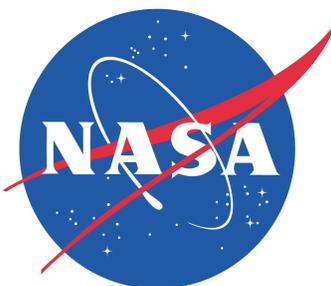


# GROUNDWATER MONITORING REPORT

OCTOBER - NOVEMBER 2002

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
JET PROPULSION LABORATORY  
PASADENA, CALIFORNIA



Contract No. N68711-98-D-5537, D.O. No. 0012-12

Naval Facilities Engineering Command  
1220 Pacific Highway, Building 127  
San Diego, CA 92132-5187

Prepared by:

**SOTA Environmental Technology, Inc.**  
16835 West Bernardo Drive, Suite 212  
San Diego, CA 92127-1613

Project No. 00HW019

Version: Final  
April 9, 2003



**GROUNDWATER  
MONITORING REPORT  
OCTOBER - NOVEMBER 2002**

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
JET PROPULSION LABORATORY  
4800 Oak Grove Drive  
Pasadena, California 91109**

Prepared for:

**Naval Facilities Engineering Command**  
1220 Pacific Highway  
San Diego, California 92132-5187

**Contract No. N68711-98-D-5537 D.O. No. 0012-12**

Prepared by:

**SOTA Environmental Technology, Inc.**  
16835 West Bernardo Drive, Suite 212  
San Diego, California 92127-1613

Version: Final  
April 9, 2003

Signature: \_\_\_\_\_

Mike Sayre, R.G., C.E.G., Professional Geologist



Date: \_\_\_\_\_

4/9/03

Signature: \_\_\_\_\_

Carl E. Schubert, Ph.D., Quality Assurance Director

Date: \_\_\_\_\_

4-9-03

Signature: \_\_\_\_\_

Dakshana Murthy, Ph.D., P.E., Program Manager

Date: \_\_\_\_\_

4/9/03

## TABLE OF CONTENTS

Section	Page
ACRONYMS/ABBREVIATIONS.....	v
EXECUTIVE SUMMARY .....	vi
1.0 INTRODUCTION .....	1
2.0 FIELD SAMPLING PROCEDURES.....	3
2.1 Shallow Monitoring Wells.....	3
2.2 Deep Multi-Port Monitoring Wells.....	3
2.3 Field Quality Assurance/Quality Control Samples.....	4
3.0 ANALYTICAL RESULTS .....	6
3.1 Volatile Organic Compounds .....	6
3.2 Perchlorate .....	8
3.3 Metals.....	8
3.4 Quality Assurance/Quality Control.....	9
4.0 DATA VERIFICATION AND VALIDATION.....	11
4.1 Data Verification.....	11
4.2 Data Validation .....	11
4.3 Data Validation Qualifiers .....	11
5.0 WATER LEVEL MEASUREMENTS .....	12
6.0 CONCLUSIONS AND RECOMMENDATIONS .....	13
7.0 REFERENCES .....	15

### LIST OF TABLES

Table 1-1	Summary of Well Construction Details for JPL Groundwater Monitoring Wells
Table 3-1	Summary of Analyses Performed on Groundwater Samples Collected from JPL Monitoring Wells, October - November 2002
Table 3-2	Location of JPL Wells/Well Screens in Aquifer Layers
Table 3-3	Summary of Volatile Organic Compounds and Perchlorate Detected in Groundwater Samples Collected from JPL Monitoring Wells, October - November 2002

Table 3-4	Summary of Volatile Organic Compounds and Perchlorate Detected during the JPL Groundwater Monitoring Program
Table 3-5	Summary of Volatile Organic Compounds and Perchlorate in Groundwater Samples Collected from Municipal Production Wells near JPL through November 2002
Table 3-6	Results of Metals Analyses of Groundwater Samples Collected from JPL Monitoring Wells
Table 3-7	Summary of Metals Detected during the JPL Groundwater Monitoring Program
Table 5-1	Groundwater Monitoring Well Water Level Measurements, October 14, 2002
Table 5-2	Groundwater Monitoring Well Water Level Measurements, November 7, 2002

## LIST OF FIGURES

Figure 1-1	Locations of JPL Groundwater Monitoring Wells and Nearby Municipal Production Wells
Figure 3-1	Contours of Carbon Tetrachloride Concentrations in Aquifer Layer 1
Figure 3-2	Contours of Carbon Tetrachloride Concentrations in Aquifer Layer 2
Figure 3-3	Contours of Carbon Tetrachloride Concentrations in Aquifer Layer 3
Figure 3-4	Contours of Trichloroethene Concentrations in Aquifer Layer 1
Figure 3-5	Contours of Trichloroethene Concentrations in Aquifer Layer 2
Figure 3-6	Trichloroethene Concentrations in Aquifer Layer 3
Figure 3-7	Contours of Tetrachloroethene Concentrations in Aquifer Layer 1
Figure 3-8	Tetrachloroethene Concentrations in Aquifer Layer 2
Figure 3-9	Contours of Tetrachloroethene Concentrations in Aquifer Layer 3
Figure 3-10	Contours of Perchlorate Concentrations in Aquifer Layer 1
Figure 3-11	Contours of Perchlorate Concentrations in Aquifer Layer 2
Figure 3-12	Contours of Perchlorate Concentrations in Aquifer Layer 3
Figure 3-13	Carbon Tetrachloride Detected at MW-3
Figure 3-14	Perchlorate Detected at MW-3
Figure 3-15	Carbon Tetrachloride Detected at MW-4
Figure 3-16	Trichloroethene Detected at MW-4
Figure 3-17	1,2-DCA Detected at MW-4
Figure 3-18	Perchlorate Detected at MW-4
Figure 3-19	Carbon Tetrachloride Detected at MW-5
Figure 3-20	Trichloroethene Detected at MW-5

- Figure 3-21 Perchlorate Detected at MW-5
- Figure 3-22 Tetrachloroethene Detected at MW-6
- Figure 3-23 Perchlorate Detected at MW-6
- Figure 3-24 Carbon Tetrachloride Detected at MW-7
- Figure 3-25 Trichloroethene Detected at MW-7
- Figure 3-26 1,2-DCA Detected at MW-7
- Figure 3-27 1,1-DCE Detected at MW-7
- Figure 3-28 Perchlorate Detected at MW-7
- Figure 3-29 Carbon Tetrachloride Detected at MW-8
- Figure 3-30 Perchlorate Detected at MW-8
- Figure 3-31 Carbon Tetrachloride Detected at MW-10
- Figure 3-32 Trichloroethene Detected at MW-10
- Figure 3-33 Perchlorate Detected at MW-10
- Figure 3-34 Carbon Tetrachloride Detected at MW-11
- Figure 3-35 Carbon Tetrachloride Detected at MW-12
- Figure 3-36 Perchlorate Detected at MW-12
- Figure 3-37 Carbon Tetrachloride Detected at MW-13
- Figure 3-38 Trichloroethene Detected at MW-13
- Figure 3-39 1,2-DCA Detected at MW-13
- Figure 3-40 Perchlorate Detected at MW-13
- Figure 3-41 Perchlorate Detected at MW-14
- Figure 3-42 Carbon Tetrachloride Detected at MW-16
- Figure 3-43 Trichloroethene Detected at MW-16
- Figure 3-44 1,2-DCA Detected at MW-16
- Figure 3-45 Perchlorate Detected at MW-16
- Figure 3-46 Carbon Tetrachloride Detected at MW-17
- Figure 3-47 Trichloroethene Detected at MW-17
- Figure 3-48 Perchlorate Detected at MW-17
- Figure 3-49 Carbon Tetrachloride Detected at MW-18
- Figure 3-50 Trichloroethene Detected at MW-18
- Figure 3-51 Tetrachloroethene Detected at MW-18
- Figure 3-52 Perchlorate Detected at MW-18

- Figure 3-53 Perchlorate Detected at MW-19
- Figure 3-54 Perchlorate Detected at MW-20
- Figure 3-55 Trichloroethene Detected at MW-21
- Figure 3-56 Tetrachloroethene Detected at MW-21
- Figure 3-57 Perchlorate Detected at MW-21
- Figure 3-58 Perchlorate Detected at MW-22
- Figure 3-59 Carbon Tetrachloride Detected at MW-23
- Figure 3-60 Trichloroethene Detected at MW-23
- Figure 3-61 Perchlorate Detected at MW-23
- Figure 3-62 Carbon Tetrachloride Detected at MW-24
- Figure 3-63 Trichloroethene Detected at MW-24
- Figure 3-64 Perchlorate Detected at MW-24
- Figure 5-1 Water-Table Elevation Contour Map, October 14, 2002
- Figure 5-2 Water-Table Elevation Contour Map, November 7, 2002
- Figure 5-3 Hydraulic Head Elevations from Deep Multi-Port Wells, October - November 2002

## **LIST OF APPENDICES**

- Appendix A - Well Development/Well Sampling Log Forms for Shallow Wells and Groundwater Sampling Field Data Sheets for Deep Multi-Port Wells
- Appendix B - Laboratory Analytical Reports and Chain-of-Custody Forms
- Appendix C - Data Validation Reports
- Appendix D - Piezometric Pressure Profile Records

## ACRONYMS/ABBREVIATIONS

1,1-DCA	1,1-Dichloroethane
1,2-DCA	1,2-Dichloroethane
1,1-DCE	1,1-Dichloroethene
AL	Drinking Water Action Level
APCL	Applied Physics and Chemistry Laboratory
ASTM	American Society for Testing and Materials
CA DHS	California Department of Health Services
CCl <sub>4</sub>	Carbon Tetrachloride
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
ClO <sub>4</sub> <sup>-</sup>	Perchlorate
Cr	Chromium
Cr (VI)	Hexavalent Chromium
DLR	Detection Limit for the Purposes of Reporting
DQOs	Data Quality Objectives
DTSC	Department of Toxic Substance Control
EPA	(United States) Environmental Protection Agency
gpm	Gallons per Minute
JPL	Jet Propulsion Laboratory
LDC	Laboratory Data Consultants, Inc.
MCLs	Maximum Contaminant Levels
µg/L	Micrograms per Liter
mg/L	Milligrams per Liter
mL	Milliliter
MS	Matrix Spikes
MSD	Matrix Spike Duplicates
MW	Monitoring Well
NASA	National Aeronautics and Space Administration
NTU	Nephelometric Turbidity Units
OU	Operable Unit
PCE	Tetrachloroethene
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RWQCB	California Regional Water Quality Control Board
SOTA	SOTA Environmental Technology, Inc.
TCE	Trichloroethene
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
Westbay	Westbay Instruments, Inc.

## EXECUTIVE SUMMARY

This report presents the results of the October - November 2002 groundwater sampling event completed as part of the groundwater monitoring program at the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL), performed under contract with Naval Facilities Engineering Command. During this sampling event, conducted from October 14 through November 7, 2002, groundwater samples were collected from 20 JPL monitoring wells, and analyzed for volatile organic compounds, perchlorate, and chromium (total and hexavalent).

All data collected were subject to data verification and all laboratory analytical data were validated pursuant to the Navy's Level IV quality assurance requirements. Some of the analytical data were qualified (i.e., flagged) based on data validation reviews, in accordance with applicable EPA guidelines. No data were rejected for non-compliance with method requirements during the course of validation and no data were qualified as unusable.

During the October - November 2002 event, three volatile organic compounds (carbon tetrachloride, trichloroethene, and tetrachloroethene) were reported at concentrations above State Maximum Contaminant Levels (MCLs) for drinking water in samples from one or more monitoring wells. Concentrations of these compounds above the MCLs have been, and continue to be, generally limited to groundwater beneath the JPL facility in Aquifer Layer 1. The carbon tetrachloride plume appears to have migrated southeast of JPL in Aquifer Layers 2 and 3, with concentrations at two off-facility wells (MW-17 and MW-18) and one active municipal production well exceeding the MCL. No samples collected from Aquifer Layer 3 contained trichloroethene concentrations exceeding the MCL and only one on-facility well sample (MW-14) exceeded the MCL in Aquifer Layer 2. Tetrachloroethene concentrations exceeding the MCL were only reported in Aquifer Layer 1 at one on-facility well (MW-7), but were not reported in any samples collected from Aquifer Layer 2, and have been consistently been reported in Aquifer Layer 3 only at one off-facility well located cross gradient of JPL (MW-21).

Perchlorate was detected during the October - November 2002 event at concentrations exceeding the AL in seven on-facility wells (MW-4 Screen 1, MW-5, MW-7, MW-8, MW-13, MW-16, and MW-24 Screen 1) and three off-facility wells (MW-17 Screen 3, MW-18 Screen 4, and MW-20 Screen 4). The highest levels of perchlorate were reported in samples from MW-7, MW-16, and MW-24 Screen 1. Perchlorate was reported in October - November 2002 samples at concentrations exceeding the Detection Limit for the Purposes of Reporting (DLR) and State Action Level in seven on-facility wells and three off-facility wells located south and east of JPL. Perchlorate concentrations exceeding the DLR appear generally limited to the JPL facility in Aquifer Layer 1, but appear to have migrated off-facility in Aquifer Layers 2 and 3. Perchlorate concentrations reported in samples from the farthest up gradient wells have generally increased over the last two years. Perchlorate was detected well above the DLR this event in Aquifer Layer 3, at MW-20, which is the farthest down gradient. Test data on drinking water from seven municipal production wells contained perchlorate concentrations exceeding the DLR. Six of these wells are located down gradient of JPL.

The total and hexavalent chromium results were generally consistent with the previous groundwater monitoring results. Total chromium was detected in all but three of the eighteen

wells sampled, but only exceed the State MCL at one on-facility well. Hexavalent chromium was only detected in on-facility well MW-13 (at the State MCL) and off-facility well MW-17 Screen 4 (below the State MCL).

During the October - November 2002 event (between October 14 and November 7, 2002), water levels rose, from roughly 1 foot to 5 feet, in all of wells except for the four nearest the mouth of the Arroyo. Groundwater gradient maps prepared for this event indicated groundwater gradients and flow directions that were generally consistent with previous observations (i.e., flow directed primarily to the south-southwest through the eastern portion of JPL and to the east-southeast in the southwest portion of JPL, Arroyo, and plain). Notably, water levels dropped in all wells (from about 1 foot to 10 feet) during the period from July 26, 2002 to October 14, 2002, except three located southeast of JPL near several municipal production wells. All but one of the increases were measured in Aquifer Layer 3, in which water levels rose from about 1 foot to almost 19 feet. The only rise in Aquifer Layer 2 water levels over this period was also measured in this area, and no increases were measured in Aquifer Layer 1. The measured water level fluctuations in this area suggest the strong influence of municipal production well activities on the deeper Aquifer Layers.

## 1.0 INTRODUCTION

This report summarizes the results from the October - November 2002 groundwater sampling event completed as part of the Groundwater Monitoring Program currently being conducted at the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL). This work is being performed by SOTA Environmental Technology, Inc. (SOTA) under contract with Naval Facilities Engineering Command, Contract No. N68711-98-D-5537 D.O. No. 0012-12. The JPL Monitoring Program was initiated in 1996 in response to a request from the United States Environmental Protection Agency (EPA). The program began during the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation of on-facility and off-facility groundwater at JPL.

The October - November 2002 groundwater monitoring event was conducted in accordance with the sampling program that was approved by the Environmental Protection Agency (EPA), Department of Toxic Substance Control (DTSC), and California Regional Water Quality Control Board (RWQCB). The purpose of the program is to monitor the elevation, flow direction, and quality of the groundwater beneath and adjacent to the JPL site.

Twenty-four wells have been installed for use in the JPL groundwater monitoring program. Nineteen of the JPL monitoring wells (MW-1 through MW-16 and MW-22 through MW-24) are on-facility wells and five are off-facility wells (MW-17 through MW-21). The JPL monitoring well locations are shown in Figure 1-1.

Thirteen of the JPL monitoring wells (MW-3, MW-4, MW-11, MW-12, MW-14, and MW-17 through MW-24) are deep wells, each equipped with a Westbay Instruments, Inc. (Westbay) multi-port casing system containing five screened intervals. Eleven of the monitoring wells are relatively shallow standpipe wells, each containing a single screened interval located just below the water table (MW-1, MW-2, MW-5 through MW-10, MW-13, MW-15, and MW-16). A summary of well construction details for the JPL groundwater monitoring wells is provided in Table 1-1.

During the October - November 2002 event, SOTA personnel collected samples from all JPL monitoring wells except on-facility wells MW-1, MW-2, MW-9, and MW-15. Shallow well MW-2 has not been sampled since it was replaced with deep multi-port well MW-14 as a JPL sampling point. Wells MW-1, MW-9, and MW-15 were not sampled during this event in accordance with the sampling program that was previously approved by the EPA, DTSC, and RWQCB.

Water levels were measured each of the JPL groundwater monitoring wells, except MW-7, prior to sampling (October 14, 2002) and after sampling (November 7, 2002) to evaluate groundwater flow directions and gradients. Water levels were not measured at MW-7 before sampling activities due to wellhead access restrictions associated with the pilot test being conducted by others.

JPL groundwater monitoring wells MW-3 through MW-8, MW-10 through MW-14, and MW-16 through MW-24 were sampled from October 15 through November 6, 2002. All of the JPL

groundwater samples were shipped to Applied Physics and Chemistry Laboratory (APCL) in Chino, California, for chemical analysis. APCL is certified by the California Department of Health Services and approved for use by the Naval Facilities Engineering Command, Quality Assurance/Quality Control (QA/QC) program. Sample collection procedures and sample analysis were conducted by SOTA in accordance with the Work Plan for Performing a Remedial Investigation/Feasibility Study (Ebasco, 1993a), which was approved by the regulatory agencies.

In addition to groundwater samples, field quality assurance/quality control (QA/QC) samples, including trip blanks, equipment blanks, duplicate samples, and a field blank were collected for laboratory analyses. Sampling records for each shallow well and field data sheets for deep multi-port wells are included in Appendix A. Laboratory analytical reports and associated chain-of-custody forms are included in Appendix B, and data validation reports are provided in Appendix C. Piezometric pressure profiling records for each deep multi-port well are included in Appendix D.

## **2.0 FIELD SAMPLING PROCEDURES**

Field sampling activities were performed in general accordance with the OU-1 Field Sampling and Analysis Plan (Ebasco, 1993b). Two different procedures were used to collect groundwater samples at JPL, one designed for the shallow wells and the other for the deep multi-port wells. These procedures are outlined below.

### **2.1 Shallow Monitoring Wells**

The sampling procedure described below was applied to all the shallow JPL monitoring wells, including MW-5, MW-6, MW-7, MW-8, MW-10, MW-13, and MW-16.

The primary equipment used to sample the shallow wells included dedicated 2-inch diameter Grundfos Redi-Flo2<sup>®</sup> pumps, a pump controller, and a 220-volt generator. All of the dedicated Grundfos Redi-Flo2<sup>®</sup> pump systems were previously decontaminated prior to their permanent installation, as outlined in the OU-1 Field Sampling and Analysis Plan (Ebasco, 1993b).

Prior to sample collection, the water in each shallow well casing was purged (by pumping at about 2.5 gpm) to remove groundwater that may have been exposed to the atmosphere and thus may not be representative of undisturbed aquifer conditions. This purged groundwater was discharged into 500 or 1,000-gallon polyethylene storage tanks for subsequent disposal by SOTA in accordance with Federal, State, and local regulations.

The temperature, pH, electrical conductivity, and turbidity of the water removed from each well were monitored during purging for stabilization. Calibration, or standardization of the field instruments used to measure temperature, pH, electrical conductivity, and turbidity, was performed according to the manufacturer's specifications at the beginning of each sampling day. After three casing volumes had been purged, or after the measured temperature, pH, turbidity, and electrical conductivity of the water had stabilized (when two successive measurements made approximately 3 minutes apart were within approximately 10 percent of each other), groundwater samples were collected using the dedicated pump.

During sampling for VOCs, the pumping rate was reduced to minimize sample agitation and volatilization. All sample bottles were filled completely without overflowing, capped, labeled, and immediately placed in a cooler with ice. Samples collected for VOCs had zero headspace. All information concerning sampling was noted on the Well Development/Well Sampling Log forms included in Appendix A.

### **2.2 Deep Multi-Port Monitoring Wells**

Sampling of the deep multi-port monitoring wells at JPL required specialized sampling equipment manufactured by Westbay. This equipment included a pressure profiling/sampling probe with a surface control unit. To ensure proper use, field personnel using this equipment were trained by Westbay personnel. Copies of the detailed operations manuals for the Westbay

pressure profiling/sampling probe are included in the OU-1 and OU-3 Field Sampling and Analysis Plans (Ebasco, 1993b; 1994).

The Westbay sampling probe and sample-collection bottles were decontaminated prior to sampling each screened interval in the deep multi-port wells according to the following procedures:

- Each 250-mL stainless-steel sample-collection bottle was washed in a solution of non-phosphate detergent (Liquinox<sup>®</sup>) and distilled water, followed by a solution of an acidic detergent (Citranox<sup>®</sup>) and distilled water.
- Each bottle was rinsed with distilled water.
- The interior surfaces of the Westbay sampling probe, and the hoses and valves associated with the Westbay sample bottles were decontaminated by forcing several volumes of a solution of Liquinox<sup>®</sup> and distilled water through them, followed by forcing several volumes of a solution of Citranox<sup>®</sup> and distilled water. A final rinse with distilled water was carried out. Each of these decontamination procedures was completed using clean plastic spray bottles used only for this purpose.

Purging before sampling was not required in the deep multi-port monitoring wells because the groundwater sample was collected directly from the aquifer, thus ensuring that the groundwater sample was not exposed to the atmosphere. However, at each screened interval, an initial sample was collected in order to check temperature, pH, electrical conductivity, and turbidity in the field. Samples for laboratory analysis were then collected and transferred to sample containers as described in Section 2.1. Results of the field analyses were recorded on groundwater sampling field data sheets, which are included in Appendix A. Calibration of field instruments was carried out according to procedures described previously.

### **2.3 Field Quality Assurance/Quality Control Samples**

Field QA/QC samples were collected to verify the quality of sampling procedures. The field QA/QC program included the collection of duplicate samples, equipment blanks, trip blanks, a field blank, and a source blank. Laboratory QA/QC samples were used by the laboratory according to analytical method requirements.

Duplicate samples for VOCs, perchlorate, and chromium (total and hexavalent) analyses were collected from one shallow monitoring well (MW-16) and five deep multi-port monitoring wells: MW-3 (Screen 4), MW-4 (Screen 2), MW-11 (Screen 3), MW-19 (Screen 5), and MW-23 (Screen 3).

Matrix-Spike (MS) and Matrix-Spike Duplicate (MSD) samples were collected for 10% of samples that were analyzed for VOCs, perchlorate, and chromium (total and hexavalent). These samples were used for laboratory QA/QC requirements.

One equipment blank was collected during each day of sampling the deep multi-port wells to identify potential cross-contamination due to inadequate sampling equipment decontamination. Because only dedicated sampling equipment was used, equipment blanks were not collected during sampling of the shallow wells. The equipment blanks consisted of distilled water that was passed through a stainless-steel Westbay sample collection bottle after decontamination. The equipment blanks were analyzed for the same constituents as the groundwater samples.

A trip blank, consisting of reagent-grade water placed in two 40-mL glass vials by the laboratory, was transported with the empty sample bottles to the field and back to the laboratory with the groundwater samples. One trip blank was submitted for VOC analysis with each shipment of groundwater samples to the laboratory. Trip blanks were used to identify potential cross-contamination of groundwater samples during transport.

A field blank, consisting of laboratory prepared reagent-grade water transferred in the field into two 40-mL glass vials, was transported back to the laboratory and analyzed for VOCs. The field blank was used to identify potential ambient air contamination from groundwater sample contamination.

During this sampling event, one source blank was collected to evaluate whether the source water or sample containers may have affected the analytical results. The source blank, consisting of sample bottles filled with distilled water, was analyzed for VOCs.

### 3.0 ANALYTICAL RESULTS

The groundwater samples collected during this sampling event were analyzed for the following:

- Volatile Organic Compounds by EPA Method 524.2
- Total Chromium (Cr) by EPA Method 200.8
- Hexavalent Chromium [Cr(VI)] by EPA Method 7196
- Perchlorate ( $\text{ClO}_4^-$ ) by CA DHS/EPA Method 314.0

A summary of the samples collected and the analyses performed on each sample is presented in Table 3-1. Analytical laboratory reports and associated chain-of-custody forms are included in Appendix B.

The aquifer beneath JPL was divided into four aquifer layers based primarily on correlations interpreted from lithologic cross sections (Foster Wheeler, 2000). Table 3-2 provides a list of the JPL Westbay monitoring well screens and their corresponding aquifer layers. These divisions were used to prepare contour maps (Figures 3-1 through 3-12) for carbon tetrachloride ( $\text{CCl}_4$ ), trichloroethene (TCE), tetrachloroethene (PCE), and perchlorate ( $\text{ClO}_4^-$ ) concentrations reported during this event in each aquifer layer.

#### 3.1 Volatile Organic Compounds

Groundwater samples collected during the October - November 2002 sampling event were analyzed for over 60 different VOCs in accordance with EPA Method 524.2. Results of the analyses for VOCs in these samples are summarized in Table 3-3 along with the State and Federal Maximum Contaminant Levels (MCLs) for drinking water as listed in Title 22 of the California Code of Regulations and in the EPA Health Advisory Guidelines. The VOC results compiled from the long-term sampling events that have been completed to date are summarized in Table 3-4.

Nine chemicals have been most commonly reported with concentrations above the laboratory detection limits [ $\text{CCl}_4$ , TCE, PCE, 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), Freon 113, chloroform, and  $\text{ClO}_4^-$ ]. The concentrations of these compounds versus time were plotted, if at any time they exceeded their respective MCL in the period from August/September 1996 through October - November 2002. The plots are presented in Figures 3-13 through 3-64.

A small number of compounds were detected in the JPL samples collected during the October - November 2002 event, and three VOCs [carbon tetrachloride, TCE, and PCE] were found in one or more wells at concentrations that exceeded State and/or Federal MCLs. The concentrations of carbon tetrachloride, TCE, and PCE detected in each aquifer layer were contoured on site maps to show the spatial distribution of each constituent (Figures 3-1 through 3-9). The analytical results for compounds that exceeded MCLs are discussed below.

- Carbon tetrachloride was detected in eight of the 15 on-facility wells sampled (MW-3, MW-5, MW-7, MW-8, MW-12, MW-13, MW-16, and MW-24), and two of the five off-facility wells (MW-17 and MW-18). Concentrations of carbon tetrachloride equal to or exceeding the State MCL (0.5 µg/L) were reported in samples from eight of the 15 on-facility wells sampled (MW-3 Screen 2, MW-5, MW-7, MW-8, MW-12 Screens 2, 3, and 4, MW-13, MW-16, and MW-24 Screen 1) and two of the five off-facility wells (MW-17 Screen 3 and MW-18 Screen 4). The highest concentrations of carbon tetrachloride were reported in on-facility wells MW-7 (150 µg/l) and MW-24 Screen 1 (22.2 µg/l).
- Trichloroethene was detected in 12 of the 15 on-facility wells sampled (all except MW-11, MW-12, and MW-22), and four of the five off-facility wells (all except MW-20). Reported TCE concentrations exceeded the State and Federal MCL (5.0 µg/L) in five on-facility wells (MW-5, MW-7, MW-8, MW-14 Screen 2, and MW-24 Screen 1) and one off-facility well (MW-21 Screen 1). The highest concentrations of TCE were reported in samples from on-facility well MW-5 (18.9 µg/L) and off-facility well MW-21 Screen 1 (11.3 µg/L).
- Tetrachloroethene was detected in eleven of the 15 on-facility wells sampled (all except MW-3, MW-11, MW-12, and MW-16), and in three of the five off-facility wells (all except MW-17 and MW-20). The State and Federal MCL (5.0 µg/L) was exceeded only in on-facility well MW-7 (32.8 µg/L), and off-facility well MW-21 (5.6 µg/L in Screen 4 and 10.9 µg/l in Screen 5).

Additional data regarding VOC concentrations in samples collected from the municipal production wells near JPL were obtained from the California Department of Health Services (CA DHS) Drinking Water Program. The most recently available analytical results were compiled for samples collected from 15 municipal and private drinking water wells owned and operated by the City of Pasadena, La Canada Irrigation District, Lincoln Ave. Water Company, Valley Water Company, Rubio Canon Land & Water Company, and Las Flores Water Company. The most recent production well data, summarized in Table 3-5 and utilized in the preparation of the concentration contour maps for CCl<sub>4</sub>, PCE, and TCE in Figures 3-1 through 3-9, indicate the following:

- CCl<sub>4</sub> concentrations were reported above the MCL at the City of Pasadena Well #52 in October 2002 and have previously been reported (February 1998) above the MCL at the inactivated City of Pasadena Arroyo Well.
- PCE concentrations were reported above the MCL at the Las Flores Water Company Well #2 in September 2002. Recent samples from Valley Water Company Wells #1 and #3, revealed PCE concentrations near the MCL (4.1 and 4 µg/L, respectively).
- TCE was detected in recent samples from all of the City of Pasadena Wells, both Lincoln Avenue Water Company wells and two of the four Valley Water Company wells (Wells #1 and #3) TCE concentrations in the most recent samples from all the municipal production wells were reported below the MCL.

### 3.2 Perchlorate

Perchlorate ( $\text{ClO}_4^-$ ) is among the unregulated chemicals requiring monitoring (Title 22, California Code of Regulations §64450). It is "unregulated" because it has no MCL. For contaminants found in drinking water that lack MCLs, the California Department of Health Services (DHS) uses an advisory action level (AL) set at 4  $\mu\text{g/L}$  to protect consumers from their adverse health effects. On January 18, 2002, DHS reduced the perchlorate AL (from the previous Interim Action Level of 18  $\mu\text{g/L}$ ) to 4  $\mu\text{g/L}$ , which corresponds to the current detection limit for purposes of reporting (DLR) and the level at which DHS is confident about the quantitation of the contaminant in drinking water.

Perchlorate analyses were conducted on groundwater samples from the October - November 2002 event using ion chromatography (EPA 314.0 modified) and the results are summarized in Table 3-3. Perchlorate was detected at concentrations exceeding the AL in seven on-facility wells (MW-4 Screen 1, MW-5, MW-7, MW-8, MW-13, MW-16, and MW-24 Screen 1) and three off-facility wells (MW-17 Screen 3, MW-18 Screen 4, and MW-20 Screen 4). The highest levels of perchlorate were reported in samples from MW-7 (13,300  $\mu\text{g/l}$ ), MW-16 (2,000  $\mu\text{g/l}$ ), and MW-24 (985  $\mu\text{g/l}$  in Screen 1). The October - November 2002 perchlorate concentrations, contoured for each of the three aquifer layers, are presented in Figures 3-10, 3-11, and 3-12.

Additional data regarding perchlorate concentrations in samples collected from the fifteen municipal production wells near JPL were obtained from the CA DHS Drinking Water Program. The most recently available analytical results were compiled for samples collected from municipal and private drinking water wells owned and operated by the City of Pasadena, La Canada Irrigation District, Lincoln Ave. Water Company, Valley Water Company, Rubio Canon Land & Water Company, and Las Flores Water Company. The most recent reported results indicated perchlorate concentrations exceeding the DLR/AL (4  $\mu\text{g/L}$ ) at all three active City of Pasadena Wells (Well #52, Ventura Well, and Windsor Well), Lincoln Avenue Water Company Well #5, Valley Water Company Well #1, Rubio Canon Land & Water Company Well #4, and Las Flores Water Company Well #2. The most recent drinking water data are summarized in Table 3-5 and presented in the concentration contour maps in Figures 3-10 through 3-12.

### 3.3 Metals

Groundwater samples collected during the October - November 2002 event were analyzed for total chromium and hexavalent chromium. The results of the chromium analyses are presented in Table 3-6. Table 3-7 presents a summary of metals data from all quarterly sampling events completed to date during the long-term monitoring program, including results for arsenic and lead collected during annual monitoring events. The October - November 2002 metals results are summarized below.

- Total chromium was detected in all wells sampled except MW-3, MW-5, and MW-17. The total chromium concentrations reported ranged from 0.002 to 0.057  $\text{mg/l}$ ,

with only the highest concentration exceeding the State MCL (0.05 mg/L) reported at on-facility well MW-13.

- Hexavalent chromium was detected only in on-facility well MW-13 (0.050 mg/L) and off-facility well MW-17 Screen 4 (0.045) mg/L. No Federal MCL has been established for hexavalent chromium. Hexavalent chromium is currently regulated by the State under the MCL for total chromium (0.05 mg/L).

### **3.4 Quality Assurance/Quality Control**

The temperature, pH, electrical conductivity, and turbidity of the water removed from each well were monitored during purging for stabilization. Review of the current and historical field turbidity data revealed both negative values (values that have no physical meaning) and outliers (significantly higher than previous measurements). It should be noted that the turbidity meter used has a full-scale reading of 800 NTU with an accuracy of +/- 10 NTU, and will read to -10 NTU. A negative reading can occur if the groundwater measured has a lower turbidity than the calibration fluid used. The outliers, which have been observed from the inception of the project, are all limited to deep wells and may be related to the relatively high gas levels in some samples. Often samples collected from these wells were noted to “effervesce”, a condition that would appear to the instrument as turbidity. Historic data has not shown any apparent correlation between metal concentrations and turbidity. Accordingly, stabilization of turbidity was not used as a criterion for determining whether shallow wells had been adequately purged and samples collected after purging a minimum of three casing volumes, in accordance with the FSP.

Review of the QA/QC data provided with the laboratory analytical results indicates that all of the analytical results obtained from October - November 2002 samples are acceptable for their intended use of characterizing aquifer quality. Surrogate compound, matrix and blank spike, and method blank results were used by the laboratory to determine the accuracy and precision of the analytical techniques with respect to the JPL groundwater matrix, and to identify anomalous results due to laboratory contamination or instrument malfunction. In addition to laboratory QA/QC samples, SOTA personnel collected QA/QC samples in the field in general accordance with Quality Assurance Project Plan (QAPP) (Ebasco, 1993c). The field QA/QC samples included duplicate samples, equipment rinsate blanks, trip blanks, a field blank, and a source blank.

Duplicate samples were used to evaluate the precision of the laboratory analyses. Duplicate samples for VOCs, perchlorate, and chromium (total and hexavalent) analyses were collected from one shallow monitoring well (MW-16) and five deep multi-port monitoring wells: MW-3 (Screen 4), MW-4 (Screen 2), MW-11 (Screen 3), MW-19 (Screen 5), and MW-23 (Screen 3). All of the analytical results for the duplicate samples, presented in Table 3-3 and Table 3-6, were comparable to the results of the original groundwater samples.

Equipment rinsate blanks were collected each day that non-dedicated sampling equipment was used. The equipment rinsate blanks, consisting of distilled water run through the sampling equipment after decontamination, were analyzed for all contaminants of concern to monitor possible cross-contamination of samples due to inadequate decontamination. No contaminants

were detected in any of the equipment rinsate blanks, except trace concentrations of methylene chloride in equipment rinsate blank ER-3, toluene in ER-11 and ER-12, and m/p xylene in ER-17 and ER-18, with all detections below the laboratory's Practical Quantitation Limit (PQL).

Trip blanks were used to help identify cross-contamination of groundwater samples during transport and/or deficiencies in the laboratory bottle cleaning and sample handling procedures. A laboratory-prepared trip blank, consisting of reagent-grade water placed in VOA vials and transported with the sample bottles to the field, was submitted to the laboratory with each daily shipment of groundwater samples for VOC analysis. No VOCs were detected in any of the trip blanks except trace concentrations of methylene chloride in trip blanks TB-4, TB-5, TB-6, TB-7, TB-12, TB-17, TB-18, TB-19, TB-20, TB-21, TB-22, and TB-23 with all detections reported below or near the laboratory's PQL.

One source blank and one field blank were collected during this sampling event, consisting of sample bottles filled with the distilled water used for decontamination and equipment rinsate blanks. The source blank and field blank were analyzed for VOCs and used to evaluate the influence of ambient conditions or sample containers on the analytical results. No VOCs were detected in the source blank or the field blank.

## **4.0 DATA VERIFICATION AND VALIDATION**

The purpose of data verification and validation is to assure that the data collected meet the data quality objectives (DQOs) outlined in the Quality Assurance Project Plan of the Groundwater Monitoring Plan (Ebasco, 1993c). The process is intended to ensure that the data are of sufficient quality for use in meeting the objectives outlined in the Groundwater Monitoring Plan.

### **4.1 Data Verification**

All data collected were subjected to data verification. In general, verification identifies non-technical errors in the data package that can be corrected (e.g., typographical errors). Data verification included proofreading and editing hard-copy data reports to assure that data correctly represent the analytical measurement. Data verification also included verifying that the sample identifiers on laboratory reports (hard copy) matched those on the chain-of-custody record.

### **4.2 Data Validation**

Data validation was performed by an independent subcontractor, Laboratory Data Consultants, Inc., Carlsbad, CA (LDC). One hundred percent of all data analyzed by a fixed-base analytical laboratory (APCL) were validated. One hundred percent of the data were subjected to Level IV quality assurance requirements of the Navy (Navy, 1996 and Navy, 1999). The data were further evaluated to help ensure suitability and usability for the purpose of the groundwater monitoring report.

Data validation is a systematic process that is used to interpret, define, and document analytical data quality and determine whether the data quality is sufficient to support the intended use(s) of the data. Validation of a data package includes reconstruction of sample preparation, analysis of the raw data, reconciliation of the raw data with the reduced results, identification of data anomalies, and qualification of data to identify data usability limitations.

### **4.3 Data Validation Qualifiers**

Analytical data were qualified based on data validation reviews. For chemical data, qualifiers were assigned in accordance with the applicable USEPA National Functional Guidelines for Data Validation (EPA, 1994a and 1994b). Individual laboratory data flags can be found in Appendix C. No data were rejected for non-compliance with method requirements during the course of validation.

## 5.0 WATER LEVEL MEASUREMENTS

Water level measurements were recorded before the sampling event on October 14, 2002, and after the sampling event on November 7, 2002, to evaluate groundwater flow directions and gradients beneath and adjacent to JPL. Water levels in the shallow wells were measured using a Solinst water level meter. In the deep multi-port wells, the hydraulic head at each sampling port was measured with a Westbay pressure-transducer probe. Water table elevation measurements taken before sampling are provided in Table 5-1 and have been contoured in Figure 5-1. Water table elevation measurements taken after sampling are provided in Table 5-2 and have been contoured in Figure 5-2.

The estimated groundwater flow direction both before and after sampling, depicted in Figures 5-1 and 5-2 respectively, was generally consistent with previous observations. Groundwater in Aquifer Layer 1 was estimated to flow south-southwest through the eastern portion of JPL and east-southeast through the southwest portion of JPL, the Arroyo Seco, and plain. The groundwater gradients estimated for both the beginning and end of the event ranged from about 0.2 feet per foot near MW-9, at the northern end of the Arroyo, down to 0.007 feet per foot across the Arroyo and plain.

During the October - November 2002 event, water levels dropped about 1 foot in wells near the mouth of the Arroyo Seco (MW-1, MW-9, MW-11, and MW-15), while water levels in the remaining shallow wells rose roughly 1 to 5 feet. Similar fluctuations were measured in the deep multi-port wells screened in Aquifer Layer 1, which rose an average of about 2.5 feet, with the only decrease measured at well MW-11 near the mouth of the Arroyo. Increases in the hydraulic head elevations were measured in all the deep multi-port wells Screens 2 through 5, ranging from roughly 2.5 feet to over 12.5 feet during the event. The hydraulic heads measured before and after sampling at each deep multi-port well screen are presented graphically in Figure 5-3. The pressure-profile records for the deep wells are included in Appendix D.

Notably, water levels dropped in all wells (from about 1 foot to 10 feet) during the period from July 26, 2002 to October 14, 2002, except three located southeast of JPL (MW-17, MW-18, and MW-20). All but one of the increases were measured in Aquifer Layer 3, in which water levels rose from about 1 to 2 feet at wells MW-17 and MW-18 up to almost 19 feet at well MW-20. The only rise in Aquifer Layer 2 water levels was also measured at MW-20 (Screen 2), and no increases were measured in Aquifer Layer 1. The measured water level fluctuations in this area suggest the strong influence of municipal production well activities on the deeper Aquifer Layers.

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

The chemical plumes beneath JPL are adequately defined and generally stable, albeit that they are migrating in response to natural forces and local groundwater pumping. The concentration contour maps prepared to describe the data of this event, when compared with those describing earlier events, generally indicate the continued migration of contaminants into Aquifer Layers 2 and 3 southeast of the JPL facility. The most recent results from the CA DHS Drinking Water Program (December 2002) database reported that two production wells located down gradient of JPL contained carbon tetrachloride or tetrachloroethene concentrations exceeding California MCLs and six wells contained perchlorate concentrations exceeding the DLR/AL.

The following conclusions are based upon interpretation of analytical data and field measurements collected during the October - November 2002 event and previous events of the JPL Monitoring Program.

- The October - November 2002 analytical results revealed three VOCs (carbon tetrachloride, trichloroethene, and tetrachloroethene) reported at concentrations above California MCLs in one or more JPL monitoring wells.

**Carbon tetrachloride** concentrations above the MCL generally appear limited to the JPL facility in Aquifer Layer 1 (Figure 3-1), but have migrated south and east of JPL in Aquifer Layers 2 and 3. The only production well reporting a carbon tetrachloride concentration exceeding the MCL in the most recent CA DHS Drinking Water Program database was City of Pasadena Well #52 located southeast and down gradient of JPL.

**Trichloroethene** concentrations above the MCL in Aquifer Layer 1 were reported in four on-facility wells (MW-5, MW-7, MW-8, and MW-24) and one off-facility well (MW-21) south of JPL. Only one well (MW-14 Screen 2) was reported to contain a trichloroethene concentration above the MCL in Aquifer Layer 2 and no well screens in Aquifer Layer 3 exceeded the MCL. No production wells located near JPL reported trichloroethene concentrations exceeding the MCL in the most recent CA DHS Drinking Water Program database.

**Tetrachloroethene** concentrations reported above the MCLs were generally limited to on-facility wells in Aquifer Layer 1, although tetrachloroethene has been consistently reported above the MCL in Aquifer Layer 3 at off-facility well MW-21 located cross gradient of JPL. The only production well reporting a tetrachloroethene concentration exceeding the MCL in the most recent CA DHS Drinking Water Program database was Las Flores Water Co. Well #2 which is located farthest southeast and down gradient of JPL.

- **Perchlorate** was reported at concentrations exceeding the DLR/AL (4 µg/l) in seven on-facility wells in the central and southern portion of JPL (MW-4, MW-5, MW-7, MW-8, MW-13, MW-16, and MW-24), and three off-facility wells southeast of JPL (MW-17, MW-18, and MW-20). Perchlorate concentrations exceeding the DLR/AL generally appear limited to the JPL facility in Aquifer Layer 1, but appear to be migrating southeast of JPL in Aquifer Layers 2 and 3. Overall, perchlorate concentrations decreased from those of the last event, at all wells except those furthest up gradient, which greatly increased in comparison with the

previous event. This finding suggests that perchlorate is continuing to leach into groundwater at the facility.

Perchlorate was again detected in the farthest down gradient well (MW-20) during this event, as it had been during the April/May 2002 event, this time well above the DLR/AL. Six municipal production wells located down gradient of JPL also reported perchlorate concentrations exceeding the DLR/AL in the most recent CA DHS Drinking Water Program database. Notably, perchlorate was reported above the DLR/AL in samples collected in July and September 2002 at two municipal production wells at the southeast end of the study area located down gradient of well MW-20. In light of these data, one or more additional monitoring wells may be warranted in the future to further define the down gradient extent of the perchlorate plume.

- **Total chromium** was detected in all except three wells sampled but exceeded the State MCL (0.05 mg/L) only at well MW-13, consistent with previous results. The total chromium concentrations reported ranged from 0.002 to 0.057 mg/l. **Hexavalent chromium** was only detected at well MW-13 (0.050 mg/l) and off-facility well MW-17 Screen 4 (0.045) mg/L. No Federal MCL has been established for hexavalent chromium, which is currently regulated by the State under the MCL for total chromium (0.05 mg/L).
- Groundwater gradient maps prepared using the October - November 2002 water level measurements indicated groundwater gradients and flow directions generally consistent with previous observations, (i.e., flow directed primarily to the south-southwest through the eastern portion of JPL and to the east-southeast in the southwest portion of JPL, Arroyo, and plain). During the October - November 2002 event, water levels dropped roughly 1 foot at the four wells located nearest the mouth of the Arroyo, while water levels in the remaining wells rose from about 1.3 to 12.7 feet. Notably, water levels dropped in all wells during the period from July 26, 2002 to October 14, 2002, except three located southeast of JPL near several municipal production wells. All but one of the increases were measured in Aquifer Layer 3, in which water levels rose from about 1 to 2 feet at wells MW-17 and MW-18 up to almost 19 feet at well MW-20. The only rise in Aquifer Layer 2 water levels over this period was also measured at MW-20 (Screen 2), and no increases were measured in Aquifer Layer 1. The measured water level fluctuations in this area suggest the strong influence of municipal production well activities on the deeper Aquifer Layers.

At the direction of NASA JPL and the Naval Facilities Engineering Command, a reevaluation of the JPL Groundwater Monitoring Program is currently being conducted. It is recommended that the results of the October - November 2002 monitoring event be incorporated into this evaluation to help develop a new work plan for groundwater monitoring activities at JPL.

## 7.0 REFERENCES

- California Department of Health Services. *MCLs, DLRs, and Unregulated Chemicals Requiring Monitoring*. February 27, 2002.
- California Department of Health Services Drinking Water Program. *California Drinking Water Data*. Updated May 20, 2002.
- EPA, 1991. *Management of Investigation-Derived Wastes During Site Inspections*: USEPA Office of Research and Development: EPA/540/G-91/009, May 1991, 35 pp.
- EPA, 1992. *Guide to Management of Investigation-Derived Wastes*: USEPA Office of Solid Wastes and Emergency Response, Publication: 9345.3-03FS, April 1992.
- EPA, 1994a. *Laboratory Data Validation Functional Guidelines for Evaluating Organics Analysis*. February 1994.
- EPA, 1994b. *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analysis*. February 1994.
- Ebasco, 1993a. *Work Plan for Performing a Remedial Investigation/Feasibility Study, National Aeronautics and Space Administration Jet Propulsion Laboratory*. Pasadena, California December 1993.
- Ebasco, 1993b. *Field Sampling and Analysis Plan for Performing a Remedial Investigation at Operable Unit 1: On-Site Groundwater*. National Aeronautics and Space Administration Jet Propulsion Laboratory. Pasadena, California. December 1993.
- Ebasco, 1993c. *Quality Assurance Program for Performing a Remedial Investigation for the National Aeronautics and Space Administration Jet Propulsion Laboratory*. Pasadena, California. December 1993.
- Ebasco, 1994. *Field Sampling and Analysis Plan for Performing a Remedial Investigation at Operable Unit 3: Off-Site Groundwater*. National Aeronautics and Space Administration Jet Propulsion Laboratory. Pasadena, California. May 1994.
- Foster Wheeler, 2000. *Report Quarterly Groundwater Monitoring Results. July-August 2000*.
- Freeze, A. R., and Cherry, J. A., 1979. *Groundwater*. Prentice Hall, Englewood Cliffs, New Jersey, 604 pp.
- Naval Facilities Engineering Service Center (NFESC). *Navy Installation Restoration Chemical Data Quality Manual (IR CDQM)*. September, 1999.
- NFESC. *Navy Installation Restoration Laboratory Quality Assurance Guide*, 1996.