Focused Feasibility Study
North Hollywood Operable Unit
San Fernando Valley Area 1 Superfund Site
Los Angeles County, California

U.S. Environmental Protection Agency
Region 9
75 Hawthorne Street
San Francisco, California 94105

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Executive Summary

The U.S. Environmental Protection Agency (EPA), under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 33 United States Code (USC) § 9601 et seq., (CERCLA, commonly known as Superfund) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, has conducted a focused feasibility study (FFS) to address groundwater contamination caused by releases of volatile organic compounds (VOCs), chromium and other contaminants in the North Hollywood Operable Unit (NHOU) of the San Fernando Valley (SFV) Area 1 Superfund Site in Los Angeles County, California.

This FFS identifies, evaluates, and compares alternatives for improving the Existing NHOU Extraction and Treatment System (referred to in the FFS as the Existing NHOU Extraction and Treatment System) and presents EPA's preferred alternative. The planned improved remedy for the NHOU is referred to in this FFS as "the Second Interim Remedy." This FFS also evaluates certain emerging contaminants in the NHOU and addresses data needs in the existing NHOU monitoring network.

Purpose and Overview

VOC contamination, primarily trichloroethylene (TCE) and tetrachloroethylene (PCE), in the NHOU groundwater is currently being addressed by the Existing NHOU Extraction and Treatment System. The Existing NHOU Extraction and Treatment System, designed to achieve VOC plume containment and reduction of VOC contaminant mass using groundwater extraction, air stripping, and vapor-phase granular activated carbon (VPGAC) treatment, began operating in December 1989 and remains in operation 20 years later. The treated water, which is delivered to the water supply system for the City of Los Angeles, has consistently had levels of TCE and PCE well below the maximum contaminant level (MCL) for drinking water of 5 micrograms per liter (μg/L).

Although the Existing NHOU Extraction and Treatment System has reduced contaminant migration in the groundwater and removed substantial VOC mass from the aquifer, significant VOC contamination remains in the groundwater. In addition, changing groundwater conditions in the aquifer and the discovery of VOC contamination in new areas have demonstrated that the Existing NHOU Extraction and Treatment System is not capable of fully containing the VOC plume. EPA has also discovered new contaminants in NHOU groundwater in excess of MCLs or state notification levels, including chromium; 1,4-dioxane; 1,2,3-trichloropropane (TCP); and other select emerging chemicals. The Existing NHOU Extraction and Treatment System was not designed to treat chromium or the emerging chemicals. Consequently, elevated concentrations of chromium resulted in the shutdown in 2007 of one NHOU remedy (extraction) well, NHE-2, that serves an important plume containment function. The shutdown of this well also reduces the amount of water that the NHOU system contributes to the City of Los Angeles drinking water supply.

The Existing NHOU Extraction and Treatment System's inability to fully contain the groundwater plume, and the discovery of new contaminants, necessitates the selection and implementation of a new remedy for the NHOU.

Selection and implementation of a Second Interim Remedy is intended to address the continued presence of significant VOC contamination in groundwater, the presence of chromium and other emerging chemicals in exceedance of the MCLs or state notification levels, and the need to achieve more complete capture of the VOC plume. The scope of the Second Interim Remedy does not include restoration of the aquifer (i.e., removal of all manmade contaminants), in part because additional data are needed in some areas of the aquifer where the extent of contamination must be better defined before EPA can determine what additional remedial actions, if any, are needed to address these other areas of groundwater contamination. In the meantime, EPA considers it important to implement a Second Interim Remedy as soon as practicable to prevent further migration of the known high-concentration contaminant plumes, as described above, as well as to collect additional data to evaluate the need for (and scope of) further action.

To ensure that the groundwater cleanup achieved by the Second Interim Remedy is sustained over the long term, EPA will continue to work closely with the state to pursue effective and timely remediation of contaminant source areas at individual facilities within the NHOU. This includes controlling contaminant sources that occur above, at, or below the water table to maximize the ability of the Second Interim Remedy to contribute to long-term remediation of groundwater contamination.

Site Description

In 1986, EPA designated four Superfund sites in the SFV, as follows:

- Area 1 – North Hollywood: includes the NHOU and the Burbank Operable Unit (BOU).
- Area 2 – Crystal Springs: includes the Glendale North and Glendale South Operable Units (referred to collectively as the Glendale OU or GOU).
- Area 3 – Verdugo: located in the eastern end of the valley between the Verdugo and San Gabriel mountains.
- Area 4 – Pollock: includes the area of VOC groundwater contamination located southeast of the Glendale OU.

The SFV is an important source of drinking water for the Los Angeles metropolitan area. The Los Angeles Department of Water and Power (LADWP) produces groundwater for public distribution from six well fields near the NHOU. The North Hollywood, Rinaldi-Toluca, and Tujunga Well Fields are the primary production areas in the North Hollywood vicinity. Over the past 10 years, the groundwater from LADWP well fields in the SFV, including the NHOU, has contributed approximately 15 percent of the City's municipal supply. The NHOU treatment system typically accounts for approximately 2 percent of LADWP's total extraction from the SFV groundwater basin.

The NHOU is located in the eastern half of the SFV, where alluvial fill is present to more than 1,200 feet below ground surface (bgs). The alluvial fill consists of sand and gravel interbedded with localized lenses of clay and silt. The depth to groundwater in the North Hollywood area ranges from approximately 200 to 300 feet bgs.

In the NHOU, the alluvial-fill aquifer is divided into depth regions that exhibit flow characteristics similar to that of the remainder of the basin:

- Depth Region 1 is present from approximately 200 to 280 feet bgs; this is where shallow remedial investigation (RI) monitoring wells, older production wells, and facility monitoring wells (at sites under the jurisdiction of the Regional Water Quality Control Board, Los Angeles Region [RWQCB]) are screened. The NHOU extraction wells are screened in Depth Region 1 and the upper part of Depth Region 2.
- Depth Region 2 is present from approximately 280 to 420 feet bgs and has a high hydraulic conductivity (permeability); most production wells are screened in this region.
- Depth Region 3 occurs from approximately 420 to 700 feet bgs. Newer production wells, such as those in the Rinaldi-Toluca and Tujunga Well Fields (located north of the NHOU treatment system) and the wells in the western portion of the North Hollywood Well Field are screened in Depth Region 3.

Regionally, groundwater flow is southeast, toward the Los Angeles River Narrows. The groundwater flow direction in the NHOU is influenced by pumping of the production well fields surrounding the Existing NHOU Extraction and Treatment System and the BOU remedy wells. The BOU remedy wells are located 2 to 4 miles east of the NHOU. Pumping of the BOU remedy wells has created a large cone of depression to the east-southeast of the NHOU.

Site History

In the 1980s, TCE was consistently detected in SFV production wells at concentrations greater than the MCL for drinking water. Chlorinated solvents, including TCE and PCE, were widely used in the United States starting in the 1940s for dry cleaning and for degreasing machinery. Disposal was not well regulated at that time.

In 1986, EPA placed the SFV Area 1 Superfund Site on the National Priorities List (NPL). In 1989, the NHOU treatment system was constructed by LADWP with financial support from EPA. Source investigations and remediation activities are currently in progress under the lead of RWQCB and the California Department of Toxic Substances Control (DTSC).

In 2003, EPA's Third NHOU Five-Year Review reported that the TCE and PCE groundwater plume the remedy was designed to capture was migrating vertically and laterally beyond the remedy's zone of hydraulic control. Also in 2003, LADWP raised concerns regarding detections of total chromium and hexavalent chromium in extraction well NHE-2. Chromium was used in the metal plating and aerospace industry (metal fabrication), as well as for corrosion inhibition in industrial cooling towers, from the 1940s through the 1980s.

In July 2006, after a year of unusually high rainfall and rising groundwater levels in the SFV, the total chromium concentration detected at NHOU extraction well NHE-2 began to increase. In 2007, the elevated concentrations of chromium at well NHE-2 caused total chromium concentrations in the combined NHOU treatment system effluent to exceed 30 μg/L (60 percent of the MCL, which is 50 μg/L). As a result, the California Department of Public Health (CDPH) advised LADWP to shut down well NHE-2 or divert the water produced by the well to a nonpotable use. Chromium concentrations at this well have subsequently ranged from approximately 280 to 440 μg/L. In addition, 1,4-dioxane was detected at well NHE-2 during 2007 and 2008 at concentrations ranging from 4 to 7 μg/L. The CDPH notification level for 1,4-dioxane is 3 μg/L.

Extraction well NHE-2 remained shut down until September 2008, when modification of the discharge piping was completed to restore this well to service to contain the plume. The NHE-2 effluent is currently discharged to the Los Angeles Bureau of Sanitation sewer system. A long-term wellhead treatment method for well NHE-2, including treatment for chromium and 1,4-dioxane (if necessary), is expected to be implemented prior to the implementation of the NHOU Second Interim Remedy.

Over the past several years, Honeywell has been conducting facility-specific investigation and cleanup activities for VOCs and heavy metals contamination at their former North Hollywood facility. As a part of these facility-specific activities, Honeywell implemented in-situ treatment of chromium contamination in the groundwater and the vadose zone at the Honeywell facility in January 2009.

Summary of Available Data

This FFS presents an evaluation of available soil and groundwater contaminant data in the NHOU, with an emphasis on the period from January 2003 through December 2007 (referred to as "recent data" in this FFS). Analytical data typically available from the mid-1980s through 2002 (referred to as "historical data" in this FFS) were also reviewed. The objectives of the data evaluation include the following:

- Provide an updated interpretation of the nature and extent of groundwater contamination in the NHOU.
- Delineate target volumes for groundwater remediation and provide updated hydrogeologic data for groundwater modeling.
- Provide a foundation to develop an improved monitoring well network to further define the nature and extent of contamination in areas with limited existing data.
- Assist in the selection of the preferred remedial alternative for the Second Interim Remedy.

This data evaluation focuses primarily on TCE, PCE, and chromium (total and hexavalent), which are the primary chemicals of concern (COCs) in the NHOU. Data on select emerging contaminants that have been detected at notable concentrations (regulatory limits or notification levels) were also reviewed.

EPA has collected and reviewed contaminant data for many facilities in and around the NHOU for use in preparation of this FFS. The fact that EPA does not have data or has limited data from some facilities is not an indication that a particular facility did not contribute to the contamination. It is possible that additional sources or facilities that have not yet been identified have contributed, or are contributing, to groundwater contamination in the NHOU.

TCE and PCE

Depth Region 1

TCE and PCE concentrations exceeding 5 µg/L are present in a wide area of the NHOU and merge with a TCE and PCE plume in the BOU, to the east. Smaller TCE "hot spots," with concentrations ranging from 50 to 2,900 µg/L, occur within Depth Region 1 of the NHOU.

An area of particularly high TCE concentrations (ranging from 50 to greater than 1,000 µg/L) is centered near the southern boundary of the Honeywell facility. The peak TCE concentration detected recently at the Honeywell facility was 2,900 µg/L, in October 2006. The historical high TCE concentration at the Honeywell facility was 17,000 µg/L in July 1996. TCE concentrations at North Hollywood treatment system extraction well NHE-2, located approximately 1,000 feet south-southwest (downgradient) of the Honeywell facility, increased substantially since 2006, reaching a maximum of 1,300 µg/L in April 2007. With few exceptions, PCE concentrations are less than TCE concentrations in the NHOU.

Another area of high TCE concentrations is centered on Lockheed monitoring well LC1-CW06, with a recent peak concentration of 1,200 µg/L. Therefore, the horizontal extent of this TCE hot spot between LC1-CW06 and the easternmost NHOU extraction wells is poorly defined. TCE has been detected as high as 242 µg/L in the closest extraction well, NHE-7, located approximately 2,300 feet to the south. PCE concentrations exceed TCE concentrations in most wells near Burbank Airport to the east of well LC1-CW06, and PCE concentrations in excess of 100 µg/L are distributed over a much larger area (in excess of 6,000 feet across).

A northern hot spot of TCE/PCE in excess of 10 µg/L has been detected in Depth Region 1, north of the western plume, extending north from RI monitoring well NH-C01-325 (the maximum recent concentration of PCE was 28 µg/L, in December 2006). This detection of PCE appears to be distinct from the main western plume.

Another area with TCE/PCE concentrations in excess of 10 µg/L has been detected in Depth Region 1, northwest of the western plume at Hewitt Landfill, at monitoring well 4909F. The maximum recent TCE and PCE detections in groundwater from this well have been 74 and 23 µg/L, respectively.

Depth Regions 2 through 4

In Depth Regions 2 through 4, TCE and PCE concentrations in excess of the MCL are also distributed over a substantial area of the NHOU. Notable hot spots include the following:

- Northwest, centered at RI monitoring well NH-C05-460, northeast of the Rinaldi-Toluca Well Field
- West, centered near the southern boundary of the Honeywell facility
- Southeast, centered east of the Whitnall Well Field

The northwest hot spot in Depth Regions 2 through 4 includes the southernmost production wells in the Rinaldi-Toluca Well Field, where TCE concentrations have historically and recently exceeded the MCL. The highest TCE concentrations for this plume (120 µg/L) have been detected at RI well NH-C05-460. The lateral extent of this plume to the west, north, and east, as well as the vertical extent, are poorly delineated. Additional groundwater investigation is needed to delineate the magnitude and horizontal extents of VOC contamination in this area.

The west hot spot in Depth Regions 2 through 4 is located north of extraction well NHE-2. TCE has been detected at concentrations as high as 330 µg/L near the core of this plume. These wells are screened primarily in Depth Region 2. TCE and PCE concentrations generally decrease with depth in these wells. To the west of the core of this plume, TCE concentrations exceeding the MCL have been detected in several North Hollywood West production wells to 14.4 µg/L.

To the south, PCE and TCE have been detected in Depth Regions 2 through 4 at concentrations exceeding the MCL in RI monitoring well cluster NH-C03-380 through NH-C03-680, with a recent peak detection of 39 µg/L at a depth of 580 feet bgs and 25.6 µg/L at nearby production well NH-28. Three of the Whitnall Well Field production wells near RI monitoring well cluster NH-C02 have detections of TCE, PCE, or both, that exceed MCLs. Additional groundwater investigation is needed to delineate the magnitude and horizontal extent of VOC contamination in this area.

Chromium

Depth Region 1

According to the available groundwater data for the NHOU, total and hexavalent chromium detections in excess of the state MCL for total chromium of 50 µg/L are located at, or south (downgradient) of, the Honeywell site. Additionally, historical data indicate chromium concentrations above the MCL at the Bradley Landfill in the northernmost portion of Area 1 within the NHOU.

The highest total chromium concentration (48,000 µg/L) recently detected in groundwater in Depth Region 1 was at Honeywell facility monitoring well GW-1; hexavalent chromium was detected at a maximum concentration of 34,000 µg/L at this well in April 2007. Seven additional Honeywell monitoring wells in Depth Region 1 have reported total and hexavalent chromium concentrations in excess of 1,000 µg/L. The chromium plume is poorly defined to the southeast of the Honeywell facility.

Total chromium has recently been detected at the active NHOU extraction wells at maximum concentrations ranging from 2 µg/L at NHE-8 (1.34 µg/L hexavalent chromium) to 20.3 µg/L at NHE-3 (16.8 µg/L hexavalent chromium). Since late 2006, total chromium concentrations increased at NHE-2 to a maximum concentration of 401 µg/L (430 µg/L hexavalent chromium) in April 2007.

Total and hexavalent chromium have been detected in groundwater in Depth Region 1 at concentrations between 5 µg/L and 50 µg/L (the MCL for total chromium) at wells located north, south, and east of the NHOU. To the north, there are fewer groundwater monitoring wells. As a result, the nature and extent of total and hexavalent chromium in groundwater in the northern portion of the NHOU will continue to be evaluated and defined as groundwater sampling data are collected and evaluated.

Depth Regions 2 through 4

The highest recent chromium concentrations in Depth Regions 2 through 4 have been detected at Honeywell facility monitoring well GW-12A-319 (2,010 μg/L total chromium and 2,000 μg/L hexavalent chromium). Concentrations of total chromium exceeding the MCL were also recently detected at two additional Depth Region 2 monitoring wells at the Honeywell facility. In most of the SFV, total and hexavalent chromium concentrations are typically elevated in only the uppermost aquifer zones.

Emerging Chemicals

Available recent data (January 2003 to December 2007) for several of the emerging chemicals of potential concern, including TCP, 1,4-dioxane, n-nitrosodimethylamine (NDMA), and perchlorate, were reviewed as part of this FFS for the NHOU. Thallium and methyl tertiary butyl ether (MTBE) were also evaluated but were not detected in the NHOU, or they were present at concentrations below the MCLs and notification levels and were not investigated further. As additional monitoring data become available, it will be possible to more fully assess the potential for emerging chemicals to reach the North Hollywood treatment system with the passage of time.

TCP

In Depth Region 1, TCP has been detected at 25 wells in or adjacent to the NHOU. Detected concentrations of TCP at these wells range from 0.0017 to 0.016 μg/L. Higher concentrations of TCP, ranging from 0.288 to 170 μg/L, have been detected in the BOU south of Burbank Airport. In Depth Region 2, TCP was detected at 16 monitoring wells in or adjacent to the NHOU at concentrations ranging from 0.0023 to 0.13 μg/L. Higher concentrations of TCP, to 0.56 and 0.73 μg/L, have been detected in the BOU south and east of Burbank Airport.

1,4-Dioxane

In Depth Region 1, 1,4-dioxane has recently been detected in groundwater samples from 20 monitoring wells in or adjacent to NHOU at concentrations that exceed the state drinking water notification level. Fifteen detections of 1,4-dioxane that exceeded the notification level occurred at Honeywell facility monitoring wells at concentrations ranging from 4.7 to 90 μg/L. In Depth Regions 2 through 4, the only detections of 1,4-dioxane above the notification level occurred at three Honeywell facility monitoring wells at concentrations ranging from 3.9 to 9.2 μg/L.

NDMA

In Depth Region 1, NDMA has recently been detected above the notification level in or adjacent to the NHOU at fourteen monitoring wells. Recent maximum concentrations at these wells range from 0.012 to 0.034 μg/L. Detectable concentrations of NDMA below the notification level have been measured in 16 additional wells in Depth Region 1 of the NHOU. In Depth Regions 2 through 4, the maximum recent NDMA concentration was 0.12 μg/L at Lockheed monitoring well LB5-CW02. NDMA was recently detected above the notification level in two other monitoring wells in NHOU at concentrations of 0.057 and 0.066 μg/L.

Perchlorate

Perchlorate has been detected at concentrations exceeding the MCL in five wells in Depth Region 1 of the NHOU at concentrations ranging from 10 to 45 µg/L. Perchlorate has been detected at 23 other Depth Region 1 wells in or adjacent to NHOU at concentrations below the MCL, ranging from 0.47 to 4.9 µg/L. In Depth Regions 2 through 4 of the NHOU, perchlorate has been detected in excess of the MCL at Rinaldi-Toluca Well Field production well RT-7, which is located in the northern part of the well field. Perchlorate has also been detected at 11 other Depth Region 2 through 4 monitoring wells, all at concentrations below the MCL.

Remedial Action Objectives

The Second Interim Remedy at the NHOU is intended to achieve the following Remedial Action Objectives (RAOs):

- Contain areas of contaminated groundwater that exceed the MCLs and notification levels to the maximum extent practicable.
- Prevent further degradation of water quality at the Rinaldi-Toluca and North Hollywood West production wells by preventing the migration toward these well fields of the more highly contaminated areas of the VOC plume located to the east-southeast.
- Achieve improved hydraulic containment to inhibit horizontal and vertical contaminant migration in groundwater from the more highly contaminated areas and depths of the aquifer to the less contaminated areas and depths of the aquifer, including the southeast portion of the NHOU in the vicinity of the Erwin and Whitnall production well fields.
- Remove contaminant mass from the aquifer.

The Existing NHOU Extraction and Treatment System was designed with the understanding that some of the groundwater with low VOC concentrations would migrate eastward and be captured by the extraction wells of the adjacent groundwater treatment systems in the BOU and the GOU. Additional data obtained during design and implementation of the Second Interim Remedy will improve EPA's ability to determine the nature of a final remedy for the NHOU.

Preliminary Cleanup Goals

The groundwater extracted and treated by the Second Interim Remedy may ultimately be mixed with water from other sources, disinfected, and delivered to LADWP customers as potable water. Alternatively, the treated groundwater may be reinjected to the aquifer.

For the drinking water end use option, EPA proposes to use the federal and state drinking water MCLs as the cleanup levels for the treated groundwater. For the emerging chemicals (other than hexavalent chromium) for which MCLs have not been established (e.g., 1,4-dioxane), EPA proposes to use the CDPH notification levels as the cleanup levels for the treated groundwater.

An MCL for hexavalent chromium does not currently exist, but the State has initiated development of a public health goal and may promulgate an MCL within the next several years. Based on discussions with LADWP, it is EPA's understanding that LADWP will continue to use a voluntary cleanup level of 5 µg/L for hexavalent chromium for water it will accept for use in its water supply system. Consequently, under the drinking water end use option, chromium treatment at the NHOU will be needed so that LADWP's voluntary cleanup level of 5 µg/L can be met. Therefore, the EPA cleanup level for hexavalent chromium in treated water is 5 µg/L.

For the reinjection end use option, removal of hexavalent and total chromium will also be needed to comply with the State of California's anti-degradation policy, which establishes cleanup levels for reinjection into the aquifer. The anti-degradation policy allows for injection of treated groundwater at concentrations less than or equal to the groundwater quality at the injection location(s). Accordingly, the treated water cleanup levels for the reinjection end use will be established during remedial design based on the COC concentrations in the groundwater at the injection well location(s).

The primary cleanup goal for the Second Interim Remedy is to achieve containment of the most significant concentrations of the VOC- and chromium-contaminated groundwater. The remedial alternatives are designed to establish a capture zone that contains contaminated groundwater in the aquifer with VOC concentrations greater than 5 µg/L at most locations in the NHOU groundwater plume. For this FFS, a target concentration for capture and treatment of hexavalent and total chromium of 5 µg/L is assumed in anticipation of the issuance of a significantly lower state MCL for hexavalent chromium. This approach will provide containment of the most significantly contaminated portions of the groundwater plume in the NHOU.

Remedial Alternatives Considered

In consideration of the limitations of the existing treatment system, as well as the RAOs and Preliminary Cleanup Goals, a range of remedial alternatives was developed. The first alternative (Alternative 1) consists of continued operation of the Existing NHOU Extraction and Treatment System (essentially a "no further action" alternative), which will serve as a baseline against which to evaluate other alternatives. EPA developed eight additional alternatives (2a through 5b), all of which include varying levels of new or expanded groundwater extraction and treatment components.

The following general response actions are common to all of the remedial alternatives:

- Institutional controls (ICs) in the form of a groundwater management plan (i.e., a written agreement between EPA and LADWP) to mitigate the potential negative impacts to the NHOU system performance that could result from unexpected groundwater withdrawal by LADWP in and near the NHOU;
- Groundwater and treatment system monitoring, including approximately 37 new groundwater monitoring wells;
- Wellhead treatment at extraction well NHE-2 to remove 1,4-dioxane; and
- Chromium treatment for groundwater extracted by well NHE-2.

The primary objective of Alternatives 2a, 2b, and the other "action" alternatives considered in this FFS is to improve hydraulic containment, particularly for highly contaminated groundwater in the NHOU. To achieve this objective, Alternatives 2a through 5b include expansion and improvement of the Existing NHOU Groundwater Extraction and Treatment System. Remedial alternatives 2a through 5b include the following additional common elements:

- Repair and/or modify (deepen) existing extraction wells NHE-1 through NHE-8 to improve capture of the VOC plume.
- Construct new extraction wells and associated pipelines to improve hydraulic containment of highly contaminated groundwater south of LADWP's southern Rinaldi-Toluca wells and east of LADWP's North Hollywood West Well Field. The modified extraction well field assumed for Alternatives 2a through 5b consists of the eight existing NHOU extraction wells (NHE-1 through NHE-8) pumping at 250 gpm each (long-term average) and three new extraction wells (NEW-1, NEW-2, and NEW-3) pumping at 350 gpm each (long-term average). The new extraction wells would be located near the northwest boundary of the western 50 µg/L VOC and chromium target volumes in Depth Regions 1 and 2, respectively. The purpose of the new extraction wells would be to prevent migration of VOC and chromium contamination from the western target volumes to the Rinaldi-Toluca and North Hollywood West Well Field to the northwest and west.
- Refurbish the existing air stripper and add a second air stripper to provide sufficient primary VOC treatment capacity to handle the increased volume of groundwater from the extraction wells.
- Chromium treatment for groundwater extraction wells (in addition to NHE-2) where chromium concentrations are expected to be highest. The primary difference between Alternatives 2a through 5b is the number of extraction wells treated for chromium.

Alternatives 2a, 3a, 4a & 5a include the following to allow for discharge of treated water to LADWP's water supply system:

- Liquid phase granular activated carbon (LPGAC) treatment installed downstream from each of the air strippers to provide "double barrier" VOC treatment as required by CDPH.

Alternatives 2b, 3b, 4b & 5b include the following to allow for reinjection of treated water to the aquifer:

- Installation of six injection wells and an associated pipeline, and nine additional monitoring wells to monitor the water quality impacts near the injection wells.

For purposes of developing and comparing costs, an operation and maintenance period of 30 years is assumed, although the need for treatment and containment of the contaminated groundwater is likely to extend beyond 30 years.

Alternative 1 – Existing NHOU Extraction and Treatment System

A no-action alternative, which is required by the NCP to provide a baseline for comparison to other alternatives, was evaluated in the 1987 ROD for the NHOU. The no action alternative was eliminated from consideration in the 1987 ROD because "the contamination plumes (in the groundwater) would continue to migrate downgradient, rendering additional wells unusable." Rather than reconsidering the no action alternative, Alternative 1 consists of continued use of the Existing NHOU Extraction and Treatment System, with minor modification and increased monitoring.

In addition to the common components for all remedial alternatives identified above, Alternative 1 include the following:

- **Continued operation of NHE extraction wells.** Extraction of contaminated groundwater using the seven operable extraction wells (NHE-2 through NHE-8) at the average pumping rates during Water Years 2002 through 2006.
- **Wellhead chromium treatment at extraction well NHE-2.** Currently the water pumped from NHE-2 is treated for VOCs and discharged to the Los Angeles sanitary sewer system. The long-term plan is to reconnect NHE-2 to the NHOU treatment system.

Alternatives 2a and 2b – Expand Extraction Well System and Operate Chromium Wellhead Treatment Systems at Extraction Wells NHE-1 and NHE-2

The major difference between Alternatives 2a and 2b compared with Alternatives 3a through 5b is the scale of chromium treatment. Under Alternatives 2a and 2b, separate wellhead chromium treatment systems would be installed at NHE-1 and NHE-2. The goal of the wellhead chromium treatment for wells NHE-1 and NHE-2 under Alternatives 2a and 2b would be to decrease total chromium concentrations in the NHOU treatment plant effluent to 5 μg/L or less.

Alternative 2a includes the components common to all alternatives and the "action" alternatives described above, and assumes delivery of treated groundwater to LADWP for blending and further treatment for potable use. Alternative 2a also includes the following specific actions:

- **LPGAC system downstream from each of the air strippers** to provide "double barrier" treatment for VOCs.
- **Wellhead chromium treatment at well NHE-1** where chromium concentrations are expected to be similar to those detected at well NHE-2.
- **Wellhead chromium treatment at well NHE-2**.

Alternative 2b is nearly identical to Alternative 2a, but assumes reinjection of the treated groundwater into the aquifer rather than delivery to LADWP, resulting in the following differences:

- **Construction of six new injection wells**, a pipeline from the NHOU treatment plant to the injection wells, and nine new monitoring wells in the vicinity of the injection wells.
- **No LPGAC system** downstream from each of the air strippers, as there would be no need to provide "double barrier" treatment for VOCs.

Alternatives 3a and 3b – Expand Extraction Well System and Operate Chromium Treatment System for Combined Effluent from Extraction Wells NHE-1 and NHE-2

Alternatives 3a and 3b were developed to evaluate the cost-effectiveness of operating a single chromium treatment system for the combined flow from wells NHE-1 and NHE-2, compared with operation of two individual wellhead chromium treatment systems at these wells (as assumed under Alternatives 2a and 2b). Other components of Alternatives 3a and 3b are identical to those of Alternatives 2a and 2b.

Alternative 3a includes the components common to all alternatives and the "action" alternatives, and assumes delivery of treated groundwater to LADWP for blending and further treatment for potable use. Alternative 3a includes the following specific actions:

- **LPGAC system downstream from each of the air strippers** to provide "double barrier" treatment for VOCs.
- **Ex situ chromium treatment** at the NHOU groundwater treatment facility for the combined discharge groundwater extracted from wells NHE-1 and NHE-2.

Alternative 3b is nearly identical to Alternative 3a, but assumes reinjection of the treated groundwater into the aquifer rather than delivery to LADWP, resulting in the following differences:

- **Construction of six new injection wells**, a pipeline from the NHOU treatment plant to the injection wells, and nine new monitoring wells in the vicinity of the injection wells.
- **No LPGAC system** downstream from each of the air strippers, as there would be no need to provide "double barrier" treatment for VOCs.

Alternatives 4a and 4b – Expand Extraction Well System and Operate Ex Situ Chromium Treatment System for Multiple Extraction Wells

Alternatives 4a and 4b incorporate chromium treatment for the combined influent from extraction well NHE-1 and two of the three new extraction wells (NEW-2 and NEW-3), along with wellhead chromium treatment for NHE-2. Groundwater modeling results indicate that under expected future SFV well field pumping scenarios, new extraction wells NEW-2 and NEW-3 would intercept groundwater containing high concentrations of chromium at levels similar to NHE-1 and NHE-2.

Alternative 4a includes the components common to all alternatives and the "action" alternatives, and assumes delivery of treated groundwater to LADWP for blending and further treatment for potable use. Alternative 4a also includes the following specific actions:

- **LPGAC system downstream from each of the air strippers** to provide "double barrier" treatment for VOCs.
- **Wellhead chromium treatment at well NHE-2**.
- **Ex situ chromium treatment** at the NHOU groundwater treatment facility to treat the combined influent from extraction well NHE-1 and new extraction wells NEW-2 and NEW-3 (a peak combined pumping rate of 1,100 gpm).

Alternative 4b is nearly identical to Alternative 4a, but assumes reinjection of the treated groundwater into the aquifer rather than delivery to LADWP, resulting in the following differences:

- **Construction of six new injection wells**, a pipeline from the NHOU treatment plant to the injection wells, and nine new monitoring wells in the vicinity of the injection wells.
- **No LPGAC system** downstream from each of the air strippers, as there would be no need to provide "double barrier" treatment for VOCs.

Alternatives 5a and 5b – Expand Extraction Well System and Operate Ex Situ Chromium Treatment System for All Extraction Wells

Alternatives 5a and 5b incorporate chromium treatment of influent from all the extraction wells. These alternatives were originally developed in anticipation of the State issuing a proposed PHG for hexavalent chromium that is significantly less than 5 μg/L. Since a proposed PHG has not yet been issued, these alternatives have been retained in the FFS for the sake of completeness.

Alternative 5a includes the components common to all alternatives and the "action" alternatives, and assumes delivery of treated groundwater to LADWP for blending and further treatment for potable use. Alternative 5a includes the following specific actions:

- **LPGAC system downstream from each of the air strippers** to provide "double barrier" treatment for VOCs.
- **Ex situ chromium treatment** at the NHOU groundwater treatment facility to treat the combined influent from all of the extraction wells.

Alternative 5b is nearly identical to Alternative 5a, but assumes reinjection of the treated groundwater into the aquifer rather than delivery to LADWP, resulting in the following differences:

- **Construction of six new injection wells**, a pipeline from the NHOU treatment plant to the injection wells, and nine new monitoring wells in the vicinity of the injection wells.
- **No LPGAC system** downstream from each of the air strippers, as there would be no need to provide "double barrier" treatment for VOCs.

Comparative Analysis of the Remedial Alternatives

The following nine CERCLA evaluation criteria are used in the FFS to evaluate and compare the remedial alternatives described above:

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost
8. State acceptance
9. Community acceptance

The following table provides a comparative analysis of the remedial alternatives using the nine CERCLA evaluation criteria. A detailed comparison of the alternatives is presented in Section 5 of this FFS.

	ALTERNATIVES				
Evaluation Criteria	1a Existing Remedy	2a and 2b Expand Extraction Well System plus Chromium Wellhead Treatment at Wells NHE-1 & NHE-2	3a and 3b Expand Extraction Well System plus Chromium Treatment for Combined Flow from Wells NHE-1 and NHE-2	4a and 4b Expand Extraction Well System plus Ex Situ Chromium Treatment for Wells NHE-1 & 2 and NEW-2 & 3	5a and 5b Expand Extraction Well System plus Ex Situ Chromium Treatment for All Extraction Wells
Protection of Human Health & the Environment	○	⦿	⦿	●	●
Compliance with Applicable or Relevant and Appropriate Requirements	●	●	●	●	●
Long-term Effectiveness & Permanence	○	⦿	⦿	●	●
Reduction of Toxicity, Mobility, or Volume through Treatment	○	⦿	⦿	●	●
Short-term Effectiveness	●	●	●	●	●
Implementability	○	⦿	⦿	●	⦿
Cost*: Option "a": Provide Treated Water to LADWP	$40,100,000	$91,700,000	$82,600,000	$107,800,000	$119,900,000
Option "b": Reinject Treated Water	Not applicable	$118,100,000	$109,000,000	$134,200,000	$146,300,000
State Agency Acceptance	DTSC and LARWQCB concur with EPA's preferred alternative.				
Community Acceptance	Community acceptance for the recommended alternative will be evaluated after the public comment period.				

● Meets Criteria Best ⦿ Meets Criteria Moderately ○ Meets Criteria Least

* Costs are given as net present value of construction and operation and maintenance costs, assuming 30 years operation and 7% discount rate.

EPA's Preferred Alternative

EPA's Preferred Alternative is Alternative 4a, which includes the construction of three new extraction wells, the modification/rehabilitation of several existing extraction wells, expanded VOC treatment, chromium treatment for NHE-1, NHE-2 and two of the new extraction wells, and use of the treated water in LADWP's water supply system.

Based on the information currently available, EPA believes the Preferred Alternative meets the threshold criteria and provides the best balance of trade-offs among the other alternatives. Under Alternative 4a, the installation of additional extraction wells, the modification of existing extraction wells, and expansion of the VOC treatment system will achieve significantly improved plume capture and prevent further degradation of water quality at the Rinaldi-Toluca and North Hollywood West well fields. This alternative will also result in permanent and significant reduction in the mobility and volume of VOCs in groundwater in the NHOU. Alternative 4a also specifically provides for chromium removal from the extraction wells where the highest chromium concentrations are expected to occur and will achieve the treated water cleanup level of 5 μg/L for hexavalent chromium under a wide range of expected pumping scenarios.

The reuse option under Alternative 4a, delivery of treated water to LADWP, provides the greatest beneficial use of the treated water and at a significantly lower cost than reinjection.

The Preferred Alternative includes the installation and sampling of new monitoring wells to evaluate performance of the remedy and to better characterize the plume in certain areas of the NHOU. EPA will use the resulting data to evaluate the need for and scope of additional remedial actions within the NHOU.

The State has expressed support for EPA's Preferred Alternative.

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Acronyms and Abbreviations

μg/L	micrograms per liter
1,2-DCA	1,2-dichloroethane
1987 ROD	North Hollywood Operable Unit Interim Record of Decision of September 24, 1987
AOP	advanced oxidation process
ARAR	applicable or relevant and appropriate requirement
BAC	biologically active carbon
Basin Plan	*Water Quality Control Plan for the California Regional Water Quality Control Board, Los Angeles Region*
bgs	below ground surface
BOU	Burbank Operable Unit
CAO	Cleanup and Abatement Order
CCR	California Code of Regulations
CDPH	California Department of Public Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chemical of concern
DCA	1,1-dichloroethane
DCE	dichloroethylene
DHS	California Department of Health Services
DTSC	California Department of Toxic Substances Control
DWR	Department of Water Resources
EPA	U.S. Environmental Protection Agency
FFS	focused feasibility study
ft^3	cubic feet
GAC	granular activated carbon
GOU	Glendale North and South Operable Units
gpm	gallons per minute

IC	institutional control
JMM	James M. Montgomery Consulting Engineers, Inc.
LADWP	Los Angeles Department of Water and Power
LPGAC	liquid-phase granulated activated carbon
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/L	milligrams per liter
MTBE	methyl tertiary butyl ether
MWD	Metropolitan Water District
MWH	Montgomery Watson Harza Americas Inc.
NAS	National Academy of Science
NCP	National Contingency Plan
NDMA	n-nitrosodimethylamine
NH Complex	North Hollywood Pumping Station Complex
NHOU Chromium Evaluation	North Hollywood Operable Unit Chromium Evaluation
NHOU	North Hollywood Operable Unit
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPV	net present value
O&M	operation and maintenance
OEHHA	Office of Environmental Health Hazard Assessment
OU	operable unit
PCE	tetrachloroethylene
PHG	public health goal
ppt	parts per trillion
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	Record of Decision
RSL	risk screening level

RWQCB	Regional Water Quality Control Board, Los Angeles Region
SARA	Superfund Amendments and Reauthorization Act
SCAQMD	South Coast Air Quality Management District
SDWA	Safe Drinking Water Act
SFV	San Fernando Valley
SVOC	semivolatile organic compound
TBC	To Be Considered
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TCP	1,2,3-trichloropropane
ULARA	Upper Los Angeles River Area
USC	United States Code
UV	ultraviolet
UV/Ox	UV/peroxide
VOC	volatile organic compound
VPGAC	vapor-phase granulated activated carbon

SECTION 1

Introduction

The U.S. Environmental Protection Agency (EPA), under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 33 United States Code (USC) § 9601 et seq., (CERCLA, commonly known as Superfund) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, is conducting a focused feasibility study (FFS) to address groundwater contamination caused by releases of volatile organic compounds (VOCs) and chromium in the North Hollywood Operable Unit (NHOU) of the San Fernando Valley (SFV) Area 1 Superfund Site in Los Angeles County, California. This FFS also evaluates certain emerging contaminants in the NHOU and addresses data needs in the existing NHOU monitoring network. Development of the FFS and evaluation of remedial alternatives are based on the guidelines set forth in the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988).

1.1 Focused Feasibility Study Purpose and Overview

VOC contamination, primarily trichloroethylene (TCE) and tetrachloroethylene (PCE), in the NHOU groundwater is currently being addressed by the existing NHOU extraction and treatment system selected as the interim remedy in the September 24, 1987, NHOU interim Record of Decision (1987 ROD). Construction of the existing NHOU extraction and treatment system, designed to achieve VOC plume containment and reduction of VOC contaminant mass using groundwater extraction, air stripping, and vapor-phase granular activated carbon (VPGAC) treatment, was completed in March 1989 (Existing NHOU Extraction and Treatment System, NHOU system, or NHOU treatment system). The Existing NHOU Extraction and Treatment System began operating in December 1989 and remains in operation 20 years later, with the treated water delivered to the water supply system for the City of Los Angeles. The Existing NHOU Extraction and Treatment System was designed to extract and treat 2,000 gallons per minute (gpm) of groundwater, but has averaged approximately 800 gpm. Various factors have contributed to the system's operation at less than design flows, including the fact that extraction Well NHE-1 has not been used because the water table has dropped below its screen depth. The contaminant influent levels have ranged from 9 to 108 micrograms per liter (μg/L) for TCE and 4 to 15 μg/L for PCE since January 2004. The effluent water from the treatment system has consistently had levels of TCE and PCE well below the maximum contaminant level (MCL) for drinking water of 5 μg/L.

Although the Existing NHOU Extraction and Treatment System has reduced contaminant migration in the groundwater and removed significant VOC mass from the NHOU, changing groundwater conditions in the aquifer and the discovery of VOC contamination in new areas have demonstrated that the Existing NHOU Extraction and Treatment System is not capable of fully containing the VOC plume. In addition, since operation of the Existing NHOU Extraction and Treatment System began in 1989, EPA has discovered new contaminants in NHOU groundwater in excess of MCLs or state notification levels, including chromium; 1,4-dioxane; 1,2,3-trichloropropane (TCP); and other select emerging chemicals. The Existing NHOU Extraction and Treatment System was not designed to treat chromium or the emerging chemicals. Consequently, elevated concentrations of chromium resulted in the shutdown in 2007 of one NHOU remedy (extraction) well, NHE-2, that serves an important plume containment function. The shutdown of this well also reduces the amount of water that the NHOU system contributes to the City of Los Angeles drinking water supply.

The Existing NHOU Extraction and Treatment System's inability to fully contain the groundwater plume, and the discovery of new contaminants, necessitates the selection and implementation of a new remedy for the NHOU. This FFS identifies, evaluates, and compares alternatives for improving the Existing NHOU Extraction and Treatment System, and presents a comparative analysis of these remedial alternatives that will be the basis for selecting a preferred alternative. The planned improved remedy for the NHOU is referred to in this FFS as "the Second Interim Remedy."

Selection and implementation of a Second Interim Remedy is intended to address the continued presence of significant VOC contamination in groundwater, the detection of chromium and other emerging chemicals in exceedance of the MCLs or state notification levels, and the need to achieve more complete capture of the VOC plume. The scope of the Second Interim Remedy is:

1. Containment of the known highest-concentration VOC, chromium, and emerging contaminant plumes in groundwater in the immediate vicinity of the Existing NHOU Extraction and Treatment System. This will prevent the highest contaminant concentrations from migrating to the nearby Rinaldi-Toluca and North Hollywood West production wells and areas of the aquifer with significantly lower contaminant concentrations.
2. Improved delineation of groundwater contamination located beyond the immediate vicinity of the Existing NHOU Extraction and Treatment System to determine whether additional remedial actions are necessary.
3. Expansion of the NHOU groundwater monitoring well network to adequately monitor performance of the Second Interim Remedy and provide data required to optimize future system performance.

The scope of the Second Interim Remedy does not include restoration of the aquifer (removal of all manmade contaminants). Furthermore, additional data are needed in some areas of the aquifer where the extents of contamination are incompletely delineated (described in Section 2.7) before EPA can determine what additional remedial actions, if any, are needed to address these other areas of groundwater contamination. In the meantime, EPA considers it important to implement a Second Interim Remedy as soon as practicable to prevent further migration of the known high-concentration contaminant plumes, as described above, as well as to collect additional data to evaluate the need for (and scope of) further action.

To ensure that the groundwater cleanup achieved by the Second Interim Remedy is sustained over the long term, EPA will continue to work closely with the state to pursue effective and timely remediation of contaminant source areas at individual facilities within the NHOU. This includes controlling contaminant sources that occur above, at, or below the water table to maximize the ability of the Second Interim Remedy to contribute to long-term remediation of groundwater contamination.

1.2 Site Description

The NHOU lies within the SFV, which is a 112,000-acre, alluvial basin in the south-central portion of the Transverse Ranges (see Figure 1-1, figures are located at the end of each section). The SFV is bordered on the east by the Verdugo Mountains, on the west by the Simi Hills, on the north by the Santa Susana and San Gabriel Mountains, and on the south by the Santa Monica Mountains. The SFV Superfund Sites are located in the eastern portion of the SFV, between the Verdugo and Santa Monica Mountains. There are four Superfund sites in the SFV, as follows:

- Area 1 – North Hollywood: Includes the NHOU and the Burbank Operable Unit (BOU).
- Area 2 – Crystal Springs: Includes the Glendale North and Glendale South Operable Units (referred to collectively as the GOU).
- Area 3 – Verdugo: This site was removed from the National Priorities List (NPL) in 2004.
- Area 4 – Pollock.

A basinwide remedial investigation (RI) was completed in 1992 to better characterize groundwater conditions in the SFV groundwater basin. EPA has signed Records of Decision (RODs) for the NHOU (1987), the BOU (1989), and the GOU (1993). In each case, EPA selected an interim pump-and-treat remedy to contain VOC-contaminated groundwater and remove contaminant mass. The SFV Area 3 – Verdugo site was deleted from the NPL on October 12, 2004, after issuance of a no-action ROD for that site. No Superfund remedy has been selected by EPA for the Area 4 site, but the Los Angeles Department of Water and Power (LADWP) currently operates a pump and treat system to remove VOCs from groundwater that is used as part of the City's water supply system.

The Existing NHOU Extraction and Treatment System has been operating since 1989, and the BOU interim remedy has been operating since 1996. The GOU, which consists of two extraction well fields and one treatment plant, began limited operations in August 2000 and achieved full operational capacity in June 2002.

The SFV is an important source of drinking water for the Los Angeles metropolitan area, the Cities of Glendale, Burbank, San Fernando, La Canada-Flintridge, and the unincorporated area of La Crescenta. The SFV is located in the Upper Los Angeles River Area (ULARA), which is under adjudicated water rights managed by the ULARA Watermaster (State Water Resources Control Board, 2002). In addition to the NHOU extraction wells, LADWP produces groundwater for public distribution from six well fields near the NHOU. The well fields are North Hollywood West, North Hollywood East, Rinaldi-Toluca, Tujunga, Whitnall, and Erwin (see Figure 1-1). The North Hollywood West Well Field is located west of the NHOU system. The North Hollywood East Well Field is located south and southeast of the NHOU treatment system. The Rinaldi-Toluca and Tujunga Well Fields are located northwest of the NHOU system. The Erwin and Whitnall Well Fields are located southeast of the NHOU system. The North Hollywood, Rinaldi-Toluca, and Tujunga Well Fields are the primary production areas in the North Hollywood vicinity. Over the past 10 years, the groundwater from LADWP well fields in the SFV, including the NHOU, has contributed approximately 15 percent of the City's municipal supply (LADWP, 2007). The NHOU treatment system typically accounts for approximately 2 percent of LADWP's total extraction from the SFV groundwater basin (ULARA Watermaster, 2006a).

The NHOU treatment facility is located at 11845 Vose Street, North Hollywood. Extraction well NHE-1 (inoperable) is also located at this address. The remaining seven extraction wells associated with the NHOU treatment system (NHE-2 through NHE-8) are located in an electric transmission line right-of-way southeast of the NHOU treatment facility and on LADWP property along Kittridge Avenue, North Hollywood (LADWP, 2003) (see Section 4).

1.2.1 Geology and Hydrogeology

The mountains surrounding the SFV comprise crystalline and sedimentary rocks that eroded during the Quaternary Period (from approximately 1.8 million years ago to present) and resulted in valley fill deposits up to 2,000 feet thick in the SFV (James M. Montgomery Consulting Engineers, Inc. [JMM], 1992). Lateral zonation in these deposits is present because of the migration of the Tujunga fan (drainages) at the northeast corner of the SFV, which deposits alluvium from the San Gabriel Mountains. Faults form the lateral bedrock boundaries of the aquifer depth regions described in this section (CH2M HILL, 1996).

The NHOU is located in the eastern half of the SFV, where alluvial fill is present to more than 1,200 feet below ground surface (bgs) (EPA, 1998). The alluvial fill consists of sand and gravel interbedded with localized lenses of clay and silt (EPA, 1987). The Verdugo Fault crosses the northeast portion of the North Hollywood area. Aquifer transmissivity increases where the base of the alluvium deepens from northeast to southwest across the fault, resulting in variations in groundwater elevations (CH2M HILL, 1996). Geologic cross sections are presented in the *Remedial Investigation of Groundwater Contamination in the San Fernando Valley, Remedial Investigation Report* (JMM, 1992).

The depth to groundwater in the North Hollywood area ranges from approximately 200 to 300 feet bgs (CH2M HILL, 2003) (see Figure 1-2). In the NHOU, the alluvial-fill aquifer is divided into depth regions that exhibit flow characteristics similar to that of the remainder of the basin (CH2M HILL, 1996). Depth Region 1 is present from 200 to 280 feet bgs; this is where shallow RI wells, older production wells, and facility monitoring wells (at sites under the jurisdiction of the Regional Water Quality Control Board, Los Angeles Region [RWQCB]) are screened. Depth Region 2 is present from 280 to 420 feet bgs and has a high hydraulic conductivity (permeability); most production wells are screened in this region. Depth Region 3 occurs from 420 to 700 feet bgs. Newer production wells, such as those in the Rinaldi-Toluca and Tujunga Well Fields (located north of the NHOU treatment system) and the wells in the western portion of the North Hollywood Well Field are screened in Depth Region 3 (EPA, 1998). The NHOU extraction wells and most RI monitoring wells are screened in Depth Region 1 and the upper part of Depth Region 2.

Regionally, groundwater flow is southeast, toward the Los Angeles River Narrows (EPA, 1998) (see Figure 1-1). Locally, groundwater flow is influenced by well field pumping and by groundwater recharge at the Hansen, Branford, and Tujunga spreading grounds (CH2M HILL, 1996). The groundwater flow direction in the NHOU is influenced by pumping of the production well fields surrounding the Existing NHOU Extraction and Treatment System and the BOU remedy wells. The BOU remedy wells are located 2 to 4 miles east of the NHOU. Pumping of the BOU remedy wells has created a large cone of depression to the east-southeast of the NHOU.

1.2.2 Site History

Prior to World War II, most land in the SFV was occupied by farms, orchards, and ranchland. Inspection of historical air photos indicates that by 1938, a small airfield was present at the site of today's Burbank Airport, bordered by the Valhalla Memorial Park to the south, and open fields to the east, west, and south. By 1949, after the war, the Burbank Airport had expanded to approximately its present size, and nearly all the land in Burbank and North Hollywood was occupied by housing developments and industrial facilities. Accompanying these land use changes in the 1940s was a substantial increase in population and groundwater withdrawals from the SFV (ULARA Watermaster, 2006c). In the 1950s, the North Hollywood, Erwin, Whitnall, and Verdugo Well Fields were constructed by LADWP in the North Hollywood area to meet the increasing demand for water. In 1968, groundwater withdrawals from the SFV were reduced to achieve "safe yield" from the basin, and more surface water was imported to the basin from external sources.

In 1979, industrial contamination was found in groundwater in the San Gabriel Valley (to the east of the SFV), prompting the California Department of Public Health (CDPH; formerly the California Department of Health Services) to request that all major water providers in the region, including those in the SFV, sample and analyze groundwater for potential industrial contaminants. TCE was consistently detected in a large number of production wells at concentrations greater than the MCL for drinking water (EPA, 2003). Chlorinated solvents, including TCE and PCE, were widely used in the United States starting in the 1940s for dry cleaning and for degreasing machinery. Disposal was not well regulated at that time. Chromium was used in the metal plating and aerospace industry (metal fabrication), as well as for corrosion inhibition in industrial cooling towers, from the 1940s through the 1980s. The distribution of TCE, PCE, and chromium in shallow and deeper groundwater in the eastern SFV as of December 2007 is shown on Figures 1-3 through 1-7. These maps are based on 2007 data, where available, and historical data where few recent data are available. To replace wells contaminated by TCE and PCE, and to provide more operational flexibility for groundwater recharge and pumping in the SFV, LADWP constructed the Rinaldi-Toluca Well Field (1988 and 1989) and the Tujunga Well Field (1993).

Because of the elevated groundwater contamination in the SFV, the NHOU interim remedy was given fast-track status. In 1986, EPA placed the SFV Area 1 Superfund Site on the NPL, and LADWP prepared the *Operable Unit Feasibility Study for the North Hollywood Well Field Area of the North Hollywood-Burbank NPL Site* (LADWP, 1986), which was the basis for selection and design of the current NHOU treatment system. By 1987, LADWP and EPA entered into a cooperative agreement that provided Federal funds for a remedial investigation of the SFV. Also in 1987, EPA issued an interim ROD for the NHOU, which selected a groundwater containment remedy that was to include extraction and treatment of VOC-contaminated groundwater using a treatment system designed by LADWP.

In 1989, the NHOU treatment system was constructed by LADWP with financial support from EPA. The NHOU groundwater treatment system consists of eight groundwater extraction wells (NHE-1 through NHE-8), an air-stripping treatment system to remove VOCs from the extracted groundwater, and ancillary equipment. The components of the groundwater remedial system for the NHOU are described in more detail in Section 1.3. The treatment system commenced operation in December 1989 and remains in operation today; however, the system has only occasionally achieved sustained operation at its design treatment capacity of 2,000 gpm because of several factors (discussed further in Section 4). More recently, extraction well NHE-2 was shut down for eighteen months in response to high levels of total chromium detected in groundwater samples from this well (discussed in more detail below).

From the late 1980s to late 1990s, EPA provided funds to RWQCB to conduct assessments of facilities in the SFV to determine the extent of solvent usage and to assess past and current chemical handling, storage, and disposal practices. These investigations were conducted pursuant to RWQCB's Well Investigation Program and resulted in source remediation activities at several facilities within the SFV. Source investigations and remediation activities are currently in progress under the lead of RWQCB and the California Department of Toxic Substances Control (DTSC).

The RWQCB has issued Cleanup and Abatement Orders (CAOs) to two parties in the NHOU. In December 1987, Lockheed was issued a CAO (No. 87-161) by RWQCB. The CAO directed Lockheed to remediate contaminated soil and groundwater at Plant B-1 (in the BOU) and to complete a comprehensive site assessment at all of Lockheed's other Burbank Airport facilities, including Plants B5 and C1 (in the NHOU), to determine the sources and extents of soil and groundwater contamination. The second party in the NHOU to receive a CAO was Honeywell, in 2003 (described below).

In December 1992, an RI for the SFV groundwater basin, including installation and subsequent regular monitoring of 84 groundwater wells, was completed under a cooperative agreement between EPA and the LADWP. The RI was conducted to evaluate the groundwater quality throughout the SFV basin and assist in identifying the best treatment method(s) and optimal locations to install groundwater treatment systems to address the SFV groundwater contamination.

In 1999, EPA provided funds to RWQCB to investigate potential chromium sources in the SFV. In November 2002, RWQCB released the findings from its investigation of more than 4,000 potential source sites, recommending further assessment of 106 sites. Of these 106 sites, 7 facilities in the SFV were issued CAOs from RWQCB. In the NHOU, RWQCB issued a CAO in February 2003 to Honeywell International, Inc., for chromium contamination in groundwater at its North Hollywood facility. This CAO was amended in April 2007 to include investigation and mitigation of emerging contaminants at the Honeywell facility and to address elevated chromium concentrations at NHOU extraction well NHE-2. Evaluation of potential groundwater contaminant sources in the SFV is ongoing.

In 1993, 1998, and 2003, EPA conducted five-year reviews (required by CERCLA) to evaluate the protectiveness of the NHOU interim remedy. The *Third NHOU Five-Year Review* (EPA, 2003) reported that the TCE and PCE groundwater plume the remedy was designed to capture was migrating vertically and laterally beyond the remedy's zone of hydraulic control. This conclusion was based largely on EPA's evaluation of the current NHOU groundwater conditions and LADWP findings in the *Draft Evaluation of the North Hollywood Operable Unit and Options to Enhance Its Effectiveness* (LADWP, 2002). The *Final Evaluation of the North Hollywood Operable Unit and Options to Enhance Its Effectiveness* (LADWP, 2003) raised concerns regarding detections of total chromium and hexavalent chromium in extraction well NHE-2.

To better understand the current groundwater conditions in the NHOU, EPA conducted an evaluation of chromium and select chemicals that were detected throughout the SFV groundwater basin. The NHOU Chromium Evaluation (EPA, 2006) is a review of available data for total and hexavalent chromium and select emerging contaminants within the NHOU as of May 2005. According to the available data at that time, chromium and TCP were occasionally detected at NHOU extraction well NHE-2 at or above the MCL for chromium (50 μg/L) and the CDPH (formerly the California Department of Health Services) notification level for TCP (0.005 μg/L).

In July 2006, after a year of unusually high rainfall and rising groundwater levels in the SFV, the total chromium concentration detected at NHOU extraction well NHE-2 began to increase. In 2007, the elevated concentrations of chromium at well NHE-2 caused total chromium concentrations in the combined NHOU treatment system effluent to exceed 30 μg/L (60 percent of the MCL). As a result, the CDPH advised LADWP to shut down well NHE-2 or divert the water produced by the well to a nonpotable use. Chromium concentrations at this well have subsequently ranged from approximately 280 to 440 μg/L. In addition, 1,4-dioxane was detected at well NHE-2 during 2007 and 2008 at concentrations ranging from 4 to 7 μg/L. The CDPH notification level for 1,4-dioxane is 3 μg/L.

Extraction well NHE-2 remained shut down until September 2008, when modification of the discharge piping was completed to restore this well to service to contain the plume. The NHE-2 effluent is currently discharged to the Los Angeles Bureau of Sanitation sewer system. This work was conducted by Honeywell as an interim measure, pursuant to a CAO from RWQCB that requires Honeywell to clean up the chromium contamination and to restore lost water caused by the shut down of well NHE-2. A long-term wellhead treatment method for well NHE-2, including treatment for chromium and 1,4-dioxane (if necessary), is expected to be implemented prior to the implementation of the NHOU Second Interim Remedy.

Key historical events that occurred at the NHOU are listed in Table 1-1.

TABLE 1-1
Chronology of North Hollywood Operable Unit Events
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Period	Key Event
1979	Final judgment of 1924 water rights in the ULARA completed; Los Angeles County Superior Court appoints ULARA Watermaster.
1979	Organic chemicals were found in the groundwater within the San Gabriel Valley, east of SFV. CDPH (formerly the California Department of Health Services) requested all major groundwater users to test for industrial chemicals.
1980	Congress enacted CERCLA. The CDPH detected TCE, PCE, and other VOCs at concentrations that exceeded the MCLs in a large number of production wells in the SFV; those wells were removed from service. An alternative water supply was obtained from the Metropolitan Water District (MWD) where needed.
1981	LADWP and Southern California Association of Governments began a 2-year study funded by EPA titled *Groundwater Management Plan – San Fernando Valley Basin*.
1982	LADWP conducted depth-specific packer sampling at Well Number 24. Results indicated that TCE concentrations were 50 times greater in the upper zone than in all other zones.
July 1983	*Groundwater Management Plan – San Fernando Valley Basin* completed. The study found widespread VOC contamination in the eastern SFV and also located a contaminant plume migrating to the southeast at 300 feet per year.
1984	Four SFV Superfund Sites proposed for listing on the NPL.
1985	Groundwater samples from 27 of 38 of LADWP's most active wells in the North Hollywood Well Fields had a concentration of TCE greater than the MCL; four wells had PCE concentrations greater than the MCL. LADWP shut down several contaminated wells in the eastern portion of the well field.
July 1986	The SFV Area 1 Superfund Site was placed on the NPL. LADWP commissioners approved a Negative Declaration for the NHOU project.
August 1986	The South Coast Air Quality Management District (SCAQMD) issued a permit to construct and operate the air stripper for the NHOU treatment system.
October 1986	The CDPH issued an amended water system permit for the NHOU treatment system.
November 1986	The LADWP completed the *Operable Unit Feasibility Study for the North Hollywood Well Field Area of the North Hollywood-Burbank NPL Site, San Fernando Valley Groundwater Basin,* which was the basis for selection and design of the current NHOU treatment system.
1987	LADWP signed a cooperative agreement with EPA providing Federal funds for a basinwide RI. The SFV Areas 1 and 2 were subdivided into operable units to provide a discrete interim remedy for each operable unit.
	RWQCB issued CAO 87-171 to Lockheed Martin for investigation and cleanup of properties in the SFV including Plants B5 and C1, which are located within the NHOU.
September 1987	ROD signed for the NHOU; groundwater remedy includes extraction and treatment.
March 1989	Construction of the NHOU treatment system was completed.
December 1989	Operation of the NHOU treatment system began.
March 1991	Lockheed entered into a consent decree with the EPA relating to the former Plant C1, which was located within the NHOU, on property that is now the Burbank Airport.
December 1992	An SFV basinwide RI was completed. A basinwide groundwater monitoring program was established, including sampling of 84 RI wells.
July 1993	First NHOU 5-year review (EPA, 1993) completed.
July 1998	Second NHOU 5-year review (EPA, 1998) completed.

TABLE 1-1
Chronology of North Hollywood Operable Unit Events
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Period	Key Event
January 1999	EPA initiated chromium source investigation by providing funds to RWQCB to investigate 4,040 potential chromium sources in the SFV.
February 1999	The Office of Environmental Health Hazard Assessment (OEHHA) of the California Environmental Protection Agency formally adopted a public health goal (PHG) for total chromium of 2.5 µg/L. The PHG assumed a concentration of 0.2 µg/L for hexavalent chromium.
November 2001	OEHHA withdrew its PHG of 2.5 µg/L after a study by the Chromium Toxicity Review Committee concluded that the state total chromium MCL of 50 µg/L is protective.
August 2002	The RWQCB completed *Chromium Investigation: San Fernando Valley Phase I; Inspections Final Report*; further assessment was recommended for 105 sites. The RWQCB issued four CAOs to parties throughout the San Fernando groundwater basin.
February 2003	The RWQCB issued CAO No. R4-2003-0037 to Honeywell International Inc., for chromium requiring that Honeywell "assess, cleanup, and abate the effects of contaminants discharged to soil and groundwater."
September 2003	Third NHOU 5-year review (EPA, 2003) completed.
2003 – 2004	Legislative deadline for hexavalent chromium PHG to be established by OEHHA, and subsequent MCLs to be issued by the CDPH passes. The hexavalent chromium PHG and MCL were not established.
September 2004	The RWQCB issued a letter to Honeywell International Inc., which revised the February 2003 CAO to include VOCs as part of the CAO investigation and cleanup.
January 2006	EPA completed the NHOU Chromium Evaluation.
December 2006	Chromium concentration at NHOU well NHE-2 reaches 200 µg/L.
January 2007	The concentration of total chromium in the NHOU treatment system discharge (point of compliance) reached 33.7 µg/L, slightly more than 60 percent of the MCL for chromium (50 µg/L).
February 2007	CDPH advised LADWP to shut down well NHE-2 or divert the water extracted by that well to a nonpotable use.
April 2007	The RWQCB issued two CAO amendments to Honeywell to (1) expedite chromium treatment and conduct a comprehensive soil and groundwater assessment at the Honeywell facility and (2) replace water lost because of the closure of well NHE-2 due to elevated chromium concentrations.
May 2007	Honeywell submitted a work plan to RWQCB and EPA for wellhead treatment of chromium and 1,4-dioxane at extraction well NHE-2.
September 2007	Site assessment at Honeywell began following work plan review and approval by SFV agencies. Honeywell submits permit applications for wellhead treatment at well NHE-2 and chromium treatment at the Honeywell facility.
September 2008	Well NHE-2 returned to service following modifications completed by Honeywell to extract the groundwater and discharge the effluent to the city sewer system.
January 2009	Construction of in situ treatment for chromium groundwater contamination at the Honeywell facility in North Hollywood was completed under the supervision of the RWQCB.

1.3 Groundwater Remedial Activities

This section describes groundwater remedial activities currently being implemented or in the design phase at the NHOU.

1.3.1 Existing NHOU Extraction and Treatment System

The Existing NHOU Extraction and Treatment System, which was selected as an interim remedy in 1987, addresses the VOC-contaminated groundwater plume. The objective of the interim remedy was containment of the VOC plume and removal of significant contaminant mass. The 1987 ROD selected groundwater extraction and treatment by air stripping (referred to as "aeration" in historical documents).

Groundwater is pumped from extraction wells to the treatment plant where it enters the air stripper. The air stripper consists of a vertical column containing a packing medium (to increase surface area) over which a countercurrent flow of air is introduced to strip VOCs from the groundwater. The air emissions are filtered through granulated activated carbon (GAC) to remove the VOCs prior to discharge to the atmosphere (EPA, 1987).

The existing NHOU groundwater treatment system includes the following components:

- **Extraction Wells and Piping**
  - Eight groundwater extraction wells originally designed to pump 250 to 300 gpm each. Of the eight wells, seven are functioning.
  - Approximately 11,000 feet of 12-inch-diameter conveyance (influent) pipeline between extraction wells NHE-1 to NHE-8, and 16-inch-diameter conveyance (influent) pipeline from well NHE-1 to the treatment system.
  - Approximately 460 feet of 16-inch-diameter conveyance effluent pipeline from the treatment system to the North Hollywood Pumping Station Complex (NH Complex), where treated water is introduced into the water supply system and blended with water from other sources.
- **Treatment System**
  - Air stripping tower (12 feet in diameter and 45 feet high) designed for a capacity of 2,000 to 2,400 gpm.
  - Air blower with a capacity of 8,000 cubic feet (ft^3) per minute.
  - Chemical storage and feed facility for sodium hexametaphosphate and the chlorination system.
  - Two VPGAC vessels; each vessel is 10 feet in diameter and 8 feet high.
  - Air heater.

Extracted groundwater is treated with approximately 1 milligram per liter (mg/L) of sodium hexametaphosphate prior to entering the air-stripper to minimize scaling of the packing material (EPA, 1998). After VOCs transfer to the air stream, the air stream is heated to reduce its relative humidity and passed through two parallel 7,000-pound GAC units to adsorb VOCs prior to releasing the air to the atmosphere. The treated groundwater discharged from the air stripper is disinfected with chlorine and piped to the NH Complex (North Hollywood Sump). Prior to serving it to consumers, LADWP blends the groundwater with surface water from the Los Angeles Aqueduct Filtration Plant and the MWD, and with groundwater from other LADWP well fields within the NHOU (EPA, 1998).

1.3.2 In Situ Chromium Treatment at Honeywell Facility

Over the past several years, Honeywell has been conducting facility-specific investigation and cleanup activities for VOCs and heavy metals contamination under the CAO (and amendments) issued by RWQCB. As a part of these facility-specific activities, Honeywell submitted a work plan to RWQCB to implement in situ treatment of chromium contamination in the groundwater and the vadose zone at the Honeywell facility (MWH, 2004; 2006; 2007a; and 2007b). The chromium remediation work plan was approved by RWQCB in 2007 and the construction of the in situ treatment system was completed in January 2009.

If left unmitigated or uncontained, the chromium contamination is expected to result in further degradation of the aquifer. Additionally, the unmitigated chromium contamination has resulted in increased chromium influent concentrations at NHOU extraction well NHE-2, impeding the effectiveness of the NHOU remedy.

Honeywell's work plan defines the objectives of the proposed source area in situ treatment as follows:

- "To reduce the mass of hexavalent chromium in the vadose zone (through conversion to the trivalent state), thereby inhibiting future migration of chromium from the vadose zone into the underlying groundwater.
- To reduce chromium concentrations in groundwater.
- To provide hydraulic control of the onsite groundwater chromium plume."

The in situ chromium treatment at the Honeywell facility consists of the following two key components:

1. Vadose zone treatment is being accomplished via percolation of a reductant solution (calcium polysulfide and water) from an infiltration basin located in the known source area at the former Honeywell facility (see Figure 1-8). Horizontal dimensions of the basin are approximately 45 by 50 feet near the center of the former Allied Signal site. Creation of reducing conditions in soil moisture of the vadose zone will decrease the mass of available mobile (hexavalent) chromium in the vadose zone through conversion to the trivalent state, which precipitates to very low concentrations (less than 10 µg/L). The percolation of the reductant solution will displace some of the hexavalent chromium downward from the vadose zone to the water table. The spent reductant solution, together with VOC- and chromium-contaminated groundwater, is recovered by two onsite extraction wells located south (downgradient) of the infiltration basin, treated to remove chromium (via anion exchange) and VOCs (via granular activated carbon), replenished with additional calcium polysulfide, and recirculated through the vadose zone.
2. Groundwater remediation at the chromium source area will be accomplished by hydraulic control via groundwater extraction and in situ chemical reduction of hexavalent chromium to trivalent chromium, which has limited mobility under the geochemical conditions present in groundwater of the NHOU. As noted above, groundwater extraction occurs from the two on-site wells south of the source area, extracted groundwater is treated to remove chromium and VOCs, then additional reductant solution is added and the treated water recirculated. Two additional

extraction wells are present north and east (upgradient) of the infiltration basin to lower the hydraulic gradient (and groundwater velocities) in the planned treatment zone. In addition to recirculating the treated groundwater through the infiltration basin, reductant containing water is also injected into several injection wells and trenches located downgradient and cross-gradient of the source area to provide additional hydraulic control and treatment of the chromium plume in groundwater.

1.4 NHOU Chromium Evaluation

In 2006, EPA completed the NHOU Chromium Evaluation (EPA, 2006) to evaluate the status of and appropriate response to chromium and several selected groundwater contaminants in the NHOU. An earlier study was conducted to investigate trends of chromium contamination in groundwater in the adjacent BOU and GOU (CH2M HILL, 2005). An improved understanding of the nature and extent of chromium groundwater contamination in the NHOU was important in determining whether, or when, chromium contamination would reach the Existing NHOU Extraction and Treatment System, which was designed to treat VOCs but not chromium. The following key conclusions were reached in the NHOU Chromium Evaluation:

- The present and future groundwater contaminants of primary concern are TCE, PCE, and chromium. Emerging chemicals appear to be limited in lateral extent and concentrations in the NHOU; however, they are mobile and persistent. Concentrations of some of these emerging chemicals have exceeded CDPH notification levels (referred to as action levels prior to 2005) for drinking water at a limited number of monitoring locations.
- Oxidation-reduction conditions in the NHOU appear to favor the stability of the more mobile hexavalent chromium in the dissolved phase rather than the reduced form (trivalent chromium). However, hexavalent chromium has not migrated as far, or as quickly, as VOCs in the NHOU.
- Chromium concentrations in samples collected from the Honeywell facility monitoring wells suggest that there is a significant chromium source mass at the site. At the time of the NHOU Chromium Evaluation, total and hexavalent chromium concentrations were detected as high as 270 μg/L at several of Honeywell's onsite monitoring wells, with decreasing concentrations detected at offsite monitoring wells to the south and west. Honeywell is currently remediating this chromium, as described previously in this section.

1.5 Summary of Risks from Contaminated Groundwater

As part of the RI for the SFV in 1992 (JMM, 1992), a baseline human-health risk assessment was conducted. The major transport pathway considered in the risk assessment was use of contaminated groundwater. Residential use of groundwater for potable supply was identified as the most significant exposure pathway (via ingestion and inhalation) because the NHOU treated water is delivered to LADWP for municipal drinking water supply.

The baseline risk assessment identified VOCs, in particular TCE and PCE, as the primary risk drivers for the SFV Superfund sites, which includes the NHOU. TCE and PCE are classified as probable human carcinogens based on laboratory studies performed on animals. Among the metals considered in the RI risk assessment, chromium had the highest hazard index (5.8).

Because the VOCs in groundwater were significantly greater than the MCLs at the time of the RI, the original NHOU risk evaluation consisted of a comparison of the VOCs concentrations in groundwater with the groundwater MCLs. Since then, Region 9 has periodically compared the VOC concentrations in groundwater with the Superfund Regional Screening Levels (RSLs) (formerly known as Preliminary Remediation Goals) and has determined that the original approach and evaluation of risk remains valid.

Since the 1992 RI, much higher concentrations of total and hexavalent chromium, TCE, PCE, and other VOCs have been detected in the NHOU, particularly at the Honeywell facility. Recent concentrations of TCE detected in the NHOU have been up to 500 times greater than the MCL, and recent peak concentrations of total chromium have exceeded the California MCL by a factor of nearly 1,000.

Because groundwater is the primary contaminated medium at the site, and groundwater/ surface water interactions do not occur within the NHOU, the ecological risk posed by contaminants in groundwater is negligible.

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Figure 1-1 Location Map

Figure 1-1, continued

Figure
1-2 Schematic Hydrogeologic Section

Figure 1-2, continued

Figure
1-3 San Fernando Valley Basin TCE Concentrations in Shallow Zone Groundwater, 2007

Figure 1-3, continued

Figure
1-4 San Fernando Valley Basin TCE Concentrations in Deeper Zone Groundwater, 2007

Figure 1-4, continued

Figure
1-5 San Fernando Valley Basin PCE Concentrations in Shallow Zone Groundwater, 2007

Figure 1-5, continued

Figure
1-6 San Fernando Valley Basin PCE Concentrations in Deeper Zone Groundwater, 2007

Figure 1-6, continued

Figure
1-7 San Fernando Valley Basin Chromium Concentrations in Shallow Zone Groundwater, 2003 through 2008

Figure 1-7, continued

Figure
1-8 Schematic Diagram of In Situ Chromium Treatment Process Implemented by Honeywell

SECTION 2

Data Evaluation

Section 2 presents an evaluation of available soil and groundwater contaminant data in the NHOU, with an emphasis on the period from January 2003 through December 2007 (referred to as "recent data" in this FFS). Analytical data typically available from the mid-1980s through 2002 (referred to as "historical data" in this FFS) were also reviewed. Information for facilities that were identified by EPA in the 1990s as potential groundwater contamination sources for VOCs in the NHOU is summarized in Appendix E.

EPA and the state have been actively involved in source identification, investigation, and remediation activities. These activities will continue because they are important to assure that the groundwater remedy is maximally effective and the groundwater quality improvements gained by the NHOU remedy are sustained over time.

2.1 Objectives

The objectives of the data evaluation include the following:

- Provide an updated interpretation of the nature and extent of groundwater contamination in the NHOU.
- Delineate target volumes for groundwater remediation and provide updated hydrogeologic data for groundwater modeling.
- Provide a foundation to develop an improved monitoring well network to further define the nature and extent of contamination in areas with limited existing data.
- Assist in the selection of the preferred remedial alternative for the Second Interim Remedy.

2.2 Data Sources

The groundwater data presented in this section are maintained in the SFV basinwide groundwater database (CH2M HILL, 2006) and include recent (January 2003 through December 2007) groundwater level and groundwater quality data from the following sources:

- EPA – Data from 23 RI monitoring wells located within or adjacent to the NHOU.
- Cities of Burbank and Glendale – Groundwater production and groundwater quality data for eight BOU treatment facility wells, two Lake Street treatment facility wells, and eight GOU treatment facility wells.
- RWQCB – Groundwater quality data for facilities located within or adjacent to the NHOU for which RWQCB receives monitoring data. Lockheed, with 130 active

monitoring wells in the SFV, and Honeywell, with 40 active monitoring wells, report groundwater quality data to both RWQCB and EPA.

- LADWP – Groundwater production and quality data for 37 LADWP production wells located within or near the boundaries of the NHOU, and the 7 active North Hollywood treatment facility extraction wells.

In addition to the groundwater data described above, available soil, soil gas, and groundwater data were reviewed for select facilities previously investigated by EPA as potentially responsible for groundwater contamination in the NHOU. These data were considered during identification of the data needs. Figure 2-1 shows the locations for these facilities. A summary of available data for these facilities is provided in Appendix E.

This data evaluation focuses primarily on TCE, PCE, and chromium (total and hexavalent), which are the primary chemicals of concern (COCs) in the NHOU. Data on select emerging contaminants that have been detected at notable concentrations (regulatory limits or notification levels) were also reviewed. The quantity of TCE and PCE data in the NHOU improved substantially in 1989, after construction of the RI monitoring wells and implementation of periodic monitoring. The availability of hexavalent chromium data for groundwater samples improved substantially starting in January 2000, after RWQCB directed facilities in the SFV to increase sampling of groundwater for hexavalent chromium.

Analytical results for chromium have been reported in various ways at different times and for different facilities or monitoring networks in the OUs. For this evaluation, chromium species identified in the database as total chromium, dissolved chromium, or chromium are assumed to represent the sum of all dissolved chromium species present in a groundwater sample and are referred to herein as total chromium. Where used without these qualifiers in this report, "chromium" refers generally to all chromium species. Entries in the SFV database for "chromium-6" are assumed to represent dissolved hexavalent chromium. Some of the total chromium database entries, especially older data, might include results for unfiltered samples, which would likely contain colloidal or particulate chromium species, and thus might not be representative of dissolved concentrations.

EPA and RWQCB have worked with facilities in the SFV to standardize sample collection procedures for total and hexavalent chromium. Additionally, EPA and RWQCB are working with facilities and municipal water suppliers in the SFV to conduct sampling to expand areal coverage and to provide groundwater analytical data in a standardized electronic format. These modifications to the SFV groundwater monitoring program are designed to increase the availability, consistency, quality, reporting, and management of groundwater quality data in the SFV.

EPA has collected and reviewed contaminant data for many facilities in and around the NHOU for use in preparation of this FFS. The fact that EPA does not have data or has limited data from some facilities is not an indication that a particular facility did not contribute to the contamination. It is possible that additional sources or facilities that have not yet been identified have contributed, or are contributing, to groundwater contamination in the NHOU.

2.3 Hydrogeologic Conditions

Groundwater in the eastern SFV occurs primarily in alluvial valley-fill deposits of Quaternary age, eroded from the adjacent San Gabriel and Verdugo Mountains. The valley fill is estimated to be at least 1,200 feet thick in places and is bounded to the east and at depth by low-permeability granitic and metamorphic bedrock. The valley-fill deposits of the eastern SFV are relatively permeable and have been subdivided by previous investigators using different classification schemes. For the RI, the valley-fill alluvium was subdivided into the following four lithologic/aquifer zones (JMM, 1992):

- **Upper Zone.** The upper zone consists of layers and lenses of silt, sand, and gravel from ground surface to approximately 250 feet bgs. According to aquifer tests conducted during the SFV basinwide RI, hydraulic conductivities in the upper zone range from approximately 30 to 360 feet per day. The water table commonly occurs in this zone. In late 2004, only the lower 20 to 50 feet of this zone were saturated within much of the NHOU. Groundwater levels increased by varying amounts in the SFV between 2004 and 2006, then subsequently declined. Available data from monitoring wells in the vicinity of the NHOU extraction system indicate that groundwater levels typically rose 20 to 40 feet from 2004 to 2006, then declined approximately 10 feet through 2008.
- **Middle Zone.** The middle zone is approximately 50 feet thick and, in some areas, contains increased proportions of fine-grained sand and silt as compared with the other zones in the SFV basin. Because of its fine-grained nature and anticipated poor yield characteristics, few production wells have been completed in this zone. In some areas of the SFV, the middle zone acts as a confining layer. However, in the north and west parts of the NHOU, the middle zone appears to consist of more permeable sediments that might allow significant vertical groundwater flow.
- **Lower Zone.** The lower zone consists of interbedded sand, silt, and gravel, with cobbles in the upper portion. This zone is estimated to be 200 to 250 feet thick, and hydraulic conductivity ranges from 130 to 900 feet per day. Many of LADWP's water supply wells in the NHOU have long well screens that include this highly productive zone.
- **Deep Zone.** Where encountered during drilling, the deep zone consists mainly of fine-grained, relatively low-permeability sediments, including silt and clay. Few wells have penetrated this zone; therefore, thickness and hydraulic characteristics of this zone are poorly understood.

Since 1996, EPA and CH2M HILL (1996) have been defining aquifer zones in the NHOU by depth regions, which are defined somewhat differently than the four zones described above and in the SVF basinwide RI report. Four depth regions have been identified (see Figure 1-2); all are below the water table and correspond to common screened intervals (typically placed in more permeable strata) for monitoring and production wells in the NHOU. The depths and thicknesses of the depth regions can vary depending on location within the NHOU. Following are descriptions of the four depth regions:

- **Depth Region 1.** This depth interval occurs from approximately 200 to 280 feet bgs, with a typical thickness of 75 feet. Depth Region 1 generally corresponds with the saturated part of the upper zone and the upper half of the middle zone (as defined above); it includes the screened intervals for most shallow monitoring wells and some older production wells.

- **Depth Region 2.** This depth interval ranges from approximately 280 to 420 feet bgs, with a typical thickness of 140 feet. Depth Region 2 generally corresponds with the lower half of the middle zone and the upper part of the lower zone; it includes highly permeable deposits that are penetrated by most production wells in the NHOU.
- **Depth Region 3.** This depth interval occurs from approximately 420 to 660 feet bgs, with a typical thickness of 240 feet. Depth Region 3 generally corresponds with the lower part of the lower zone and the upper part of the deep zone; it can be very permeable and includes the screened intervals for many of the newer production wells in the NHOU.
- **Depth Region 4.** This depth interval includes all of the basin-fill alluvial deposits deeper than 660 feet bgs, with a typical thickness ranging from 100 feet to more than 500 feet; it generally corresponds with the lower part of the deep zone, which few wells have penetrated.

A conceptual cross section illustrating both systems for defining vertical zones in the SFV is shown on Figure 1-2. The depth to groundwater measured recently at monitoring wells in the vicinity of the NHOU extraction system ranged from approximately 200 to 300 feet bgs. The land surface in the NHOU generally slopes to the south-southeast at a steeper gradient than the water table, which also slopes to the south-southeast, with some local variability caused by pumping from the various well fields in the area. Therefore, both the depth to the water table and the elevation of the water table decrease to the south-southeast.

The depth to groundwater in nonpumping wells near the NHOU extraction well field is approximately 240 to 250 feet bgs. Groundwater levels measured at most NHOU monitoring wells declined approximately 20 to 50 feet from the mid-1990s to 2004, which corresponds to increases in groundwater production and declines in recharge in the SFV. Pumping groundwater levels at the NHOU extraction wells reportedly approached the depths of the pump intakes in 2003 to 2004, near the bottom of the screened intervals, in the range of approximately 260 to 290 feet bgs. This condition limited extraction well pumping rates.

Groundwater withdrawals for water supply in the SFV during 2005 and 2006 were less than the average for the previous 20 years, and groundwater recharge at spreading basins in the SFV in 2005 was significantly above average. During Water Year 2004-2005 (October 1, 2004 to September 30, 2005), precipitation in the SFV was more than twice the 100-year mean, with 42.64 inches on the valley floor and 47.54 inches in the mountain areas (ULARA Watermaster, 2006a). In response, groundwater levels rose 20 to 40 feet in the vicinity of the NHOU extraction well field between 2004 and 2006. Groundwater levels subsequently declined approximately 10 feet from the 2006 levels through 2008. Available historical data for production and monitoring wells in the vicinity of the NHOU extraction system indicate that the water table has fluctuated from 200 feet bgs (or shallower) to 260 feet bgs at least three times in the past 40 years.

Horizontal hydraulic gradients in the eastern SFV are generally south and east, toward the Los Angeles River Narrows, where essentially all groundwater and surface water outflow from the SFV occurs. In the NHOU, horizontal hydraulic gradients range from south to southeast, with the active production well fields having localized effects on groundwater flow. The groundwater flow direction near the NHOU extraction system has changed in response to seasonal and annual variations in pumping rates at the nearby Rinaldi-Toluca Well Field (to the northwest), the western portion of the North Hollywood Well Field, and the Whitnall Well Field (to the south). Pumping in the BOU (to the east) and more distant well fields in the NHOU has also affected hydraulic gradients and groundwater flow directions, although to a lesser extent.

Near production wells and well fields, vertical hydraulic gradients develop from Depth Regions 1 and 4 toward Depth Regions 2 and 3, where most groundwater withdrawals occur. Past groundwater level measurements at clustered RI wells in the NHOU indicate near-neutral to substantial downward vertical gradients from Depth Region 1 to Depth Region 2. The downward hydraulic gradients are likely caused by a combination of decreased pumping from Depth Region 1 (the upper aquifer zone) as groundwater levels decline and stable or increased pumping from Depth Regions 2 and 3 (the lower aquifer zone).

Groundwater flow velocities in the NHOU were estimated during the RI to range from approximately 290 to 1,000 feet per year, depending on location (JMM, 1992). Estimated groundwater flow velocities are generally highest in the area of the NHOU extraction system where aquifer hydraulic conductivities are highest.

2.4 Recent VOC Concentrations in Groundwater

Section 2.4 describes recent (2003 to 2007) concentrations of VOCs in groundwater in the NHOU, focusing on TCE and PCE, which pose a greater human health risk than the other VOCs due to their wider distribution and significantly higher concentrations. Historical concentrations are summarized in EPA's five-year review reports for the NHOU (EPA, 1998; 2003; and 2008) and annual SFV groundwater monitoring reports (CH2M HILL, 2003; 2004; 2005; and 2007). Analytical data available for the period from the mid-1980s through 2002 (referred to as historical data in this document) were also reviewed.

2.4.1 TCE and PCE in Depth Region 1

Figure 2-2 shows the maximum reported TCE and PCE concentrations from January 2003 through December 2007 in Depth Region 1 and the estimated isoconcentration contours for these contaminants. This period was selected as being representative of recent conditions in the NHOU, which are most relevant to the selection of a groundwater remedial alternative. Also shown are TCE and PCE concentration contours, which are based on the constituent with the higher concentration at each data point. The objective of preparing combined TCE/PCE plume maps in this FFS was to consider both of these important VOCs when evaluating the effectiveness of the proposed remedial alternatives.

The data shown on Figure 2-2 indicate that TCE and PCE concentrations exceeding 5 µg/L are present in a wide area of the NHOU and merge with a TCE and PCE plume in the BOU, to the east. Smaller TCE "hot spots," with concentrations ranging from 50 to 2,900 µg/L, occur within Depth Region 1 of the NHOU.

An area of particularly high TCE concentrations (ranging from 50 to greater than 1,000 µg/L) is centered near the southern boundary of the Honeywell facility, between facility monitoring wells GW-7 and GW-11-273. Well GW-11-273 is one of several offsite monitoring wells constructed by Honeywell at the request of EPA and RWQCB in 2004 and 2005. These wells were constructed as nested wells with low-flow (Barcad®) sampling ports at several discrete depth intervals. Well GW-11-273 was constructed with a sampling port at 273 feet bgs. The additional monitoring wells with two or more Barcad® sampling ports include GW-12A, GW-16, and GW-17, which are located offsite, south of the Honeywell facility. The peak TCE concentration detected recently (since 2004) at the Honeywell facility was 2,900 µg/L, detected at well GW-7 in October 2006. The historical high TCE concentration at the Honeywell facility, which also occurred at well GW-7, was 17,000 µg/L in July 1996. TCE concentrations at North Hollywood treatment system extraction well NHE-2, located approximately 1,000 feet south-southwest (downgradient) of Honeywell facility monitoring well GW-7, increased substantially since 2006, reaching a maximum of 1,300 µg/L in April 2007. The remainder of the western plume is generally distributed along the axis of the NHOU extraction system, with TCE concentrations decreasing to the south. With few exceptions, PCE concentrations are less than TCE concentrations in the NHOU.

Another area of high TCE concentrations is centered on Lockheed facility well LC1-CW06, with a recent peak concentration of 1,200 µg/L. There are no additional recent analytical data for groundwater in Depth Region 1 within approximately 2,000 feet of this hot spot. Therefore, the horizontal extent of this TCE hot spot between LC1-CW06 and the easternmost NHOU extraction wells is poorly defined. TCE has been detected as high as 242 µg/L in the closest extraction well, NHE-7, located approximately 2,300 feet to the south. PCE concentrations exceed TCE concentrations in most wells near Burbank Airport to the east of well LC1-CW06, and PCE concentrations in excess of 100 µg/L are distributed over a much larger area (in excess of 6,000 feet across).

A northern hot spot of TCE/PCE in excess of 10 µg/L has been detected in Depth Region 1, north of the western plume, extending north from RI monitoring well NH-C01-325 (the maximum recent concentration of PCE was 28 µg/L, in December 2006). This detection of PCE appears to be distinct from the main western plume because RI well NH-VPB-07 is between NH-C01-325 and the plume, and it has not had any recent detections of PCE or TCE above the MCL.

Another area with TCE/PCE concentrations in excess of 10 µg/L has been detected in Depth Region 1, northwest of the western plume at Hewitt Landfill, at monitoring well 4909F. The maximum recent TCE and PCE detections in groundwater from this well have been 74 and 23 µg/L, respectively.

2.4.2 TCE and PCE in Depth Regions 2 through 4

In Depth Regions 2 through 4, TCE and PCE concentrations in excess of the MCL are also distributed over a substantial area of the NHOU (see Figure 2-3). Notable hot spots include the following:

- Northwest, centered at RI monitoring well NH-C05-460, northeast of the Rinaldi-Toluca Well Field

- West, centered near the southern boundary of the Honeywell facility
- Southeast, centered east of the Whitnall Well Field

The northwest hot spot in Depth Regions 2 through 4 includes the southernmost 9 of the 15 production wells in the Rinaldi-Toluca Well Field, where TCE concentrations have historically and recently exceeded the MCL. The highest TCE concentrations for this plume (120 µg/L) have been detected at RI well NH-C05-460. This well is located approximately 2,000 feet east of the Rinaldi-Toluca Well Field. Concentrations of TCE and PCE at the remaining (northern) Rinaldi-Toluca production wells have been lower than the MCLs from January 2003 through August 2008 (the most recent month of available data). The lateral extent of this plume to the west, north, and east, as well as the vertical extent, are poorly delineated. Additional groundwater investigation is needed to delineate the magnitude and horizontal extents of VOC contamination in this area.

The west hot spot in Depth Regions 2 through 4 is located north of extraction well NHE-2. TCE has been detected at concentrations as high as 220 µg/L in Honeywell facility monitoring well GW-16-317, 330 µg/L in well GW-11-316, 310 µg/L in well GW-12A-319, and 98 µg/L in well GW-14B, all near the core of this plume. These wells are screened primarily in Depth Region 2. TCE and PCE concentrations generally decrease with depth in these wells (see Figure 2-3). To the west of Honeywell, TCE concentrations exceeding the MCL have been detected in North Hollywood West production wells NH-23 (14.4 µg/L), NH-43A (33 µg/L), NH-26 (8.15 µg/L), NH-30 (8.08 µg/L), and NH-34 (6.72 µg/L).

To the south, PCE and TCE have been detected in Depth Regions 2 through 4 at concentrations exceeding the MCL in RI monitoring well cluster NH-C03-380 through NH-C03-680, with a recent peak detection of 39 µg/L at a depth of 580 feet bgs and 25.6 µg/L at nearby production well NH-28 (see Figure 2-3). Farther to the southeast, TCE has also been detected in Depth Regions 2 through 4 at concentrations exceeding the MCL in RI monitoring well cluster NH-C02, with recent peak detections of 39 µg/L at a depth of 325 feet bgs and 120 µg/L at a depth of 520 feet bgs (see Figure 2-3). This well cluster is the site of the highest TCE concentration (120 µg/L) detected at a depth greater than 500 feet within the NHOU. Three of the Whitnall Well Field production wells near RI monitoring well cluster NH-C02 have detections of TCE, PCE, or both, that exceed MCLs. Additional groundwater investigation is needed to delineate the magnitude and horizontal extent of VOC contamination in this area.

2.4.3 Other VOCs

Concentrations of 1,1-dichloroethane (DCA), 1,2-DCA, 1,1-dichloroethene (DCE), cis-1,2-DCE, 1,1,1-trichloroethane (TCA), carbon tetrachloride, and methylene chloride have commonly been reported in excess of MCLs in Depth Region 1 groundwater samples from NHOU wells. These VOCs typically have been detected in the same wells as TCE and PCE in the NHOU, but at significantly lower concentrations. Therefore, maps depicting concentrations of these other VOCs are not presented in this FFS. Recent maximum detected concentrations of these compounds in Depth Region 1 groundwater are as follows:

- 1,1-DCA – 30 µg/L at Honeywell facility monitoring well GW-1 (2006)
- 1,2-DCA – 3.7 µg/L at Honeywell facility monitoring well GW-11 (2005)

- 1,1-DCE – 86 μg/L at Honeywell facility monitoring well GW-15 (2006)
- cis-1,2-DCE – 44 μg/L at Honeywell facility monitoring well GW-1 (2005)
- 1,1,2-TCA – 11 μg/L at Honeywell facility monitoring well GW-7 (2006)
- Carbon tetrachloride – 13.1 μg/L at Lockheed facility monitoring well V14SSPW3 (2007)
- Methylene chloride – 31 μg/L at Hewitt Landfill monitoring well V14HEWC9 (2007)

Concentrations of 1,1-DCE, 1,2-DCA, carbon tetrachloride, cis-1,2-DCE, and methylene chloride have commonly been reported in excess of MCLs in groundwater samples from selected NHOU wells screened in Depth Region 2 and 3. These VOCs typically have been detected in the same wells as TCE and PCE in the NHOU. Recent, maximum detected concentrations of these compounds in Depth Region 2 groundwater are as follows:

- 1,1-DCE – 27 μg/L at Honeywell facility monitoring well GW-11-319 (2006)
- 1,1-DCA – 5.1 μg/L at Honeywell facility monitoring well GW-12A-319 (2006)
- 1,2-DCA – 1.5 μg/L at Honeywell facility monitoring well GW-12A-319 (2007)
- Carbon tetrachloride – 6.8 μg/L at RI monitoring well NH-C02-520 (2004)
- cis-1,2-DCE – 25 μg/L at Honeywell facility monitoring well GW-12A-319 (2007)
- Methylene chloride – 34 μg/L at RI monitoring well NH-C02-520 (2005)

2.5 Chromium Concentrations in Groundwater

Under natural conditions, chromium commonly occurs in two valence states in groundwater, trivalent and hexavalent. Trivalent and hexavalent chromium can exist simultaneously, although one state typically has a much higher concentration than the other. In the NHOU, total chromium concentrations detected in groundwater generally are approximately equal to hexavalent chromium concentrations, indicating that hexavalent chromium is the predominant dissolved species of chromium. The mobility of trivalent chromium in groundwater is generally much lower than that of hexavalent chromium because trivalent chromium forms insoluble precipitates and tends to adsorb strongly to common aquifer solids such as iron oxides and clay minerals. By contrast, hexavalent chromium does not form insoluble solids and is weakly adsorbed to subsurface materials.

Water samples are analyzed for chromium most commonly as total chromium, which represents the sum of trivalent and hexavalent chromium. Samples may or may not be filtered before analysis. However, EPA policy recommends that chromium samples be filtered in the field prior to submittal to the laboratory. Reported total chromium concentrations in the NHOU are highly variable at some wells partly because of differing analytical methods used by the various laboratories and variations in sample collection, filtration, and preservation during previous investigations. These investigations were performed by various state and Federal agencies and property owners or operators. Over time, analytical methods, sample collection and management processes, and regulatory guidance have been developed or updated to enhance the quality of chromium sampling and data results.

Trace concentrations of chromium occur naturally in groundwater in the SFV. Wells in areas of the SFV not known to be impacted by anthropogenic chromium are typically less than 3 μg/L. The source of the naturally occurring chromium is the sediment comprising the aquifer material.

2.5.1 Chromium in Depth Region 1

Figure 2-4 shows total and hexavalent chromium concentrations detected within the NHOU from January 2003 to December 2007 in Depth Region 1. According to the available groundwater data for the NHOU, total and hexavalent chromium detections in excess of the state MCL for total chromium of 50 µg/L are located at, or south (downgradient) of, the Honeywell site. Additionally, historical data indicate chromium concentrations above the MCL at the Bradley Landfill in the northernmost portion of Area 1 within the NHOU (see Appendix E). More recently (March 2004), total and hexavalent chromium concentrations in groundwater samples from Bradley Landfill were 13 µg/L or less, well below the current MCL for total chromium of 50 µg/L.

The highest total chromium concentration (48,000 µg/L) recently detected in groundwater in Depth Region 1 was at Honeywell facility monitoring well GW-1; hexavalent chromium was detected at a maximum concentration of 34,000 µg/L at this well in April 2007. Seven additional wells in Depth Region 1 have reported total and hexavalent chromium concentrations in excess of 1,000 µg/L. These are Honeywell monitoring wells GW-3, GW-4, GW-7, GW-10, GW-12A-284, GW-15, and GW-16-277. The maximum total chromium results for these wells range from 1,130 µg/L (GW-16-277) to 37,000 µg/L (GW-10), and the hexavalent chromium results for these wells range from 1,300 µg/L at GW-16-277 to 39,000 µg/L at GW-10. The chromium plume is poorly defined to the southeast of the Honeywell facility.

Total chromium has recently been detected at the active NHOU extraction wells at maximum concentrations ranging from 2 µg/L at NHE-8 (1.34 µg/L hexavalent chromium) to 20.3 µg/L at NHE-3 (16.8 µg/L hexavalent chromium). Since late 2006, total chromium concentrations increased at NHE-2 to a maximum concentration of 401 µg/L (430 µg/L hexavalent chromium) in April 2007. Chromium concentrations at this well have subsequently ranged from approximately 280 to 440 µg/L. Historically (1990 through 2002), total and hexavalent chromium concentrations have been highest at extraction well NHE-2, where the maximum total chromium concentration prior to 2006 had been 97 µg/L (March 1999) and the maximum hexavalent chromium concentration had been 50 µg/L (August 2001).

Total and hexavalent chromium have been detected in groundwater in Depth Region 1 at concentrations between 5 µg/L and 50 µg/L (the MCL for total chromium) at wells located north, south, and east of the NHOU (see Figure 2-4). To the north, there are fewer groundwater monitoring wells, and any groundwater data collected from existing facility wells have not consistently been provided to EPA for entry in the SFV groundwater database (if such data exist). As a result, the nature and extent of total and hexavalent chromium in groundwater in the northern portion of the NHOU will continue to be evaluated and defined as groundwater sampling data are collected and evaluated. EPA has been pursuing the collection of additional groundwater quality data from potential source facilities in this area.

2.5.2 Chromium in Depth Regions 2 through 4

Detections of total and hexavalent chromium in Depth Regions 2 through 4 are presented on Figure 2-5. The highest recent chromium concentrations have been detected at Honeywell facility monitoring well GW-12A-319 (2,010 μg/L total chromium and 2,000 μg/L hexavalent chromium). Concentrations of total chromium exceeding the MCL were also recently detected at two additional monitoring wells at the Honeywell facility, GW-14B (412 μg/L total chromium and 430 μg/L hexavalent chromium) and GW-16-377 (963 μg/L total chromium and 1,100 μg/L hexavalent chromium). In most of the SFV, total and hexavalent chromium concentrations are typically elevated in only the uppermost aquifer zones.

2.6 Emerging Chemicals

Select "emerging chemicals" have been detected in the SFV groundwater basin or at the groundwater treatment plants at the NHOU, BOU, and the GOU. These contaminants are considered to be "emerging" because they have begun to be detected in the SFV groundwater basin in the past 5 to 10 years, as more sensitive analytical methods have been developed that can detect the low concentrations that typically occur in environmental media such as groundwater. To better understand the occurrence and extent of these emerging chemicals, and their potential to reach the treatment plants previously discussed, regulatory agencies requested groundwater monitoring and data reporting for these contaminants. Available recent data (January 2003 to December 2007) for several of the emerging chemicals of potential concern, including TCP, 1,4-dioxane, n-nitrosodimethylamine (NDMA), and perchlorate, were reviewed as part of this FFS for the NHOU. Thallium and methyl tertiary butyl ether (MTBE) were also evaluated but were not detected in the NHOU, or they were present at concentrations below the MCLs and notification levels[1] and were not investigated further. As additional monitoring data become available, it will be possible to more fully assess the potential for emerging chemicals to reach the North Hollywood treatment system with the passage of time.

The data presented in this section are reported for facilities that have complied with regulatory agency requests to monitor for these constituents and to provide the results to EPA, RWQCB, or both. This does not indicate that these facilities are the only contributors to groundwater contamination in the NHOU. It is possible that additional, but as yet unidentified, sources or facilities have contributed, or are contributing, to groundwater contamination in the NHOU.

2.6.1 TCP

The state established a drinking water notification level of 0.005 μg/L for TCP in 1999, after it was detected in groundwater in the BOU. Neither CDPH nor EPA has established an MCL for TCP in drinking water. However, OEHHA has developed and proposed a draft PHG of 0.0007 μg/L (0.7 part per trillion, [ppt]) for TCP. Currently, the NHOU remedy meets the target goal of 60 percent of the notification level at the plant effluent, although it is not designed to remove TCP at the lower levels suggested by the draft PHG. If this draft PHG leads to a notification level or MCL that is lower than the current notification level, the NHOU remedy may require additional enhancement. TCP has been used as a solvent and pesticide ingredient. The CDPH lists TCP as a known carcinogen.

[1] Prior to 2005, the notification levels were referred to by CDPH as "action levels." The notification levels are health-based advisory levels established "to provide information to public water systems, regulatory agencies, and the public about certain nonregulated chemicals in drinking water that lack MCLs. When chemicals are found at concentrations greater than these levels, certain requirements and recommendations apply" (CDPH, 2006).

In Depth Region 1, TCP has been detected at 25 wells in or adjacent to the NHOU (see Figure 2-6). Detected concentrations of TCP at these wells range from 0.0017 to 0.016 µg/L, with the highest concentrations (greater than 0.010 µg/L) occurring at Honeywell monitoring wells GW-2, GW-5, and GW-7, and at RI monitoring wells NH-C02-220 and NH-VPB-05 (located in the southeast part of NHOU). Higher concentrations of TCP, ranging from 0.288 to 170 µg/L, have been detected at Lockheed facility monitoring wells located in the BOU, south of Burbank Airport.

In Depth Region 2, TCP was detected at 16 monitoring wells in or adjacent to the NHOU at concentrations ranging from 0.0023 to 0.13 µg/L (see Figure 2-7). TCP concentrations in Depth Region 2 of the NHOU exceeded the notification level of 0.005 µg/L at the Honeywell facility (monitoring wells GW-12A-319, GW-14B, and GW-16-317), Lockheed monitoring well LC1-CW05, and in the southeast part of the NHOU near the boundary with the BOU (wells NH-C02-325 and NH-C02-520). Higher concentrations of TCP, to 0.56 and 0.73 µg/L, have been detected in the BOU, south and east of Burbank Airport.

Detected concentrations of TCP are generally higher in Depth Region 1 monitoring wells than in deeper regions, as suggested by declining concentrations with depth in Honeywell's GW-12A, GW-16, and GW-17 monitoring well clusters. Most TCP concentrations exceeding the state drinking water notification level in NHOU monitoring wells were detected for the first time during sampling in 2006. In previous years, the MDL was higher than the drinking water notification level, resulting in non-detect results above the notification level.

2.6.2 1,4-Dioxane

The state established a drinking water notification level of 3 µg/L for 1,4-dioxane in 1998. Neither CDPH nor EPA has established an MCL for 1,4-dioxane in drinking water. 1,4-Dioxane, a semivolatile organic compound (SVOC), is commonly associated with 1,1,1-trichloroethane (TCA) and TCE contamination in groundwater. 1,4-dioxane was a commonly used additive and stabilizer for TCA, and is a suspected additive and stabilizer for TCE, although it was not always identified as such in the batches of TCE sold in the United States. EPA lists 1,4-dioxane as a probable human carcinogen.

In Depth Region 1, 1,4-dioxane has recently been detected in groundwater samples from 20 monitoring wells in or adjacent to NHOU at concentrations that exceed the state drinking water notification level (see Figure 2-8). Fifteen detections of 1,4-dioxane that exceeded the notification level occurred at Honeywell facility monitoring wells at concentrations ranging from 4.7 to 90 µg/L. The highest concentrations of 1,4-dioxane in groundwater underlying the Honeywell facility have occurred at monitoring wells GW-10 and GW-5 (37 and 90 µg/L, respectively). Monitoring well GW-10 is in the vicinity of historical maximum TCE and TCA concentrations detected in the NHOU and an active soil vapor extraction system operated by Honeywell to remove VOC contamination from the vadose zone. 1,4-dioxane was also detected at concentrations exceeding the notification level at the following wells:

- Lockheed facility monitoring wells LC1-CW-03 and LB5-CW03 at concentrations of 3.9 and 5.5 µg/L, respectively
- Tuxford and Penrose Landfill monitoring wells 4917B and 4918B at concentrations of 5.18 and 5.5 µg/L, respectively

- NHOU extraction wells NHE-2 and NHE-4 at concentrations of 7 and 3.2 µg/L, respectively

In Depth Regions 2 through 4, the only detections of 1,4-dioxane above the notification level occurred at Honeywell facility wells GW-11-316, GW-12A-319, and GW-16-317 at concentrations ranging from 3.9 to 9.2 µg/L (see Figure 2-9).

2.6.3 NDMA

The state revised the drinking water notification level for NDMA in 2002 to 0.01 µg/L. Neither CDPH nor EPA has established an MCL for NDMA in drinking water. NDMA has been used in the production of rocket fuel and in other industrial processes. CDPH lists NDMA as a known human carcinogen.

In Depth Region 1, NDMA has recently been detected above the notification level in or adjacent to the NHOU at nine Honeywell facility wells and five Lockheed facility monitoring wells in or adjacent to the NHOU (see Figure 2-10). Recent maximum concentrations at these wells range from 0.012 to 0.034 µg/L. NDMA concentrations have also been recently detected above the notification level at monitoring wells LB5-CW03 and V14PA1W3, located in the BOU, at concentrations of 0.032 and 0.018 µg/L, respectively. Detectable concentrations of NDMA below the notification level have been measured in 16 additional wells in Depth Region 1 of the NHOU.

In Depth Regions 2 through 4, the maximum recent NDMA concentration was 0.12 µg/L at Lockheed monitoring well LB5-CW02. NDMA was recently detected above the notification level in two other Lockheed facility monitoring wells in NHOU at concentrations of 0.057 and 0.066 µg/L (see Figure 2-11).

2.6.4 Perchlorate

The state established a drinking water MCL for perchlorate of 6 µg/L on October 18, 2007. EPA has not established an MCL for perchlorate in drinking water. Perchlorate is a solid propellant in rockets and fireworks and has been used in other industrial processes. The primary health concern regarding perchlorate is interference with human thyroid function.

Perchlorate has been detected at concentrations exceeding the MCL in five wells in Depth Region 1 of the NHOU (Honeywell facility wells GW-3, GW-7, GW-10, and GW-15, and Penrose Landfill monitoring well 4918B) at concentrations ranging from 10 to 45 µg/L (see Figure 2-12). Perchlorate has been detected at 23 other Depth Region 1 wells in or adjacent to NHOU at concentrations below the MCL, ranging from 0.47 to 4.9 µg/L. Perchlorate has also been detected at concentrations (generally below 1 µg/L) below the MCL at several wells near the Burbank Airport in the BOU.

In Depth Regions 2 through 4 of the NHOU, perchlorate has been detected in excess of the MCL at Rinaldi-Toluca Well Field production well RT-7, which is located in the northern part of the well field (see Figure 2-13). Perchlorate has also been detected at the following Depth Regions 2 through 4 monitoring wells, all at concentrations below the MCL:

- Four other Rinaldi-Toluca production wells near RT-7 (RT-3, RT-4, RT-6, and RT-8)
- Honeywell facility monitoring well clusters GW-11, GW-12A, GW-16, and GW-17

- Lockheed facility monitoring well LB5-CW02
- Wells 3831Q and NH-C02-520 in the southeast part of the NHOU

2.7 Summary of Data Needs and Recommended Additional Monitoring Wells

An objective of this evaluation is to identify key data needs in the NHOU groundwater monitoring network and to provide recommendations to address them. The analysis of existing data needs was used to (1) identify proposed monitoring well locations to improve understanding of the NHOU contaminant distribution and the hydrogeologic system and (2) assess the progress of ongoing and future remedial actions for the site. This includes the following:

1. Adequately characterize the lateral and vertical extent of contaminant plumes and known hotspot areas and their relationship to known source areas.
2. Provide sufficient data to measure the progress of future remedial actions in reducing contaminant concentrations over time in areas targeted for remediation.
3. Provide data to estimate the extent of hydraulic capture provided by the remedy extraction well network.
4. Provide information to assess the potential for chromium, emerging chemicals, or both to impact groundwater treatment plant performance and efficiency.
5. Develop a monitoring/sentinel well network to detect the migration of known COCs and emerging chemicals from known plume and hot spot areas.

The recommended new well locations are presented on Figure 2-14. The specific data need addressed by each well location is summarized in Table 2-1. In addition to the RI monitoring well network, EPA has requested that select facilities sample and analyze existing groundwater monitoring wells. Additional facility-specific offsite monitoring wells have recently been constructed by Honeywell (2008); locations are shown on Figure 2-14.

TABLE 2-1
Data Need and Recommendation Summary
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Data Need	Purpose/Recommendation	Recommended Wells	Map Location Identifier
Few data are available to define hydraulic gradients and the northwesterly extent of VOC and chromium contamination in groundwater between the Rinaldi-Toluca Well Field and monitoring wells at the Honeywell and Lockheed facilities, where the highest concentrations of chromium and VOCs in NHOU groundwater have been detected at depths lower than existing NHOU extraction or RI monitoring wells. TCE and PCE concentrations exceed MCLs at several of the Rinaldi-Toluca production wells that are screened at depths substantially greater than the screened depths of most extraction and monitoring wells in the NHOU.	Installation of monitoring wells between the Rinaldi-Toluca production wells and the areas with high VOC and chromium concentrations (near the Honeywell and Lockheed facilities) will allow improved plume delineation, improved understanding of hydraulic gradients in this area, and monitoring to protect drinking water. One existing RI monitoring well (NH-VPB-06) is screened in Depth Region 1 in this area. Under a CAO with the State, Honeywell installed monitoring wells in this area in two or more depth intervals. Installation of one additional monitoring well in Depth Region 2 is recommended.	Depth Region 2 – one well	A
Few data are available to define the lateral and vertical extents of contamination of the northern "hot spot" of VOC contamination detected in Depth Region 2 at RI monitoring well NH-C05. The source of this contamination is not known.	Installation of several monitoring wells northeast of the Rinaldi-Toluca Well Field will help define the extent of a VOC "hot spot" in this area and provide early warning of potential future contaminant concentrations before they reach production wells. Installation of one additional monitoring well in Depth Region 1, four wells in Depth Region 2, and 1 well in Depth Region 3 is recommended.	Depth Region 1 – one well Depth Region 2 – four wells Depth Region 3 – one well	B
Few data are available to define the lateral and vertical extents of contamination near the western portion of the Burbank Airport and contaminant concentrations migrating southward toward extraction wells NHE-7 and NHE-8.	Installation of monitoring wells between the western part of the Burbank Airport and extraction wells NHE-7 and NHE-8 will allow improved plume delineation and provide data to assist in verifying the effectiveness of the remedy (specifically, regarding hydraulic capture in this area). Installation of two additional monitoring wells in Depth Region 1, two wells in Depth Region 2, and one well in Depth Region 3 or 4 is recommended.	Depth Region 1 – two wells Depth Region 2 – two wells Depth Region 3 or 4 – one well	C
Few data are available to define contaminant concentrations between extraction wells NHE-6 and NHE-7, an area of concern for potential migration of contaminated groundwater beyond the capture zone of the existing NHOU extraction and treatment system.	Installation of a monitoring well in this area will allow improved delineation of plumes emanating from two upgradient VOC source areas (Honeywell and Burbank Airport). Installation of one monitoring well in Depth Region 1 is recommended	Depth Region 1 – one well	D
The source, lateral extent, and vertical extent of VOC contamination detected at RI monitoring well cluster NH-C02 (between the Whitnall Well Field and extraction wells NHE-7 and NHE-8) are not adequately defined. TCE and PCE concentrations exceed MCLs at several of the Whitnall and Erwin production wells that are screened at depths substantially greater than the screened depths of most extraction and monitoring wells in the NHOU.	Installation of additional monitoring wells in the area between the Whitnall Well Field and extraction wells NHE-7 and NHE-8 will allow improved plume delineation and monitoring to protect drinking water resources. Installation of one additional monitoring well in Depth Region 1, two wells in Depth Region 2, and one well in Depth Region 3 or 4 is recommended.	Depth Region 1 – one well Depth Region 2 – two wells Depth Region 3 or 4 – one well	E

TABLE 2-1
Data Need and Recommendation Summary
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Data Need	Purpose/Recommendation	Recommended Wells	Map Location Identifier
Few data are available to define hydraulic gradients and the western extent of VOC and chromium contamination in groundwater between the North Hollywood West Well Field and monitoring wells at the Honeywell facility, where some of the highest concentrations of chromium and VOCs in NHOU groundwater have been detected. Concentrations of TCE and PCE at some of the North Hollywood West production wells have exceeded MCLs.	Installation of monitoring wells between the North Hollywood West production wells and an area of known high VOC and chromium concentrations near the Honeywell facility will allow improved plume delineation, improved understanding of hydraulic gradients in this area, and provide sentinel monitoring to protect drinking water resources. Honeywell is currently planning to install monitoring wells in this area in two or more depth regions. Installation of two additional monitoring wells in Depth Region 1 and two wells in Depth Region 2 is recommended.	Depth Region 1 – two wells Depth Region 2 – two wells	F
Few data are available to define the hydraulic gradient and extent of contamination between the Hewitt Landfill, where TCE concentrations as high as 74 µg/L have recently been detected, and the Rinaldi-Toluca water supply well field to the northeast.	Installation of another background monitoring well to the west of Hewitt Landfill and two sentinel monitoring wells northeast of the Hewitt Landfill will help define the source of this VOC plume and provide early warning of potential future contaminant concentrations before they reach production wells. Installation of two new monitoring wells in Depth Region 1 and one new well in Depth Region 2 is recommended.	Depth Region 1 – two wells Depth Region 2 – one well	G
Few data are available to define the extent of contamination south of the Penrose Landfill, where TCE concentrations as high as 36.6 µg/L have recently been detected.	Installation of two new monitoring wells south of Penrose Landfill will help define the extent of this VOC plume. Installation of one new monitoring well in Depth Region 1 and one new well in Depth Region 2 is recommended.	Depth Region 1 – one well Depth Region 2 – one well	H
Few data are available to define the hydraulic gradient and extent of contamination south of NHOU extraction wells NHE-2 and NHE-3, where VOC and chromium concentrations increased substantially in 2006.	Installation of two new monitoring wells south of wells NHE-2 and NHE-3 will help define the southern extent of VOC and chromium contamination and provide gradient information that will enhance monitoring of remedy performance in this critical area. Installation of one new monitoring well in Depth Region 1 and one new well in Depth Region 2 is recommended.	Depth Region 1 – one well Depth Region 2 – one well	I
Few data are available to define the hydraulic gradient and contaminant contaminations in groundwater southeast of the Honeywell facility, specifically in the area of the former Pacific Steel Treating and Fleetwood Machine Products facilities.	Installation of a background monitoring well between the Honeywell and Pacific Steel Treating facilities and two additional monitoring wells at the downgradient edge of the Fleetwood Machine Products facility will provide information on groundwater quality in this area and potential groundwater impacts in the vicinity. Installation of two new monitoring wells in Depth Region 1 and one new well in Depth Region 2 is recommended.	Depth Region 1 – two wells Depth Region 2 – one well	J
Few data are available to define the potential impacts to groundwater quality resulting from spills and leaks at the Hawker-Pacific facility, where spills and leaks of VOCs and chromium-containing fluids have been documented.	Installation of two new monitoring wells on or immediately south from the Hawker-Pacific facility will help determine the impacts to groundwater quality in this area and define the hydraulic gradient between the Honeywell and Lockheed facilities, where few	Depth Region 1 – one well Depth Region 2 – one well	K

TABLE 2-1
Data Need and Recommendation Summary
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Data Need	Purpose/Recommendation	Recommended Wells	Map Location Identifier
	groundwater level data are available. Installation of one new monitoring well in Depth Region 1 and one new well in Depth Region 2 is recommended.		
Few data are available southwest of extraction well NHE-2 to determine whether contamination has bypassed NHE-2 in the year it was shut down.	Installation of two new monitoring wells southwest of well NHE-2 will help define the southern extent of VOC and chromium contamination and provide gradient information that will enhance monitoring of remedy performance in this critical area. Installation of one new monitoring well in Depth Region 1 and one new well in Depth Region 2 is recommended.	Depth Region 1 – one well Depth Region 2 – one well	L
Few data are available to define contaminant concentrations and hydraulic gradients southeast of extraction well NHE-6, an area of concern for potential migration of contaminated groundwater beyond the capture zone of the existing NHOU extraction and treatment system.	Installation of two new monitoring wells southeast of well NHE-2 will help define the extent of VOC and chromium contamination, provide gradient information that will enhance monitoring of remedy performance in this critical area, and provide sentinel monitoring upgradient from the Whitnall well field. Installation of one new monitoring well in Depth Region 1 and one new well in Depth Region 2 is recommended.	Depth Region 1 – one well Depth Region 2 – one well	M

Figure
2-1 Selected Facility Locations

Figure 2-1, continued

Figure
2-2 Maximum Concentration of TCE and PCE in Groundwater, Depth Region 1

Figure 2-2, continued

Figure
2-3 Maximum Concentration of TCE and PCE in Groundwater, Depth Regions 2 Through 4

Figure 2-3, continued

Figure
2-4 Maximum Concentration of Chromium in Groundwater, Depth Region 1

Figure 2-4, continued

Figure
2-5 Maximum Concentration of Chromium in Groundwater, Depth Regions 2 Through 4

Figure 2-5, continued

Figure
2-6 Maximum Concentration of TCP in Groundwater, Depth Region 1

Figure 2-6, continued

Figure
2-7 Maximum Concentration of TCP in Groundwater, Depth Regions 2 Through 4

Figure 2-7, continued

Figure
2-8 Maximum Concentration of 1,4-Dioxane in Groundwater, Depth Region 1

Figure 2-8, continued

Figure
2-9 Maximum Concentration of 1,4-Dioxane in Groundwater, Depth Regions 2 Through 4

Figure 2-9, continued

Figure
2-10 Maximum Concentration of NDMA in Groundwater, Depth Region 1

Figure 2-10, continued

Figure
2-11 Maximum Concentration of NDMA in Groundwater, Depth Regions 2 Through 4

Figure 2-11, continued

Figure
2-12 Maximum Concentration of Perchlorate in Groundwater, Depth Region 1

Figure 2-12, continued

Figure
2-13 Maximum Concentration of Perchlorate in Groundwater, Depth Regions 2 Through 4

Figure 2-13, continued

Figure
2-14 Recommended Additional Monitoring Well Locations

Figure 2-14, continued

SECTION 3

Development of Preliminary Cleanup Goals

Preliminary cleanup goals establish a basis for the evaluation and selection of remedial alternatives and are developed from the Remedial Action Objectives (RAOs) and Applicable or Relevant and Appropriate Requirements (ARARs). Preliminary cleanup goals are generally set at the lowest of the following values:

- Numerical cleanup criteria established by ARARs
- Levels determined to be protective of human health
- Levels determined to be protective of ecological receptors

3.1 Remedial Action Objectives

The RAOs provide a description of what the remedy is expected to accomplish; they define the scope and magnitude of site cleanup required to protect human health and the environment. Where applicable, RAOs take into consideration the type of contamination, routes of exposure, receptors, and acceptable contaminant concentrations. The Second Interim Remedy at the NHOU is intended to achieve the following RAOs:

- Contain areas of contaminated groundwater that exceed the MCLs and notification levels to the maximum extent practicable.
- Prevent further degradation of water quality at the Rinaldi-Toluca and North Hollywood West production wells by preventing the migration toward these well fields of the more highly contaminated areas of the VOC plume located to the east-southeast.
- Achieve improved hydraulic containment to inhibit horizontal and vertical contaminant migration in groundwater from the more highly contaminated areas and depths of the aquifer to the less contaminated areas and depths of the aquifer, including the southeast portion of the NHOU in the vicinity of the Erwin and Whitnall production well fields.
- Remove contaminant mass from the aquifer.

The remedial alternatives presented in this FFS are designed to limit the migration of the most highly contaminated groundwater plume located south and east from the Rinaldi-Toluca and the North Hollywood West well fields. The TCE and PCE concentrations detected at the Rinaldi-Toluca wells are approximately 5 to 50 µg/L. The TCE and PCE concentrations detected at the North Hollywood West wells are approximately 5 to 15 µg/L. By comparison, the TCE/PCE concentrations in groundwater underlying the Honeywell facility range from 50 to more than 1,000 µg/L. Similarly, the chromium concentrations detected at the Rinaldi-Toluca and North Hollywood West well fields range from non-detect to 7 µg/L, while chromium concentrations in groundwater underlying the Honeywell facility range from non-detect to 48,000 µg/L. Accordingly, the remedial alternatives are designed to protect the Rinaldi-Toluca and North Hollywood West well fields by capturing the higher-concentration VOC and chromium groundwater plumes and preventing them from reaching these well fields.

Low levels of VOC contamination (approximately 5 to 15 µg/L) in groundwater occur in continuous plumes that extend throughout much of the SFV groundwater basin, and are not limited to specific OUs of the SFV Area 1 and Area 2 Superfund Sites (see Figures 1-3 through 1-6). The Existing NHOU, BOU, and GOU Extraction and Treatment Systems were designed with this in mind. Thus, lower concentration portions of the plumes located south and southeast of the existing NHOU extraction wells that are not captured by those wells have been, and will continue to be, captured in part by certain LADWP Erwin and Whitnall production wells and in part by the BOU and GOU groundwater extraction and treatment systems. As a part of the NHOU Second Interim Remedy, additional investigation will be conducted in the vicinity of the Erwin and Whitnall production well fields to provide data and information for determining whether and what kind of additional remedial measures might be needed in this portion of the SFV basin. The Existing NHOU Extraction and Treatment System was designed with the understanding that some of the groundwater with low VOC concentrations would migrate eastward and be captured by the extraction wells of the adjacent groundwater treatment systems in the BOU and the GOU. Both of these OUs have substantially greater extraction and treatment rates than the NHOU. The BOU in particular, with an extraction and treatment capacity of 9,000 gpm, creates a large hydraulic "cone of depression" that would be anticipated to capture much of the contaminated groundwater that is not contained by the NHOU extraction wells and migrates eastward of the NHOU. The remainder of the contaminated groundwater migrating eastward from the NHOU is expected to be captured by the GOU extraction wells. The GOU extraction wells have a capacity of 5,000 gpm and are located in the Los Angeles River Narrows, where they were designed to intercept and extract contaminated groundwater that is not captured by the remedies for the North Hollywood and BOU.

Additional data obtained during design and implementation of the Second Interim Remedy will improve EPA's ability to determine the nature of a final remedy for the NHOU. EPA's decision to propose a Second Interim Remedy, rather than continue with the existing remedy until additional data are available to develop a final remedy, is consistent with the National Contingency Plan (NCP). Groundwater in the NHOU is known to be spreading into less contaminated portions of the aquifer because of the Existing NHOU Extraction and Treatment System's failure to completely capture the targeted plume. Delaying action could result in the following:

- Continued contaminant migration, necessitating additional treatment, increasing costs, and complicating the operation of existing or planned treatment facilities.
- Increased likelihood that additional water supply wells in the SFV would have to be modified, removed from service, or operated intermittently, or that groundwater produced by additional wells would require treatment to remove contaminants.
- Increased cost, difficulty, and time required for containment of contaminant plumes or restoration of the aquifer because continued contaminant migration would increase the volume, contaminant concentrations, and potential constituents of concern in that contaminated groundwater.

3.2 Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA requires that remedial actions implemented at CERCLA sites attain any federal or more stringent state environmental standards, criteria, or limitations that are determined to be ARARs, unless a waiver is granted. Section 3.2 identifies and evaluates potential ARARs that could affect development of a Second Interim Remedy at the NHOU.

3.2.1 Identification of Applicable or Relevant and Appropriate Requirements

Applicable requirements are cleanup standards, criteria, or limitations promulgated under federal or state law that specifically address the situation at a CERCLA site. A requirement is applicable if the jurisdictional prerequisites of the environmental standard directly correspond when objectively compared with site conditions.

If a requirement is not legally applicable, the requirement is evaluated to determine whether it is relevant and appropriate. Relevant and appropriate requirements are cleanup standards, control standards, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable, address problems or situations sufficiently similar to the circumstances of the proposed response action and are well suited to the conditions of the site. The criteria for determining relevance and appropriateness are listed in 40 Code of Federal Regulations (CFR) 300.400(g)(2).

Pursuant to EPA guidance, ARARs are generally classified as (1) chemical-specific, (2) location-specific, or (3) action-specific. These categories were developed to help define ARARs; however, some do not fall precisely into one group. These categories of ARARs are defined as follows:

- **Chemical-specific ARARs:** Laws and requirements that regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limitations for specific hazardous substances. If, in a specific situation, a chemical is subject to more than one discharge or exposure limit, the more stringent of the requirements should generally be applied.
- **Location-specific ARARs:** Requirements that relate to the geographical or physical position of the site rather than the nature of the contaminants or the proposed site remedial actions. These requirements may limit the placement of the remedial action, and may impose additional constraints on the cleanup action. For example, location-specific ARARs may refer to activities near wetlands, endangered species habitat, or areas of historical or cultural significance.
- **Action-specific ARARs:** Requirements that apply to specific actions associated with site remediation. Action-specific ARARs often define acceptable handling, treatment, and disposal procedures for hazardous substances. These requirements are triggered by the particular remedial activities selected to accomplish a remedy. Examples of action-specific ARARs include requirements applicable to landfill closure, wastewater discharge, hazardous waste disposal, and air pollution emissions.

To-be-considered criteria (TBCs) do not meet the definition of an ARAR, but might still be useful in determining whether to take action at a site, or to what degree action is necessary. This can be particularly true when there are no ARARs for a site, action, or contaminant. TBCs are defined in 40 CFR Section 300.400(g)(3). Chemical-specific TBCs may be used in the absence of ARARs or when an existing ARAR is not sufficiently protective to develop cleanup levels (EPA, 1988). TBC documents are nonpromulgated advisories or guidance that are not legally binding and are issued by federal or state governments; they may provide useful information or recommended procedures for remedial action. Although TBCs do not have the status of ARARs, they are considered together with ARARs to establish the required level of cleanup for protection of human health or the environment. The critical difference between a TBC and an ARAR is that an entity is not required to comply with or meet a TBC when implementing a remedial action, unless that TBC is adopted as a cleanup standard in the ROD.

CDPH drinking water notification levels are considered TBCs for evaluating concentrations of the three emerging chemicals (TCP, 1,4-dioxane, and NDMA) present in the NHOU for which MCLs have not been established. The CDPH notification levels are not ARARs, but serve as target goals for the NHOU treated water to ensure it will meet the intended beneficial offsite use.

An MCL or notification level that does not specifically relate to one of the COCs in the basin (e.g., byproducts typically produced by disinfection of water using chlorine compounds) is not an ARAR for the NHOU treated groundwater effluent.

3.2.2 Potential ARARs for NHOU Remedial Actions

The 1987 ROD identified the following as ARARs:

- **Safe Drinking Water Act.** Requires that treated water from the remedy meet the MCL for TCE (5 µg/L) and the state notification level for TCE (5 µg/L) and PCE (4 µg/L).
- **Resource Conservation and Recovery Act (RCRA)**. Requires that spent hazardous carbon generated from the treatment process, if any, be disposed of at a RCRA Class 1 disposal facility.
- **Clean Air Act**. Requires the groundwater treatment facility (specifically, the air discharging from the air stripper) to meet all substantive conditions stipulated in the SCAQMD permit.

The ARARs were reviewed as part of the five-year reviews conducted in 1993, 1998, 2003, and 2008, after the 1987 ROD was issued and the Existing NHOU Extraction and Treatment System was constructed.

A summary of the recommended potential chemical-specific and action-specific ARARs and TBCs for further remedial actions in the NHOU is provided in Tables 3-1, 3-2, and 3-3, respectively. No location-specific ARARs were identified for the site during the 1987 ROD, and none have been identified for the alternatives presented in this FFS.

The current regulatory standards for TCE, PCE, and the other VOCs discussed in Section 2.4.3 are the state and federal MCLs.

TABLE 3-1
Potential Chemical-specific Applicable or Relevant and Appropriate Requirements
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Source	Citation	Applicable or Relevant and Appropriate	Description	Findings and Comments
SDWA (2 USC 300 et seq.)	National Primary Drinking Water Standards, including 40 CFR 141.61 and 40 CFR 141.62	Relevant and appropriate	Chemical-specific drinking water standards and MCLs have been promulgated under the SDWA; MCLGs above zero are considered chemical-specific ARARs under the NCP (40 CFR 300.430(e)(2)(i)(B)). When the MCLGs are equal to zero, which is generally the case for a chemical considered to be a carcinogen, the MCL is considered the chemical-specific ARAR instead of the MCLG (40 CFR 300.430(e)(2)(i)(C)). Established MCLs for COCs are listed in Table 3-4. Cleanup levels for the SFV treated effluent were established in the 1987 ROD at 5 µg/L for TCE and 4 µg/L for PCE. However, the MCL and cleanup level for PCE has since been changed to 5 µg/L. These cleanup levels will apply to the effluent from the treatment plant. Cleanup levels for groundwater in the aquifer are not established at this time in any of the alternatives.	The MCLs are ARARs for the purpose of establishing cleanup levels for the treated water from the NHOU treatment plant. 40 CFR 300.430(e)(2)(i)(B) and 40 CFR 300.430(e)(2)(i)(C) require that the remedy selected attain non-zero MCLGs or MCLs for each contaminant if the groundwater is a current or potential drinking water source. "At the tap" SDWA requirements are not ARARs; they regulate offsite activity. After the water leaves the treatment plant, EPA considers it to be offsite. Any SDWA requirement that is not relevant as a cleanup level (i.e., it does not specifically relate to one of the COCs in the basin) is not an ARAR and only applies to LADWP before it delivers the water to its customers.
SDWA (42 USC 300 et seq.)	National Primary Drinking Water Standards, 40 CFR 141, including 40 CFR 141.23 and 40 CFR 141.24	Relevant and appropriate	Requires monitoring to determine compliance with MCLs.	Substantive monitoring requirements in 40 CFR 141.23 and 40 CFR 141.24 are relevant and appropriate, to ensure that treated effluent is meeting cleanup levels.
State of California Domestic Water Quality and Monitoring Regulations	California Safe Drinking Water Regulations, including 22 CCR 64431 and 22 CCR 64444	Relevant and appropriate	Contains provision for California domestic water quality; establishes MCLs for primary drinking water chemicals.	The MCLs are ARARs for the purpose of establishing cleanup levels for COCs in the water extracted from the basin and treated at the treatment plant.

Notes:
CCR = California Code of Regulations
MCLG = maximum contaminant level goal
SDWA = Safe Drinking Water Act

TABLE 3-2
Potential Action-specific Applicable or Relevant and Appropriate Requirements
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Source	Citation	Applicable or Relevant and Appropriate	Description	Findings and Comments
Clean Air Act SCAQMD	Air Pollution Control Equipment Permit 144890 was granted August 29, 1986. This permit does not appear to have been renewed.	Substantive require-ments of the permit are applicable	In California, the authority for enforcing the standards established under the Clean Air Act has been delegated to the state. The program is administered by the SCAQMD in Los Angeles. Permit 144890 (held by LADWP) requires 90 percent removal efficiency for TCE and PCE air emissions and a not-to-exceed level of 2 pounds per day of total VOCs.	The existing system includes use of air stripping technology to remove VOCs from the groundwater. Emissions from the air stripper must meet SCAQMD limits and the other substantive provisions established in this permit. Although a permit is not required for the air stripper pursuant to CERCLA § 121(d), LADWP obtained a permit in advance of construction in 1986. According to SCAQMD, the permit from the SCAQMD remains valid, and the emission limits and other substantive requirements in it are applicable. If the air stripping treatment system is modified significantly as part of the selected remedy, the substantive provisions of SCAQMD Rule 1401 (which limits air emissions of identified toxics from new or modified sources) may apply.
SDWA (42 USC 300 et seq.)	Federal Underground Injection Control Plan, 40 CFR 144, including 40 CFR 144.12, 40 CFR 144.13 and 40 CFR 146.10	Applicable	Prohibits injection wells from (1) causing a violation of primary MCLs in the receiving waters and (2) adversely affecting the health of persons. Provides that contaminated ground-water that has been treated may be reinjected into the formation from which it is withdrawn if such injection is conducted pursuant to a CERCLA cleanup and is approved by EPA	40 CFR 144.12 and 40 CFR 144.13 are applicable to NHOU treated water if it is reinjected into the aquifer.

TABLE 3-2
Potential Action-specific Applicable or Relevant and Appropriate Requirements
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Source	Citation	Applicable or Relevant and Appropriate	Description	Findings and Comments
RCRA	RCRA Sections 3020 (a) and (b)	Applicable	RCRA section 3020(a) bans hazardous waste disposal by underground injection into a drinking water aquifer (within ¼ mile of a well), or above such a formation. However, Section 3020(b) exempts from this ban on reinjection of treated contaminated groundwater if the following criteria are met: (1) the reinjection is part of a response action under CERCLA; (2) the water is treated to substantially reduce hazardous constituents prior to reinjection, and (3) the response action is sufficient to protect human health and the environment upon completion.	RCRA Sections 3020(a) and (b) are applicable to NHOU treated water if it meets the definition of hazardous waste and is reinjected into the aquifer.
Los Angeles RWQCB Water Quality Control Plan (Basin Plan)	Basin Plan, Chapters 2 and 3	Applicable	The Basin Plan incorporates State Water Resources Control Board Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California." Resolution No. 68-16 requires maintenance of existing state water quality unless it is demonstrated that a change will benefit the people of California, will not unreasonably affect present or potential uses, and will not result in water quality less than that prescribed by other state policies.	The substantive requirements of the Basin Plan will apply to NHOU treated water if it is reinjected into the aquifer.
California Water Code and State Water Resources Control Board Model Well Standards Ordinance (1989)	Division 7, Chapter 10, Section 13700 et seq.	Applicable	The California Water Code requires the State Water Resources Control Board to adopt a model well ordinance implementing the standards for well construction, maintenance, and abandonment contained in the construction requirements for wells, in conformance with DWR Bulletin 74-81. DWR Bulletin 74-90 updates DWR Bulletin 74-81.	If the selected alternative involves well construction or maintenance, substantive provisions of this code will be applicable.

TABLE 3-2
Potential Action-specific Applicable or Relevant and Appropriate Requirements
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Source	Citation	Applicable or Relevant and Appropriate	Description	Findings and Comments
California Hazardous Waste Regulations, Generator Requirements	22 CCR 66262.10	Applicable	22 CCR 66262.10 lists the sections of California law with which a generator of hazardous waste must comply.	The selected remedy need only comply with the substantive provisions of the regulations listed in 22 CCR 66262.10. Each alternative being considered in the FFS has the potential to generate hazardous waste. Examples of hazardous wastes generated onsite include: (1) spent granular activated carbon filters from the air stripper, (2) purged water from new or modified wells that meets characteristic waste levels, and (3) well casing soils from new or modified wells that meet characteristic waste levels.
California Hazardous Waste Regulations, Generator Requirements	22 CCR 66262.11	Applicable	Requires waste generators to determine if wastes are hazardous, and establishes procedures for such determinations.	The substantive requirements will be applicable to management of waste materials generated by a groundwater treatment plant and to any waste generated while installing new wells.
California Hazardous Waste Regulations, Generator Requirements	22 CCR 66262.34(a)(1)(A)	Relevant and appropriate	Waste stored onsite should be placed in containers or tanks that are in compliance with California Hazardous Waste Regulations.	Storage of hazardous waste accumulated onsite must be in compliance with substantive requirements for interim status facilities.
California Hazardous Waste Regulations, Storage of Hazardous Waste	22 CCR 66265.170 et seq. (Article 9) 22 CCR 66265.190 et seq. (Article 10)	Applicable	Regulates use and management of containers, compatibility of wastes with containers, and special requirements for certain wastes.	Substantive provisions of Articles 9 and 10 will be applicable if hazardous waste is generated and accumulated onsite.
California Land Disposal Restrictions, Requirements for Generators	22 CCR 66268.3, 22 CCR 66268.7, 22 CCR 66268.9, and 22 CCR 66268.50	Applicable	Compliance with land disposal regulation treatment standards is required if hazardous waste (e.g., contaminated soil) is placed on land. Soil treatability variance may be invoked, according to 40 CFR 268.44 (h)(3) and (4).	Hazardous waste hauled offsite must meet "land-ban" requirements.

TABLE 3-2
Potential Action-specific Applicable or Relevant and Appropriate Requirements
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Source	Citation	Applicable or Relevant and Appropriate	Description	Findings and Comments
California Land Disposal Restrictions, Requirements for Generators	22 CCR 66268.1 et seq. (Article 1)	Applicable	Prior to transporting for offsite disposal, hazardous waste must be characterized to determine whether land disposal restriction treatment standards apply and whether the waste meets the treatment standards. This information must be provided to the offsite facility with the first waste shipment.	The substantive requirements will be applicable to management of waste materials generated by a groundwater treatment plant and to any waste generated while installing new wells.
Spent Carbon Disposal	40 CFR 268.40	Applicable	Attain land disposal treatment standards before putting waste into landfill to comply with land disposal restriction.	Substantive requirements apply.

Note:

NPDES = National Pollutant Discharge Elimination System
SCAQMD = South Coast Air Quality Management District
DWR = Department of Water Resources
CFR = Code of Federal Regulations
CCR = California Code of Regulations
RWQCB = Regional Water Quality Control Board

TABLE 3-3
To-Be-Considered Criteria
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Source	Citation	Description	Findings and Comments
California PHGs, California Environmental Protection Agency, and OEHHA	California Calderon-Sher SDWA of 1996, California Health and Safety Code 116365	OEHHA has adopted PHGs for chemicals in drinking water. PHGs are levels of drinking water contaminants at or below which adverse health effects are not expected to occur from a lifetime of exposure.	In the absence of MCLs, the state PHGs adopted by OEHHA have been considered during selection of cleanup goals for extracted groundwater.
CDPH Drinking Water Notification Levels	California Health & Safety Code § 116455	CDPH has established drinking water notification levels (formerly known as action levels) based on health effects, but in some cases they are based on organoleptic (taste and odor) values for chemicals without MCLs.	In the absence of MCLs, the drinking water notification levels established by CDPH have been considered during selection of cleanup goals for extracted groundwater.

The current regulatory standard for total chromium in SFV groundwater is the state MCL of 50 µg/L. State legislation passed in 2001 required CDPH to adopt an MCL for hexavalent chromium by January 1, 2004. However, before CDPH can adopt an MCL, OEHHA must first issue a PHG for the contaminant. The schedule for issuing a PHG for hexavalent chromium was delayed, pending completion of a study by the National Toxicology Program (part of the U.S. Department of Health and Human Services) on the toxicity of hexavalent chromium that was released in May 2007. As of July 2009, the PHG has not been issued; therefore, an MCL for hexavalent chromium has not been developed. OEHHA previously indicated that it expected to issue a proposed PHG for hexavalent chromium in 2008 and that a final PHG may be issued 1 to 2 years later, after which CDPH would develop and adopt an MCL. Therefore, the existing state MCL for total chromium (50 µg/L) is used as the regulatory standard for assessing total and hexavalent chromium in groundwater in the NHOU. If an MCL for hexavalent chromium is adopted that is substantially lower than the state MCL of 50 µg/L for total chromium, the conclusions presented in this report regarding the impacts of hexavalent chromium in the NHOU and at the NHOU treatment system may require reevaluation. In addition, a higher degree of chromium treatment may be required of any future remedy in order to ensure that the treated water continues to meet drinking water standards.

State or federal MCLs have not been promulgated for TCP, 1,4-dioxane, or NDMA. For these emerging chemicals that lack MCLs, the CDPH notification levels, which are health-based advisory levels for drinking water use, were considered as alternative cleanup levels for extracted groundwater in the NHOU. Notification levels are established as precautionary measures for contaminants that may be considered candidates for establishment of MCLs. Although not an enforceable standard, a notification level is the concentration of a contaminant in drinking water that DHS has determined, based on available scientific information, does not pose a significant health risk but warrants notification. CDPH requires that drinking water purveyors notify the public if notification levels are exceeded, unless the wells in question are taken out of service.

3.3 Preliminary Cleanup Goals

The groundwater extracted and treated by the Second Interim Remedy may ultimately be mixed with water from other sources, disinfected, and delivered to LADWP customers as potable water. Alternatively, the treated groundwater may be reinjected to the aquifer. In consideration of the RAOs, ARARs, and TBC criteria, preliminary cleanup goals for the Second Interim Remedy were developed for the following:

- Treatment of the groundwater extracted by the NHOU system and ultimately used by LADWP for potable water supply (drinking water end use option)
- Treatment of the groundwater extracted by the NHOU system and reinjected into the aquifer (reinjection option)
- Containment of the contaminated groundwater within the NHOU, which covers an area of approximately 4 square miles of the SFV

3.3.1 Cleanup Levels for Drinking Water End Use

For the drinking water end use option, EPA proposes to use the federal and state drinking water MCLs as the cleanup levels for the treated groundwater. For the emerging chemicals (other than hexavalent chromium) for which MCLs have not been established (e.g., 1,4-dioxane), EPA proposes to use the CDPH notification levels as the cleanup levels for the treated groundwater.

An MCL for hexavalent chromium does not currently exist, but the State has initiated development of a public health goal and may promulgate an MCL within the next several years. Based on discussions with LADWP, it is EPA's understanding that LADWP will continue to use a voluntary cleanup level of 5 µg/L for hexavalent chromium for water it will accept for use in its water supply system. Consequently, under the drinking water end use option, chromium treatment at the NHOU will be needed so that LADWP's voluntary cleanup level of 5 µg/L can be met. Therefore, the EPA cleanup level for hexavalent chromium in treated water is 5 µg/L.

These cleanup levels, along with data from the expanded groundwater monitoring well network, will serve as a trigger for initiating further response actions to address the contaminant in question so as to ensure that drinking water standards are not exceeded in the treated water from the NHOU treatment system.

Table 3-4 lists the regulatory water quality standards and criteria for the COCs most commonly detected in the NHOU that exceed the MCLs and notification levels. The table also shows the cleanup level for each COC proposed under the drinking water end use option.

TABLE 3-4
Cleanup Levels for Selected Chemicals of Concern
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Contaminant of Concern	Cleanup Levels[a,b] (µg/L)	Basis for Treatment Goal
Trichloroethylene (TCE)	3	Federal and California MCL
Tetrachloroethylene (PCE)	3	Federal and California MCL
Total Chromium	30[c]	California MCL
Hexavalent Chromium	5	See discussion in text, above
1,4-Dioxane	3	CDPH Notification Level

[a]The California Department of Public Health permitting process may require lower concentrations in the treated effluent.

[b]Cleanup levels for the reinjection end use option will be determined during remedial design based on the injection locations.

[c]The planned treatment process for hexavalent chromium will reduce total chromium concentrations to below 5 µg/L.

3.3.2 Cleanup Levels for Reinjection End Use

For the reinjection end use option, removal of hexavalent and total chromium will also be needed to comply with the State of California's anti-degradation policy, which establishes cleanup levels for reinjection into the aquifer. The anti-degradation policy allows for injection of treated groundwater at concentrations less than or equal to the groundwater quality at the injection location(s). Accordingly, the treated water cleanup levels for the reinjection end use will be established during remedial design based on the COC concentrations in the groundwater at the injection well location(s).

3.3.3 Plume Containment

As described in Section 3.1, the RAOs for plume containment in the aquifer focus on containing groundwater at the MCL wherever practicable and limiting migration of the more highly contaminated groundwater. Therefore, the primary cleanup goal for the aquifer is to achieve containment of the most significant concentrations of the VOC- and chromium-contaminated groundwater. A comparison of Figures 2-2 and 2-3 with Figures 2-4 and 2-5 indicates that the area of elevated chromium concentrations in groundwater in the NHOU is much smaller than, and within the boundaries of, the area of elevated VOC concentrations. Therefore, achieving containment of the VOC (specifically TCE) plume in the NHOU will also contain most of the chromium plume where concentrations exceed 5 µg/L, and all of the known chromium plume that exceeds the MCL. The remedial alternatives are designed to establish a capture zone that contains contaminated groundwater in the aquifer with VOC concentrations greater than 5 µg/L at most locations in the NHOU groundwater plume. For purposes of this FFS, a target concentration for capture and treatment of hexavalent and total chromium of 5 µg/L is assumed in anticipation of the issuance of a significantly lower state MCL for hexavalent chromium. This approach will provide containment of the most significantly contaminated portions of the groundwater plume in the NHOU.

Concentrations of VOCs of approximately 5 to 50 µg/L (1 to 10 times the MCL) are currently present at, and will be captured under the Second Interim Remedy, by select LADWP production wells located upgradient (Rinaldi-Toluca), cross gradient (North Hollywood West) and downgradient (Whitnall, and Erwin) of the NHOU extraction well capture zone and by the BOU and GOU remedy extraction/treatment systems to the east and south (respectively) of the NHOU system.

SECTION 4

Development and Description of Remedial Alternatives

Section 4 develops and describes the remedial alternatives for achieving the RAOs at the NHOU. Section 4.1 introduces the Existing NHOU Extraction and Treatment System and describes the current groundwater monitoring network. Section 4.2 describes the general response actions common to all of the new remedial alternatives and how the specific remedial technologies and process options function. Section 4.3 presents remedial alternatives that incorporate the identified technologies and process options and describes the projected performance of each alternative with respect to containment and mass removal in the NHOU.

4.1 Existing NHOU Extraction and Treatment System

The Existing NHOU Extraction and Treatment System was designed to remove VOC contaminant mass and to contain the groundwater plume in the most significantly contaminated portions of the NHOU, which are primarily located in groundwater Depth Region 1 (see Figure 2-2). For several reasons, the 2,000-gpm design flow rate of the first interim remedy has not been met. Notably, a key remedy component, extraction well NHE-1, was shut down because of insufficient groundwater yield in December 1989, before the Existing NHOU Extraction and Treatment System became operational. Well NHE-1 has not been pumped since then. Additional factors contributing to the inability of the NHOU interim remedy to meet the 2,000-gpm flow rate goal include declining groundwater levels, maintenance problems, and periodic voluntary shutdowns by LADWP of extraction well NHE-2 due to elevated chromium concentrations.

To increase the overall pumping and treatment rate for the Existing NHOU Extraction and Treatment System, the LADWP implemented recommendations made during the *Third North Hollywood Operable Unit Five-Year Review* (EPA, 2003) and improved system maintenance practices. The LADWP also discontinued voluntary well shut downs, and in 2004 it changed its chromium policy to allow for operating the NHOU extraction wells based on limiting the concentration of total dissolved chromium in the treatment plant effluent to 30 μg/L or less (i.e., 60 percent of the MCL, to provide a margin of safety) rather than based on chromium concentrations detected in samples from individual extraction wells.

Until recently, implementation of the modified LADWP policy regarding chromium, combined with decreasing chromium concentrations detected at extraction well NHE-2 between 2004 and 2006, eliminated the need for voluntary well shut downs. However, total and hexavalent chromium concentrations rose sharply at well NHE-2 during the last quarter of 2006 and the first quarter of 2007, reaching 200 μg/L in January 2007. By April 2007, total and hexavalent chromium concentrations at NHE-2 reached a peak of approximately 400 μg/L. Chromium concentrations at this well have subsequently ranged from approximately 280 to 440 µg/L. The high concentration of chromium in groundwater extracted by well NHE-2 caused the treatment plant effluent to exceed the target concentration for total chromium of 30 µg/L. Consequently, well NHE-2 was shut down from February 2007 to August 2008, as described in Section 1.2.2.

The Existing NHOU Extraction and Treatment System's effectiveness is also currently limited because it was designed to extract and treat groundwater primarily from Depth Region 1, where known groundwater contamination existed in the 1980s. With the exception of extraction well NHE-6, the NHOU extraction wells are screened in Depth Region 1 and the upper part of Depth Region 2 to maximum depths ranging from 270 to 300 feet bgs. Well NHE-6 is screened to a depth of 378 feet bgs, which includes much of Depth Region 2. However, elevated concentrations of TCE and PCE are present in the lower part of Depth Region 2 and in Depth Region 3, north of extraction well NHE-2 and south of extraction wells NHE-7 and NHE-8. Therefore, the extraction system is capable of only limited containment of these deeper contaminant plumes.

For these reasons, the Existing NHOU Extraction and Treatment System has not achieved complete containment of the VOC contamination within the NHOU. The result has been the continued migration of TCE and PCE contamination in groundwater, particularly to the northwest, south, and west of the extraction wells. As a result, at certain LADWP production wells and locations in the NHOU, PCE and TCE concentrations are present at two to ten times the MCL (10 to 50 µg/L), as shown on Figures 2-2 and 2-3.

The Existing NHOU Extraction and Treatment system was not designed to address emerging chemicals in the NHOU, including those that have been detected sporadically or at concentrations below the MCLs or CDPH notification levels. In developing the remedial alternatives, EPA considered several organic and inorganic contaminants that have been identified since the mid-1990s. While these contaminants will continue to be monitored and evaluated, exceedances of the action levels for these contaminants have been marginal and not uniformly present (with the exception of chromium), with no discernible trends (beyond the potential source facility). Hexavalent chromium is the emerging chemical of greatest concern in NHOU because it has been detected at high concentrations at extraction well NHE-2 and several upgradient monitoring wells. For this reason, options to treat dissolved total and hexavalent chromium will be included as part of all alternatives for the Second Interim Remedy. Concentrations of the other emerging chemicals detected to date in groundwater samples from the NHOU extraction wells have been generally below CDPH notification levels or MCLs. Exceptions include the following:

- TCP has sporadically been detected at concentrations ranging from 0.006 to 0.008 µg/L (above the notification level of 0.005 µg/L) at extraction well NHE-5. TCP has not been detected in the combined influent to the NHOU groundwater treatment system, likely due to dilution resulting from mixing with groundwater from the other NHOU extraction wells, where concentrations have been very low to nondetectable.

- 1,4-Dioxane has recently been detected consistently at concentrations above the notification level of 3 µg/L at extraction well NHE-2 and several upgradient monitoring wells. Concentrations of 1,4-dioxane at the other NHOU extraction wells have ranged from 0.6 to 1.7 µg/L.

4.2 Evaluation of Remedial Technologies and Process Options

In consideration of the limitations of the existing treatment system described above, as well as the ARARs and RAOs (see Section 3), a range of remedial alternatives was developed. The first alternative (Alternative 1) consists of continued operation of the Existing NHOU Extraction and Treatment System. Alternatives 2a through 5b all include new or expanded groundwater extraction and treatment components. The following general response actions are common to all of the remedial alternatives:

- Institutional controls (ICs) in the form of a groundwater management plan (i.e., a written agreement between EPA and LADWP regarding extraction rates for the NHOU Second Interim Remedy and the production well fields) to mitigate the potential negative impacts to the NHOU system performance that could result from unexpected groundwater withdrawal by water purveyors (e.g., LADWP) in and near the NHOU.
- Groundwater and treatment system monitoring, including approximately 37 new groundwater monitoring wells.
- Wellhead treatment at extraction well NHE-2 using an advanced oxidation process (AOP) to remove 1,4-dioxane and a secondary treatment process to remove byproducts resulting from AOP.
- Chromium treatment for groundwater extracted by well NHE-2.

Remedial alternatives 2a through 5b include the following additional common elements:

- Repair and/or modify (deepen) existing extraction wells NHE-1 through NHE-8 to improve capture of the VOC plume.
- Construct new extraction wells and associated pipelines to improve hydraulic containment of highly contaminated groundwater south of LADWP's southern Rinaldi-Toluca wells and east of LADWP's North Hollywood West Well Field.
- Refurbish the existing air stripper and add a second air stripper to provide sufficient primary VOC treatment capacity to handle the increased volume of groundwater from the extraction wells.
- Chromium treatment for groundwater extraction wells (in addition to NHE-2) where chromium concentrations are expected to be highest. The primary difference between Alternatives 2a through 5b is the number of extraction wells treated for chromium.

Alternatives 2a, 3a, 4a & 5a include the following to allow for discharge of treated water to LADWP's water supply system:

- Liquid phase granular activated carbon (LPGAC) treatment installed downstream from each of the air strippers to provide "double barrier" VOC treatment as required by CDPH.

Alternatives 2b, 3b, 4b & 5b include the following to allow for reinjection of treated water to the aquifer:

- Installation of six injection wells and an associated pipeline, and nine additional monitoring wells to monitor the water quality impacts near the injection wells.

Specific plans for evaluation and implementation of each of these potential general response actions are discussed further in Sections 4.2 and 4.3.

4.2.1 Institutional Controls

The SFV groundwater basin is an important source of drinking water for the Los Angeles metropolitan area; the Cities of Glendale, Burbank, and San Fernando; La Canada-Flintridge; and the unincorporated area of La Crescenta. The ULARA Watermaster manages the water rights for the SFV groundwater basin under a judgment by the Superior Court of California. Within that framework, LADWP manages the operations and maintenance of the Existing NHOU Extraction and Treatment System as well as drinking water production from its several well fields located in the vicinity of the existing NHOU interim remedy.

The groundwater contamination in the SFV Basin limits LADWP's ability to fully exercise its water rights, and it also creates a significant challenge for LADWP to operate its production wells in a manner that is compatible with the groundwater contamination containment goals of the Existing NHOU Extraction and Treatment System. Because pumping from LADWP production wells has the potential to impair the effectiveness of the NHOU remedy, ICs are an important component of the NHOU remedy.

There are no specifically-tailored IC instruments currently in place at the site. However, certain governmental controls in place in the SFV act as effective institutional controls to prevent exposure to contaminated groundwater. The primary governmental control is the 1979 Final Judgment in the Superior Court of California, County of Los Angeles, (Superior Court Case No. 650079) in the case titled The City of Los Angeles, Plaintiff vs. City of San Fernando, et al., Defendants. The 1979 Final Judgment concluded over twenty years of litigation, including a California Supreme Court decision (14 Cal.3d 199 [1975]), which upheld the Pueblo Right of the City of Los Angeles, to all groundwater in the ULARA Basin from precipitation within the ULARA and all surface and groundwater flows from the Sylmar and Verdugo Basins 14 Cal. 3d 199 (1975). The Final Judgment also established the water rights of the cities of Los Angeles, Glendale and Burbank to all water imported from outside the Basin and either spread or delivered within the Basin. The Final Judgment created the entity known as "Watermaster" with full authority to administer the adjudication, under the auspices of the Superior Court.

Under the Final Judgment, only the cities of Los Angeles, Burbank, and Glendale are permitted to extract groundwater from the Basin. Each of these municipalities administers a public drinking water system, which is regulated and subject to permits issued by the CDPH. These drinking water regulatory controls and the Watermaster's authority to regulate and allocate water resources ensure centralized control over area groundwater. However, these controls do not address the issue of how the operation of municipal production wells can interfere with plume containment by the NHOU remedy. EPA is continuing to evaluate how additional institutional controls might be structured to mitigate the effects of production well operation on EPA's remedies with respect to plume containment.

In regard to the NHOU remedy, EPA and LADWP have initiated discussions on how to structure a groundwater resources management program that would protect the effectiveness and integrity of the NHOU remedy while being consistent with LADWP's drinking water production requirements. To be an effective IC, the groundwater resources management program and the implementation mechanisms for that program will be defined in a reliable, formal agreement.

4.2.2 Groundwater Monitoring

Section 2 of this FFS presents and evaluates groundwater data in the NHOU and recommends the installation of additional monitoring wells in the NHOU. Monitoring groundwater levels and groundwater quality from the proposed new monitoring wells and selected existing wells will allow for evaluation of contaminant plume migration, natural attenuation of VOCs and chromium, and the effectiveness of the selected remedial actions. The specific monitoring objectives that were used to develop a modified groundwater monitoring network as part of the selected remedy include the following:

- Fill key data needs as described in Section 2.7
- Provide information critical to monitor the progress of the remedy
- Develop the data necessary for evaluating and, as necessary, selecting future additional response actions for areas of the VOC plume that may not be captured by the Second Interim Remedy

Under all alternatives, groundwater monitoring within the NHOU is expected to include continued sampling and analysis of the existing RI monitoring wells in NHOU, selected facility monitoring wells, LADWP production wells, and extraction wells in the North Hollywood area for VOCs, chromium, emerging chemicals, and parameters indicative of geochemical conditions that may affect chromium speciation and transport. In addition to these new monitoring wells, the following existing and proposed wells would be sampled as part of the groundwater monitoring network for the selected remedial alternative:

- The 23 existing groundwater monitoring wells installed by EPA in and adjacent to the NHOU during the RI.
- The 8 existing NHOU extraction wells (assuming NHE-1 is deepened as assumed in Alternatives 2a through 5b) and any new NHOU extraction wells installed in the future. Monitoring of three new extraction wells is assumed in this FFS (under Alternatives 2a through 5b) for the purpose of cost estimation.
- Selected facility (e.g., Honeywell and Lockheed) groundwater monitoring wells that are suitably located to help achieve the monitoring objectives described in this section. Sampling and analysis of 40 facility monitoring wells are assumed (approximately half of the existing monitoring wells that are screened in aquifer depth regions of interest in, or adjacent to, the NHOU).

- LADWP production wells that are impacted by contaminants emanating from the NHOU and that are suitably located to help achieve the monitoring objectives described in this section. Sampling and analysis of a total of 20 LADWP production wells (most of the active and inactive production wells of the North Hollywood, Rinaldi-Toluca, Erwin, and Whitnall well fields) are assumed.

For the purposes of this FFS, it is assumed that the future sampling regimen for the new and existing monitoring wells described above would be similar to the SFV Basinwide sampling program, and would include:

- Monthly sampling at the extraction wells and quarterly to annual sampling at the selected monitoring and production wells for VOCs, hexavalent chromium, 1,4-dioxane, and TCP.
- Annual sampling of the extraction wells, selected monitoring wells, and selected production wells for dissolved metals (including total chromium), NDMA, perchlorate, nitrate, common anions, alkalinity, and total dissolved solids.

Depending on the analytical results for groundwater samples collected from the new monitoring wells, construction of additional monitoring wells may be required to further delineate contaminant plumes or determine the locations for continuing sources of groundwater contamination. After the first year of sampling results for all new wells have been evaluated, the frequency and analyte list for the monitoring program may be modified to optimize the efficiency and effectiveness of the NHOU monitoring program. Table 4-1 provides the current analyte list for wells in the NHOU monitoring network.

4.2.3 Plume Containment

The existing strategy for plume containment in the NHOU (through a series of extraction wells and groundwater treatment) is sound and is an integral part of the alternatives being considered for the Second Interim Remedy. Extraction of groundwater within the currently identified contaminant plumes can prevent further migration of highly contaminated groundwater in the vicinity of the Honeywell and Lockheed facilities in the NHOU. The principal means of achieving hydraulic containment is by placing extraction wells at multiple locations and depths, with the appropriate pumping rates, to intercept the contaminant plumes. Mass removal will result from hydraulic containment (via groundwater extraction and treatment), and can be enhanced or optimized by having extraction wells pump from the most highly contaminated portions of the aquifer. Plume containment (and the associated contaminant mass removal) through groundwater extraction and treatment is retained as a key component of the alternatives.

4.2.3.1 Target Volume Development

To evaluate the effectiveness of the existing or a proposed groundwater extraction well field, it is first necessary to define the volume of contaminated groundwater that is targeted for hydraulic containment.

VOC target volumes were developed for the NHOU FFS by first plotting the maximum reported TCE and PCE concentrations that have been recently detected at groundwater monitoring wells (from January 2003 through December 2007). Maps were prepared that

TABLE 4-1
Existing EPA RI Monitoring Well Network Analyte List
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

	Standard SFV RI Monitoring Well Analytical Suite [a]					Expanded (FFS) Analytical Suite[b]			
Sample Location	VOCs	Hexavalent Chromium	Nitrate	Dissolved Metals[c]	Inorganics, TDS, Alkalinity[c]	TCP	1,4-Dioxane	NDMA	Perchlorate
NH-C01-325	X	X	X	X	X	X	X	X	X
NH-C01-450[e]	X	X	X	X	X	X	X	X	X
NH-C01-660	X	X	X	X	X	X	X	X	X
NH-C01-780	X	X	X	X	X	X	X	X	X
NH-C02-220	X	X	X	X	X	X	X	X	X
NH-C02-325	X	X	X	X	X	X	X	X	X
NH-C02-520	X	X	X	X	X	X	X	X	X
NH-C02-681	X	X	X	X	X	X	X	X	X
NH-C03-380	X	X	X	X	X	X	X	X	X
NH-C03-580	X	X	X	X	X	X	X	X	X
NH-C03-680	X	X	X	X	X	X	X	X	X
NH-C03-800	X	X	X	X	X	X	X	X	X
NH-C04-240	X	X	X	X	X				
NH-C04-375	X	X	X	X	X				
NH-C04-460	X	X	X	X	X				
NH-C05-320[d]	X	X	X	X	X	X	X	X	X
NH-C05-460	X	X	X	X	X	X	X	X	X
NH-C06-160	X	X	X	X	X	X	X	X	X
NH-C06-285	X	X	X	X	X	X	X	X	X
NH-C06-425	X	X	X	X	X				
NH-VPB-01	X	X	X	X	X	X	X	X	X
NH-VPB-02	X	X	X	X	X	X	X	X	X
NH-VPB-03[d]	X	X	X	X	X	X	X	X	X
NH-VPB-04	X	X	X	X	X	X	X	X	X

TABLE 4-1
Existing EPA RI Monitoring Well Network Analyte List
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Sample Location	Standard SFV RI Monitoring Well Analytical Suite [a]					Expanded (FFS) Analytical Suite[b]			
	VOCs	**Hexavalent Chromium**	**Nitrate**	**Dissolved Metals[c]**	**Inorganics, TDS, Alkalinity[c]**	**TCP**	**1,4-Dioxane**	**NDMA**	**Perchlorate**
NH-VPB-05	X	X	X	X	X	X	X	X	X
NH-VPB-06	X	X	X	X	X	X	X	X	X
NH-VPB-07	X	X	X	X	X	X	X	X	X
NH-VPB-08	X	X	X	X	X	X	X	X	X
NH-VPB-09[f]	X	X	X	X	X	X	X	X	X
NH-VPB-10	X	X	X	X	X	X	X	X	X
NH-VPB-11[d]	X	X	X	X	X	X	X	X	X
NH-VPB-12[d]	X	X	X	X	X	X	X	X	X
NH-VPB-13[d]	X	X	X	X	X	X	X	X	X
NH-VPB-14[d]	X	X	X	X	X	X	X	X	X

[a]Standard SFV Basin analytical suite and methods as described in annual RI monitoring reports for the SFV Superfund Site.

[b]Expanded analytical suite, including analyses for emerging chemicals, in support of the NHOU FFS (2005 through 2007). X = groundwater samples collected for minimum of two consecutive sample events or once from wells included in the annual sampling program; **X** = groundwater samples continue to be collected as part of SFV Basin analytical suite.

[c]Dissolved metals included during annual sampling event for all SFV Basin RI monitor wells.

[d]Well was dry when sampled, or there was insufficient pump submergence for water to reach surface. Will be sampled in future if groundwater levels rise sufficiently.

[e]Pump is inoperable and pipe is separated from surface completion. Well has been placed on list for repair or replacement consideration.

[f]Pump was removed during construction of the Los Angeles County Library facility adjacent to the well; unable to replace. Other sampling methods are being considered.

illustrate the maximum PCE and TCE concentrations detected during this period at wells in Depth Region 1 (see Figure 2-2) and in Depth Regions 2 through 4 (see Figure 2-3). The data from wells screened in Depth Regions 2 through 4 were combined into a single data set because most of the deeper wells sampled within the NHOU have screened intervals that extend through multiple depth regions. Similar maps were prepared for the dissolved chromium, TCP, 1,4-dioxane, NDMA, and perchlorate concentrations detected in the NHOU (see Figures 2-4 through 2-13). TCE, PCE, and chromium data were contoured, and target volumes of contaminated groundwater were identified. In the case of the VOC data set, the higher of the two values for PCE or TCE at a particular sampling location was used in the contouring. Available data indicate that the zones within the NHOU where emerging chemical concentrations exceed the MCLs or CDPH notification levels are small and generally fall within the target zones for TCE, PCE, and chromium; therefore, separate target zones were not developed for the emerging chemicals.

The initial target volumes for VOCs were defined as all areas where PCE or TCE concentrations in groundwater exceed 5 µg/L (equivalent to the MCL). In some portions of Depth Region 1 in the NHOU, nearby LADWP production wells, including the southern half of the Rinaldi-Toluca Well Field, the North Hollywood West Well Field, the Erwin Well Field, and the Whitnall Well Field, capture groundwater with VOC concentrations of 5 µg/L or greater. Although the contaminated groundwater near these LADWP wells is part of the target volume for containment by the NHOU extraction system, some of the contaminated groundwater within the target volumes will most likely continue to be captured by the nearby LADWP production wells as long as these production wells continue to be pumped at much higher rates than the NHOU extraction wells. In addition, as noted in Section 2.7, some areas of low to moderate VOC contamination that are separate from the high-concentration plumes noted at Honeywell and Lockheed, are not yet adequately defined for development of a remedy that will achieve complete containment of these areas within the NHOU. At present, the low-to moderate-concentration plumes that escape containment by the existing NHOU extraction wells are ultimately captured and treated by the BOU or GOU extraction and treatment systems, or are captured by LADWP production wells and mitigated via blending with other water sources.

Additional target volumes were defined in Depth Region 1 to represent the less extensive, but higher concentration areas, within the NHOU; these target volumes are defined as all groundwater with VOC concentrations that exceed 50 µg/L (ten times the MCL). They are the primary target volumes for VOC plume containment for the Second Interim Remedy. Similarly, for Depth Region 2 the VOC target volumes encompass all areas where VOC concentrations in groundwater exceed 5 and 50 µg/L. The extents of the target volumes in Depth Regions 1 and 2 are presented on Figures 4-1 and 4-2, respectively.

For chromium contamination, the target volumes in Depth Regions 1 and 2 are also defined as all groundwater where dissolved total or hexavalent chromium concentrations exceed 5 and 50 µg/L. Although the current MCL for total chromium is 50 µg/L, a lower MCL for hexavalent chromium is expected to be promulgated by the state. The chromium target volumes in Depth Regions 1 and 2 are also shown on Figures 4-1 and 4-2, respectively.

Depth Region 1. In Depth Region 1 of the NHOU, TCE and PCE concentrations have been detected in exceedance of 5 µg/L in a wide area extending from near State Highway 170 (the

Hollywood Freeway) and the Hewitt Pit Landfill in the west, merging with a larger area of groundwater contamination in the BOU to the east (see Figure 2-2). A smaller area of groundwater contamination exists to the north, in the vicinity of the Tuxford and Penrose Landfills. For the purposes of this FFS, these areas are collectively referred to as the 5 μg/L VOC target volume in Depth Region 1 (see Figure 4-1).

Two 50 μg/L VOC target volumes are also defined in Depth Region 1, and are referred to herein as the western and eastern 50 μg/L VOC target volumes. The western 50 μg/L VOC target volume is located near the Honeywell facility and includes a “hot spot” of VOCs recently detected near the eastern boundary of the Hewitt Pit Landfill. The eastern 50 μg/L VOC target volume is located near the Lockheed facility and merges with the VOC plume in the BOU (see Figures 2-2 and 4-1).

Two 5 μg/L chromium target volumes are defined in Depth Region 1 of the NHOU, centered around the Honeywell and Lockheed facilities, and are referred to as the western and eastern 5 μg/L chromium target volumes (see Figure 4-1). Chromium has also been infrequently detected at three other monitoring wells (NH-VPB-02, NH-VPB-03, and 4918B; see Figure 2-4) in the NHOU at concentrations ranging from 6 to 7 μg/L, slightly in excess of the 5 μg/L target concentration. These wells are not included in the 5 μg/L chromium target volumes in this FFS, but will continue to be monitored for potential future consideration. A single 50 μg/L chromium target volume is also defined in Depth Region 1 of the NHOU, centered at the Honeywell facility, and is referred to as the 50 μg/L chromium target volume (see Figure 4-1).

Depth Regions 2 through 4. In Depth Regions 2 through 4 of the NHOU, TCE and PCE concentrations have been detected in exceedance of 5 μg/L in a similar area as in Depth Region 1 (from near State Highway 170 and the Hewitt Pit Landfill in the west, merging with a larger area of groundwater contamination in the BOU to the east; see Figure 2-3). For the purposes of this FFS, these areas are collectively referred to as the 5 μg/L VOC target volume in Depth Region 2 (see Figure 4-2).

There are three significant areas where TCE and PCE concentrations exceed 50 μg/L in Depth Regions 2 through 4 of the NHOU. The target volume near the Honeywell facility is referred to herein as the western 50 μg/L VOC target volume (see Figure 4-2), and it corresponds with the 50 μg/L contour for VOCs detected in Depth Regions 2 and 3, as shown on Figure 2-3.

The target volume south of the Lockheed facility (see Figure 4-2) is referred to as the southern 50 μg/L VOC target volume, and it includes monitoring well NH-C02-520. The TCE concentrations in groundwater samples from this well, which is screened in Depth Region 3, have recently been detected as high as 120 μg/L. Additional monitoring wells are proposed (see Section 2.7) to provide further delineation of VOC contamination in this area, after which the southern 50 μg/L VOC target volume will be redefined, if necessary. Despite the limited definition currently possible for the VOC contamination in Depth Regions 2 and 3 in this area, a preliminary definition of a southern 50 μg/L VOC target volume was used in evaluating the effectiveness of the remedial alternatives to contain the deeper contamination known to exist in this area.

The target volume northeast of the Rinaldi-Toluca Well Field in Depth Regions 2 through 4 (see Figure 2-3) is referred to as the northern 50 μg/L VOC target volume, and it includes monitoring well NH-C05-460. TCE concentrations in groundwater samples from this well, which is screened in Depth Regions 2 and 3, have recently been detected as high as 120 μg/L. Additional monitoring wells are proposed (see Section 2.7) to provide further delineation of this plume.

Three 5 μg/L chromium target volumes are defined in Depth Regions 2 through 4 of the NHOU, centered around the Honeywell facility, the Lockheed facility, and LADWP production well EW-6. These are referred to as the western, eastern, and southern 5 μg/L chromium target volumes, respectively (see Figure 4-2). Chromium has also been sporadically detected at three other monitoring wells (NH-VPB-02, NH-VPB-03, and 4918B; see Figure 2-4) in the NHOU at concentrations ranging from 6 to 7 μg/L, slightly in excess of the 5 μg/L target concentration. These wells are not included in the 5 μg/L chromium target volumes in this FFS, but will continue to be monitored. A single 50 μg/L chromium target volume in Depth Region 2 occurs in the NHOU, centered at the Honeywell facility (see Figure 4-2).

4.2.3.2 Evaluation of Hydraulic Containment

As explained in Section 4.1, the Existing NHOU Extraction and Treatment System was designed to hydraulically contain the groundwater plume and remove VOC contaminant mass in the most significantly contaminated portions of the NHOU. Hydraulic containment is achieved by pumping the extraction wells at rates sufficient to cause all contaminated groundwater within the target volumes to flow towards the extraction wells. If hydraulic containment of a target volume is achieved and maintained, the contaminated groundwater within the target volume will eventually be captured by the extraction wells, preventing or limiting contaminant migration to other wells. Achieving hydraulic containment for the NHOU target volumes is especially important because of the numerous active water supply well fields in and around the NHOU area.

The volume of groundwater within the NHOU that is contaminated with VOCs is significantly greater than the volume contaminated with hexavalent chromium. The chromium target volumes (5 and 50 μg/L) are mostly encompassed by the 50 μg/L VOC target volumes. Therefore, if simulations suggest that the VOC target volume within a given area is successfully captured by an extraction well configuration, it is assumed that the chromium target volume, if present, also would be captured. However, in cases where a given extraction well configuration does not provide complete hydraulic containment of a given VOC target volume, additional flowline analyses were performed to evaluate whether the chromium target volume would be fully captured.

In simple aquifer systems (e.g., one water-bearing unit with a constant, unidirectional hydraulic gradient), algebraic solutions can be used to estimate the zone of hydraulic containment (i.e., the capture zone) for an extraction well field. However, the hydrogeologic system in the SFV is much more complex and requires numerical groundwater flow modeling to evaluate the interactions of the NHOU extraction wells, surrounding municipal water supply well fields, the layered aquifer system, and various sources of groundwater recharge.

The forecasted effectiveness of plume containment resulting from different groundwater extraction well configurations considered in this FFS was evaluated using an updated version of the original SFV Basin groundwater flow model developed for the RI. There are several versions of this model that were generated as it was updated and refined over time. A discussion of model revisions and calibration results is presented in Appendix B. Containment modeling results specific to evaluation of the remedial alternatives are discussed in Section 4.3. The level of detail considered in the groundwater flow model for the NHOU FFS was appropriate for preliminary evaluation of the several remedial alternatives under consideration by EPA. However, it is anticipated that additional modeling will be conducted during remedial design of the selected remedial alternative for the NHOU. During the remedial design phase, details regarding the number, locations, screened intervals, capacities, and operating schedule for the extraction wells and/or injection wells for the selected remedy will be considered in greater detail.

The alternatives considered in this FFS include the operation of existing and potential new groundwater extraction wells to improve hydraulic containment and contaminant mass removal within the NHOU. The updated groundwater flow model was used to estimate the extent of hydraulic containment provided by each extraction well configuration. The extent of hydraulic containment provided by a particular pumping configuration is influenced by changes in hydrologic conditions within the NHOU and the SFV, especially groundwater recharge at spreading basins and pumping from large production well fields. Therefore, a capture zone created by a set of extraction wells will expand and contract over time due to seasonal and long-term fluctuations in water levels and flow rates, even if the pumping rates from the extraction well field remain constant. For this reason, it is important to consider the baseline conditions that are assumed to occur during the capture zone evaluation.

The approach used in the FFS analysis incorporates two sets of baseline conditions upon which the effectiveness of each alternative extraction well configuration is evaluated. The first set of baseline conditions is the ULARA Watermaster (2006c) "average" pumping forecast for the SFV Basin for 2007 through 2017 (referred to herein as the Forecast Average Production Scenario). The historical and average forecast well field pumping, spreading basin recharge, and other recharge from 1982 through 2017 are indicated on Figure 4-3. The forecasted 2007 through 2017 pumping rates for the various production well fields in the SFV Basin under this pumping scenario were provided by the ULARA Watermaster and used as input to the model. This approach tests the long-term effectiveness of a given well field configuration in capturing contamination under long-term, average forecast conditions.

To estimate the extent of containment achieved by the NHOU extraction well scenario for each alternative during this period, groundwater flowlines were generated starting at the edge of each target volume and run to completion (i.e., the groundwater flowline either reaches a well or exits the model). Starting points for the groundwater flowlines in Depth Region 1 were at the water table. Starting points for the flowlines in Depth Regions 2 and 3 were at the midpoint of the model layer (depth region) of interest.

The second set of assumed baseline conditions includes an extended dry period from 2007 through 2017, with more dry years than wet years. This assumption was also provided by the ULARA Watermaster. The historical and maximum forecast well field pumping, spreading basin recharge, and other recharge from 1982 through 2017 (referred to herein as the Forecast Maximum Pumping Scenario) are indicated on Figure 4-4. Additional simulations were conducted to evaluate the forecasted extent of hydraulic containment that would be achieved by the NHOU extraction well fields for each remedial alternative during a period of maximum groundwater production rates in and near the NHOU.

The overall objective of this evaluation strategy is to test the ability of the groundwater extraction alternatives to achieve hydraulic containment of the groundwater contaminant target volumes under a range of assumed municipal production pumping rates, water levels, flow directions, and hydraulic gradients. Results of groundwater modeling evaluation for each alternative are presented in Section 4.3.

4.2.4 VOC Treatment

This section describes the process options considered for treatment of VOCs in groundwater pumped from existing and potential future extraction wells.

4.2.4.1 Air Stripping

Water quality data provided by LADWP indicate that the existing NHOU groundwater treatment plant is effectively treating groundwater collected from the NHOU extraction wells for TCE, PCE, carbon tetrachloride, and other VOCs commonly detected in the NHOU in excess of MCLs prior to mixing with water from other sources and distribution in LADWP's water supply system. Therefore, ex situ (aboveground) treatment of groundwater for VOCs, using air stripping, is expected to continue in conjunction with groundwater extraction to decrease VOC concentrations in treated water to, or below, the MCLs under all alternatives.

The existing treatment plant for removing VOCs from groundwater at the NHOU includes the following major components, which are shown schematically on Figure 4-5 (LADWP, 2002):

- Groundwater from the extraction wells is conveyed to the NHOU treatment plant by a 12-inch-diameter pipeline (the NHOU well collector line) from wells NHE-2 to NHE-8. The pipeline from well NHE-1 to the treatment facility is 16 inches in diameter.
- Groundwater from the extraction wells is treated to remove VOCs by using a packed air stripping (aeration) tower, which was designed for an influent rate of 2,000 gpm containing 650 μg/L of TCE and 100 μg/L of PCE. The air-blower capacity is 8,000 ft^3 per minute. Before entering the air stripper, the influent groundwater is treated with sodium hexametaphosphate to limit scaling. The design removal efficiency of the air stripper is 99.25 percent for TCE and PCE.
- Air stripping treatment technologies operate by transferring contaminants from the aqueous to the gas phase. The off-gas from the air stripper contains VOCs and must be treated prior to discharge to the atmosphere. The air stream exiting the air stripper contains most of the TCE and PCE that was present in the groundwater. This air stream is treated with VPGAC to remove the TCE and PCE before the air is discharged to the atmosphere. Before entering the VPGAC vessels, the air stream is heated to reduce its relative humidity, which increases the VPGAC adsorption capacity.

- Untreated influent, treated effluent, and air exiting the VPGAC treatment vessels at the NHOU treatment plant are monitored by LADWP to ensure compliance with permit requirements, ARARs, and LADWP policies.
- Treated groundwater exiting the air stripper is chlorinated and conveyed to LADWP's North Hollywood Complex, where it is blended with water from other sources and distributed via the potable water supply system. Once the treated water exits the air stripper, processes applied to the NHOU treated water are not a part of EPA's remedy.

Air stripping has proven to be effective at the NHOU treatment plant for treatment of VOCs, and it is a relatively low-cost and energy-efficient process compared to other VOC treatment technologies. However, the existing NHOU air stripper has occasionally required extended maintenance in the past, and EPA's experience with similar systems suggests the need to have redundant capabilities. Therefore, the existing air stripper is retained as the only VOC treatment process in Alternative 1, which has the lowest influent flow of all the alternatives. The existing air stripper will be augmented by a second air stripper of similar capacity, as well as a second VOC treatment system, for the other remedial alternatives, which have higher projected influent flow rates. It should be further noted that the TCE concentration in the VOC treatment system influent was at the historical maximum (108 μg/L) during January 2007, the most recent month that the influent was sampled while well NHE-2 was discharging to the air stripper. The additional operational flexibility provided by a second VOC treatment system at NHOU might be required if VOC concentrations continue to rise in response to higher pumping rates or future rises of the water table.

4.2.4.2 Liquid Phase Granular Activated Carbon

Liquid phase granular activated carbon (LPGAC) adsorption is another VOC removal technology that is robust and cost effective. The performance of LPGAC is influenced by the location of the process within the overall treatment train. Pretreatment can reduce the organic load on the LPGAC process, remove suspended solids that might interfere with the adsorption process or cause hydraulic plugging, and change the adsorbability of the organic compounds entering the LPGAC process. All of these factors affect LPGAC performance. The LPGAC treatment process is illustrated on Figure 4-6.

LPGAC systems are the most commonly used carbon adsorption systems for treatment of water contaminated with VOCs. In an LPGAC system, the contaminated water is directed through the adsorbant (GAC) in a packed bed or a basin. Most of the organic and some inorganic solutes are adsorbed (retained) by the carbon, and the purified water is allowed to pass through the system. When the effluent concentrations approach discharge limitations or the adsorptive capacity of the carbon is exhausted, the spent carbon is replaced or regenerated. For LPGAC systems, the carbon is typically removed offsite and reactivated, disposed of, or destroyed.

Activated carbon reactivation can be performed onsite or contracted to an offsite facility. In most treatment facilities, disposal and total replacement of the activated carbon is most economical. LPGAC is identified by the EPA as one of the two best available technologies (packed tower air stripping is the other technology) for the removal of VOCs from drinking water supplies.

LPGAC adsorbers can perform various process functions, including removal of residual hydrogen peroxide and partially oxidized byproducts from an upstream advanced oxidation process (AOP) system and adsorption of small concentrations of VOCs that pass through an upstream air stripper. In addition, LPGAC is particularly effective at adsorbing TCP, which has been detected in exceedance of CDPH notification levels at several NHOU monitoring wells.

4.2.5 Chromium Treatment

This section describes the treatment process alternatives that may be applied to treat chromium as an adjunct to the existing VOC treatment.

After initial screening, two ex situ treatment alternatives for chromium were retained for consideration: (1) ferrous iron reduction with filtration, and (2) ion exchange using a vendor resin replacement service. Following is a summary of each of these potential ex situ treatment processes.

4.2.5.1 Ferrous Iron Reduction with Filtration

Ferrous iron reduction decreases total chromium concentrations by chemically reducing hexavalent chromium (Cr+6) to trivalent chromium (Cr+3) and co-precipitating the trivalent chromium with ferric iron. The ferric iron and trivalent chromium co-precipitate is flocculated and removed using a conventional clarifier and media filter polishing or a microfilter. In this process, hexavalent chromium is reduced by ferrous iron ions according to the following chemical equation:

$$NaCrO_4 + 3FeCl_2 + 8H_2O \rightarrow 2NaCl + Cr(OH)_3 + 3Fe(OH)_3 + 4HCl \qquad \text{(Equation 1)}$$

The key components of a ferrous iron reduction and filtration system include a series of reactors for ferrous iron reduction of hexavalent chromium to trivalent chromium. The first reactor is an inline vessel/pipeline reactor; the second reactor is a mixed tank reactor. These reactors are followed by aerated and stirred tank reactors for oxidation of residual ferrous iron to ferric iron. A microfilter system coupled with a backwash system then removes the ferric iron and trivalent chromium precipitate (solids). A batch-thickening and dewatering system receives the resulting solids sludge.

The ferrous iron treatment process is illustrated on Figure 4-7, and the equipment required is listed in Table 4-2. Based on the groundwater data evaluation (see Section 2), a probable scenario for adding ex situ chromium treatment is in response to high chromium concentrations at wells NHE-1 and NHE-2. Based on the nominal design rates for wells NHE-1 and NHE-2, the combined groundwater production from these wells will be a maximum of 600 gpm, and the long-term average is expected to be 500 gpm. If additional wells become contaminated with elevated concentrations of chromium, or if the MCL is lowered substantially, ex situ chromium treatment for the combined flow from a larger number of NHOU extraction wells may be required. Under such a scenario, the combined production rate for the affected extraction wells is expected to be in the range from 1,500 to 4,000 gpm (peak). A wide range of chromium concentrations could be treated using the ferrous iron reduction process (100 to 2,000 μg/L) with the same equipment and a small cost differential. The target treatment system effluent concentration for hexavalent and total chromium is assumed to be 5 μg/L or less.

TABLE 4-2
Summary of Conceptual Ferrous Iron Reduction Hexavalent Chromium Treatment System Equipment
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Equipment Name	Equipment Description
Reductant Addition	
Ferrous Chloride Addition System	Ferrous chloride solution tote bin and chemical pump
Chromium Reduction Reactors	
Inline Pipe Reactor	5 minutes residence time (3,000 gallons)
Stirred Tank Reactor	25 minutes residence time (15,000 gallons)
Turbine Mixer	0.5 horsepower/1,000 gallons (7.5 horsepower)
Residual Ferrous Iron Oxidation Reactors	
Stirred Tank Reactors (3)	25 minutes residence time (15,000 gallons)
Turbine Mixers (3)	0.5 horsepower/1,000 gallons (7.5 horsepower)
Blowers (3)	100 standard ft^3 per minute/10,000 gallons
pH Increase System (3)	pH-controlled caustic addition system
Microfilter System	
Vertical Microfilter Fiber Vessels and Controls	One bank of 20 vessels per 300 gpm flowrate
Backwash Water Recovery and Waste Solids System	
Cone Bottom Thickening Tanks	Two at 10,000 gallons
Plate and Frame Filter Press	10 ft^3
Flocculent Feed System	Makedown tank (100 gallons) and two gear pumps
pH Reduction System	pH-controlled acid addition system

Note:
Pumping rate is 600 gpm; the range of influent concentrations is 100 to 2,000 µg/L hexavalent chromium.

4.2.5.2 Anion Exchange

Anion exchange decreases total chromium concentrations by exchanging hexavalent chromium oxy-anions for chloride anions using a bed of selective ion exchange resins. The ion exchange resin is regenerated offsite by a vendor service. There are two main types of anion ion exchange resins, strong-base and weak-base. The hexavalent chromium is removed by anion ion exchange according to the following chemical equation:

$$CrO_4{}^{2-} + R\text{---}\ 2Cl^- \rightarrow R\text{---}\ CrO_4{}^{2-} + 2Cl \qquad \text{(Equation 2)}$$

The major components of an anion exchange system for the NHOU plant would be three ion exchange adsorber vessels and a backwash system. The backwash system removes broken resin beads and trace suspended solids, and it recovers backwash water. A dewatering system for backwash solids is not included. Instead, disposal as a wet sludge is assumed. An example system is illustrated on Figure 4-8. The conceptual equipment scope, including key ancillary equipment, is listed in Table 4-3. Similar to the ferrous-iron reduction system for chromium treatment, an anion-exchange system could be scaled up or down in capacity to accommodate a changing number of extraction wells or concentrations requiring treatment.

The anion exchange process for ex situ chromium treatment may produce trace quantities of NDMA, or similar partially oxidized byproducts from the anion-exchange resin, in the treated (effluent) water under certain conditions. As noted in Section 2.6.3, the state notification level for NDMA is very low (0.010 µg/L). Production of NDMA resulting from anion-exchange treatment of chromium-contaminated groundwater is currently being tested at the GOU, and results should be available in 2009. Furthermore, the anion-exchange system being tested at the GOU may not be capable of consistently decreasing chromium concentrations to below 5 μg/L. If the test at GOU demonstrates that the anion exchange process produces NDMA concentrations above the notification level, or that it cannot consistently achieve chromium concentrations below 5 μg/L, this treatment method would be eliminated from consideration for use at the NHOU.

TABLE 4-3
Summary of Conceptual Anion Ion Exchange Hexavalent Chromium Treatment System Equipment
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Equipment Name	Equipment Description
pH Reduction System	pH-controlled acid addition system
Anion Ion Exchange Vessels	
One Set of Three	Three vessels total
Each Vessel	10-foot-diameter by 8-foot-tall stainless steel
Anion Ion Exchange Resin	Duolite™ A7 (400 ft^3 per vessel)
Backwash Water Recovery and Waste Solids System	
Slant Bottom Tank	25,000 gallons
Return Water Pump	50 gpm at 40 pounds per square inch gauge
Sludge Pump	50 gpm at 20 pounds per square inch gauge
pH Increase System	pH-controlled caustic addition system

Note:
Assumed maximum pumping rate is 600 gpm.

4.2.5.3 Comparison of Potential Ex Situ Chromium Treatment Technologies

Under the assumptions previously listed, capital costs for implementing the ferrous iron reduction or anion exchange process for ex situ chromium treatment are approximately equal. However, annual operation and maintenance (O&M) costs for anion exchange are calculated to be more than twice that of ferrous iron reduction. Furthermore, there are concerns that the anion-exchange process may produce NDMA and may not be capable of consistently decreasing chromium concentrations to below 5 μg/L. Therefore, it is assumed in this FFS that the ferrous iron reduction option would be selected, and it is carried forward for system equipment scope requirements, permit requirements, space requirements, O&M requirements and costs for remedial alternatives that include ex situ chromium treatment.

4.2.6 1,4-Dioxane Treatment

AOPs, such as ozone/hydrogen-peroxide- and ultraviolet/hydrogen-peroxide-based (UV/Ox) processes, have been shown to be commercially viable treatment processes for 1,4-dioxane, and were considered for this FFS. Biological methods for 1,4-dioxane treatment were also considered for this FFS, but results of pilot-scale systems have been inconsistent, and full-scale commercially viable biological treatment processes have not been identified. AOPs effectively remove 1,4-dioxane (and other VOCs) via oxidation with hydroxide radicals. Hydroxide radicals can be generated through four types of AOP: (1) ozone with hydrogen peroxide, (2) UV light with hydrogen peroxide, (3) ozone with UV light, and (4) ozone with UV light and hydrogen peroxide. Of these AOPs, ozone with hydrogen peroxide and UV light with hydrogen peroxide are the most common. The UV-light and hydrogen peroxide AOP currently provides the most flexibility for future process modifications and is least likely to produce potentially harmful bromate as a byproduct.

This combination is assumed to be the process option to be implemented for treatment of 1,4-dioxane. The AOP for 1,4-dioxane treatment is illustrated on Figure 4-9.

It is important to note that AOP-based treatment requires substantially more energy than air stripping and the use of potentially hazardous chemicals (such as hydrogen peroxide). Furthermore, AOP is not very effective at treating groundwater for carbon tetrachloride, which is present in the NHOU extraction wells at a concentration of approximately 1 μg/L (the state MCL for carbon tetrachloride is 0.5 μg/L). The existing air stripper at the NHOU treatment plant, however, is effectively reducing carbon tetrachloride concentrations to below the detection limit. Therefore, AOP (using UV light and hydrogen peroxide) is recommended for use in the NHOU on a wellhead-treatment scale to remove 1,4-dioxane where needed, such as extraction well NHE-2, to maintain 1,4-dioxane concentrations in the combined effluent from the NHOU treatment system below the state notification level.

Hydrogen-peroxide-based AOP reactors produce an effluent with residual hydrogen peroxide, partially oxidized byproducts of VOCs and naturally occurring organic materials, and saturated alkanes (i.e., 1,1-dichloroethane, 1,2-dichloroethane, TCP, and carbon tetrachloride), which are not treated by AOP. The saturated alkanes can be effectively treated by a combination of the VOC removal processes described in Section 4.2.4 (air stripping and LPGAC), which would be applied to the combined flow from all extraction wells under all of the remedial alternatives except for Alternative 1. Therefore, wellhead treatment for these compounds is not required. However, removal of hydrogen peroxide and partially oxidized organic compounds should occur immediately downstream from any wellhead AOP treatment system.

Removal of the trace concentrations of hydrogen peroxide introduced by AOP is necessary to allow downstream processes to maintain an appropriate chlorine residual concentration and for downstream biologically active carbon (BAC) to function properly. Hydrogen peroxide can be removed by adding a reducing agent, such as sodium metabisulfite, to the effluent stream from the AOP. For the purposes of this FFS, it is assumed that sodium metabisulfite addition will be applied to the treatment process immediately downstream from the AOP treatment system, due to the low capital cost for metabisulfite addition and its ability to control hydrogen peroxide levels.

The partially oxidized byproducts in the AOP-treated water typically include acetone, ketones, and ketoacids. A common method to eliminate these compounds is to direct the AOP effluent through BAC columns (following the sodium metabisulfite addition). The BAC columns consist of LPGAC adsorber columns with a developed biological population that aerobically breaks down the partially oxidized byproducts. Because BAC is a biological process, the CDPH requires downstream treatment to meet surface water treatment requirements for potable water use. Therefore, following the AOP treatment for 1,4-dioxane, LPGAC to remove hydrogen peroxide, and BAC to remove partially oxidized organic byproducts, the water must be treated by coagulation, filtration, and disinfection. The ferrous-iron reduction process (see Section 4.2.5) under consideration for wellhead chromium treatment at wells NHE-1 and NHE-2 includes the coagulation and filtration steps required for surface water treatment. The iron used in the ferrous-iron reduction process is a coagulant, and the process will utilize a State-approved membrane microfilter to perform the filtration step. After the microfiltration step, the water will be disinfected with chlorine (sodium hypochlorite addition) for a minimum chlorine dose (CT value) of

4 milligrams per liter per minute. This will provide four-log removal of viruses at 15 degrees Celsius, according to CDPH (e-mail communication dated January 14, 2009).

4.2.7 Reinjection of Treated Groundwater

A second discharge option, reinjection, was considered in this FFS as an alternative to distribution to the LADWP water supply system (the approach currently implemented at the NHOU). Reinjection of treated groundwater back into the aquifer using injection wells is the specific technology selected for further evaluation in this FFS.

The potential advantage of reinjection over delivery to LADWP is reduced costs for water treatment; less treatment may be required for reinjection than for delivery as drinking water. In addition, reinjection could increase the rate of groundwater “flushing” through the most contaminated part of the aquifer in NHOU, which could result in a modest increase in the rate of groundwater remediation.

Potential disadvantages of reinjection include: the treated water could potentially become contaminated again following reinjection (by mixing with existing groundwater contaminants in the aquifer); low concentrations of emerging chemicals could be injected into areas of the aquifer where they currently are not present; and additional infrastructure would need to be constructed, including injection wells and pipelines. Details regarding the configuration of the injection wells, treatment system components, and ancillary equipment are discussed in Section 4.3.

4.3 Description of Alternatives

This section presents the remedial alternatives considered for the NHOU Second Interim Remedy, each of which incorporates specific configurations and combinations of the technologies and process options discussed in Section 4.2 (referred to herein as “components” of the remedial alternatives). The remedial alternatives are evaluated under different groundwater scenarios in the SFV Basin to determine the level of containment and mass removal expected to be achieved by each. The number, location, and pumping capacity of the groundwater extraction wells in the remedial alternatives are estimated and will be finalized during remedial design.

As a baseline against which to compare other alternatives, Alternative 1 assumes continued operation of the existing NHOU extraction and treatment system and delivery of treated groundwater to LADWP with few modifications. Alternatives 2a through 5b include significant improvements to the NHOU extraction and treatment system, as well as two options for reuse of treated groundwater.

Table 4-4 summarizes the major components of each alternative. Several of these components are common to all of the remedial alternatives, including Alternative 1, and several are common to Alternatives 2a through 5b. These common components are described in more detail in Sections 4.3.1 and 4.3.2. The principal differences between the remedial alternatives are the scale and approach taken for chromium treatment in the extracted groundwater, and the method for reuse of extracted and treated groundwater. Sections 4.3.3 through 4.3.7 describe the specifics of each alternative, including how the common and individual components are assembled to develop each alternative, and the anticipated impacts of each on hydraulic containment and water quality in the NHOU.

The final configuration of the remedial alternative selected for implementation will be based on performance criteria that will be described in the new decision document and on additional information and data acquired during remedial design. The details of each alternative described in this FFS (e.g., the number of and locations for new extraction wells or pipelines) are based on preliminary modeling efforts and a level of evaluation appropriate for a feasibility study. The configuration of components for the selected remedial alternative will be further developed, and potentially modified, during the remedial design phase of remedy implementation. However, the configurations of each remedial alternative being considered are adequately developed for the purposes of comparing costs and potential effectiveness of each alternative. The current level of development of the remedial alternatives is suitable to estimate costs within the range of uncertainty specified by EPA guidelines for a feasibility study (+50 to -30 percent). For purposes of developing and comparing costs, an operation and maintenance period of 30 years is assumed, although the need for treatment and containment of the contaminated groundwater is likely to extend beyond 30 years.

4.3.1 Common Components for All Remedial Alternatives

As noted in Section 4.3, several potential components of the Second Interim Remedy are shared by all of the remedial alternatives developed and evaluated in this FFS. These common components include the following.

4.3.1.1 Institutional Controls

As described in Section 4.2.1, ICs will be developed that consist of a groundwater resources management program to protect the effectiveness and integrity of the NHOU remedy from adverse impacts caused by LADWP's drinking water production requirements. During remedial design, EPA will work with LADWP to develop a formal agreement between the agencies with the goal of mitigating the effects of production well operation on EPA's remedies with respect to plume containment.

4.3.1.2 Groundwater and Treatment System Monitoring

Groundwater and treatment system monitoring will continue as currently performed by EPA, LADWP, and facilities in the NHOU. The groundwater monitoring network will be expanded with the addition of approximately 37 additional groundwater monitoring wells, as described in Section 4.2.2. Approximate locations for the proposed new monitoring wells are shown on Figure 2-14; specific locations for the proposed monitoring wells may be adjusted following remedy selection, during the remedial design phase of remedy implementation.

4.3.1.3 Wellhead 1,4-Dioxane Treatment at Extraction Well NHE-2

Wellhead treatment for 1,4-dioxane will occur at well NHE-2, where concentrations ranging from 4 to 9 µg/L have been detected since 2006 (the CDPH notification level for 1,4-dioxane is 3 µg/L). The wellhead treatment system for 1,4-dioxane currently planned by Honeywell is assumed to be implemented in 2009. This treatment system is designed for a pumping rate of 140 gpm, which is approximately half of the target pumping rate for NHE-2 after it is

TABLE 4-4
Summary of Remedial Alternative Components
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Remedial Alternative Component	Alternative 1	Alternative 2a	Alternative 2b	Alternative 3a	Alternative 3b	Alternative 4a	Alternative 4b	Alternative 5a	Alternative 5b
Institutional Controls (groundwater management plan to balance the long-term effectiveness of the NHOU remedy with the groundwater needs for public drinking water)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Groundwater Monitoring (continue existing monitoring and install 37 new monitoring wells)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Groundwater Extraction	Continue operating existing seven active extraction wells at current pumping rates	Expand extraction well field to 11 wells	Expand extraction well field to 11 wells	Expand extraction well field to 11 wells	Expand extraction well field to 11 wells	Expand extraction well field to 11 wells	Expand extraction well field to 11 wells	Expand extraction well field to 11 wells	Expand extraction well field to 11 wells
Primary VOC Treatment	Continue operating existing air stripper	Refurbish existing air stripper and install a second air stripper	Refurbish existing air stripper and install a second air stripper	Refurbish existing air stripper and install a second air stripper	Refurbish existing air stripper and install a second air stripper	Refurbish existing air stripper and install a second air stripper	Refurbish existing air stripper and install a second air stripper	Refurbish existing air stripper and install a second air stripper	Refurbish existing air stripper and install a second air stripper
Secondary VOC Treatment	None	LPGAC following each air stripper	None	LPGAC following each air stripper	None	LPGAC following each air stripper	None	LPGAC following each air stripper	None
End Use of Treated Groundwater	Continue delivery to LADWP for municipal use	Continue delivery to LADWP for municipal use	Reinjection	Continue delivery to LADWP for municipal use	Reinjection	Continue delivery to LADWP for municipal use	Reinjection	Continue delivery to LADWP for municipal use	Reinjection
1,4-Dioxane Treatment (wellhead treatment at NHE-2)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chromium Treatment	Wellhead treatment at NHE-2	Wellhead treatment at NHE-1 and NHE-2	Wellhead treatment at NHE-1 and NHE-2	Ex situ treatment for combined flow from NHE-1 and NHE-2	Ex situ treatment for combined flow from NHE-1 and NHE-2	Wellhead treatment at NHE-2 and ex situ treatment at the NHOU plant for the combined flow from NHE-1 and two new extraction wells	Wellhead treatment at NHE-2 and ex situ treatment at the NHOU plant for the combined flow from NHE-1 and two new extraction wells	Ex situ treatment at the NHOU plant for the combined flow from all extraction wells	Ex situ treatment at the NHOU plant for the combined flow from all extraction wells

deepened under Alternatives 2a through 5b. Therefore, the 1,4-dioxane treatment system planned by Honeywell will be replaced or enlarged under Alternatives 2a through 5b to accommodate a peak flow rate of 300 gpm and an average flow rate of 250 gpm. The treatment technology to be applied will be the UV light and hydrogen-peroxide AOP and a secondary process to remove byproducts resulting from AOP, as described in Section 4.2.6. The 30-year O&M period for treatment of VOCs at the NHOU is assumed to also apply to wellhead 1,4-dioxane treatment at NHE-2 for purposes of this FFS. The estimated O&M duration will be re-evaluated if 1,4-dioxane concentrations change significantly during this period.

4.3.1.4 Chromium Treatment at Extraction Wells

Chromium treatment will occur for groundwater extracted by well NHE-2 and for other extraction wells where chromium concentrations are expected to be highest. The primary difference between Alternatives 2a/2b through 5a/5b is the number of extraction wells treated for chromium. Details regarding chromium treatment for each remedial alternative are presented in Sections 4.3.3 through 4.3.7.

4.3.2 Common Components for "Action" Alternatives 2, 3, and 4

As noted in Section 4.3, several potential components of the Second Interim Remedy are shared by all of the "action" alternatives (Alternatives 2a through 5b) developed and evaluated in this FFS. These common components include the following:

4.3.2.1 Repair and/or Modify Existing Extraction Wells

Extraction well NHE-1. To achieve the design pumping rate and desired capture, NHE-1 would likely require deepening by 125 feet. The low yield of well NHE-1 is suspected to be primarily due to low groundwater levels resulting from its proximity to the west branch of the North Hollywood Well Field and the Rinaldi-Toluca Well Field, combined with its relatively shallow well completion depth (276 feet bgs). Local hydrogeologic conditions or well design may also have contributed to the limited yield of this well. Because of the relatively small diameter of the well screen in extraction well NHE-1 (10 inches), replacement of this well with a deeper well of similar construction is assumed to be necessary to achieve a long-term average pumping rate of 250 gpm (required to achieve the planned hydraulic containment). The assumed target screened interval for a replacement for well NHE-1 is from 190 to 401 feet; however, the screened interval may be adjusted during the remedial design phase, depending on results of future groundwater level and quality data.

Extraction wells NHE-2, NHE-4, and NHE-5. Pumping at extraction wells NHE-2, NHE-4, and NHE-5 has been restricted to rates substantially lower than the design peak flow rate of 300 gpm (long-term average design flow rates are 250 gpm each) due to low groundwater levels and other factors. Replacement of wells NHE-2, NHE-4, and NHE-5 with deeper wells of similar construction is assumed to be necessary to achieve long-term average pumping rates of 250 gpm each under most future SFV pumping scenarios (required to achieve the planned hydraulic containment). Assumed target screened intervals for these wells under Alternatives 2a through 5b are as follows:

- NHE-2: 190 to 390 feet bgs

- NHE-4: 180 to 400 feet bgs
- NHE-5: 180 to 415 feet bgs

Similar to extraction well NHE-1, the screened intervals for these wells may be adjusted during the remedial design phase. Alternatively, the existing wells could remain active in their present configuration, and wells with deeper screened intervals could be constructed adjacent to each existing well. These paired (deeper) wells would also be connected to the existing NHOU treatment plant. The pumping rates at each extraction well pair could be adjusted, depending on the depth to the water table, to maximize pumping from the most contaminated aquifer zone, typically Depth Region 1.

Extraction wells NHE-3, NHE-6, NHE-7, and NHE-8. These extraction wells are screened at appropriate depths for plume containment and have been able to pump at or near design pumping rates for most of the operational history of the NHOU treatment system. They are not expected to require replacement or modification at present. However, routine repair or replacement of pumps and ancillary equipment will be required as part of an ongoing O&M program to maintain design pumping rates. To ensure optimal long-term performance of these wells, it is assumed they will be rehabilitated using swabbing, surging, sand bailing, and over-pumping techniques. Additional rehabilitation efforts (e.g., acid-flushing or jetting) will also be considered on a case-by-case basis, depending on results of the initial rehabilitation efforts.

4.3.2.2 Construct Three New Extraction Wells

Under the “action” alternatives, an estimated three new extraction wells (NEW-1, NEW-2, and NEW-3) would be added to the treatment system to further limit contaminant migration and to improve contaminant mass removal. For purposes of this FFS, the exact number, location, and pumping rates for these wells are estimated and will be finalized during remedial design. These new wells (New Northwestern Wells) will be located northwest of the existing NHOU treatment system in locations (see Figure 4-10) selected to prevent VOC and chromium migration towards the Rinaldi-Toluca well field and the western portion of the North Hollywood well field. Each of the New Northwestern Wells will be designed to pump at a maximum rate of 420 gpm (350 gpm long-term average). Screened intervals for these wells are expected to be approximately 220 to 420 feet bgs, but this could (along with the specific locations) be revised during the remedial design phase following selection of a remedy. Pumping rates and schedules for these wells should be optimized periodically during the Second Interim Remedy to achieve the desired capture zones, in consideration of pumping rates and drawdown resulting from the southern production wells in the Rinaldi-Toluca well field. If implementation of the in-situ groundwater remediation planned by Honeywell (see Section 1.3.2) occurs at approximately the same time as start up of the Second Interim Remedy, pumping scenarios for the three New Northwestern Wells will be evaluated and modified, if necessary, to ensure that the effectiveness of both remedies is not jeopardized. Approximately 1,500 feet of new 8-inch-diameter pipeline will be required to connect the New Northwestern Wells to the NHOU treatment plant.

4.3.2.3 VOC Treatment

Construction of two parallel VOC removal systems will be necessary to treat the volume of groundwater produced by the existing NHOU extraction wells and the proposed additional extraction wells under Alternatives 2a through 5b. The NHOU treatment plant will be augmented to accommodate peak and average pumping rates of 3,600 and 3,050 gpm respectively, and for peak VOC concentrations up to 650 µg/L of TCE and 100 µg/L of PCE. It is assumed that the existing air stripper would be refurbished and a second air stripper, similar in capacity to the original (see Section 4.2.4.1), would be installed and operated in parallel with the existing system (see Figure 4-5). The combined maximum capacity of the two parallel air strippers would be 4,800 gpm or more at the anticipated influent VOC concentrations, allowing expansion of the extraction well network or pumping rates in the future, if necessary. The second, parallel treatment train will also allow improved operational flexibility during maintenance cycles or unplanned downtime; while one treatment train is down for maintenance, the other can continue operating, allowing most of the NHOU extraction wells to continue pumping at a reduced rate.

If delivery of the treated water to LADWP is selected as the end use option for treated groundwater (Alternatives 2a, 3a, 4a, and 5a), then an LPGAC based treatment system (see Figure 4-6) will be installed downstream from the air strippers to provide "double barrier" VOC treatment, as required by CDPH. A conventional LPGAC treatment technology will be used for this purpose and is described in detail in Section 4.2.4.2. LPGAC will also remove VOCs not removed by the air stripping process, most notably TCP. TCP is not currently detected in the influent to the Existing NHOU Extraction and Treatment System, but it has been detected in groundwater within the NHOU at concentrations exceeding the notification level of 0.005 µg/L.

4.3.2.4 End Use Options for Treated Water

Alternatives 1, 2a, 3a, 4a, and 5a assume that the groundwater treated by the NHOU treatment plant would continue to be blended with water from other sources, delivered to the City of Los Angeles, and used as part of the drinking water system of the LADWP. As noted above, redundant VOC treatment (air stripping followed by LPGAC) would be implemented under Alternatives 2a, 3a, 4a, and 5a to meet CDPH requirements for drinking water from severely impaired sources. In addition, chromium treatment would be implemented under Alternatives 2 through 5 (both "a" and "b" options) to reduce total and hexavalent chromium concentrations in the combined effluent from the NHOU treatment system. The approach and number of wells selected for chromium treatment varies between alternatives, as discussed below.

Reinjection of treated groundwater into the aquifer using injection wells is assumed under Alternatives 2b, 3b, 4b, and 5b. Redundant VOC treatment would not be required under the reinjection option. Reinjection of the treated water would supplement recharge to the aquifer, making the water available for future pumping and use by LADWP. The configuration of the injection wells, treatment system components, and ancillary equipment are discussed in the FFS. The six injection wells would be located north (upgradient) of the NHOU extraction wells. In this configuration, the treated groundwater would be reinjected into the aquifer at the northern boundary of the VOC and chromium plumes, and supplement the hydraulic gradient driving contaminated groundwater toward the extraction wells.

For the reinjection scenarios, because the treated groundwater would no longer be delivered to LADWP, it is assumed that the existing NHOU extraction and treatment system would have to be replaced, including the extraction wells (NHE-1 through NHE-8), the pipeline from the extraction wells to the treatment plant site, and existing VOC treatment unit (air stripper). In addition, land would have to be purchased to site a new treatment system, extraction wells, and injection wells. For cost estimating purposes, components of the reinjection option are assumed to include:

- Six injection wells installed in an east-west line about 2,000 feet north of Sherman Way (the exact location of the injections wells would be determined during remedial design), with well screens in Depth Region 1 of the aquifer.
- A pipeline constructed from the NHOU treatment plant to the injection wells; total pipeline length is assumed to be 9,000 feet.
- Nine additional monitoring wells (six in Depth Region 1, three in Depth Region 2) installed in the area of the injection wells to monitor groundwater levels and water quality in the vicinity of the new injection wells.
- In accordance with RWQCB requirements, reinjected water would meet the State's anti-degradation policy (e.g., COC concentrations equal to or less than COC concentrations in the aquifer at the injection locations).

4.3.3 Alternative 1 – Existing NHOU Extraction and Treatment System

A no-action alternative, which is required by the NCP to provide a baseline for comparison to other alternatives, was evaluated in the 1987 ROD for the NHOU. The no action alternative was eliminated from consideration in the 1987 ROD because "the contamination plumes (in the groundwater) would continue to migrate downgradient, rendering additional wells unusable" (EPA, 1987). Hydraulic gradients and contaminant plume locations in the aquifer system at the NHOU at present remain similar to the conditions in 1987, and shutting down the existing NHOU treatment system now would result in the same outcome as the 1987 no action alternative, i.e., further migration of contamination to downgradient water supply wells. Therefore, rather than reconsidering the no action alternative, Alternative 1 consists of continued use of the Existing NHOU Extraction and Treatment System, with minor modification and increased monitoring.

4.3.3.1 Components of Alternative 1

In addition to the common components for all remedial alternatives, including ICs, groundwater and treatment system monitoring, and wellhead 1,4-dioxane treatment at extraction well NHE-2 (see Section 4.3.1), specific actions to be implemented under Alternative 1 include the following:

- **Continued operation of NHE extraction wells.** Extraction of contaminated groundwater using the seven operable extraction wells (NHE-2 through NHE-8) is assumed to continue at the average pumping rates during Water Years 2002 through 2006, as summarized in Table 4-5. It should be noted that 2002 to 2006 average pumping rates are generally similar to average pumping rates for the entire period of operation (Water Years 1990 through 2006) for the NHOU extraction wells. Average "uptime" for the NHOU extraction system, defined as the actual period of operation divided by the period of record (1990 to 2006), is approximately 86 percent. Therefore, it is assumed that the system will continue to operate in the future with an uptime of approximately 86 percent. These average rates include periods when the treatment system was shut down for 1 month or longer. Maximum pumping rates are also summarized in Table 4-5 and indicate that five of the extraction wells are capable of pumping more than 300 gpm for periods of 30 days or longer. However, due to maintenance issues, chromium concerns at NHE-2, and groundwater level changes in the North Hollywood area, the historical and recent (2002 to 2006) long-term average combined pumping rate from the NHOU extraction well field is approximately 800 gpm.

- **Wellhead chromium treatment at extraction well NHE-2.** It is assumed that wellhead treatment for chromium and 1,4-dioxane at NHE-2 will be implemented prior to implementation of the Second Interim Remedy. Currently the water pumped from NHE-2 is treated for VOCs and discharged to the Los Angeles sanitary sewer system. The long-term plan is to reconnect NHE-2 to the NHOU treatment system. This will require completion of the CDPH 97-005 process, which is assumed to occur in 2010 for purposes of this FFS. Costs for construction, operation, and maintenance of the chromium wellhead treatment system planned by Honeywell for NHE-2 are included under Alternative 1, because the treatment process is expected to be operating by the time the Second Interim Remedy is in place.

TABLE 4-5
Screen Depths and Historical Pumping Rates for NHOU Extraction Wells
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Location	Screened Interval (feet bgs)	Rated Capacity (gpm)	Average Pumping Rate, Water Years 1990-2006 (gpm)	Average Pumping Rate, Water Years 2002-2006 (gpm)	Maximum Monthly Pumping Rate, Water Years 1990-2006 (gpm)	Maximum Monthly Pumping Rate, Water Years 2002-2006 (gpm)
NHE-1	190 to 276	NA	0	0	0	0
NHE-2	190 to 300	300	69	76	221	186
NHE-3	190 to 286	300	119	144	368	312
NHE-4	180 to 280	300	90	92	342	256
NHE-5	180 to 266	300	39	28	280	191
NHE-6	180 to 378	300	156	163	429	429
NHE-7	180 to 270	300	163	150	404	404
NHE-8	180 to 280	300	181	189	369	364
Combined Pumping	NA	NA	817	842	2,006	1,894

Note:

NA = Not applicable (pump removed from NHE-1; not operated since December 1989 because of poor yield)

4.3.3.2 Model Forecast Hydraulic Containment under Alternative 1

The performance of the existing NHOU extraction well field, using average pumping rates for the period from 2002 through 2006 for the extraction wells, is analyzed under each of the two baseline production well pumping scenarios described in Section 4.2.3 (the Forecast Average Pumping Scenario and the Forecast Maximum Pumping Scenario). The extent of hydraulic containment provided by this alternative under each of the baseline regional pumping scenarios is evaluated using the groundwater flow model as discussed in Section 4.2.3 and Appendix B. The results of this analysis for each scenario are discussed below.

Forecast Average Production Scenario. As noted in Section 4.2.3, the ULARA Watermaster provided forecast quantities for groundwater pumping and spreading (recharge) in the SFV Basin for Water Years 2007 through 2017 under typical climatic conditions. Figures 4-11 and 4-12 illustrate the simulated movement of groundwater and contamination under Alternative 1 based on the Forecast Average Production Scenario. Under the Forecast Average Production Scenario for Alternative 1, all but the extreme southeastern portion and the northern isolated portion of the western 50 μg/L VOC target volume is captured by the NHOU extraction well field. The uncaptured portions of the target volume move downgradient to nearby LADWP production wells of the Whitnall and Rinaldi-Toluca well fields. In addition, the Forecast Average Production Scenario for Alternative 1 predicts the northwest portion of the eastern 50 μg/L target volume is captured by extraction wells NHE-7 and NHE-8, with the remainder migrating to the east and eventually being removed by the BOU extraction system.

The simulated groundwater flowlines originating at the perimeter of the 5 μg/L VOC target volume in Depth Region 1 are also shown on Figure 4-11. Results suggest that a small area of the northern portion of the 5 μg/L target volume is contained by the NHOU extraction wells. However, most of the flowlines in the 5 μg/L VOC target volume that originate in the NHOU are captured by the Rinaldi-Toluca, North Hollywood West, and Whitnall Well Fields. The remainder escapes to the east, where it is eventually is captured by the BOU or GOU extraction well fields.

The simulated flowlines originating from the 5 and 50 μg/L VOC target volumes in Depth Region 2 are shown on Figure 4-12. Results suggest that very little of the groundwater within the 5 μg/L VOC target volume, and none of the northern or southern 50 μg/L VOC target volumes, is captured by the extraction wells, but much of the western 50 μg/L VOC target volume is captured. Nearly all of the uncaptured contaminated groundwater in these depth regions is forecast to migrate toward the Rinaldi-Toluca, North Hollywood, Whitnall, and Erwin Well Fields, or the BOU and GOU. Flowlines were also started in Depth Region 3 (not shown) to simulate migration of deeper contamination that has been detected in well NH-CO2-520. These flowlines also suggest that contaminated groundwater in Depth Region 3 is not captured and migrates to the east toward the BOU.

As discussed in Section 4.2.3.2, in cases where the VOC target volumes are not captured, an individual flowline analysis was performed on the chromium target volumes to evaluate the degree of capture of the chromium plumes that exceed the MCL. Results suggest that most of the western 5 μg/L chromium target volume and the 50 μg/L chromium target volume is captured by extraction wells in Depth Region 1, but much of the eastern chromium 5 μg/L target volume in Depth Region 1 escapes capture and migrates toward the BOU. It should be noted that most of the eastern 5 μg/L chromium target volume originates in the BOU, and, therefore, would not be expected to be contained by the NHOU extraction wells. In Depth Region 2, the majority of the western 5 μg/L chromium target volume and the 50 μg/L chromium target volume are captured, but the eastern 5 μg/L chromium target volume is forecast to escape capture and migrate to the southeast toward the BOU.

Forecast Maximum Production Scenario. Figures 4-13 and 4-14 illustrate the simulated movement of groundwater and contamination under Alternative 1 under the Forecast Maximum Production Scenario. It is apparent from the groundwater contours and groundwater flowlines that the contaminant migration patterns under this scenario are significantly different from those prevalent under average pumping conditions.

Results suggest that approximately half of the western 50 μg/L VOC target volume in Depth Region 1, including parts of the high-concentration core, will be drawn to the northwest in response to pumping from the Rinaldi-Toluca Well Field under this scenario. As it moves to the northwest, the contaminated groundwater is drawn downward into Depth Region 2 (orange flowlines), which is the depth from which this well field produces the majority of its groundwater supply. Most of the southern portion of the western 50 μg/L VOC target volume would be captured by the North Hollywood West Well Field. Almost none of the groundwater that resides in the eastern 50 μg/L target volume (within the NHOU) is forecast to be captured by NHE-7 and NHE-8 under this scenario; this plume is mostly captured by several LADWP production wells of the Whitnall Well Field located in this area.

Because of the high volume of groundwater pumping across the basin in the Forecast Maximum Production Scenario, most of the groundwater that resides within the 5 μg/L VOC target volume of Depth Region 1 is forecast to be captured by the Rinaldi-Toluca, North Hollywood West, and Whitnall Well Fields.

The simulated flowlines originating from the 5 and 50 μg/L VOC target volumes in Depth Regions 2 through 4 are shown on Figure 4-14. Results suggest that very little of the groundwater within either the 5 or the 50 μg/L VOC target volumes is pulled upward into Depth Region 1 and captured by the extraction wells. Nearly all of the contaminated groundwater in these depth regions is forecast to escape capture and migrate toward the Rinaldi-Toluca, North Hollywood, Whitnall, and Erwin Well Fields.

Since the western VOC target volume is not forecast to be completely captured under the Forecast Maximum Pumping Scenario of Alternative 1, an analysis of the extent of containment of the chromium target volumes was performed. Results suggest that in Depth Region 1, much of the northern halves of the western 5 μg/L chromium target volume and the 50 μg/L chromium target volume (where concentrations are highest) migrates to the northwest toward the Rinaldi-Toluca Well Field, while much of the southern portions of these target volumes are captured by the NHOU extraction wells. The eastern 5 μg/L chromium target volume in Depth Region 1 is mostly forecast to escape capture and migrate to the east, toward the BOU.

In Depth Region 2, nearly all of the groundwater in the 50 μg/L chromium target volume is forecast to migrate to the northwest towards the Rinaldi-Toluca Well Field. The eastern and western 5 μg/L chromium target volumes are forecast to largely escape capture and migrate toward LADWP production well fields or the BOU under this scenario.

4.3.4 Alternatives 2a and 2b – Expand Extraction Well System and Operate Chromium Wellhead Treatment Systems at Extraction Wells NHE-1 and NHE-2

The primary objective of Alternatives 2a, 2b, and the other "action" alternatives considered in this FFS is to improve hydraulic containment, particularly for highly contaminated groundwater in the NHOU. To achieve this objective, Alternatives 2a through 5b include expansion and improvement of the Existing NHOU Groundwater Extraction and Treatment System. The major difference between Alternatives 2a and 2b compared with Alternatives 3a through 5b is the scale of chromium treatment. Under Alternatives 2a and 2b, separate wellhead chromium treatment systems would be installed at NHE-1 and NHE-2. The goal of the wellhead chromium treatment for wells NHE-1 and NHE-2 under Alternatives 2a and 2b would be to decrease total chromium concentrations in the NHOU treatment plant effluent to 5 μg/L or less. Details for Alternatives 2a and 2b are provided below.

4.3.4.1 Components of Alternative 2a

Alternative 2a includes the following components common to all alternatives (see Section 4.3.1) and the "action" alternatives (see Section 4.3.2), and assumes delivery of treated groundwater to LADWP for blending and further treatment for potable use, as follows:

1. Develop and implement institutional controls.
2. Continue monitoring the existing wells and NHOU treatment system, and install and monitor 37 new monitoring wells.
3. Implement wellhead treatment for 1,4-dioxane at extraction well NHE-2.
4. Repair and/or modify existing extraction wells NHE-1 through NHE-8 to improve capture of the 5 μg/L target volume zone, to the extent possible.
5. Construct three new extraction wells to improve hydraulic containment of highly contaminated groundwater present south of LADWP's southern Rinaldi-Toluca wells and east of LADWP's North Hollywood West Well Field.
6. Construct a second air stripper to operate in parallel with the existing air stripper at the NHOU treatment plant site, for primary VOC treatment.

In addition to the common components listed above, Alternative 2a includes the following specific actions:

- **Delivery of treated groundwater to LADWP as the end use.** This will require construction of an LPGAC system downstream from each of the air strippers to provide "double barrier" treatment for VOCs.
- **Wellhead chromium treatment at well NHE-1.** Initiation of pumping at the modified extraction well NHE-1 is expected to result in extraction of chromium contaminated

groundwater at concentrations similar to those detected at well NHE-2. Ex situ treatment of chromium by using ferrous iron reduction with microfiltration would be implemented as the wellhead treatment system at well NHE-1 (described in Section 4.2.5). Alternatively, an anion-exchange-based treatment process could be installed if pilot test results expected from GOU in 2009 demonstrate that the process is effective and does not produce excessive NDMA, similar materials, or other problematic organic compounds. A peak pumping rate of 300 gpm is assumed for chromium treatment (250 gpm average long-term flow rate). For purposes of this FFS, it is assumed the peak chromium concentration in the influent to the wellhead treatment system would be 600 µg/L, (1.5 times the current concentration at NHE-2) and would require treatment to 5 µg/L or less. The 30-year O&M period for treatment of VOCs at the NHOU is assumed to also apply to wellhead chromium treatment at NHE-1 for purposes of this FFS. The estimated O&M duration will be reevaluated if chromium concentrations change significantly.

- **Wellhead chromium treatment at well NHE-2.** Alternative 2 also includes wellhead treatment for chromium in the extracted groundwater from NHE-2, where high concentrations of chromium (200 to 400 µg/L) have been detected since fall 2006. The ex situ treatment system for chromium currently planned by Honeywell is designed for a pumping rate of 140 gpm, which is approximately half of the target pumping rate for NHE-2 after it is deepened under Alternative 2. Therefore, the chromium treatment system planned by Honeywell will be replaced or enlarged to accommodate a peak flow rate of 300 gpm and an average flow rate of 250 gpm. A 30-year O&M period for treatment of VOCs at the NHOU is assumed to also apply to the wellhead chromium treatment at well NHE-2, similar to NHE-1.

4.3.4.2 Components of Alternative 2b

Alternative 2b is nearly identical to Alternative 2a, but assumes reinjection of the treated groundwater into the aquifer rather than delivery to LADWP, resulting in the following differences:

1. Construction of six new injection wells, a pipeline from the NHOU treatment plant to the injection wells, and nine new monitoring wells in the vicinity of the injection wells.
2. No LPGAC system downstream from each of the air strippers, as there would be no need to provide “double barrier” treatment for VOCs.

4.3.4.3 Model Forecast Hydraulic Containment under Alternatives 2a and 2b

The modified extraction well field assumed for Alternatives 2a and 2b consists of the eight existing NHOU extraction wells (NHE-1 through NHE-8) pumping at 250 gpm each (long-term average) and three new extraction wells (NEW-1, NEW-2, and NEW-3) pumping at 350 gpm each (long-term average). The new extraction wells would be located near the northwest boundary of the western 50 µg/L VOC and chromium target volumes in Depth Regions 1 and 2, respectively. The purpose of the new extraction wells would be to prevent migration of VOC and chromium contamination from the western target volumes to the Rinaldi-Toluca and North Hollywood West Well Field to the northwest and west under the Forecast Maximum Pumping Scenario.

Forecast Average Pumping Scenario. Figures 4-15 and 4-16 illustrate the migration of groundwater in the target volumes under Alternative 2a and 2b under the Forecast Average Production Scenario. The results of this simulation show that the expanded extraction well field and the addition of the three new extraction wells will be effective in capturing the majority of the western 50 μg/L VOC target volume in Depth Region 1. The only portion of this target volume that escapes capture by the extraction wells is within the isolated 50 μg/L contour located adjacent to the Rinaldi-Toluca Well Field, at the Hewitt Landfill. This target volume is poorly delineated at present and will require further investigation prior to development of a containment or remediation strategy. The modified well field also provides hydraulic containment of all but a few flowlines along the southern and eastern perimeter of the eastern 50 μg/L VOC target volume in Depth Region 1 (the portion of this target volume that is within the NHOU). The uncontained portions of the eastern 50 μg/L target volume, nearly all of which are within the BOU, are forecast to migrate towards the BOU extraction wells. Similar to Alternative 1, a majority of the 5 μg/L VOC target volume in Depth Region 1 is forecast to be captured by LADWP production wells or the BOU extraction wells under this scenario. However, substantially more of the 5 μg/L VOC target zone would be captured under this alternative than under Alternative 1. In Depth Region 2, model results indicate that the modified well field also provides full containment of the western 50 μg/L VOC target volume in Depth Region 2, while the majority of the southern and northern 50 μg/L VOC target volumes in Depth Region 2 escape capture and migrate to the east toward the BOU and the Rinaldi-Toluca Well Field, respectively. For Depth Region 2, also similar to Alternative 1, a majority of the 5 μg/L VOC target volume is forecast to be captured by LADWP production wells or the BOU extraction wells under this scenario. Again, however, substantially more of the 5 μg/L VOC target zone would be captured under this alternative than under Alternative 1.

Results indicate that all of the western 5 μg/L chromium target volume and the 50 μg/L chromium target volume is captured by extraction wells in Depth Region 1, but much of the eastern chromium 5 μg/L target volume in Depth Region 1 escapes capture and migrates toward the BOU. Again, it should be noted that most of the eastern 5 μg/L chromium target volume originates in the BOU, and, therefore, would not be expected to be contained by the NHOU extraction wells. In Depth Region 2, the western 5 μg/L chromium target volume and the 50 μg/L chromium target volume are contained, but the eastern 5 μg/L chromium target volume is forecast to escape capture and migrate to the southeast toward the BOU, similar to Depth Region 1.

Forecast Maximum Pumping Scenario. Figures 4-17 and 4-18 illustrate the simulated movement of groundwater and contamination for Alternatives 2a and 2b under the Forecast Maximum Production Scenario. Similar to Alternative 1 under the Maximum Production Scenario, the increased production from the Rinaldi-Toluca, Tujunga, and North Hollywood West Well Fields significantly influences the extent of hydraulic containment. However, simulation results shown on Figure 4-18 clearly forecast that the enhanced well field under Alternatives 2a and 2b will provide complete containment of the main body of the western 50 μg/L VOC target volume despite a strong hydraulic gradient to the northwest. The only portion of this target volume that escapes capture by the extraction wells is within the isolated 50 μg/L contour located at the Hewitt Landfill, adjacent to the Rinaldi-Toluca Well Field. The eastern 50 μg/L VOC target volume in Depth Region 1 is also largely captured by the NHOU extraction wells, although a significant percentage of the flowlines in the southern part of this target zone are forecast to migrate to the northernmost Whitnall Well Field production wells. Under the Forecast Maximum Production Scenario, most of the 5 μg/L VOC target volume in NHOU is contained by the extraction wells, although a significant fraction of the flowlines are forecast to reach production wells in the Rinaldi-Toluca, North Hollywood (West Branch), and Whitnall Well Field production wells (see Figure 4-17).

The simulation results for Depth Region 2 indicate that the western 50 μg/L VOC target volume is fully captured by the NHOU extraction wells. However, the southern 50 μg/L VOC target plume is forecast to escape capture by the extraction wells and migrate toward the Whitnall Well Field and the BOU. The northern 50 μg/L target plume for Depth Region 2 would again be fully captured by the Rinaldi-Toluca Well Field.

Results indicate that all of the western 5 μg/L chromium target volume and the 50 μg/L chromium target volume would be contained by extraction wells in Depth Region 1, but the southern half of the eastern chromium 5 μg/L target volume in Depth Region 1 would escape capture and migrate toward the Whitnall Well Field. In Depth Region 2, the western 5 μg/L chromium target volume and the 50 μg/L chromium target volume would be fully contained by the extraction wells, but the southern portion of the eastern 5 μg/L chromium target volume is forecast to escape capture by the extraction wells and migrate toward the Whitnall Well Field and the BOU.

4.3.5 Alternatives 3a and 3b – Expand Extraction Well System and Operate Chromium Treatment System for Combined Effluent from Extraction Wells NHE-1 and NHE-2

Alternatives 3a and 3b were developed to evaluate the cost-effectiveness of operating a single chromium treatment system for the combined flow from wells NHE-1 and NHE-2, compared with operation of two individual wellhead chromium treatment systems at these wells (as assumed under Alternatives 2a and 2b). The goal of the ex situ chromium treatment for wells NHE-1 and NHE-2 under Alternatives 3a and 3b would be to decrease total chromium concentrations in the NHOU treatment plant effluent to 5 μg/L or less, similar to Alternatives 2a and 2b. Other components of Alternatives 3a and 3b are identical to those of Alternatives 2a and 2b and are summarized below.

4.3.5.1 Components of Alternative 3a

Alternative 3a includes the following components common to all alternatives (see Section 4.3.1) and the "action" alternatives (see Section 4.3.2), and assumes delivery of treated groundwater to LADWP for blending and further treatment for potable use, as follows:

1. Develop and implement institutional controls.
2. Continue monitoring of the existing wells and NHOU treatment system, and install and monitor 37 new monitoring wells.
3. Implement wellhead treatment for 1,4-dioxane at extraction well NHE-2.

4. Repair and/or modify existing extraction wells NHE-1 through NHE-8 to improve capture of the 5 µg/L target volume zone, to the extent possible.
5. Construct three new extraction wells to improve hydraulic containment of highly contaminated groundwater present south of LADWP's southern Rinaldi-Toluca wells and east of LADWP's North Hollywood West Well Field.
6. Construct a second air stripper to operate in parallel with the existing air stripper at the NHOU treatment plant site, for primary VOC treatment.

In addition to the common components listed above, Alternative 3a includes the following specific actions:

- **Delivery of treated groundwater to LADWP as the end use.** This will require construction of an LPGAC system downstream from each of the air strippers to provide "double barrier" treatment for VOCs.
- **Ex situ chromium treatment.** Ex situ treatment of chromium using ferrous iron reduction with microfiltration would be implemented at the NHOU groundwater treatment facility (described in Section 4.2.5), for the combined discharge groundwater extracted from wells NHE-1 and NHE-2. Alternatively, an anion-exchange-based treatment process could be installed, if pilot test results expected from the GOU in 2009/2010 demonstrate that the process is effective and does not produce excessive NDMA, similar materials, or other problematic organic compound. Combined chromium treatment for these two wells will require a separate pipeline from well NHE-2 to NHE-1 and the NHOU treatment facility. The 30-year O&M period for treatment of VOCs at the NHOU is assumed to also apply to ex situ chromium treatment for purposes of this FFS. The estimated O&M duration will be re-evaluated if chromium concentrations change significantly. It is assumed that the ex situ chromium treatment system will be capable of treating up to 600 gpm (the peak combined design capacity of extraction wells NHE-1 and NHE -2) at a maximum chromium concentration of 600 µg/L (identical to Alternative 2).

4.3.5.2 Components of Alternative 3b

Alternative 3b is nearly identical to Alternative 3a, but assumes reinjection of the treated groundwater into the aquifer rather than delivery to LADWP, resulting in the following differences:

1. Construction of six new injection wells, a pipeline from the NHOU treatment plant to the injection wells, and nine new monitoring wells in the vicinity of the injection wells.
2. No LPGAC system downstream from each of the air strippers, as there would be no need to provide "double barrier" treatment for VOCs.

4.3.5.3 Model Forecast Hydraulic Containment under Alternatives 3a and 3b

Alternatives 3a and 3b include deepening of existing extraction wells and construction of new extraction wells identical to Alternatives 2a and 2b. Therefore, the hydraulic containment forecasts under Alternatives 3a and 3b for each regional pumping scenario (Forecast Average and Forecast Maximum Production Scenarios) are identical to those under

Alternatives 2a and 2b, which are presented in Section 4.3.4 and depicted on Figures 4-15 through 4-18.

4.3.6 Alternatives 4a and 4b – Expand Extraction Well System and Operate Ex Situ Chromium Treatment System for Multiple Extraction Wells

Alternatives 4a and 4b incorporate chromium treatment for the combined influent from extraction well NHE-1 and two of the three new extraction wells (NEW-2 and NEW-3), along with wellhead chromium treatment for NHE-2. Groundwater modeling results indicate that under expected future SFV well field pumping scenarios, new extraction wells NEW-2 and NEW-3 would intercept groundwater containing high concentrations of chromium at levels similar to NHE-1 and NHE-2. Alternatives 4a and 4b include chromium treatment for both of these new extraction wells. Therefore, it is assumed under Alternatives 4a and 4b that chromium concentrations at extraction wells NHE-1, NEW-2, and NEW-3 would reach similar levels as well NHE-2 (400 µg/L), and thus require chromium treatment. Similar to Alternatives 2a through 3b, the goal of the ex situ chromium treatment under Alternatives 4a and 4b would be to decrease total chromium concentrations in the NHOU treatment plant effluent to 5 µg/L or less.

4.3.6.1 Components of Alternative 4a

Alternative 4a includes the following components common to all alternatives (see Section 4.3.1) and the "action" alternatives (see Section 4.3.2), and assumes delivery of treated groundwater to LADWP for blending and further treatment for potable use, as follows:

1. Develop and implement institutional controls.
2. Continue monitoring of the existing wells and NHOU treatment system, and install and monitor 37 new monitoring wells.
3. Implement wellhead treatment for 1,4-dioxane at extraction well NHE-2.
4. Repair and/or modify existing extraction wells NHE-1 through NHE-8 to improve capture of the 5 µg/L target volume zone, to the extent possible.
5. Construct three new extraction wells to improve hydraulic containment of highly contaminated groundwater present south of LADWP's southern Rinaldi-Toluca wells and east of LADWP's North Hollywood West Well Field.
6. Construct a second air stripper to operate in parallel with the existing air stripper at the NHOU treatment plant site, for primary VOC treatment.

In addition to the common components listed above, Alternative 4a includes the following specific actions:

- **Delivery of treated groundwater to LADWP as the end use.** This will require construction of an LPGAC system downstream from each of the air strippers to provide "double barrier" treatment for VOCs.
- **Wellhead chromium treatment at well NHE-2.** Similar to Alternatives 2a and 2b, Alternative 4a includes wellhead treatment for chromium in the extracted groundwater

from NHE-2. As noted for Alternatives 2a and 2b, the chromium treatment system planned by Honeywell will be replaced or enlarged to accommodate a peak flow rate of 300 gpm and an average flow rate of 250 gpm. A 30-year O&M period for treatment of VOCs at the NHOU is assumed to also apply to the wellhead chromium treatment at well NHE-2.

- **Ex situ chromium treatment.** Ex situ treatment of chromium using ferrous iron reduction with microfiltration would be implemented at the NHOU groundwater treatment facility (described in Section 4.2.5). However, this system will be sized to treat the combined influent from extraction well NHE-1 and new extraction wells NEW-2 and NEW-3 (a peak combined pumping rate of 1,100 gpm). Alternatively, an anion-exchange-based treatment process could be installed, if pilot test results expected from the GOU in 2009/2010 demonstrate that the process is effective and does not produce excessive NDMA, similar materials, or other problematic organic compounds. A 30-year O&M period for treatment of VOCs at the NHOU is assumed to also apply to ex situ chromium treatment for purposes of this FFS.

4.3.6.2 Components of Alternative 4b

Alternative 4b is nearly identical to Alternative 4a, but assumes reinjection of the treated groundwater into the aquifer rather than delivery to LADWP, resulting in the following differences:

1. Construction of six new injection wells, a pipeline from the NHOU treatment plant to the injection wells, and nine new monitoring wells in the vicinity of the injection wells.
2. No LPGAC system downstream from each of the air strippers, as there would be no need to provide "double barrier" treatment for VOCs.

4.3.6.3 Model Forecast Hydraulic Containment under Alternatives 4a and 4b

Alternatives 4a and 4b include deepening of existing extraction wells and construction of new extraction wells identical to Alternatives 2a through 2b. Therefore, the hydraulic containment forecasts under Alternatives 4a and 4b for each regional pumping scenario (Forecast Average and Forecast Maximum Production Scenarios) are identical to those under Alternatives 2a through 2b, which are presented in Section 4.3.4 and depicted on Figures 4-15 through 4-18.

4.3.7 Alternatives 5a and 5b – Expand Extraction Well System and Operate Ex Situ Chromium Treatment System for All Extraction Wells

Alternatives 5a and 5b incorporate chromium treatment of influent from all the extraction wells. Under Alternatives 5a and 5b, chromium treatment for the combined flow from all the extraction wells would enable the NHOU system to achieve a hexavalent chromium concentration of less than 2 μg/L in the treated water. These alternatives were originally developed in anticipation of the State issuing a proposed PHG for hexavalent chromium that is significantly less than 5 μg/L. Since a proposed PHG has not yet been issued, these alternatives have been retained in the FFS for the sake of completeness.

4.3.7.1 Components of Alternative 5a

Alternative 5a includes the following components common to all alternatives (see Section 4.3.1) and the "action" alternatives (Section 4.3.2), and assumes delivery of treated groundwater to LADWP for blending and further treatment for potable use, as follows:

1. Develop and implement institutional controls.
2. Continue monitoring the existing wells and NHOU treatment system, and install and monitor 37 new monitoring wells.
3. Implement wellhead treatment for 1,4-dioxane at extraction well NHE-2.
4. Repair and/or modify existing extraction wells NHE-1 through NHE-8 to improve capture of the 5 µg/L target volume zone, to the extent possible.
5. Construct three new extraction wells to improve hydraulic containment of highly contaminated groundwater present south of LADWP's southern Rinaldi-Toluca wells and east of LADWP's North Hollywood West Well Field.
6. Construct a second air stripper to operate in parallel with the existing air stripper at the NHOU treatment plant site, for primary VOC treatment.

In addition to the common components listed above, Alternative 5a includes the following specific actions:

- **Delivery of treated groundwater to LADWP as the end use.** This will require construction of an LPGAC system downstream from each of the air strippers to provide "double barrier" treatment for VOCs.
- **Ex situ chromium treatment.** Similar to Alternatives 3a through 4b, ex situ treatment of chromium using ferrous iron reduction with microfiltration would be implemented at the NHOU groundwater treatment facility (described in Section 4.2.5). However, this system would be sized to treat the combined influent from all of the extraction wells. Alternatively, an anion-exchange-based treatment process could be installed if pilot test results expected from the GOU in 2009/2010 demonstrate that the process is effective and does not produce excessive NDMA, similar materials, or other problematic organic compounds. A peak combined pumping rate of 3,600 gpm is assumed for chromium treatment (3,050 gpm average long-term flow rate). It is further assumed that as a result of blending with water from extraction wells with relatively low concentrations of chromium, the peak chromium concentration in the combined influent to the NHOU treatment system would be in the range from 100 to 600 µg/L and would require treatment to 5 µg/L or less. Similar to Alternatives 2a through 4b, a 30-year O&M period for treatment of VOCs at the NHOU is assumed to also apply to ex situ chromium treatment for purposes of this FFS.

4.3.7.2 Components of Alternative 5b

Alternative 5b is nearly identical to Alternative 5a, but assumes reinjection of the treated groundwater into the aquifer rather than delivery to LADWP, resulting in the following differences:

1. Construction of six new injection wells, a pipeline from the NHOU treatment plant to the injection wells, and nine new monitoring wells in the vicinity of the injection wells.
2. No LPGAC system downstream from each of the air strippers, as there would be no need to provide “double barrier” treatment for VOCs.

4.3.7.3 Model Forecast Hydraulic Containment under Alternatives 5a and 5b

Alternatives 5a and 5b include deepening of existing extraction wells and construction of new extraction wells, identical to Alternatives 2a through 4b. Therefore, the hydraulic containment forecasts under Alternatives 5a and 5b for each regional pumping scenario (Forecast Average and Forecast Maximum Production Scenarios) are identical to those under Alternatives 2a and 32b, which are presented in Section 4.3.2 and depicted on Figures 4-15 through 4-18.

Figure
4-1 VOC and Chromium Target Volumes in Depth Region 1

Figure 4-1, continued

Figure
4-2 VOC and Chromium Target Volumes in Depth Region 2

Figure 4-2, continued

Figure
4-3 San Fernando Valley Well Field Pumping Rates, Showing Forecast Average Pumping Scenario for 2007 Through 2017

Figure 4-3, continued

Figure
4-4 San Fernando Valley Well Field Pumping Rates, Showing Forecast Maximum Pumping Scenario for 2007 Through 2017

Figure 4-4, continued

Figure
4-5 Existing NHOU Treatment System Process Flow Diagram - Air Stripping

Figure 4-5, continued

Figure 4-6 VOC Treatment Process Flow Diagram – Liquid Phase Granular Activated Carbon

Figure 4-6, continued

Figure 4-7 Chromium Treatment Process Flow Diagram – Iron Coprecipitation with Filtration

Figure 4-7, continued

Figure
4-8 Chromium Treatment Process Flow Diagram - Weak Base Anion Ion Exchange

Figure 4-8, continued

Figure
4-9 Wellhead 1,4-Dioxane Treatment Process Flow Diagram – Advanced Oxidation Process

Figure
4-10 Locations for Proposed Components of Second Interim Remedy

Figure
4-11 Alternative 1: NHOU Extraction Well Field Operation at Current Rates, Flowlines Originating in Depth Region 1, Forecast Average Production Scenario

Figure 4-11, continued

Figure
4-12 Alternative 1: NHOU Extraction Well Field Operation at Current Rates, Flowlines Originating in Depth Region 2, Forecast Average Production Scenario

Figure 4-12, continued

Figure
4-13 Alternative 1: NHOU Extraction Well Field Operation at Current Rates, Flowlines Originating in Depth Region 1, Forecast Maximum Production Scenario

Figure 4-13, continued

Figure
4-14 Alternative 1: NHOU Extraction Well Field Operation at Current Rates, Flowlines Originating in Depth Region 2, Forecast Maximum Production Scenario

Figure 4-14, continued

Figure
4-15 Alternatives 2a, 3a, 4a, and 5a: Expansion of NHOU Extraction Well Field, Flowlines Originating in Depth Region 1, Forecast Average Production Scenario

Figure 4-15, continued

Figure
4-16 Alternatives 2a, 3a, 4a, and 5a: Expansion of NHOU Extraction Well Field, Flowlines Originating in Depth Region 2, Forecast Average Production Scenario

Figure 4-16, continued

Figure
4-17 Alternatives 2a, 3a, 4a, and 5a: Expansion of NHOU Extraction Well Field, Flowlines Originating in Depth Region 1, Forecast Maximum Production Scenario

Figure 4-17, continued

Figure
4-18 Alternatives 2a, 3a, 4a, and 5a: Expansion of NHOU Extraction Well Field, Flowlines Originating in Depth Region 2, Forecast Maximum Production Scenario

SECTION 5

Detailed Analysis of Remedial Alternatives

Section 5 presents a detailed evaluation of the remedial alternatives, including an analysis of each alternative using the nine criteria specified in the NCP. Section 5 also provides a comparative analysis of the remedial alternatives to facilitate EPA's selection of a preferred alternative, based on the criteria specified in CERCLA (EPA, 1988).

5.1 Description of Evaluation Criteria

The NCP (40 CFR Section 300.430(e)(9)(iii)) describes the nine CERCLA criteria used to evaluate the alternatives under consideration. The nine CERCLA evaluation criteria are:

1. **Overall protection of human health and the environment** - this criterion assesses whether an alternative achieves overall protection of human health and the environment. Alternatives are assessed to determine whether they are adequately protective, in both the short and long term, from unacceptable risks posed by groundwater contaminants present at the NHOU. The assessment of overall protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

2. **Compliance with ARARs** - this criterion addresses the attainment of federal and state ARARs (or the basis for invoking a waiver). The potential ARARs for the remedial alternatives are described in Section 3.

3. **Long-term effectiveness and permanence** - this criterion assesses the extent to which each remedial alternative reduces risk after the remedial action objectives are met. Residual risk can result from exposure to untreated waste or treatment residuals. The magnitude of the risk depends on the quantity and concentration of the wastes and the adequacy and reliability of controls, if any, that are used to manage untreated waste and treatment residuals. For the alternatives evaluated in this FFS, treatment residuals may include spent carbon, concentrated brines, or sludges.

4. **Reduction of toxicity, mobility, or volume through treatment** - this criterion addresses the preference, as stated in the NCP, for selecting remedial actions employing treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as a principal element of the action. This preference is satisfied when treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, reduction of total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media.

5. **Short-term effectiveness** - this criterion evaluates the effects of each remedial alternative on human health and the environment during construction and operation, as well as the time required to meet the RAOs.

6. **Implementability** - this criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation.

7. **Cost** - this criterion addresses the total cost of each alternative. This includes the capital costs (design, initial permitting, construction, startup, and contingencies), annual O&M costs (labor, materials, energy, laboratory analysis, and other services), and net present value (total cost in today's dollars for capital and O&M costs, assuming a discount rate of 7 percent and a period of operation of 30 years). The cost estimates are considered order-of-magnitude level estimates, with an expected accuracy of +50 to -30 percent.

8. **State acceptance** - this criterion evaluates the technical and administrative issues and concerns the state may have regarding each alternative. This criterion is typically addressed more fully in the ROD and responsiveness summary.

9. **Community acceptance** - this criterion evaluates the issues and concerns the public may have regarding each alternative. This criterion will be addressed in the ROD and responsiveness summary, after public comments on this FFS and the Proposed Plan have been received.

The NCP categorizes the nine CERCLA evaluation criteria into three groups: (1) threshold criteria, (2) primary balancing criteria, and (3) modifying criteria. Each category of criteria has its own weight when applied to the evaluation of alternatives.

1. Threshold criteria are requirements that each alternative must meet to be eligible for selection as the preferred alternative. Threshold criteria include the overall protection of human health and the environment, and compliance with ARARs (unless a waiver is obtained).

2. Primary balancing criteria weigh the effectiveness and cost trade-offs among alternatives. Primary balancing criteria include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The primary balancing criteria are the main technical criteria upon which the alternatives evaluation is based.

3. Modifying criteria include state and community acceptance, which may be used to modify aspects of the selected alternative when preparing the ROD. Modifying criteria are generally evaluated after public comment on the FFS and the proposed plan.

The two threshold and the five primary balancing criteria are used to evaluate alternatives in the detailed analysis phase, and consideration is given to the state and community acceptance criteria.

The Office of Management and Budget Circular A-90 and EPA guidance require the use of a 7 percent discount rate when conducting present worth analyses and developing cost estimates for site decision documents. Therefore, a 7 percent discount rate was used to develop net present worth cost estimates in this FFS.

5.2 Evaluation of Alternatives

Section 5.2 presents an evaluation of the remedial alternatives in relation to the nine Superfund evaluation criteria. This section identifies advantages and disadvantages among the alternatives in relation to each criterion. Detailed cost estimates for each alternative are presented in Appendix D. See Section 4 for the detailed descriptions of each of the nine alternatives.

5.2.1 Alternative 1

Alternative 1 includes continued operation of the existing groundwater remedy, continued delivery of treated groundwater to LADWP, an expanded groundwater monitoring network, implementation of wellhead treatment for chromium and 1,4-dioxane at well NHE-2, and ICs for groundwater management.

5.2.1.1 Overall Protection of Human Health and the Environment

At present, the NHOU treatment plant is removing TCE, PCE, and other VOCs to below the MCLs from the water pumped from the six operating NHOU extraction wells (NHE-3 through NHE-8) that currently discharge to the treatment plant (well NHE-2 is currently discharging to a sewer due to elevated chromium levels). However, Alternative 1 does not provide double barrier treatment for VOCs in the treated effluent, which is blended by LADWP with water from other sources for distribution in the city’s drinking water system. Furthermore, elevated concentrations of chromium and other emerging contaminants, which cannot be treated by the Existing NHOU Extraction and Treatment System, have recently been detected in the NHOU. As a result of its causing elevated concentrations of chromium in NHOU treatment system effluent, extraction well NHE-2 was shut down in February 2007. The well remained offline until September 2008, when Honeywell completed installation of a temporary wellhead treatment unit to remove VOCs which enabled the well to be brought back on line, although with discharge to a sanitary sewer. Ultimately, wellhead chromium and 1,4-dioxane treatment systems will be installed to ensure that the groundwater extracted by well NHE-2 meets drinking water standards for those contaminants, at which time the discharge from NHE-2 will be redirected to the influent pipeline of the existing NHOU treatment plant and ultimately be used in LADWP’s drinking water supply system. If chromium or other emerging contaminants were detected at unacceptable concentrations at other NHOU extraction wells in the future, under Alternative 1 they would have to be shut down in order to maintain compliance with the treatment standards for providing the water to LADWP.

In addition to being negatively impacted by chromium and other emerging contaminants, the Existing NHOU Extraction and Treatment System has failed to provide adequate containment of the VOC plume. The existing system was primarily designed for containment and treatment of contaminated groundwater in Depth Region 1, but has experienced operational issues that have limited its ability to achieve that objective. As a result, contaminated groundwater has migrated from areas with high concentrations of TCE, PCE, and chromium contamination (50 μg/L or greater) to areas of lower concentrations or no contamination, in some cases beyond the targeted area for hydraulic containment of the Existing NHOU Extraction and Treatment System. In addition, monitoring data collected since the system began operation have shown that the VOC plume is more widespread than initially thought in Depth Regions 2 and 3, where the existing system has very limited containment ability. Hydraulic containment of groundwater under Alternative 1 is essentially the same as under the Existing NHOU Extraction and Treatment System, and thus Alternative 1 is forecasted to allow continued migration of groundwater from areas with high levels of contamination to areas of lower levels of contamination.

Migration of contaminated groundwater in the NHOU has resulted in contamination of numerous LADWP production wells. Voluntary decreased use and shutdown of water supply wells in areas where high concentrations of contaminants have migrated away from the NHOU system has been implemented by LADWP as an interim measure to ensure protection of human health. However, the aquifer underlying the NHOU is an important source of water supply for LADWP, and shutdowns or use limitations at water supply wells cannot continue indefinitely without negatively impacting water supply options for the LADWP and other groundwater users in the SFV.

In summary, Alternative 1 does not provide double barrier treatment for VOCs, it will only provide treatment for chromium and 1,4-dioxane at well NHE-2 (not yet implemented), and it does not provide adequate hydraulic containment of the most highly contaminated groundwater in the NHOU (no improvement compared to the Existing NHOU Extraction and Treatment System). Therefore, although the Existing NHOU Extraction and Treatment System is currently extracting some of the contaminated groundwater from the NHOU and treating it to safe levels, continued operation as described in Alternative 1 is considered to provide a low level of overall protection of human health and the environment.

5.2.1.2 Compliance with ARARs

Monitoring of the effluent water from the Existing NHOU Extraction and Treatment System indicates that the system adequately treats contaminants to below state and Federal MCLs, or California notification levels (for contaminants that do not have MCLs). However, well NHE-2 is currently discharging extracted groundwater to the sewer rather than the treatment system because the groundwater contains excessive levels of chromium. Well NHE-2 is expected to be reconnected to the Existing NHOU Extraction and Treatment System after wellhead treatment for chromium and 1,4-dioxane are implemented. Blending of water discharged by the NHOU treatment system with other water sources prior to delivery by LADWP will further reduce contaminant concentrations below MCLs and notification levels. Therefore, Alternative 1 is expected to comply with MCLs and all other ARARs.

5.2.1.3 Long-term Effectiveness and Permanence

As noted above, Alternative 1 fails to meet the remedial action objective of containing the contaminated groundwater and preventing its migration toward water supply well fields. The contaminants in groundwater that escape capture continue to exist as “untreated waste” and thus pose a residual risk. In addition, groundwater with elevated concentrations of chromium and other emerging contaminants is likely to migrate toward extraction wells NHE-3 through NHE-6. Future shutdowns of these extraction wells, if necessary in response to increasing concentrations of chromium or other emerging contaminants, would further exacerbate the problem of inadequate hydraulic containment.

For the contaminated groundwater that is captured, Alternative 1 will permanently remove most of the VOCs and chromium that are treated by the air stripper and the planned NHE-2 wellhead chromium and 1,4-dioxane treatment systems, respectively. These treatment processes will produce a relatively small quantity of spent carbon from the VPGAC unit used to remove VOCs from the air stream produced by the air stripper, and either brine or sludge from the NHE-2 wellhead chromium treatment unit. The wellhead AOP system assumed to be installed at well NHE-2 will destroy 1,4-dioxane during the treatment process. Established procedures for handling, disposal, or regeneration of these wastes are either in place, or will be implemented when necessary. Therefore, residual risks from treatment residuals are expected to be minimal.

5.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Under Alternative 1, the existing extraction wells and treatment system will continue to provide a modest degree of reduction of the mobility and volume of VOCs, chromium, and emerging contaminants in groundwater by extracting contaminated groundwater and providing treatment that reduces the toxicity of contaminants.

Toxicity of VOCs in the effluent stream from the extraction wells is permanently reduced during regeneration of the spent carbon from the VPGAC units. The anticipated wellhead treatment for chromium and 1,4-dioxane would permanently reduce the toxicity of these contaminants in extracted groundwater from well NHE-2, but would not reduce the toxicity of chromium extracted from other NHOU extraction wells.

5.2.1.5 Short-term Effectiveness

Alternative 1 requires construction of new monitoring wells and wellhead treatment systems for chromium and 1,4-dioxane at extraction well NHE-2. These activities are not expected to pose any substantial risks to the community during construction or implementation, nor do they pose significant risks to workers beyond general hazards associated with any large construction project. Construction of the new monitoring wells may create a temporary nuisance to residents. No negative environmental impacts are anticipated in the areas where facilities would be constructed.

5.2.1.6 Implementability

No difficulties are anticipated with the availability of services and materials required to implement Alternative 1. Techniques for drilling the new monitoring wells and refurbishing the existing air stripper are well known and follow standard industry practices. The time required to implement Alternative 1 is negligible, as the primary treatment processes (the NHOU air stripper and VPGAC unit) are already constructed and operating, and wellhead treatment at NHE-2 can be installed in 6 months or less.

The ICs component of Alternative 1 is expected to be implementable from an administrative standpoint. Continued coordination will be required with the ULARA Watermaster and LADWP to implement and maintain the ICs. Municipal use of groundwater treated by the wellhead treatment system at NHE-2 will require compliance with the CDPH 97-005 policy. Compliance with the CDPH 97-005 policy requires collection and submittal of extensive water quality data and analysis to CDPH, followed by agency review. This process is anticipated to require 6 to 12 months to complete. As noted previously, the ability of

Alternative 1 to achieve cleanup levels for chromium in the combined effluent from the NHOU treatment system in the future is uncertain. Because of this uncertainty, LADWP and/or State agencies may not accept either of the planned end use options for the treated water under these alternatives.

5.2.1.7 Cost

Total capital cost for Alternative 1 is estimated to be approximately $16.3 million. Annual O&M costs for the air stripper and monitoring wells, including periodic sampling and analysis, are estimated to be $3.8 million. Assuming a discount rate of 7 percent, the total net present value (NPV) for this alternative over a 30-year period is estimated to be $40.1 million. Appendix D provides details of the estimated costs for Alternative 1.

5.2.1.8 State Acceptance

This criterion will be addressed more fully in the ROD and responsiveness summary once public comment on the FFS and proposed plan have been received. However, state agencies have indicated that the existing remedy is not acceptable because the continued migration of VOCs and chromium contamination in groundwater would further degrade the aquifer. Furthermore, CDPH has stated that double barrier treatment processes for VOCs should be provided if the treated water will ultimately be blended with water intended for municipal supply by LADWP. Alternative 1 includes only a single barrier VOC treatment process (air stripping).

5.2.1.9 Community Acceptance

This criterion will be addressed in the ROD and responsiveness summary, after public comments on this FFS and the Proposed Plan have been received. The LADWP has indicated that Alternative 1 is not acceptable because of the continued migration of groundwater contamination and the potential for chromium contamination to migrate and further degrade the aquifer.

5.2.2 Alternatives 2a and 2b

Alternatives 2a and 2b include: the deepening and refurbishment of existing NHOU extraction wells; wellhead treatment of chromium at extraction wells NHE-1 and NHE-2; wellhead treatment of 1,4-dioxane at extraction well NHE-2; expansion of the groundwater monitoring network; construction of three new extraction wells and associated pipelines; installation of a new air stripper for VOC removal at the NHOU treatment plant site; and ICs for groundwater management. Alternative 2a also includes installation of two new LPGAC systems following the air strippers at the NHOU treatment plant site to provide double barrier VOC treatment as required by CDPH. Under Alternative 2b, new injection wells, a pipeline from the NHOU treatment plant site to the injection wells, and additional monitoring wells would be constructed instead of the LPGAC treatment systems.

5.2.2.1 Overall Protection of Human Health and the Environment

Alternatives 2a and 2b include new extraction wells and modifications to increase pumping from the existing NHOU extraction wells, resulting in improved hydraulic containment compared to the Existing NHOU Extraction and Treatment System. Alternatives 2a and 2b also provide treatment of the emerging contaminants of greatest concern in the NHOU (hexavalent chromium, and 1,4-dioxane) using wellhead treatment, and Alternative 2a provides double barrier treatment for VOCs. These improvements to the Existing NHOU Extraction and Treatment System would provide significantly improved hydraulic containment and treatment of the most highly contaminated groundwater in the NHOU.

Alternatives 2a and 2b include two (parallel) VOC treatment systems, which will minimize system downtime for treatment system maintenance. Coupled with the improved hydraulic containment from the expanded extraction system, these improvements will limit the spread of contaminants in the NHOU and maximize the amount of contaminated groundwater removed from the most highly contaminated portion of the NHOU. However, some areas of VOC contamination (mostly where concentrations are less than 50 µg/L) in groundwater that have already escaped hydraulic containment by the Existing NHOU Extraction and Treatment System, or that have been recently discovered at other locations in the North Hollywood area, are forecasted to continue migrating toward the BOU and some LADWP production wells under these alternatives.

Alternatives 2a and 2b are expected to achieve and maintain a substantially improved level of protection of human health relative to the Existing NHOU Extraction and Treatment System. However, under expected future production pumping scenarios, new extraction wells NEW-2 and NEW-3 are forecasted to intercept groundwater contaminated with high levels of chromium. If that occurs, these two wells may have to be shut down or operated at a lower capacity, which would in turn reduce the ability of Alternatives 2a and 2b do not include sufficient chromium treatment capacity to prevent further degradation of water quality at LADWP's nearby well fields adequately treat groundwater extracted by extraction wells NEW-2 and NEW-3.

5.2.2.2 Compliance with ARARs

The VOC, chromium, and 1,4-dioxane treatment systems included in Alternatives 2a and 2b are expected to be capable of treating these contaminants to levels that meet MCLs and comply with all other ARARs for delivery to LADWP. However, under expected future pumping scenarios, Alternative 2b (for which reinjection is the end use of treated water) may not comply with the state's anti-degradation policy ARAR because of the lack of chromium treatment for wells NEW-2 and NEW-3.

5.2.2.3 Long-term Effectiveness and Permanence

Alternatives 2a and 2b will permanently remove nearly all of the VOCs, 1,4-dioxane, and chromium from groundwater that is treated by the VOC treatment systems and the planned NHE-1 and NHE-2 wellhead treatment systems. However, chromium treatment is not provided for extraction wells NEW-2 and NEW-3, which may become contaminated with elevated chromium concentrations under expected future pumping conditions. The primary VOC treatment process, air stripping, will remove nearly all of the TCE, PCE, and other VOCs from the extracted groundwater, and transfer it to the VPGAC units. Under Alternative 2a, VOCs not removed by the air strippers, including TCP, will largely be captured by the LPGAC units. Spent carbon will be produced from the VPGAC and LPGAC units, and either brine or sludge from the wellhead chromium treatment units will be produced. Established procedures for handling, disposal, or regeneration of these wastes are either in place, or will be implemented when necessary. Therefore, residual risks from treatment residuals are expected to be minimal.

Implementation of the ICs summarized in Section 4.2.1 will ensure that this alternative prevents the continued migration of contaminants and remains protective in the long-term.

As noted in Section 4.2.7, implementation of the reinjection option for discharge of treated water (Alternative 2b) could increase the rate of groundwater "flushing" through the most contaminated part of the aquifer in NHOU, which could result in a modest increase in the rate of groundwater remediation. However, reinjecting the treated water would likely result in it becoming contaminated again following reinjection by mixing with existing groundwater contaminants in the aquifer.

5.2.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Under Alternatives 2a and 2b, the installation of additional extraction wells and the modification of existing extraction wells will result in permanent and significant reduction in the mobility and volume of VOCs, chromium, and emerging contaminants in the NHOU. This would significantly and permanently reduce contaminant mobility and, by virtue of the treatment process and/or carbon regeneration, the toxicity of contaminants. TCE, PCE, and other VOCs in groundwater extracted under Alternatives 2a and 2b will be removed with an expanded treatment system that traps VOCs in granular activated carbon, and then permanently destroys them at an off-site carbon regeneration facility. The implementation of wellhead chromium and 1,4-dioxane treatment at extraction well NHE-2, and wellhead chromium treatment at well NHE-1, would reduce the toxicity and mobility of these contaminants as they are extracted from the aquifer. However, under expected future pumping conditions, chromium contamination is expected to impact other extraction wells that lack chromium treatment under Alternatives 2a and 2b.

5.2.2.5 Short-term Effectiveness

Repairs and modifications to the existing NHOU extraction wells, construction of new monitoring and extraction wells, construction of the new VOC treatment system components and wellhead treatment systems for chromium and 1,4-dioxane, and implementation of these remedy elements under Alternatives 2a and 2b would likely require 1 to 3 years. Construction of new pipelines and wells under Alternative 2a may create a temporary nuisance to residents. Under Alternative 2b, construction of the injection wells, additional pipelines, and additional monitoring wells may create an additional nuisance to residents. These activities would not be expected to pose substantial risks to the community during construction or implementation, nor would they pose any risks to workers beyond general hazards associated with any large construction project. No adverse environmental impacts are anticipated in the areas where facilities would be constructed.

During the design, permitting, and construction process, it is assumed that wellhead treatment for chromium and 1,4-dioxane at NHE-2 would be implemented as planned by Honeywell, and the existing NHOU treatment system will continue to be operated in such a manner that the contaminant concentrations in the treatment plant effluent remain below the MCLs and notification levels. Therefore, Alternatives 2a and 2b are expected to be protective of human health in the short term.

5.2.2.6 Implementability

There are no difficulties anticipated with the availability of services and materials required to implement Alternatives 2a and 2b. Techniques for drilling the new wells and constructing the new VOC treatment system are well known and will follow standard industry practices. The recommended wellhead treatment processes for chromium and 1,4-dioxane are relatively new; however, the technologies involved have been successfully implemented at other sites with similar hydrogeologic conditions. Therefore, no insurmountable technical feasibility issues are anticipated with implementation. The injection wells required under Alternative 2b can be difficult and costly to operate and maintain. Vendors are available for well repair, installation, and related services. Several contractors are capable of implementing the ex situ (wellhead) treatment processes. During the design phase for the components of Alternatives 2a or 2b, operation of the Existing NHOU Extraction and Treatment System will continue.

The ICs component of Alternatives 2a and 2b is expected to be implementable from an administrative standpoint. Access agreements would be required for installation and sampling of the new monitoring and extraction wells, and additional permitting efforts are anticipated for the new pipeline between the new extraction wells and the NHOU treatment system. Also, municipal use of the treated groundwater will require compliance with the CDPH 97-005 policy.

Under expected future pumping scenarios, hexavalent chromium levels in the NHOU effluent may not meet the cleanup level, as a result of the lack of chromium treatment at wells NEW-2 and NEW-3. Because of this uncertainty, LADWP and/or State agencies may not accept either of the planned end use options for the treated water under these alternatives.

5.2.2.7 Cost

The estimated capital cost for Alternative 2a is $46.5 million. Annual O&M costs for Alternative 2a are estimated to be $8.3 million. The estimated capital cost for Alternative 2b (reinjection) is $89.3 million. Annual O&M costs for Alternative 2b are estimated to be $8.1 million. Assuming a discount rate of 7 percent, the total NPVs over a 30-year period are estimated to be $91.7 million for Alternative 2a and $118.1 million for Alternative 2b. Appendix D provides details of the cost estimates for Alternatives 2a and 2b.

5.2.2.8 State Acceptance

State acceptance for Alternatives 2a or 2b is currently unknown and will be assessed based on input received during the public comment period. However, the State has expressed its support for Alternative 4a.

5.2.2.9 Community Acceptance

Community acceptance for Alternatives 2a or 2b is currently unknown and will be assessed based on input received during the public comment period.

5.2.3 Alternatives 3a and 3b

Alternatives 3a and 3b include: the deepening and refurbishment of existing NHOU extraction wells; a single ex situ treatment system (600 gpm capacity) at the NHOU treatment plant site to treat chromium in groundwater from the combined flows of extraction wells NHE-1 and NHE-2 (instead of the separate wellhead treatment systems included under Alternatives 2a and 2b); construction of a new pipeline connecting wells NHE-1 and NHE-2 to the combined ex situ chromium treatment system; wellhead treatment of 1,4-dioxane at extraction well NHE-2; expansion of the groundwater monitoring network; construction of three new extraction wells; installation of a new air stripper for VOC removal at the NHOU treatment plant site; and ICs for groundwater management. Alternative 3a would also include installation of two new LPGAC systems following the air strippers at the NHOU treatment plant site to provide double barrier VOC treatment as required by CDPH. Under Alternative 3b, six new injection wells, a pipeline from the NHOU treatment plant site to the injection wells, and nine additional monitoring wells will be constructed instead of the LPGAC treatment systems.

5.2.3.1 Overall Protection of Human Health and the Environment

Alternatives 3a and 3b include new extraction wells and modifications to increase pumping from the existing NHOU extraction wells, resulting in improved hydraulic containment. Alternatives 3a and 3b also provide treatment of the emerging contaminants of greatest concern in the NHOU using wellhead treatment at NHE-2 for 1,4-dioxane and ex-situ chromium treatment for the combined flow from wells NHE-1 and NHE-2. Alternative 2a provides double barrier treatment for VOCs. These improvements to the Existing NHOU Extraction and Treatment System would provide significantly improved hydraulic containment and treatment of the most highly contaminated groundwater in the NHOU.

Alternatives 3a and 3b include two (parallel) VOC treatment systems, which will minimize system downtime for treatment system maintenance. Coupled with the improved hydraulic containment from the expanded extraction system, these improvements will limit the spread of contaminants in the NHOU and maximize the amount of contaminated groundwater removed from the most highly contaminated portion of the NHOU. However, some areas of VOC contamination (mostly where concentrations are less than 50 μg/L) in groundwater that have already escaped hydraulic containment by the Existing NHOU Extraction and Treatment System, or that have been recently discovered at other locations in the North Hollywood area, are forecasted to continue migrating toward the BOU and some LADWP production wells under these alternatives.

Alternatives 3a and 3b are expected to achieve and maintain a substantially improved level of protection of human health relative to the Existing NHOU Extraction and Treatment System. However, under expected future production pumping scenarios, new extraction wells NEW-2 and NEW-3 are forecasted to intercept groundwater contaminated with high levels of chromium. If that occurs, these two wells may have to be shut down or operated at a lower capacity, which would in turn reduce the ability of Alternatives 3a and 3b to prevent further degradation of water quality at LADWP's nearby well fields.

5.2.3.2 Compliance with ARARs

The VOC, chromium, and wellhead 1,4-dioxane treatment systems included in Alternatives 3a and 3b are expected to be capable of treating these contaminants to levels that meet MCLs and comply with all other ARARs for delivery to LADWP. The ex situ chromium treatment system included in Alternatives 3a and 3b is also expected to attain ARARs for reinjection or delivery to LADWP. However, under expected future pumping scenarios, Alternative 3b (for which reinjection is the end use of treated water) may not comply with the state's anti-degradation policy ARAR because of the lack of chromium treatment for wells NEW-2 and NEW-3.

5.2.3.3 Long-term Effectiveness and Permanence

Alternatives 3a and 3b will permanently remove nearly all of the VOCs, 1,4-dioxane, and chromium from groundwater that is treated by the VOC treatment systems, the planned ex situ chromium treatment system for wells NHE-1 and NHE-2, and the wellhead 1,4-dioxane treatment. However, chromium treatment is not provided for extraction wells NEW-2 and NEW-3 (to be constructed under Alternatives 2a through 5b), which may become contaminated with elevated chromium concentrations under expected future pumping conditions. The primary VOC treatment process, air stripping, will remove nearly all of the TCE, PCE, and other VOCs from the extracted groundwater, and transfer it to the VPGAC units. Under Alternative 3a, VOCs not removed by the air strippers, including TCP, will largely be captured by the LPGAC units. Spent carbon will be produced from the VPGAC and LPGAC units, and either brine or sludge from the wellhead chromium treatment units will be produced. Established procedures for handling, disposal, or regeneration of these wastes are either in place, or will be implemented when necessary. Therefore, residual risks from treatment residuals are expected to be minimal.

Implementation of the ICs summarized in Section 4.2.1 will ensure that this alternative prevents the continued migration of contaminants and remains protective in the long-term.

As noted in Section 4.2.7, implementation of the reinjection option for discharge of treated water (Alternative 3b) could increase the rate of groundwater "flushing" through the most contaminated part of the aquifer in NHOU, which could result in a modest increase in the rate of groundwater remediation. However, reinjecting the treated water would likely result in it becoming contaminated again following reinjection by mixing with existing groundwater contaminants in the aquifer.

5.2.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Under Alternatives 3a and 3b, the installation of additional extraction wells and the modification of existing extraction wells will result in permanent and significant reduction in the mobility and volume of VOCs, chromium, and emerging contaminants in the NHOU. This would significantly and permanently reduce contaminant mobility and, by virtue of the treatment process and/or carbon regeneration, the toxicity of contaminants. TCE, PCE, and other VOCs in groundwater extracted under Alternatives 3a and 3b will be removed with an expanded treatment system that traps VOCs in granular activated carbon, and then permanently destroys them at an off-site carbon regeneration facility. The implementation of wellhead 1,4-dioxane treatment at extraction well NHE-2, and ex situ chromium treatment for the combined flows from wells NHE-1 and NHE-2, would reduce the toxicity and mobility of these contaminants as they are extracted from the aquifer. However, chromium treatment is not provided at other extraction wells that may become contaminated under expected future pumping conditions under Alternatives 2a and 2b.

5.2.3.5 Short-term Effectiveness

Repairs and modifications to the existing NHOU extraction wells, construction of new monitoring and extraction wells, construction of the new VOC treatment system components, ex situ chromium treatment system, wellhead 1,4-dioxane treatment system, and implementation of these remedy elements under Alternatives 3a and 3b would likely require 1 to 3 years. Construction of new pipelines and wells under Alternative 3a may create a temporary nuisance to residents. Under Alternative 3b, construction of the injection wells, additional pipelines, and additional monitoring wells may create an additional nuisance to residents. The additional new pipeline (from extraction well NHE-2 to NHE-1 and the NHOU treatment system) required under Alternatives 3a and 3b could be an additional temporary nuisance to residents during construction but should not extend the overall construction period nor create any adverse impacts on the community. These activities would not be expected to pose substantial risks to the community during construction or implementation, nor would they pose any risks to workers beyond general hazards associated with any large construction project. No adverse environmental impacts are anticipated in the areas where facilities would be constructed.

During the design, permitting, and construction process, it is assumed that wellhead treatment for chromium and 1,4-dioxane at NHE-2 would be implemented as planned by Honeywell, and the existing NHOU treatment system will continue to be operated in such a manner that the contaminant concentrations in the treatment plant effluent remain below the MCLs and notification levels. Therefore, Alternatives 3a and 3b are expected to be protective of human health in the short term.

5.2.3.6 Implementability

There are no difficulties anticipated with the availability of services and materials required to implement Alternatives 3a and 3b. Techniques for drilling the new wells and constructing the new VOC treatment system are well known and will follow standard industry practices. The recommended ex situ treatment process for chromium and wellhead treatment process for 1,4-dioxane are relatively new; however, the technologies involved have been successfully implemented at other sites with similar hydrogeologic conditions. Therefore, no insurmountable technical feasibility issues are anticipated with implementation. The injection wells required under Alternative 3b can be difficult and costly to operate and maintain. Vendors are available for well repair, installation, and related services. Several contractors are capable of implementing the ex situ (wellhead) treatment processes. During the design phase for the components of Alternatives 3a or 3b, operation of the Existing NHOU Extraction and Treatment System will continue.

The ICs component of Alternatives 3a and 3b is expected to be implementable from an administrative standpoint. Access agreements would be required for installation and sampling of the new monitoring and extraction wells, and additional permitting efforts are anticipated for the new pipeline between the new extraction wells and the NHOU treatment system. Also, municipal use of the treated groundwater will require compliance with the CDPH 97-005 policy.

Under expected future pumping scenarios, hexavalent chromium levels in the NHOU effluent may not meet the cleanup level, as a result of the lack of chromium treatment at wells NEW-2 and NEW-3. Because of this uncertainty, LADWP and/or State agencies may not accept either of the planned end use options for the treated water under these alternatives.

5.2.3.7 Cost

The estimated capital cost for Alternative 3a is $45.3 million. Annual O&M costs for Alternative 3a are estimated to be $7.7 million. The estimated capital cost for Alternative 3b is $88.1 million. Annual O&M costs for Alternative 3b are estimated to be $6.9 million. Assuming a discount rate of 7 percent, the total NPVs over a 30-year period are estimated to be $82.6 million for Alternative 3a (LADWP-delivery option) or $109.0 million for Alternative 3b (reinjection option). Appendix D provides details of the cost estimates for these alternatives.

5.2.3.8 State Acceptance

State acceptance for Alternatives 3a and 3b is currently unknown and will be assessed based on input received during the public comment period. However, the State has expressed its support for Alternative 4a.

5.2.3.9 Community Acceptance

Community acceptance for Alternatives 3a and 3b is currently unknown and will be assessed based on comments received during the public comment period.

5.2.4 Alternatives 4a and 4b

Alternatives 4a and 4b include chromium treatment for four of the existing and new extraction wells (NHE-1, NHE-2, NEW-2 and NEW-3, see Section 4.3.6). Alternatives 4a and 4b also include: the deepening and refurbishment of existing NHOU extraction wells; expansion of the groundwater monitoring network; construction of three new extraction wells; installation of a new air stripper for VOC removal at the NHOU treatment plant site; ICs for groundwater management; a single ex situ treatment system (1,100 gpm capacity) at the NHOU treatment plant site to treat chromium in the combined flow from extraction wells NHE-1, NEW-2, and NEW-3; and wellhead chromium and 1,4-dioxane treatment at NHE-2. Alternative 4a would also include installation of two new LPGAC systems following the air strippers at the NHOU treatment plant site to provide double barrier VOC treatment as required by CDPH. Under Alternative 4b, six new injection wells, a pipeline from the NHOU treatment plant site to the injection wells, and nine additional monitoring wells would be constructed instead of the LPGAC treatment systems.

5.2.4.1 Overall Protection of Human Health and the Environment

Alternatives 4a and 4b include new extraction wells and modifications to increase pumping from the existing NHOU extraction wells, resulting in improved hydraulic containment. Alternatives 4a and 4b also provide treatment of the emerging contaminants of greatest concern in the NHOU using wellhead treatment at NHE-2 for chromium and 1,4-dioxane, and ex-situ chromium treatment for the combined flow from wells NHE-1, NEW-2 and NEW-3. Alternative 4a will provide double barrier treatment for VOCs. Alternatives 4a and 4b include two (parallel) VOC treatment systems, which will minimize system downtime for treatment system maintenance. Coupled with the improved hydraulic containment from the expanded extraction system, these improvements will limit the spread of contaminants in the NHOU and maximize the amount of contaminated groundwater removed from the most highly contaminated portion of the NHOU. However, some areas of VOC contamination (mostly where concentrations are less than 50 μg/L) in groundwater that have already escaped hydraulic containment by the Existing NHOU Extraction and Treatment System, or that have been recently discovered at other locations in the North Hollywood area, are forecasted to continue migrating toward the BOU and some LADWP production wells under these alternatives.

Alternatives 4a and 4b are expected to achieve and maintain a substantially improved level of protection of human health relative to the Existing NHOU Extraction and Treatment System. In addition, Alternatives 4a and 4b would provide enhanced protection of human health by including chromium treatment where chromium is likely to be present in groundwater at high concentrations (i.e., in the vicinity of new extraction wells NEW-2 and NEW-3, in addition to wells NHE-1 or NHE-2).

5.2.4.2 Compliance with ARARs

The VOC, chromium, and 1,4-dioxane treatment systems included in Alternatives 4a and 4b are expected to be capable of treating these contaminants to levels that meet MCLs and comply with all other ARARs for delivery to LADWP. Alternative 4b (for which reinjection is the end use of treated water) is expected to comply with ARARs, including the state's anti-degradation policy. Furthermore, Alternatives 4a and 4b are expected to comply with the ARARs under the expected future pumping scenarios, including those that could result in chromium concentrations increasing significantly at new extraction wells NEW-2 and NEW-3, in addition to wells NHE-1 and NHE-2.

5.2.4.3 Long-term Effectiveness and Permanence

Alternatives 4a and 4b will permanently remove nearly all of the VOCs and 1,4-dioxane from groundwater that is treated by the VOC treatment systems and the planned wellhead 1,4-dioxane treatment system for well NHE-2. The chromium treatment system included in Alternatives 4a and 4b will have the capability to remove chromium from the combined discharge from new extraction wells NEW-2 and NEW-3, in addition to NHE-1 and NHE-2. The primary VOC treatment process, air stripping, will remove nearly all of the TCE, PCE, and other VOCs from the extracted groundwater, and transfer it to the VPGAC units. Under Alternative 4a, any VOCs not removed by the air strippers (including TCP) will largely be captured by the LPGAC units. Spent carbon will be produced from the VPGAC and LPGAC units, and either brine or sludge from the wellhead chromium treatment units will be produced. Established procedures for handling, disposal, or regeneration of these wastes are either in place, or will be implemented when necessary. Therefore, residual risks from treatment residuals are expected to be minimal.

Implementation of the ICs summarized in Section 4.2.1 will ensure that this alternative prevents the continued migration of contaminants and remains protective in the long-term.

As noted in Section 4.2.7, implementation of the reinjection option for discharge of treated water (Alternative 4b) could increase the rate of groundwater "flushing" through the most contaminated part of the aquifer in NHOU, which could result in a modest increase in the rate of groundwater remediation. However, reinjecting the treated water would likely result in it becoming contaminated again following reinjection by mixing with existing groundwater contaminants in the aquifer. TCE, PCE, and other VOCs in groundwater extracted under Alternatives 4a and 4b will be removed with an expanded treatment system that traps VOCs in granular activated carbon, and then permanently destroys them at an off-site carbon regeneration facility.

5.2.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Under Alternatives 4a and 4b, the installation of additional extraction wells and the modification of existing extraction wells, will result in permanent and significant reduction in the mobility and volume of VOCs, chromium, and emerging contaminants in the NHOU. This would significantly and permanently reduce contaminant mobility and, by virtue of the treatment process and/or carbon regeneration, the toxicity of contaminants. TCE, PCE, and other VOCs in groundwater extracted under Alternatives 4a and 4b will be removed with an expanded treatment system that traps VOCs (in granular activated carbon), and then permanently destroys them at an off-site carbon regeneration facility. The implementation of wellhead chromium and 1,4-dioxane treatment at extraction well NHE-2, and ex situ chromium treatment for the combined flow from wells NEW-2, and NEW-3, would reduce the toxicity and mobility of these contaminants as they are extracted from the aquifer.

5.2.4.5 Short-term Effectiveness

Repairs and modifications to the existing NHOU extraction wells, construction of new monitoring and extraction wells, construction of the new VOC treatment system components, ex situ chromium treatment system, wellhead chromium treatment system, wellhead 1,4-dioxane treatment system, and implementation of these remedy elements under Alternatives 4a and 4b would likely require 1 to 3 years. Construction of new pipelines and wells under Alternative 3a may create a temporary nuisance to residents. Under Alternative 4b, construction of the injection wells, additional pipelines, and additional monitoring wells may create an additional nuisance to residents. These activities would not be expected to pose substantial risks to the community during construction or implementation, nor would they pose any risks to workers beyond general hazards associated with any large construction project. No adverse environmental impacts are anticipated in the areas where facilities would be constructed.

During the design, permitting, and construction process, it is assumed that wellhead treatment for chromium and 1,4-dioxane at NHE-2 would be implemented as planned by Honeywell, and the existing NHOU treatment system will continue to be operated in such a manner that the contaminant concentrations in the treatment plant effluent remain below the MCLs and notification levels. Therefore, Alternatives 4a and 4b are expected to be protective of human health in the short term.

5.2.4.6 Implementability

There are no difficulties anticipated with the availability of services and materials required to implement Alternatives 4a and 4b. Techniques for drilling the new wells and constructing the new VOC treatment system are well known and will follow standard industry practices. The recommended ex situ treatment process for chromium and wellhead treatment process for 1,4-dioxane are relatively new; however, the technologies involved have been successfully implemented at other sites with similar hydrogeologic conditions. Therefore, no insurmountable technical feasibility issues are anticipated with implementation. The injection wells required under Alternative 4b can be difficult and costly to operate and maintain. Vendors are available for well repair, installation, and related services. Several contractors are capable of implementing the ex situ (wellhead) treatment processes. During the design phase for the components of Alternatives 4a or 4b, operation of the Existing NHOU Extraction and Treatment System will continue.

The ICs component of Alternatives 4a and 4b is expected to be implementable from an administrative standpoint. Access agreements would be required for installation and sampling of the new monitoring and extraction wells, and additional permitting efforts are anticipated for the new pipeline between the new extraction wells and the NHOU treatment system. Also, municipal use of the treated groundwater will require compliance with the CDPH 97-005 policy.

5.2.4.7 Cost

The estimated capital cost for Alternative 4a is $52.3 million. Annual O&M costs for Alternative 4a are estimated to be $9.2 million. The estimated capital cost for Alternative 4b is $95.0 million. Annual O&M costs for Alternative 4b are estimated to be $8.3 million. Assuming a discount rate of 7 percent, the total NPVs over a 30-year period are estimated to be $107.8 million for Alternative 4a and $134.2 million for Alternative 4b. Appendix D provides details of the cost estimates for these alternatives.

5.2.4.8 State Acceptance

The State has expressed its support for Alternative 4a.

5.2.4.9 Community Acceptance

Community acceptance for Alternatives 4a and 4b is currently unknown and will be assessed based on input received during the public comment period.

5.2.5 Alternatives 5a and 5b

Alternatives 5a and 5b assume chromium treatment for all of the existing and new extraction wells. Alternatives 5a and 5b also include: the deepening and refurbishment of existing NHOU extraction wells; expansion of the groundwater monitoring network; construction of three new extraction wells; installation of a new air stripper for VOC removal at the NHOU treatment plant site; ICs for groundwater management; a single ex situ treatment system (4,800 gpm capacity) at the NHOU treatment plant site to treat chromium in groundwater from the combined flows from all NHOU extraction wells; and wellhead 1,4-dioxane treatment at NHE-2. Alternative 5a would also include installation of two new LPGAC systems following the air strippers at the NHOU treatment plant site to provide double barrier VOC treatment as required by CDPH. Under Alternative 5b, six new injection wells, a pipeline from the NHOU treatment plant site to the injection wells, and nine additional monitoring wells would be constructed instead of the LPGAC treatment systems.

5.2.5.1 Overall Protection of Human Health and the Environment

Alternatives 5a and 5b include new extraction wells and modifications to increase pumping from the existing NHOU extraction wells, resulting in improved hydraulic containment. In addition, Alternatives 5a and 5b provide enhanced protection of human health by using ex-situ chromium treatment for the combined flow from all of the existing and new NHOU extraction wells. Alternative 5a would provide double barrier treatment for VOCs.

Alternatives 5a and 5b include two (parallel) VOC treatment systems, which will minimize system downtime for treatment system maintenance. Coupled with the improved hydraulic containment from the expanded extraction system, these improvements will limit the spread of contaminants in the NHOU and maximize the amount of contaminated groundwater removed from the most highly contaminated portion of the NHOU. However, some areas of VOC contamination (mostly where concentrations are less than 50 µg/L) in groundwater that have already escaped hydraulic containment by the Existing NHOU Extraction and Treatment System, or that have been recently discovered at other locations in the North Hollywood area, are forecast to continue migrating toward the BOU and some LADWP production wells under these alternatives.

In summary, Alternatives 5a and 5b are expected to achieve and maintain a substantially improved level of protection of human health.

5.2.5.2 Compliance with ARARs

Alternatives 5a and 5b are expected to comply with the ARARs. The VOC, chromium, and wellhead 1,4-dioxane treatment systems included in Alternatives 5a and 5b are expected to be capable of treating these contaminants to levels that meet MCLs and comply with all other ARARs for delivery to LADWP. Alternative 5b (for which reinjection is the end use of treated water) is expected to comply with ARARs, including the state's anti-degradation policy.

5.2.5.3 Long-term Effectiveness and Permanence

The primary VOC treatment process, air stripping, will remove nearly all of the TCE, PCE, and other VOCs from the extracted groundwater, and transfer it to the VPGAC units. Under Alternative 5a, VOCs not removed by the air strippers, including TCP, will largely be captured by the LPGAC units. Spent carbon will be produced from the VPGAC and LPGAC units (LPGAC is not included under Alternative 5b), and either brine or sludge from the wellhead chromium treatment units will be produced. Established procedures for handling, disposal, or regeneration of these wastes are either in place, or will be implemented when necessary. Therefore, residual risks from treatment residuals are expected to be minimal.

Implementation of the ICs summarized in Section 4.2.1 will ensure that this alternative prevents the continued migration of contaminants and remains protective in the long-term.

Alternative 5b could increase the rate of groundwater "flushing" through the most contaminated part of the aquifer in NHOU, which could result in a modest increase in the rate of groundwater remediation. However, reinjecting the treated water may result in it becoming contaminated again following reinjection by mixing with existing groundwater contaminants in the aquifer.

5.2.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Implementation of Alternative 5a or 5b will result in further reduction of the mobility and volume of VOCs and chromium in groundwater by increasing the volume of contaminated groundwater extracted and treated in the NHOU. The chromium treatment systems included in Alternatives 5a and 5b would reduce the toxicity and mobility of hexavalent chromium in the discharge from all extraction wells.

Under Alternatives 5a and 5b, the installation of additional extraction wells and the modification of existing extraction wells will result in permanent and significant reduction in the mobility and volume of VOCs, chromium, and emerging contaminants in the NHOU. Through the treatment process and/or carbon regeneration, the toxicity of TCE, PCE, and other VOCs in groundwater extracted under Alternatives 5a and 5b will be permanently reduced. The implementation of wellhead 1,4-dioxane treatment at extraction well NHE-2 would reduce the toxicity and mobility of this contaminant in the groundwater extracted from the aquifer.

5.2.5.5 Short-term Effectiveness

Repairs and modifications to the existing NHOU extraction wells, construction of new monitoring and extraction wells, construction of the new VOC treatment system components, ex situ chromium treatment system, wellhead 1,4-dioxane treatment system, and implementation of these remedy elements under Alternatives 5a and 5b would likely require 1 to 3 years. Construction of new pipelines and wells under Alternative 5a may create a temporary nuisance to residents. Under Alternative 5b, construction of the injection wells, additional pipelines, and additional monitoring wells may create an additional nuisance to residents. These activities would not be expected to pose substantial risks to the community during construction or implementation, nor would they pose any risks to workers beyond general hazards associated with any large construction project. No adverse environmental impacts are anticipated in the areas where facilities would be constructed.

During the design, permitting, and construction process, it is assumed that wellhead treatment for chromium and 1,4-dioxane at NHE-2 would be implemented as planned by Honeywell, and the existing NHOU treatment system will continue to be operated in such a manner that the contaminant concentrations in the treatment plant effluent remain below the MCLs and notification levels. Therefore, Alternatives 5a and 5b are expected to be protective of human health in the short term

5.2.5.6 Implementability

There are no difficulties anticipated with the availability of services and materials required to implement Alternatives 5a and 5b. Techniques for drilling the new wells and constructing the new VOC treatment system are well known and will follow standard industry practices. The recommended ex situ treatment process for chromium and wellhead treatment process for 1,4-dioxane are relatively new; however, the technologies involved have been successfully implemented at other sites with similar hydrogeologic conditions. Due to the large size and capacity of the chromium-treatment process under Alternatives 5 and 5b, its design, construction, and operation may present some technical challenges. These challenges are anticipated to be surmountable and should not significantly affect implementation. Alternative 5b includes injection wells, which can be difficult and costly to operate and maintain. Vendors are available for well repair, installation, and related services. Several contractors are capable of implementing the ex situ (wellhead) treatment processes. During the design phase for the components of Alternatives 5a or 5b, operation of the Existing NHOU Extraction and Treatment System will continue.

The ICs component of Alternatives 5a and 5b is expected to be implementable from an administrative standpoint. Access agreements would be required for installation and sampling of the new monitoring and extraction wells, and additional permitting efforts are anticipated for the new pipeline between the new extraction wells and the NHOU treatment system. Also, municipal use of the treated groundwater will require compliance with the CDPH 97-005 policy.

5.2.5.7 Cost

The estimated capital cost for Alternative 5a $61.7 million. Annual O&M costs for Alternative 5a are estimated to be $9.4 million. The estimated capital cost for Alternative 5b is $104.4 million. Annual O&M costs for Alternative 5b are estimated to be $8.6 million. Assuming a discount rate of 7 percent, the total NPVs are estimated to be $118.5 million for Alternative 5a and $146.3 million for Alternative 5b. Appendix D provides details of the cost estimates for these alternatives.

5.2.5.8 State Acceptance

State acceptance for Alternatives 5a and 5b is currently unknown and will be assessed based on input received during the public comment period. However, the State has expressed its support for Alternative 4a.

5.2.5.9 Community Acceptance

Community acceptance for Alternatives 5a and 5b is currently unknown and will be assessed based on input received during the public comment period.

5.3 Comparative Analysis of Remedial Alternatives

Section 5.3 presents a comparative analysis of the relative performance for each of the remedial alternatives using the evaluation criteria. A summary of the evaluation is presented in Table 5-1.

5.3.1 Overall Protection of Human Health and the Environment

Alternative 1 does not provide adequate hydraulic containment of the most highly contaminated groundwater in the NHOU. Furthermore, although it is able to remove contaminants in extracted groundwater to acceptable levels, Alternative 1 does not provide double barrier protection for drinking water (the current beneficial use). Therefore, Alternative 1 is considered to provide a relatively low level of protection of human health and the environment compared to Alternatives 2a through 5b.

Alternatives 2a through 5b would each achieve improved hydraulic containment of the most highly contaminated groundwater in the NHOU and thus the same level of improvement in this regard compared to Alternative 1. Under Alternatives 2a, 3a, 4a, and

5a (LADWP-delivery for end use of treated groundwater), double barrier treatment for VOCs provides an added level of safety towards ensuring that treated water meets all drinking water standards and requirements.

Alternatives 2a through 3b provide for chromium treatment only from extraction wells NHE-1 and NHE-2. Under expected future production pumping scenarios, new extraction wells NEW-2 and NEW-3 are forecasted to intercept groundwater contaminated with high levels of chromium. Only Alternatives 4a through 5b include chromium treatment for groundwater extracted by these two extraction wells.

Alternatives 5a and 5b expand chromium treatment to include all of the existing and new NHOU extraction wells. However, chromium treatment is not expected to be required at all wells in order to meet the cleanup levels for either end use, and a larger quantity of treatment residuals would be produced by the chromium treatment system under Alternatives 5a and 5b than the other alternatives.

5.3.2 Compliance with ARARs

Alternatives 1, 2a, 3a, 4a, and 5a (i.e., those alternatives where treated water is delivered to the LADWP water supply system) are expected to comply with the current MCLs and with all other ARARs for those alternatives. Alternatives 4b, and 5b (for which reinjection is the end use of treated water) are expected to comply with ARARs, including the State's anti-degradation policy, under a wide range of pumping scenarios. However, Alternatives 2b and 3b may result in chromium concentrations exceeding the cleanup level in the NHOU treated effluent and thus fail to comply with the State's anti-degradation policy ARAR under the expected future pumping scenarios, or if the current Honeywell effort to remediate hexavalent chromium in the vadose zone and aquifer in situ is less effective than expected.

5.3.3 Long-term Effectiveness and Permanence

Each alternative provides some degree of long-term protection. Alternative 1 would be effective in removing contaminants from the water that it captures and treats, but its limited extraction system would allow areas of high VOC and chromium contamination to migrate towards LADWP well fields, and the existing extraction system will not prevent hexavalent chromium from migrating to other NHOU extraction wells that lack chromium treatment.

Under Alternatives 2a through 5b, the improvements to the extraction and treatment system will result in containment of the high concentration plumes and prevent further degradation of water quality in the vicinity of the LADWP well fields. These alternatives will thus have a much higher degree of long-term protection than Alternative 1. However, implementation of the reinjection option for discharge of treated water (Alternatives 2b, 3b, 4b, and 5b) would likely result in treated water becoming contaminated again following reinjection.

Alternatives 4a and 4b would provide an increased level of effectiveness and permanence as compared to Alternatives 2a through 3b, as they provide for chromium removal from new NHOU extraction wells NEW-2 and NEW-3. Alternatives 5a and 5b expand chromium treatment to include all of the existing and new NHOU extraction wells. However, chromium treatment is not presently required at all existing extraction wells, nor is it predicted to be needed in the future unless an MCL for hexavalent chromium is set at a level

TABLE 5-1
Comparison of Remedial Alternatives
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Feasibility Criteria	Alternative 1 Existing Remedy	Alternatives 2a and 2b Expand Extraction Well System plus Chromium Wellhead Treatment at Wells NHE-1 & NHE-2	Alternatives 3a and 3b Expand Extraction Well System plus Chromium Treatment for Combined Flow from Wells NHE-1 & NHE-2	Alternatives 4a and 4b Expand Extraction Well System plus Ex Situ Chromium Treatment for Wells NHE-1 and -2 and NEW-2 and -3	Alternatives 5a and 5b Expand Extraction Well System plus Ex Situ Chromium Treatment for All Extraction Wells
Threshold Criteria					
Overall Protection of Human Health and the Environment	Currently removes VOC contaminants in extracted groundwater to acceptable levels; however, does not provide adequate hydraulic containment of the most highly contaminated groundwater in the NHOU, nor does it provide double barrier protection for drinking water (the current beneficial use). Provides for chromium treatment only at well NHE-2.	Containment of the VOC plume is significantly improved compared to Alternative 1, including full containment of the high concentration areas. "Double barrier" protection from VOC contamination under Alternative 2a (delivery to LADWP). Provides for chromium treatment only at wells NHE-1 and NHE-2.	Similar level of protectiveness as Alternatives 2a and 2b.	Improved hydraulic containment compared to Alternative 1 (identical to Alternatives 2a through 3b); also includes chromium treatment for extraction wells NEW-1 and NEW-2.	Improved hydraulic containment compared to Alternative 1 (identical to Alternatives 2a through 4b); also includes chromium treatment for all extraction wells. However, chromium treatment is not expected to be required at all wells in order to meet the cleanup levels for either end use, and a larger quantity of treatment residuals would be produced by the chromium treatment system under Alternatives 5a and 5b.
Compliance with ARARs	Expected to comply with the current MCLs and with all other ARARs	Alternative 2a is expected to comply with the current MCLs and with all other ARARs. Treating only wells NHE-1 and NHE-2 for chromium may result in chromium concen-trations in the NHOU treated effluent exceeding the cleanup level and thus Alternative 2b may fail to comply with the State's anti-degradation policy ARAR for reinjection.	Similar to Alternative 2a, 3a is expected to comply with MCLs and ARARs under future conditions. Treating only wells NHE-1 and NHE-2 for chromium may result in chromium concentrations in the NHOU treated effluent exceeding the cleanup level and thus 3b may fail to comply with the State's anti-degradation policy ARAR.	Expected to comply with the current MCLs and with all other ARARs. If reinjection is the end use of treated water, expected to comply with ARARs, including the State's anti-degradation policy.	Expected to comply with the current MCLs and with all other ARARs. If reinjection is the end use of treated water, expected to comply with ARARs, including the State's anti-degradation policy (similar to Alternatives 4a and 4b).
Balancing Criteria					
Long-term Effectiveness and Permanence	Effective in removing contaminants from the water that it captures and treats, but its limited extraction system would allow VOC and chromium contamination to migrate towards LADWP well fields and other NHOU extraction wells that lack chromium treatment.	Improved extraction and treatment system will result in containment of the high concentration plumes and prevent further degradation of water quality in the vicinity of the LADWP well fields. However, reinjection of treated water under Alternative 2b would likely result in treated water becoming contaminated again following reinjection.	Identical long-term effectiveness and permanence as Alternatives 2a and 2b.	Chromium removal from new NHOU extraction wells NEW-2 and NEW-3 would provide an increased level of effectiveness and permanence compared to Alternatives 2a through 3b.	Similar to Alternatives 4a and 4b, with the additional capability of treating chromium extracted from all NHOU extraction wells. However, chromium treatment is not presently required at all existing extraction wells, nor is it predicted to be needed in the future unless an MCL for hexavalent chromium is set at a level below 5 μg/L. Treatment of the combined discharge from all of the extraction wells under Alternatives 5a and 5b would require significantly more energy and result in production of greater volumes of treatment residuals than the other alternatives.
Reduction of Toxicity, Mobility, and Volume Through Treatment	Toxicity, mobility, and volume of contaminants in extracted groundwater will be permanently reduced by treatment. However, due to smaller groundwater extraction rates compared to the other alternatives, Alternative 1 will provide a lower degree of reduction of toxicity, mobility, and volume through treatment. Alternative 1 also provides less treatment for chromium in groundwater.	Will result in further reduction of the mobility and volume of VOCs and chromium in groundwater compared to Alternative 1, by increasing the volume of contaminated groundwater that is contained, extracted and treated in the NHOU. TCE, PCE, and other VOCs in groundwater will be removed with an expanded treatment system that traps VOCs and permanently destroys them at an off-site carbon regeneration facility. Chromium will be removed from groundwater extracted by wells NHE-1 and NHE-2.	Identical reduction of toxicity, mobility, and volume of contaminants as Alternatives 2a and 2b.	Similar reduction of mobility of VOCs and chromium as Alternatives 2a through 3b. The combined chromium treatment system for extraction wells NHE-1, NEW-2, and NEW-3 would provide a greater degree of chromium mass removal from the extracted groundwater than Alternatives 2a through 3b, and also produce more treatment residuals.	Similar reduction of mobility of VOCs and chromium as Alternatives 2a through 4b. The combined chromium treatment system for all extraction wells would slightly increase chromium mass removal from the extracted groundwater than Alternatives 2a through 3b, and produce more treatment residuals.

TABLE 5-1
Comparison of Remedial Alternatives
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Feasibility Criteria	Alternative 1 Existing Remedy	Alternatives 2a and 2b Expand Extraction Well System plus Chromium Wellhead Treatment at Wells NHE-1 & NHE-2	Alternatives 3a and 3b Expand Extraction Well System plus Chromium Treatment for Combined Flow from Wells NHE-1 & NHE-2	Alternatives 4a and 4b Expand Extraction Well System plus Ex Situ Chromium Treatment for Wells NHE-1 and -2 and NEW-2 and -3	Alternatives 5a and 5b Expand Extraction Well System plus Ex Situ Chromium Treatment for All Extraction Wells
Short-term Effectiveness	No substantial risks or environmental impacts would be posed to the community during the limited work involved in implementing this alternative.	No substantial risks or environmental impacts to the community or workers during construction or implementation of this alternative, beyond the general hazards associated with any con-struction project. Construction of new pipelines and wells may create a temporary nuisance to residents.	No substantial risks or environmental impacts (similar to Alternatives 2a and 2b). However, construction of an additional new pipeline from extraction well NHE-2 to the NHOU treatment plant site may create an additional temporary nuisance to residents.	No substantial risks or environmental impacts (similar to Alternatives 2a and 2b). However, some nuisance to residents related to construction of new pipelines, wells, and a larger chromium treatment system.	No substantial risks or environmental impacts (similar to Alternatives 2a and 2b). However, some nuisance to residents related to construction of new pipelines, wells, and a larger chromium treatment system.
Implementability (technical)	Technically feasible to implement. No unusual technical difficulties are anticipated for design, construction, and operation of the additional extraction wells and more robust VOC treatment system. All the necessary services and materials are readily available.	Technically feasible to implement. Construction of the injection wells, pipeline, and additional monitoring wells will add significantly to the time and effort required to implement Alternative 2b (reinjection).	Technically and administratively feasible to implement. Construction of the injection wells, pipeline, and additional monitoring wells will add significantly to the time and effort required to implement Alternative 3b (reinjection).	Technically and administratively feasible to implement. Slightly more effort required to implement than Alternatives 2a through 3b (for design, construction, and operation of a chromium treatment system capable of handling the combined discharge from three extraction wells). Construction of the injection wells, pipeline, and additional monitoring wells will add significantly to the time and effort required to implement Alternative 4b (reinjection).	Alternatives 5a and 5b would require significantly more effort than Alternatives 4a and 4b (for design, construction, and operation of a chromium treatment system capable of handling the combined discharge from all of the extraction wells).
Implementability (administrative)	Continued coordination would be required with the ULARA Watermaster and LAWDP to implement and maintain the ICs. The ability of Alternative 1 to achieve cleanup levels for chromium in the combined effluent from the NHOU treatment system under the expected pumping scenarios is uncertain. Because of this uncertainty, LADWP and/or State agencies may not accept the current end use for the treated water under this alternative.	Additional administrative issues (compared to Alternative 1) are anticipated regarding permitting and access requirements for the new extraction wells and pipelines, as well as completing the permit application process for either end use option (LADWP delivery or reinjection). The ability of Alternatives 2a and 2b to achieve cleanup levels for chromium in the combined effluent from the NHOU treatment system under the expected pumping scenarios is uncertain. Because of this uncertainty, LADWP and/or State agencies may not accept either of the planned end use options for the treated water under these alternatives.	Identical administrative implementability issues as Alternatives 2a and 2b.	Additional administrative issues (compared to Alternative 1) are anticipated regarding permitting and access requirements for the new extraction wells and pipelines, as well as completing the permit application process for either end use option (LADWP delivery or reinjection). However, expanded chromium treatment should improve the acceptability of the treated water for the end use options.	Identical administrative implementability issues as Alternatives 4a and 4b.
Costs					
Estimated Total Net Present Value (NPV), Including Capital and O&M Costs for 30 Years, Assuming a 7 Percent Discount Rate	$40.1 million	Alternative 2a: $91.7 million Alternative 2b: $118.1 million	Alternative 3a: $82.6 million Alternative 3b: $109.0 million	Alternative 4a: $107.8 million Alternative 4b: $134.2 million	Alternative 5a: $119.9 million Alternative 5b: $146.3 million
Modifying Criteria					
State Acceptance	State agencies have indicated that Alternative 1 is not acceptable because of the continued migration of groundwater contamination and the potential for chromium contamination to migrate and further degrade the aquifer. The State has expressed its support for Alternative 4a, EPA's Preferred Alternative.				
Community Acceptance	LADWP has indicated that this alternative is not acceptable. Public acceptance to be determined	To be determined.	To be determined.	To be determined.	To be determined.

below 5 µg/L. Treatment of the combined discharge from all of the extraction wells under Alternatives 5a and 5b would require significantly more energy and result in production of greater volumes of treatment residuals than would be produced under Alternatives 2a through 4b, which focus chromium treatment on those wells requiring it.

5.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

All alternatives provide for reduction of toxicity, mobility, or volume through extraction of contaminated groundwater and treatment of VOCs at the NHOU treatment plant. TCE, PCE, and other VOCs in groundwater extracted from the NHOU will be removed with a treatment system that traps VOCs in granular activated carbon, and then permanently destroys them at an off-site carbon regeneration facility. The overall rate of groundwater extraction for Alternative 1 is significantly less than the flow rates for Alternatives 2a through 5b, and thus Alternative 1 will provide a lower degree of reduction of toxicity, mobility, and volume through treatment. In addition, Alternative 1 also provides less treatment for chromium in groundwater.

Under Alternatives 2a through 3b, chromium will be removed by wellhead treatment at extraction wells NHE-1 and NHE-2. The combined chromium treatment system for additional extraction wells included in Alternatives 4a through 5b would provide a greater degree of chromium mass removal from the extracted groundwater than Alternatives 2a through 3b.

5.3.5 Short-term Effectiveness

The modifications to the Existing NHOU Extraction and Treatment System included in Alternative 1 are minor, and do not pose substantial risks to the community or construction workers during implementation. No adverse environmental impacts are anticipated in the areas where facilities would be constructed.

Similar to Alternative 1, no special worker-protection issues or environmental impacts are anticipated under Alternatives 2a through 5b. Construction of pipelines from the new extraction wells to the NHOU treatment plant may create a temporary nuisance to residents but should not pose any significant risks. Similarly, under Alternatives 2b, 3b, 4b, and 5b, construction of the injection wells, additional pipelines, and additional monitoring wells may create an additional nuisance to residents but do not pose any substantial risks to the community or construction workers.

Alternatives 2a through 5b would take longer to implement (approximately 3 years) than Alternative 1, which is largely in place already. During that time, the existing NHOU treatment system would continue to be operated in such a manner that the contaminant concentrations in the treatment plant effluent remain below the MCLs and notification levels. Therefore, Alternatives 2a through 5b are expected to be equally protective of human health in the short term as Alternative 1.

5.3.6 Implementability

All alternatives are considered to be technically feasible to implement, although implementation of Alternatives 2a through 5b will require substantially more effort than Alternative 1. Alternatives 5a and 5b are expected to be significantly more difficult to implement from a technical standpoint than Alternatives 2a through 4b, due to the relatively large chromium treatment system required. As noted in the discussion of Compliance with ARARs, the ability of Alternatives 2b and 3b to achieve cleanup levels for chromium in the combined effluent from the NHOU treatment system under the expected pumping scenarios is uncertain. Because of this uncertainty, LADWP and/or State agencies may not accept either of the planned end use options for the treated water under these alternatives. Therefore, implementation of Alternatives 1 through 3b is expected to be more difficult than Alternatives 4a and 4b from an administrative standpoint.

5.3.7 Cost

A summary of the capital, annual O&M, and net present value (NPV) cost for each alternative is presented in Table 5-2. These cost estimates are based on a 7 percent discount rate and 30-year O&M period.

TABLE 5-2
Summary of Estimated Costs for Remedial Alternatives
Focused Feasibility Study, North Hollywood Operable Unit, San Fernando Valley Area 1 Superfund Site

Alternative	Capital Costs ($)	Annual O&M Costs ($)	Total Estimated NPV (assuming 30 Years of O&M at 7% Discount Rate) ($)
1 (LADWP delivery)	16,300,000	3,772,000	40,100,000
2a (LADWP delivery option)	46,500,000	8,318,000	91,700,000
2b (reinjection option)	89,300,000	8,091,000	118,100,000
3a (LADWP delivery option)	45,300,000	7,679,000	82,600,000
3b (reinjection option)	88,100,000	6,876,000	109,000,000
4a (LADWP delivery option)	52,300,000	9,364,000	107,800,000
4b (reinjection option)	95,000,000	8,561,000	134,200,000
5a (LADWP delivery option)	60,500,000	9,344,000	119,900,000
5b (reinjection option)	103,300,000	8,541,000	146,300,000

Note:

Capital costs have been rounded to the nearest $100,000. Annual O&M costs have been rounded to the nearest $1,000. Total estimated NPV has been rounded to the nearest $100,000.

As described in Appendix C, numerous assumptions have been made in estimating these costs. Details of the cost estimates for each alternative are provided in Appendix D. It is expected that deviations from the assumptions would have a much larger impact on the relative difference in costs between Alternative 1 (continued operation of the Existing NHOU Extraction and Treatment System) compared to Alternatives 2a through 5b. Deviation from the cost assumptions would not likely have as large of an impact on the relative costs of Alternatives 2a through 5b, which have several major components in common that are not included in Alternative 1.

Alternative 1 is the lowest-cost alternative (see Table 5-2) over a 30-year period. Alternatives 2a and 3a, which are identical except for the individual versus combined chromium treatment units for extraction wells NHE-1 and NHE-2, are the next highest-cost alternatives. The difference between costs for these alternatives is within the range of uncertainty in the cost estimate, and should be considered approximately equal. Alternatives 4a and 5a have progressively higher costs, largely due to the higher flow volumes to be treated for chromium. Estimated costs for implementation of the reinjection option for end use of treated water (Alternatives 2b, 3b, 4b, and 5b), which includes construction of additional wells and pipelines, are substantially greater than the LADWP-delivery option (Alternatives 2a, 3a, 4a, and 5a), which requires double barrier VOC treatment.

5.3.8 State Acceptance

State agencies have indicated that Alternative 1 is not acceptable because of the continued migration of groundwater contamination and the potential for chromium contamination to migrate and further degrade the aquifer. The State has expressed its support for Alternative 4a, EPA's Preferred Alternative.

5.3.9 Community Acceptance

The LADWP has indicated that Alternative 1 is not acceptable because of the continued migration of groundwater contamination and the potential for chromium contamination to migrate and further degrade the aquifer. Acceptance from community members other than LADWP is currently unknown and will be assessed based on the input received during the public comment period.

5.4 Preferred Alternative

EPA's Preferred Alternative is Alternative 4a, which includes the construction of three new extraction wells, the modification/rehabilitation of several existing extraction wells, expanded VOC treatment, chromium treatment for NHE-1, NHE-2 and two of the new extraction wells, and use of the treated water in LADWP's water supply system. Figure 4 schematically illustrates the major components of Alternative 4a.

Based on the information currently available, EPA believes the Preferred Alternative meets the threshold criteria and provides the best balance of trade-offs among the other alternatives. Under Alternative 4a, the installation of additional extraction wells, the modification of existing extraction wells, and expansion of the VOC treatment system will achieve significantly improved plume capture and prevent further degradation of water quality at the Rinaldi-Toluca and North Hollywood West well fields. This alternative will also result in permanent and significant reduction in the mobility and volume of VOCs in groundwater in the NHOU. Alternative 4a also specifically provides for chromium removal from the extraction wells where the highest chromium concentrations are expected to occur and will achieve the treated water cleanup level of 5 μg/L for hexavalent chromium under a wide range of expected pumping scenarios.

The reuse option under Alternative 4a, delivery of treated water to LADWP, provides the greatest beneficial use of the treated water and at a significantly lower cost than reinjection.

The Preferred Alternative includes the installation and sampling of new monitoring wells to evaluate performance of the remedy and to better characterize the plume in certain areas of the NHOU. EPA will use the resulting data to evaluate the need for and scope of additional remedial actions within the NHOU. The State has expressed support for EPA's Preferred Alternative.

SECTION 6
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Appendix A
Summary of Recent Analytical Data
(January 2003 through December 2007)

Appendix B
Groundwater Model Development

Appendix C
Design Assumptions and Calculations

Appendix D
Cost Estimates

Appendix E
Facility Data Summary