboveground, and reinjected.

Based on these studies, NASA installed a demonstration treatment plant located on JPL in the source area in early 2005 (NASA, 2003a; NASA, 2005b). The demonstration study area location is illustrated in Figure 2-1. The demonstration study consists of two extraction wells, two injection wells, liquid-phase granular activated carbon (LGAC) treatment to remove VOCs, and an FBR to remove perchlorate, as depicted in Figure 2-2. This system has been successful in the demonstration phase (NASA, 2005c; NASA 2005d; NASA, 2006a). This ROD documents expansion and continued operation of the demonstration system as the response action, as shown in Figures 2-1 and 2-2.

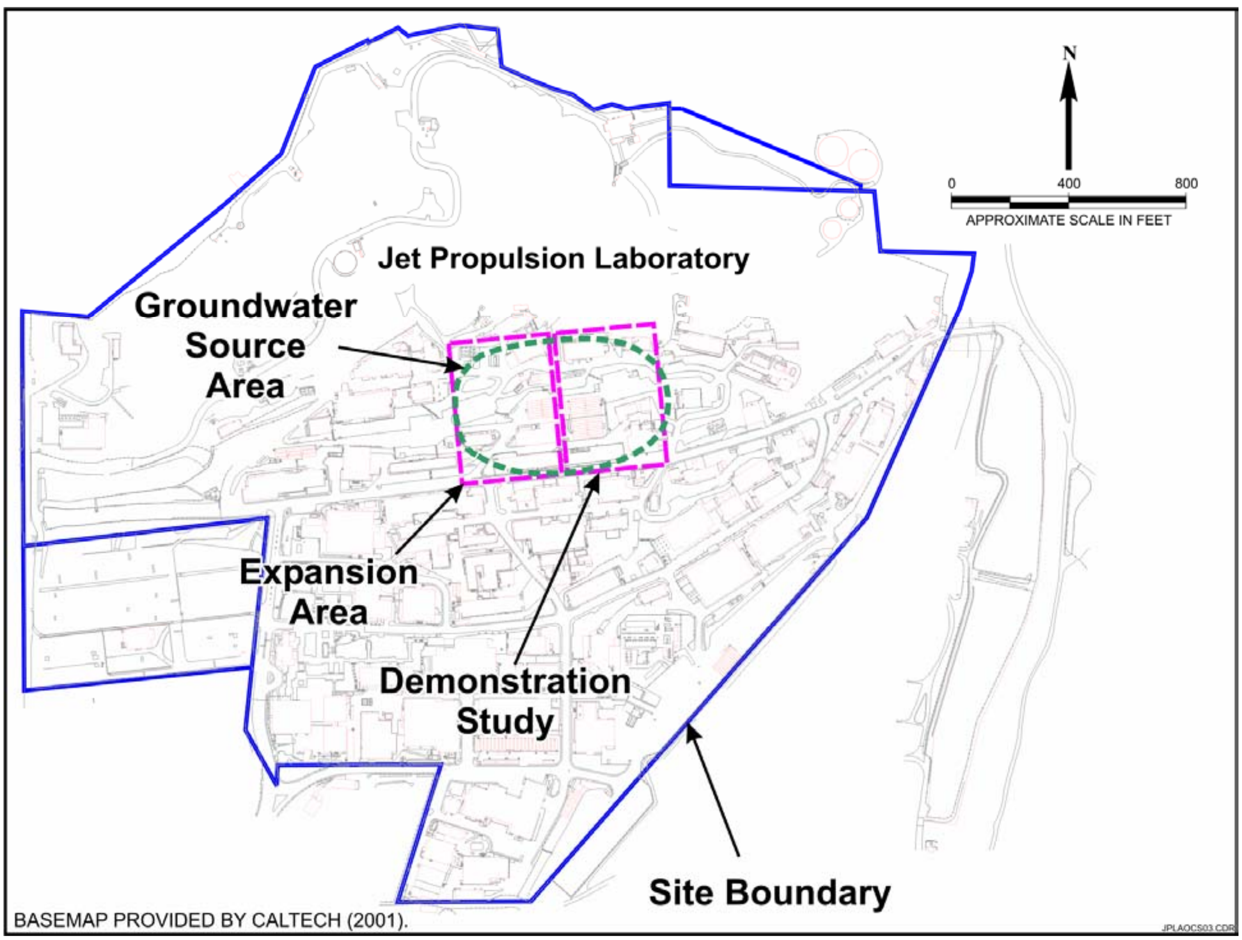


Figure 2-1. Location of the Existing Source Area Groundwater Demonstration Study

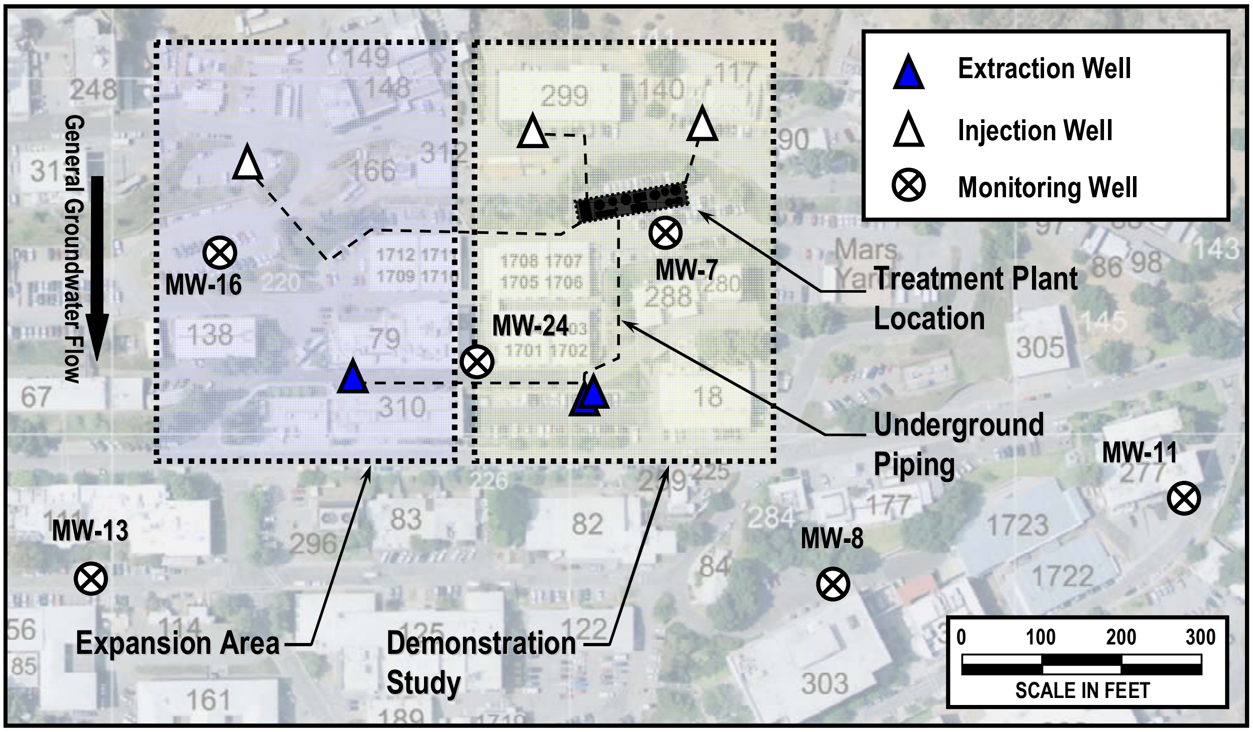


Figure 2-2. Layout of the Existing Demonstration System and the Expansion Area

3.0: COMMUNITY PARTICIPATION

All CERCLA documentation associated with the JPL site is available to the public at the following Web site: http://jplwater.nasa.gov. The Proposed Plan for OU-1 at NASA JPL (NASA, 2005a) and supporting documents were made available to the public via the Administrative Record maintained at JPL and the information repositories maintained at the JPL Library, Altadena Public Library, the La Cañada Flintridge Public Library, and the Pasadena Central Library. The index to the Administrative Record for OU-1 is included in Appendix A.

NASA has held several public meetings and community information sessions during the past two years to inform the communities surrounding JPL about the progress of environmental programs at JPL. The methods used by NASA to ensure that communities are properly informed and included in the CERCLA process are described in the *Superfund Community Relations Plan* (NASA, 1994) and *Community Relations Plan: Amendment 1* (NASA, 2003b).

In January 2004, public meetings were held to inform the public about the progress of remedial activities and current status of each operable unit. NASA's plan for an expanded treatability study using an FBR to treat perchlorate in groundwater beneath the JPL facility (i.e., OU-1) was discussed at these meetings, as well as the current status of work on OU-2 and OU-3. A newsletter summarizing this information and noting the upcoming meetings was mailed in January 2004 to nearly 15,000 residents of communities surrounding the JPL facility.

In April 2004, another public meeting was held to present information to the public regarding potential public health impacts due to chemicals in the groundwater from the JPL facility. A more recent community information session was held in March 2005 to again update the public about the current status of each OU. Designed to be a more interactive, informal meeting, the evening provided an opportunity for attendees to speak one-on-one with project leaders and members of NASA's environmental team at different poster displays and ask questions about the cleanup effort.

Public notifications of the Proposed Plan (NASA, 2005a) and a November 16, 2005, public meeting were mailed to approximately 17,000 residences, businesses, and organizations in Altadena, La Cañada Flintridge, and Pasadena, and were e-mailed to approximately 5,000 JPL employees. Public notification of the November 16, 2005, meeting also was provided in local newspaper notices, including the *Pasadena Weekly* (November 10, 2005) and the *Pasadena Star-News* (November 1, November 9, and November 15, 2005). The text of these public notices is included in Appendix B. The required pubic meeting was held on November 16, 2005, midway through the public comment period (November 1, 2005, through December 15, 2005) and was attended by more than 30 people. The transcript from this meeting may be found at the information repositories or on the Web site http://jplwater.nasa.gov. Prior to the meeting, an information session was held to provide an opportunity for community members to talk one-on-one with the NASA team and better understand the CERCLA program at JPL.

NASA's responses to the comments received during the Proposed Plan public comment period are included in Part III of this ROD, the Responsiveness Summary.

4.0: SCOPE AND ROLE OF RESPONSE ACTION

This ROD addresses source area groundwater treatment and containment in OU-1, which comprises the groundwater located in the north-central area and directly beneath the JPL facility (see Figure 1-1). Remediating the source area is an element of the overall site cleanup strategy for restoring the aquifer. NASA has defined the source area groundwater as the 8-acre by 100-ft-thick portion of the aquifer where chemicals (specifically, carbon tetrachloride and perchlorate) have been found at concentrations over 100 times their respective MCL and notification level. It is estimated that more than 60% of the dissolved chemical mass present at the facility is located within the source area, and that it represents less than 3% of the total volume of impacted groundwater. Source area groundwater treatment and containment will improve the effectiveness and efficiency of the groundwater remedy for OU-3 by significantly reducing chemical mass in groundwater that migrates off-facility.

In addition, SVE was implemented to clean up VOCs in the on-facility soils (OU-2) (NASA, 2002). Implementation of this remedy not only addressed remediation of soil, but also enhanced the overall site cleanup strategy by removing VOCs from the vadose zone, thus reducing the source of VOCs that may migrate to the groundwater.

> Remediating the source area is a critical part of the overall site strategy for restoring the aquifer because the majority of the chemical mass that would eventually migrate to the nearby drinking water wells is located within this area.

NASA's proposed approach for remediating OU-3, off-facility groundwater, consists of wellhead treatment. NASA has funded a treatment system to remove VOCs and perchlorate from two Lincoln Avenue Water Company drinking water wells and has proposed a similar system for four City of Pasadena drinking water wells (NASA, 2006b). Effective source area treatment will reduce the duration that these larger, more expensive treatment systems in OU-3 will need to operate.

The overall site management plan thus takes into account the interrelationship of the three OUs. Figure 4-1 illustrates how the response action fits into the overall remedial site strategy.

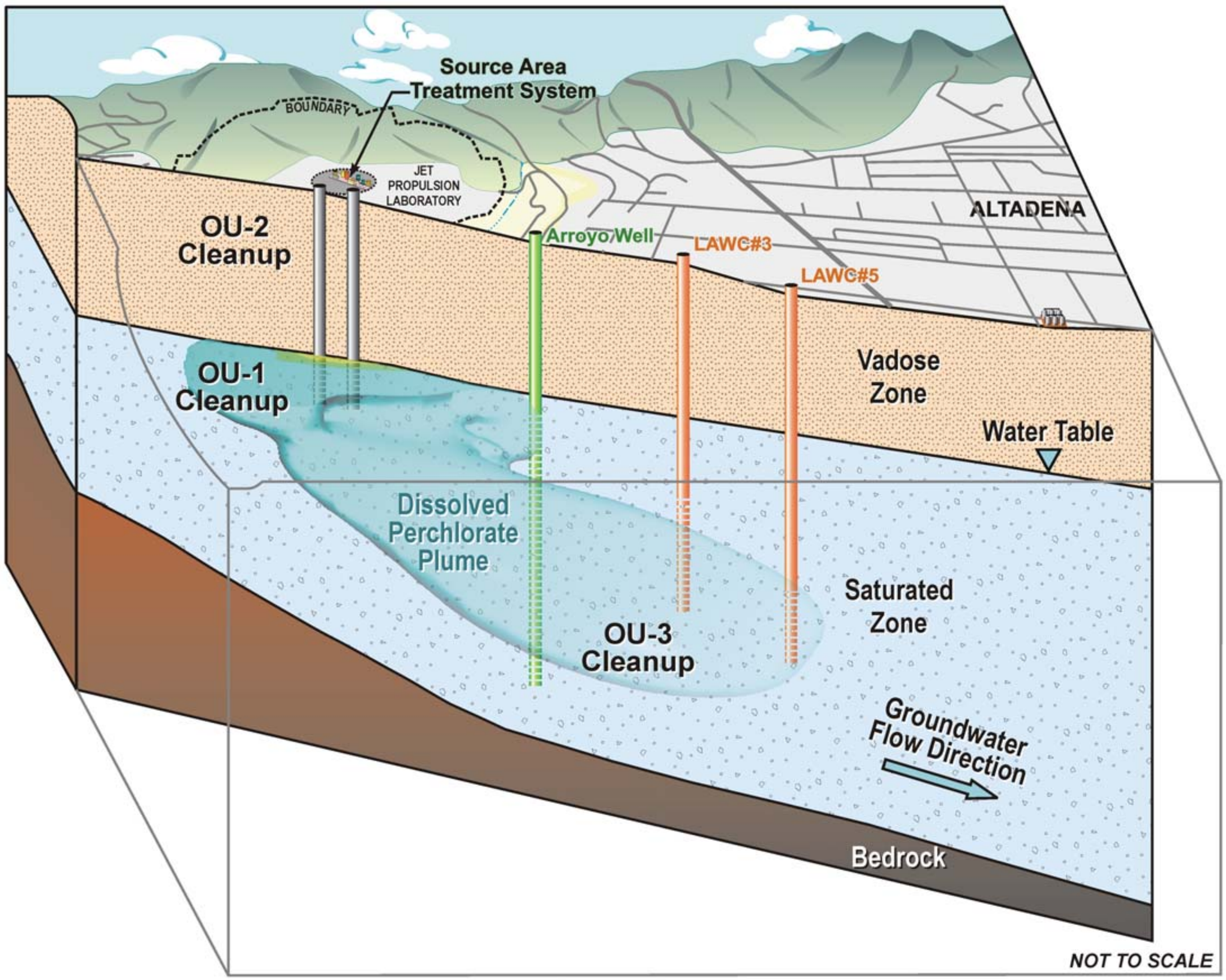


Figure 4-1. OU-1 Source Area Groundwater Remediation is an Important Component of the Overall Site Strategy

5.0: SITE CHARACTERISTICS OF OPERABLE UNIT 1 SOURCE AREA

This section presents a brief overview of the OU-1 site, including a description of the aquifer and groundwater flow, chemicals in groundwater, demonstration study results, and the conceptual site model.

5.1 JPL and Operable Unit 1 Area Setting

> The source area groundwater is an 8-acre portion of the upper aquifer layer containing over 60% of the dissolved chemical mass present. Groundwater in this area has a southerly flow direction.

An in-depth description of the area setting of OU-1, including a detailed discussion of the regional demographics, climate, physiography, geology, hydrology, hydrogeology, natural resources, and cultural resources can be found in the *National Environmental Policy Act of 1969 (NEPA) Values Assessment* (NASA, 2006c), and in the *Final Remedial Investigation (RI) for OU-1 and OU-3* (FWEC, 1999a).

The aquifer beneath JPL is generally considered unconfined. The groundwater table is located approximately 200 ft below ground surface (bgs). Based on water level and soil-type data, the aquifer has been divided into four (4) "aquifer layers." The upper three aquifer layers are present beneath JPL, and the fourth layer is found in the bottom screen interval of the easternmost off-facility JPL monitoring well. Aquifer Layer 1 comprises the upper 75 to 100 ft of the aquifer and includes the water table. Aquifer Layers 2, 3, and 4 are separated from Layer 1 by thin silt-rich intervals, or aquitards, approximately 300, 500, and 800 ft deep, respectively (FWEC, 1999a). The OU-1 groundwater source zone consists of approximately 8-acres within Layer 1.

Groundwater flow patterns are complex, due primarily to pumping of the Pasadena municipal production wells near the JPL facility (FWEC, 1999a). Near the OU-1 source area, historical groundwater-level elevation data indicate a steep southwest gradient from the mouth of the Arroyo Seco to the OU-1 system area coupled with a southeast gradient from the northeast of JPL. Flow converges to the south of the treatment system and migrates toward the southeast. Data collected from the majority of historical groundwater monitoring events has shown a southerly flow in the vicinity of the system.

Groundwater flow is significantly affected by operation of the demonstration system, with a drawdown of roughly 25-30 ft observed in the extraction wells and radial flow observed toward these wells. Monitoring data indicate that that extraction wells will effectively contain ground-water within a 150-ft radius of the extraction wells and the groundwater injected upgradient at the injection wells (NASA, 2005b).

5.2 Sources of Chemicals in Groundwater at JPL

Various seepage pits and other areas were identified at JPL as possible locations used for chemical waste disposal during historic operations. In particular, solvents (including carbon tetrachloride and TCE) were widely used during historic operations at JPL, and the dozens of these seepage pits at which these chemicals were released are the likely source of chemicals found in the source area groundwater at the JPL facility. Figure 5-1 shows the locations of 40 of these seepage pits, 11 of which are located above the groundwater source area addressed in this ROD. Table 5-1 provides the inferred use of these 11 disposal locations based on available records.

The nature and extent of VOCs, perchlorate, metals, and other organic constituents were determined through groundwater sampling conducted at the facility during the RI for OU-1 and OU-3. Groundwater samples were analyzed for a variety of organic and inorganic compounds and elements. Results in the RI and subsequent groundwater monitoring efforts show that VOCs, perchlorate, metals, and other organic constituents are present in groundwater beneath the JPL facility. Detailed information on the RI sampling strategy can be found in the RI report (FWEC, 1999a).

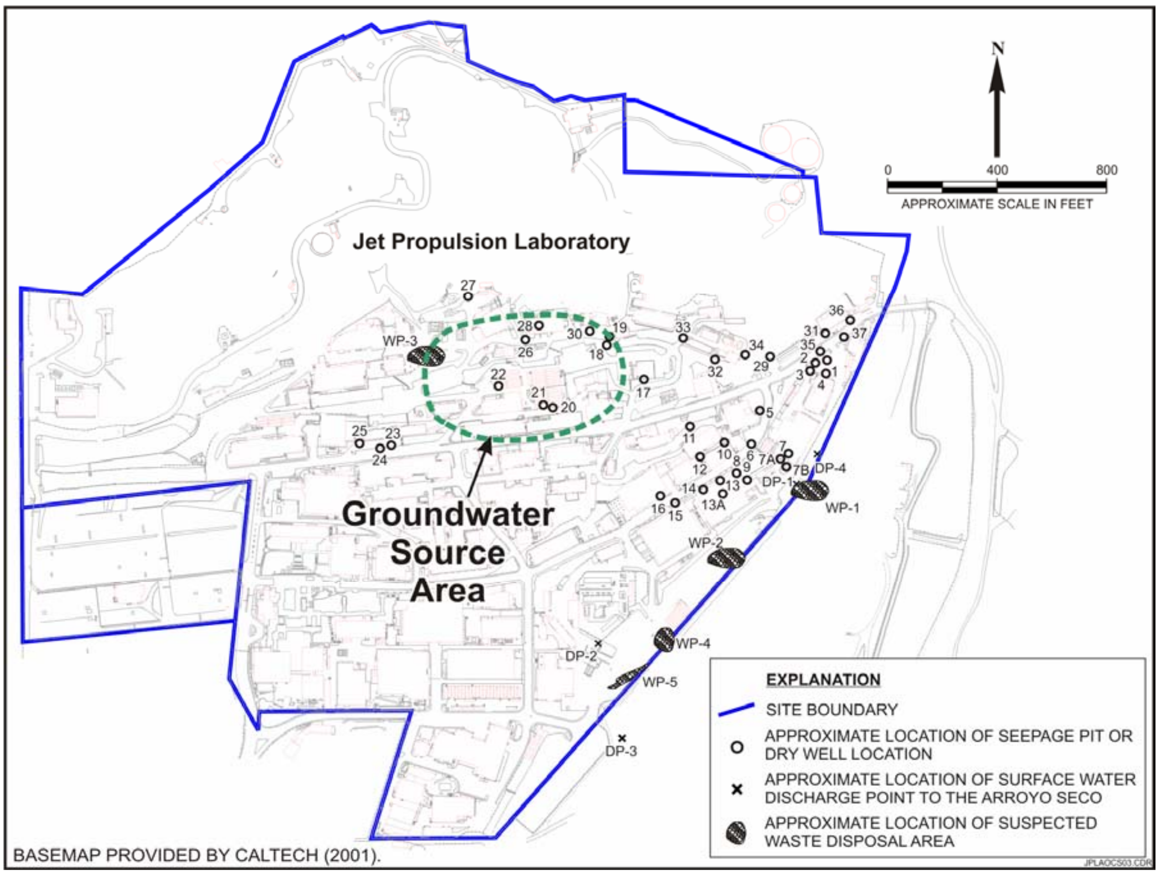


Figure 5-1. Potential Historical Chemical Waste Disposal Locations at the JPL Facility

Table 5-1. Description of Waste Disposal Locations Near the Groundwater Source Area

Seepage Pit No.	Associated Building No.	Building Still Exists (Yes/No)	Current Area Use	Inferred Use
17	55	No	Parking lot near Building 280	Solid propellant mixing facility; solvents used to clean mixing hardware were disposed of by pouring into sumps prior to installation of sanitary sewer system.
18 & 19	90	Yes	Under Pioneer Road	Shop for test cell No. 51 (solid propellant testing in Test Cell "X"); test motors and hardware soaked in tubs of solvents (included perchlorate and acetone) that were not recycled and allegedly dumped into sumps on west side of Building 90 or at east end of solid propellant preparation area (east of Building 88).
20 & 21	63	No	Under or behind retaining wall foundations	Compressors and maintenance shop; solvents routinely used for parts cleaning.
22	80	No	Under office trailers	Wind tunnel building; no history of solvent or chemical usage.
26 & 28	77	No	Under Building 299, in planter or under Pioneer Road	Structure housed experimental chemistry lab and fluorine propellant test cell with an acid-neutralizing pit constructed similar to a dry well; numerous chemicals reportedly disposed by dumping into available sumps near building; seepage pit is upgradient from MW-7.
27	246	Yes	Asphalt paved parking area	Dry well from sink at former soils test laboratory; no history of solvent or chemical usage.
30	117	Yes	Asphalt paved parking area	Building housed former solid propellant test cell where solvents used to clean rocket motors and hardware, solvents reportedly not recycled and disposed of by dumping into nearby drains and sumps.
WP-3	119	No	Asphalt paved parking area	Former salvage storage area; solvents reportedly dumped into hand-dug holes.

5.3 Chemicals and Concentrations in Source Area Groundwater at JPL

Five monitoring wells are located in or near the OU-1 source area: MW-7, MW-8, MW-13, MW-16, and MW-24 (see Figure 2-2). All of these monitoring wells, except MW-24, are single screen wells. MW-24 is a deep multiport well with five separate screened intervals for sampling, with the uppermost Screen 1 roughly corresponding in elevation to the other source area monitoring wells. During the initial phases of the RI, comprehensive suites of analyses were performed. These included VOCs, semivolatile organic compounds (SVOCs), Title 26 metals, additional metals analyses for strontium, aluminum, and hexavalent chromium (Cr^{+6}), cyanide, gross alpha/gross beta radiation; and total petroleum hydrocarbons. During the long-term monitoring, various analyses were added or dropped based on previous results or new information. Analyses during the long-term groundwater monitoring primarily included VOCs, metals [arsenic, lead, chromium (Cr and Cr^{+6})], tributyltin, 1,4-dioxane, n-nitrosodimethylamine, and perchlorate.

> Based on sampling results collected over the past ten years from monitoring wells located in the source area, the primary chemicals of interest are chlorinated VOCs and perchlorate.

Several VOCs have been detected in the OU-1 source area monitoring wells above drinking water MCLs, including carbon tetrachloride, TCE, tetrachloroethene, 1,2-dichloroethane (1,2-DCA), and 1,1-dichloroethene (1,1-DCE). In addition, perchlorate has been consistently detected above the State Public Health Goal (PHG) and current notification level of 6 micrograms per liter (µg/L). Table 5-2 summarizes the detections of VOCs and perchlorate in the source area monitoring wells.

Carbon Tetrachloride

Concentrations of carbon tetrachloride have been reported in excess of the MCL (0.5 µg/L) in samples from all five source area monitoring wells during the past decade (see Table 5-2). The highest concentration of carbon tetrachloride was reported in well MW-7 at 208 µg/L (April 2002). Concentrations in this well have since declined, reaching below the MCL in August 2005 after the OU-1 demonstration source area treatment system began operating in February 2005. Carbon tetrachloride concentrations in MW-24 (Screen 1) similarly reached the MCL for the first time in November 2005 after the OU-1 demonstration system began operation. Figure 5-2 shows the carbon tetrachloride trend for the last four years in four source area monitoring wells. Carbon tetrachloride concentrations in source area monitoring wells MW-13 and MW-16 located farther from the demonstration treatment system remain above the MCL. The change of the carbon tetrachloride plume is illustrated in the performance reports using groundwater contour maps from before and after demonstration system installation (NASA, 2005d; NASA, 2006a).

Trichloroethene (TCE)

Reported TCE concentrations have exceeded the state and federal MCL (5.0 µg/L) in all five source area monitoring wells (see Table 5-2). The highest concentrations of TCE reported during the past decade occurred in September 1996 in wells MW-13 (47 µg/L), MW-7 (39 µg/L), and MW-16 (33 µg/L). Concentrations in these wells have since declined, and have remained below the MCL in MW-16 since 2001 and in MW-7 since the OU-1 demonstration system began operating in February 2005. TCE concentrations in MW-13 remain above the MCL. TCE concentrations in MW-24 are below the MCL. Figure 5-3 presents TCE concentrations during the past four years in these four source area monitoring wells. Groundwater contour maps showing the extent of the TCE plume both before and after demonstration system installation are included in the performance reports (NASA, 2005d; NASA, 2006a).

Table 5-2. Summary of Groundwater Constituents Detected in the OU-1 Source Area (1996-2005)

Monitoring Well	Carbon Tetrachloride (µg/L)	TCE (µg/L)	PCE (µg/L)	1,1-DCE (µg/L)	1,2-DCA (µg/L)	Perchlorate (µg/L)
MW-7	<0.5-208	<0.5-39	<0.5-34.7	<0.5-12.4	<0.5-1.4	32.1-13,300
MW-8	0.038-14	0.031-24	0.016-0.5	0.01-0.9	0.064-0.6	0.69-620
MW-13	0.4-27	1-47	0.061-1.4	0.042-1.9	0.03-2.5	0.85-1,410
MW-16	0.082-125	0.046-33	0.031-7.3	0.03-5.3	0.03-2.4	97.2-13,100
MW-24 (Screen 1)	0.038-30	0.036-15	0.005-2.8	0.006-1	0.065-0.8	0.85-4,880
MW-24 (Screen 2)	0.039-58	0.006-4.3	0.005-1.5	0.004-2	0.007-0.5	0.69-700
MW-24 (Screen 3)	0.005-0.5	0.006-0.5	0.005-0.5	0.004-0.5	0.005-0.5	0.66-4
MW-24 (Screen 4)	0.005-0.5	0.006-0.5	0.009-0.5	0.004-0.5	0.007-0.5	0.66-4
MW-24 (Screen 5)	0.005-0.5	0.006-0.5	0.009-0.5	0.004-0.5	0.007-0.5	0.66-4
State MCL	0.5	5	5	6	0.5	—
Notification Level	—	—	—	—	—	6

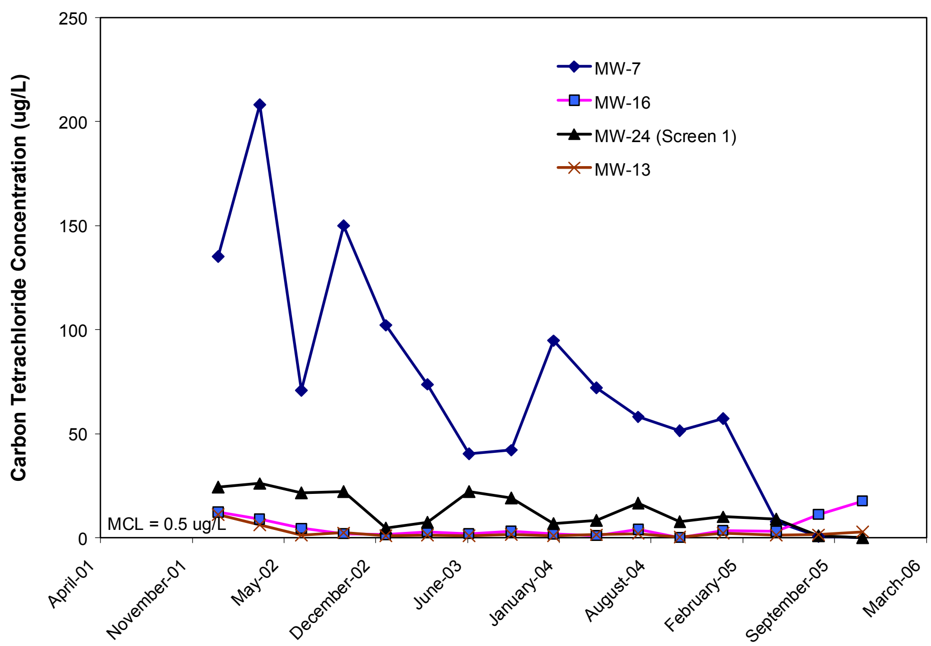


Figure 5-2. Recent Carbon Tetrachloride Concentrations in Source Area Wells

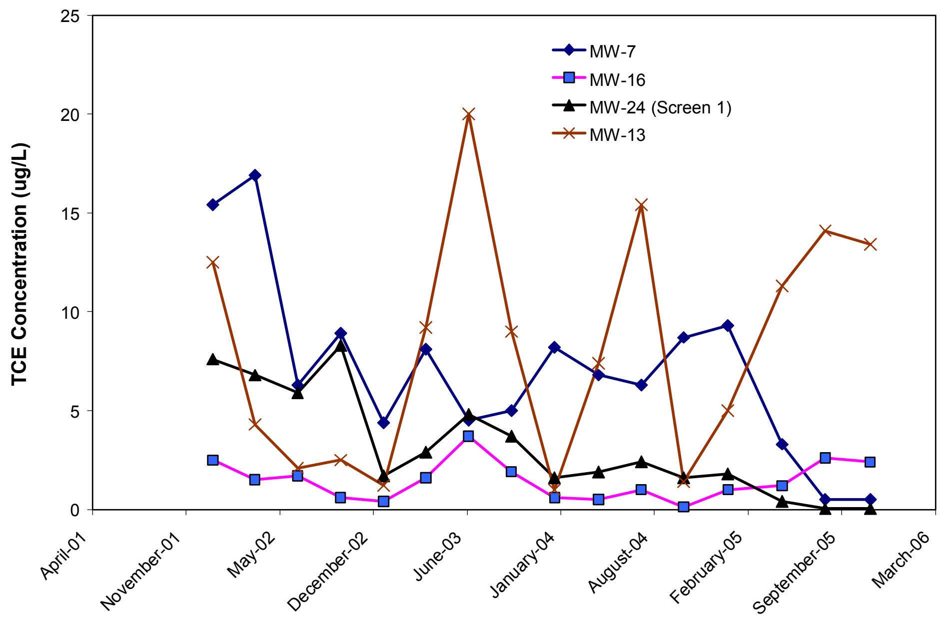


Figure 5-3. Recent TCE Concentrations in Source Area Wells

Tetrachloroethene (PCE)
The highest historical concentration of PCE was detected in source area well MW-7 (34.7 µg/L) as recently as November 2004. However, concentrations in this well fell below the state and federal MCL (5.0 µg/L) after operation of the OU-1 demonstration system began. Figure 5-4 presents PCE concentrations over time for select OU-1 source area wells. Concentrations in MW-16 recently increased above the MCL. Groundwater contour maps showing the extent of the PCE plume both before and after demonstration system installation are included in the performance reports (NASA, 2005d; NASA, 2006a).

1,1-Dichloroethene (1,1-DCE)
1,1-DCE has been detected only in MW-7 above the state MCL of 6.0 µg/L. However, 1,1-DCE has not been detected in this well since operation of the OU-1 demonstration system began. Figure 5-5 illustrates these results.

1,2-Dichloroethane (1,2-DCA)
The state MCL (0.5 µg/L) for 1,2-DCA has not been exceeded since the March 2003 groundwater sampling event (MW-16 at 0.9 µg/L) and the federal MCL (5.0 µg/L) has never been exceeded.

Perchlorate
Concentrations of perchlorate in excess of the notification level (6.0 µg/L) have been reported in samples collected from all source area groundwater monitoring wells, as shown in Figure 5-6.

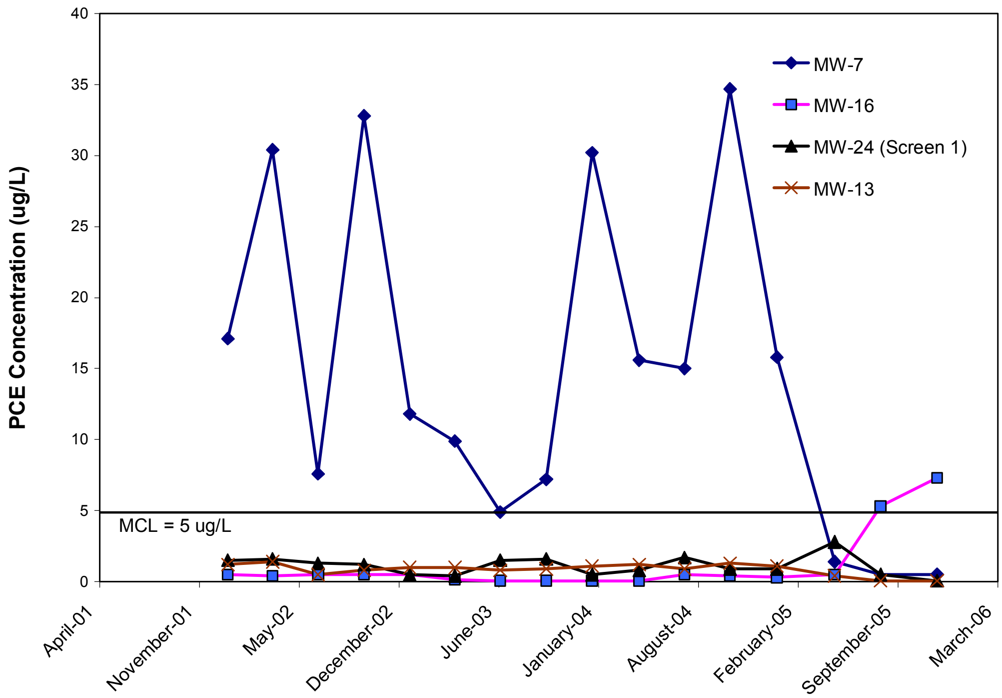


Figure 5-4. Recent PCE Concentrations in Source Area Wells

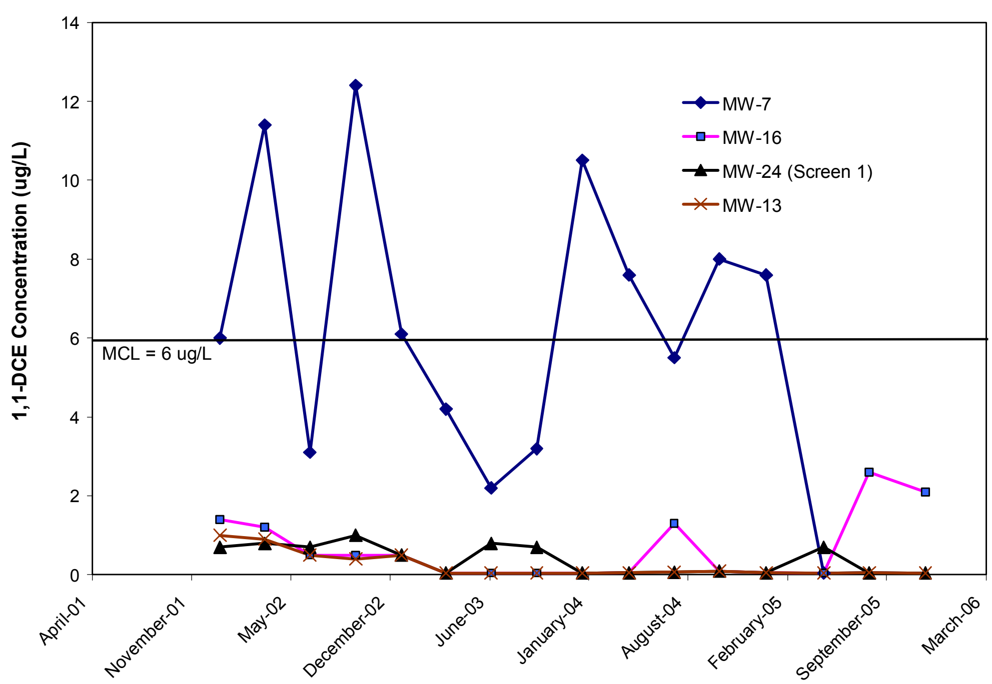


Figure 5-5. Recent 1,1-DCE Concentrations in Source Area Wells

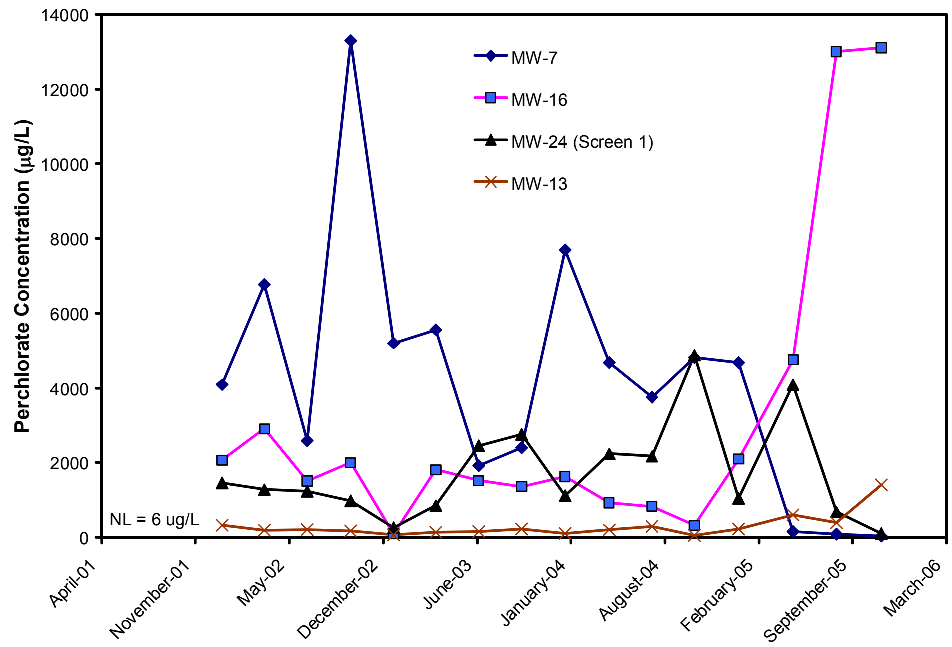


Figure 5-6. Recent Perchlorate Concentrations in Source Area Wells

Concentrations of perchlorate in these wells have generally been unstable over the last few years, which suggest there might be a continuing perchlorate source to groundwater at OU-1. The highest concentrations of perchlorate measured during the past decade were reported in samples collected from wells MW-7 (13,300 µg/L in November 2002) and MW-16 (13,100 µg/L in November 2005). Since startup of the OU-1 demonstration system, perchlorate concentrations have decreased in MW-7 by two orders of magnitude and in MW-24 (Screen 1) by one order of magnitude. However, perchlorate concentrations have increased in MW-13 and MW-16 by an order of magnitude. Groundwater contour maps showing the extent of the TCE plume both before and after demonstration system installation are illustrated in the performance reports (NASA, 2005d; NASA, 2006a).

5.4 Evaluation of the Source Area Groundwater Demonstration Study

> Significant reductions in the concentrations of VOCs and perchlorate have been observed in extraction and monitoring wells located within the demonstration study area since initiating operation in February 2005. Therefore, expansion of the system is an appropriate next action.

The existing demonstration system has two extraction wells, EW-1 screened from 218 to 268 ft bgs and EW-2 screened from 265 to 315 ft bgs (NASA, 2005b). Two injection wells are located approximately 330 ft upgradient to the north. Figure 2-2 illustrates the layout of the demonstration study system.

Extracted carbon tetrachloride concentrations were approximately 37 µg/L after system startup, as illustrated in Figure 5-7. After one year of operation, extracted concentrations have decreased below 1 µg/L in the upper extraction well EW-1 and below 20 µg/L in the deeper extraction well

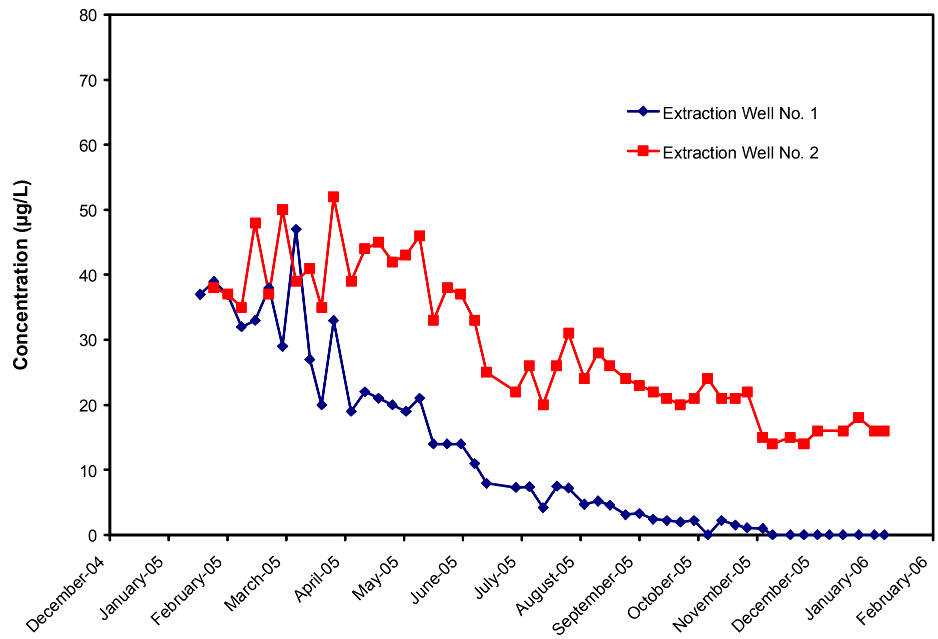


Figure 5-7. Carbon Tetrachloride Concentrations Measured in the Demonstration System Extraction Wells

EW-2. More than 10 lb of carbon tetrachloride have been removed from source area groundwater as of January 2006.

A similar decreasing trend has been observed in extracted perchlorate concentrations, which began with initial concentrations above 2,400 µg/L in EW-1 and above 1,700 µg/L in EW-2. After a year of operation, EW-1 and EW-2 extracted concentrations have decreased nearly an order of magnitude and are approaching asymptotic extraction concentrations above 200 µg/L and 500 µg/L, respectively. Figure 5-8 illustrates these trends. Approximately 413 lb of perchlorate had been removed as of January 2006.

As discussed in Section 5.2, the OU-1 demonstration system has reduced concentrations of a number of constituents to their respective MCLs in source area well MW-7, including carbon tetrachloride, TCE, PCE, and 1,1-DCE, and also has caused perchlorate concentrations to be reduced by two orders of magnitude. Similarly, the demonstration system has reduced carbon tetrachloride concentrations in MW-24 (Screen 1) to the MCL, thereby enabling all VOCs in this well to meet their respective MCLs. In addition, perchlorate concentrations have decreased by an order of magnitude in well MW-24, although concentrations are still above the notification level.

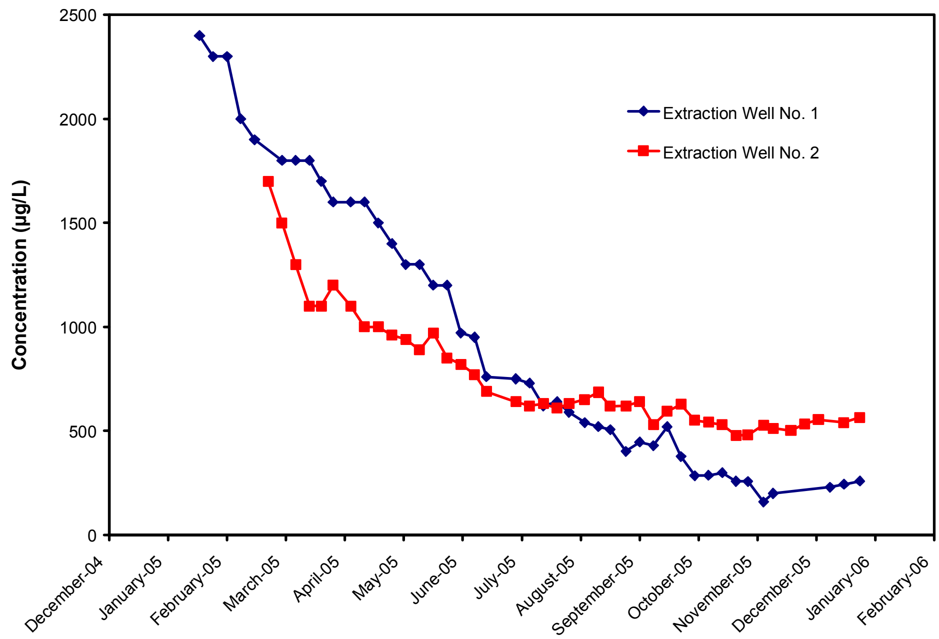


Figure 5-8. Perchlorate Concentrations Measured in the Demonstration System Extraction Wells

However, MCLs have not been met in source area monitoring wells located to the west of the demonstration system. Carbon tetrachloride concentrations still exceed the MCL in MW-13 and MW-16, and TCE concentrations exceed the MCL in MW-13. In addition, perchlorate concentrations also recently increased in each of these wells. Additional groundwater extraction and treatment is required for these source area wells. Hence, installation of additional extraction and injection wells is proposed as part of this ROD (see Figure 2-2). Extraction from these wells will allow additional mass removal.

5.5 Conceptual Site Model

Figure 5-9 is a conceptual site model for the transport of VOCs and perchlorate from the JPL seepage pits to groundwater. A summary of the potential migration pathways and fate and transport processes for chemicals associated with OU-1 is shown in Figure 5-10. The fate and transport characteristics and the potential for downgradient migration of chemicals, particularly carbon tetrachloride, TCE, and perchlorate, were described in detail in the RI Report (FWEC, 1999a). Infiltration and percolation of rainfall, which causes vertical downward flow of VOCs from the vadose zone to groundwater, appears to be the principal transport mechanism by which chemicals are introduced to groundwater at JPL. Soil vapor diffusion and advection also play a role as VOC transport mechanisms within the vadose zone. Thereafter, chemicals are mixed and transported in groundwater via a variety of physical and chemical processes.

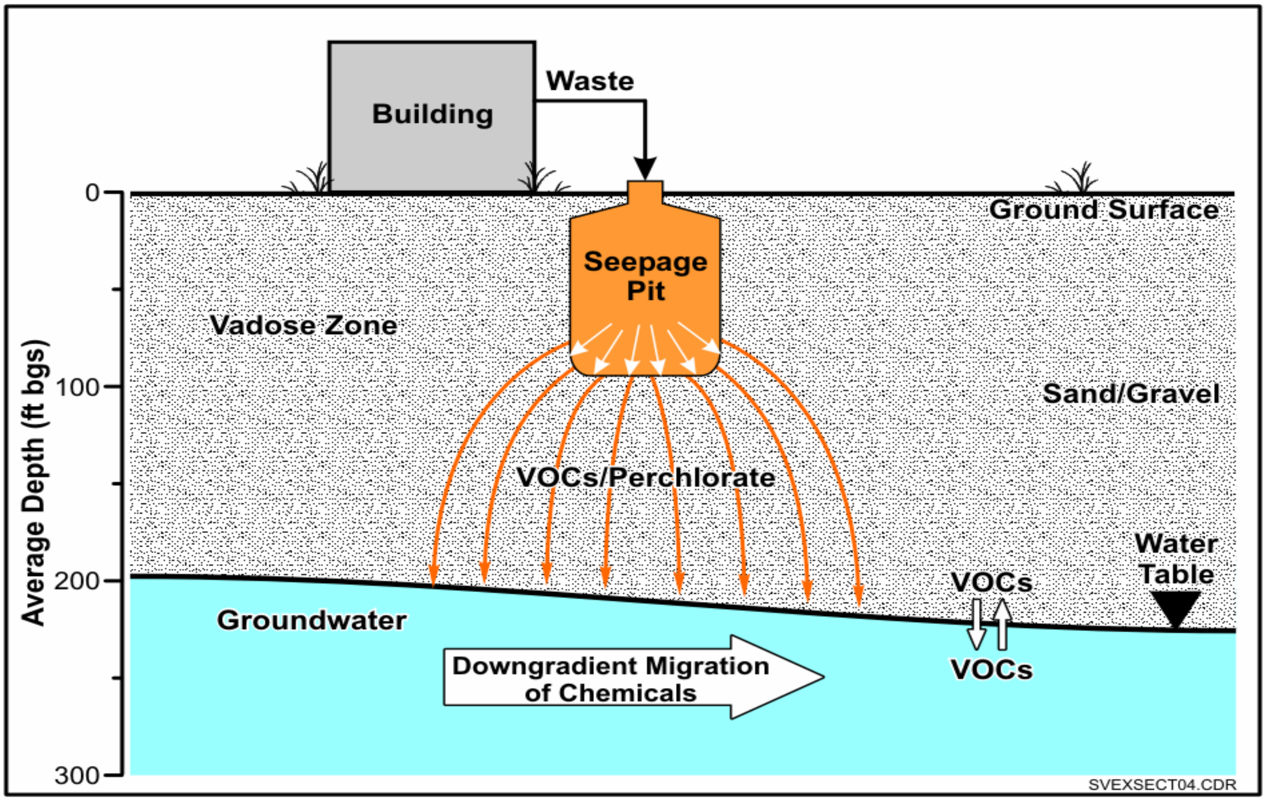


Figure 5-9. Conceptual Site Model for Transport of Chemicals

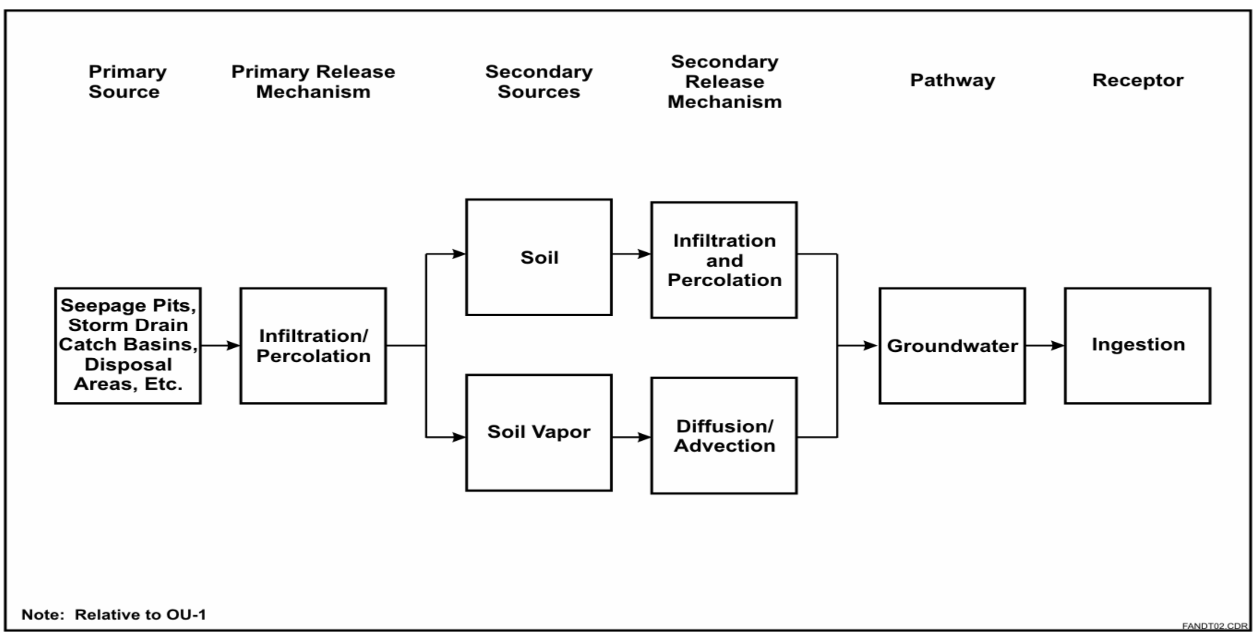


Figure 5-10. Chemical Fate and Transport Conceptual Diagram

5.5.1 Fate and Transport Modeling

With the RI data and subsequent groundwater monitoring data collected since 1995, the fate and transport of the groundwater constituents at JPL are generally well known. However, fate and transport modeling during the RI was performed as a preliminary evaluation of a scenario. For this model it was assumed that carbon tetrachloride, TCE and perchlorate might migrate further downgradient from the JPL facility, beyond their currently known limits of extent, with natural groundwater gradients present only during periods when the Pasadena and other nearby municipal wells are not operating and inhibiting further downgradient migration. The point source location for constituent migration modeling was chosen as MW-17, aquifer layer 2, because carbon tetrachloride, TCE, and perchlorate were consistently detected above MCLs at this location. The constituent path from MW-17 to MW-20 was selected for the model simulations because MW-20 is downgradient from MW-17 under natural flow conditions and there are no known physical barriers between these two points. Therefore, this path was assumed to provide an appropriate estimate of off-facility migration.

The modeling runs were carried out using SOLUTE™ (Version 4.04) software for each of the three constituents listed above (FWEC, 1999a). In these runs, source concentrations and several input parameters were based on actual facility information or on literature values that were considered to be representative of facility conditions. All input parameters were the same for all simulations with the exception of the initial constituent concentrations, which reflected actual detected values.

Results of the simulations are presented in detail in the RI (FWEC, 1999a). The simulations predicted that with an initial carbon tetrachloride concentration of 6.6 µg/L (maximum detected in MW-17 during the RI), under the defined conditions (no pumping), and with general input parameters based on conservative assumptions, the MCL of 0.5 µg/L would be exceeded in 20 years at MW-20. Similarly, modeling simulations using conservative input assumptions predicted that an initial concentration of 23 µg/L at MW-17 (maximum detected in MW-17 during the RI), would result in a concentration equal to the MCL (5.0 µg/L) at MW-20 after 31 years. With regard to perchlorate, the model indicated that an initial concentration of 55 µg/L at MW-17 (maximum detected in MW-17 during the RI) would result in a concentration at MW-20 equal to the notification level of 18 µg/L, (the DHS notification level at the time the RI fate and transport modeling work was performed) after 40 years.

The results of the fate and transport modeling used actual observed maximum concentrations for carbon tetrachloride, TCE and perchlorate during the RI. The results indicated that even under conservative assumptions, it would take long periods of time for these constituents to migrate downgradient of non-pumping Pasadena and other nearby municipal production wells at concentrations above MCLs or notification levels.

Since that time, the notification level for perchlorate has been reduced to 6 µg/L and the perchlorate concentrations in MW-20 have occasionally exceeded the new notification level. However, during the recent 2005 facility-wide groundwater sampling efforts, perchlorate was not detected in MW-20 (NASA, 2006d).

5.5.2 Exposure Pathways

The groundwater at the JPL facility is not extracted for distribution within the facility and workers at the facility do not have access to untreated water from the site. Hypothetically, the exposure mechanisms to untreated groundwater from accessing well water for humans could include ingestion (drinking), dermal (skin) contact, and inhalation of vapors from domestic water sources. For the human health risk assessment (HHRA), potential exposures to chemicals in on-facility groundwater at JPL were quantitatively evaluated for the hypothetical on-facility resident (age-adjusted adult exposed 350 days per year for 70 years) and child resident (6 years). Although a conservative approach was taken for the HHRA, NASA has no intent to use JPL for residential purposes in the foreseeable future. However, NASA based the risk assessments on potential residential use to provide the most conservative and protective results. Direct exposures through ingestion, dermal contact, and inhalation of vapors from water sources were evaluated as exposure pathways to the hypothetical receptors.

For the ecological risk assessment (ERA), an assessment of ecological risks was completed at the JPL facility. The scoping assessment concluded that no groundwater exposure pathways to plants and animals are possible at OU-1. Therefore, it was concluded that no further characterization of ecological risks to plants and animals due to groundwater impact was warranted because there were no complete exposure pathways from groundwater to facility biota. More information on the results of the HHRA and ERA is included in Section 7.0 of this document and in the RI report (FWEC, 1999a).

6.0: CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

JPL is a NASA-owned FFRDC operated by Caltech. It is the federal government's lead center for research and development related to robotic exploration of the solar system. In addition to NASA work, tasks for other federal agencies are conducted at JPL in areas such as remote sensing, astrophysics, and planetary science.

6.1 Land Uses

JPL comprises approximately 176 acres of land. Of these 176 acres, about 156 acres are federally owned. The remaining land is leased for parking from the City of Pasadena and the Flintridge Riding Club. Presently, more than 150 structures and buildings occupy JPL. Total usable building space is approximately 1,330,000 ft^2. The main developed area of JPL is the southern half, which can be divided into two general areas − the northeastern early-developed area and the southwestern later-developed area. Most of the northern half of JPL is not developed because of steeply sloping terrain (see Figure 1-1).

Currently, the northeastern early-developed part of JPL is used for project support, testing, and storage. The southwestern later-developed part is used mostly for administrative, management, laboratory, and project functions. Further development of JPL is constrained because of steeply sloping terrain to the north, the Arroyo Seco to the south and east, and residential development to the west.

Located at the northern boundary of JPL is the Gould Mesa area. This area has widely separated small buildings and is used primarily for antenna testing. The distance between buildings is a result of the terrain and the need to isolate transmitting and receiving equipment. The relatively steep mountainside between Gould Mesa and the developed area at JPL is unpopulated.

The primary land use in the areas surrounding JPL is residential and light commercial. Industrial areas, such as manufacturing, processing, and packaging, are limited. The closest residential properties are those located along the western fence line of JPL. The nearest off-facility buildings are the Flintridge Riding Club and Fire Camp #2, both located approximately 100 yards from the southern border of JPL. The total number of buildings within 2 miles of JPL is about 2,500, primarily residential and community (e.g., schools, day-care centers, churches). Land use at JPL is not expected to change significantly in the foreseeable future.

6.2 Surface Water and Groundwater Uses

There are no permanent surface water bodies within the boundaries of JPL. The Arroyo Seco Creek intermittently flows through the Arroyo Seco wash to the east of JPL. The entire JPL facility drains, via storm drains and surface runoff, into the Arroyo Seco. In addition, stormwater runoff from parts of La Cañada Flintridge mingles with that of JPL prior to discharge to the Arroyo. Within the Arroyo Seco, a series of surface impoundments are used as surface water collection and spreading basins for groundwater recharge.

Groundwater beneath the Arroyo Seco is a current source of drinking water. The Raymond Basin Watershed, Monk Hill Subarea, where JPL is located, provides an important source of potable water for many communities in the area around JPL. These communities are expected to grow at a modest rate for the foreseeable future and the use of groundwater as drinking water is expected to continue.

7.0: SUMMARY OF SITE RISKS (OU-1)

This section of the ROD summarizes the results of the baseline HHRA and the ERA for OU-1. The risk assessment process identifies potential exposure pathways and allows evaluation of the risks to humans and the ecosystem, if no further action were taken at the site.

7.1 Summary of Human Health Risk Assessment

The HHRA was completed to evaluate the potential risks to human health associated with hypothetical exposure to chemicals in untreated groundwater beneath the JPL facility. It is important to note that because groundwater is in a deep aquifer and does not recharge surface water bodies within the area of concern, and because water purveyors treat impacted groundwater before use, there is no complete or direct pathway for exposure to JPL groundwater. Nevertheless, at the request of U.S. EPA and DTSC risk assessors, a conservative hypothetical residential use scenario was evaluated during the RI (FWEC, 1999a) using U.S. EPA risk assessment guidance. It is assumed in the risk assessment that humans use untreated groundwater beneath JPL for potable purposes. Detailed results and methodologies used are presented in the RI (FWEC, 1999a). To ensure that human health is adequately protected, conservative exposure point concentrations and toxicity assumptions were used in estimating potential cancer risks and noncancer hazards.

For carcinogenic compounds, the exposure risk is expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. These risks are expressed in scientific notation (e.g., an excess lifetime cancer risk of 1.0×10^{-6} indicates that an individual experiencing the conservative maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure). According to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 1.0×10^{-6} is defined as the point of departure (i.e., the target level of risk) and the NCP-defined generally acceptable range is 1.0×10^{-6} to 1.0×10^{-4} (U.S. EPA, 1989a).

For noncarcinogenic compounds, risks are evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose or level that is not expected to cause any harmful effects. The ratio of the chronic daily intake to the reference dose is called a hazard quotient (HQ). The sum of all of the hazard quotients for each chemical compound is referred to as the hazard index (HI). An HI less than 1.0 indicates that toxic, noncarcinogenic effects from all chemical constituents and exposure routes are unlikely (U.S. EPA, 1989a).

> The only way for the public to come in contact with the groundwater located several hundred feet below the ground surface is through pumping from drinking water production wells located off-facility. These production wells are either shut down or treated prior to water distribution to customers, thus preventing a direct exposure pathway.

The two representative receptors chosen to model risk from hypothetical exposure to untreated groundwater at the JPL site were the residential adult and child. Noncancer and cancer risks were calculated based on a 6-year exposure for the child and a 30-year age-adjusted exposure averaged over 70 years for the adult. Exposure to untreated chemicals of concern in groundwater was evaluated for ingestion, inhalation, and dermal contact at each JPL monitoring well. It was assumed that the receptors were exposed to the maximum detected or 95 percent upper confidence level (UCL) concentration of chemicals of concern (whichever was higher) in each well for 350 days per year. The exposure scenario is a hypothetical situation that does not reflect realistic current or future land-use scenarios because there are no direct exposure pathways for humans to interact with untreated groundwater in the study area.

The evaluation of noncancer risks for the child receptor show that with the exception of four on-facility monitoring wells (MW-7, -13, -16 and -24), all other monitoring wells produced Hazard Index (HI) values less than 10. Analysis of the HI values based on target organ effects indicates that nine monitoring wells (MW-3, -4, -7, -8, -10, -12, -13, -16, and -24) produced HI values that exceeded the criterion value of 1.0 (see Table 7-1). In these wells, carbon tetrachloride and perchlorate were consistently the predominant chemicals contributing to the excess non-cancer risk.

Table 7-1. Summary of Non Cancer Hazard Index and Cancer Risk for OU-1 Monitoring Wells

OU-1 Well	Hazard Index	Major Chemical Contributor	Risk	Major Chemical Contributor
MW-3	2.1	arsenic, perchlorate	1.1E-04	Arsenic, bromodichloromethane, CCl_4, chloroform
MW-4	8.5	CCl_4, perchlorate	7.7E-05	1,1-DCE, 1,2-DCA, CCl_4, chloroform, TCE
MW-6	<1.0	None	4.0E-06	PCE
MW-7	190	CCl_4, perchlorate	2.2E-03	1,1-DCE, 1,2-DCA, CCl_4, chloroform, Cr^{6+}, PCE, TCE
MW-8	6.3	CCl_4, perchlorate	5.5E-05	CCl_4, chloroform, TCE
MW-10	3.2	perchlorate, nitrate	1.3E-05	Chloroform, PCE, TCE
MW-11	<1	None	1.1E-05	CCl_4, chloroform
MW-12	8.9	CCl_4, perchlorate	1.6E-04	CCl_4, chloroform
MW-13	47	CCl_4, perchlorate	5.5E-04	1,1-DCE, 1,2-DCA, CCl_4, chloroform, Cr^{6+},TCE
MW-14	<1	None	3.1E-06	Chloroform, PCE
MW-16	220	CCl_4, perchlorate	1.4E-03	1,1-DCE, 1,2-DCA, CCl_4, chloroform, Cr^{6+}, PCE, TCE
MW-22	<1	None	3.2E-06	PCE
MW-23	<1	None	5.3E-06	Chloroform, PCE, TCE
MW-24	65	CCl_4, perchlorate	5.2E-04	1,2-DCA, arsenic, CCl_4, chloroform, TCE

Evaluation of cancer risks for JPL OU-1 monitoring wells shows that greater than half of the wells had cancer risk values fall within U.S. EPA's range for acceptable levels of risk of 10^{-6} to 10^{-4} (see Table 7-1). Four wells did not have cancer risks associated with them because no carcinogenic compounds were detected during RI sampling efforts. Six wells had cancer risk values greater than 10^{-4}, of which two wells (MW-7 and MW-16) had cancer risks greater than 10^{-3}. Monitoring well MW-3 slightly exceeded the U.S. EPA acceptable risk range ($>10^{-4}$) and the constituent contributing to the majority of the risk was arsenic. During the RI, arsenic was only consistently detected in the lowest screen of MW-3, below the MCL value of 0.05 mg/L. Arsenic is a naturally-occurring metal and the arsenic detections probably reflect natural concentrations of the analyte and do not represent a human health concern. Three other JPL OU-1 monitoring wells had total cancer risks greater than 10^{-4} (MW-12, MW-13 and MW-24). A variety of chemicals contributed to the total cancer risk value of these wells. Predominant chemical contributors in these wells were as follows: MW-12 (carbon tetrachloride); MW-13 (carbon tetrachloride and hexavalent chromium), and MW-24 (carbon tetrachloride). The two OU-1 wells with the highest total cancer risk were MW-7 (risk = 2.2×10^{-3}) and MW-16 (risk = 1.4×10^{-3}). In these wells, carbon tetrachloride accounted for 91 percent and 86 percent, respectively, of the total risk value. These two wells also have the highest non-cancer risk values (HI values of 190 and 220, respectively).

Theoretical risks to human health predicted by this assessment are likely to be an overestimation of actual risk. In fact, the Agency for Toxic Substances and Disease Registry (ATSDR) has determined that on- and off-facility groundwater at JPL does not pose a present or future public health hazard because wellhead treatment and water blending are used by local water purveyors to meet stringent drinking water standards prior to distribution of the water for public use (ATSDR, 1998). Unlike state and federal guidance that requires exposures to untreated groundwater be evaluated in HHRA, the ATSDR evaluated whether residents are actually being exposed currently, or may possibly be exposed in the future, to chemicals present in groundwater at JPL.

7.2 Summary of Ecological Risk Assessment

An assessment of ecological risks was completed at JPL that qualitatively evaluated potential ecological receptors, chemicals of potential concern (COPCs), and potentially completed exposure pathways for soil, soil vapor, and groundwater. A scoping assessment of ecological risks also was completed to qualitatively evaluate potential ecological receptors, chemicals of potential concern, and potentially complete exposure pathways for groundwater. Groundwater typically underlies the ecological receptors at depths of approximately 200 ft or more, and for this reason, there are not plausible groundwater exposure pathways to plants and animals. It was concluded that no further characterization of ecological risks to plants and animals due to groundwater exposure was warranted as there were no complete exposure pathways (FWEC, 1996).

The assessment used a habitat approach as the basis for identifying potentially complete pathways between areas of impact and specific plant and animal species that may occupy the facility. Potentially affected habitats within or adjacent to the JPL facility include: urban landscape, chaparral, riparian, wetlands, southern oak woodland, and desert wash. A wide variety of plant and animal species were catalogued during field surveys. The COPCs evaluated for groundwater were the metals and VOCs that were detected in the groundwater during the RI.

The chaparral and southern oak woodland habitats are found only in the San Gabriel Mountains to the north of the JPL facility. Because no impact was known or suspected within the chaparral and southern oak woodland habitats, no potential exposure pathways were identified for these habitats. The riparian, desert wash, and wetland habitats occur off-facility (OU-3) only, and groundwater typically underlies these habitats at depths of approximately 100 ft or more. For this reason, there were no plausible groundwater exposure pathways to plants and animals within riparian, desert wash, or wetland habitats identified during the ERA. The urban landscape habitat is the predominant on-facility JPL habitat. Constituents in groundwater are found at depths between approximately 100 to 250 ft and groundwater does not recharge on-facility surface water bodies. Therefore, no groundwater exposure pathways to plants and animals were identified.

Therefore, it was concluded that no further characterization of ecological risks to plants and animals due to groundwater impact was warranted because there were no complete exposure pathways from groundwater to on-facility biota.

7.3 Basis for Action

The groundwater beneath the JPL facility contains elevated levels of chemicals that represent a continuing source. The basis for the response action is to contain the source of chemicals in groundwater to prevent further migration to receptors (i.e., production wells) located outside the JPL facility boundary, and to reduce the period of performance of actions taken in OU-3.

This response action is part of a phased approach to characterization and cleanup of groundwater affected by chemicals originating from the JPL facility. This action will be followed by a recommendation for a response action in OU-3, and finally by a long-term comprehensive remedial action designed to address all groundwater associated with both OU-1 and OU-3. A phased approach to cleanup is encouraged by Superfund Accelerated Cleanup Model (SACM) (U.S. EPA, 1992a), whereby characterization and performance data collected during initial phases are used to assess restoration potential.

8.0: REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) in interim decision documents are intended to reduce site risks (by preventing exposure to and further migration of chemicals) and provide additional data to assess the likelihood of restoring groundwater to ARAR or risk-based cleanup levels (i.e., restoration potential). U.S. EPA recommends evaluating restoration potential prior to establishing objectives for the long-term remedy (U.S. EPA, 1996). The response action will be followed by a later, more comprehensive long-term remedy. The RAOs for this response action are as follows:

- Remove chemicals in groundwater and prevent the further spread of VOCs and perchlorate from the groundwater source area.
- Reduce the amount of chemicals distributed in the source area groundwater to improve the effectiveness and efficiency – and reduce costs – of the final cleanup remedy selected for off-facility groundwater.

9.0: DESCRIPTION OF ALTERNATIVES

In January 2000, NASA completed a draft Feasibility Study that identified and evaluated various groundwater cleanup alternatives for both the source area and in off-facility areas adjacent to the JPL facility (FWEC, 2000). In addition, a literature review was conducted to assess the development status of various biological, physical, chemical, and thermal treatment technologies used for the removal of perchlorate from groundwater (NASA, 2006e). As part of this effort, NASA also conducted a number of different pilot tests to see which technologies might be the most promising for use at the JPL site. The technologies tested included reverse osmosis, FBR, packed bed reactors, in situ bioremediation, and ion exchange (NASA, 2003a). The pilot testing was completed in 2002 at which time NASA conducted a technical evaluation to determine the best remedial technique for the source area groundwater. Table 9-1 summarizes the advantages and limitations of the different perchlorate treatment technologies evaluated at JPL.

> The large depth to groundwater limits viable groundwater alternatives at JPL. Based on extensive technology evaluations and testing, two alternatives were selected: (1) no further action; and (2) expansion of the successful demonstration study consisting of groundwater extraction and aboveground treatment.

Due to the depth and extent of the chemicals in groundwater as well as the location and density of buildings at JPL, in situ bioremediation is not practical, nor cost-effective, at the JPL facility. Therefore, groundwater must be pumped from the ground and treated aboveground surface. The best aboveground perchlorate treatment depends on several factors including the perchlorate concentrations that exist, specific site conditions, and other considerations. Two perchlorate treatment processes have been proven at full-scale application at other sites and were effective based on testing at JPL: FBR and ion exchange.

- FBR is cost-effective for relatively high concentrations of perchlorate and at locations where continuous operation can be achieved, such as the source area beneath JPL. The FBR contains carbon particles covered with a coating of bacteria that destroy perchlorate. The primary advantages of this system are the destruction of perchlorate and relatively low operational cost.

- Ion exchange consists of small plastic beads, or resin, in a tank. As the water passes through the tank, perchlorate attaches to the resin. After enough perchlorate attaches to the resin, the resin is removed and sent to a licensed disposal facility, and new resin is added. Ion exchange is the only perchlorate removal technology that has been used for drinking water systems in California and is used at the NASA-funded Lincoln Avenue Water Company system. Ion exchange is more cost-effective at low perchlorate levels, such as those found in groundwater off-facility, and it is more appropriate for operations where the flowrate is varied. Cost estimates obtained for the source area indicate that ion exchange would not be cost-effective, given the relatively high perchlorate concentrations.

Table 9-1. Matrix of Perchlorate Treatment Technologies Tested at NASA-JPL

Description	Advantages	Limitations
Fluidized Bed Reactor (FBR): Envirogen conducted a 30-gpm FBR pilot test at JPL in order to evaluate system performance under site-specific conditions and to provide data to size and cost a full-scale system. A 9% solution of ethanol was used as the electron donor, along with small amounts of nitrogen and phosphorous as nutrients to promote microbial growth. No unplanned excursions were experienced during the operation of the FBR pilot test. During the pilot test, biomass film growth was managed manually and no problems were reported with maintaining a stable biomass, or in controlling the bed height or biofilm growth. Over the duration of the test, the influent perchlorate levels averaged 770 µg/L and were treated to nondetect (<4 µg/L) in the effluent.	❑ FBRs have a larger surface area for biomass growth resulting in a smaller footprint and shorter hydraulic residence time compared to PBRs. ❑ Fluidization and continuous biomass control minimizes clogging and/or channeling in the reactor. ❑ The FBR technology has been successfully commercialized (e.g., at least four full-scale systems are currently in operation). ❑ Biological treatment methods are typically less expensive in terms of both capital and operation and maintenance costs compared to physical/chemical processes. ❑ Biological treatment methods typically generate less hazardous waste than physical/chemical processes.	❑ FBRs are reportedly more expensive to build and operate than PBRs. ❑ High recycle rates are required to keep the filter media fluidized and this can increase capital and electricity costs. ❑ Operational problems have been reported in the literature related to bed media loss, bed height control, and the release of biomass into the effluent. ❑ Process is reliable, but performance issues can occur from suboptimal electron donor dosing, pH changes, temperature changes, or other conditions. ❑ Loss of biological activity could interrupt operation for several days. ❑ Use of biological method may be unfavorable for drinking water applications.
Ion Exchange: Calgon Carbon Corporation (Calgon) completed a 5-month pilot test at JPL to test the effectiveness their patented ion exchange process ($ISEP^{+TM}$) for ClO_4^- removal from groundwater. The $ISEP^{+TM}$ system consists primarily of an ion exchange unit, a ClO_4- and nitrate catalytic destruction module (PNDM), a nanofiltration system for sulfate removal from the brine, and a reverse osmosis unit for rinse water treatment. Calgon's $ISEP^{+TM}$ system is configured to operate in a continuous sequence of perchlorate adsorption, regeneration, and rinsing. Continuous operation is made possible by a system of 25 to 30 ion exchange columns that are placed on a rotating carousel. Influent perchlorate concentrations ranged from 250 to 1,200 µg/L and were treated to nondetect levels (<4 µg/L) in the effluent. The PNDM was demonstrated to reduce perchlorate concentrations in the regenerant brine from 60,000 µg/L to <125 µg/L.	❑ Existing technology that has been tested at the pilot and full-scale. ❑ Dedicated commercial vendors and commercially-available resins. ❑ Proven effectiveness at meeting <4 µg/L of perchlorate in effluent. ❑ Physical treatment technologies are more widely accepted for drinking water applications.	❑ Capital and operation and maintenance costs are significantly higher than biological techniques. ❑ Not all resins are highly selective for perchlorate, and other groundwater anions (e.g., nitrate, sulfate) may interfere with its removal. ❑ Brine treatment and disposal issues may limit cost-effectiveness.
Packed Bed Reactors (PBRs): Both lab-scale and field-scale PBR studies have been conducted at JPL by Foster Wheeler. The lab-scale study consisted of PBR column studies to demonstrate the feasibility of perchlorate reduction in both groundwater and simulated reverse osmosis (RO) rejectates. The PBR field-scale system consisted primarily of two bioreactors in series packed with Celite and two bioreactors in series packed with plastic media. Preliminary Phase I effluent data indicate that perchlorate can be reduced from influent levels of 400 µg/L down to nondetect (<4 µg/L). Phase II treatability study results were not available at the time of this review.	❑ PBR pumping requirements and costs are less than FBRs because lower total flowrates and recycle rates can be used without the need for fluidized media. ❑ Biological treatment methods are typically less expensive in terms of both capital and operation and maintenance costs compared to physical/chemical processes. ❑ Biological treatment methods typically generate less hazardous waste than physical/chemical processes.	❑ PBRs appear to be prone to channeling and clogging, and frequent backwashing (at least weekly) may be needed. ❑ Frequent backwashing may impair the ability of the biomass to degrade perchlorate. ❑ Process is reliable, but performance issues can occur from suboptimal electron donor dosing, pH changes, temperature changes, or other conditions. ❑ Loss of biological activity could interrupt operation for several days. ❑ Use of biological method may be unfavorable for drinking water applications.
In Situ Bioremediation (ISB): ISB was evaluated at JPL by ARCADIS during lab and field studies consisting of corn syrup injection to create an in situ anaerobic reactive zone. While the study appeared effective in creating mildly reducing conditions and stimulating some biodegradation of perchlorate, the high flux of groundwater limited the success of the study (ARCADIS, 2004). Due to the depth of groundwater, the variable and generally high groundwater flux, and large size of the groundwater plume at JPL, the primary challenges with ISB are finding effective methods to deliver and distribute sufficient electron donor.	❑ ISB destroys perchlorate in situ, reducing need for aboveground treatment processes. ❑ At some sites, ISB can be configured so that no aboveground treatment and/or disposal of groundwater are needed. ❑ At sites with shallow groundwater and/or a small aerial extent, semipassive or passive delivery methods may involve less capital and operation and maintenance costs compared to ex situ treatment options. ❑ Chlorinated VOCs (e.g., PCE and TCE) may also be degraded with electron donor delivery to the subsurface.	❑ The number of field-scale perchlorate applications conducted to date is limited. ❑ In situ bioremediation is best suited to sites with well-defined source areas and shallow or narrow zones of contamination. ❑ Biofouling can cause significant operation and maintenance issues. ❑ Inefficient donor delivery can lead to little or no in situ biodegradation of perchlorate. ❑ Low pH, high salinity, nitrate, etc. can influence the rate of perchlorate degradation. ❑ ISB can adversely impact groundwater quality (e.g., metals mobilization, sulfide release, methane production).
Continuously Stirred Tank Reactors (CSTRs): A laboratory-scale study was conducted for JPL to evaluate the use of a CSTR for the treatment of RO rejectates. The study demonstrated the rapid development of a perchlorate-reducing culture in a lab-scale CSTR. It was estimated in this study that the CSTR process would be able to reduce perchlorate within a residence time of 1 to 4 hours.	❑ Effectively treats very high levels of perchlorate. ❑ Can be used to reduce perchlorate in high salinity (>2%) wastewaters. ❑ Process is well understood and the system is relatively easy to maintain.	❑ Concentrations above 6,000 mg/L appear to inhibit perchlorate reduction by microbes. ❑ High organic matter present in CSTR effluent may require additional treatment. ❑ High residence times limit the ability to treat high flowrates. ❑ Process is reliable, but performance issues can occur from suboptimal electron donor dosing, pH changes, temperature changes, or other conditions.
Reverse Osmosis (RO): U.S. Filter Corporation conducted a laboratory treatability study to assess the effectiveness of using RO to remove perchlorate from JPL groundwater. Both a thin film composite membrane and a cellulose acetate membrane were evaluated. The results from the thin film composite test were more promising than the cellulose acetate membrane test. In both tests, approximately 80% of the influent stream was recovered as permeate. However, with perchlorate influent levels of 800 µg/L, the thin film membrane achieved 12 to 16 µg/L in the permeate, whereas the acetate membrane contained perchlorate levels as high as 680 µg/L. The rejectate consisted of 20% of the influent stream and contained perchlorate at approximately 3,600 µg/L for the thin film membrane and 1,600 µg/L for the cellulose acetate membrane.	❑ Dedicated commercial vendors. ❑ Physical treatment technologies are more widely accepted for drinking water applications.	❑ Low levels of perchlorate would require multiple passes through RO. ❑ Capital and operation and maintenance costs are significantly higher than biological techniques. ❑ Membrane fouling can cause significant operation and maintenance issues. ❑ Large volume (up to 20%) of waste brine must be treated and/or disposed.

The U.S. EPA has identified air stripping and LGAC as the best technologies to use for aboveground treatment of groundwater containing VOCs, referring to these as "presumptive technologies" (U.S. EPA, 1996). U.S. EPA expects these technologies to be used for removal of VOCs at "all appropriate sites." LGAC treatment is currently in place at JPL and is working effectively as part of the existing source area demonstration treatment system.

Based on earlier studies, NASA installed a demonstration treatment plant (see Figure 9-1) in early 2005, using FBR treatment for perchlorate and LGAC treatment for VOCs (NASA, 2005b). The water is pumped out of the ground, treated, and injected back into the ground approximately 330 ft north of the extraction wells. Figures 9-2 and 9-3 show the layout of the treatment plant, and Figure 9-3 describes the different components of the existing demonstration treatment system.

Construction of the demonstration treatment plant system was completed in early 2005 with design flow operations commencing in March 2005. Operations to date show that the system has been very effective in removing VOCs and destroying perchlorate. More than 400 lb of perchlorate and more than 12 lb of VOCs have been removed since commencing operation of the demonstration study (NASA, 2005d; NASA, 2006a). This system has been successful in its demonstration phase, and expansion of the system has been identified in this ROD as the Preferred Alternative.

For this response action, the Preferred Alternative of expanding the existing demonstration study system is evaluated against the No Further Action (NFA) alternative.

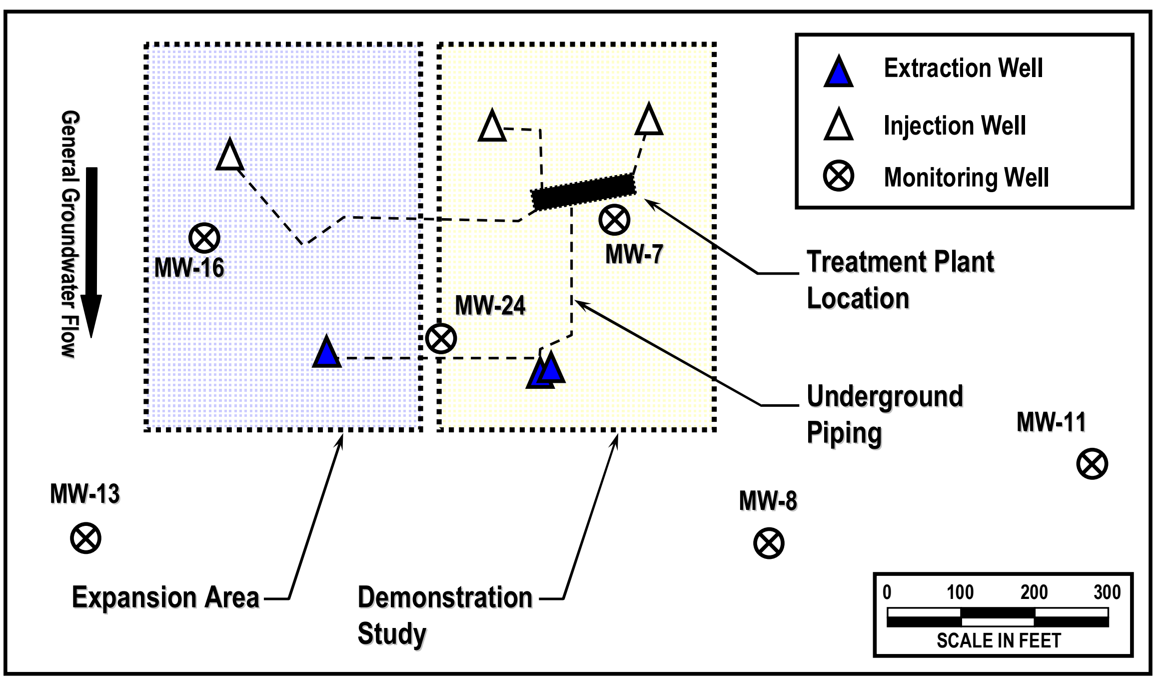
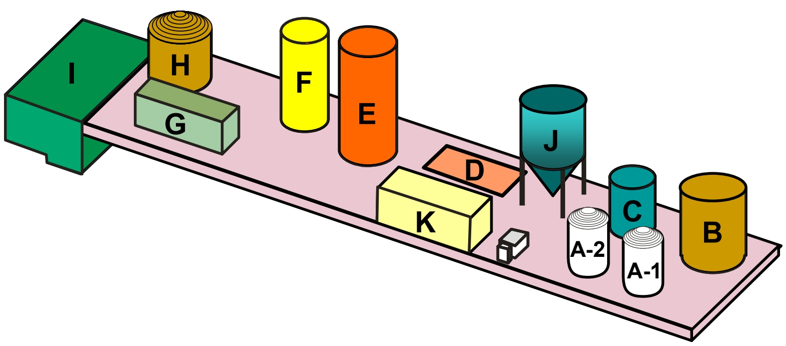


Figure 9-1. Layout of the Existing Demonstration System and the Expansion Area

Figure 9-2. Picture of the Existing Source Area Groundwater Treatment Facility



Name	Label	Description
LGAC	A-1, A-2	LGAC vessels to remove VOCs
T-202	B	LGAC backwash water and feed tank
T-201	C	FBR feed tank
FBR Skid	D	Skid with FBR fluidization pumps
FBR	E	Anoxic biological reactor used to remove perchlorate
T-401	F	Aeration tower
F-401	G	Tri-media filter
T-501	H	Treated water tank
T-801	I	Sump for holding F-401's backwash flush water.
Clarifier	J	Condenses solids prior to sanitary sewer discharge
Controls Trailer	K	Trailer contains system controls and on-site laboratory

Figure 9-3. Components of the Demonstration Study Treatment System

9.1 Alternative 1: No Further Action

9.1.1 Description of Remedy Components

The NFA alternative includes no active treatment or containment activities to remediate chemicals in on-facility groundwater at JPL, and no institutional controls to protect the public or the environment from exposure to chemicals in groundwater. However, it does include a groundwater monitoring program currently in place at JPL. As part of the NFA alternative, the results of the monitoring program are used to track concentrations and the extent of chemicals in groundwater beneath JPL over time. The concentrations and extent of chemicals in the groundwater may decrease gradually over time due to chemical or physical transformation, sorption, and/or dilution.

9.1.2 Common Elements and Distinguishing Features

Because groundwater monitoring is the only active component of the NFA alternative, this alternative is not likely to meet chemical-specific ARARs for OU-1, or help the final remedy achieve chemical specific ARARs. The NFA alternative is not likely to be effective over the long term or to meet the RAO for OU-1 in a reasonable timeframe because chemicals in the groundwater are not removed and can continue to migrate to areas off-facility. For a discussion of ARARs for OU-1, see Section 12.2 of this report.

There are no costs for the No Further Action option, other than the existing operation and maintenance (O&M) costs which are part of the existing groundwater monitoring program at OU-1.

9.1.3 Expected Outcomes

The NFA alternative is not a treatment or containment technology and is not expected to reduce the toxicity, mobility, or volume of chemicals of concern at OU-1. Under the NFA alternative, no remediation of OU-1 is planned except that which occurs naturally due to chemical/biological degradation, dispersion, advection, and sorption. The NFA alternative is not expected to prevent further migration of VOCs and perchlorate to areas off-facility, and thus is not expected to meet RAOs for OU-1.

9.2 Alternative 2: Expansion of the Existing Demonstration Treatment System

9.2.1 Description of Remedy Components

Alternative 2 involves expansion of the existing demonstration study system consisting of extraction, treatment and reinjection to remove VOCs and perchlorate from groundwater in the source area. Two different removal processes take place during treatment:

1) **VOC removal.** VOCs are removed from the groundwater by filtration through LGAC. The LGAC is used to reduce carbon tetrachloride, 1,1-TCE,

TCE, PCE, and other VOCs. Once the LGAC is exhausted of absorptive properties, the spent activated carbon is classified as hazardous or non-hazardous waste in accordance with the Code of Federal Regulations (40 CFR 261.31 to 261.33 and 261.21 to 261.24) and the California Code of Regulations (22 CCR) and disposed of accordingly.

2) **Perchlorate removal.** Perchlorate removal is achieved by using a FBR treatment system, which involves a biological process to break down and consume perchlorate from groundwater.

The extraction, treatment, and reinjection system for OU-1 currently consists of a combination of two extraction wells (EW-1 and EW-2) and two reinjection wells (IW-1 and IW-2). Additional extraction and injection wells will be installed and constructed in a manner similar to the existing extraction and reinjection wells at JPL. The extraction, treatment, and reinjection systems will be operated until the criteria for discontinuing operation have been met. Activities associated with the monitoring program will be discontinued once RAOs have been achieved.

9.2.2 Common Elements and Distinguishing Features

Source area groundwater treatment using extraction, treatment and injection will improve the effectiveness and efficiency of the groundwater remedy for OU-3 by significantly reducing chemical mass in groundwater that migrates off-facility. In addition, it will provide a benefit to the final remedy in achieving chemical specific ARARs. For more detail on ARARs, see Section 12.2 of this report.

Extraction, treatment and reinjection are presumptive remedies commonly used to clean up sites similar to OU-1, where VOCs and perchlorate are present in groundwater. VOC treatment technologies are well known (U.S. EPA, 1996). Use of FBR for perchlorate removal from groundwater has a proven track record for effectiveness, reliability, and control based on a review of full-scale operations at other sites. Several full-scale FBR systems for perchlorate removal from groundwater are currently operational. The full-scale performance of FBRs was reviewed based on reports from the 6,000-gallons-per-minute (gpm) Aerojet system, the 50-gpm Long Horn Army Ammunition Plant system, and the 400-gpm Naval Weapons Industrial Reserve Plant McGregor system (NASA, 2006e). In addition, a 150-gpm system currently is operating successfully at JPL. The system has consistently reduced the average influent perchlorate concentration from approximately 1,500 µg/L to <4 µg/L. In addition, no problems were reported with maintaining a stable biomass or in controlling the bed height or biofilm growth (NASA, 2005c; NASA 2005d; NASA, 2006a). Therefore, the treatability study successfully demonstrated that an FBR could be implemented at NASA JPL to treat perchlorate and meet target reinjection levels.

Maximum capital costs for expansion of the existing FBR extraction, treatment, and reinjection demonstration study system are estimated at approximately $1,032,000 (assuming an additional two extraction wells and two injection wells). O&M costs are estimated at approximately $825,000 annually, which does not include the costs for groundwater monitoring associated with either alternative. The extraction, treatment, and reinjection system configuration, sampling frequencies, and duration used are for cost-estimating and comparison purposes only. A summary of estimated costs is presented in Section 11.3.

9.2.3 Expected Outcomes

The extraction, treatment, and reinjection alternative is expected to permanently reduce the volume of VOCs and perchlorate at OU-1, and to reduce the chemical mass in groundwater that migrates off-facility. Thus, the treatment alternative is expected to meet RAOs for OU-1 and to improve the effectiveness and efficiency of the selected remedy for OU-3. In addition, expansion of the existing demonstration treatment system is not expected to restrict normal activities or future land use at JPL.

10.0: SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

NASA evaluated the remedial alternatives for OU-1 in accordance with the nine criteria defined in the NCP (40 CFR Part 300):

- Protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance.

These nine evaluation criteria can be categorized into three groups: threshold criteria, primary balancing criteria, and modifying criteria. All threshold criteria must be satisfied in order for a remedial alternative to be eligible for selection. The threshold criteria are protection of human health and the environment and compliance with ARARs. The primary balancing criteria are used to weigh major tradeoffs among alternatives. The primary balancing criteria are long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The modifying criteria, state and community acceptance, usually are addressed after public comments are received on the Proposed Plan. At that time, public comments are reviewed with state regulatory agencies to determine if the preferred alternative remains the most appropriate remedial action.

10.1 Comparison of Remedial Alternatives Using Evaluation Criteria

This section uses the nine evaluation criteria to compare and evaluate the remedial action alternatives for OU-1 source area groundwater. Table 10-1 summarizes the screening of the two alternatives for OU-1:

1) Alternative 1, NFA; and
2) Alternative 2, expansion of the existing demonstration treatment system.

10.2 Protection of Human Health and the Environment

Groundwater at the JPL facility is not extracted for distribution within the facility and workers at the facility do not have access to untreated water from the site. The risk assessment in the OU-1/OU-3 RI determined that although there is no complete pathway for exposure to

Table 10-1. Comparison Summary of Remedial Alternatives for OU-1

Criteria	Alternative 1	Alternative 2
Description	• No Further Action	• Expansion of the Existing Demonstration Treatment System
Overall Protection	• Not protective of environment	• Short- and long-term protection of the environment by reducing VOC and perchlorate concentrations
Compliance with ARARs	• Action- and location-specific ARARs are not applicable • Provides no benefit to the final remedy in achieving chemical-specific ARARs	• Complies with action- and location-specific ARARs • Provides benefit to the final remedy in achieving chemical-specific ARARs.
Long-Term Effectiveness and Permanence	• Not effective in long-term • VOCs and perchlorate remain in groundwater and could migrate to off-facility areas	• Effective in long-term • Established technique for removing VOCs and perchlorate from groundwater
Reduction of Toxicity Mobility, or Volume	• No reduction in mobility or volume of VOCs or perchlorate	• Significantly reduces mobility and volume of VOCs and perchlorate through treatment
Short-Term Effectiveness	• No risk to workers, community, or environment	• Does not present substantive risks to on-facility workers or community in short term
Implementability	• Easily implemented	• Technology is proven to be effective, readily available, and easily expandable
Cost	• Approximate cost: $0	• Approximate cost: $8,094,000
Conclusion	• Does not meet criteria	• Preferred Alternative

untreated groundwater from beneath the JPL site, hypothetical exposure to untreated groundwater through mechanisms including ingestion, dermal contact, and inhalation of water vapors could result in unacceptable cancer and non-cancer risks. The scoping assessment of ecological risks concluded that no complete pathway exists for ecological exposure to the untreated groundwater; therefore, no significant ecological risks exist.

Based on these assessments, Alternative 1 (NFA), and Alternative 2 (expansion of the existing demonstration treatment system), are protective of human health because there is no potential for exposure to untreated groundwater. However, if not removed, VOCs and perchlorate may continue to migrate to off-facility areas. Because of this possibility, Alternative 1 is not protective of the groundwater and environment. Under Alternative 2, the reduction of VOC and perchlorate mass in the on-facility groundwater will result in reduced chemical mass migrating to off-facility areas, thereby helping to protect the environment and improving the effectiveness and efficiency of the OU-3 groundwater remedy.

10.3 Compliance with Applicable or Relevant and Appropriate Requirements

Section 12.2 of this document contains an evaluation of ARARs that may apply to the OU-1 treatment facility. They include the Resource Conservation and Recovery Act, Safe Drinking Water Act, and policies set by the State Water Resources Control Board and Regional Water Quality Board, among others.

Action- and location-specific ARARs are not applicable to Alternative 1 (NFA). NFA does not provide any benefit to the final remedy in achieving chemical-specific ARARs because groundwater at JPL is not treated. Alternative 2 (expansion of the existing demonstration treatment system) meets all identified ARARs and reduces the migration of VOCs and perchlorate to off-facility areas, providing benefit to the final remedy in meeting chemical-specific ARARs.

10.4 Long-Term Effectiveness and Performance

Alternative 1 (NFA) is not effective over the long term under this alternative, because chemicals in the groundwater can continue to migrate into off-facility areas.

Alternative 2 (expansion of the existing demonstration treatment system) is effective for the long term. The treatment process permanently removes VOCs and perchlorate. The system would be effective over the long term through an overall reduction in the mass and volume of perchlorate and VOCs in the saturated zone that would achieve remediation goals. Alternative 2 is expected to meet the RAO of reducing migration of facility-related chemicals of interest in groundwater, thereby shortening the period of operation of the OU-3 containment/treatment system.

10.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 (NFA) is not effective in reducing the toxicity, mobility, or volume of chemicals of concern under this alternative, because chemicals in the groundwater can continue to migrate into off-facility areas.

Alternative 2 reduces the toxicity, mobility, and volume of chemicals of concern. The treatment process used for Alternative 2 destroys perchlorate, eliminating the possibility for subsequent release and exposure. The VOCs that are removed through LGAC treatment are reduced in volume and mobility compared to the untreated groundwater. Waste LGAC would be handled, treated, or disposed of by a licensed commercial waste management firm.

10.6 Short-Term Effectiveness

Alternative 1 (NFA) is not effective over the short term because, under this alternative, chemicals in the groundwater can continue to migrate into off-facility areas.

In general, Alternative 2 is expected to be effective over the short-term. There would be no risk to the community during the expanded system construction and implementation phase, as all of the components are on the JPL facility. A slight, temporary increase of short-term risk to the environment and workers would occur during construction of the new wells and trenching and the associated generation of waste. However, these risks would be mitigated through safe construction practices and engineering controls. The waste streams generated during operation would be handled, treated, or disposed of by a licensed waste management firm.

10.7 Implementability

Alternative 1 (NFA) is easily implemented. The equipment and methods used for groundwater sampling and analysis are commercially-available and currently in use.

The extraction, treatment and reinjection technologies for removal of VOCs and perchlorate included in Alternative 2 are widely used and have been proven effective during the ongoing treatability study of the OU-1 treatment system. Moreover, the treatment system has already been installed and is capable of expansion.

10.8 Costs

A summary of the present-worth costs associated with the remedial alternatives for OU-1 is presented in Table 10-2. There are no costs associated with Alternative 1.

Table 10-2. Comparison of Cost Estimates for Alternatives 1 and 2

Description	Capital Costs[a]	Annual O&M Costs[a]	Total Cost[a,b]
Alternative 1: NFA			
NFA Cost	—	—	—
Alternative 2: Extraction, Treatment, and Reinjection			
Extraction Treatment Cost	$1,032,000	$825,000	$8,094,000

(a) Costs are estimated to the nearest $1,000. Estimates are within a −30% to +50% range of accuracy.
(b) Total costs are estimated at present-worth value, assuming 15 years operation and 8% annual interest rate.

Costs associated with Alternative 2 include installation and operation of two additional extraction wells and up to two additional reinjection wells. O&M costs for Alternative 2 include operation and maintenance of the FBR system.

10.9 State Acceptance

The state acceptance criterion requires that NASA, as the responsible party, address the state's comments and concerns for each proposed remediation alternative. Comment responses have been accepted by the state. All state agencies have agreed to the proposed remedial Alternatives

1 and 2, and to the selected remedy, Alternative 2. This ROD documents state acceptance of Alternative 2. The DTSC and RWQCB concur with the recommendations of this ROD.

10.10 Community Acceptance

NASA carefully evaluated all public comments taking into consideration information provided by the public and responded to all questions. Part 3 of this ROD documents the comments that NASA received from the public regarding the proposed expansion of the existing OU-1 source area groundwater treatment system and provides NASA's responses to those comments. Although NASA received a number of comments and questions during the public comment period for the Proposed Plan, none of the public stakeholders objected to implementation of the selected remedy.

11.0: THE SELECTED REMEDY

As required by CERCLA and NCP, remedial alternatives were identified and screened based on effectiveness, implementability, and cost. These alternatives were then subject to detailed analysis using the nine criteria described in Section 10.0 of this ROD. Based on the comparative analysis of the remedial alternatives, the selected remedy for addressing OU-1 is Alternative 2, expansion of the existing demonstration treatment system. NASA, U.S. EPA, DTSC, and RWQCB agree with the selection of this alternative for remediation at OU-1.

11.1 Rationale for the Selected Remedy

Based on the evaluation of threshold and primary balancing criteria in Section 10.0, Alternative 2 is the most effective remedial alternative for removal of chemicals of concern from groundwater at JPL. Because of the potential for continued migration of VOCs and perchlorate to off-facility areas, Alternative 1 (NFA) is not protective, and the RAOs for OU-1 cannot be met under this alternative. Alternative 2 will remove VOCs and perchlorate from the groundwater, and thus reduce the migration of VOCs and perchlorate to off-facility areas. The OU-1 expanded treatment system has been running at a rate of 150 gpm since February 2005 and has consistently removed VOCs and perchlorate (NASA 2005c; NASA 2005d; NASA, 2006a).

11.2 Description of the Selected Remedy

Under the selected remedy, VOCs and perchlorate in the groundwater are treated using extraction, treatment, and reinjection methods. New wells will be installed and constructed in a manner similar to the existing OU-1 treatability study wells (EW-1, EW-2, IW-1, and IW-2). One to two new extraction wells and at least one more injection well will be installed as part of the system expansion. In total, the treatment system for OU-1 will consist of up to four extraction wells and four injection wells.

The system expansion will increase the treatment flowrate from approximately 150 gpm to a rate of approximately 350 gpm. The first treatment process is VOC removal; VOCs are removed from the groundwater by filtration through LGAC. The LGAC will be used to reduce carbon tetrachloride, 1,1-DCE, TCE, PCE, and other VOCs. Once exhausted of absorptive properties, the spent activated carbon will be classified as hazardous or non-hazardous waste in accordance with the Code of Federal Regulations (40 CFR 261.31 to 261.33 and 261.21 to 261.24) and the California Code of Regulations (22 CCR) and disposed of accordingly. The second process involved in treatment is the perchlorate removal process. Perchlorate removal will be achieved by using an FBR treatment system, which involves a biological process to break down and remove perchlorate from groundwater.

Potential post-construction refinements may include the following:

- Addition or removal of extraction or injection wells.
- Adjusting the system flowrate.

- Refining ex situ treatment components as influent concentrations change.
- Modifying ex situ treatment chemicals or amendments prior to groundwater reinjection.
- Addition or removal of monitoring wells.

Once operation of the extraction, treatment, and reinjection system is no longer necessary and/or cost-effective to mitigate VOCs and perchlorate migration to off-facility areas at levels of potential concern, the system will be shut down and dismantled.

The selected remedy also includes an ongoing groundwater monitoring program. This program will be used to evaluate the extraction, treatment, and reinjection system effectiveness and remedial progress. The groundwater monitoring program will be terminated upon achieving the RAO.

11.3 Estimated Remedy Costs

Table 11-1 presents the estimated capital costs for the full-scale extraction, treatment and reinjection system at OU-1. The term capital cost refers to the funds required to cover the initial non-recurring costs associated with purchasing and installing the technology to the point where it is ready for its intended use. The capital cost estimate for the extraction, treatment, and reinjection system at JPL OU-1 is based on the installation of a maximum of four extraction wells and four reinjection wells. Costs associated with the installation of the extraction, treatment, and reinjection wells include drilling expenses, waste disposal, well materials, and other miscellaneous expenses. The design and construction management costs also are included as part of the capital cost.

Table 11-1. Estimate of Capital Costs for Expansion of the Existing Demonstration Treatment System

Description	Total Cost
Well Installation	$480,000
Engineering & Submittals	$24,000
Capital Equipment	$18,000
System Installation	$280,000
Project Management/Design	$230,000
Total	**$1,032,000**

The O&M costs of a technology are the recurring or periodic costs incurred during the operating life of the system. The OU-1 O&M costs include labor, equipment rental, carbon replacement costs, and other expenses. Table 11-2 presents the annual O&M costs for extraction treatment and reinjection at OU-1. Groundwater monitoring costs were not included as part of the remedy operation costs.

Table 11-2. Estimate of Annual Operation and Maintenance Costs for OU-1

Field Program	Quantity	Unit	Unit Cost	Total Cost
On-site Labor	1	Per Year	$113,800	$113,800
Chemicals	1	Lot	$128,202	$128,202
Bag Filters	5	Case of 50	$213.50	$1,068
Carbon	1	Per Year	$52,800	$52,800
Electricity	12	Per Month	$3,000	$36,000
Laboratory-Performance	12	Per Month	$12,043	$144,516
Laboratory- Sanitary Sewer	24	Per Event	$1051.75	$25,242
Other Rental/Disposal	1	Lot	$39,800	$39,800
Well rehabilitation	2	Per Year	$25,500	$51,000
Reporting/Project Management	1	Per Year	$232,600	$232,600
Annual O&M Cost				**$825,028**

The total present worth for expansion of the existing demonstration treatment system is estimated to be $5,046,000 based on the capital costs and the annual OU-1 O&M costs incurred over the life of the project. The amount does not include groundwater monitoring costs. The term "present worth" represents the amount of money or principal needed today to cover the costs over the lifetime of the remediation project given a certain interest rate. This present-worth cost estimate was based on the following simplifying assumptions:

- Implementation time for the selected remedy is 15 years.
- Interest rate of 8%.

The OU-1 system configuration, sampling frequencies, and project duration listed in the proceeding sections are conservative for cost-estimating purposes only, and may vary during remedy implementation.

11.4 Expected Outcomes of the Selected Remedy

The response action for OU-1 is intended to provide source treatment and containment to prevent migration of chemicals off-facility and reduce clean up times for OU-3. JPL is located within the Raymond Basin Watershed, which is a current source of drinking water.

It is anticipated that the response action will help to reduce OU-3 groundwater treatment costs and help restore aquifer water quality. Performance objectives have been established to evaluate system effectiveness until the final remedy is in place. The performance of the system will be evaluated and optimized on a continuing basis and the information regarding the amount of VOCs and perchlorate removed will be reported to the regulatory agencies as needed to effectively evaluate system performance objectives. The performance objectives include the following:

- Reduction of overall VOC and perchlorate concentrations within the groundwater monitoring wells and extraction wells compared to baseline levels.

- Asymptotic mass removal achieved after appropriate system optimization. Asymptotic conditions will have been reached when the upper limb of the cumulative mass removal curve approaches zero.

- Operate only as long as cost-effective. The OU-1 source area groundwater treatment system will no longer be cost-effective when operating costs per unit of VOC and perchlorate mass removed from the groundwater indicate that the additional cost of continuing to operate the system is not warranted and/or when shutdown of the OU-1 system is not anticipated to significantly increase the cost of the OU-3 groundwater remedy or significantly prolong the time to achieve groundwater cleanup.

The existing groundwater monitoring network will be evaluated during the remedial design phase to determine if sufficient coverage is available to monitor changes in the lateral and vertical distribution of VOCs and perchlorate, as well as the effectiveness of cleanup. Additional groundwater monitoring wells will be installed as necessary to monitor effectiveness of the response action.

After the performance objectives have been achieved, the OU-1 system may be idled and groundwater monitoring will continue to evaluate rebound. In addition, the system will be idled if MCLs are achieved in the source area (see Section 12.2). If significant rebound occurs, the OU-1 system will be reinitiated; otherwise the system will be permanently shut down and dismantled. When performance objectives have been achieved, NASA will request shutdown of the OU-1 system. NASA will shut down the OU-1 system once approval has been granted by the U.S. EPA, DTSC and RWQCB.

Minimal environmental impacts are expected from OU-1 response action implementation. Groundwater treatment will have no adverse impacts on threatened or endangered species, cultural resources, floodplains, or wetlands. NASA expects no adverse human health impacts from this CERCLA action to occur in any off-facility community, including minority and low-income communities. With system implementation, increases in JPL traffic will be minimal and consist of transportation of equipment and supplies to and from the JPL facility, resulting in insignificant transportation impacts. There will be no measurable impact on the local economy as a result of system implementation, and thus, no socioeconomic impacts are anticipated. Also, there will be no irreversible and irretrievable commitment of resources and the cost of remediation is justified to protect the existing source of drinking water.

Additional information regarding the anticipated socioeconomic, transportation, natural resources, and environmental justice impacts associated with the implementation of OU-1 response action are discussed in the NEPA Values Assessment (NASA, 2006c).

12.0: STATUTORY DETERMINATIONS

NASA must undertake remedial actions at this CERCLA site to achieve protection of human health and the environment. In addition, the selected remedy for this site must meet applicable or relevant and appropriate environmental standards as established under federal and state environmental laws, unless a statutory waiver is justified. The selected remedy must also be cost-effective and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Finally, the remedy should also employ treatment to permanently and significantly reduce the volume, toxicity, or mobility of chemicals in the source area groundwater. This section provides a brief description of how the selected remedy, expansion of the existing demonstration system, satisfies the statutory requirements of CERCLA.

12.1 Protection of Human Health and the Environment

Groundwater at the JPL facility is not extracted for distribution within the facility and workers at the facility do not have access to untreated water from the site. Because there is no complete pathway for exposure to untreated groundwater from beneath the JPL site, there is currently no human health risk associated with OU-1. However, if not removed, VOCs and perchlorate may continue to migrate to off-facility areas. Because of this possibility, Alternative 1 (NFA) is not protective of the groundwater and environment. Under Alternative 2, the reduction of VOC and perchlorate mass in the on-facility groundwater will result in reduced chemical mass migrating to off-facility areas, thereby helping to protect the environment and improving the effectiveness and efficiency of the OU-3 groundwater remedy. Alternative 2 does generate concentrated VOC waste in the form of spent carbon; however, this waste stream is easily managed and can be disposed of safely.

12.2 Compliance with Applicable or Relevant and Appropriate Requirements

Compliance with ARARs addresses whether a remedial action alternative meets all pertinent federal and state environmental statutes and requirements. An alternative must comply with ARARs or be covered by a waiver to be acceptable. This section discusses ARARs associated with the Safe Drinking Water Act (SDWA), the Resource Conservation and Recovery Act (RCRA), and various resolutions set forth by the state and the RWQCB. However, in accordance with U.S. EPA guidance, only those requirements that are ARARs to the limited-scope interim action are discussed (U.S. EPA, 1999). An interim action must comply with ARARs triggered by the action and location (e.g., regulations concerning disposal and reinjection). However, an interim action does not need to comply with chemical-specific ARARs that will be addressed by the final remedy (e.g., attaining aquifer cleanup to certain levels).

To implement the expanded treatment system, various regulatory issues and legal considerations must be examined in regard to the injection of treated groundwater. Because the JPL is on the

National Priorities List (NPL), the site is subject to the provisions of CERCLA as amended by SARA. As such, federal regulations and policy governing reinjection of water into the subsurface will be adhered to, in conjunction with complying with the substantive requirements of state regulations and policy (U.S. EPA, 1992b). Legal considerations of reinjection must also be examined because the JPL facility is located in the adjudicated Raymond Basin Watershed.

12.2.1 Federal Regulations and Policy

Safe Drinking Water Act – Federal MCLs developed by U.S. EPA under the SDWA are potential relevant and appropriate requirements for aquifers. The point of compliance for MCLs under the SDWA is at the tap. Therefore, the MCLs are not "applicable" ARARs for NASA sites. However, MCLs are generally considered relevant and appropriate as remediation goals for current or potential drinking water sources, and therefore are potential chemical-specific federal ARARs for final groundwater remedial actions under CERCLA. Because this is an Interim ROD, establishing cleanup goals for the aquifer is not part of this response action. Cleanup goals for the aquifer will be addressed as part of the final remedy for groundwater. However, the system will be idled if MCLs are achieved within the source zone prior to implementing the final remedy for groundwater (see Section 11.4).

Resource Conservation and Recovery Act – Section 3020 of RCRA applies to the underground injection in the context of RCRA and CERCLA cleanups. RCRA section 3020(a) bans underground injection into or above a geologic formation that contains an underground source of drinking water. However, RCRA section 3020(b) provides an exemption from that ban if certain conditions are met (U.S. EPA, 2002). These conditions include the following:

- The reinjection is part of a response action under Section 104 or 106 of CERCLA, or part of RCRA corrective action intended for site cleanup;
- The groundwater is treated to substantially reduce chemicals prior to such reinjection; and
- The cleanup will, upon completion, be protective of human health and the environment.

The second point above means that treatment must occur before reinjection; however, the substantial reduction of the chemicals in the groundwater can occur either before or after reinjection of the groundwater (U.S. EPA, 2000).

The applicability of RCRA land disposal restrictions (LDRs) to groundwater reinjection performed during an RCRA corrective action or CERCLA response action is also a consideration (see RCRA sections 3004 (f), (g), and (m), and 40 CFR Parts 148 and 268). Groundwater undergoing reinjection may contain regulated chemicals; thus, the issue could be raised as to whether reinjection of groundwater should meet treatment standards identified as best demonstrated available technology (BDAT). An interpretation of the applicability of the RCRA LDRs is provided in an EPA memorandum titled "Applicability of Land Disposal Restrictions to RCRA and CERCLA Ground Water Treatment Reinjection" (U.S. EPA, 1989b). This memorandum explains that even though the LDR provisions address the same activity as RCRA section 3020, U.S. EPA interprets the provisions of RCRA section 3020 to be applicable instead of LDR provisions (U.S. EPA, 1989b).

Another potential issue is whether LDR treatment standards are relevant and appropriate for treated groundwater that is reinjected as part of a CERCLA response action. The U.S. EPA believes that the ultimate purpose of treatment is to restore the groundwater to drinking water conditions; thus, standards that have been developed to establish drinking water quality levels (e.g., MCLs) are to be used. Therefore, promulgated drinking water standards should be used where available. If no promulgated drinking water standard exists, then relevant and appropriate requirements such as health-based standards or LDR treatment standards should be used (U.S. EPA, 1989b).

RCRA Hazardous Waste Identification Criteria − These criteria (40 CFR 261) are promulgated by the federal government to define RCRA hazardous waste. An RCRA hazardous waste is a waste that appears on one of the four hazardous wastes lists (F-list, K-list, P-list, or U-list), or exhibits at least one of four characteristics (of hazardous waste) − ignitability, corrosivity, reactivity, or toxicity. Hazardous waste is regulated under RCRA Subtitle C. This requirement may apply to the disposal of LGAC media and other process waste. The spent media will be characterized in accordance with RCRA and will be disposed of accordingly.

12.2.2 State Regulations and Policy

California Safe Drinking Water Act and State MCLs – California has established standards for sources of public drinking water, under the California Safe Drinking Water Act of 1976 (H&SC Section 4010.1 and 4026[c]) and state MCLs for organic chemicals are set forth in CCR Title 22, Section 64444. Some state MCLs are more stringent than the corresponding federal MCLs. In these instances, the more stringent state MCLs are applicable to the remedial action at JPL. NASA has determined that the substantive provisions of the standards in CCR Title 22, Section 64444 are relevant and appropriate to the final remedy for groundwater because VOCs will be remediated to a level expected to protect groundwater quality. Since this is an Interim ROD, establishing cleanup goals for the aquifer is not part of this response action. Cleanup goals for the aquifer will be addressed as part of the final remedy for groundwater. However, the system will be idled if MCLs are achieved within the source zone prior to implementing the final remedy for groundwater (see Section 11.4).

General Waste Discharge Requirements – General waste discharge requirements (WDRs) associated with groundwater reinjection during remedial activities are provided by the RWQCB Los Angeles Region in Order No. R4-2005-0030, *General Waste Discharge Requirements for Groundwater Remediation at Petroleum Hydrocarbon Fuel and/or Volatile Organic Compound Impacted Sites* (RWQCB, 2005). These general WDRs are applicable to in situ groundwater remediation or the extraction of groundwater with aboveground treatment and reinjection of treated groundwater to the same aquifer zone. The requirements contained in Order No. R4-2005-0030 are consistent with all water quality control policies, plans, and regulations in the California Water Code (CWC) and the revised Water Quality Control Plan (Basin Plan) for the Los Angeles Region (RWQCB, 1994). The general WDRs are intended to protect and maintain the existing beneficial uses of the receiving groundwater (RWQCB, 2005) and are consistent with the anti-degradation provisions of State Water Resources Control Board Resolution No. 68-16.

RWQCB Order No. R4-2005-0030 requires that groundwater reinjection shall not adversely impact the receiving groundwater in terms of water quality and chemical concentrations at a "compliance point, downgradient and outside the application area." The application area at JPL is the same as the source zone (i.e., the 8-acre by 100-ft thick portion of the aquifer containing elevated levels of VOCs and perchlorate). Impacts to the water quality and chemical concentrations of the receiving groundwater will be evaluated as part of NASA's groundwater monitoring program at JPL based on analytical results from samples collected from monitoring wells located inside the application area (i.e., source area), wells located outside the source area but still within the plume of target chemicals, and wells located outside the current plume of target chemicals. Groundwater will be treated prior to reinjection (see Section 9.0) to reduce concentrations of target chemicals. All reinjected water will be treated to concentrations cleaner than the receiving water. The electron donor to be used will be the same as, or similar in nature to, carbon sources/electron donors listed in RWQCB Order No. R4-2005-0030, Provision A(c)(4). This action will comply with the substantive requirements associated with groundwater reinjection in the general WDRs and State Water Resources Control Board Resolution 68-16.

Non-RCRA (California) Hazardous Waste Identification Criteria − These criteria (CCR Title 22 Section 66261.24) are promulgated by the State of California to define non-RCRA (California) hazardous waste. A non-RCRA (California) hazardous waste can be identified as a listed waste, or as a waste that exhibits hazardous characteristics − ignitability, corrosivity, reactivity, and toxicity. This requirement may apply to the disposal of LGAC media and other process waste. The spent media will be characterized in accordance with California hazardous waste requirements and will be disposed of accordingly.

12.2.3 Legal Considerations

JPL is located in the Monk Hill Subarea of the Raymond Basin. In 1944, the Superior Court of California approved the Raymond Basin Judgment, which adjudicated the rights to groundwater production to preserve the safe yield of the groundwater basin. Adjudication refers to the practice of land owners and other parties allowing the courts to settle disputes over how much groundwater can rightfully be extracted. The courts determine an equitable distribution of water that will be available for extraction each year. In these adjudicated groundwater basins, the courts appoint a Watermaster to administer the court judgment. The Raymond Basin Management Board, made up of representatives of the water purveyors, oversees the management and protection of the Raymond Basin. A total of six Raymond Basin water purveyors operate wells within four miles of JPL.

Because the expanded treatability study includes the extraction of groundwater and NASA does not have water rights under the Raymond Basin Judgment, extracted groundwater will be reinjected into the same aquifer. NASA will coordinate with the Raymond Basin Management Board regarding specific reporting requirements associated with reinjection.

Alternative 1 (NFA) does not meet chemical-specific ARARs because groundwater at JPL is not protected. Alternative 2 (expansion of the existing demonstration treatment system) meets all identified ARARs and reduces the migration of VOCs and perchlorate to off-facility areas.

12.2.4 Other Applicable Requirements

CERCLA Offsite Rule – The off-site rule (40 CFR 300.440) applies to any response action involving the off-site transfer of CERCLA wastes. Therefore, the off-site rule will apply to disposal of spent LGAC and other process waste associated with the source area treatment system. The purpose of the off-site rule is to avoid having CERCLA wastes from response actions authorized or funded under CERCLA contribute to present or future environmental problems by directing these wastes to management units determined to be environmentally sound (preamble to final Off-Site Rule, 58 *Federal Register* 49200, 49201, Sept. 22, 1993). All waste will therefore be disposed of at a facility that is permitted to accept waste from the CERCLA site.

12.3 Cost-Effectiveness

Cost-effectiveness is determined by comparing the cost of all alternatives being considered with their overall effectiveness to determine whether costs are proportional to the effectiveness achieved. The overall effectiveness of a remedial alternative is determined by evaluating (1) long-term effectiveness and permanence, (2) reduction in toxicity, mobility, or volume through treatment, and (3) short-term effectiveness. Table 12-1 presents a comparison of costs and effectiveness of Alternative 1 (NFA) and Alternative 2, for OU-1.

Alternative 1 is not effective over the long term because, under this alternative, VOCs and perchlorate in the groundwater can continue to migrate into off-facility areas. Alternative 2 is effective over the long term because the process permanently removes VOCs and perchlorate from the groundwater and existing and future risks to off-facility groundwater are reduced. After remediation is complete, residual VOCs and perchlorate are not expected to further impact groundwater.

Alternative 1 (NFA) is not a treatment technology and does not reduce the toxicity, mobility, or volume of VOCs or perchlorate in the groundwater at OU-1. Alternative 2 (expansion of the existing demonstration treatment system) is a remedy that permanently and irreversibly removes VOCs and perchlorate from groundwater. Thus, Alternative 2 reduces the volume and mobility of VOCs and perchlorate in the groundwater at OU-1.

Table 12-1. Comparison of Costs and Effectiveness of Alternatives for OU-1

Alternative	Present-Worth Cost	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness
Alternative 1 (NFA)	$0	• Not effective over the long term • VOCs and perchlorate can continue to migrate into unaffected groundwater	• Not a treatment technology • Does not reduce toxicity, mobility, or volume of VOCs and perchlorate in groundwater	• No short-term effects on workers, public, or the environment
Alternative 2 (Expansion of the Existing Demonstration Treatment System)	$8,094,000	• Effective over the long term • VOCs and perchlorate permanently removed from groundwater	• Presumptive remedy • Permanently removes VOCs and perchlorate from groundwater	• Insignificant short-term effects on workers, the public, and the environment

Alternative 1 does not include remedial action. Because this alternative does not require construction or installation of equipment on facility, potential short-term effects to workers, the public, and the environment are minimal. Alternative 2 presents minimal risk to workers, the public, and the environment. Groundwater extraction, treatment and reinjection systems are designed so that extraction, injection wells and associated piping are under constant monitoring. The VOCs and perchlorate in the extracted groundwater are removed by an aboveground treatment system, in accordance with state and local regulations. The potential short-term effects to workers, the public, and the environment are expected to be minimal during the expansion and operation of the treatment system.

The estimated present-worth cost of Alternative 1 is $0. Because Alternative 1 does not reduce the toxicity, mobility, or volume of VOCs and perchlorate at OU-1, it is not effective in the long term, and, therefore, is not a cost-effective alternative.

The estimated present-worth cost of Alternative 2 is $8,094,000. Because Alternative 2 permanently reduces the volume of VOCs and perchlorate at OU-1, and thus reduces future risks to off-facility groundwater, it is cost-effective in the long term. The operation of OU-1 also will help to decrease the cost of remediation efforts at OU-3.

NASA and the regulatory authorities agree that the costs associated with extraction treatment and reinjection are justified because the preferred action reduces and removes VOCs and perchlorate from groundwater at JPL OU-1 and reduces the potential for continued migration of untreated groundwater to off-facility areas. Thus, groundwater beneath JPL is protected, as required under both NCP (40 CFR Section 300.430(e)(2)(B)) and State of California regulations for the beneficial use of groundwater.

12.4 Use of Permanent Solutions and Alternative Treatment Technologies

Alternative 1 (NFA) does not meet chemical-specific ARARs and cannot meet the RAO for OU-1 because, under this alternative, VOCs and perchlorate are left in place at OU-1, and unaffected groundwater beneath and surrounding JPL is not protected. In addition, Alternative 1 is not a treatment technology, does not reduce the toxicity, mobility, or volume of chemicals of concern at OU-1, and is not effective over the long term, because VOCs and perchlorate are left in place with the potential to migrate to off-facility groundwater.

Alternative 2 (expansion of the existing demonstration treatment system), the selected remedy, is a presumptive remedy that permanently removes VOCs and perchlorate from the groundwater, thus reducing the volume of chemicals of concern at OU-1. This alternative is effective over the long term, is protective of human health and the environment, and can meet all ARARs.

12.5 Preference for Treatment as a Principal Element

Expansion of the existing demonstration treatment system can permanently remove VOCs and perchlorate from the groundwater at OU-1, and thus reduce their volume and mobility. Expansion of the existing demonstration treatment system meets the CERCLA preference for treatment as a principal element.

12.6 Five-Year Review Requirements

NASA intends to remove VOCs and perchlorate in the groundwater at JPL to prevent further migration of VOCs and perchlorate to unaffected groundwater used for drinking water. A review will be conducted every five years to ensure that the remedy continues to provide adequate protection of human health and the environment. This review is required five years after finalizing the first ROD for the site. The ROD for OU-2 was signed in September 2002 (See, 42 USC 9621(c)); hence, the first review will take place in 2007.

13.0: DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan identified Alternative 2 (expansion of the existing demonstration treatment system) as the Preferred Alternative for remediation of groundwater chemicals of concern at JPL (OU-1). NASA reviewed all written and verbal comments submitted during the public comment period, and no changes to the preferred alternative and no new alternatives that NASA had not previously considered were suggested by the public during the public comment period. It was determined by NASA, U.S. EPA, DTSC, and RWQCB that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

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Part III: THE RESPONSIVENESS SUMMARY

This Responsiveness Summary is a part of the Record of Decision (ROD) for Operable Unit 1 (OU-1), source area groundwater remediation for the National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory (JPL). The purpose of the Responsiveness Summary is to provide a summary of and responses to the public's comments, concerns and questions received about NASA's *Proposed Plan for Source Area Groundwater Cleanup*, dated November 1, 2005.

NASA held a meeting on November 16, 2005, to formally present the Proposed Plan for source area groundwater cleanup to the community, and to answer questions and receive comments regarding the OU-1 system expansion. A Public Comment Period from November 1, 2005 to December 15, 2005 gave the public the opportunity to ask specific questions and make formal comments for the record. The transcript from this meeting, which may be found at the information repositories or on the Web site http://jplwater.nasa.gov, is a part of the Administrative Record for the site. The Responsiveness Summary is organized as follows:

1.0 Overview
2.0 Background on Community Involvement
3.0 Comprehensive Summary of Major Public Questions, Comments and Concerns, and NASA Responses
4.0 Comprehensive Summary of Major Regulatory Questions, Comments and Concerns, and NASA Responses
5.0 Acronyms and Abbreviations
6.0 References

1.0 OVERVIEW

As part of the November 16, 2005, Public Meeting held during the Public Comment Period, NASA presented the preferred alternative for OU-1 source area groundwater (NASA, 2005). NASA proposed expansion of the existing demonstration treatment system utilizing the extraction, treatment and reinjection system to remove volatile organic compounds (VOCs) and perchlorate to prevent further migration in the groundwater to off-site areas.

No changes to the preferred alternative and no new alternatives that had not previously been considered by NASA were suggested by the public during the public comment period. No changes in the preferred alternative are now proposed in the Record of Decision.

The selected remedy for cleanup of perchlorate and VOCs in the groundwater beneath JPL is the continued operation and expansion of the existing demonstration treatment system. The existing system consists of a two-step treatment process. The first step is VOC removal; VOCs are removed from the groundwater by filtration through liquid-phase granular activated carbon (LGAC). The second step is perchlorate removal, achieved by using a fluidized bed reactor (FBR) unit. The FBR uses a biological process to break down and remove perchlorate from groundwater. New extraction and injection wells will be installed to more than double the amount of water being treated from a rate of approximately 150 gallons per minute (gpm) to a rate of approximately 350 gpm (NASA, 2005). A detailed description of the selected remedy is provided in Section 12.0 of the ROD.

2.0 BACKGROUND ON COMMUNITY INVOLVEMENT

Initial interviews with community members and leaders in 1991 and again in 1993 indicated a relatively low level of awareness in the three surrounding communities of La Cañada Flintridge, Altadena, and Pasadena regarding the placement of JPL on the National Priorities List (NASA, 2003). During these interviews residents suggested using community newsletters to convey important information in addition to the media sources NASA was already using (NASA, 2003). NASA attempted to address these concerns through community newsletters and fact sheets distributed to members of the surrounding communities.

In May and June 2001, three public meetings were held to inform the public of the remediation alternatives considered as part of the Proposed Plan to clean up on-facility soils at JPL and a Public Comment Period gave the public a chance to ask questions and state their concerns about on-facility soils treatment. Comments submitted during the public comment period were collected and reviewed.

In January 2004, NASA held two public meetings and a meeting for JPL employees to solicit community input into the cleanup process and to update the community on NASA's groundwater cleanup efforts and plan. In April 2004, a Community Meeting on Health was held. A panel of medical and public health experts gathered, along with NASA Project and Community Outreach Managers to address questions from the public about the health effects of perchlorate and target volatile organic compounds at the JPL site (NASA, 2004).

Additional interviews of local residents, community leaders, and two JPL employees in January 2005 showed a much greater level of awareness about the Groundwater Cleanup Program, with residents commenting on their appreciation of NASA's efforts to communicate with the public (NASA, 2006).

In March 2005, NASA hosted a Community Information Session. Local residents met with members of NASA's Groundwater Cleanup Project team, local water purveyors, and health and technical experts to learn about the progress NASA has made in cleaning up groundwater beneath the Jet Propulsion Laboratory and areas adjacent to it.

NASA held a Public Meeting on the Proposed Plan for OU-1 on November 16, 2005. Public notifications of the Proposed Plan and public meeting were mailed as a newsletter to the residents of the surrounding communities, and were e-mailed to approximately 5,000 JPL employees. Public notification of the meeting on November 16 was provided in local newspaper notices. The meeting was held to present the Proposed Plan to the public and obtain official public comments. The public comment period was open from November 1 through December 15, 2005. During this time, members of the public had the opportunity to comment on and ask questions about the information presented in the public meetings and in the Proposed Plan. NASA responses to all written and oral comments received during the public comment period are provided in the following section. Oral comments were made during the public meeting and can be found in the transcript of the meeting in the Administrative Record on the program Web site (http://jplwater.nasa.gov) or at any of the following Information Repositories:

La Cañada Flintridge Public Library
4545 Oakwood Avenue
La Cañada Flintridge, CA 91011
(818) 790-3330

Pasadena Central Library
285 E. Walnut Street
Pasadena, CA 91101
(626) 744-4052

Altadena Public Library
600 E. Mariposa Avenue
Altadena, CA 91001
(626) 798-0833

JPL Library
(JPL Employees Only)
4800 Oak Grove Drive
Bldg. 111-112
Pasadena, CA 91109
(818) 354-4200

3.0 COMPREHENSIVE SUMMARY OF PUBLIC QUESTIONS AND COMMENTS AND NASA RESPONSES

The Public Comment Period for the Proposed Plan for Source Area Groundwater Cleanup at the NASA Jet Propulsion Laboratory, Pasadena, California extended from November 1, 2005 through December 15, 2005. A public meeting to provide background on and summarize the Proposed Plan and obtain public comments on the record was held November 16, 2005.

Only one letter of comment was received and one comment card was submitted during the public meeting held concerning the Proposed Plan on November 16, 2005. A number of speakers made comments or asked questions during the public meeting of November 16, 2005. In addition, in response to an email to all JPL personnel, dated November 1, 2005, questions were submitted by email pertaining to the Proposed Plan. These comments are identified below.

Each of the comment letters and other documents was reviewed, and individual significant comments within each document were identified. The email inquiries from JPL employees were responded to the sender immediately upon receipt and, as they were received during the official comment period, also are included here.

1. General Comments

Note: In some cases the email questions and answers and the public comments and responses made on November 16, 2005 to the public comments have been slightly modified for this Responsiveness Summary, to ensure that the information is updated and is easy to read in context. The original comments and responses during the November 16, 2005 public meeting are available on the transcript provided at: http://jplwater.nasa.gov

1a. Melody Comfort, Local Resident:
I consider the new plan to be responsive to all the ecological needs for the community, specifically at the JPL site, and generally for the surrounding residents, schools and businesses. From the information that I gained at this 11-16-2005 Community meeting, I consider the plan to be a sound one, utilizing access to some of the existing features of the current water treatment facility. I appreciate public updates, and the opportunity to gain clarification on my issues of concern. Thank you.

NASA Response:
NASA acknowledges and appreciates your feedback.

1b. Dorothy Thorman, Altadena Resident:
I will just make the statement that I am very glad that this process is taking place, because you know, it is wonderful. And it would be nice if all these sites that I hear there are so many toxic [Superfund] sites. And this administration has cut back on the funding for these cleanups. So I think we are very fortunate to have this taking place.

NASA Response:
NASA acknowledges and appreciates your feedback.

2. Health Implications

2a. Barbara Benton, Altadena Resident:
My name is Barbara Benton. Anyway, I spoke before this whole thing got started because I had stopped at the corner of my street about two or three years ago when they were testing one of the wells. And I said "What are you doing?" So my concern as a retired nurse and as a 35-year resident of the area, are the health implications. We have had many deaths in my community, mostly of cancer, various kinds. We had a doctor that I used to work with at USC last year. He says it doesn't show up in the records—demographic records for cancer. We have had several deaths since I was here. And I am truly concerned about my own health. I wasn't here in March. And as I think back, I was having some GI problems, and I went to the doctor, and there's something on my pancreas, which isn't cancerous, but why is it there? How did it get there? You know, they biopsied it and said it was nonmalignant. And it may or may not have had anything to do with it. But I lived here for 35 years. There has to be chemical implications; otherwise, why do you want to clean it up? You see. And I want somebody to address that. And I think all your charts and pretty pictures are nice, but the issue is, how is it impacting the health of not just the residents, but the JPL employees who have been there for a career. I want to know. And I want somebody to tell me the truth.

NASA Response:
NASA recognizes the deep concern you and other members in your community have for their own health, and the health of animals in the area. This is the reason NASA seeks to fund both on and off-site treatment of the chemicals in the groundwater.

The Agency for Toxic Substances and Disease Registry (ATSDR) conducted site visits in 1997 to assess the potential for public health hazards at JPL. Following a careful evaluation of available data, ATSDR determined that the volatile organic compounds (VOCs) in groundwater do not present a past, present, or future public health to JPL employees or nearby residents. Based on their findings, they also deemed it unlikely that perchlorate in groundwater posed a past public health hazard (ATSDR, 1998).

In January 2005 the Committee to Assess the Health Implications of Perchlorate Ingestion, National Research Council of the National Academies of Science released a study of the health implications of perchlorate ingestion. The study found no harmful effects of perchlorate at mild levels, such as those seen in the local drinking water supply (NAS, 2005). Reports of both studies can be found on the Web site at http://jplwater.nasa.gov.

NASA has made efforts to disseminate information and address public concerns about potential health effects. A Community Meeting on Health was held in April 2004 and independent medical specialists were on hand to answer questions and report findings (NASA, 2004). More information about what the medical specialists shared with the community can be found on the main page of the Web site (http://jplwater.nasa.gov).

2b. Marietta Kruells, Altadena Resident:
My name is Marietta Kruells. I'm a 20-plus year resident in Altadena. And I would like to know if it's possible to have medical information from veterinarians included in this because I think that is something that has been ignored, and I have mentioned it before, that there's a lot of horses in the area, and they are a pretty easy target—they only drink water here. They usually don't travel. They don't drink bottled water. And so I think that would be a good group to look for medical problems. That was it. Thank you.

NASA Response:
Thank you for your comment. NASA acknowledges and will consider your feedback.

3. OU-1 Onsite Treatment System

3a. Dorothy Thorman, Altadena Resident:
Does this plan clean the volatile compounds [VOCs] at the same time as the perchlorate?

NASA Response:
Yes, the water is pumped up into the treatment plan and the carbon filters take out the VOCs and then the water goes into the fluidized be reactor (FBR) where the bugs destroy the perchlorate.

3b. Melody Comfort, Altadena Resident
When the bacteria ingest the perchlorate, what really happens to the bacteria?

NASA Response:
The bacteria do not actually ingest the perchlorate. The bacteria ingest citric acid and nutrients, and while doing so release an enzyme that reduces the perchlorate to chloride and oxygen. The bacteria live and reproduce, continuing to breakdown the perchlorate. Eventually the bacteria become old and die, and result in an innocuous biomass that is safely disposed (ITRC, 2005).

3c. Melody Comfort, Altadena Resident:
If there was an earthquake and the tank fell over, are the bacteria from the FBR system harmless? They don't have any perchlorate and there are no dangerous compounds within the bacteria?

NASA Response:
The bacteria are harmless. The bacteria do not concentrate any of the perchlorate, but simply cause the perchlorate to break down during stable continuous operating conditions. If the FBR system was upset during an earthquake, groundwater extraction and treatment would automatically shut off.

3d. Unidentified Speaker at November 2005 Public Meeting:
It is a dollar constraint of a million dollars that[NASA Project Manager Steve Slaten]) is talking about just doubling the flow? Why not go ten times?

NASA Response:
Thorough investigation by NASA and its contractors about the location of the chemicals in the source areas, as well as the permeability of the aquifer below JPL, suggest that expansion of the system to 350 gpm will best balance a number of aspects including removal of the chemicals, capacity to extract and reinject the water from and back to the aquifer, and the speed of cleanup.

3e. Dick Fiedler, Lincoln Avenue Water Company Board of Directors:
Do you have to have permits in order to operate the treatment system?

NASA Response:
Yes. NASA has all the permits it needs to comply with all appropriate regulations.

3f. Unidentified Speaker at November 2005 Public Meeting:
Are you going to continue increasing the number of injection and extraction wells of this treatment system after it is up and running?

NASA Response:
A lot has been learned about the system since it was first installed as a demonstration system in 2005. Based on the information, NASA believes that it will be sufficient and give us control of the source area, but NASA will continually evaluate and verify the effectiveness of the treatment of the source area groundwater with this system.

4. Location and Monitoring and Cleanup of Chemicals in the Groundwater

4a. Unidentified Speaker at November 2005 Public Meeting:
Do you know the boundary of the high concentrations in the soil in your water table now?

NASA Response:
Yes. NASA has studied the groundwater in the Raymond Basin, including the direction and the rate of flow and the location of chemicals. There are 25 monitoring wells in the immediate vicinity of JPL, and measurements of chemicals are taken at a total of 82 locations. The information allows NASA to reasonably conclude where the higher concentrations of chemicals in the groundwater are located. This area is referred to as the source area groundwater, and is being addressed in this interim action.

4b. Dorothy Thorman, Altadena Resident:
Are there any other chemicals contaminating the aquifer and are you cleaning up those chemicals?

NASA Response:
All over the country man-made chemicals have gotten into the groundwater, including in the Raymond Basin. As for chemicals disposed of decades ago at JPL, NASA has done various studies and continues to investigate and monitor chemical locations and is cleaning up those target chemicals that originated from the JPL site. While in the cleanup process other chemicals that did not come from JPL are being treated, NASA is only responsible for the cleanup of

chemicals that came from JPL. NASA has identified all of the chemicals for which they are responsible, and are cleaning those up.

4c. Melody Comfort, Altadena Resident:
I would like an update about the new monitoring well located at John Muir High School.

NASA Response:
Initial rounds of sampling from this well show no detectable levels of perchlorate using the approved method for perchlorate analysis, EPA Method 314.0.

4d. Unidentified Speaker at November 2005 Public Meeting:
Does NASA have an idea of the size of the target area it is trying to clean?

NASA Response:
Yes. Our investigation leads us to believe the area of groundwater containing the chemicals is an area of approximately 8-10 acres, by 100-150 feet thick.

4e. Unidentified speaker at November 2005 Public Meeting:
As far as water purveyors go, are the chemicals only in the City of Pasadena and Lincoln Avenue Water Company wells or have they moved into other water purveyors?

NASA Response:
Some wells belonging both to Lincoln Avenue Water Company and the City of Pasadena have been affected at levels that are enough above the standards that they had to be shut down. These are the only purveyors that have been affected. NASA continues to regularly monitor and closely watch the water of the next closest water companies—Las Flores Water Company and Rubio Cañon Land and Water Association.

4f. Unidentified Speaker at November 2005 Public Meeting:
What standard are you using in order to decide what water needs to be cleaned up?

NASA Response:
Federal and state maximum contaminant levels (MCLs) are being used to determine cleanup areas for volatile organic compounds. There currently is no standard for perchlorate, but the State of California has set a public health goal (PHG) of 6 (six) parts per billion (PPB) and NASA is using that as its guideline until a final standard is set.

4g. Melody Comfort, Altadena Resident:
Do you have proof that the plume has moved over the last year?

NASA Response:
NASA has seen no evidence of the plume moving further away from JPL over the past year.

5. JPL Employee E-mails

5a. Larry Mallet, JPL Employee
The information is rather sparse. There is no clear indication of where wells and ports are, how long they've been operating and the extent to which materials concentrations have been reduced.

It appears that most of the concentrations are in a small 8 acre area. What if the dispersion of toxic materials is much wider and outside of this area? How have you come to the conclusion that primary risk is in an 8 acre area? What if the dispersion of toxic waste is much higher? What if detection is merely reflecting the removal of waste from small local sites around wells, rather than from a widely dispersed area? What arrangements exist for independent review outside of NASA and JPL?

The information reflected is spartan.

What outside/independent organizations have been involved in reviewing NASA/JPL plans?

NASA Response:
These written pieces are one of the ways NASA keeps the community informed. NASA also uses fact sheets that are offered at the JPL Open House and other events in the area and the Web site is updated regularly and includes copies of technical documents and recent reports. In addition, NASA offers public meetings and community involvement sessions, and many people contact us directly for additional information, as you did.

One of your questions regarded dispersion of the chemicals. The current newsletter focuses on the source area, because that is the site where NASA is currently proposing to expand a treatment system. An earlier newsletter, the August Bilingual Newsletter (see http://cercla.jpl.nasa.gov/NMOWeb/adminrecord/docs/NAS710324.pdf), discussed the opening of a NASA-funded plant for Lincoln Avenue Water Company in Altadena. Funding that treatment plant is one of NASA's actions to address chemicals that have dispersed from the source and moved offsite.

To facilitate cleanup of the area, NASA divided the site into what are called Operable Units. Each Operable Unit covers a separate medium (i.e., soils or water) and geographic area. OU-1 pertains to groundwater directly underneath the site occupied by the Jet Propulsion Laboratory. The current newsletter describes how NASA is proposing to expand the successful onsite treatment plant. OU-2 refers to the soils directly underneath JPL, for which remediation via soil vapor extraction for the last few years has been so successful that it is almost complete. OU-3 includes all groundwater outside the JPL fenceline in the Monk Hill subarea, east and southeast of JPL.

The focus of the November 2005 newsletter, and of NASA's public meeting on November 16, 2005 was cleanup of the "source area," an eight-acre portion of OU-1, directly beneath JPL. Cleanup at the source is important to reduce the chemicals that will migrate off-facility and thus will help reduce the length of time required to fully clean up the groundwater plume. NASA understands, however, that chemicals have migrated beyond the JPL fenceline, thus NASA's cleanup extends to the NASA-funded treatment plant at the Lincoln Avenue Water Company and to our cooperation on cleanup with Pasadena Water and Power.

NASA installed monitoring wells in a broad area to the east and southeast of JPL, to ensure the most efficient cleanup of the area from which chemicals from the JPL site are involved. The first monitoring wells were installed in 1989 and quarterly groundwater monitoring began in 1996. The furthest monitoring well from the JPL site, MW 25, is approximately three miles from the monitoring well considered to be closest to the source of chemicals, MW 7. A map of the well locations is provided in the quarterly groundwater monitoring technical memoranda (http://cercla.jpl.nasa.gov/NMOWeb/AdminRecord/ADMIN_KeyDocuments.asp). The southernmost well (MW 25) is at the City Yard near the 210 freeway at W. Hammond Street in Pasadena.

NASA posts quarterly results of our groundwater sampling results on the webpage, following validation of the data received by each sampling effort. These results are found on the "Key Documents" portion of the Administrative Record on the Web site, at: http://cercla.jpl.nasa.gov/NMOWeb/AdminRecord/ADMIN_KeyDocuments.asp. Many of these 25 wells are "multiport" wells, that is, they have the ability to sample distinct zones within a particular well. There is a total of 82 zones sampled in the 25 wells. (Note: Well MW-2 no longer is in operation).

Even after all the separate actions discussed above are taken, NASA will study what further actions must be taken to constitute a "final remedy" to ensure that all chemicals on- and off-site are cleaned up and treated to the appropriate levels established by federal and state health standards.

Lastly, but importantly, while NASA is the lead federal agency responsible for implementation of these cleanup actions, all our studies and actions are thoroughly reviewed by a number of state and federal regulators, including the U.S. Environmental Protection Agency, the California Regional Water Quality Control Board, the California Department of Toxic Substances Control and the California Department of Health Services.

5b. Robert Smythe, JPL Employee
I am a member of section 383, and involved with optical interferometry. We take precise measurements that can be disrupted by vibration caused by pumps, fans and other sources. If the proposed pumping/processing facility is close to one of our optical laboratories, our ability to acquire the needed data from our experiments could be compromised. Can you tell me where these stations will be located, and will any attempt be made to isolate their vibration sources, both from shaking the ground or from acoustical noises close by?

NASA Response:
NASA understands the concerns of programs such as yours at JPL, and will undertake efforts to preclude impacting your work. The proposed construction will include equipment to drill water wells and dig trenches to bury pipes. This activity will be similar to other common construction

that takes place routinely on JPL. The location of this activity should be north and south of Bldg 79. These operations will be coordinated with JPL Health and Safety and Facilities to minimize impacts such as noise and vibration, and employees will be notified via Inside JPL and Daily Planet. Four wells and the treatment facility have been operating 24/7 in this area since early this year.

5c. Edouard Schmidtlin, JPL Employee
It is too bad that engineers were careless (or that there were no laws or collect system) tens of years ago, but it is good that we are now doing something about it, in terms of monitoring and cleanup I wonder how deep and wide the plume of pollution is today.
Are the JPL water fountains safe (I am specifically in Bldg. 301) or could the water be polluted from the past?

NASA Response:
Drinking water at JPL meets all safe drinking water standards. The groundwater directly beneath JPL is not used as a drinking water source. The source of drinking water for JPL is Pasadena Water & Power (PWP), owned by the City of Pasadena. The City of Pasadena is required to undertake rigorous and frequent monitoring of its water quality and that information must be reported to the State Department of Health Services which oversees drinking water quality for the State.

The City of Pasadena monitors all of its wells, and in all instances, including historically, has shut down any well when it sees the level of chemical approaching a State health and drinking water standard or guideline. Consequently, each well is shut down prior to reaching a level that would exceed safe drinking water requirements.

NASA has a groundwater program that is cleaning up the residual of chemicals released many decades ago from practices that were common at the time. Current use of chemicals is strictly controlled, and all stormwater runoff at JPL is monitored and the data collected show that no releases off-site occur.

The source area of chemicals targeted for cleanup by our onsite treatment plant is an area about 100 feet thick and about eight acres in size. Groundwater adjacent to JPL has also been impacted at much lower concentrations over hundreds of acres. This off-facility groundwater is being addressed by cooperating with the neighboring water companies.

5d. Don Langford, JPL Employee
This [sounds acceptable] even though it is disruptive if you work above the JPL firestation. But I did not see any indication that the chemical count was going down even though 75 million gallons of water have been cleaned up and put back into the ground. Is there evidence that the underground is getting cleaned up or is it possible that all of La Cañada above JPL is draining into JPL space?

NASA Response:
NASA realizes that construction of the existing plant created some noise, traffic and parking disruptions and appreciates the tolerance all of you located near the construction have shown toward this effort. The additional construction, will consist only of the drilling of two or three wells and connecting pipes to those wells. There will be some loud noises and vibrations associated with drilling of the wells, but the duration of construction is likely to last no more than two months for each well. NASA will be installing one injection well and one extraction well. We will do our best to minimize any disturbance to those employees located in the area.

The on-site treatment plant has been operating since February 2005 and the data indicate that the plant is reducing the chemicals in the groundwater. The plant (that includes its initial start-up period) has removed about 500 pounds of perchlorate and 15 pounds of volatile organic compounds. Further, the most recent influent levels now show 500 ppb of perchlorate, down from 2000 ppb at commencement of the on-site cleanup.

More information may be found at our Web site: http://jplwater.nasa.gov/.

Groundwater from La Cañada Flintridge flows southeasterly from La Cañada Flintridge towards the Arroyo Seco, but it does not flow through this upper part of the JPL site. Monitoring wells south and southeast of JPL may more likely reflect some contribution of chemicals from La Cañada Flintridge.

6. Raymond Basin Management Board (RBMB) Letter

Written questions and comments received by the Raymond Basin Management Board during the Public Comment Period for the Proposed Plan for Source Area Groundwater Cleanup are summarized and addressed below.

6a. General Comment:
The document obtained by the Raymond Basin is a summary of the Proposed Plan; therefore, supporting data and information were not included. The document indicates that "Supporting technical documents are available by visiting any of the public information repositories listed on the last page of this summary or at the NASA JPL Groundwater Cleanup Web site at http://JPLwater.nasa.gov:," however, appropriate technical documents for the Proposed Plan cannot be found on that Web site. The Proposed Plan is Phase II of the expanded treatability study as described in the ETS Work Plan, which adds one additional extraction well and two additional injection wells to the existing demonstration treatment system. Specific comments are based solely on data obtained as described above.

NASA Response:
Applicable backup documentation includes the following:

1. The Expanded Treatability Study Work Plan: http://jplwater.nasa.gov/NMOWeb/AdminRecord/docs/NAS710247.htm
2. Installation Report: http://jplwater.nasa.gov/NMOWeb/AdminRecord/docs/NAS710364.htm

3. Groundwater Monitoring Reports: http://jplwater.nasa.gov/NMOWeb/AdminRecord/ADMIN_KeyDocuments.asp
4. Progress Report (April – August 2005): http://jplwater.nasa.gov/NMOWeb/AdminRecord/docs/NAS710375.pdf

6b. Specific Comment, Page 2:
The Proposed Plan states, "Figure 2 shows the layout of the existing demonstration study system and the proposed expansion. One or two new extraction wells and one or more injection wells will be installed as part of the proposed expansion. The actual number and location of wells will be determined as part of the design phase."

It is unclear if the design refinements will resolve the apparent discrepancy between the proposed expansion, as described in Figure 2 of the Proposed Plan, and Phase II, as described in Figure 1-2 of the ETS Work Plan.

NASA Response:
The design refinements will be documented in an OU-1 Treatment System Expansion Work Plan and will resolve the difference between what was proposed in the Expanded Treatability Study Work Plan (Figure 1-2) and the Proposed Plan (Figure 2).

6c. Specific Comment, Page 2:
The Proposed Plan indicates, "This Proposed Plan summarizes information collected over a number of years. All project-related documentation can be found in the Administrative Record. Copies of the Administrative Record are also available at the information repositories on page 10 and on the project Web site at http://jplwater.nasa.gov."

The Web site does not appear to contain "all project-related documentation," particularly documentation for data interpretation and reporting, as described in Section 5-5 of the ETS Work Plan.

NASA Response:
Please see response to Comment No. 6a above regarding the list of reports that contain recent data and interpretations. More reports will be added to the Web site as they are produced.

6d. Specific Comment, Page 2:
Figure 2 shows that groundwater in the vicinity of the demonstration system generally flows in a north-south direction.

This north-south groundwater flow seems inconsistent with actual water level measurements. According to data in Table F-1 of the Quarterly Progress Report groundwater in that area flowed northeasterly in October 2004 and northwesterly in January, March, and April 2005. This northwesterly flow, which is opposite to the normal southeasterly flow, appears to be the most logical explanation for the persistence of groundwater contamination beneath the NASA JPL, as described in the OU3 RI Work Plan. The north-south groundwater flow direction was used in the groundwater flow model which, in turn, was used to design the proposed expanded *treatability study system, including selection of well locations and pumping rates, as described in the ETS Work Plan. As a result, the design appears to be based upon incorrect assumptions.*

NASA Response:
Historical groundwater-level elevation data indicate a steep southwest gradient from the mouth of the Arroyo Seco to the OU-1 system area coupled with a southeast gradient from the northeast of JPL. Flow converges to the south of the treatment system and migrates toward the southeast. Data collected from the majority of historical groundwater monitoring events has shown a southerly flow in the vicinity of the system. Groundwater flow in the vicinity of the OU-1 system is relatively stagnant, and as a result groundwater-level elevations may indicate differing flow directions during select monitoring events. However, overall groundwater flow is historically toward the south in this area, as further evidenced by inclusion of recent groundwater level elevation data from upgradient monitoring well IRZ-IW2, which exhibits groundwater levels higher than those in MW-7. The groundwater elevation contour maps showing conditions after system startup in April and July 2005 (documented in the Progress Report [April – August 2005], see response to comment No. 1) indicate groundwater flow is significantly affected by operation of the system, with a drawdown of roughly 25-30 ft observed in the extraction wells and radial flow observed toward these wells. Although no groundwater level elevation data were collected from the injection wells, monitoring data indicate that it appears that that extraction wells will effectively contain groundwater within a 150-ft radius of the extraction wells and the groundwater injected upgradient at IW-1 and IW-2.

6e. Specific Comment, Page 5:
One of the objectives of the Proposed Plan is to "remove chemicals in groundwater and prevent the further spread of VOCs and perchlorate from the groundwater source area." Because groundwater beneath the source area appears to flow in a southeasterly direction, extraction at Wells EW-1 and EW-2 most likely will not adequately capture contaminated groundwater in the vicinity of MW-7. Based solely on the accessible background data it appears that injection at Wells IW-1 and IW-2 would actually push groundwater down gradient toward MW-11.

NASA Response:
Groundwater monitoring data has indicated that groundwater flow in the immediate vicinity of the OU-1 system is toward the south or south/southwest. Groundwater-level elevation data collected since system startup have indicated that it appears the extraction wells effectively contain groundwater within a 150-ft radius of the extraction wells and the groundwater injected upgradient at IW-1 and IW-2. Therefore, the monitoring data indicate that chemicals in groundwater in the vicinity of MW-7 will be contained by the ETS extraction wells, and not migrate toward downgradient monitoring wells.

6f. Comment 1 from Raymond Basin Management Board
Since JPL plans to extract water from the Basin, how will JPL replenish the basin to cover water lost in the process?

NASA Response:
The volume of water discharged to the sanitary sewer in the treatment process will be *deminimus*. In fact, through November 2005 NASA has injected more water than it has extracted. Therefore, NASA does not need to cover water lost in the process.

Since completing construction of the facility, NASA has treated and reinjected approximately 51M gallons of water (measured by flow meters installed on the extraction and injection well pipelines). Of this 51M gallons, approximately 48,000 gallons (0.15 ac-ft) has been discharged to the sanitary sewer or shipped off-site. The remaining treated water has been reinjected back into the aquifer.

As you know, in response to your earlier concerns regarding discharged water, NASA installed a clarification system at an additional cost of several hundred thousand dollars that minimizes the amount of water discharged to the sanitary sewer by concentrating the solids prior to batch discharge to the sanitary sewer. Wastewater from the OU-1 plant is discharged in batches of 12,000 gallons. To date, three discharges have been conducted, as summarized in [the table below]. Another 12,000 gallons of wastewater was hauled offsite for disposal.

Summary of Discharges to the Sanitary Sewer

Batch Number	Date of Discharge	Volume
1	April 5, 2005	12,000
2	September 26, 2005	12,000
3	October 31, 2005	12,000
	Total	**36,000**

Discharge to the sanitary sewer is conducted in accordance with the Los Angeles County Sanitation District (LACSD) industrial waste discharge permit for JPL. The OU-1 plant was inspected in November 2005 by the LACSD and the system was in full compliance.

The concrete pad is fully contained by a twelve inch concrete curb. The area within the curb is 3,590.75 ft^2 and drains to the sump that is part of the clarification system. Therefore, any rainwater that falls within the curbed area of the treatment facility is captured by the system and eventually injected into the aquifer. Each inch of rain that falls on the pad equates to approximately 2,200 gallons of water entering the system. With over 36 inches of rain falling so far in 2005, an estimated 81,000 gallons (0.25 ac-ft) of rainwater has been processed at the treatment plant and reinjected.

In addition, tap water is used for various purposes within the curbed area of the concrete pad. This water drains to the sump. To date, approximately 2,500 gallons of water has been used (based on the water meter installed at the facility). Therefore, over 83,000 gallons (0.255 ac-ft) of rainwater and tap water has been injected into the aquifer by the treatment system. This volume significantly exceeds the volume of water discharged to the sanitary sewer or hauled off-site (i.e., 48,000 gallons).

The proposed system expansion would double the treatment flow rate. Based on system operations to date, NASA does not expect discharged water volumes to exceed 0.5 ac-ft/yr after system expansion. Additionally, NASA will consult with the Board prior to any operational changes that could result in discharged water of over 2 ac-ft per year.

6g. Comment 2 from Raymond Basin Management Board
Please provide formal documentation to the board that your proposed cleanup project in OU-1 is in full compliance with all legal and regulatory requirements of the Regional Water Quality Control Board, the Department of Health Services, and U.S. Environmental Protection Agency, and any other agencies with jurisdiction over your project.

NASA Response:
The NASA-JPL Federal Facilities Agreement (FFA) was finalized in December 1992 and signed by NASA, the U.S. Environmental Protection Agency, the California Regional Water Quality Control Board, and the California Department of Toxic Substances Control. The FFA is the regulating document for the NASA-JPL Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Program and provides the formal documentation requested. NASA has received approval from all FFA parties, including the Regional Water Quality Control Board, for the OU-1 Expanded Treatability Study. The FFA is available online at: http://jplwater.nasa.gov/NMOWeb/AdminRecord/docs/NAS70753.pdf. State agency approval documents are also in the Administrative Record.

6h. Comment 3 from Raymond Basin Management Board
The Board understands you have completed some groundwater modeling for your project specific to OU-1. Please provide the Board with all documents and electronic files relating to the groundwater modeling work you are performing.

NASA Response:
NASA has been closely coordinating groundwater modeling efforts with the Raymond Basin Management Board. NASA provided electronic files associated with modeling efforts to the Raymond Basin Management Board in September 2003, January 2004, and February 2004, and conducted a meeting with representatives from the RBMB on March 31, 2005. Please let me know if these files should be provided to others.

5.0 ACRONYMS AND ABBREVIATIONS

AR	Administrative Record
ATSDR	Agency for Toxic Substances and Disease Registry
EPA	United States Environmental Protection Agency
FBR	fluidized bed reactor
FS	feasibility study
GAC	granular activated carbon
gpm	gallons per minute
ITRC	Interstate Technology and Regulatory Council
JPL	Jet Propulsion Laboratory
LGAC	liquid-phase granular activated carbon
M	million
MW	monitoring well
NASA	National Aeronautics and Space Administration
NPL	National Priorities List
OU	operable unit
PHG	public health goal
PPB	parts per billion
RBMB	Raymond Basin Management Board
RI	Remedial Investigation
ROD	Record of Decision
SVE	soil vapor extraction
VOC	volatile organic compound

6.0 REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1998. *Public Health for Jet Propulsion Laboratory.* U.S. Department of Health and Human Services.

Interstate Technology and Regulatory Council (ITRC). 2005. *Perchlorate: Overview of Issues, Status, and Remedial Options*. September.

National Academies of Science (NAS). 2005. *Health Implications of Perchlorate Ingestion.* National Research Council of the National Academies, Board on Environmental Studies and Toxicology, Division of Earth and Life Studies.

National Aeronautics and Space Administration (NASA). 2003. *Final Community Relations Plan: Amendment 1*. NASA Jet Propulsion Laboratory. NAS7.10383, NASA-JPL SSIC No. 9661. January 23.

National Aeronautics and Space Administration (NASA). 2004. *Summary of NASA-JPL Groundwater Cleanup Community Meeting on Health.* NASA Jet Propulsion Laboratory. NAS7.010386, NASA-JPL SSIC No. 9661. June 3.

National Aeronautics and Space Administration (NASA). 2005. *Proposed Plan for Source Area Groundwater Cleanup at NASA-JPL.* NASA Jet Propulsion Laboratory. NAS7.010383, NASA-JPL SSIC No. 9661. November 1.

National Aeronautics and Space Administration (NASA). 2006. *Final Community Relations Plan: Amendment 2*. NASA Jet Propulsion Laboratory. NAS7.010388, NASA-JPL SSIC No. 9661. March 15.

Appendix A
Administrative Record Index for OU-1

RECORD NUMBER	RECORD DATE	SUBJECT	AUTHOR AFFILIATION
010371	11/01/2005	NOVEMBER 2005 BILINGUAL NEWSLETTER	NASA
010382	11/01/2005	PROPOSED PLAN FACT SHEET FOR SOURCE AREA GROUNDWATER CLEANUP AT NASA JET PROPULSION	NASA
010383	11/01/2005	PROPOSED PLAN FOR SOURCE AREA GROUNDWATER CLEANUP AT THE NASA JET PROPULSION	NASA
010378	10/27/2005	TECHNICAL MEMORANDUM: THIRD QUARTER 2005 GROUNDWATER MONITORING RESULTS, OCT. 14, 2005	BATTELLE
010375	10/07/2005	TECHNICAL MEMORANDUM OPERABLE UNIT 1 DEMONSTRATION STUDY PROGRESS REPORT, APRIL TO	BATTELLE
010367	08/30/2005	TECHNICAL MEMORANDUM: SECOND QUARTER 2005 GROUNDWATER MONITORING RESULTS	BATTELLE
010369	07/11/2005	TECHNICAL MEMORANDUM OPERATIONS SUMMARY: JANUARY 2005 THROUGH JUNE 2005 NATIONAL	BATTELLE
010364	06/01/2005	FINAL OU-1 EXPANDED TREATIBILITY STUDY - JUNE 1, 2005	BATTELLE
010362	04/15/2005	TECHNICAL MEMORANDUM FIRST QUARTER 2005 GROUNDWATER MONITORING RESULTS	BATTELLE
010357	03/02/2005	FINAL GROUNDWATER MONITORING REPORT	GEOFON
010366	03/01/2005	MARCH 2005 NEWSLETTER - UPDATE ON GROUNDWATER CLEANUP PROJECT	NASA
010347	01/04/2005	FINAL QUARTERLY GROUNDWATER MONITORING REPORT, JULY-AUGUST 2004	GEOFON
010328	09/08/2004	FINAL QUARTERLY GROUNDWATER MONITORING REPORT, APRIL-MAY 2004	GEOFON
010324	08/14/2004	BILINGUAL NEWSLETTER: AN UPDATE ON GROUNDWATER CLEANUP ACTIVITIES AT JPL, AUGUST 2004	NASA
010322	07/16/2004	FINAL QUARTERLY GROUNDWATER MONITORING REPORT, FEBRUARY 2004	GEOFON
010332	05/01/2004	MAY 2004 NEWSLETTER: NASA BEGINS CONSTRUCTION AT JPL OF GROUNDWATER TREATMENT UNIT	NASA
010301	04/20/2004	POSTCARD SENT TO RESIDENTS AND AN INFORMATIONAL FLYER ANNOUNCING A COMMUNITY MEETING	NASA
010292	02/05/2004	FINAL QUARTERLY GROUNDWATER MONITORING REPORT (Q4), OCTOBER-NOVEMBER 2003	GEOFON
010326	02/05/2004	FINAL QUARTERLY GROUNDWATER MONITORING REPORT (Q2), APRIL-MAY 2003	GEOFON
010327	02/05/2004	FINAL QUARTERLY GROUNDWATER MONITORING REPORT (Q3), JULY-AUGUST 2003	GEOFON
010283	01/27/2004	BROCHURES, FACT SHEETS, AND TRANSCRIPTS FROM THE PUBLIC MEETINGS HELD IN JANUARY 2004	NASA
010302	01/23/2004	NEWSPAPER ANNOUNCEMENTS ON JANUARY 23 AND 27, 2004 IN THE PASADENA STAR-NEWS	NASA
010247	10/16/2003	REVISED FINAL OPERABLE UNIT 1 EXPANDED TREATABILITY STUDY WORK PLAN	BATTELLE
010325	09/03/2003	FINAL QUARTERLY GROUNDWATER MONITORING REPORT (Q1), JANUARY-FEBRUARY 2003	GEOFON
010277	06/30/2003	FIELD PILOT TESTING OF A DYNAMIC SUSPENDED BED REACTOR FOR REMOVAL OF PERCHLORATE IN	FOSTER WHEELER
010280	05/27/2003	FINAL ANNUAL REPORT ON THE JPL LONG TERM GROUNDWATER MONITORING PROGRAM FROM	SOTA
010279	04/09/2003	FINAL QUARTERLY GROUNDWATER MONITORING REPORT FOR OCTOBER TO NOVEMBER 2002	SOTA
010106	01/23/2003	FINAL COMMUNITY RELATIONS PLAN: AMENDMENT 1	NASA
010282	10/10/2002	WORK PLAN FOR A PILOT STUDY TO CREATE AN IN SITU REACTIVE ZONE AND DEMONSTRATE	ARCADIS
010278	10/08/2002	FINAL QUARTERLY GROUNDWATER MONITORING REPORT FOR JULY 2002	SOTA
010005	08/06/2002	QUARTERLY GROUNDWATER MONITORING REPORT, APRIL-MAY 2002	SOTA
010004	04/05/2002	QUARTERLY GROUNDWATER MONITORING REPORT, JANUARY-FEBRUARY 2002	SOTA
010003	01/18/2002	QUARTERLY GROUNDWATER MONITORING REPORT, OCTOBER 2001	SOTA
010002	10/12/2001	QUARTERLY GROUNDWATER MONITORING REPORT, JULY 2001	SOTA
002445	07/27/2001	GROUNDWATER MONITORING REPORT - APRIL, 2001	SOTA
002442	04/27/2001	QUARTERLY GROUNDWATER MONITORING REPORT - JANUARY 2001 THROUGH FEBRUARY 2001	SOTA
002095	03/01/2001	FINAL FOURTH ANNUAL REPORT ON QUARTERLY GROUNDWATER MONITORING - NOVEMBER 1999	FOSTER WHEELER
002106	02/01/2001	FINAL QUARTERLY GROUNDWATER MONITORING RESULTS - SEPTEMBER 2000 THROUGH OCTOBER 2000	FOSTER WHEELER

Appendix A
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RECORD NUMBER	RECORD DATE	SUBJECT	AUTHOR AFFILIATION
000215	12/11/2000	TECHNICAL PAPER, "REMOVAL AND DESTRUCTION OF PERCHLORATE AND OTHER ANIONS FROM	CALGON
001130	12/01/2000	QUARTERLY GROUNDWATER MONITORING RESULTS - JULY 2000 THROUGH AUGUST 2000	FOSTER WHEELER
000998	07/01/2000	QUARTERLY GROUNDWATER MONITORING RESULTS - MARCH 2000 THROUGH APRIL 2000	FOSTER WHEELER
000995	03/01/2000	QUARTERLY GROUNDWATER MONITORING RESULTS - NOVEMBER 1999 THROUGH DECEMBER 1999	FOSTER WHEELER
000994	01/01/2000	DRAFT FEASIBILITY STUDY (FS) FOR OU 1 AND OU 3	FOSTER WHEELER
000984	12/01/1999	PERCHLORATE TREATABILITY STUDIES: USE OF REVERSE OSMOSIS AND BIOTREATMENT FOR REMOVAL	FOSTER WHEELER
000993	12/01/1999	QUARTERLY GROUNDWATER MONITORING RESULTS - AUGUST 1999	FOSTER WHEELER
000670	11/12/1999	TRANSMITTAL OF SUPERFUND SOLUTIONS COMMUNITY NEWSLETTER NUMBER 2	JPL
000569	08/05/1999	FINAL PUBLIC HEALTH ASSESSMENT	ATSDR
001001	08/01/1999	FINAL REMEDIAL INVESTIGATION (RI) FOR OU 1 AND OU 3 (VOLUMES I AND II)	FOSTER WHEELER
001000	07/01/1999	QUARTERLY GROUNDWATER MONITORING RESULTS - MAY 1999 THROUGH JUNE 1999	FOSTER WHEELER
000218	06/28/1999	FINAL REPORT FOR REMOVAL OF PERCHLORATE AND OTHER CONTAMINANTS FROM GROUNDWATER AT	CALGON
000999	05/01/1999	QUARTERLY GROUNDWATER MONITORING RESULTS - FEBRUARY 1999 THROUGH MARCH 1999	FOSTER WHEELER
000216	04/06/1999	FINAL PROJECT REPORT "APPLICATION OF ION-EXCHANGE TECHNOLOGY FOR PERCHLORATE REMOVAL	MONTGOMERY WATSON
001008	03/01/1999	QUARTERLY GROUNDWATER MONITORING RESULTS - OCTOBER 1998 THROUGH NOVEMBER 1998	FOSTER WHEELER
000983	12/01/1998	SECOND ANNUAL REPORT ON LONG-TERM QUARTERLY GROUNDWATER MONITORING PROGRAM	FOSTER WHEELER
000541	10/16/1998	NASA JPL TOUR HANDOUT - SUPERFUND BACKGROUND INFORMATION	JPL
001006	10/01/1998	QUARTERLY GROUNDWATER MONITORING RESULTS - JULY 1998 THROUGH AUGUST 1998	FOSTER WHEELER
001012	08/01/1998	QUARTERLY GROUNDWATER MONITORING RESULTS - APRIL 1998 THROUGH MAY 1998	FOSTER WHEELER
001011	04/01/1998	QUARTERLY GROUNDWATER MONITORING RESULTS - JANUARY 1998 THROUGH FEBRUARY 1998	FOSTER WHEELER
000997	03/01/1998	QUARTERLY GROUNDWATER MONITORING RESULTS - SEPTEMBER 1997 THROUGH OCTOBER 1997	FOSTER WHEELER
000976	01/01/1998	QUARTERLY GROUNDWATER MONITORING PROGRAM ANNUAL REPORT AUGUST 1996 TO JULY 1997	FOSTER WHEELER
001005	09/01/1997	QUARTERLY GROUNDWATER MONITORING RESULTS - JUNE 1997 THROUGH JULY 1997	FOSTER WHEELER
001004	04/01/1997	QUARTERLY GROUNDWATER MONITORING RESULTS - FEBRUARY 1997 THROUGH MARCH 1997	FOSTER WHEELER
001003	03/01/1997	QUARTERLY GROUNDWATER MONITORING RESULTS - OCTOBER 1996 THROUGH NOVEMBER 1996	FOSTER WHEELER
001002	12/01/1996	QUARTERLY GROUNDWATER MONITORING RESULTS - AUGUST 1996 THROUGH SEPTEMBER 1996	FOSTER WHEELER
000794	01/01/1994	FINAL SUPERFUND COMMUNITY RELATIONS PLAN (CRP)	JPL
000753	12/30/1992	TRANSMITTAL OF FINAL FEDERAL FACILITY AGREEMENT	USEPA
000849	01/01/1991	REMEDIAL INVESTIGATION/FEASIBILITY (RI/FS) STUDY WORK PLAN	EBASCO
000845	11/01/1990	SUPPLEMENTAL INFORMATION TO THE EXPANDED SITE INSPECTION REPORT (HAZARD RANKING SYSTEM	EBASCO
000843	05/01/1990	EXPANDED SITE INSPECTION REPORT	EBASCO
000240	04/11/1988	PRELIMINARY ASSESSMENT/SITE INSPECTION REPORT	EBASCO

APPENDIX B

PUBLIC NOTICES

AFFIDAVIT OF INSERTION

NASA

This is to certify that the following ad ran in the San Gabriel Valley Newspaper publications on the following dates:

November 1, 9, 15, 2004.

Each ad 31.5 inches with tagline of "Public Comment Period".

Before me, a notary public, personally appeared

[illegible]
Signature

Asst. Credit Manager
Title

State of California
County of Los Angeles
Sworn and subscribed before me
November 18, 2005

EVELYN ADAMS WILSON
Commission # 1406705
Notary Public - California
Los Angeles County
My Comm. Expires Mar 23, 2007

Evelyn Adams Wilson
Notary Public Signature

Public Comment Period

November 1 - December 15, 2005

& Public Meeting

PROPOSED PLAN FOR

Source Area Groundwater Cleanup At NASA Jet Propulsion Laboratory

NASA is seeking public comment from November 1 through December 15, 2005 on NASA's Proposed Plan for Source Area Groundwater Cleanup at the Jet Propulsion Laboratory (JPL) site.

NASA invites the public to offer oral or written comments and ask questions about NASA's Proposed Plan at a:

Public Meeting

Wednesday, November 16, 2005
7-9 p.m.
Altadena Community Center
730 E. Altadena Drive, Altadena

During this meeting NASA will explain its proposal to expand the on-site groundwater treatment plant at JPL. Following the presentation, NASA will listen to attendees' formal verbal comments that will be transcribed and become part of the final record when NASA makes its final decision on the proposed action. After NASA formally takes people's comments, attendees will have the opportunity to speak with regulators and NASA's technical experts on a one-on-one basis.

NASA proposes to expand the existing demonstration treatment plant located on JPL at what is termed the "source area." Since it began operating earlier this year, the plant has proven quite successful in removing perchlorate and volatile organic compounds from the source area groundwater where the majority of the chemicals are located. NASA proposes to more than double the amount of water being treated, going from a rate of about 150 gallons per minute (gpm) to a rate of approximately 350 gpm. The system currently uses two wells to extract groundwater, and after the water is treated, two wells re-inject the clean water. NASA's proposed expansion would involve installing one more extraction well and one more injection well to make the system even more effective. The Proposed Plan provides information about the alternatives considered to meet groundwater cleanup objectives and the rationale for the proposed expansion option.

You may review the Proposed Plan and supporting technical documents on the Web at the NASA JPL Groundwater Cleanup Website at http://JPLwater.nasa.gov, by requesting a copy from Merrilee Fellows (below), or by visiting any of the NASA public information repositories located at the:

Pasadena Central Library
285 E. Walnut St.
Pasadena
California 91101
(626) 744-4052

Altadena Public Library
600 E. Mariposa Ave.
Altadena
California 91001
(626) 798-0833

La Cañada Flintridge Public Library
4545 Oakwood Ave.
La Cañada Flintridge
California 91011
(818) 790-3330

JPL Repository
(JPL Employees Only)
4800 Oak Grove Dr.
Bldg. 111
(818) 354-4200

Comments or questions on NASA's Proposed Plan may be submitted electronically to mfellows@nasa.gov or by mail to the attention of:

Ms. Merrilee Fellows
NASA Water Cleanup Outreach Manager
NASA Management Office, 180-801
Jet Propulsion Laboratory
4800 Oak Grove Drive, Pasadena, CA 91109

All comments must be submitted electronically by midnight December 15, 2005, or, if comments are posted by mail, the comments must bear a postmark of no later than December 15, 2005.