Proposed Plan

Groundwater Remediation at NASA JPL

FINAL

October 2014

INTRODUCTION

National Aeronautics and Space Administration (NASA) has been conducting environmental investigations and cleanup activities at the Jet Propulsion Laboratory (JPL) in Pasadena, CA for more than two decades. These activities have been performed under the *Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)*[1]. NASA has already implemented several cleanup initiatives to accelerate remediation of *groundwater* and soils while considering options for the final remedy. Specifically, three groundwater treatment plants are already operating and cleaning up groundwater: one treatment plant is treating water from two Lincoln Avenue Water Company (LAWC) wells in Altadena, the Monk Hill Treatment System (MHTS) is treating water from four City of Pasadena wells (Arroyo Well, Well 52, Ventura Well, and Windsor Well), and a third treatment plant located within the JPL fenceline is operating to clean water directly underneath JPL. NASA has completed a Focused *Feasibility Study* to evaluate the overall effectiveness of these groundwater *interim actions* and to determine whether additional cleanup measures are required for on-facility and off-facility groundwater. In addition, the existing three-system treatment alternative is compared to a *no-action alternative*, which is required by the *National Oil and Hazardous Substances Pollution Contingency Plan (NCP)* and CERCLA to serve as the baseline condition for comparison with other remedial alternatives.

This *Proposed Plan* outlines NASA's *preferred alternative* to conduct a remedial action for cleaning up the on-facility groundwater beneath JPL (*Operable Unit [OU]*1), as well as the off-facility groundwater (OU3). Under the preferred alternative, NASA would continue the effective interim remedies currently underway, and continue the groundwater monitoring program. NASA's preferred alternative also includes the addition of *institutional controls (ICs)* to restrict access to chemicals in groundwater originating from JPL. As the lead agency, NASA is required to issue the Proposed Plan to fulfill requirements under CERCLA §117(a) and NCP §300.430(f)(2).

NASA will make a final decision on the proposed cleanup remedy after reviewing and considering all information submitted during a 30-day public comment period. NASA may modify its preferred alternative based on public comments, before issuing a *Record of Decision (ROD)*.

PUBLIC MEETING AND COMMENT PERIOD MARK YOUR CALENDAR

Public Comment Period: November 3 - December 3, 2014
Public Meeting: 7 to 9 p.m., November 12, 2014 at the Altadena Senior Center, 560 E. Mariposa St., Altadena

NASA invites public comment on the actions described in this Proposed Plan. Supporting technical documents (including the *Remedial Investigation* report and Focused Feasibility Study) are available in the *Administrative Record* file by visiting any of the public *information repositories* listed on the last page of this summary or at the NASA JPL Groundwater Cleanup website: **http://JPLwater.nasa.gov**.

The public can also call **(818) 393-0754** for information.

Comments on NASA's Proposed Plan may be submitted electronically to mfellows@nasa.gov or by mail to the attention of **Merrilee Fellows, NASA Manager for Community Involvement, Jet Propulsion Laboratory, NASA Management Office, 180-801, 4800 Oak Grove Drive, Pasadena, CA 91109.**

No specific format for the comments is necessary. All comments must be submitted either electronically before midnight on December 3, 2014, or the comments must be postmarked no later than December 3, 2014. Oral and written comments will be accepted at the public meeting and NASA will prepare a transcript of the meeting.

[1] Definitions of *italicized* words are in the glossary on pages 14 and 15.

SUMMARY OF PREFERRED ALTERNATIVE

NASA's preferred alternative for groundwater is to continue operating the three existing *treatment systems* in OU1 and OU3. The three systems have proven effective and will continue to remove target chemicals from groundwater including *perchlorate* and *volatile organic compounds (VOCs).* NASA's preferred alternative also includes the addition of various ICs to ensure impacted groundwater within the JPL site is not utilized without appropriate evaluation and/or treatment. This alternative includes continuation of the routine groundwater monitoring program to monitor remedy performance and effectiveness.

The OU1 (on-facility) treatment system consists of three groundwater extraction wells, *ex situ* treatment using *liquid-phase granular activated carbon (LGAC)* to remove VOCs and a *fluidized bed reactor (FBR)* to treat perchlorate, and re-injection of treated water into injection wells located at the JPL facility (Figure 1). The design capacity of this treatment plant is 300 gallons per minute (gpm). The on-facility treatment plant is currently operated by NASA as the interim remedial action for OU1.

The LAWC system includes two extraction wells (LAWC#3 and LAWC#5), LGAC treatment for VOCs, and *ion exchange* for treatment of perchlorate, with a maximum capacity of 2,000 gpm. The treated water is used as a source of drinking water for LAWC customers. The system has been operating effectively since 2004. Operation of the LAWC treatment plant is funded by NASA as part of the interim remedial action for off-facility groundwater (OU3).

The MHTS consists of four extraction wells (Arroyo Well, Well 52, Ventura Well, and Windsor Well), LGAC treatment for VOCs and ion exchange for treatment of perchlorate with a maximum capacity of 7,000 gpm. The treated water is used as a source of drinking water for City of Pasadena residents. The system has been operating effectively since 2011. Operation of the MHTS is funded by NASA as part of the interim remedial action for OU3.

Continuation of the current systems is preferred by NASA because historical operating data demonstrate that there has been a decreasing trend in perchlorate and VOC concentrations in the extracted groundwater over the duration of operation, and the systems have consistently treated chemicals to below cleanup levels for OU1 and established drinking water criteria for OU3, including *maximum contaminant levels (MCLs)*. Based on this information, the existing OU1 and OU3 treatment systems are considered protective of human health and the environment and are effectively working to remove site-related chemicals from the groundwater in an aquifer. In addition, these systems have been effective in containing chemicals originating from JPL, and the OU3 systems have restored use of a valuable groundwater resource for Altadena and Pasadena.

Also, ICs would be implemented as part of the preferred alternative via a legal agreement with the Raymond Basin Management Board and/or the State of California. The agreements would include commitments that require the agency to notify NASA of any proposed new extraction wells in the Monk Hill Subarea (see Figure 2), and that NASA evaluate the impact of any proposed extraction wells within/near the capture zones on the remedies for OU1 and OU3. In addition, NASA would conduct annual reviews of new well permits in the Monk Hill Subarea as an additional control to prevent exposure to chemicals.

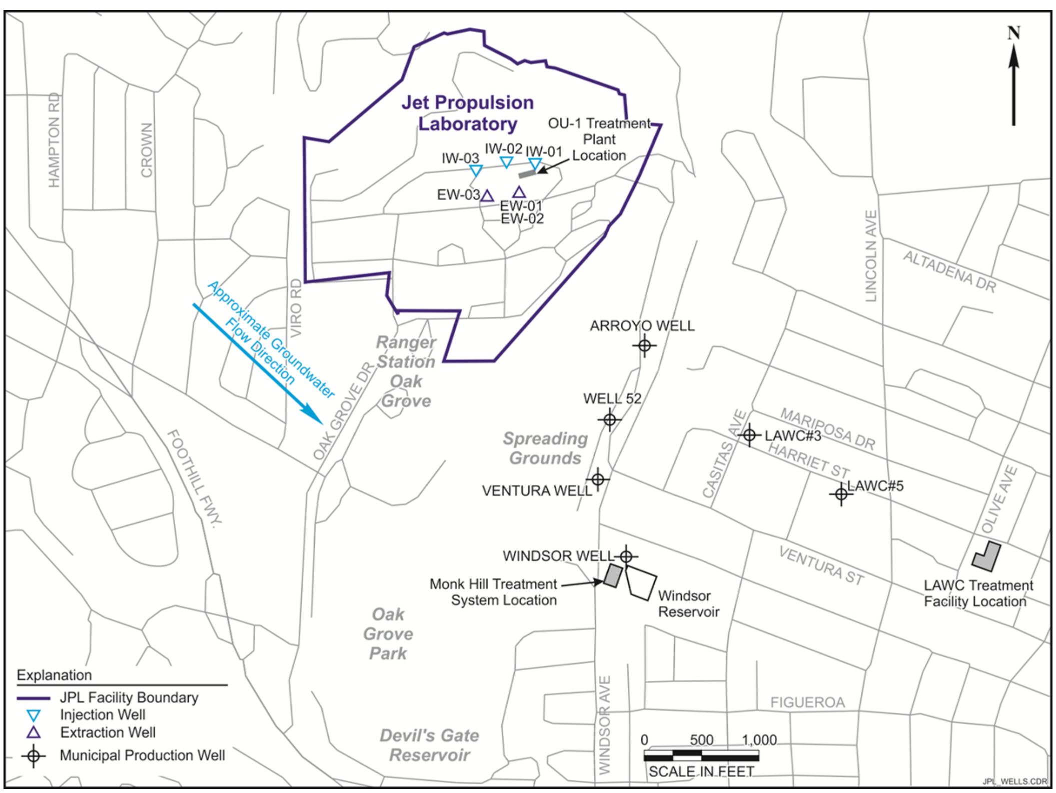

Figure 1. Map showing the location of the OU1 and OU3 treatment systems.

SITE BACKGROUND

In the 1940s and 1950s, liquid wastes from materials used and produced at JPL (such as solvents, solid and liquid rocket propellants, cooling tower chemicals, and analytical laboratory chemicals) were disposed of into seepage pits, a practice considered common at that time. VOCs and perchlorate have been found in groundwater beneath the north-central portion of JPL and in certain areas of deep groundwater adjacent to JPL. Specifically, groundwater extracted from two drinking water wells operated by the LAWC, and four drinking water wells operated by the City of Pasadena (Arroyo Well, Well 52, Windsor Well, and Ventura Well) have been found to contain these chemicals.

NASA has been investigating and taking actions to clean up the groundwater associated with historic practices since the mid-1980s. In October 1992, the site was placed on the U.S. Environmental Protection Agency (U.S. EPA) *National Priorities List* of sites governed by CERCLA, as amended by the *Superfund Amendments and Reauthorization Act (SARA)*. NASA entered into a *Federal Facilities Agreement (FFA)* and was designated the lead agency responsible for carrying out the CERCLA investigation and cleanup process at JPL. The government agencies included in the FFA are NASA, U.S. EPA, the California Department of Toxic Substances Control, and the California Regional Water Quality Control Board. These agencies collaborate with NASA to provide regulatory oversight for the JPL Site.

A groundwater monitoring program has been in place at JPL since August 1996 and has been expanded as the number of monitoring wells in place was also expanded. JPL monitoring wells are sampled on a quarterly basis to maintain a comprehensive understanding of the subsurface conditions within OU1 and OU3 groundwater. Figure 2 shows the locations of monitoring wells within the JPL monitoring well network.

Historical groundwater monitoring activities have indicated that four target chemicals (carbon tetrachloride, *trichloroethylene [TCE]*, tetrachloroethylene, and perchlorate) have been detected in JPL monitoring wells at concentrations above the state and federal drinking water standards for each chemical. Carbon tetrachloride, TCE, and perchlorate continue to be consistently detected above state and federal drinking water standards. The perchlorate, carbon tetrachloride, and TCE plumes originating from JPL currently extend approximately 1 mile southeast of the *source area* (see Figure 2). Groundwater monitoring data from NASA's groundwater monitoring well network and nearby drinking water production wells are published quarterly and made available at http://JPLwater.nasa.gov.

OU1 Source Area Treatment System: Since system startup in early 2005, the OU1 treatment system has successfully treated more than 3,300 acre feet of groundwater, removing approximately 1,800 pounds of perchlorate and 40 pounds of VOCs. Influent perchlorate concentrations at the OU1 system have decreased significantly, from approximately 2,300 µg/L in February 2005 to approximately 25 µg/L in August 2014. Concentrations of perchlorate and VOCs at the effluent of the OU1 system (i.e., treated water) are consistently non-detect. In addition, operation of the source area treatment system appears to have resulted in a significant reduction of chemicals of concern in wells MW-7, MW-16 and MW-24, which are located within the treatment zone.

OU3 Systems: Since system startup in July 2004, the 2,000 gpm LAWC treatment facility has successfully treated over 20,400 acre feet of groundwater, removing approximately 1,060 pounds of perchlorate and 230 pounds of VOCs. The MHTS began operations in July 2011 and has successfully treated approximately 12,800 acre feet of groundwater, removing approximately 900 pounds of perchlorate and 92 pounds of VOCs. MHTS has a 7,000 gpm treatment capacity, although the actual treatment rate is dependent on demand. Groundwater treated by the LAWC system and MHTS achieves all applicable drinking water requirements. Influent chemical concentrations at both systems are decreasing over time. Recent data show chemical concentrations have decreased by 50% or more compared to the highest influent chemical concentrations.

Sunset Reservoir Wells: Perchlorate has been detected in City of Pasadena production wells (Sunset, Bangham, Copelin, Garfield, and Villa; collectively referred to as the Sunset Reservoir wells), located approximately 3 to 4 miles downgradient of the JPL facility. In 2005, NASA conducted an additional investigation to determine if the occurrence of perchlorate in the Sunset Reservoir wells was associated with chemical migration from the JPL facility. The additional investigation included installation of two new monitoring wells (MW-25 and MW-26), groundwater modeling, analysis of groundwater monitoring well data dating back to the early 1990s, analysis of production well water quality data dating back to 1940, and a perchlorate isotope study. Upon completion of the investigation and subsequent technical interactions with City of Pasadena and the regulators, NASA concluded that (1) the chemicals from the JPL facility are captured within the Monk Hill Subarea, and (2) the perchlorate detected at the Sunset Reservoir wells is of a different origin than that used at, and originating from, JPL.

The path forward for the Sunset Reservoir wells consists of continued monitoring of groundwater between the JPL site and the Sunset Reservoir wells. Data from this monitoring will be evaluated, at a minimum, as part of the CERCLA Five-Year Reviews for JPL.

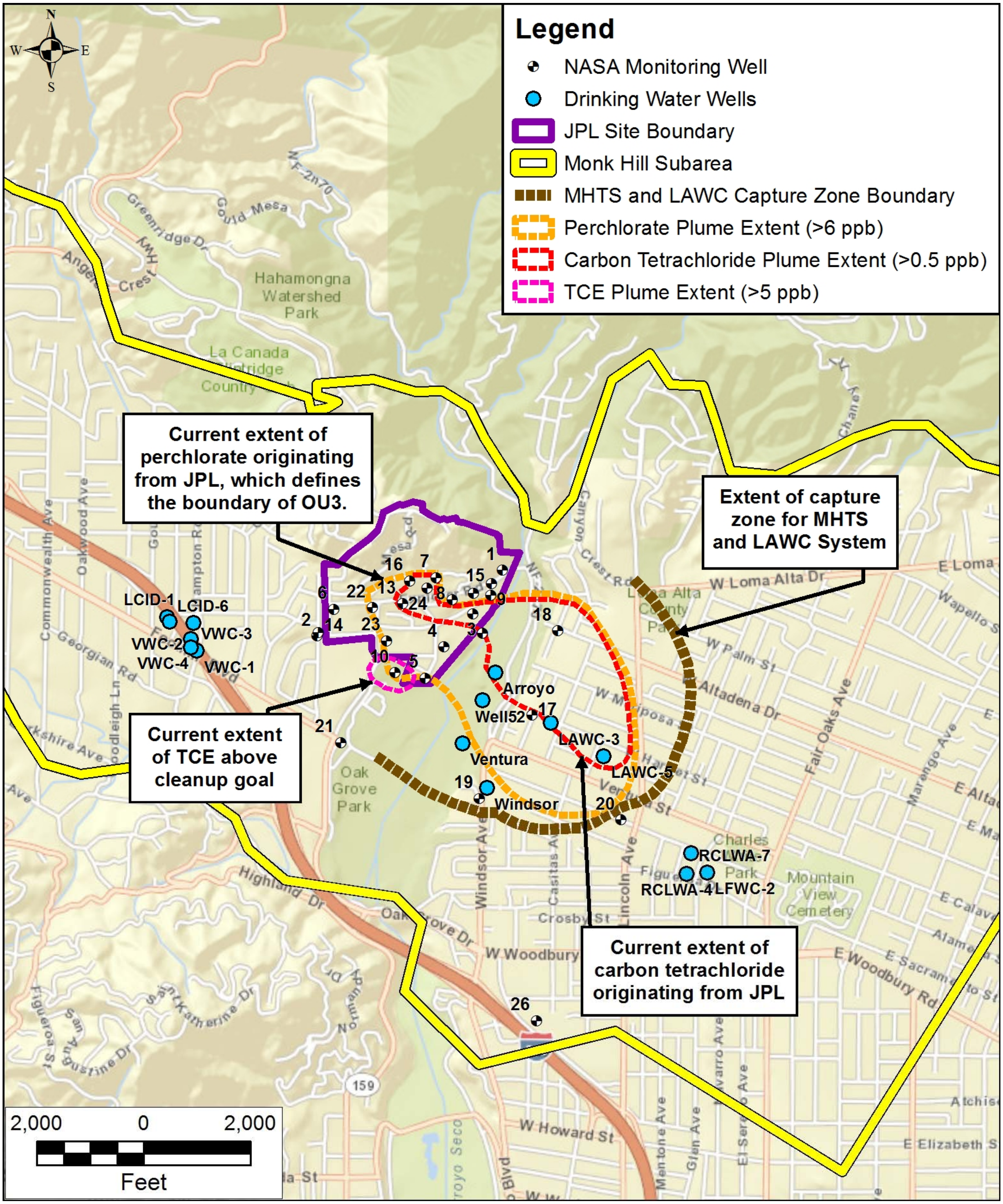

Figure 2. Map showing the extent of perchlorate, carbon tetrachloride, and TCE above cleanup goals.

Previous Environmental Activities at JPL

CERCLA requires a thorough and often lengthy process to fully investigate site contamination and risks, and determine the best methods for cleanup. As the responsible agency, NASA has conducted a number of detailed investigations and studies on the site and adjacent areas since the mid-1980s. All CERCLA documentation associated with the JPL site, including the information that supports the Preferred Alternative in this Proposed Plan, can be found at the information repositories listed on page 6 of this summary and on the Administrative Record website located at http://jplwater.nasa.gov.

These studies have helped NASA identify and understand the type and extent of chemicals in soil and groundwater. As part of the CERCLA investigation activities for groundwater, NASA:

- **Conducted a *remedial investigation (RI)* from 1994 to 1998**. The RI report, which characterized the nature and extent of the chemicals in groundwater, was completed in the fall of 1999. The RI for OU1 and OU3 included *human health and ecological risk assessments* to investigate the possible effects to human health and the environment if no cleanup occurred.
- **Initiated a groundwater monitoring program in August 1996,** analyzing for VOCs and other chemicals, including perchlorate, metals, and other parameters. Analytical results are summarized in quarterly reports and technical memoranda that are available in the information repositories and on the Administrative Record website.
- **Conducted computer modeling and aquifer testing in the early 2000s** at and adjacent to JPL to characterize the complex groundwater conditions and groundwater flow.
- **Completed a draft Feasibility Study in January 2000** that identified and evaluated various groundwater cleanup alternatives for the source area and in areas adjacent to the JPL facility.
- **Completed soil cleanup in 2007.** The ROD for OU2 was signed in September 2002. *Soil vapor extraction (SVE)* was identified as the preferred alternative for OU2 to remove VOCs from the soil and prevent migration of the chemicals to the groundwater. SVE proved to be effective in removing the VOCs from on-facility soils, and the cleanup of soils was completed in 2007.

In addition to these studies, NASA funded treatment facilities for LAWC and the City of Pasadena in the early 1990s to remove VOCs from drinking water wells that were affected by chemicals from JPL. In July 2004, NASA funded additional treatment facilities at LAWC to remove perchlorate. In 2011, NASA implemented an interim remedial action to also remove perchlorate and VOCs from four City of Pasadena drinking water wells. Both perchlorate removal systems use ion exchange technology, which has successfully treated perchlorate in the water since operation was initiated. This interim remedial action is one part of the current preferred alternative.

NASA has also conducted a number of studies to determine the best technologies to treat groundwater in the source area. In the late 1990s and early 2000s, NASA conducted pilot testing of several technologies to address dissolved perchlorate in source area groundwater, including a study that evaluated the effectiveness of a biological treatment technology called an FBR. Based on these studies, NASA installed a demonstration treatment plant located on JPL in the source area in early 2005. This system, which consisted of LGAC treatment to remove VOCs and a FBR to remove perchlorate, was successful in the demonstration phase, and the system was subsequently expanded as the interim remedial action for OU1 in 2007. Source area treatment consists of pumping water out of the ground, treating it, and then re-injecting the water back into the ground. Water treated at the source area treatment plant is not used for drinking water purposes.

Scope and Role of Operable Unit/Response Action

As the lead agency, NASA has conducted a number of detailed investigations and studies on the site and adjacent areas since the early 1990s (see above). These studies have helped NASA identify and understand the type and extent of chemicals in soil and groundwater. As part of this effort, NASA divided the site into three separate areas referred to as OUs. Designated by numbers, OU1 consists of on-facility groundwater (the “source area”), OU2 consists of on-facility soils, and OU3 consists of off-facility groundwater adjacent to JPL. NASA completed remediation of OU2 in 2007, removing VOCs from soil beneath the JPL facility. In remediating the soil, NASA enhanced the overall site cleanup strategy by eliminating the source of VOCs that could migrate to groundwater. This Proposed Plan identifies the preferred alternative for OU1 and OU3.

The response action described in this Proposed Plan is necessary to address target chemicals in the aquifer being used by the local community to meet drinking water standards (i.e., MCLs). In addition, active treatment provides hydraulic control to prevent the migration of chemicals in groundwater. Source area groundwater (i.e., OU1) treatment improves the effectiveness and efficiency of the response action by significantly reducing chemical mass in groundwater that could migrate off facility.

Summary of Site Risks

NASA's extensive investigations and monitoring have shown that concentrations of carbon tetrachloride, TCE, and perchlorate in the JPL groundwater plume exceed drinking water standards. State and federal standards for drinking water are set at levels protective of public health. Thus, restoration of the aquifer is necessary.

The groundwater directly beneath the JPL facility is not extracted for distribution and on-site workers at the facility do not have access to untreated water from the site. Even so, a human health risk assessment was completed for OU1 to evaluate the potential risks associated with hypothetical exposure to chemicals in untreated groundwater beneath the JPL facility. This assessment showed that carbon tetrachloride and perchlorate were the predominant chemicals contributing to hypothetical cancer and non-cancer risks. These two chemicals are removed by the existing OU1 treatment system.

No direct exposure pathways to OU1 groundwater exist for the human or ecological receptors. The OU1 treatment system would have to malfunction to release untreated groundwater for any exposure to occur. Continuous monitoring and redundancies that are built into the treatment system to prevent a system malfunction make this exposure pathway highly unlikely.

In addition, there is no real exposure potential to untreated groundwater for residents living in areas overlying OU3 because the chemicals are located in groundwater that is more than 300 feet below the surface. Groundwater pumped from nearby water production wells must meet strict drinking water quality standards prior to distribution to consumers. Treatment facilities to remove perchlorate and VOCs are in place for Pasadena and LAWC production wells. Therefore, no direct exposure pathways to OU3 groundwater exist for human or ecological receptors. The only possible exposure pathway would be if a water treatment system malfunctioned. However, redundancies that are built into the treatment systems and continuous monitoring make this exposure pathway highly unlikely.

Removal of VOCs in the *vadose zone* (OU2) was completed in 2007. In addition, VOCs in OU3 are located in deep groundwater. Therefore, *vapor intrusion* of VOCs to buildings located above OU1 and OU3 is not an exposure pathway.

The ecological scoping assessment conducted as part of the OU1/OU3 Remedial Investigation concluded that no groundwater exposure pathways to plants and animals are possible at the site. Therefore, no further characterization of ecological risks to plants and animals due to groundwater impact was warranted.

Remedial Action Objectives

Based on the site risks, the following *remedial action objectives* have been identified for groundwater at the JPL CERCLA Site:

1. Protect human health and the environment by preventing exposure to VOCs (carbon tetrachloride and TCE) and perchlorate in groundwater originating from JPL.
2. Restore unrestricted beneficial use of groundwater containing VOCs and perchlorate originating from JPL.
3. Prevent further migration of carbon tetrachloride, TCE, and perchlorate beyond the current extent.

Cleanup Goals

Because the groundwater is used as a source of drinking water, California and federal MCLs are identified as the cleanup goals. The preferred alternative will address groundwater at OU1 and OU3 with chemical concentrations greater than these cleanup goals. The MCLs for the primary chemicals of concern are provided in Table 1 (next page).

Other chemicals are monitored by JPL as part of the groundwater monitoring program and drinking water permits; however, their levels do not exceed established standards.

Administrative Record

A project Administrative Record is a collection of documents that forms the basis for selecting a response action at an environmental restoration site. The Administrative Record associated with the preferred alternative for JPL groundwater is available at:

http://jplwater.nasa.gov

Information Repositories

CERCLA also requires that information developed, received, published or made available to the public related to response actions be available for public inspection and copying at an information repository located at or near the site. JPL information repository locations are:

La Cañada Flintridge Public Library

4545 Oakwood Ave.
La Cañada Flintridge, CA 91011
(818) 790-3330

Altadena Public Library

600 East Mariposa Ave.
Altadena, CA 91001
(626) 798-0833

Pasadena Central Library

285 East Walnut St.
Pasadena, CA 91101
(626) 744-4052

JPL Library

(JPL Employees Only)
Building 111, Room 112
(818) 354-4200

SUMMARY OF ALTERNATIVES EVALUATED

NASA identified and evaluated alternatives to achieve the remedial action objectives for JPL groundwater. Based on the success of the existing interim remedies and the lack of other viable alternatives, two alternatives were evaluated:

- **No-Action Alternative** - In accordance with the requirements of CERCLA, a no-action alternative was evaluated as a baseline condition on which to compare other remedial alternatives.
- **Active Treatment Alternative** - This alternative consists of continued operation of the three existing treatment systems in OU1 and OU3, continued groundwater monitoring, and the addition of ICs.

The no-action alternative would entail no active remediation of groundwater at OU1 or OU3, no monitoring, and no periodic reviews. The no-action alternative does not meet the remedial action objectives. Specifically, it does not protect human health or the environment, it does not restore beneficial use of groundwater, and it does not prevent further migration of chemicals in groundwater.

The active treatment alternative does meet all the remedial action objectives. This alternative is comprised of groundwater extraction, aboveground treatment, and discharge of treated water, consistent with the current interim remedies. Currently, there are three treatment systems operating at the JPL site: (1) the OU1 source area treatment system, (2) the OU3 MHTS, and (3) the OU3 LAWC treatment system. The active treatment alternative also includes the addition of various ICs to ensure impacted groundwater within the JPL site is not utilized without appropriate evaluation and/or treatment. Also, this alternative includes continuation of the routine groundwater monitoring program to monitor remedy performance and effectiveness.

Based on the concentration of chemicals to be treated (higher concentrations at the source area in OU1 and lower concentrations downgradient at OU3), the technologies selected as part of the interim remedies to achieve the aboveground treatment are different for OU1 and OU3. Also, the end use of the treated groundwater from OU1 and OU3 are different. Treated groundwater from OU1 is re-injected into the aquifer and treated groundwater from OU3 is used by City of Pasadena and LAWC for drinking water.

Table 1. Cleanup goals for JPL groundwater.

Chemical	Federal Standard (µg/L)	California Standard (µg/L)
Carbon Tetrachloride	5	0.5
TCE	5	5
Perchlorate	—	6

µg/L = micrograms per liter

In situ technologies were considered, but were determined to be impractical at JPL

NASA considered and evaluated technologies for in situ treatment of groundwater using physical, chemical, or biological processes. In situ treatment was considered to determine if it could enhance the existing interim remedy systems to reduce life-cycle costs. Drinking water production wells would still need aboveground treatment even if in situ treatment was performed, and the type of material injected for treatment would need to be carefully considered and approved by the California State Water Resources Control Board to ensure that it would not adversely impact water quality at the water supply wells. *In situ chemical oxidation* would treat VOCs but not perchlorate. Implementation of an *enhanced bioremediation* injection to promote anaerobic biodegradation of both VOCs (i.e., TCE and carbon tetrachloride) and perchlorate could potentially treat all chemicals of concern at the site. However, the depth and extent of the chemicals in groundwater significantly complicate implementation of any in situ remedy. Additionally, the numerous existing structures at the JPL facility limit access to areas where in situ injections would be required and the geology beneath JPL is not favorable for successful implementation of in situ injections. Because the existing source area interim remedy has been very successful in removing chemicals, it is unlikely that in situ treatment would further reduce the remediation timeframe or life-cycle costs of the overall remedy, which means it is not a cost-effective option.

NASA previously evaluated the best treatment technologies for groundwater extracted from the production wells. In January 2000, NASA completed a draft Feasibility Study, which identified and evaluated various groundwater cleanup alternatives for both OU1 and OU3. As part of this effort, NASA conducted a number of different tests to see which technologies might be the most effective for use at the JPL site. The technologies included reverse osmosis, FBR, packed-bed reactors, and ion exchange.

The best perchlorate treatment is dependent on several factors, including perchlorate concentrations, concentrations of other chemicals, and site-specific conditions. Two aboveground perchlorate treatment processes have proven to be effective at full scale at JPL and other sites: FBR and ion exchange. An FBR contains carbon particles covered with a coating of bacteria that destroy perchlorate. FBR technology is cost-effective for relatively high concentrations of perchlorate (greater than 100 to 200 µg/L) and at locations where continuous operation can be achieved, such as the source area beneath JPL.

SUMMARY OF ALTERNATIVES EVALUATED (CONT.)

However, FBR technology is not cost-effective for perchlorate concentrations in the range present in the City of Pasadena and LAWC production wells. Also, microbial populations used in an FBR would be difficult to maintain for these systems, as operational flexibility is necessary to meet seasonal water supply needs.

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 placed in the tank. Ion exchange has been approved for numerous drinking water systems in California, and has performed well at the LAWC system and MHTS. Ion exchange is cost-effective at low perchlorate levels, such as those found in the City of Pasadena and LAWC production wells, and it is more appropriate for the seasonal variability in water supply operations associated with these systems. In addition, ion exchange is simpler to operate than an FBR and does not require maintaining an active population of microorganisms. Therefore, NASA chose ion exchange as the preferred treatment technology for perchlorate removal at the LAWC treatment plan and City of Pasadena MHTS.

U.S. EPA has identified *air stripping* and LGAC as the best technologies to use for VOCs, referring to these as "presumptive technologies" for aboveground treatment of groundwater containing VOCs. U.S. EPA expects one of these technologies to be used for removal of VOCs at "all appropriate sites." LGAC treatment is currently in place and working effectively as part of both the LAWC treatment plant and the MHTS. While both technologies are effective, use of LGAC is more cost-effective than air stripping given the concentrations of VOCs in the groundwater. Also, air stripping alters the water chemistry in such a way that other treatment would need to be added prior to ion exchange to prevent scaling (i.e., residues, corrosion, or fouling), thus increasing complexity and cost of the air stripping technology.

Lastly, NASA evaluated the use of ICs as part of the remedy. ICs are restrictive measures placed on the use of land or an area to ensure effectiveness of a given remedy. ICs that would be implemented for the JPL site include legal agreements with the Raymond Basin Management Board and/or the California State Water Resources Control Board. These agreements would include commitments that require these agencies notify NASA of any proposed new extraction wells in the Monk Hill Subarea, and that NASA, in coordination with the agencies, evaluate the impact of any proposed extraction wells near the site. In addition, NASA could conduct annual reviews of new well permits in the Monk Hill subarea as an additional control to evaluate and prevent potential exposure to site-related chemicals.

EVALUATION OF ALTERNATIVES

Nine evaluation criteria were developed by U.S. EPA under the NCP for evaluation of remedial action alternatives. This proposed action is evaluated against these criteria. The nine criteria are categorized into three groups: threshold criteria, primary balancing criteria, and modifying criteria (see Table 2):

The threshold criteria must be satisfied for an alternative to be eligible for selection. The balancing criteria are used among alternatives to weigh major tradeoffs, such as effectiveness and implementability. The modifying criteria are taken into account after the public comment period has ended and all comments have been reviewed and considered (in this case, by NASA) to determine if the preferred alternative remains the most appropriate remedial action or if modifications are needed.

For this remedial action, the preferred alternative is evaluated against the no-action alternative.

Table 2. U.S. EPA remedial alternative evaluation criteria.

Category	Evaluation Criteria
Threshold Criteria - Must be satisfied by the remedial alternative	1. Overall protection of human health and the environment 2. Compliance with *applicable or relevant and appropriate requirements (ARARs)*
Balancing Criteria - Used to balance and compare remedial alternatives that meet threshold criteria	3. Long-term effectiveness and permanence 4. Reduction of toxicity, mobility, or volume through treatment 5. Short-term effectiveness 6. Implementability 7. Cost
Modifying Criteria - Evaluated during the state and public comment periods and incorporated into the final alternative selection	8. State acceptance 9. Community acceptance Note: State and community acceptance were not evaluated at the time of the Feasibility Study.

Evaluation of Alternatives (Cont.)

Table 3 provides a summary of NASA's evaluation of the two alternatives. A more detailed evaluation of alternatives is provided in the following subsections.

Overall Protection of Human Health and the Environment. This criterion assesses whether an alternative provides adequate public health and environmental protection, and describes how health and environmental risks posed by the site will be eliminated, reduced, or controlled through treatment, engineering controls, or other means.

Although there are no human health or ecological exposure pathways for chemicals in groundwater at OU1, the no-action alternative does not prevent the spread of chemicals, and therefore does not protect the environment. In addition, the no-action alternative does not restore the groundwater aquifer being used by the local community (LAWC and the City of Pasadena) for drinking water. Therefore, the no-action alternative is not considered protective of human health and the environment at OU3, where chemicals are present at concentrations above the MCLs and groundwater is used as a drinking water source.

The preferred alternative, which includes groundwater extraction and ex situ treatment, has been implemented as the interim remedies at both OU1 and OU3. Data collected to date for these treatment systems have demonstrated that they can effectively contain and treat extracted groundwater to the required criteria, and that operation of the systems is resulting in decreased concentrations of chemicals within the groundwater. The preferred alternative is considered to have a high degree of overall protection of human health and the environment.

Compliance with ARARs. Compliance with ARARs addresses whether a remedial alternative meets all pertinent federal and state environmental statutes and requirements. An alternative must comply with ARARs, or be covered by a waiver.

Treated water would be required to comply with the most stringent of the federal and state MCLs, set forth in the Safe Drinking Water Act (40 Code of Federal Regulations § 141.61(a) and (c)) and the Code of California Regulations (Title 22, § 64444). Data from the existing treatment systems, which would continue to operate under the preferred alternative, demonstrate that the systems can effectively treat the chemicals in the extracted groundwater to concentrations below the MCLs. Therefore, the preferred alternative complies with this ARAR.

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 landowners and other parties allowing the courts to settle disputes over how much groundwater can rightfully be extracted. In an adjudicated groundwater basin, the court appoints a Watermaster to administer the court judgment and determine an equitable distribution of water that will be available for extraction each year.

Table 3. Summary of alternatives against the U.S. EPA remedial alternative evaluation criteria.

Alternative	Overall 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
Alternative 1: No Action	No	No	○	○	N/A	N/A	$0	NR	NR
Alternative 2: Active Treatment	Yes	Yes	●	●	◑	●	$90M	NR	NR

○ Low ◑ Moderate ● High NR = Not Rated N/A = Not Applicable

Evaluation of Alternatives: Compliance with ARARs

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, including the City of Pasadena and LAWC, operate wells in the Monk Hill Subarea. The City of Pasadena and LAWC will continue to be subject to the extraction, reporting, and monitoring requirements associated with the Raymond Basin Judgment.

Resource Conservation and Recovery Act (RCRA) hazardous waste identification criteria are promulgated by the federal government to define RCRA hazardous waste. As is currently occurring at three treatment systems included in the preferred alternative, solid waste, consisting of spent ion exchange resin beads, wastes from the LGAC process, and other treatment process waste are generated during operation of the treatment systems. The spent media and other wastes are characterized in accordance with RCRA requirements and disposed of accordingly.

Non-RCRA (California) hazardous waste identification criteria are promulgated by the State of California to define non-RCRA (California) hazardous waste. This requirement may also apply to the disposal of ion exchange, LGAC media, and other process waste from ex situ treatment operations under the preferred alternative. The spent media and other wastes are characterized in accordance with California hazardous waste requirements and disposed of accordingly.

Section 3020 of RCRA applies to the underground injection in the context of RCRA and CERCLA cleanups, such as that included as part of the preferred alternative for OU1. 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, including that the groundwater is treated to substantially reduce chemicals prior to such re-injection. The groundwater is treated prior to re-injection at the OU1 treatment system. Based on this, activities at OU1 would be exempt from the RCRA underground injection control ban.

General waste discharge requirements associated with any groundwater re-injection during remedial activities are provided by the Regional Water Quality Control Board. These discharge requirements are applicable to in situ groundwater remediation or the extraction of groundwater with aboveground treatment and re-injection of treated groundwater to the same aquifer zone. The general discharge requirements are intended to protect and maintain the existing beneficial uses of the receiving groundwater and are consistent with the anti-degradation provisions of State Water Resources Control Board Resolution No. 68-16. Groundwater is treated prior to re-injection to reduce concentrations of target chemicals and the preferred alternative complies with the substantive requirements associated with groundwater re-injection and State Water Resources Control Board Resolution 68-16.

The preferred alternative complies with all identified ARARs and would prevent further migration of VOCs and perchlorate in groundwater. The no-action alternative does not meet ARARs because chemicals are left in place, and untreated groundwater does not meet drinking water standards.

Because the drinking water treatment plants constituting the preferred alternative would be leased and operated by the City of Pasadena and LAWC, a number of regulations need to be complied with in addition to NASA's requirements under CERCLA:

- The City of Pasadena and LAWC are required to comply with all applicable regulations associated with drinking water identified in California Code of Regulations Titles 17 and 22. This includes obtaining certification of treatment plant operators and a permit to operate the system from the state.
- The City of Pasadena and LAWC are required to comply with the requirements of California Department of Public Health Policy Memorandum 97-005 associated with purveying water from an aquifer located within a CERCLA OU. This policy requires additional documentation from the drinking water purveyor prior to restoring use of the drinking water supply wells. Policy Memo 97-005 was considered during design and implementation of the OU3 interim action, which is included as part of the preferred alternative.
- As part of construction, the City of Pasadena and LAWC were required to comply with the *California Environmental Quality Act (CEQA)*, a state environmental protection law that applies to projects undertaken or requiring approval by state or local government agencies. CEQA imposes requirements on those agencies that are similar to the requirements that the National Environmental Protection Act imposes on federal agencies. In particular, CEQA requires California public agencies to identify the significant environmental effects of its actions to, where feasible, either avoid, and/or mitigate, any significant environmental effects.
- The MHTS is located within the City of Pasadena's city limits; therefore, as part of the MHTS construction, the City of Pasadena was required to obtain local permits prior to constructing the new treatment facility. These included a Conditional Use Permit and a Building Permit. LAWC complied with the construction permitting requirements of the County of Los Angeles when it built its treatment plant in 2004.

Evaluation Alternatives: Balancing Criteria

Long-Term Effectiveness. Long-term effectiveness addresses the ability of an alternative to maintain reliable protection of human health and the environment over time, including the degree of certainty that the alternative will prove successful.

Overall, there has been a general decreasing trend in perchlorate and VOC concentrations in the extracted groundwater over the duration of system operation at OU1 and OU3. At OU1, concentrations of TCE within the treatment zone monitoring wells (i.e., MW-7, MW-13, MW-16, and MW-24) are now below the state and federal MCL (5.0 µg/L), and concentrations of carbon tetrachloride are near the state MCL of 0.5 µg/L (maximum concentration of 0.7 µg/L in one treatment zone monitoring well). Perchlorate concentrations in MW-7 and MW-24 have declined from 13,300 µg/L and 4,880 µg/L to concentrations of 35.0 µg/L and 9.9 µg/L, respectively. These data demonstrate that operation of the OU1 treatment system has significantly reduced the chemical concentrations within the source area.

Perchlorate and VOC concentrations are also showing decreasing concentrations within the groundwater at OU3. At MW-17 (located between MHTS and LAWC production wells), monitoring data indicate that there is a decreasing trend in perchlorate and carbon tetrachloride concentrations over time. TCE concentrations in MW-17 continue to be relatively stable and below the MCL. In addition, perchlorate has not been detected at concentrations above the MCL and no increasing trends have been observed at the Rubio Cañon Land and Water Association (RCLWA) production wells, which are located downgradient of the LAWC wells. Data from the RCLWA wells along with data from MW-17 demonstrate that operation of the OU3 interim remedy is effectively preventing further migration of chemicals in groundwater.

Operation of the two drinking water treatment systems at OU3 will be effective for the long term. The systems permanently remove chemicals from groundwater by extracting the groundwater and treating it to remove VOCs and perchlorate before the drinking water is provided to customers. Results from routine monitoring of the treatment systems has demonstrated that perchlorate and VOC concentrations are consistently below detection limits following ion exchange and LGAC treatment at the MHTS and LAWC treatment systems. The system controls have proven to be reliable, and monitoring and system oversight required by CERCLA and the OU3 drinking water permits will ensure safe operation continues. Also, implementation of ICs will further enhance long-term effectiveness by ensuring exposure to chemicals in groundwater does not occur if a new well is installed in the Monk Hill Subarea.

Based on the current rate of chemical removal and data collected over the past 10 years, the preferred alternative is likely to operate for 10 to 20 more years. The technologies and equipment proposed have proven to be effective over such duration. It is estimated that at the end of this duration, groundwater chemical concentrations will be below the cleanup goals, thus making the groundwater suitable for drinking water without additional treatment for VOCs and perchlorate.

The no-action alternative would not remove the chemicals; therefore, long-term effectiveness would not be achieved.

Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment. The evaluation of this criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies to permanently and significantly reduce toxicity, mobility, and volume of chemicals in groundwater.

The preferred alternative uses treatment that permanently and irreversibly removes chemicals from the groundwater, thereby reducing the volume and mobility of chemicals in groundwater around JPL. The FBR, which treats perchlorate from source area groundwater at OU1, meets the U.S. EPA preference for reduction in toxicity and volume by degrading the perchlorate through biological treatment. At OU3, the perchlorate treatment technology transfers perchlorate from the groundwater to the ion exchange media. VOCs are also transferred from groundwater to carbon media at the OU1 and OU3 treatment systems. The ion exchange and carbon media would be properly disposed (either at an approved landfill or via thermal treatment) in accordance with federal and state regulations as is currently the case for the OU1 and OU3 treatment systems. The preferred alternative would reduce toxicity, mobility, and volume of affected groundwater.

The no-action alternative would leave chemicals in the groundwater to spread and further impact groundwater. Therefore, the no-action alternative does not permanently or significantly reduce toxicity, mobility, or volume of chemicals in groundwater.

Figure 3. Ion Exchange vessels used to remove perchlorate at the LAWC treatment system.

Evaluation of Alternatives: Balancing and Modifying Criteria

Short-Term Effectiveness. The evaluation of short-term effectiveness addresses how well human health and the environment are protected from impacts during the construction and implementation of a remedial alternative, and the length of time until protectiveness is achieved.

Because the treatment systems included in the preferred alternative were previously installed as part of the interim remedies, short-term impacts are limited to continued operation of these systems. Operation of the treatment systems would present minimal risks to workers, the public, and the environment. The systems are designed to shut down in case of malfunction and automatically alert operating staff if a shutdown occurs. The chemicals in the extracted water would be removed by the aboveground treatment system in accordance with state and federal regulations.

Potential short-term impacts to the community as a result of the preferred alternative are primarily related to truck traffic associated with system maintenance (e.g., LGAC and ion exchange media change-out). Other community impacts may include noise associated with pump operation or other maintenance activities such as well rehabilitation. These short-term noise impacts are mitigated to the greatest extent possible through the use of sound dampening engineering controls.

Potential impacts to site workers are safety concerns associated with routine system *operation and maintenance (O&M)* activities for the treatment systems, which are mitigated to the maximum extent practical through the use of personal protective equipment as required based on site conditions (e.g., hearing protection when working under high decibel circumstances).

The potential for unacceptable risk due to exposure to untreated groundwater will be mitigated in the preferred alternative through the existing adjudicated water rights within the basin and ICs which will further control groundwater extraction.

No construction or implementation activities are associated with the no-action alternative. The no-action alternative generates no short-term negative impacts, but does not reduce existing impacts from the chemicals in groundwater.

Implementability. Evaluation of implementability addresses the technical and administrative feasibility of implementing an alternative, including an evaluation of the availability of technologies, services, and materials required during implementation.

The preferred alternative represents that which has been implemented as the interim remedial actions for both OU1 and OU3. Therefore, the administrative and technical implementability of this alternative is high. All construction activities have been completed, so implementation of this alternative includes only continued O&M of the three treatment systems and establishing the ICs. The treatment systems have been operating effectively, and continued operation of the systems is considered highly implementable. All required permitting is currently in place for operation of the treatment systems, and the regulatory agencies and community have previously accepted this alternative, further increasing the administrative implementability of the preferred alternative.

The no-action alternative has a high level of implementability because there are no technologies, services, or materials required for implementation.

Cost. Evaluation of cost addresses the total cost of the remedial action, including capital and O&M costs.

The preferred alternative includes continued operation of the OU1 source area treatment system and also the two OU3 drinking water treatment systems. For OU1, actual annual O&M costs have ranged from approximately $800,000 to $1,000,000. This cost includes labor, materials, laboratory costs, well rehabilitation, and reporting/project management.

For OU3, actual annual costs incurred for O&M of the LAWC treatment system have ranged from approximately $800,000 to $900,000. The actual annual O&M costs for the MHTS have ranged from approximately $3,300,000 to $3,700,000. LAWC and MHTS costs include labor, materials, equipment leases, electricity, laboratory costs, and reporting.

Implementation of ICs and the groundwater monitoring program are estimated at $600,000 per year.

Current present value costs for the preferred alternative are estimated at $6.0M per year (total cost of $90M assuming 15 years of implementation), including operation of all three systems, ICs, and monitoring. These costs are considered reasonable to achieve the remedial action objectives at the JPL site because drinking water wells have been impacted and treatment is necessary to meet the remedial action objectives.

The no-action alternative would not result in any costs.

State Acceptance. Evaluation of this criterion addresses any concerns regarding the preferred alternative and other alternatives raised by the State of California regulatory agencies and state comments on ARARs. The evaluation of state acceptance will be fully addressed during the public comment period and preparation of the ROD.

Community Acceptance. Evaluation of this criterion addresses the apparent acceptability of the alternative to the community. The evaluation of community acceptance for this Proposed Plan will be fully addressed during the public comment period and preparation of the ROD.

Effectiveness of the Preferred Alternative

Based on the evaluation of the criteria described on the previous pages, implementation of the preferred alternative – continued operation of the OU1 source area treatment system, continued operation of the LAWC treatment system and MHTS, and ICs – is the most effective remedial action for meeting the remedial action objectives. The no-action alternative is not appropriate because there would be no removal of target chemicals from the aquifer, and further migration of chemicals in groundwater would not be controlled. Therefore, the remedial action objectives would not be met.

NASA's preferred alternative would achieve the remedial action objectives, protecting human health from exposure to VOCs and perchlorate originating from JPL. Results from periodic monitoring of the treatment systems, as well as NASA's ongoing groundwater monitoring program, would be used to monitor the effectiveness of the preferred alternative.

The preferred alternative satisfies the statutory requirements in CERCLA Section 121 (b) that the selected alternative:

- Be protective of human health and the environment
- Comply with ARARs
- Be cost-effective
- Implement treatment solutions that are technically practicable
- Satisfy the regulatory preference for treatment solutions that reduce the volume or mass of target chemicals, as well as chemical mobility and toxicity.

The preferred alternative can change in response to public comment or new information.

Community Participation

Over the past several years, NASA has engaged residents of the communities surrounding JPL, updating them on the status of the cleanup by holding public meetings, sending out newsletters, maintaining a website (http://jplwater.nasa.gov), and meeting with community groups, individuals, health care and local government representatives, and water purveyors.

In January 2004, public meetings were held to inform the public and JPL employees about the progress of cleanup activities that included describing several possible alternatives to treat perchlorate beneath the JPL facility. A newsletter on the project was mailed to residents of communities surrounding JPL.

In April 2004, another public meeting was held to discuss questions about potential public health effects associated with chemicals in the groundwater near JPL. Newsletters were distributed to more than 15,000 local residents in August 2004 and March 2005 that described cleanup actions funded by NASA at the two LAWC wells.

A community information session was held in March 2005, providing an opportunity for attendees to speak with NASA project staff and contractors involved in the cleanup. The OU3 systems (the existing treatment plant for LAWC and the then proposed MHTS) also were discussed at this session.

On November 16, 2005, a public meeting was held to provide information, and take public comments on a Proposed Plan for the OU1 source area groundwater treatment system as an interim remedy. On May 3, 2006, a public meeting was held to provide information, and take public comments on a Proposed Plan for the off-facility OU3 treatment systems as an interim remedy.

Progress of the OU1 system, LAWC plant, and MHTS has continued to be communicated to the community via newsletters (e.g., annual year-in-reviews), site tours, and the JPL CERCLA Program website.

NASA is now asking for public comment on the preferred alternative presented in this Proposed Plan for the final remedy at both OU1 and OU3. The public meeting regarding this final remedy will be held on November 12, 2014, and written comments will be accepted through December 3, 2014.

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Glossary and Abbreviations

Administrative Record: A collection of all documents used to select and justify remedial actions. These documents are available for public review.

Air Stripping: A treatment system that removes VOCs from contaminated groundwater or surface water by forcing an airstream through the water and causing the compounds to evaporate. The air can be further treated (for example, by using granular activated carbon) before it is released into the atmosphere.

Applicable or Relevant and Appropriate Requirement (ARAR): A federal or state law or regulation that must be followed during implementation of the remedy selected for site cleanup.

California Environmental Quality Act (CEQA): A state environmental protection law that applies to projects undertaken or requiring approval by state or local government agencies. CEQA requires California public agencies to identify the significant environmental effects of its actions to, where feasible, either avoid, and/or mitigate, any significant environmental effects.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): Legislation from 1980 that authorizes federal action to respond to the release, or the threat of release, into the environment of hazardous substances, pollutants, or chemicals that may present an imminent or substantial danger to public health or welfare or to the environment. Commonly referred to as Superfund.

Ecological Risk Assessment: A quantitative process that estimates the risk to plants and animals from exposure to chemicals at a site.

Enhanced Bioremediation: The activity of naturally occurring bacteria is stimulated by circulating water-based solutions through contaminated soils to enhance in situ biological breakdown of organic contaminants or immobilization of inorganic contaminants. Nutrients, oxygen, or other additives may be used to enhance bioremediation and contaminant removal from subsurface materials.

Ex Situ: Cleanup that requires soil or water to be removed for treatment.

Feasibility Study: An engineering evaluation of technologies that may be used to clean up a site. A Feasibility Study evaluates site conditions, technical problems, costs, and human and ecological impacts to determine the effectiveness of potentially applicable technologies.

Federal Facilities Agreement (FFA): A legal document that defines the roles and responsibilities of the government agencies associated with a federal facilities CERCLA site.

Fluidized Bed Reactor (FBR): A tank where media and microbes are suspended by flowing water. FBR is utilized to biologically treat groundwater.

Groundwater: Water beneath the ground surface that fills spaces between soil particles.

Human Health Risk Assessment: A quantitative process that estimates the risk to human health from exposure to chemicals at a site.

In Situ: Cleanup is performed with soil or water left in place.

In Situ Chemical Oxidation: A technique whereby a compound is introduced into the subsurface to chemically break down organic contaminants, changing them to harmless substances.

Information Repository: The physical location where a collection of site information is maintained. Documents in an information repository are available for public review.

Institutional Controls (ICs): Instruments such as administrative and legal controls that help minimize the potential for human exposure to contamination.

Interim Action: A limited scope remedial action used to protect human health and the environment and/or prevent migration of chemicals. Interim actions are conducted prior to determining the final cleanup action but often become part of the final cleanup action.

Ion Exchange: A method of treating water for the removal of perchlorate or other ions. Water is passed through a bed of resin and ions are exchanged between the water and the resin.

Liquid-Phase Granular Activated Carbon (LGAC): A form of carbon that is heated to promote "active" sites which can adsorb pollutants. LGAC has a strong potential to attract and adsorb VOCs from extracted groundwater.

Maximum Contaminant Level (MCL): U.S. EPA standards for drinking water quality. The legal threshold limit on the amount of a substance that is allowed in public water systems.

National Oil and Hazardous Substances Pollution Contingency Plan (NCP): A regulation issued by U.S. EPA to implement the requirements of CERCLA.

National Priorities List: A list of uncontrolled hazardous-substance release sites in the United States that are priorities for long-term remedial evaluation and response. The National Priorities List is compiled by U.S. EPA pursuant to Section 105 of CERCLA.

No-Action Alternative: A remedial action alternative that involves no additional site environmental activities beyond a remedial investigation.

Glossary and Abbreviations

Operable Unit (OU): An area designated under NASA's program to identify, investigate, assess, characterize, clean up, or control past releases of hazardous substances.

Operation and Maintenance (O&M): Activities and their associated costs that are needed to operate and maintain a site remedial activity or technology.

Perchlorate: A chemical compound that is a primary component of solid rocket propellant that dissolves readily in water.

Preferred Alternative: The preferred approach to site cleanup presented in the Proposed Plan and determined based on its ability to achieve the cleanup objectives. The preferred alternative can change as a result of public comment or new information.

Proposed Plan: A document that summarizes cleanup information and solicits public input. A Proposed Plan includes a summary of the environmental conditions at a site, as determined by the remedial investigation; describes remedial alternatives for the site; provides a summary of ARARs; and provides a brief analysis to support the preferred alternative.

Resource Conservation and Recovery Act (RCRA): RCRA was enacted in 1976 and is the principal Federal law in the United States governing the disposal of solid waste and hazardous waste.

Record of Decision (ROD): A document that summarizes how a site will be cleaned up and justifies the selection of the cleanup method chosen.

Remedial Action Objective: Specific goals for protecting human health and the environment.

Remedial Investigation (RI): A field study that includes collecting and analyzing field samples to evaluate the types and concentrations of chemicals present at a site.

Superfund Amendments and Reauthorization Act (SARA): Additions and changes to the CERCLA process that reflected the U.S. EPA's past experiences.

Soil Vapor Extraction (SVE): A treatment technology in which VOCs are removed from soils by induced airflow.

Source Area: The area where the majority of chemicals remain in groundwater at elevated concentrations. The source area correlates with the suspected chemical release area.

Treatment System: A system designed to treat/remove chemicals from groundwater. A treatment system may use multiple treatment technologies to remove chemicals.

Trichloroethylene (TCE): A chemical compound that was used to clean and remove grease from metal parts.

Vadose Zone: The area of soil below the ground surface but above the groundwater table. The vadose zone is also called the unsaturated zone, referring to the fact that the soils are above the groundwater table.

Vapor Intrusion: VOC vapors present in subsurface soils at some sites can migrate to buildings and other structures, and result in elevated chemical concentrations in indoor air that may pose a risk to human health. This migration of VOC vapors is referred to as vapor intrusion.

Volatile Organic Compound (VOC): A chemical compound that contains the element carbon and that readily evaporates into air at room temperature.

Key References

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NASA. 2006. Perchlorate Treatment Technologies Literature Review. June. JPL Record No. 10428.

Public Comment Requested for the Proposed Groundwater Remedy at NASA JPL

For More Information

Information

Documents on NASA's groundwater cleanup activities at JPL are available for review at the following Information Repositories:

Para más información en español llame a:
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NASA JPL
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La Cañada Flintridge Public Library
4545 Oakwood Ave. ● La Cañada Flintridge, CA 91011 ● (818) 790-3330

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