Water-Quality Changes and Organic-Carbon Characterization During Recharge with Recycled Water at a Research Basin in Montebello Forebay, Los Angeles County, California, 1991–1996

Edited by Roy A. Schroeder

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Contributing Authors: Robert Anders, Larry B. Barber, Jerry A. Leenheer, Ted I. Noyes, Ronald R. Rathbun, Terry F. Rees, Colleen A. Rostad, Roy A. Schroeder, Kevin A. Thorn, *and* Steven J. Younger

PREFACE

The demand that population growth is placing on water resources provides an impetus for increasing use of “recycled” or “reclaimed” wastewater to augment water supplies, especially in the arid southwestern United States. The Central Ground-Water Basin (Central Basin) in south-central Los Angeles County, California, is an area in which recharge has been augmented using wastewater (currently subjected to tertiary treatment that includes chlorination-dechlorination and dual-media filtration) at large infiltration basins in the Montebello Forebay for the past 40 years. This area presents an opportunity to study water-quality changes during infiltration and subsurface transport of recycled water over short and long timescales and distances. A small research basin was constructed in the Montebello Forebay to develop analytical methods and investigate processes that occur during recharge of recycled water over distances as great as a few tens of feet and ground-water traveltimes ranging to several days. The results from investigations by the U.S. Geological Survey (USGS) between 1992 and 1995 are presented in 12 topical chapters in two parts by various authors herein. Results from later investigations that extend farther downgradient for distances of several miles and traveltimes of several decades have been presented at several scientific conferences and in publications by Anders and Schroeder (1997), Barber and others (1997), Schroeder and others (1997), Leenheer and others (2001), and Schroeder and Anders (2002), and in a companion publication to this report to be published later this year.

A brief introduction to the study in Chapter 1 is followed by a description of the constructed basin and its instrumentation in Chapter 2. Chapter 3 contains a short description of the geohydrology in the study area: a USGS report by Reichard and others (2003) provides greater detail. Chapter 4 describes microbial changes that occur beneath the basin as a result of recharge with recycled water. As expected, organisms capable of oxidizing and reducing nitrogen were found to be abundant, insofar as they occur naturally in the soil as well as in wastewater. Transport of fecal coliform and algae downward through the soil beneath the basin floor was noted, and that result led to the recent initiation of studies on virus transport at the constructed basin using bacteriophage. Chapter 5 summarizes the attenuation that occurs in aqueous concentration for a number of inorganic constituents and organic carbon beneath the basin as recycled water percolates downward. Reduction in concentration of total dissolved nitrogen ranged from about 20 to about 60 percent and was determined to be dependent on timing and duration of wetting and drying cycles during recharge, with conditions that produce the establishment of longer periods of anoxia favoring greater removal by denitrification. The reduction in concentration of dissolved organic carbon (DOC) was about one-third and was not dependent on operating conditions that affect redox status in the subsurface, such as duration of wet and dry cycles and thickness of the unsaturated zone, which did affect nitrogen removal. Much of the material in Chapters 4 and 5 is from a Master's thesis by Anders (1997) and also has been summarized by Anders and Schroeder (1997).

The seven remaining chapters comprise part II of this report and describe changes in organic carbon as recycled water percolates beneath the constructed basin. Chapter 6 presents the framework in which this part of the study was conducted and includes broad characterization of organic matter as defined operationally by the analytical methodologies as well as the identification of specific organic compounds. In Chapter 7, the authors use element ratios and nuclear magnetic resonance (NMR) spectrometry to conclude that organic matter in colloids is derived primarily from bacteria and that organic content of colloidal material decreases as mineral (aluminosilicate) content increases with increasing subsurface depth. Chapter 8 details the characterization of DOC by sorption on ion-exchange resins. Only a small shift in composition was observed in profiles of various organic fractions beneath the basin as the concentration of all fractions declines in concert with the decrease in DOC with depth. Chapter 9 describes the use of infrared (IR) and ultraviolet/visible (UV/VIS) spectrometry to characterize the DOC at a structural level and shows the abundant presence and persistence of surfactants and their metabolites in recycled water beneath the basin—a result that is confirmed by NMR spectometry in Chapter 10. The methods described in Chapters 8, 9, and 10 form the analytical foundation for later work described by Leenheer and others (2001) that demonstrated the persistence of surfactant metabolites, even after nearly 30 years and transport over several miles in the aquifer. Transport and fate of halogenated organic compounds resulting from the chlorination of recycled water are described in Chapter 11. Perhaps the most important finding in this chapter is that the trihalomethane (THM) formation potential of organic carbon in recycled water is lower than in natural organic carbon from most surface-water sources. Chapter 12 presents the results of gas chromatography-mass spectrometry (GC/MS) analysis for several specific organic compounds as part of an effort to find a compound that could serve as a conservative (is not sorbed or degraded) tracer for recycled water in ground water and is not naturally present. To date, no such compound suitable over long distances and traveltimes has been found that can serve as an independent verification on inorganic constituents, such as chloride and boron, that are elevated in recycled water but do occur naturally.

The results presented here document the attenuation in nitrogen and organic carbon in recycled water, sometimes referred to as "polishing," during the early stages by soil aquifer treatment that is sought by water regulators and purveyors; but are generally unable to answer the question of long-term sustainability and to what extent removal is due to temporary storage on the soils. For that reason, the study was extended following completion of this work to include downgradient public-supply wells and multilevel monitoring wells where reclaimed water that originated many years ago is present. The work described in these 12 chapters contributed to the development of methods used in the subsequent investigations.

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FIGURES

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

CONVERSION FACTORS

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
feet (ft)	0.3048	meters
miles mi)	1.609	kilometers
	Area	
acre	0.4047	hectare
square inch (in^2)	6.452	square centimeter
square foot (ft^2)	0.09290	square meter
	Volume	
cubic inch (in^3)	16.39	cubic centimeter
acre-foot (acre-ft)	1,233	cubic meter
	Flow rate	
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
foot per day (ft/d)	0.3048	meter per day
gallon per minute (gal/min)	0.06309	liter per second
	Mass	
pound, avoirdupois (lb)	0.4536	kilogram
	Pressure	
pound per square inch (lb/in^2)	6.895	kilopascal

Temperature in degrees Celsius (^{o}C) may be converted to degrees Fahrenheit (^{o}F) as follows:

$$^{o}F=1.8\ ^{o}C+32.$$

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at $25^{o}C$).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

VERTICAL DATUM

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum *derived* from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

ABBREVIATIONS

ABS	alkylbenzene sulfonate
AMU	atomic mass unit
APEC	alkylphenol polyethyoxy carboxylate
APEO	alkylphenol polyethoxylate
Ba	barium
BGLB	brilliant green lactose broth
C	carbon
^{13}C	carbon-13
^{13}C-NMR	carbon-13 nuclear magnetic resonance [spectrometry]
cfu	colony forming units
Cl	chloride

cm	centimeter
cm/s	centimeter per second
cm^2	square centimeter
cm^3	cubic centimeter
CO_2	carbon dioxide
CP/MAS	cross polarization/magic angle spinning [NMR spectrometry]
da	dalton [atomic mass unit]
δD	delta deuterium
$\delta^{15}N$	delta nitrogen–15
$\delta^{18}O$	delta oxygen-18
DATS	dialkyltetraline sulfonate and dialkylindane sulfonates
DO	dissolved oxygen
DOC	dissolved-organic carbon
DOC_f	dissolved-organic carbon fractionation
DOC_{mw}	dissolved-organic carbon molecular-weight
DOM	dissolved organic matter
Eh	electrochemical potential
EM	electromagnetic
FTIR	Fourier transform infrared spectrometry
GC-ECD	gas chromatography with electron-capture detection
GC/MS	gas chromatography-mass spectrometry
g	gram
g/cm^3	gram per cubic centimeter
$>$	greater than
Hz	hertz [unit of frequency equal to one cycle per second]
H	hydrogen
HCl	hydrochloric acid
HPI	hydrophilic
HPI_a	hydrophilic acid
HPI_b	hydrophilic base
HPI_n	hydrophilic neutral
HPO	hydrophobic
HPO_a	hydrophobic acid
HPO_b	hydrophobic base
HPO_n	hydrophobic neutral
ID	identification
IR	infrared [spectrometry]
δ	isotope mass ratio
ε	isotope-separation factor
KBr	potassium bromide
kHz	kilohertz
KHP	potassium hydrogen phthalate
$<$	less than
LAS	linear alkylbenzene sulfonate
L	liter
Li	lithium
M	meter
$[M^+]$	molecular ion
MBAS	methylene blue active substances
MCL	maximum contaminant level
MLS	multilevel sampler
MPN	most probable number
meq/L	milliequivalent per liter
meq/100 g	millequivalent per 100 grams soil

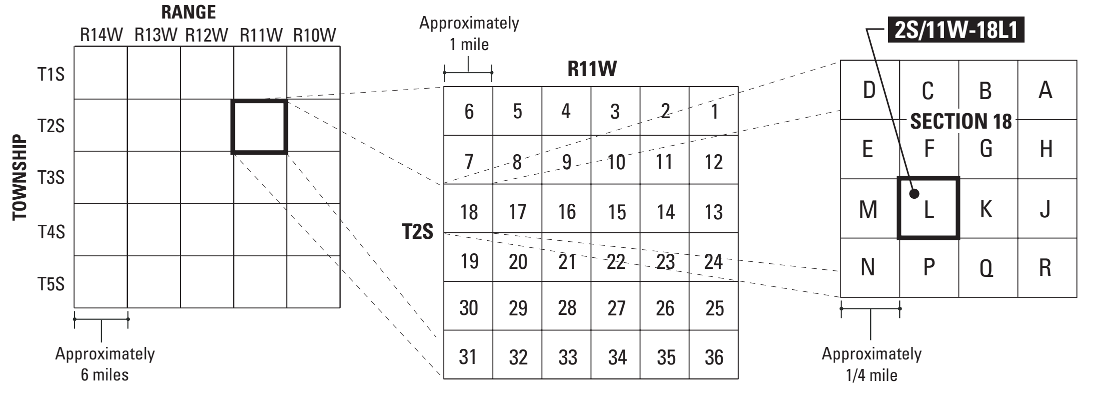
mg	milligram
mg C/L	milligram carbon per liter
mHz	megahertz
min	minute
mL	milliliter
mm	millimeter
ms	millisecond
m/z	mass-to-charge ratio for molecular ion in GC/MS analysis
µeq/L	microequivalent per liter
µL	microliter
µm	micrometer
µs	microsecond
nm	nanometer
N	nitrogen
NaOH	sodium hydroxide
^{15}N	nitrogen-15
N_2	nitrogen gas
NH_4	ammonium
NMR	nuclear magnetic resonance
NO_2	nitrite
NO_3	nitrate
NOE	nuclear Overhauser enhancement
O	oxygen
PO_4	orthophosphate
$^{o}/_{oo}$	per mil (parts per thousand)
ppm	part per million
^{31}P	phosphorus-31
PO_4-P	phosphate as phosphorus
POC	particulate organic carbon
PVC	polyvinyl chloride
s	second
SC	specific conductance
SEMS	scanning electron microscopy
SIM	selected-ion monitoring
SPC	sulfophenyl carboxylate
SPE	solid-phase extraction
Sr	strontium
SRFA	Suwannee River fulvic acid
TBA	tetrabutylammonium hydrogen sulfate
THM	trihalomethane
TIC	total inorganic carbon
TNTC	too numerous to count
TOC	total organic carbon
torr	unit of pressure equal to 1/760th of an atmosphere
TOX	total organic halides
UV/VIS	ultraviolet/visible [spectrometry]
VOC	volatile organic compound

Organizations

AWWA	American Water Works Association
MWD	Metropolitan Water District of Southern California
NWIS	National Water Information System
NWQL	National Water Quality Laboratory (USGS)
U.S. EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WRD	Water Replenishment District of Southern California

WELL-NUMBERING SYSTEM

Wells are identified and numbered according to their location in the rectangular system for the subdivision of public lands. Identification consists of the township number, north or south; the range number, east or west; and the section number. Each section is divided into sixteen 40-acre tracts lettered consecutively (except I and O), beginning with "A" in the northeast corner of the section and progressing in a sinusoidal manner to "R" in the southeast corner. Within the 40-acre tract, wells are sequentially numbered in the order they are inventoried. The final letter refers to the base line and meridian. In California, there are three base lines and meridians; Humboldt (H), Mount Diablo (M), and San Bernardino (S). All wells in the study area are referenced to the San Bernardino base line and meridian (S) Well numbers consist of 15 characters and follow the format 002S011W018L001S. In this report, well numbers are abbreviated and written 2S/11W-18L1. Wells in the same township and range are referred to only by their section designation, -18L1. The following diagram shows how the number for well 2S/11W-18L1 is derived.



Well-numbering diagram (Note: maps in this report use abbreviated well numbers such as **"18L1"**)

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ABSTRACT

During the early 1990s, the U.S. Geological Survey (USGS) investigated water-quality changes that occur in treated municipal wastewater (recycled water) at a small research basin constructed in the Montebello Forebay of the Central Ground-Water Basin in south-central Los Angeles County. The instrumented research basin is located on a 1/2-acre site at the upgradient end of the San Gabriel River Coastal Spreading Grounds where recharge has been augmented using recycled water since 1961. The facility was used to measure attenuation in selected constituents as recycled water delivered to the basin percolates downward and moves laterally beneath the basin. Attenuation in aqueous concentration was found to range from 20 to 60 percent for total dissolved nitrogen and was about one-third for dissolved organic carbon (DOC). Isotopic data confirmed permanent loss of nitrogen by denitrification. Detailed investigations showed that there were no large differences in the loss of various components of the DOC at the structural or compound level, although surfactants and their metabolites were abundant and did persist in the subsurface. The DOC of wastewater origin was found to have a lower trihalomethane (THM) formation potential upon chlorination than does organic matter of natural origin from most surface-water sources.

The organization of this report into 12 topical chapters, and the report's relation to additional USGS publications from this study, is noted in a preface.

PART I

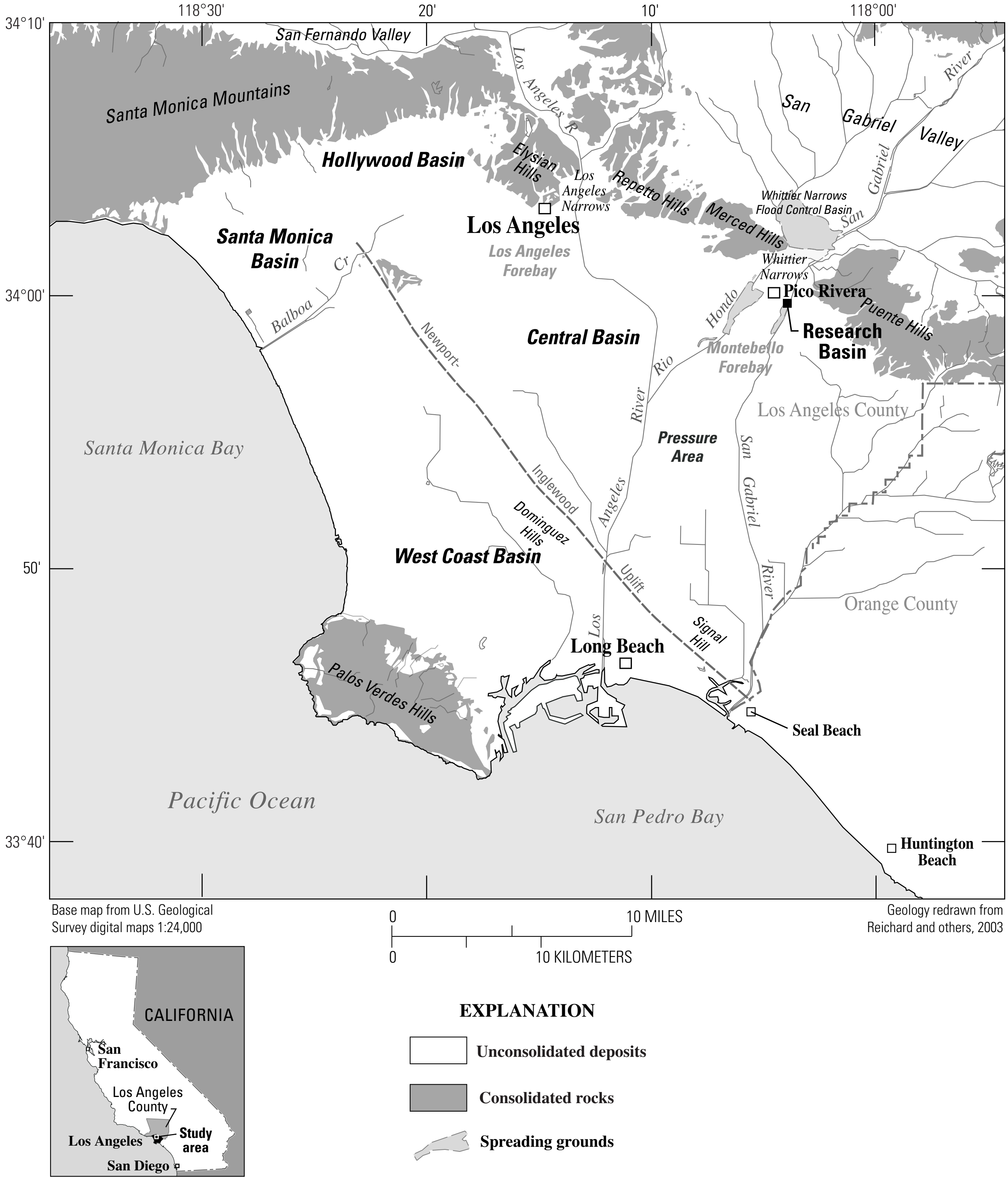
CHAPTER 1: INTRODUCTION

By Roy A. Schroeder *and* Robert Anders

Owing to increases in the demand for water in the western United States, water-resources managers recognize the need to develop methods to optimize available supplies. One method of providing additional water resources that is receiving widespread attention, especially in southern California and Arizona, is wastewater reclamation and reuse (the terms “recycled” and “reclaimed” water are used interchangeably throughout this report as they are in the industry). Reuse can be characterized as potable or nonpotable, direct or indirect. Direct nonpotable-water reuse for urban irrigation, cooling, industrial processing, recreation, and agriculture is already widely practiced, leaving resources of high-quality fresh water for potable use (California State Water Resources Control Board, 1987). The only potable-water reuse currently practiced in the United States is indirect, wherein wastewaters are discharged to the environment and withdrawn downgradient or downstream from either underground or surface sources (Sloss and others, 1996, and references therein).

In southern California, 240,000 acre-feet per year (acre-ft/yr) of the locally supplied water comes from reclaimed water, and most (183,000 acre-ft/yr) of this is used to recharge local ground-water basins (Anders and Schroeder, 1997, from Metropolitan Water District of Southern California [MWD], unpub. data). Since 1991 approximately 50,000 acre-ft/yr of reclaimed water has been used by the Water Replenishment District of Southern California (WRD) to artificially recharge the Montebello Forebay area of the Central Ground Water Basin (Central Basin) in south-central Los Angeles County (fig. 1). It is estimated that almost 1 million residents in the Montebello Forebay area, where artificial recharge using reclaimed water has been practiced since 1961, receive some reclaimed water in their household supply. Artificial recharge in the Montebello Forebay is accomplished by diverting water, including reclaimed water, into large holding ponds at the Rio Hondo (570 acres) and the San Gabriel River Coastal Spreading Grounds (128 acres), located in Montebello and Pico Rivera, respectively, and into the unlined reach of the San Gabriel River (156 acres) adjacent to the San Gabriel River Coastal Spreading Grounds (fig. 2). These holding ponds, or spreading basins, and the unlined reach of the San Gabriel River, allow the reclaimed water to infiltrate into the ground and replenish the ground-water aquifers in the area. As improvements are made to increase the treatment capacity of the domestic wastewater at the Whittier Narrows, Pomona, and San Jose Creek Water Reclamation Plants, located north of the Montebello Forebay, the supply of reclaimed water potentially available to the spreading grounds will increase.

However, there are restrictions on the use of reclaimed water for spreading purposes. Artificial recharge using reclaimed water is regulated under Title 22 of the California Administrative Code, and the California Regional Water Quality Control Board, through input from the State Department of Health Services, sets permissible limits on the amount of reclaimed water that can be used for replenishment purposes. Beginning in 1991, the quantity of reclaimed water authorized for surface spreading in the Montebello Forebay was increased to no more than 50 percent of recharged water annually and to 35 percent during any 3-year period. The regulation states that, “reclaimed water used for groundwater recharge of domestic water supply aquifers by surface spreading shall be at all times of a quality that fully protects public health” (Barclay's California Code of Regulations, 1978; and California Department of Health Services, 1978). This regulation does not account for the effects of infiltration and mixing on the quality of the reclaimed water.



Base map from U.S. Geological Survey digital maps 1:24,000

Geology redrawn from Reichard and others, 2003

Figure 1. Location of the research basin study area in Montebello Forebay, Los Angeles County, California.

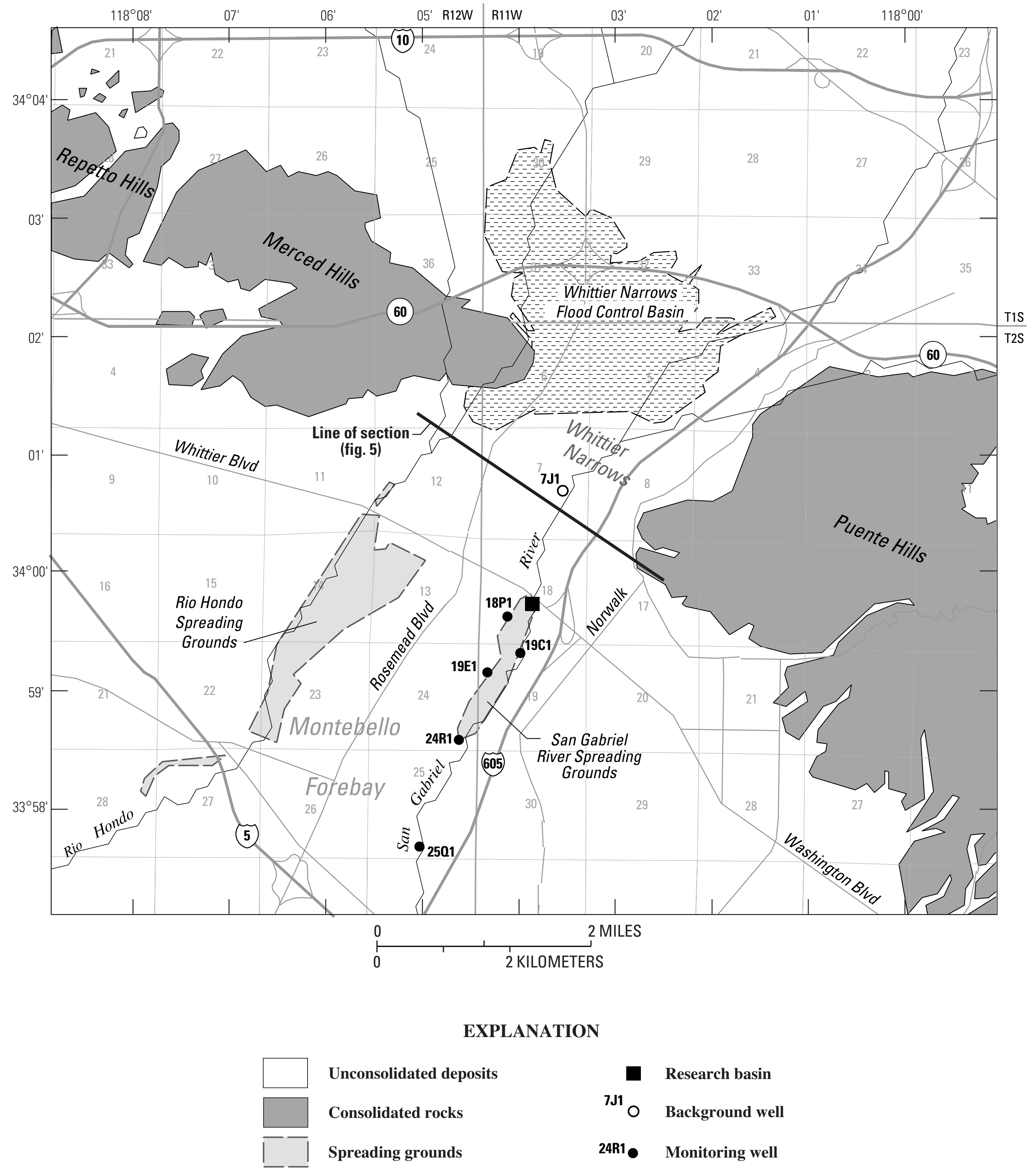


Figure 2. Location of the U.S. Geological Survey/Water Replenishment District of Southern California research basin in Pico Rivera, Los Angeles County, California.

Although the use of reclaimed water is adequately monitored in general, and a 1987–91 epidemiologic study failed to detect any adverse effects on health (Sloss and others, 1996), there is little quantitative information on the changes in quality of the reclaimed water as it enters the spreading grounds, percolates to the water table, and mixes with ground water beneath the spreading grounds, or as the reclaimed water moves from the spreading grounds to the point of withdrawal. If more information were available, the regulation could be revised to allow for possible quality improvements of the reclaimed water during artificial recharge and still provide adequate protection to public health. The ongoing study described herein was undertaken to better understand the processes that contribute to the changes in quality of the reclaimed water during artificial recharge and to provide information that can be used to revise and update the regulations on indirect potable reuse in California.

To facilitate this study, the United States Geological Survey (USGS), in cooperation with the Water Replenishment District of Southern California (WRD), constructed a research basin on an approximately 1/2-acre site at the north (upgradient) end of the San Gabriel River Coastal Spreading Grounds (fig. 1).

Purpose and Scope

The purpose of this report is to describe the water-quality changes that resulted during three recharge experiments using reclaimed water at the research basin in 1993–1994. The results are presented in 12 chapters, each of which deals with a different aspect of the study, and in 9 appendixes, which consist of tables of data. The first part of the report (chapters 1–5) contains a description of the study area and its instrumentation, microbiology, and inorganic water quality. The second part (chapters 6–12) describes the characterization of natural and contaminant organic matter and the changes that take place during recharge. This characterization required extensive development of new analytical protocols for separation and isolation of organic matter. These methods are described briefly herein; detailed descriptions of methods are given in cited references.

Acknowledgments

This study was funded by a cooperative agreement between the Water Replenishment District of Southern California and the U.S. Geological Survey. The authors also acknowledge the support of the County Sanitation Districts of Southern California, which operate the treatment plants that produce the reclaimed water, and the Los Angeles County Department of Public Works, which operates the diversion facilities and spreading grounds in Montebello Forebay where the reclaimed water and (or) stormwater and imported water are recharged. The authors thank Dr. Rodger Baird, Anthony Buono, Julia Huff, Rick Iwatsubo, Dr. Eric Reichard, Dr. Ralph Seiler, Kay Witter, and Jerrald Woodcox for providing helpful reviews and comments and several staff members for graphics and report preparation.

CHAPTER 2: RESEARCH BASIN CONSTRUCTION AND INSTRUMENTATION

By Terry F. Rees *and* Robert Anders

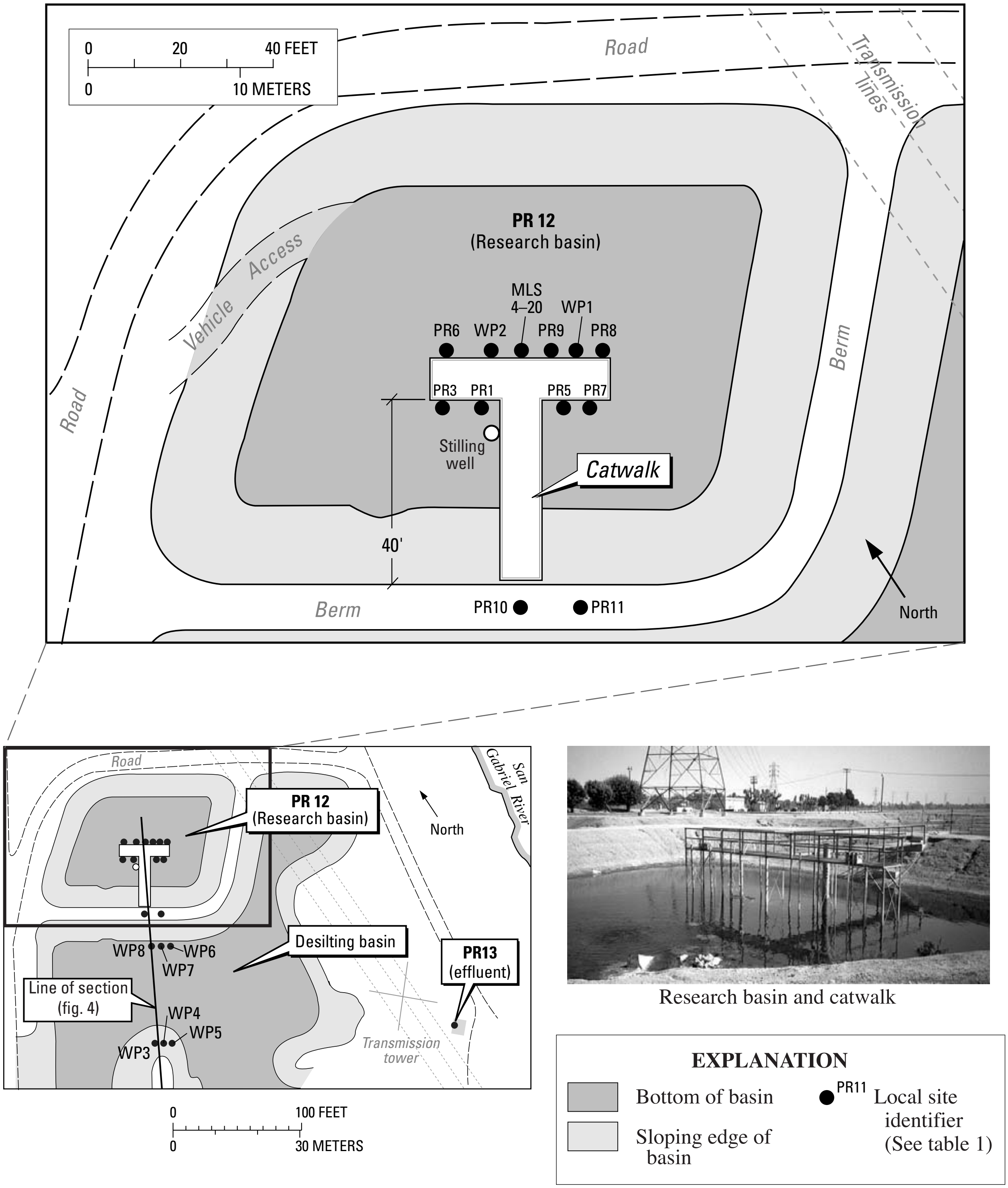
The USGS/WRD research basin was constructed at the north end of the San Gabriel River Coastal Spreading Grounds located between Whittier Boulevard and Washington Boulevard in Pico Rivera, Los Angeles County, California (figs. 1, 2). Overlying silt was excavated from the site to expose a well-sorted sand and gravel unit about 10 ft below local land surface. The excavated material was used to construct a berm around the research basin to isolate it from the rest of the spreading grounds and a settling (desilting) basin (fig. 3) at the head of the spreading grounds. The berm was constructed with a 3:1 (horizontal-to-vertical) slope and was topped by a 10-foot-wide access road. This construction left an exposed percolation area of about one-half acre and provided an operating water depth of about 8 ft to the catwalk (fig. 4).

Reclaimed water is delivered from the water-reclamation facilities, where it has undergone tertiary treatment, to the spreading grounds through an 8-foot-diameter culvert. The tertiary treatment consists of dual-media (anthracite coal and sand and gravel) filtration followed by chlorination and dechlorination. A small percentage of the flow can be diverted on demand to the research basin through a 6-inch pipeline using a PACO PC 51 non-clog 100 gal/min submersible pump installed in the culvert (PR13) (fig. 3). A constant head is maintained in the research basin by controlling the pump using a SOR float-operated, water-level control switch installed in a stilling well (fig. 3) located in the research basin (PR12).

Research-basin instrumentation was installed in bore holes drilled using a 4 1/2-inch hollow-stem auger. A description of all instruments installed follows and their locations and site designations are shown in figures 2–4. A schematic (fig. 4) shows distance of instruments from the center of the pond and depth below the research basin. Some of the instruments have received little or no use to date but are intended for possible future use.

To facilitate collection of unsaturated-zone pore-moisture samples, suction lysimeters (sites designated PR1, 3 and 5 in figs. 3 and 4—PR4 not shown in figures) were installed at depths of about 5, 10, 15, 25, and 50 ft below the research-basin floor at each site. The lysimeters were installed by drilling to the deepest depth and then suspending the deepest lysimeter in the hollow-stem auger flights. Sufficient silica flour was poured into the flights to encase the lysimeter's porous-cup from at least 1 ft below the bottom to at least 1 ft above the top of the cup. Bentonite chips were placed into the borehole annulus above and below the silica flour as the auger flights were withdrawn, thereby providing a hydraulic seal above and below each lysimeter. A bentonite seal was installed from the top of the silica flour for the 5-foot (shallowest) lysimeter to land surface.

Three different types of suction lysimeters were installed: ceramic, stainless steel, and Teflon. The two-stage ceramic-cup lysimeters (PR1) are constructed by Soil Moisture Equipment Corporation, Santa Barbara, California, from polyvinyl chloride (PVC) pipe to which a porous ceramic cup is attached. The two-stage construction and the installation of a check valve between the stages allow these lysimeters to be used successfully to depths of at least 250 ft (Schroeder and others, 1993; Umari and others, 1995). Collected samples are delivered to the surface through small-diameter access tubes. Ceramic-cup lysimeters can be used to collect pore-moisture samples for major inorganic constituents (Peters and Healy, 1988), but they may not provide reliable samples for organic constituents, and the small pore opening (nominal pore size of 1.4 µm) makes them unsuitable for collection of microorganisms (Dazzo and Rothwell, 1974). Stainless steel lysimeters (PR3) obtained from Soil Measurement Systems, Tucson, Arizona, were installed to permit collection of samples for analysis of organic constituents and microorganisms. These lysimeters are constructed entirely from welded stainless steel and utilize a porous fretted steel material for the porous cup. Because the porous steel fret has a much larger mean pore diameter (50 µm) than do the ceramic cups, they cannot produce as high a suction, and they do not work as well in drier soils. All-Teflon lysimeters (PR5) obtained from Timco Manufacturing, Inc., also were installed. These lysimeters have the potential to be used for collecting samples for both inorganic and organic constituents, but they have the disadvantage of being strongly hydrophobic, requiring extreme suction to collect water from the soil pores.



Research basin and catwalk

EXPLANATION

▨	Bottom of basin
☐	Sloping edge of basin
● PR11	Local site identifier (See table 1)

Figure 3. Location of instrumentation sites at the U.S. Geological Survey/Water Replenishment District of Southern California research basin, Montebello Forebay, Los Angeles County, California. (See table 1 for description of instrumentation.)

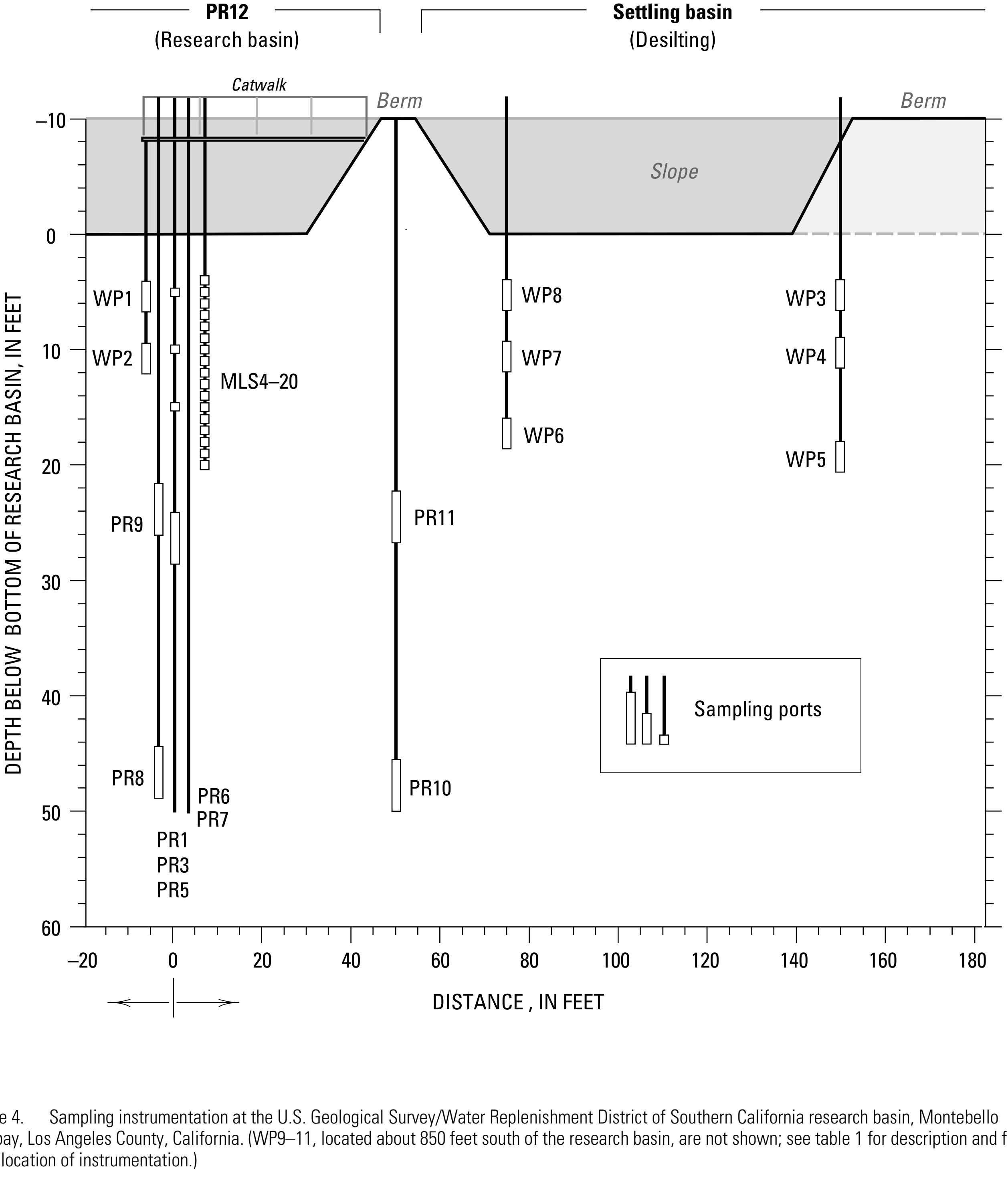


Figure 4. Sampling instrumentation at the U.S. Geological Survey/Water Replenishment District of Southern California research basin, Montebello Forebay, Los Angeles County, California. (WP9–11, located about 850 feet south of the research basin, are not shown; see table 1 for description and figure 3 for location of instrumentation.)

The research basin is instrumented for two independent methods of measuring soil-moisture contents. The first method uses neutron thermalization by hydrogen atoms in water (Troxler Electronic Laboratories, Inc., 1983). A sealed 2-inch-diameter galvanized steel neutron-log access tube was installed by augering a bore hole (PR6) to a depth of 50 ft below the research-basin floor and carefully segregating the cuttings delivered to the surface. The tube was lowered into the hollow-stem auger flights, and auger rotation then was reversed. The collected cuttings were reintroduced into the hole as the flights unscrewed themselves from the hole. A bentonite surface seal was installed to minimize vertical leakage down the borehole. To facilitate collection of soil gas samples, one-fourth-inch copper gas-sampling tubes were attached to this access tube prior to installation at depths of 5, 10, 15, 25, and 40 ft below the floor of the research basin.

The second method for measuring soil-moisture content is based on response of radio waves to changes in dielectric constant of the soil (Troxler Electronic Laboratories, Inc., 1992). Wet soil has a higher dielectric constant than does dry soil, resulting in a frequency shift for the resonant radio waves. In this technique a logging tool is used that has a radio-frequency generator and a detector antenna. The generator propagates a wave through the access tube into the soil, and the antenna measures the reflected signal. The access tube for this method (PR7) is a 2-inch-diameter PVC pipe, and the method of installation is the same as described for the neutron-log access tube.

The instrumentation for the saturated zone of the research basin includes two 2-inch-diameter PVC monitoring wells and two 2-inch-diameter galvanized-steel well points installed in the center of the research basin, two 2-inch-diameter PVC monitoring wells (piezometers) installed in the surrounding berm, and nine 2-inch-diameter galvanized-steel well points installed at various depths downgradient. The four monitoring wells have 5-foot screens and the well points have 2.5-foot screens. Monitoring wells within the research basin were installed at 49 ft (PR8, below the clay lens) and 25 ft (PR9, above the clay lens) below the floor of the research basin. The monitoring wells at the top of the 10-foot berm were installed at 60 ft (PR10, below the clay lens) and 36 ft (PR11, above the clay lens) below land surface. The monitoring wells located above the clay lens were installed by drilling just to the clay lens, placing bentonite seals at the bottom, and then suspending the screens and casings inside the hollow-stem auger flights. Monterey Number 2 (coarse) sand then was tremied around and above the screens to act as a formation filter. The bore holes were grouted from the top of the sand filters to the top of the bore holes using a bentonite slurry. The monitoring wells located below the clay lens were installed using the same techniques, except the bore holes were drilled to 55 ft below the floor of the research basin, and 5-foot bentonite seals were installed below the screens. The tops of the screens did not penetrate the clay lens. The grout seals extended from the top of the sand filters, through the clay lens, to the surface of the boreholes.

The 2-inch-diameter well points consisted of a conical drive shoe at the bottom, a well screen of 2.5 ft, and a galvanized-steel pipe that extended from the depth of installation to a sufficient height to provide access during recharge experiments. The well points were hammer-driven into undisturbed soil using a 75-pound jackhammer; because they were driven into undisturbed soil, no sand filter or bentonite seals were used. Eleven well points were installed: two near the center of the research basin at depths of about 5 and 10 ft (WP1 and WP2, respectively); three a short distance south from the research basin in the downgradient direction of regional ground-water flow at depths of about 5, 10, and 20 ft below the desilting basin (WP8, WP7, and WP6, respectively); three 150 ft south of the research basin at depths of about 5, 10, and 20 ft (WP3, WP4, and WP5, respectively); and three more 850 ft south of the research basin. These farthest downgradient well points were installed at depths of about 5, 10, and 15 ft below the spreading ground (WP9, WP10, and WP11, respectively). The 4 monitoring wells and 11 well points were hydraulically developed using air-surging.

The final research basin instrumentation was an all-Teflon multiple-level sampler (MLS3–20) designed to allow collection of samples at 1-foot intervals from just below the water table to a depth of 20 ft below the floor of the research basin. This sampler received by far the greatest use during the recharge experiments. It consists of 18 one-fourth-inch Teflon tubes extending from the floor of the basin, down the inside of a 2-inch PVC casing, and out holes drilled through the PVC at selected depths. The down-hole end of the tubes is screened with a fine Teflon fabric. The vertical spacing between the tubes is 1 ft starting at a depth of 4 ft (port at 3-foot depth does not operate) below the research-basin floor and extending to a depth of 20 ft. The design of the sampler is similar to that of the PVC multiple-level samplers used at the U. S. Geological Survey Otis Air Force Base research site and has been described in detail by LeBlanc and others (1991).

Two-foot-square concrete footings were installed on top of each bore hole through which the sample tubing or casing was passed. Galvanized pipe was set in these footings to allow routing of the tubes and casings to a catwalk above the basin. The catwalk extends from the southern berm to the center of the basin where instrumentation is installed (fig. 3). The catwalk provides access to the instrumentation during recharge experiments.

In table 1, descriptive information on the instrumentation is cross referenced to station names, USGS site identification numbers (site ID), and local identifiers (local ID). Most chemical and water-level data are stored and can be retrieved from NWIS (the USGS computerized database) by station name or by site ID. Station name is the “State well number” for piezometers and lysimeters, and site ID is the 13-digit latitude and longitude (in degrees, minutes, and seconds) followed by 2 digits that distinguish sites (for example, different depths of a multilevel well) having the same latitude and longitude. Alphanumeric acronyms, composed of parts of these various identifiers, are used (because of their brevity and simple descriptive nature) throughout this report and in the schematic (fig. 4) to designate samplers and sites.

Table 1. Descriptive information and cross reference to various alphanumeric identifiers used to designate sites at and near the research basin, Montebello Forebay, Los Angeles County, California

[ft, feet; —, site not formally established; PVC, polyvinyl chloride]

Station name	USGS site identification No.	Local identifier	Description
2S/11W-18L10SLYS	335943118042201	PR1-CR-RED at 50 ft	Ceramic-cup lysimeters at designated depths beneath the research basin
2S/11W-18L11SLYS	335943118042202	PR1-CR-ORG at 25 ft	
2S/11W-18L12SLYS	335943118042203	PR1-CR-YEL at 13.5 ft	
2S/11W-18L13SLYS	335943118042204	PR1-CR-BLU at 6 ft	
2S/11W-18L14S A INTRVL	335943118042205	PR2 (MLS20) at 20 ft	All-teflon multilevel sampler at designated depths from 3 to 20 ft beneath the research basin
2S/11W-18L14S B INTRVL	335943118042206	PR2 (MLS19) at 19 ft	
2S/11W-18L14S C INTRVL	335943118042207	PR2 (MLS18) at 18 ft	
2S/11W-18L14S D INTRVL	335943118042208	PR2 (MLS17) at 17 ft	
2S/11W-18L14S E INTRVL	335943118042209	PR2 (MLS16) at 16 ft	
2S/11W-18L14S F INTRVL	335943118042210	PR2 (MLS15) at 15 ft	
2S/11W-18L14S G INTRVL	335943118042211	PR2 (MLS14) at 14 ft	
2S/11W-18L14S H INTRVL	335943118042212	PR2 (MLS13) at 13 ft	
2S/11W-18L14S I INTRVL	335943118042213	PR2 (MLS12) at 12 ft	
2S/11W-18L14S J INTRVL	335943118042214	PR2 (MLS11) at 11 ft	
2S/11W-18L14S K INTRVL	335943118042215	PR2 (MLS10) at 10 ft	
2S/11W-18L14S L INTRVL	335943118042216	PR2 (MLS9) at 9 ft	
2S/11W-18L14S M INTRVL	335943118042217	PR2 (MLS8) at 8 ft	
2S/11W-18L14S N INTRVL	335943118042218	PR2 (MLS7) at 7 ft	
2S/11W-18L14S O INTRVL	335943118042219	PR2 (MLS6) at 6 ft	
2S/11W-18L14S P INTRVL	335943118042220	PR2 (MLS5) at 5 ft	
2S/11W-18L14S Q INTRVL	335943118042221	PR2 (MLS4) at 4 ft	
2S/11W-18L14S R INTRVL	335943118042222	PR2 (MLS3) at 3 ft	
2S/11W-18L15SLYS	335943118042223	PR3-SS-RED at 49 ft	Stainless steel lysimeters at designated depths beneath the research basin
2S/11W-18L16SLYS	335943118042224	PR3-SS-ORG at 25 ft	
2S/11W-18L17SLYS	335943118042225	PR3-SS-YEL at 15 ft	
2S/11W-18L18SLYS	335943118042226	PR3-SS-GRE at 10 ft	
2S/11W-18L19SLYS	335943118042227	PR3-SS-BLU at 5 ft	
2S/11W-18L20SLYS	335943118042228	PR4-CR-YEL at 15 ft	Ceramic-cup lysimeters at designated depths beneath the research basin
2S/11W-18L21SLYS	335943118042229	PR4-CR-GRE at 9 ft	
2S/11W-18L22SLYS	335943118042230	PR5-TF-RED at 48 ft	Teflon lysimeters at designated depths beneath the research basin
2S/11W-18L23SLYS	335943118042231	PR5-TF-ORG at 25 ft	
2S/11W-18L24SLYS	335943118042232	PR5-TF-YEL at 15 ft	
2S/11W-18L25SLYS	335943118042233	PR5-TF-GRE at 10 ft	
2S/11W-18L26SLYS	335943118042234	PR5-TF-BLU at 5 ft	
Neutron probe access tube	335943118042235	PR6-NEUTRON	Soil-moisture instrumentation

Table 1. Descriptive information and cross reference to various alphanumeric identifiers used to designate sites at and near the research basin, Montebello Forebay, Los Angeles County, California—Continued

Station name	USGS site identification No.	Local identifier	Description
40 ft soil gas tube, Pico Test Site	335943118042236	PR6-GAS at 40 ft	Soil-gas instrumentation
25 ft soil gas tube, Pico Test Site	335943118042237	PR6-GAS at 25 ft	
15 ft soil gas tube, Pico Test Site	335943118042238	PR6-GAS at 15 ft	
10 ft soil gas tube, Pico Test Site	335943118042239	PR6-GAS at 10 ft	
5 ft soil gas tube, Pico Test Site	335943118042240	PR6-GAS at 5 ft	
Radio frequency attenuation tube	335943118042241	PR7-RFA at 40 ft	Soil-moisture instrumentation
2S/11W-18L27S	335943118042242	PR8 at 49 ft	PVC monitoring wells at designated depths beneath the research basin
2S/11W-18L28S	335943118042243	PR9 at 25 ft	
2S/11W-18L29S	335943118042244	PR10 at 60 ft	
2S/11W-18L30S	335943118042245	PR11 at 36 ft	
Research basin pond	335943118042246	PR12	
Sewage effluent	335943118042247	PR13	
2S/11W-18L31S	335943118042248	WP1 at 7 ft	Galvinized-steel well points
2S/11W-18L32S	335943118042249	WP2 at 12 ft	
2S/11W-18L33S	335943118042401	WP3 at 7 ft	
2S/11W-18L34S	335943118042402	WP4 at 11.6 ft	
2S/11W-18L35S	335943118042403	WP5 at 20.6 ft	
—	—	WP6 at 18.7 ft	
—	—	WP7 at 12 ft	
—	—	WP8 at 7 ft	
—	—	WP9 at 7.2 ft	
—	—	WP10 at 12 ft	
—	—	WP11 at 17 ft	
2S/11W-18P1S	335935118042901	1620QQ	Other PVC monitoring wells
2S/11W-19E1S	335859118045001	1611R	
2S/11W-19C1S	335921118043001	1620RR	
2S/12W-24R1S	335738118051301	1612T	
2S/12W-25Q1S	335835118045801	1613V	
2S/11W-7J1S	340045118035501	City of Whittier production well	Background well

CHAPTER 3: GEOLOGIC AND HYDROLOGIC SETTING

By Robert Anders *and* Roy A. Schroeder

A brief geohydrologic description of the study area is given in this chapter. More extensive descriptions can be found in Reichard and others (2003). The two main hydrologic features of the Central Basin are the Whittier Narrows and the Montebello Forebay area (fig. 1). The Whittier Narrows is a gap between the Puente Hills and La Merced Hills through which the Rio Hondo and San Gabriel Rivers exit southward from the San Gabriel Valley (Nikkel and others, 1989). The Montebello Forebay area, the most important area of recharge in the Central Basin, extends southward from the Whittier Narrows (California Department of Water Resources, Southern District, 1961). The water-bearing aquifers (fig. 5), which consist of sedimentary deposits of sand, gravel, silt, and clay, range in age from Holocene to early Pleistocene and extend to a maximum depth of about 1,050 ft below land surface in the Central Basin. The Holocene alluvium contains parts of the semiperched aquifer, the Bellflower aquiclude, and the eastern arm of the Gaspar aquifer. From the Whittier Narrows south (about 8 mi) to the Imperial Highway, the Bellflower aquiclude is not present and the Gaspar aquifer is exposed at land surface. Beneath the Gaspar aquifer are several aquifer units that are either merged or in direct hydraulic connection with each other, including the Gardena and Gage aquifers of the upper Pleistocene Lakewood Formation and the Hollydale, Jefferson, Lynwood, Silverado, and Sunnyside aquifers of the lower Pleistocene San Pedro Formation (California Department of Water Resources, Southern District, 1961).

Major structural features of the study area are the northeast-trending Rio Hondo, Pico, and Cemetery Faults in the Whittier Narrows and Montebello Forebay area. The fault trends are virtually parallel to the northeast-to-southwest direction of ground-water movement in the Montebello Forebay area and do not affect the main subsurface inflow of ground water to the Central Basin through the Whittier Narrows (California Department of Water Resources, Southern District, 1961).

Analysis of core material and water levels was used to characterize geohydrological conditions on a local scale at and near the research basin.

Lithology

Core material was recovered at approximately 1-foot intervals to a depth of 35 ft below the floor of the research basin [45 ft below land surface at the berm (PR10)] by driving a stainless steel, split-spoon core barrel through the bottom of the hole drilled by hollow-stem augering. A lithology log was compiled from field observations. Grain-size distribution of the core material was determined at the USGS Sediment Laboratory in Salinas, California, using sieves to analyze the sand fraction and hydrometers to analyze the fine fractions using methods described by Guy (1969).

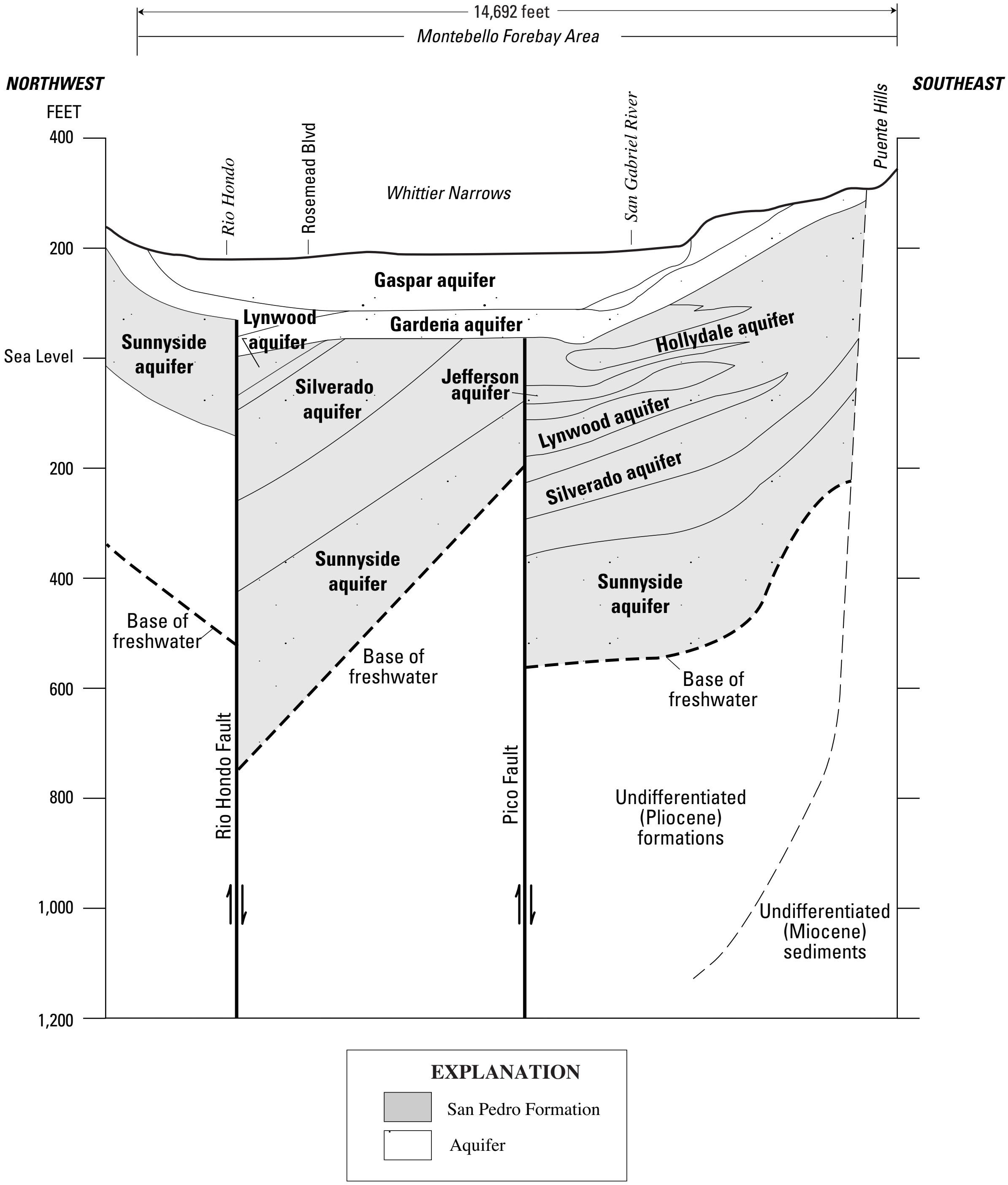


Figure 5. Hydrogeologic section of the Montebello Forebay area, Los Angeles County, California (after California Department of Water Resources, Southern District, 1961). Line of section shown in figure 2.

A lithologic log (table 2) compiled from visual inspection indicates that soil beneath the research basin is predominantly fine-to-coarse, moderately sorted, grayish-brown sand. Measured grain-size distributions beneath the research basin (PR10) indicate mostly medium to coarse sand (fig. 6). Both the descriptive lithology and the measured grain-size distribution indicate the presence of a clay-rich lens beginning about 31 ft below the floor of the research basin (about 40 ft below land surface). Presence of this clay lens also is confirmed by electromagnetic induction (EM) and natural gamma radiation logs at PR8 and PR10 (fig. 7). Cores for analysis of grain size were recovered from the berm (PR10), just outside the research basin, and results indicate a clay-rich lens that may be as thin as 1 ft; the EM log within the basin (PR8) suggests a thickness of perhaps a few feet. The lens may thin southward, or be of variable thickness, even over short distances at the research basin. Below the clay lens is a lower sand unit, the depth of which is not known from this study because drilling stopped at about 50 ft below the floor of the research basin.

Vertical Hydraulic Conductivity

Cores were collected for a distance of several feet beneath the research basin to measure vertical hydraulic conductivities. The cores were obtained by driving a manually operated piston sampler into the unconsolidated sediment using an electric jackhammer. The core barrels were retrieved, cut to remove any unused portion, sealed at both ends to minimize further disturbance, and transported to the San Diego State University Water Laboratory where they were cut into short sections.

A constant-head permeameter test was chosen to measure the hydraulic conductivities of the core sections (Fetter, 1988). Cores were first completely saturated from the bottom to prevent air bubbles, which would have the effect of lowering the hydraulic conductivities by decreasing the cross-sectional area of soil through which the water can flow. Then water was allowed to flow from the top through the core section at a steady rate from a chamber with an overflow to supply the water at a constant head. Hydraulic conductivity (K) is calculated from a variation of Darcy's law:

$$K = (V\,L)/(A\;t\;h)$$

where

V is the volume of water discharging in time t,
L is the length of the sample,
A is the cross-sectional area of the sample, and
h is the hydraulic head.

The cross-sectional area of each core was 19.635 cm^2 (3.043 in^2) and lengths varied from 13.5 to 23.5 cm (5.3 to 9.3 in.). The three hydraulic heads used for the analysis were 60, 70, and 80 cm. Water discharged through the apparatus was measured after 60 seconds and ranged from less than 1 cm^3 (0.06 in^3) to almost 200 cm^3 (12 in^3).

Table 2. Lithologic log for selected core segments from beneath the research basin, Montebello Forebay, Los Angeles County, California

[Rock-color terms from Goddard and others, 1948; depth, in feet below bottom of research basin]

Depth		Description
From	To	
1	2.4	Silty sand, very fine to very coarse; poorly sorted; angular to sub-rounded; moderate cohesion; very dark grayish-brown (10YR 3/2).
2.8	3.9	Sand, very fine to very coarse; no silt or clay; moderately sorted; angular to sub-rounded; gray (10YR 6/1).
4.0	4.8	As above with slight increase in silt.
4.8	5.6	Sand, some silt, very fine to fine; well sorted; angular to sub-angular; grayish-brown (2.5YR 5/2).
5.6	7.0	Sand, some silt, very fine to coarse; well sorted; skewed toward fine; angular to sub-angular; grayish-brown (2.5Y 5/2).
7.0	8.0	Sand, some gravel granules and pebbles, very fine to very coarse; poorly sorted; angular to sub-rounded; grayish-brown (2.5Y 5/2).
8.5	9.7	Sand, abundant granules and small pebbles, fine to very coarse; moderately sorted; skewed toward coarse; angular to sub-rounded; light brownish gray (2.5Y 6/2).
10.0	11.5	As above
11.5	12.9	Sand, some gravel granules, fine to very coarse; moderately sorted; skewed toward coarse; angular to sub-rounded; grayish brown (2.5Y 5/2).
13.0	14.2	Sand, some gravel granules, trace gravel pebbles, fine to very coarse; moderately sorted; skewed toward coarse; angular to sub-rounded; grayish brown (2.5Y 5/2).
30.5	31.4	Sand, very fine to very coarse, moderately sorted; skewed toward coarse; angular to sub-angular; light yellowish brown (2.5Y 6/3).
31.4	32.0	Silt, moderately consolidated; moderately to highly fractured; olive yellow (2.5Y 6/6).
32.2	32.8	Sand, very fine to coarse; well sorted; skewed toward fine; angular to sub-angular; light olive brown (2.5Y 5/3).
33.0	33.5	Sand, very fine to medium; very well sorted; skewed toward fine; angular to sub-angular; light olive brown (2.5Y 5/3).
34.3	34.8	Sand, very fine to coarse; well sorted; skewed toward fine; angular to sub-angular; light olive brown (2.5Y 5/3).

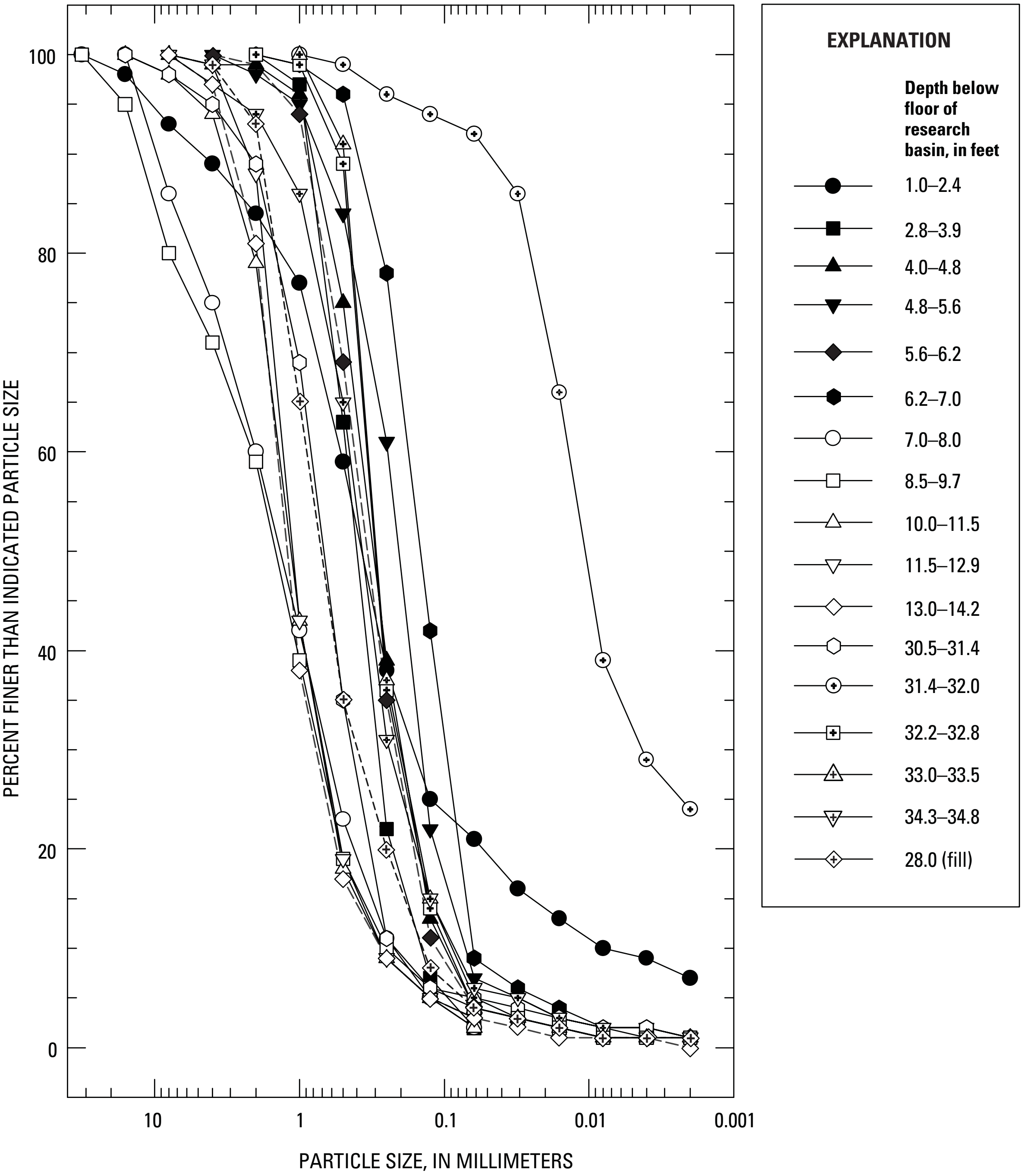


Figure 6. Grain-size distribution for core material collected from selected depths at PR10 beneath the research basin, Montebello Forebay, Los Angeles County, California.

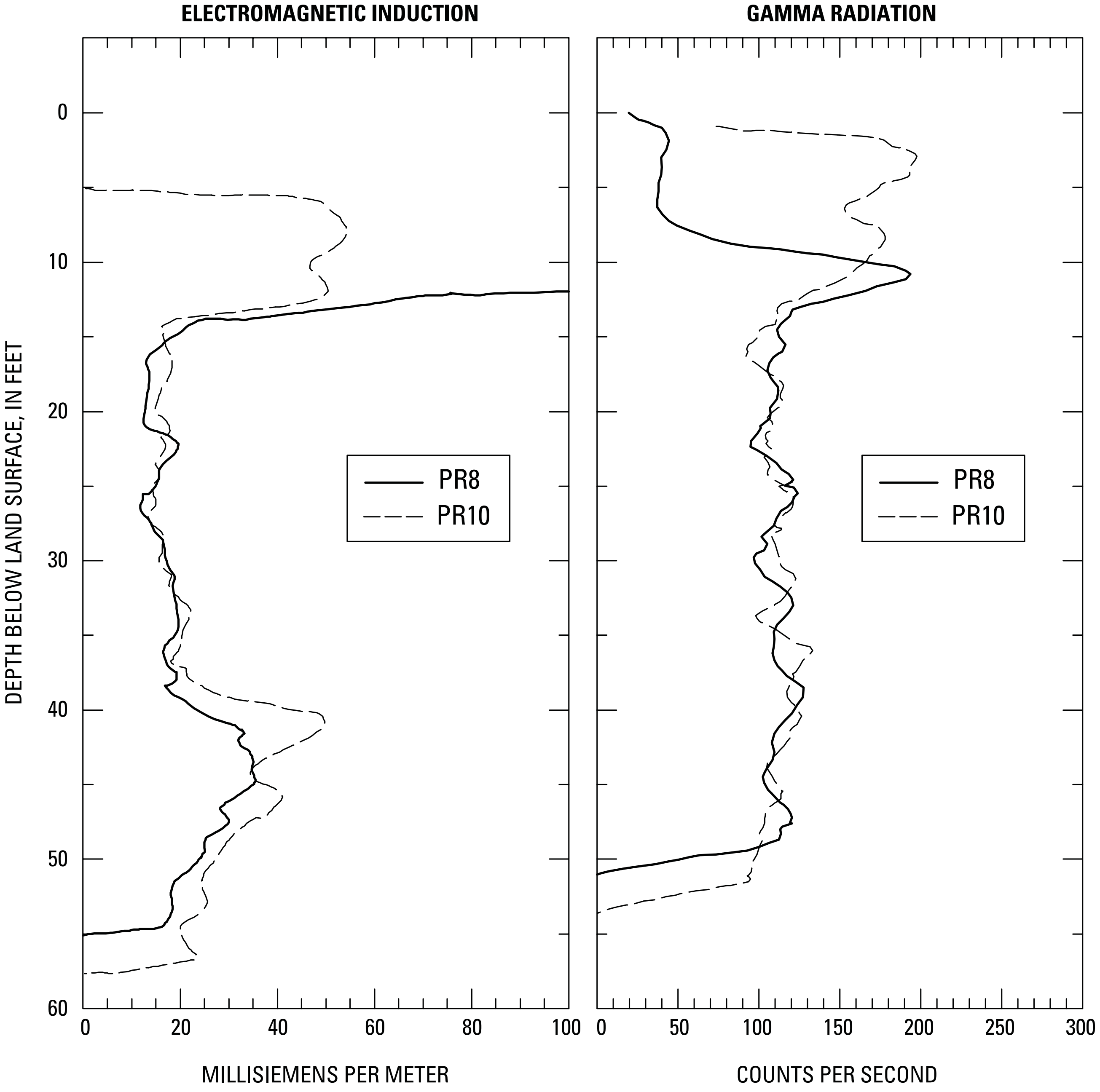


Figure 7. Electromagnetic induction and natural gamma radiation logs at PR8 and PR10 below research basin, Montebello Forebay, Los Angeles County, California.

Vertical hydraulic conductivities calculated on the basis of these permeameter measurements ranged from 0.8 to 87.6 ft/d (fig. 8). The very low value nearest the floor of the research basin reflects accumulation of a thin layer of fine-grained, organic-rich sediment on the floor of the basin (an infiltration layer). Although thin, and probably of variable effective thickness, this material exerts a strong influence on the rate at which percolation occurs during a recharge experiment. Higher values of hydraulic conductivity in the percolation zone beneath the basin are likely to more closely approximate conditions in shallow parts of the aquifer.

An infiltration/percolation test was done at the research basin when the hydraulic conditions were similar to those that prevailed during the second of three recharge experiments. Reclaimed water was pumped into the research basin until the basin was full, after which the pump was turned off and the water drained in 3 days. The volume of water that infiltrated into the ground during the 3-day period was slightly less than 2 acre-ft. The surface area of the pond is about 8,250 ft^2 (dimensions about 75 by 110 ft); therefore, the rate at which reclaimed water infiltrated the research-basin floor is between 2 and 3 ft/d, equivalent to a water-transport rate (adjusted for porosity as discussed in the following section) of 8 to 12 ft/d through the soil if no lateral movement (mounding or advection) were to occur. The fact that a period of only about 2 days was required to replace preexisting soil moisture to a depth of 20 ft, as discussed in subsequent sections on water-quality changes during recharge, indicates that no more than a small increase occurs in the size of the recharge plume (assuming only mounding with no mixing or advection) after 2 days.

Horizontal Hydraulic Conductivity

Analysis of grain-size distributions, using the physicoempirical model of Arya and Paris (1981), yielded a preliminary estimate for horizontal hydraulic conductivity of 230 ft/d with a net porosity of 0.24 (T.F. Rees, USGS, written commun., 1995).

Subsequently, slug tests were done to determine more reliable values for horizontal hydraulic conductivity at the research basin. The tests were done by recording water-level changes following displacement of a known volume of water by lowering a PVC pipe into monitoring well PR9, located at the center of the research basin and above the clay lens. Water-level changes were measured every second by means of a CR-10 data logger. The resulting data were analyzed using the Geraghty and Miller, Inc., Reston, Virginia, computer program AQTESOLV and the Bouwer-Rice straight-line solution for an unconfined aquifer. The analysis yielded horizontal hydraulic-conductivity values that ranged from 85 to 125 ft/d. The method used and its inherent limitations are discussed by Anders (1997).

Hydraulic Conditions During the Recharge Experiments

Periodic water-level measurements were made between January 1993 and December 1995, and the results are given in appendix 1. Included in the table are measurements made from the monitoring wells and well points installed at the research basin and from monitoring wells (2S/11W-18P1, -19C1, -19E1, -24R1, and -25Q1) downgradient and south of the research basin.

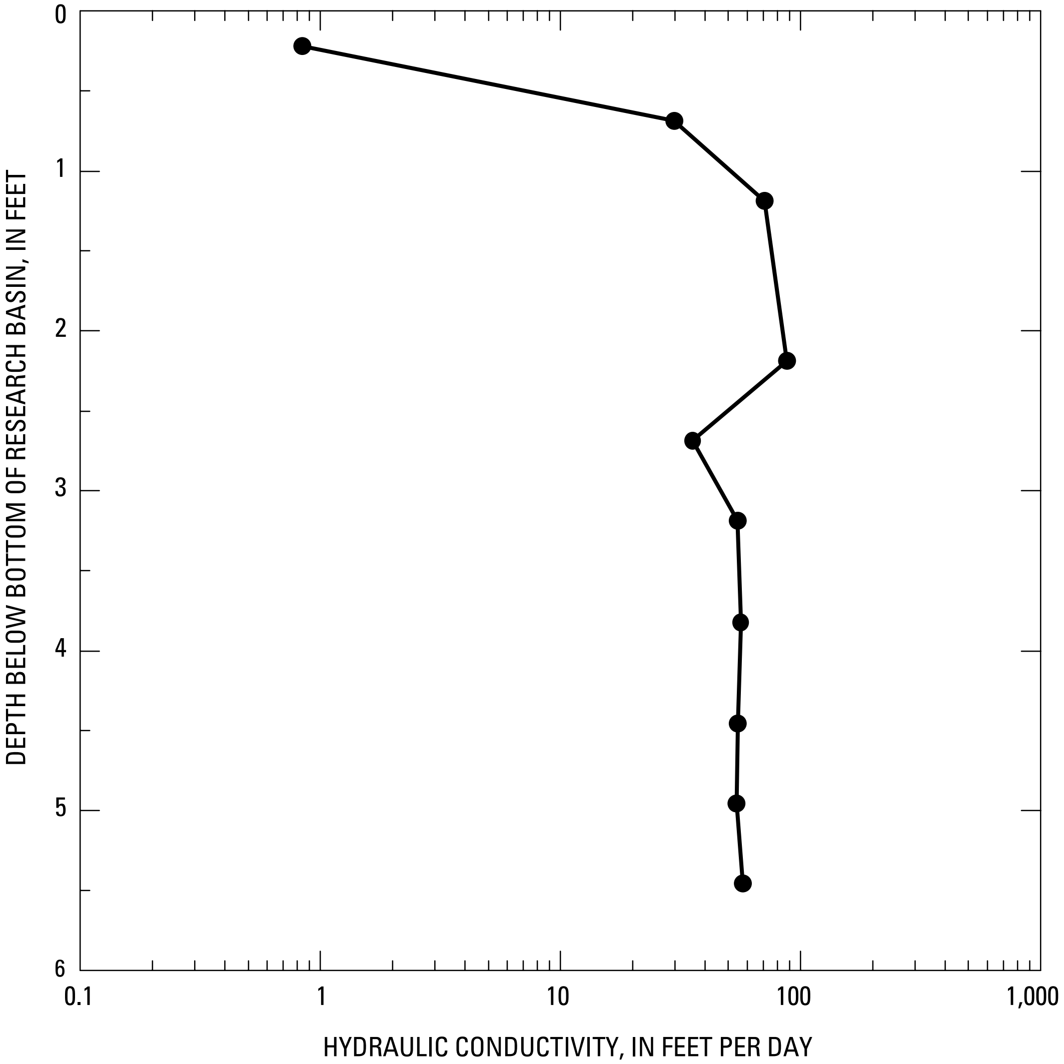


Figure 8. Vertical hydraulic conductivity of core material from selected depths beneath the research basin, Montebello Forebay, Los Angeles County, California.

As shown in appendix 1, the depth to water varied at the research basin; the water table was near (within about 1 ft) of the floor of the basin during the first two recharge experiments, whereas an 8- to 12-foot unsaturated zone existed beneath the basin floor at the time of the third recharge experiment (fig. 9). The volume of water added during each of these recharge experiments was 2.1, 12.5, and 25.6 acre-ft, respectively. Although standing water was present in the adjacent spreading grounds (which includes the settling basin immediately east and south of the research basin) during each of the first two recharge experiments, actual delivery of water in substantial quantities to the spreading grounds was occurring only during the first experiment and this apparently limited the volume of reclaimed water that could be infiltrated at the research basin during the experiment. The differing hydraulic conditions that prevailed at the research basin during the three recharge experiments probably represent the range in biogeochemical conditions that occur, with the second experiment representing intermediate conditions, as discussed in greater detail in chapter 5, “Changes in Common Chemical Constituents During Recharge.”

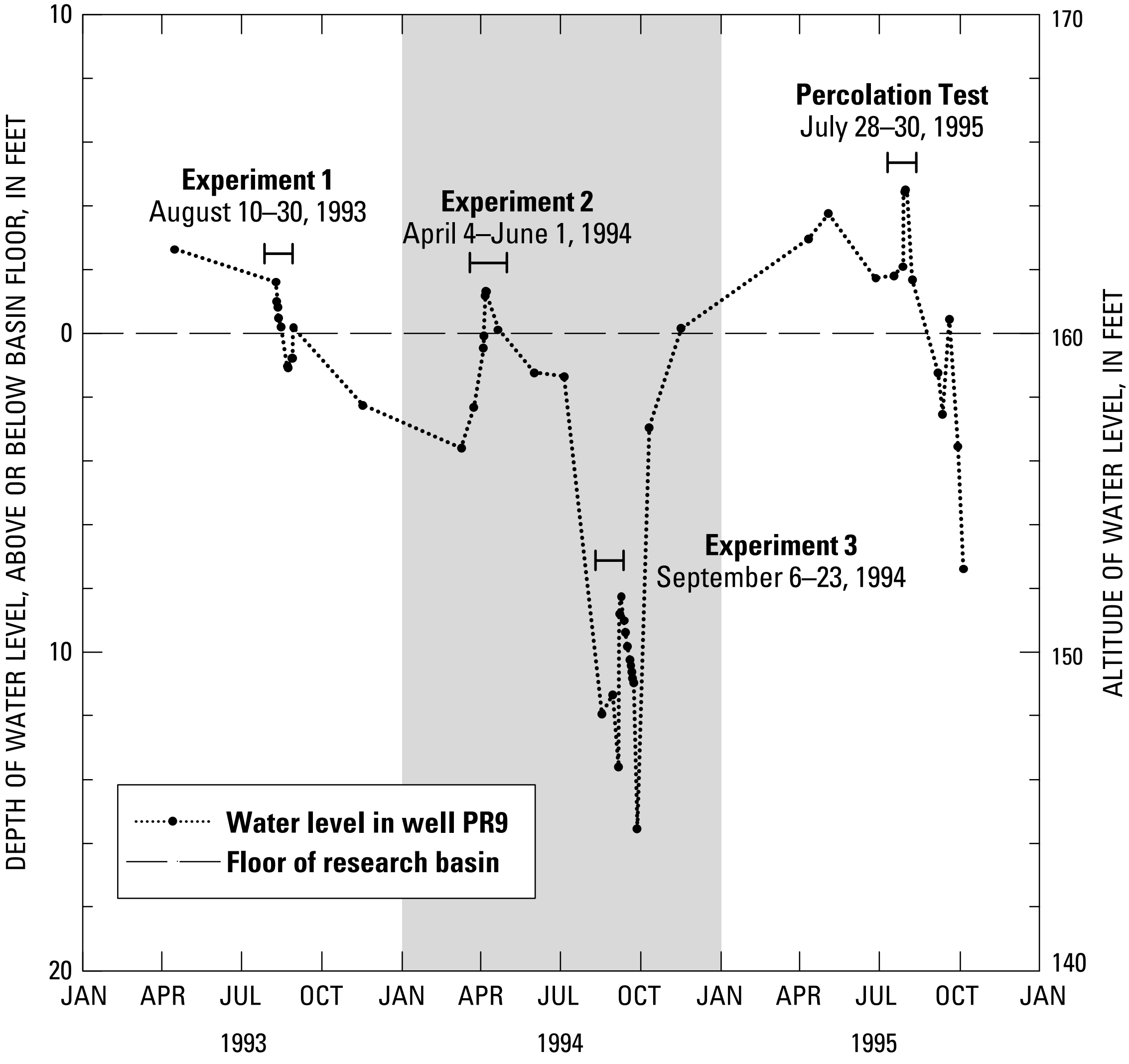


Figure 9. Depth and altitude of water level at the research basin, Montebello Forebay, Los Angeles County, California, January 1993–December 1995.

CHAPTER 4: MICROBIOLOGICAL CHANGES DURING RECHARGE

By Robert Anders *and* Roy A. Schroeder

Although the primary focus of analyses during recharge experiments at the research basin was on chemical constituents, some analyses also were done for microorganisms. These included coliform bacteria and groups of bacteria commonly involved in nitrogen oxidation and reduction transformations. Although coliform bacteria and nitrogen concentrations generally have not been a problem in production wells from the area, both are regulated relative to the use of reclaimed water for ground-water recharge by the California Regional Water Quality Control Board under Title 22 of the California Administrative Code.

Methods

Core and water samples were collected for enumerating total and fecal coliform bacteria, nitrifying, and nitrate-reducing and denitrifying bacteria. Core samples were collected in January 1993. Water samples were collected during the first two of the three recharge experiments—in August 1993 and April–June 1994. Water samples were collected from the pipeline (PR13) that supplies wastewater effluent (recycled water) to the research basin, from the pond that developed in the research basin itself (PR12), from the recycled water percolating through the research basin using sampling ports of the multiple-level sampler beneath the basin, and from monitoring wells in and around the research basin.

Core samples were collected by driving a flame-sterilized, split-spoon core barrel through the bottom of the hole produced by hollow-stem augering. Samples were collected to a depth of about 45 ft below the top of the berm on the south side of the research basin (about 35 ft beneath the basin floor). The core material was placed in sterile polyethylene “Whirl-Pak” bags and stored at 4°C in the dark until analysis within 24 hours. The cores were analyzed for total and fecal coliform bacteria by the filter membrane procedure, and for nitrifying, and for nitrate-reducing and denitrifying bacteria by the most probable number (MPN) method as described by Britton and Greeson (1987).

Water samples collected in August 1993 were placed in sterile 50-mL bottles and stored at 4°C until analysis later the same day in the laboratory. The samples were analyzed for total and fecal coliform bacteria and for nitrate-reducing and denitrifying bacteria. The MPN method was used to enumerate total and fecal coliform bacteria as described by Britton and Greeson (1987). The method was modified by substituting lactose broth for lauryl tryptose broth owing to the possible presence of stressed coliform bacteria. All the fermentation tubes that were positive for gas (carbon dioxide) production, heavy growth, or an acidic reaction were transferred into brilliant green lactose broth (BGLB) and EC broth. Those tubes that were positive for gas production in the BGLB were reported as containing coliform bacteria, and those tubes that were positive for gas production in the EC broth were reported as containing fecal coliform bacteria. For the samples collected August 16 and August 23, only the 10-mL-dilution fermentation tubes were used, and therefore those results are recorded as either detected (+) or not detected (–) for total and fecal coliform bacteria.

The nitrate-reducing and denitrifying bacteria were enumerated using a three-tube MPN method with six five-tube decimal (10X) dilutions modified from Britton and Greeson (1987). Nearly all tubes that yielded a positive test for nitrate-reducers also tested positive for denitrifying bacteria; therefore, those results are combined as a single MPN in the data tables. All water samples collected August 16 and three samples collected August 23 were discarded owing to contamination of the nitrate broth, and one sample collected August 30 was discarded before final results were recorded.

Water samples collected in April 1994 during the second recharge experiment were analyzed for total and fecal coliform bacteria, for nitrifying (ammonia- and nitrite-oxidizing) bacteria, and for nitrate-reducing and denitrifying bacteria. The membrane filter procedure as described in AWWA (1992) was used for enumerating total and fecal coliform bacteria. The samples were collected in 250-mL sterile bottles, and thiosulfate tablets were added to remove any possible influence from chlorine. Several samples collected April 6, 1994, were too numerous to count (TNTC), prohibiting the development of the characteristic green sheen associated with the presence of total coliform bacteria or the blue colony color associated with fecal coliform bacteria.

The nitrate-reducing and denitrifying bacteria were enumerated by the same procedure used for the August 1993 sampling, and the procedure to enumerate the nitrifying bacteria was modified to include three five-tube 10X dilutions.

Bacterial Distributions in Cores

The distribution of fecal coliform, nitrifying (ammonia- and nitrite-oxidizing), and nitrate-reducing and denitrifying bacteria from selected cores beneath the research basin is given in table 3. No fecal coliform bacteria were detected within the soil column.

There is some evidence that ammonia-oxidizing bacteria are more abundant at shallower than at greater depths, although most reported bacterial densities are near the measurement detection limits. Nitrite-oxidizing bacteria also were detected in about half the core samples. The density of nitrate-reducing and denitrifying bacteria varied by as much as two orders of magnitude throughout the soil column and was generally at least two orders of magnitude greater than the densities of nitrifying bacteria.

Table 3. Distribution of selected bacteria in cores beneath the research basin, Montebello Forebay, Los Angeles County, California

[Depth, in feet below bottom of research basin; cfu, colony forming units; MPN/g, most probable number per gram; <, less than indicated value]

Depth		Fecal coliform (cfu)	Ammonia-oxidizing (MPN/g wet soil)	Nitrite-oxidizing (MPN/g wet soil)	Nitrate-reducing/ denitrifying (MPN/g wet soil)
From	To				
2.8	3.9	<1	930	230	93,000
4.0	4.8	<1	2,300	2,300	210,000
4.8	5.6	<1	230	<30	4,300
5.6	6.2	<1	390	230	93,000
6.2	7.0	<1	230	<30	9,300
7.0	8.0	<1	230	<30	240,000
8.5	9.7	<1	430	150	23,000
10.0	11.5	<1	230	430	240,000
11.5	12.9	<1	230	230	1,100,000
13.0	14.2	<1	230	40	240,000
30.5	31.4	<1	230	90	460,000
31.4	32.0	<1	<30	<30	90
32.0	32.2	<1	<30	<30	9,300
32.17	32.25	<1	<30	<30	15,000
32.25	32.8	<1	<30	<30	43,000
33.0	33.5	<1	<30	<30	460,000
34.3	34.8	<1	<30	<30	460,000

Total and Fecal Coliform in Water

Results of weekly measurements for total and fecal coliform densities in water from the multilevel sampler and from piezometers during the first recharge experiment in August 1993 are shown in table 4. Numbers varied considerably during the first 3 weeks after recharge began, with the greatest change occurring in samples from the second week. Total coliform detections beneath the research basin increased from two samples on August 10 to 9 samples on August 16, 5 days after recharge stopped. Fecal coliform detections increased from none to three samples during the same period. On August 23, 12 days after filling of the research basin was discontinued, detection had fallen to two samples for total coliform and to none for fecal coliform. By August 30, no detections were found for total and fecal coliform.

Densities of total and fecal coliform bacteria in water below the research basin are shown in table 5 for immediately before recharge, 2 days after the second recharge experiment began in April 1994, and more than 1 month after recharge was discontinued. The data show that there was a rapid buildup of both total and fecal coliform soon after recharge began, and then a return to nondetectable levels after recharge was discontinued. This rapid increase from nondetectable levels in both the soil and water prior to recharge to detectable levels in the water after recharge suggests that some mechanism (for example, direct physical transport with the percolating reclaimed water) other than simple grow-back of preexisting bacteria is operating. More extensive study would be needed to confirm a mechanism and source. Although a similar, but far less distinctive, pattern appears to exist for nitrogen-transforming bacteria, as discussed in the following section, it is more likely that those results are largely explained by stimulation of natural populations as fresh recycled water reaches the underlying soil.

Table 4. Distribution of total coliform and fecal coliform bacteria during August 1993 recharge experiment at research basin, Montebello Forebay, Los Angeles County, California

[MPN, most probable number; mL, milliliter; +, detected; –, not detected; —, no data; coliform data given left of slash, fecal coliform data given right of slash; see table 1 for sample identifier]

Sample identifier	Total coliform/fecal coliform			
	Aug. 10 (MPN/100mL)	Aug. 16 (+ or -)	Aug. 23 (+ or -)	Aug. 30 (MPN/100mL)
MLS4	–/–	+/–	–/–	–/–
MLS5	–/–	+/+	–/–	–/–
MLS6	–/–	+/–	–/–	–/–
MLS7	–/–	+/–	+/–	–/–
MLS9	2/–	+/–	–/–	–/–
MLS11	–/–	+/+	+/–	–/–
MLS13	–/–	+/+	–/–	–/–
MLS15	–/–	–/–	–/–	–/–
MLS19	2/–	+/–	–/–	–/–
PR8	–/–	+/–	–/–	–/–
PR9	–/–	–/–	–/–	—
PR10	–/–	–/–	–/–	–/–
PR11	–/–	–/–	–/–	–/–
PR12	80/–	+/+	+/–	–/–
PR13	—/–	–/–	–/–	–/–

Table 5. Distribution of total coliform and fecal coliform bacteria in water below the research basin, Montebello Forebay, Los Angeles County, California, during April/June 1994 recharge experiment

[CFU, colony forming units; mL, milliliter; –, not detected; —, no data; TNTC, too numerous to count; coliform data given left of slash, fecal coliform data given right of slash; see table 1 for sample identifier]

	Total coliform/fecal coliform		
Sample identifier	April 4	April 6	June 1
		CFU/100mL)	
MLS4	–/–	10/2	–/–
MLS5	–/–	18/2	–/–
MLS6	–/–	11/2	–/–
MLS7	–/–	8/2	–/–
MLS8	–/–	28/1	–/–
MLS9	–/–	TNTC/18	–/–
MLS10	–/–	19/6	–/–
PR9	–/–	9/–	–/–
PR12	—/—	TNTC/16	—/—
PR13	—/—	TNTC/—	—/—

Nitrogen-Transforming Bacteria in Water

Nitrifying bacteria in water samples from beneath the research basin were analyzed only during the second recharge experiment. Both ammonia-oxidizing and nitrite-oxidizing bacteria were detected (table 6) in most samples before, during, and after recharge; densities clearly increased with depth (but perhaps only slightly at shallower depths) soon after recharge.

Nitrate-reducing and denitrifying bacteria were abundant in the reclaimed water itself. Values of MPN were about 10^4 per mL in the research basin (PR12) and in the effluent (PR13) during the first recharge experiment in August 1993 (table 7*A*), and values were similar during the second recharge experiment in April–June 1994 (table 7*B*). The numbers decrease by about an order of magnitude in both the effluent (PR13) and the research basin (PR12) during the experiment and also decrease by about an order of magnitude in percolating water taken from the multilevel sampler beneath the basin. The decrease could be due to removal on soil and (or) die-off. The numbers from the multilevel sampler (table 7*A*) were generally highest in the August 23 samples during the first recharge experiment but only slightly higher than those collected during the recharge before and after this date. Data collected during the second experiment indicate that background bacterial densities beneath the research basin decline by one-to-two orders of magnitude when recharge is not occurring (compare data in table 7*B*, from April 6, 2 days after recharge commenced, to June 1, 41 days after recharge was discontinued).

No strongly discernible pattern with depth is apparent for denitrifiers during either recharge experiment (fig. 10). In fact, the August 1993 data (table 7*A*) indicate slightly higher numbers for piezometers screened below the clay lens (PR8 and PR10), and therefore unaffected by recharge from the research basin, than for piezometers screened above the clay lens (PR9 and PR11). The deeper piezometers also contain much higher manganese concentrations (appendixes 2 and 3), indicating a more reducing (less oxidizing) environment that may be conducive to maintaining high “natural” bacterial levels in areas or depths not affected by recharge from the research basin. It seems clear from these results that nitrate-reducing and denitrifying bacteria are ubiquitous, in both reclaimed water and in ambient (preexisting) water at the research basin.

Table 6. Distribution of ammonia-oxidizing and nitrite-oxidizing bacteria in water below research basin, Montebello Forebay, Los Angeles County, California, during April/June 1994 recharge experiment

[MPN, most probable number; mL, milliliter; –, not detected; —, no data; see table 1 for sample identifier]

Sample identifier	Ammonia-oxidizing			Nitrite-oxidizing		
	Apr. 4	Apr. 6	Jun. 1	Apr. 4	Apr. 6	Jun. 1
	(MPN/mL)					
MLS4	330	490	–	700	80	790
MLS5	490	790	40	80	330	170
MLS6	790	330	20	230	230	230
MLS7	1,300	2,400	80	1,700	230	230
MLS8	1,300	1,300	50	490	230	230
MLS9	–	490	–	20	140	50
MLS10	–	490	–	20	80	80
PR9	–	–	230	–	20	230
PR12	—/—	24,000	—/—	—/—	490	—/—
PR13	—/—	2,400	—/—	—/—	1,300	—/—

Table 7A. Distribution of nitrate-reducing and denitrifying bacteria in water below research basin, Montebello Forebay, Los Angeles County, California, during August 1993 recharge experiment

[MPN, most probable number; mL, milliliter; —, no data; see table 1 for sample identifier]

Sample identifier	Aug. 10	Aug. 23	Aug. 30
	(MPN/mL)		
MLS4	7,900	—	790
MLS5	49,000	—	790
MLS6	49,000	—	490
MLS7	3,300	4,900	1,300
MLS9	1,700	4,900	240
MLS11	330	1,400	1,400
MLS13	1,700	2,800	790
MLS15	790	1,300	330
MLS19	3,300	2,200	1,700
PR8	490	330	2,200
PR9	130	310	260
PR10	180	220	4,900
PR11	3,300	170	790
PR12	49,000	1,400	3,500
PR13	33,000	3,300	17,000

Table 7B. Distribution of nitrate-reducing and denitrifying bacteria in water below research station, Montebello Forebay, Los Angeles County, California, during April/June 1994 recharge experiment

[MPN, most probable number; mL, milliliter; —, no data; see table 1 for sample identifier]

Sample identifier	Apr. 4	Apr. 6	June 1
	(MPN/mL)		
MLS4	1,700	1,400	790
MLS5	790	2,700	790
MLS6	1,400	49,000	230
MLS7	1,100	1,100	330
MLS8	460	1,700	70
MLS9	130	33,000	700
MLS10	4,900	2,400	340
PR9	4,900	700	1,700
PR12	—/—	24,000	—/—
PR13	—/—	23,000	—/—

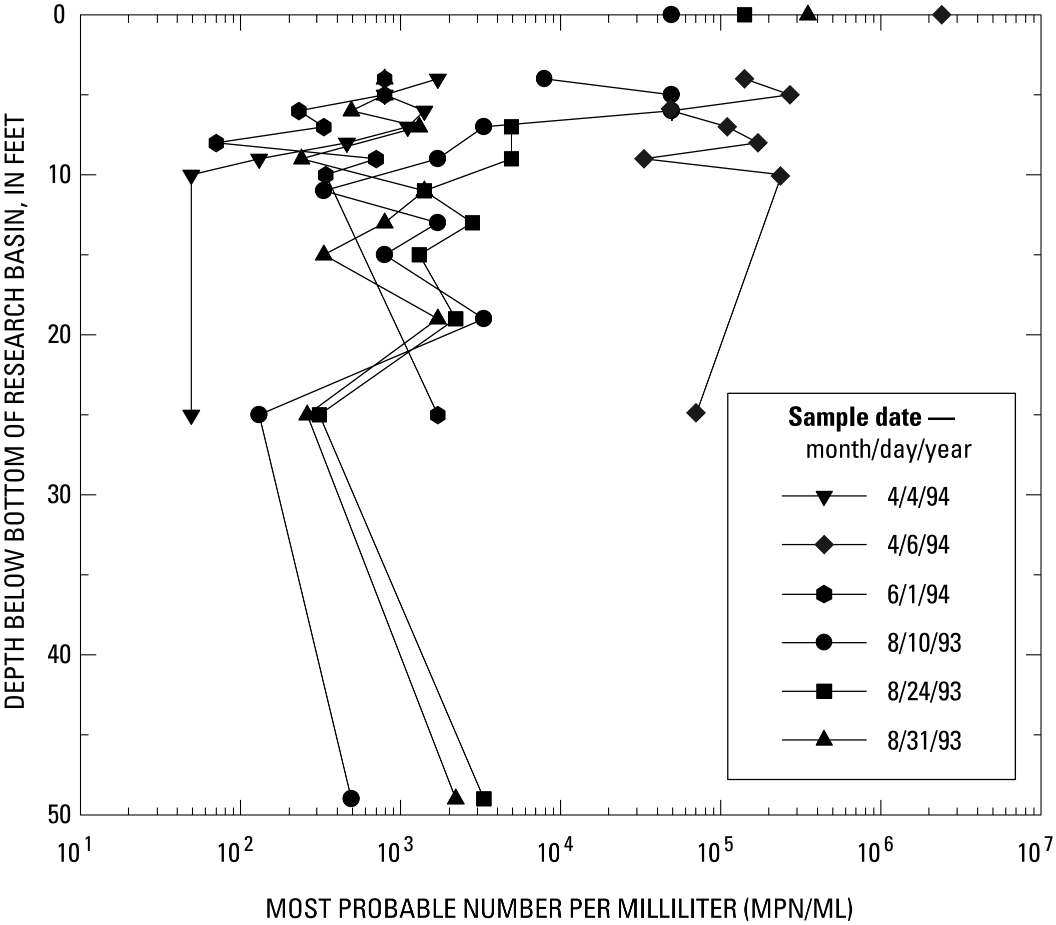


Figure 10. Distribution of nitrate-reducing and denitrifying bacteria at the research basin, Montebello Forebay, Los Angeles County, California, during recharge experiments (data from PR12 at surface, multilevel sampler at 4 to 20 feet, PR9 at 25 feet, and PR8 at 50 feet).

CHAPTER 5: CHANGES IN COMMON CHEMICAL CONSTITUENTS DURING RECHARGE

By Roy A. Schroeder *and* Robert Anders

As indicated earlier (fig. 9), reclaimed water was discharged to the research basin on three occasions: from 10:45 a.m., August 10, to 3:35 p.m., August 11, 1993; from 8:00 p.m., April 4, to 5:00 p.m., April 21, 1994; and from 5:35 p.m., September 6, to 5:15 p.m., September 23, 1994. The volume of water added during each to these recharge experiments was 2.1, 12.5, and 25.6 acre-ft, respectively. The local water table was approximately coincident with the floor of the research basin when the first two recharge experiments began, and as much as 15 ft below the floor of the research basin during the third experiment (fig. 9).

The primary objective for the first experiment was to test operation of the instrumentation. Many more (greater than 150) water-quality samples were collected during the second experiment, and they were analyzed for a much broader suite of inorganic, isotopic, and organic constituents. For this reason, most of the data analysis is focused on the second experiment. The third experiment was to confirm results from the second experiment for organic compounds of wastewater origin. In this chapter of the report, results are discussed for selected water-quality constituents, particularly nitrogen and organic carbon; and the results for characterization and analysis of organic matter are discussed in several chapters following this chapter.

Methods for Common Chemical Constituents

Samples for analysis of common inorganic water-quality constituents were obtained using peristaltic (shallow) or submersible (deep) pumps and composited in an 8-L high-density polyethylene churn splitter, pressure filtered through a 0.45-µm cellulose acetate membrane, and distributed into glass or polyethylene bottles for any additional preservation and storage. Aliquots for analysis of major cations and trace metals (inorganic priority pollutants) were preserved by addition of nitric acid to approximately pH 2. Aliquots for nutrients were preserved with mercuric chloride and chilled to 4°C pending analysis within a few days of collection. Samples for analysis of dissolved organic carbon were collected and processed separately from those for inorganic constituents by nitrogen-pressure filtration through a 0.45-µm silver membrane housed in a 200-mL stainless steel canister. (Procedures used to obtain and process samples for detailed analysis of organic carbon are discussed in the applicable chapters in the second part of this report.)

Major cations, trace elements, and nutrients were analyzed by the USGS National Water Quality Laboratory (NWQL) in Arvada, Colorado (Timme, 1994), using methods described by Fishman and Friedman (1989). Anions shown in appendix 5, 6, and 7 were analyzed locally by the USGS San Diego Geochemistry Laboratory using high-pressure ion chromatography. Water isotopes were analyzed by the USGS Isotope Laboratory in Reston, Virginia, using methods described by Epstein and Mayeda (1953), Kendall and Coplen (1985), and Coplen (1988), and results are reported in per mil ($^{o}/_{oo}$) using the standard delta (δ) notation (Craig, 1961a, b). Several nitrogen-isotope analyses on nitrate and a few on ammonia were done by a contract laboratory for the USGS National Water Quality Laboratory. Organic carbon was analyzed by one of this report's authors (L. B. Barber) using a heated persulfate oxidation method. Specific conductance, pH, alkalinity, (titration to pH = 4.5), water temperature, dissolved molecular oxygen (Winkler titration), and chlorine (Hach colormetric comparison) were determined in the field immediately after sample collection. The results from all analyses are compiled in tables in appendixes at the end of this report, and analyzed constituents are listed in table 8.

Table 8. Inorganic, isotopic, and field constituents analyzed for this study, Montebello Forebay, Los Angeles County, California

Field data	Major ions	Nutrients	Minor elements	Trace elements	Isotope ratios
Conductance	Calcium	Nitrate	Fluoride	Arsenic	Hydrogen
pH	Magnesium	Nitrite	Bromide	Beryllium	Nitrogen
Temperature	Sodium	Ammonia	Silica	Cadmium	Oxygen
Oxygen	Potassium	Phosphate	Barium	Chromium	
Alkalinity	Sulfate		Boron	Cobalt	
Chlorine	Chloride		Iron	Copper	
			Lithium	Lead	
			Manganese	Molybdenum	
			Strontium	Nickel	
				Silver	
				Vanadium	
				Zinc	

Chemical Attenuation During Recharge

Recognition that hydraulic and chemical processes at the research basin are influenced by recharge operations at the adjacent San Gabriel River Coastal Spreading Grounds is essential to the interpretation of water-quality changes that occur during recharge experiments at the research basin. The hydraulic influence is readily apparent from the water-level measurements, and the effect on chemical composition is also apparent from differences in major-ion composition on April 4, 1994, when, just prior to initiation of the second recharge experiment, sulfate and chloride concentrations (fig. 11) in piezometers at depths of 25 and 50 ft beneath the research basin (PR8, 9, 10, and 11) fall between concentrations in an upgradient (background) monitoring well (2S/11W-7J1) and the recycled-water effluent (PR13). More conclusive confirmation of chemical changes comes from identification of specific organic compounds of wastewater origin prior to recharge. Accordingly, the chemical composition of soil moisture beneath the research basin prior to recharge is influenced by timing and quantity of prior recharge from both natural [stormwater and (or) imported water] and artificial (reclaimed water) sources.

Water-quality samples were collected at the research basin on April 4, 1994 (day 0), just prior to filling the research basin; April 5–8 (including multiple samples for some days); April 21 (day 17), the last day reclaimed water was added to the research basin; and June 1 (day 58), almost 6 weeks after flow to the research basin was halted. The results of these analyses are given in tables in the appendixes, and selected data used in the discussion that follows are reproduced in figures and tables that are incorporated in the text.

Mixing and Displacement During Recharge

A two-component mixing model using chloride as the conservative tracer was chosen to evaluate the displacement, or mixing, of preexisting soil moisture as the recycled water percolated beneath the floor of the research basin. The fraction (f) of recycled water in the research basin (PR12) that is present in samples from the multilevel sampler (MLS) and from monitoring wells (PR8, 9, 10, and 11) is calculated using the equation:

$$f = (C - C_0) / (C_{POND} - C_0),$$

where

C_0 is the concentration prior to recharge,

C is the concentration at selected sampling times after the recharge experiment began, and

C_{POND} is the average concentration in reclaimed water standing in the research basin (PR12) during the course of the recharge experiment.

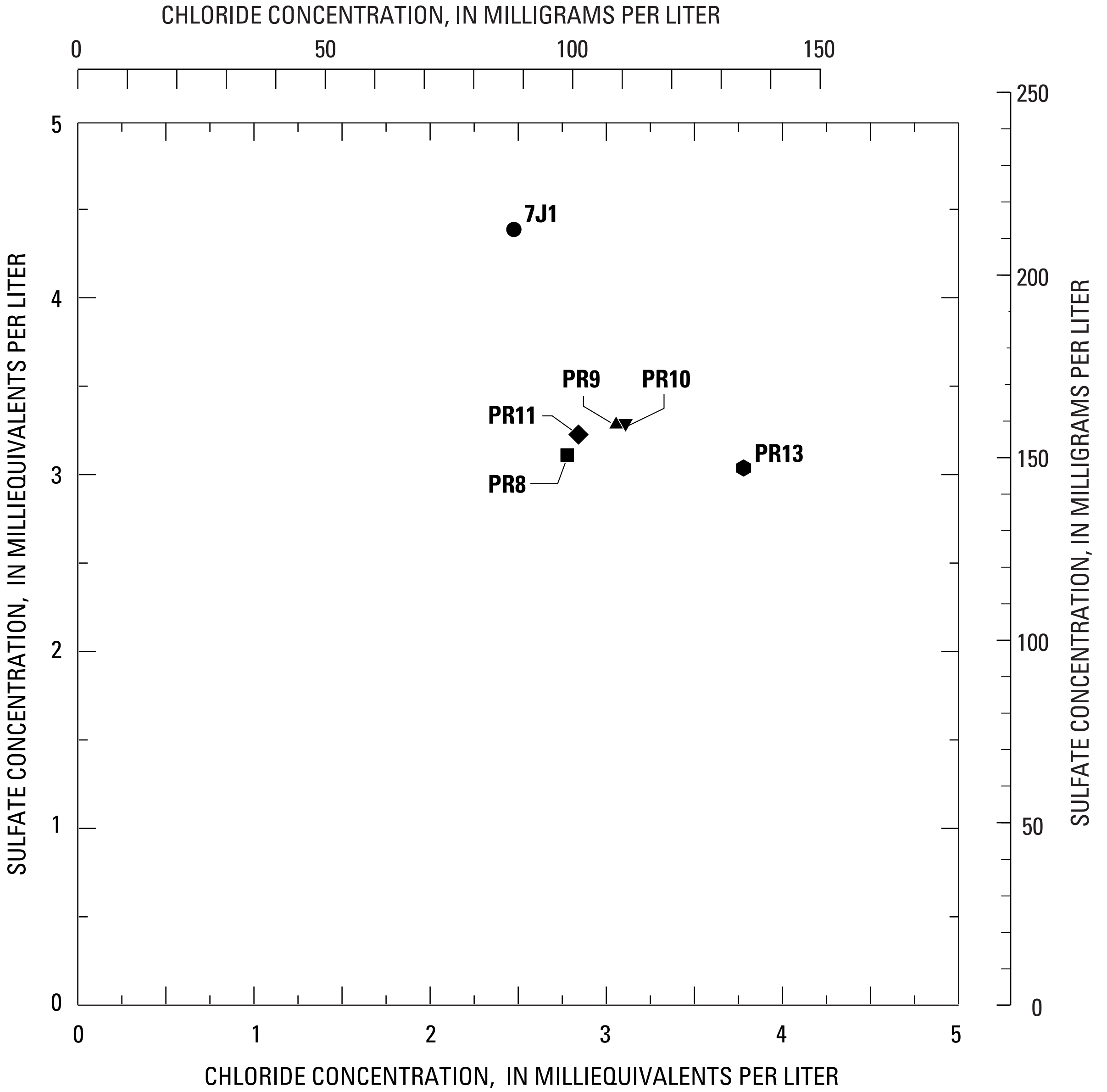


Figure 11. Effect of recycled water on ground-water composition at the research basin, Montebello Forebay, Los Angeles County, California (7J1, background well; PR8, 9, 10, and 11, piezometers at the research basin; and PR13, wastewater effluent).

Use of this rather simple calculation is possible only because chemical composition of the effluent in the pond (PR12) remained fairly constant during the entire period of the second recharge experiment. Mean and standard deviations for selected constituents in the basin itself (PR12) during the first 3 days after filling with effluent began were: chloride = 133.6 ± 4.2 mg/L (n = 18); nitrate-N = 6.0 ± 0.4 mg/L (n = 17); nitrite-N = 1.5 ± 0.2 mg/L (n = 17); ammonia-N = 4.7 ± 0.6 mg/L (n = 17); and total (inorganic) nitrogen = 12.2 ± 0.8 mg/L (n = 17). By comparison, there was much greater variability during the third recharge experiment in September 1994 when chloride concentration was 130 ± 14 mg/L (calculations from data in appendixes 3 and 4).

It is recognized that the mixing model is an oversimplification, especially during the initial period of recharge when hydraulic conditions are still far from steady state, because percolation of recycled water is actually a continuous process similar to piston flow in which the percolating water that displaces preexisting soil moisture at a given depth is actually a mixture of soil moisture transported from above (rather than the instantaneous concentration before recharge). The simple model could be replaced with a transient one-dimensional (depth-dependent) transport and mixing model if data collection were much more frequent during the rapidly changing early period of recharge. Nevertheless, the simple model is useful for illustrating temporal and depth-related concentration patterns resulting from constituent transport and removal efficiencies as discussed below.

Soon after recharge from the research basin begins, chloride at the multilevel sampling ports and the 25-foot piezometers (PR9 and 11) increases from preexisting levels near 100 mg/L to the 130–140 mg/L concentration that exists in the research basin. Displacement of preexisting water is virtually complete ($f = 1$) within 2 days at the 5, 10, and 15-foot multilevel ports; and within 3 to 4 days at a depth of 25 ft—slightly sooner beneath the research basin (PR9) than just outside the research basin (PR11) (figs. 12*A*, *B*). In fact, in some cases the calculated value for f exceeds 1, which would imply a contribution greater than 100 percent. A value greater than 1 could indicate dissolution and downward transport of desiccated salt by the "first flush" of recharge. However, this conclusion should be considered as tentative because natural variability in the research basin (PR12) coupled with analytical imprecision translate to an uncertainty of about ± 0.2 for individual values of f. Precision in calculated f values would be improved if differences in chloride concentration between preexisting soil water and the percolating recharge (effluent) were greater. However, such differences often are likely less than those that prevailed at the time of this experiment in April 1994, which was soon after the period of winter rains that would be expected to result in comparatively fresher water in shallow soil zones beneath the basin.

Hydrogen- and oxygen-isotope ratios confirm the observation that displacement of preexisting water is rapid and nearly complete, although fewer data exist for these isotopes than for chloride. As recharge proceeds, preexisting soil water that is isotopically heavier [δD about –55 per mil ($^{o}/_{oo}$]), δ^{18}O about –7.7 $^{o}/_{oo}$] is displaced by isotopically lighter water (fig. 13). As shown in figure 13, the isotope ratios do not become quite as negative (isotopically light) as the effluent itself (PR13), for which $\delta D = -62.7\ ^{o}/_{oo}$ and $\delta^{18}O = -8.65\ ^{o}/_{oo}$, perhaps due to slight enrichment in deuterium and oxygen-18 during evaporation from water standing in the research basin itself (PR12). Isotopic analyses were not obtained for recycled water in the research basin.

The percent removal for other constituents in the percolating water can be calculated by comparing measured concentrations to "predicted" concentrations based on conservative behavior for chloride. The values of f obtained from chloride data are used to calculate these predicted concentrations. For times long after recharge has begun, such that hydraulic steady state prevails beneath the basin ($f = 1$), removal efficiency is a simple comparison of concentration in the sample with average concentration in the research basin. However, to obtain removal estimates for the early period of recharge, before steady state is established and at depths below which displacement is complete ($f < 1$), predicted concentrations (C_{PRED}) for the nonconservative constituent first must be calculated from

$$C_{PRED} = f\ C_{POND} + (1 - f)\ C_0,$$

where

C_0	is the concentration prior to recharge,
C_{POND}	is the average concentration in reclaimed water in the research basin, and
values of f	were obtained from chloride data.

The measured concentration from individual samples collected at different times is then compared with the predicted concentration to obtain percent removal of selected constituents for each sample.

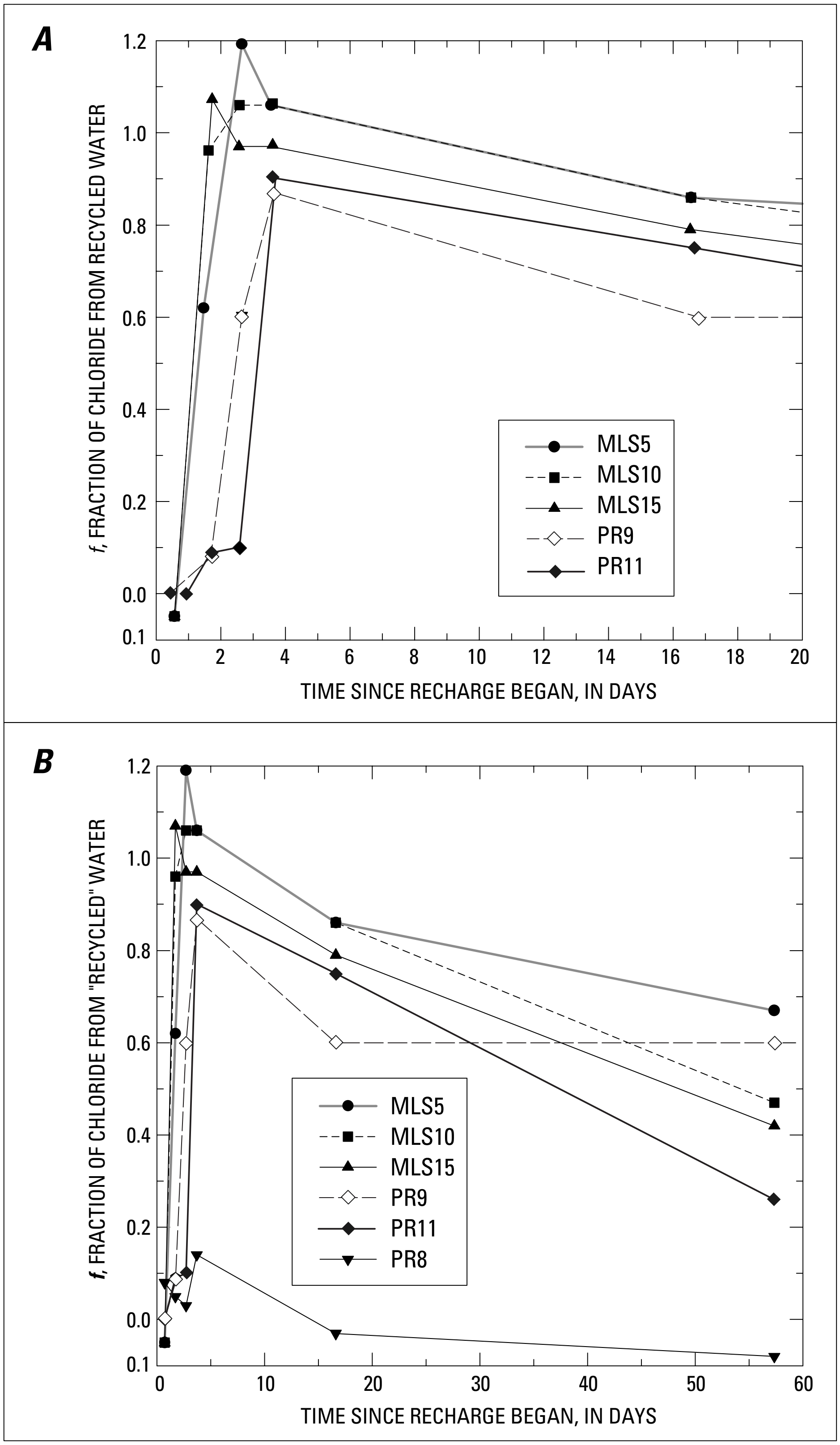


Figure 12. Displacement of preexisting chloride at multilevel samplers (MLS, at indicated depths in feet) and piezometers (PR9 and 11, above the clay lens; PR8, below the clay lens) beneath the research basin, Montebello Forebay, Los Angeles County, California, as the basin is filled with recycled water for the periods up to (*A*) 17 days and (*B*) during the subsequent drying cycle.

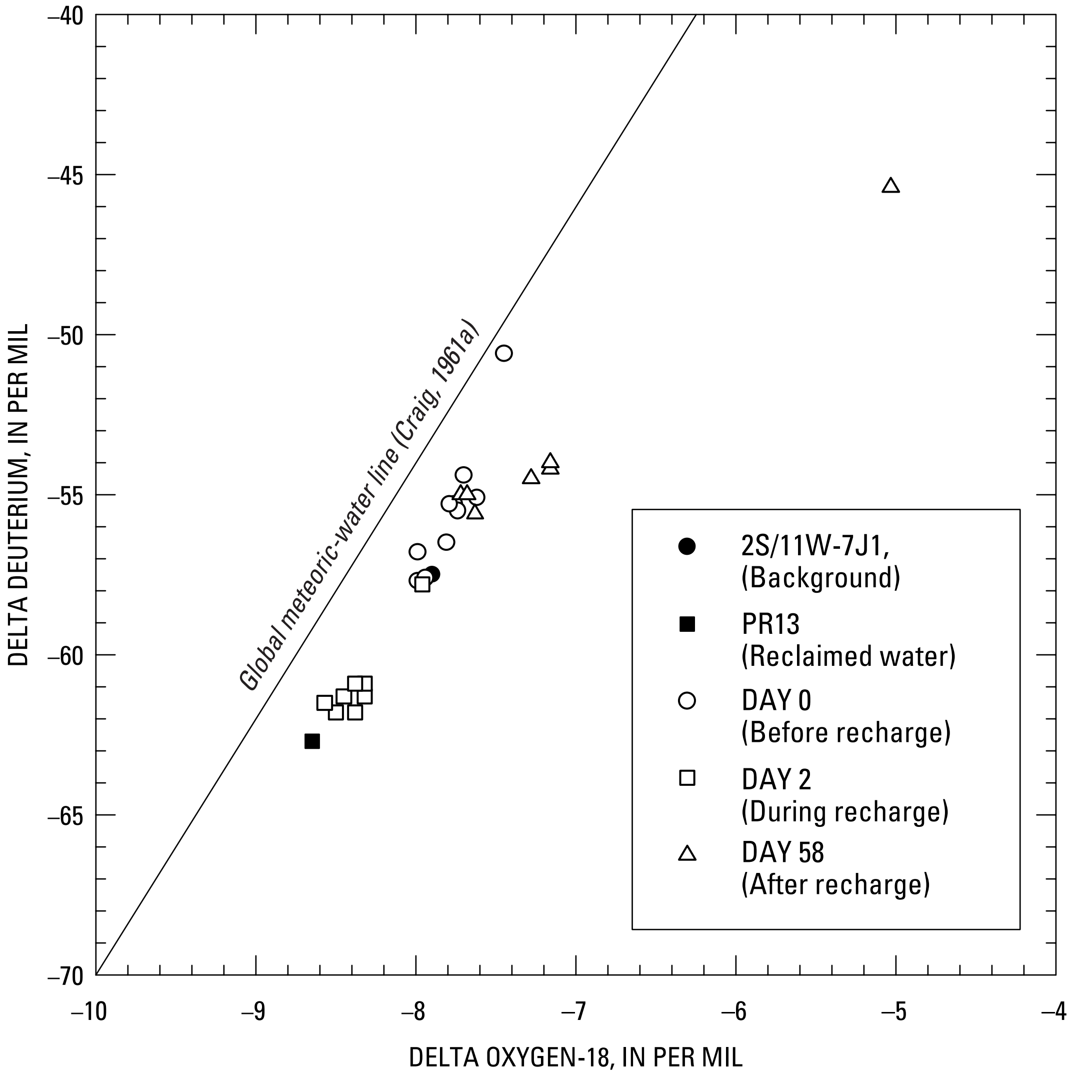


Figure 13. Displacement of preexisting water (day 0) beneath the research basin, Montebello Forebay, Los Angeles County, California, as the research basin is filled with recycled water and then its return to prior isotopic composition about 6 weeks after recharge is discontinued (day 58).

Nitrogen

Results from these calculations for nitrogen are shown in figure 14. To remove the considerable variability, some of which may reflect real differences in a rapidly evolving system and some which is due to analytical imprecision, results from all depths sampled by the multilevel sampler at a given time were combined to obtain averages that are plotted in the figure. The total-nitrogen values used in the calculations are, in fact, based on analyses of inorganic species only (ammonium, nitrate, and nitrite)—organic nitrogen was not analyzed. The error introduced by this omission is not known and may be somewhat variable given the ease with which microorganisms interconvert ammonia and proteinaceous organic nitrogen. A single sample of effluent taken from PR13 in May 1996 had a dissolved organic nitrogen concentration of only 0.9 mg/L, which represented a little less than 10 percent of total inorganic nitrogen present.

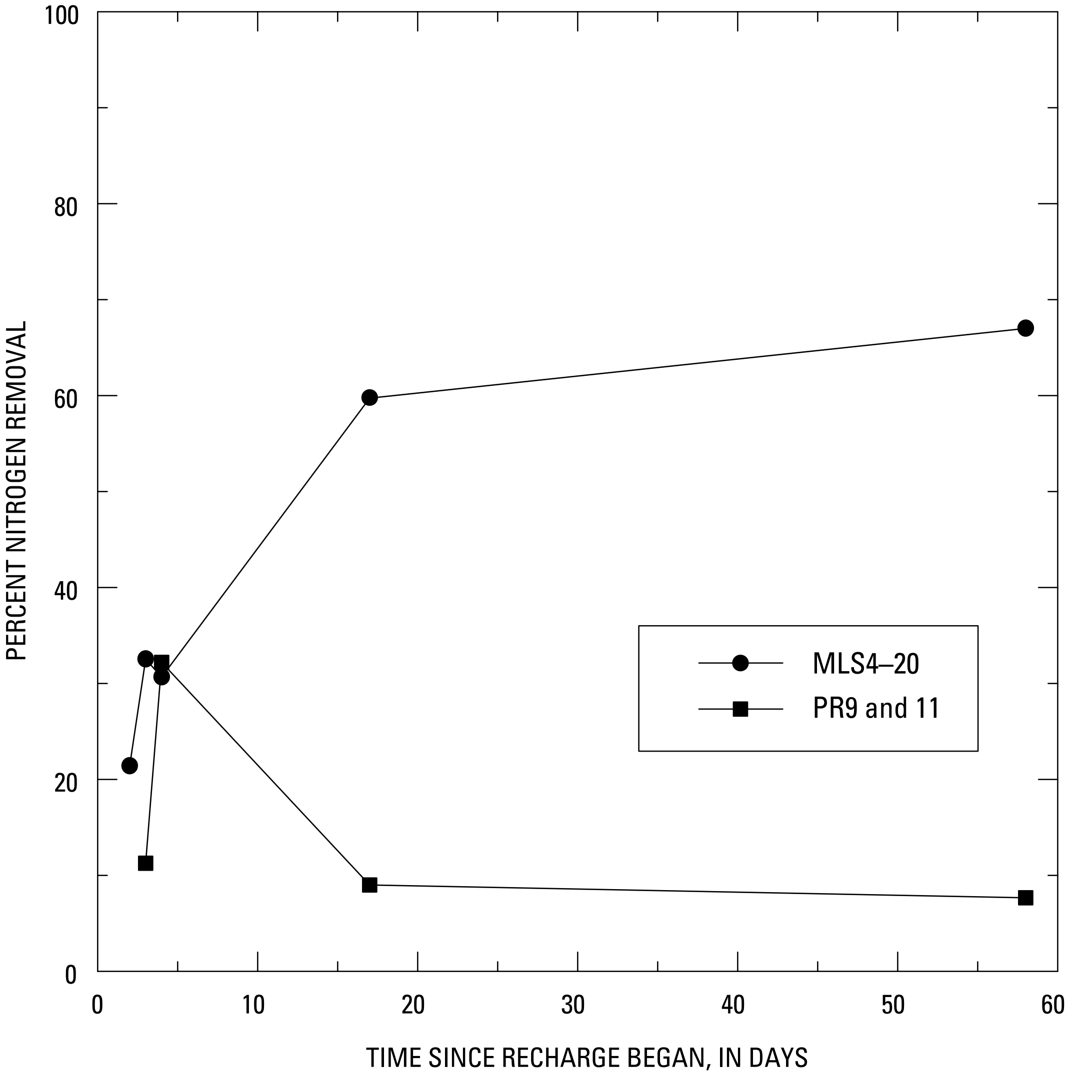


Figure 14. Removal of nitrogen beneath the research basin, Montebello Forebay, Los Angeles County, California, as the research basin is filled with recycled water (MLS4–20, average for multilevel sampler; PR9 and 11, average for piezometers above the clay lens).

Results summarized in figure 14 indicate that nitrogen removal in the multilevel sampler rises rapidly to about 30 percent after 3 days, and then increases more slowly to about 60 percent on the 17th and last day that recycled water was added to the research basin. Samples for which only a small fraction ($f < 0.2$) of recharged water is present are omitted from the calculation because they yield very large computational anomalies. This occurs in samples collected from shallow depth soon after recharge, and for a somewhat longer period in samples from deeper levels. Calculations based on samples from a single depth are subject to very high uncertainty; therefore, the low (10 percent) and high (30 percent) ends of the range for the 25-foot piezometers (PR9 and 11) may themselves not be different. However, lower removal rates in the deeper ports of the multilevel sampler do provide additional evidence for less removal at greater depth.

It is important to note that the actual percentages are less important than is the fact that a large amount of nitrogen removal occurs during (and after) recharge. On the basis of additional chemical and isotopic evidence that is discussed later, the processes leading to decreased concentrations are likely to take place during any recharge experiment in the research basin, and during regional spreading of recycled water as well. Actual removal rates differ somewhat under different environmental and operational conditions. For example, the low infiltration rate and resultant more stagnant conditions that prevailed during the first recharge experiment led to almost complete removal of nitrogen, as well as low oxygen and high manganese concentrations (covariance of these constituents is explained in the section "Chemical and Isotopic Evidence for Denitrification").

Organic Carbon

Organic carbon (fig. 15) also is removed during, and after, recharge. Fewer concentration data exist for organic carbon than for nitrogen. The measured concentration of dissolved organic carbon in the research basin was 9.18 mg/L on the second day of recharge. Calculations based on samples for which chloride indicates sufficient recharge water is present to justify computation ($f > 0.2$) yield an average removal of slightly less than 35 percent after 2 days and slightly more than 35 percent thereafter. However, the range in removal, from 21 to 59 percent, is quite large, and the highest removals occurred at intermediate depths. (Organic carbon removal is discussed in more detail in the second part of this report.)

Zinc

Zinc is the last constituent for which removal efficiencies were calculated in the manner described above. It was the only inorganic trace metal found to be present at levels much higher than detection limits in the recycled water and elevated above natural levels. Zinc is abundant in urban environments (Schroeder, 1995, and references therein) and in reclaimed water as indicated by its mean concentration of 48 µg/L (range from 41 to 58 µg/L) in the research basin (PR12) during the second recharge experiment. Percent removal, plotted in figure 16 and concentration data (though highly variable), given in appendix 3, show that downward transport of zinc is somewhat efficient initially, especially at the shallowest ports of the multilevel sampler. However, removal percentage exceeds 70 percent by the 17th and last day of recharge. On the basis of these results, it is concluded that zinc is not a suitable tracer of reclaimed-water movement over long distances and traveltimes.

Arsenic

The maximum contaminant level (MCL) of 50 µg/L for arsenic in drinking water will be lowered to 10 µg/L in the next few years. Analysis of 23 samples of reclaimed water from PR12 and PR13 (appendix 2) yields a mean dissolved arsenic concentration of only 2.7 µg/L (highest concentration of 4 µg/L)—much less than even the reduced MCL. For that reason, the only analyses done for this study were those associated with the first recharge experiment in September 1993. Results of measurements taken from beneath the recharge basin found about 40 percent of almost 300 samples had a concentration higher than 10 µg/L, but that none exceeded 50 µg/L. It also has been reported that 10 µg/L was exceeded in only about 7 percent of more than 100 ground-water monitoring samples from the Central and adjacent West Coast Basins (Land and others, 2002). Factors that can affect arsenic concentration include mineral composition of the local aquifer soil, speciation (inorganic or organic) of the element, sorption, and redox state. Without further study, it is not possible to ascertain which of these factors is most important; however, it is clear from low concentrations in the effluent that wastewater is not a direct source of arsenic in ground water. Furthermore, it appears that the arsenic mobilization that is observed over short distances in the recharge experiment does not occur over long distances, based on the results from Land and others (2002).

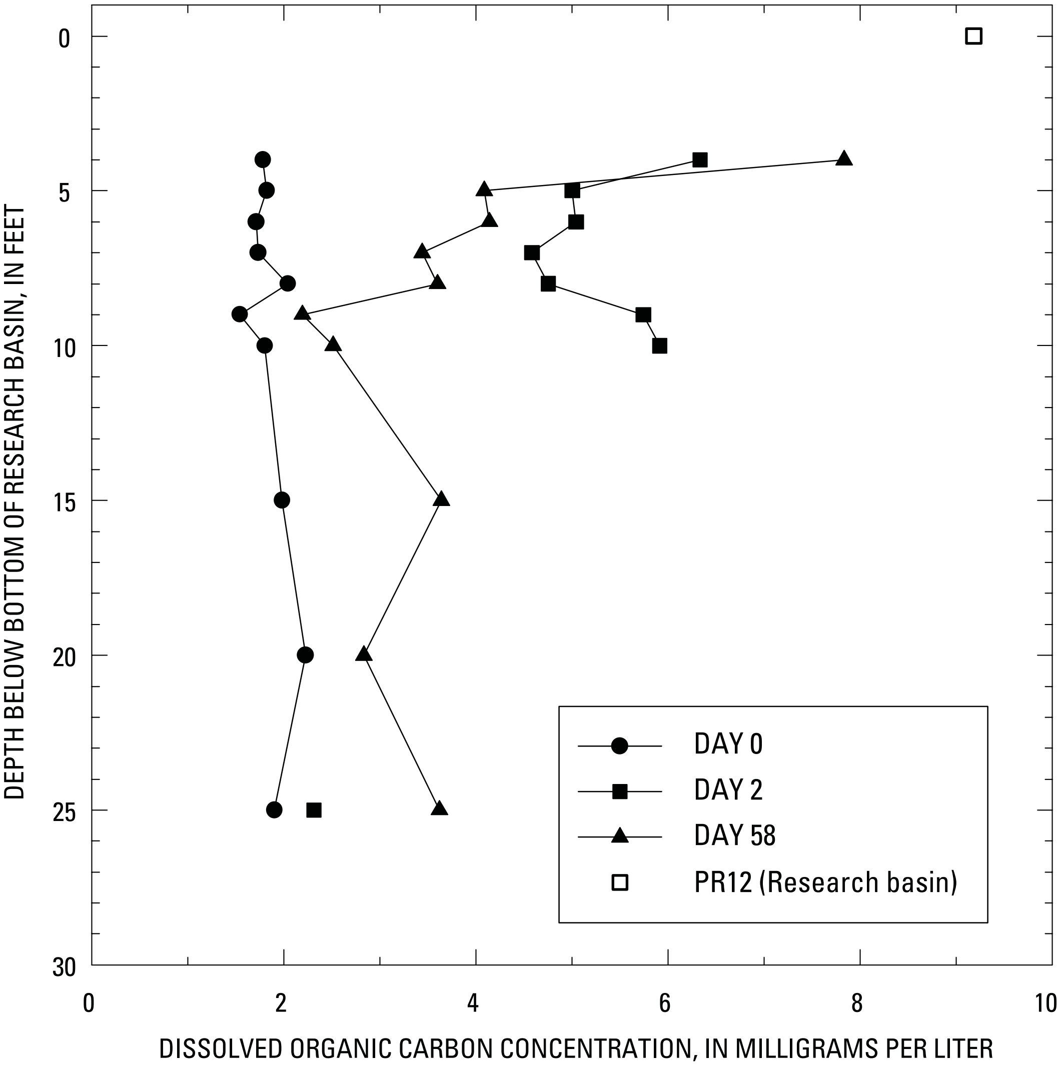


Figure 15. Change in dissolved organic carbon concentrations beneath the research basin, Montebello Forebay, Los Angeles County, California, before (day 0), during (day 2), and after (day 58) recharge with recycled water.

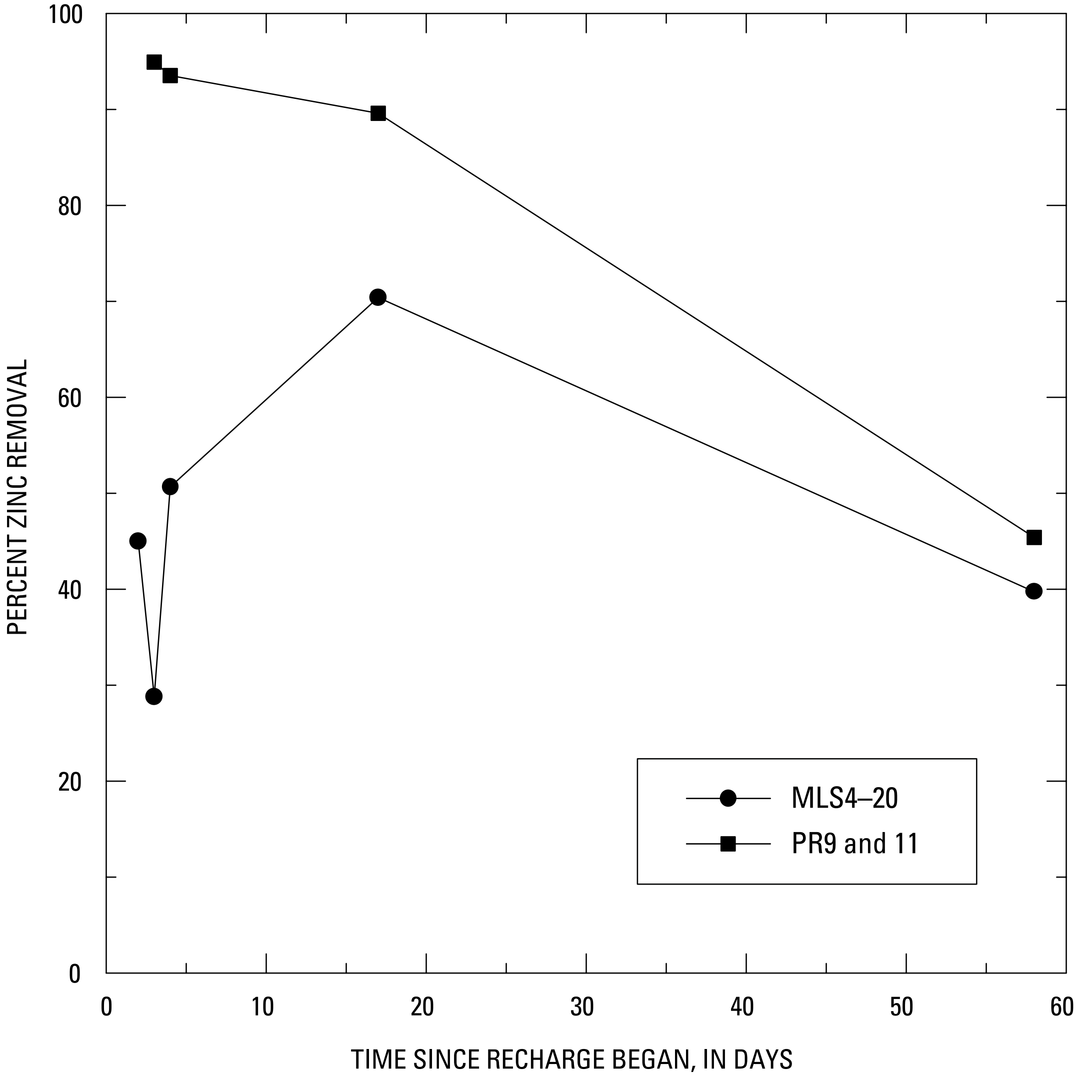


Figure 16. Removal of zinc beneath the research basin, Montebello Forebay, Los Angeles County, California, as the research basin is filled with recycled water (MLS4–20, average for multilevel sampler; PR9 and 11, average for piezometers above the clay lens).

Chemical and Isotopic Evidence for Denitrification

Differences in chemical concentrations between the reclaimed-water effluent before delivery to the research basin (PR13) and in the research basin itself (PR12) are small for nearly all constituents. The most notable exception is nitrogen. During the first recharge experiment in August 1993, concentrations (as nitrogen) in the effluent (PR13) were about 13 mg/L for ammonia, 3 mg/L for nitrate, and about 2 mg/L for nitrite over a period of about 20 days. Yet in the research basin itself (PR12), ammonia remained less than 1 mg/L, and nitrate plus nitrite was about 5 mg/L (appendix 2). No reason for the low ammonia concentration is known; however, the fact that the research basin was filled initially in about 1 day, and only sporadic additions were made thereafter to maintain a full basin, may have allowed sufficient algal growth to remove the ammonia (green color of the water quickly intensified as recycled water was added to the research basin).

A similar, but far less dramatic, shift to a greater proportion of nitrogen in the oxidized state as effluent accumulated in the research basin was observed during the second recharge experiment in April 1994. In this experiment, the research basin was filled with a much larger volume of reclaimed water (12.5 acre-ft over 17 days in comparison with 2.1 acre-ft over 21 days in the first experiment). Replenishment with the much larger volume may have been responsible for keeping variability in concentrations low, although even in the second experiment there was a decrease in ammonia-nitrogen concentrations from about 5 mg/L during the first few days of recharge to a little more than 2 mg/L on the last (17th) day of recharge (fig. 17).

Nitrogen dominance continues its shift in the direction of oxidized species as reclaimed water infiltrates beneath the research basin (figs. 18*A*–*H*). Much of the shift reflects removal of ammonia, but the fact that nitrate plus nitrite concentrations in the multilevel sampler and the 25-foot piezometers reach levels during the first few days of recharge that are slightly higher than those in the research basin itself implies that some oxidation of reduced nitrogen must be taking place beneath the research basin. However, as recharge continues to day 17, concentrations of nitrogen decrease and there is a noticeable shift to higher ammonia abundance (fig. 18*G*). By 41 days after filling of the research basin was discontinued, ammonia actually predominates at the shallower depths (fig. 18*H*).

The shifts in nitrogen speciation are accompanied by an initial decrease in dissolved-manganese (also iron) concentrations as reclaimed water percolates beneath the research basin; this decrease is followed by an increase as recharge continues through day 17, and by further increases as the research basin empties and water beneath the research basin stagnates (fig. 19). Dissolved-oxygen concentrations vary inversely with manganese and decline to near the detection limit of about 0.4 mg/L after recharge is stopped (fig. 20). However, as shown in figure 19, manganese concentrations remained high, in excess of 1,000 µg/L at the piezometers beneath the clay lens (PR8 and PR10) throughout the recharge experiment, confirming (as do chloride and other chemical data) that the clay lens represents a barrier to measurable downward percolation during recharge at the research basin.

Dissolved-iron and dissolved-manganese concentrations usually are low in neutral and alkaline solutions unless oxygen is absent because both elements are very insoluble in their higher oxidation states. Manganese can be reduced, and thereby reach high dissolved concentrations, at a higher redox potential (less reducing environment) than can iron. Thermodynamic calculations for a few samples from beneath the research basin using WATEQ4F (Plummer and others, 1984) and based on the nitrogen redox couples (nitrate/nitrite and nitrate/ammonia) and on manganese concentrations yield Eh values of about 350 to 450 millivolts. In fact, the manganese redox couple is close to that for nitrate reduction. The high levels of manganese, very low levels of oxygen, and apparent removal of nitrogen all suggest that microbial denitrification is occurring beneath the research basin.

Further evidence of denitrification comes from nitrogen-isotope ratios measured for a few samples collected before (April 4, 1994), during (April 6), and after (June 1) filling of the research basin. Denitrification results in a decrease in nitrate concentrations and typically is accompanied by enrichment in nitrogen-15 in the remaining nitrate (Schroeder and others, 1993, and references therein). Such enrichment is observed in this study for sample pairs from 1-foot intervals between 5 and 10 ft below the research-basin floor (table 9). As reclaimed water replaces and mixes with existing ground water, nitrogen concentrations increase, and the δ^{15}N decreases from about 35 $^{o}/_{oo}$ to about 10 $^{o}/_{oo}$, a value typical of domestic and municipal wastewater. Following cessation of recharge, denitrification occurs and δ^{15}N increases again to about 60 $^{o}/_{oo}$ at day 58, long after recharge has ceased. The enrichment in nitrogen-15 can be expressed in terms of an isotope-separation (fractionation) factor, ε, from the equation

$$\delta^{15}N_f = \delta^{15}N_i + \varepsilon Ln[NO_3^-]_f \,/\, [NO_3^-]_i,$$

where

the subscripts "*i*" and "*f*" refer to initial and final isotope-ratio and nitrate-concentration data.

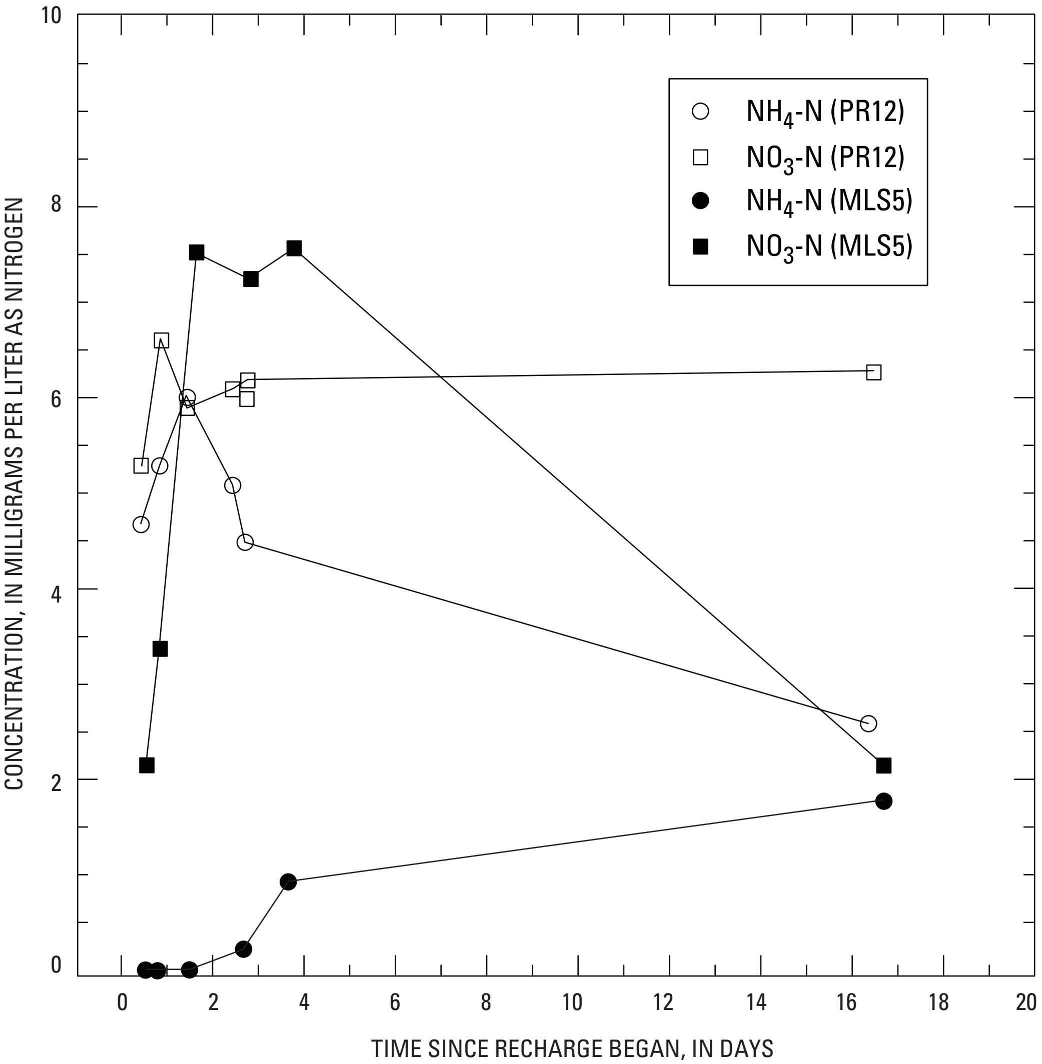


Figure 17. Changes in ammonia (NH_4-N) and nitrate (NO_3-N) concentrations in recycled water in the research basin (PR12) and from 5 feet beneath the floor of the research basin, Montebello Forebay, Los Angeles County, California, during the second recharge experiment that began in April 1994.

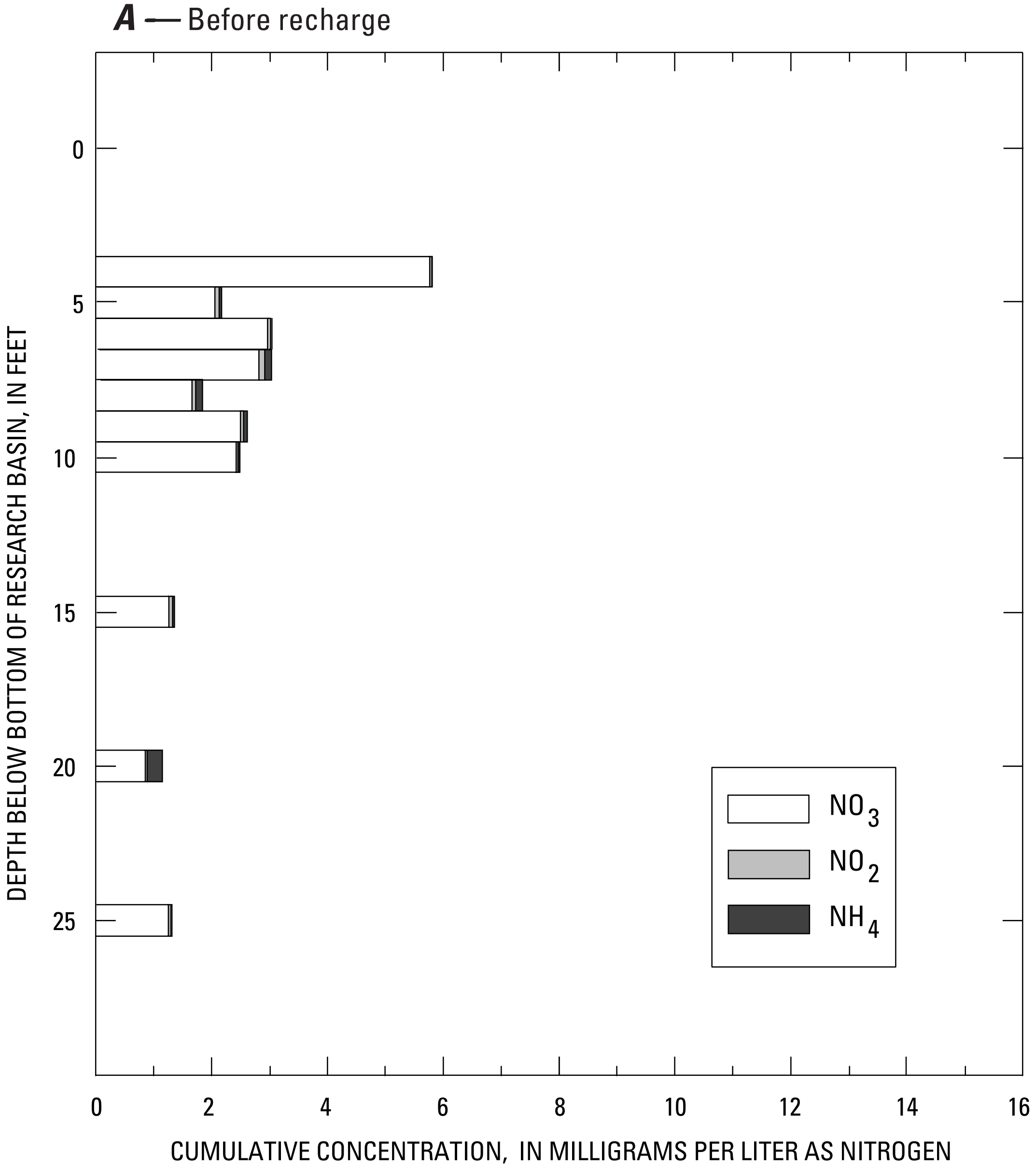
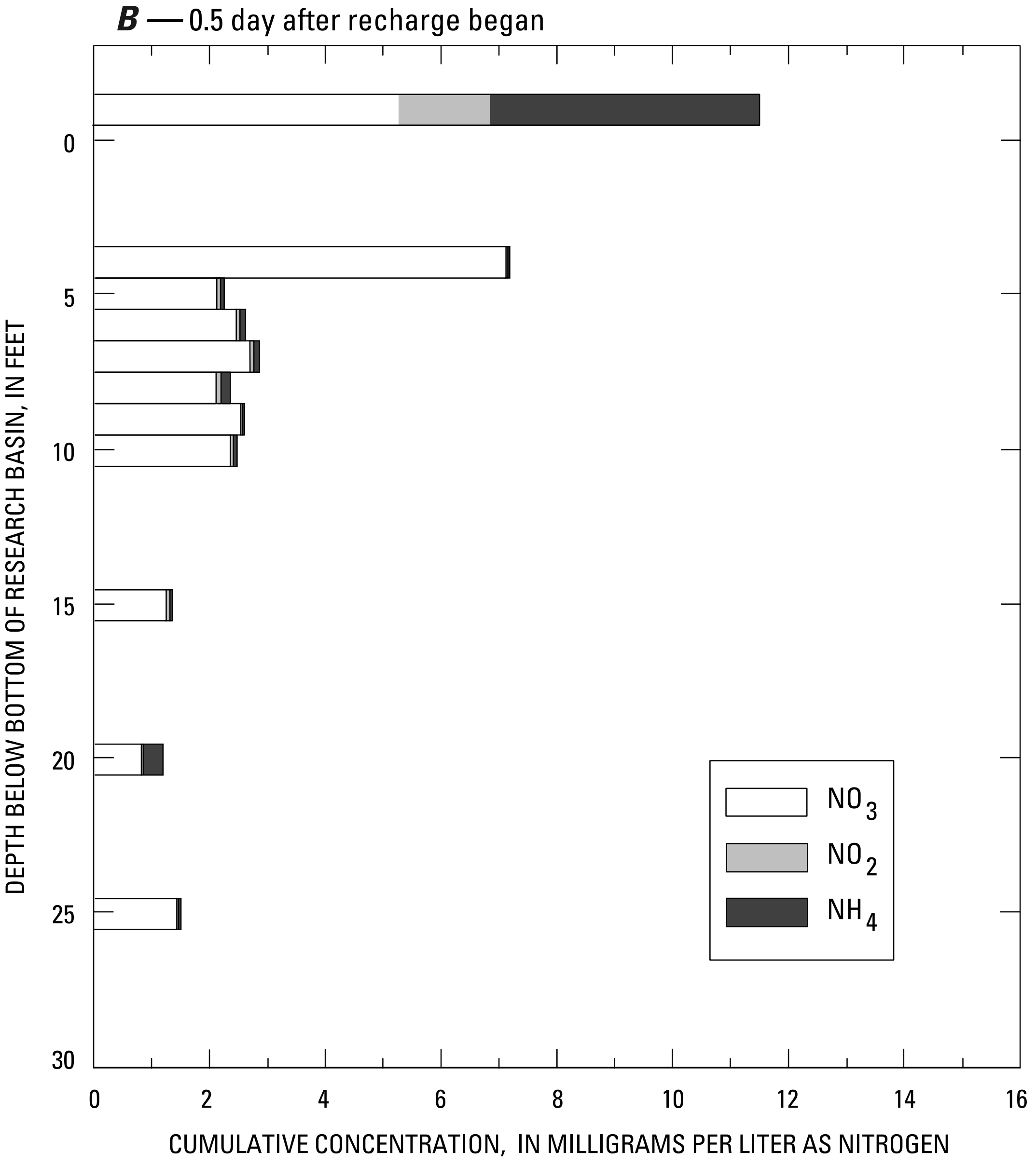


Figure 18. Changes in concentration and distribution of nitrogen species in the research basin, Montebello Forebay, Los Angeles County, California, as the research basin is filled with recycled water for 17 days: *A*, before recharge; *B*, 0.5 day after recharge began; *C*, 1 day after recharge began; *D*, 2 days; *E*, 3 days; *F*, 4 days; *G*, 17 days (last day of recharge); *H*, 58 days (41 days after recharge discontinued). NO_3, nitrate; NO_2, nitrite; NH_4, ammonia.



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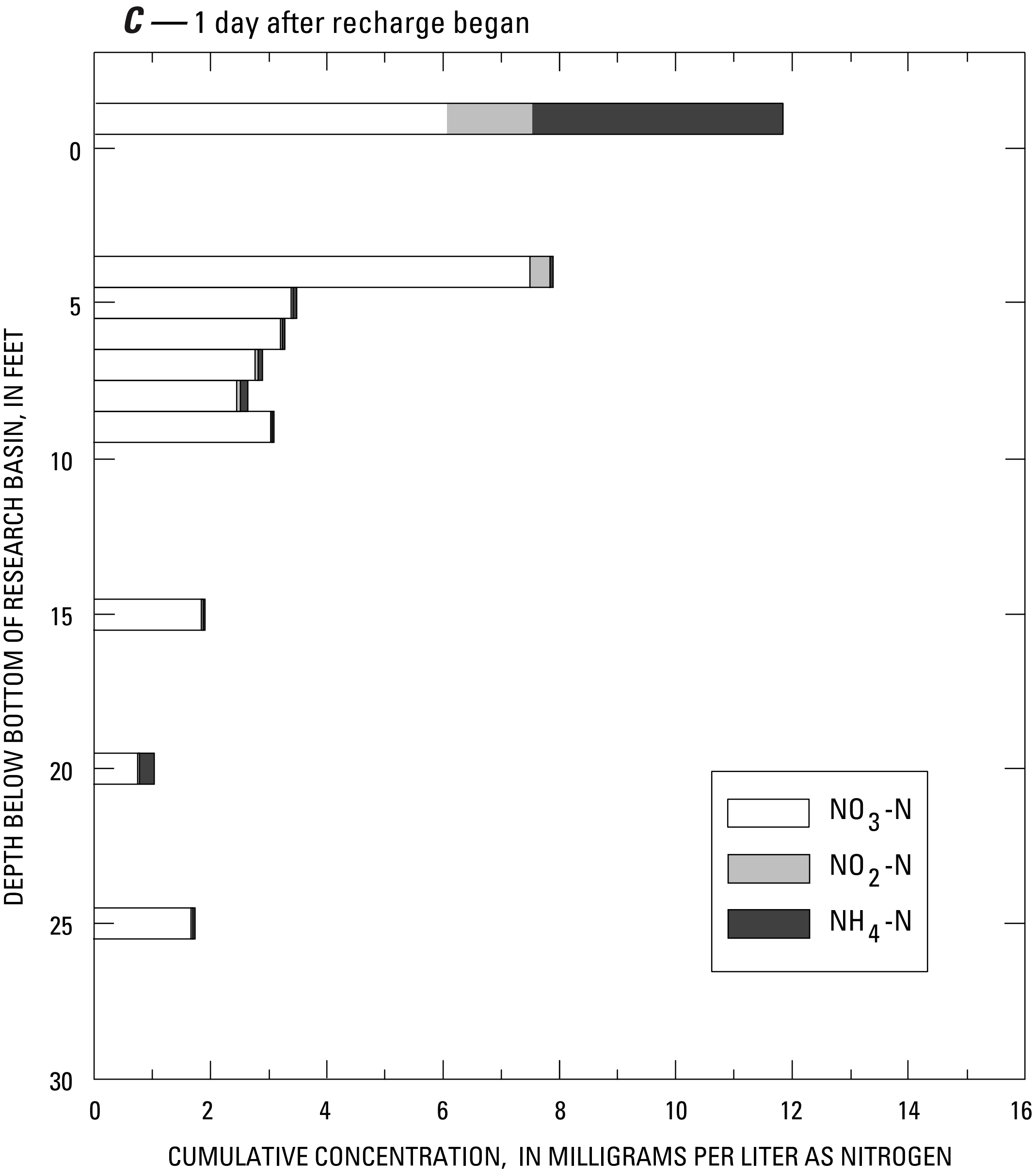

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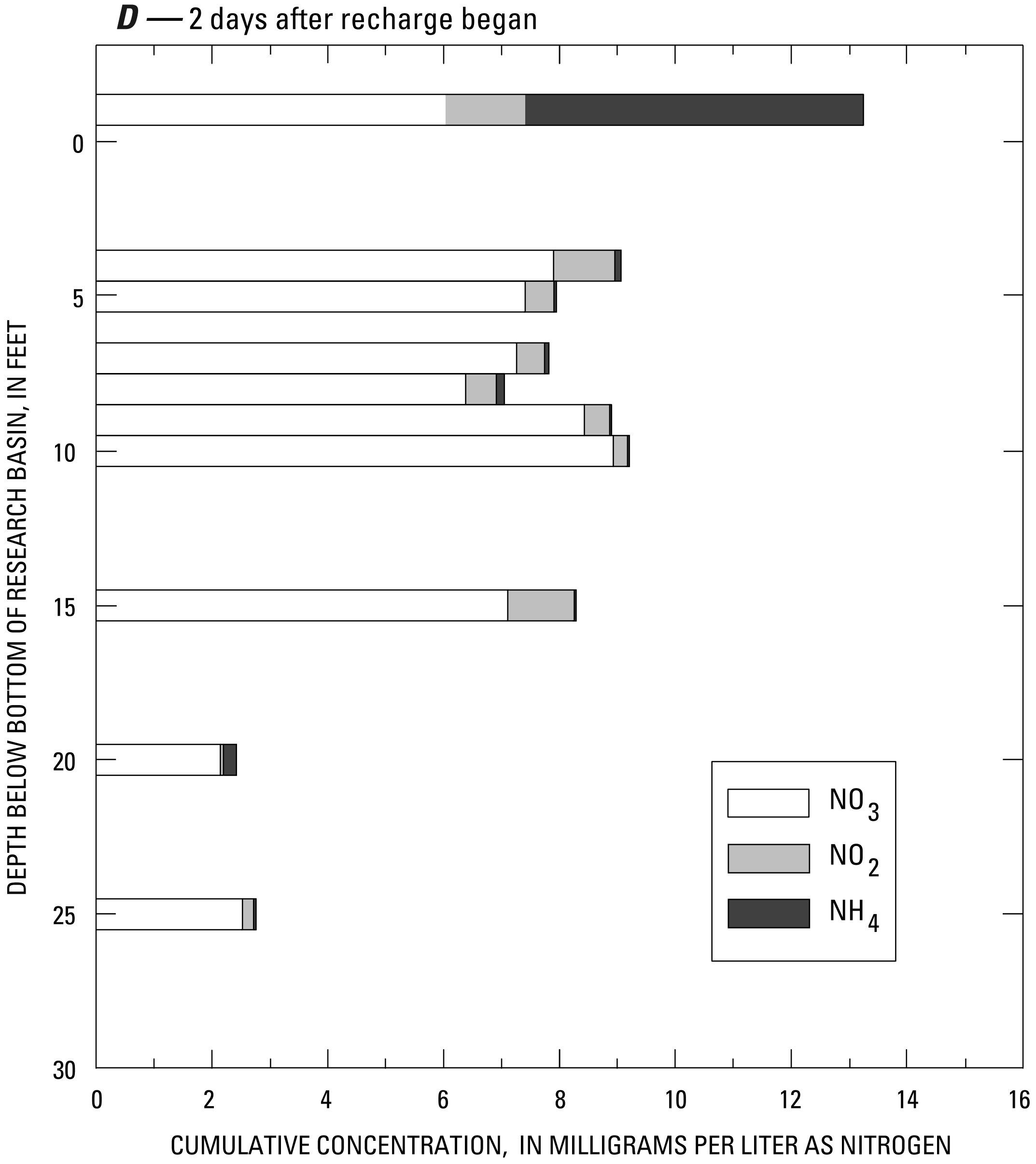

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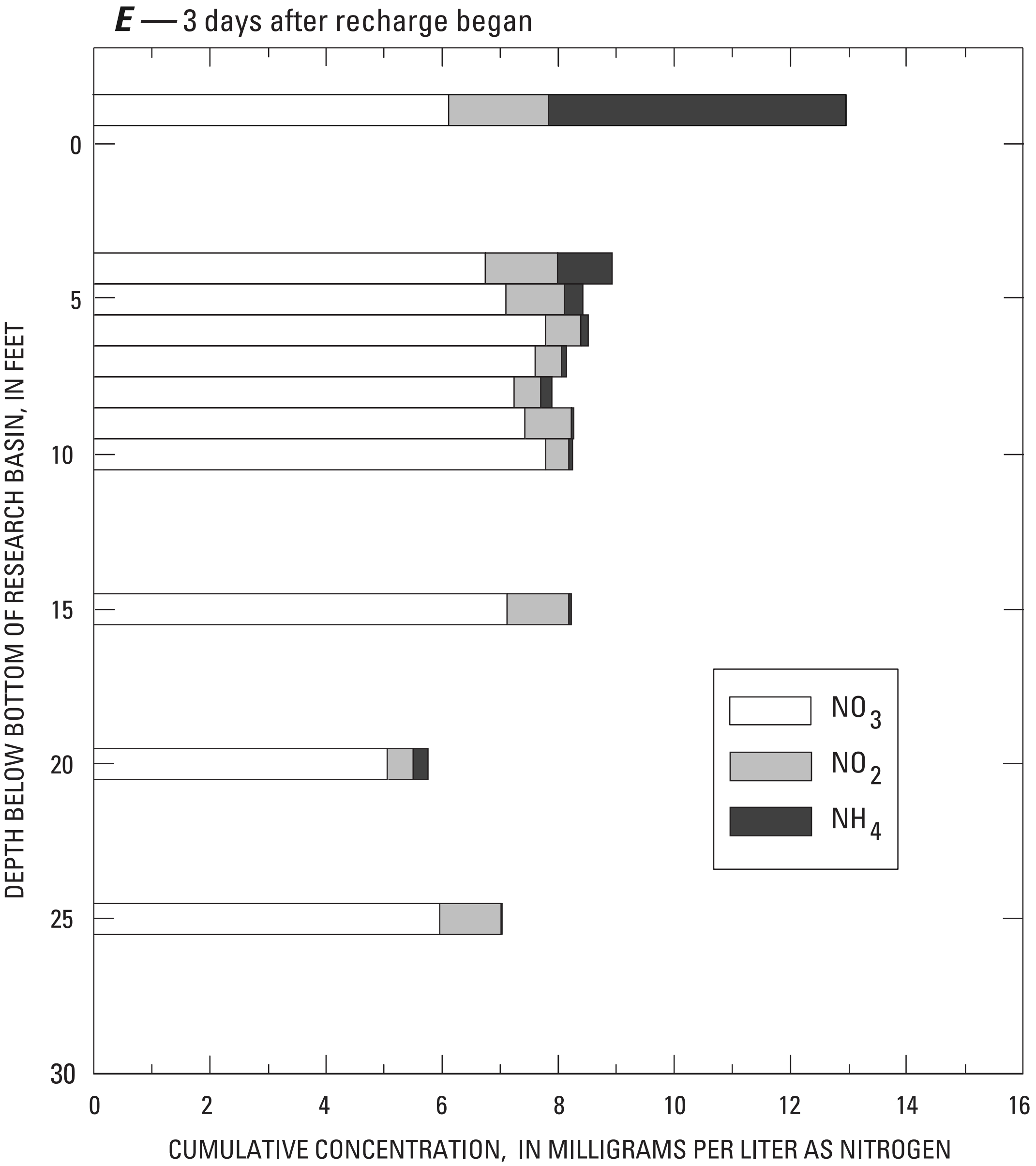

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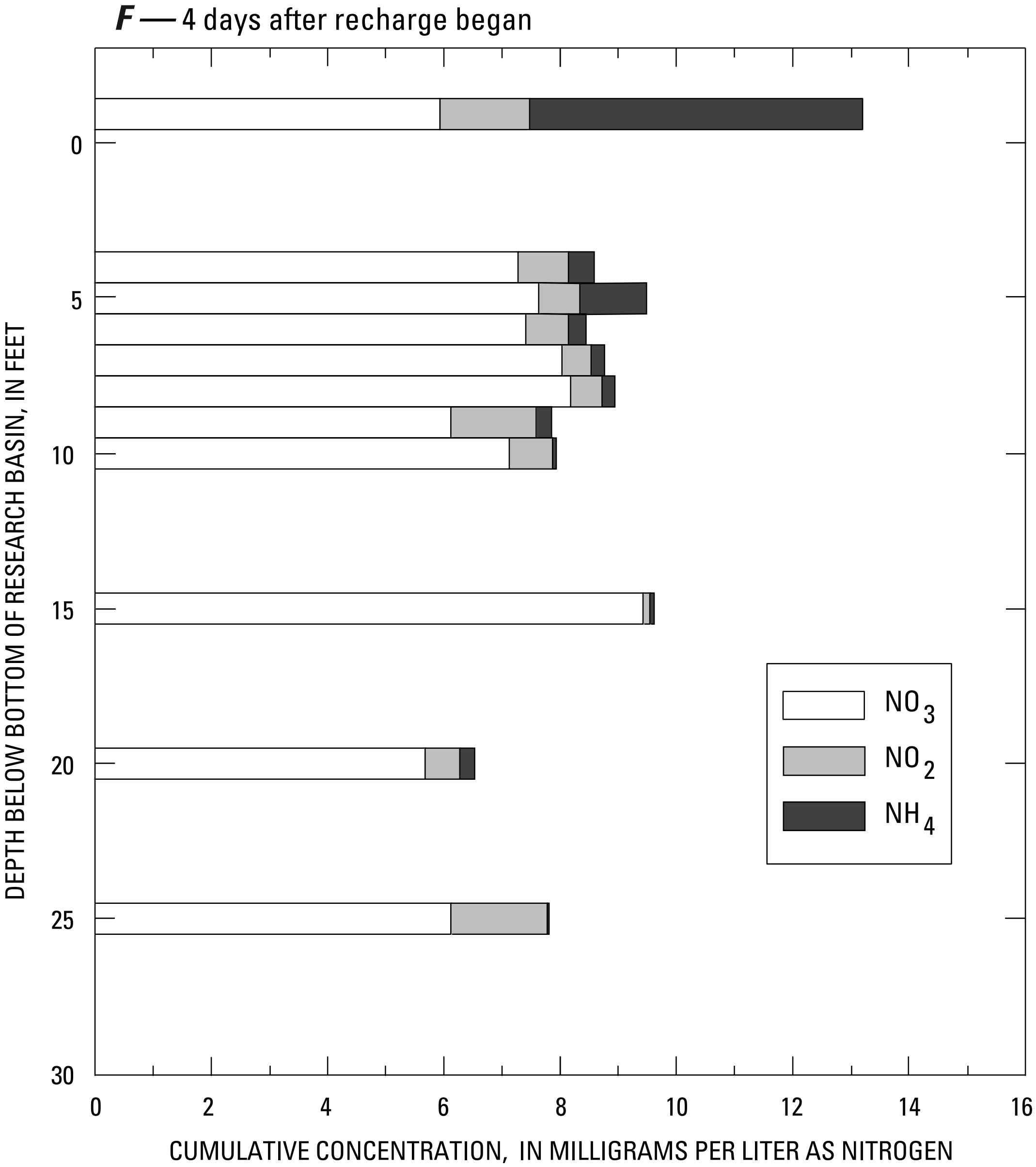

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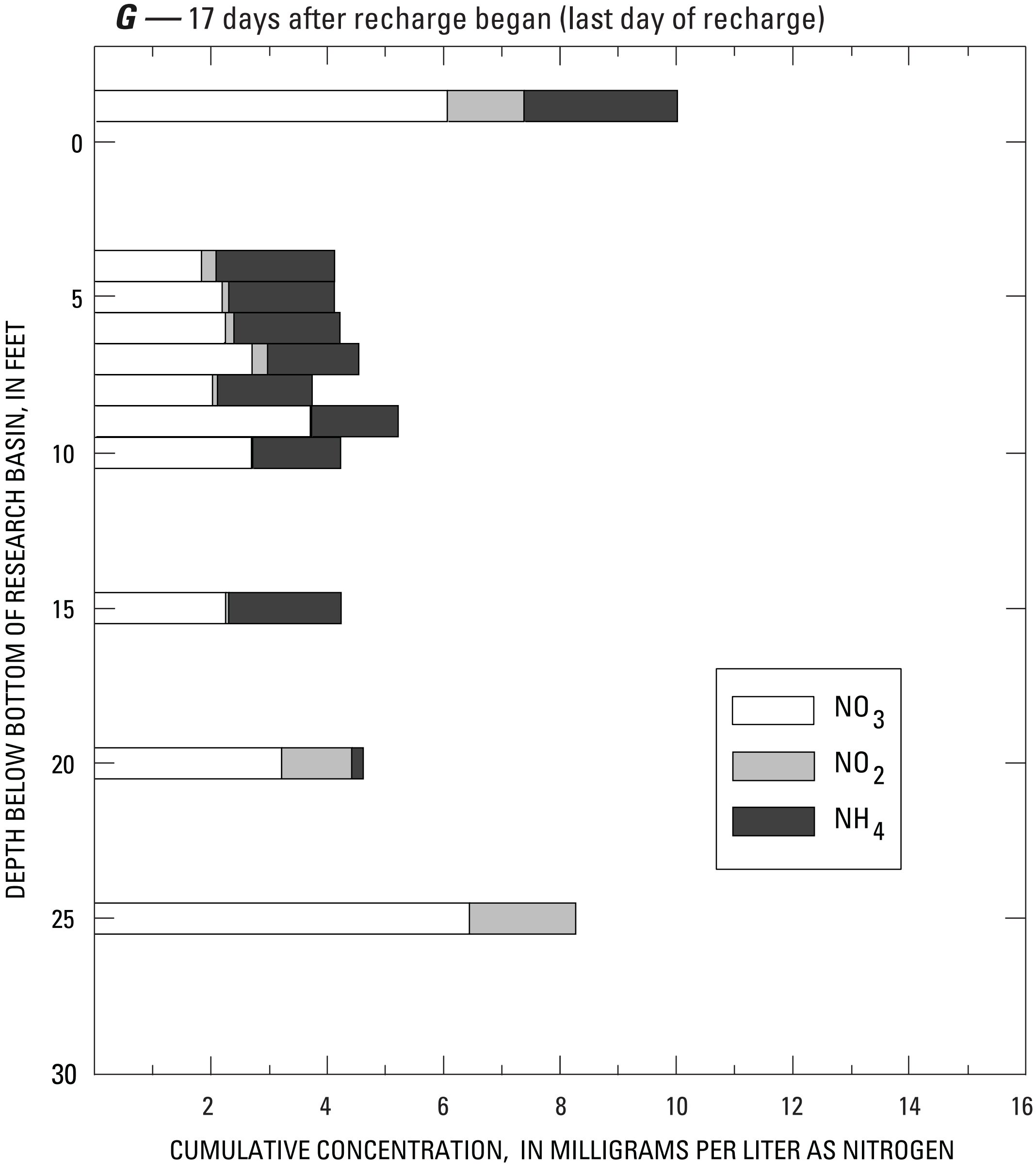

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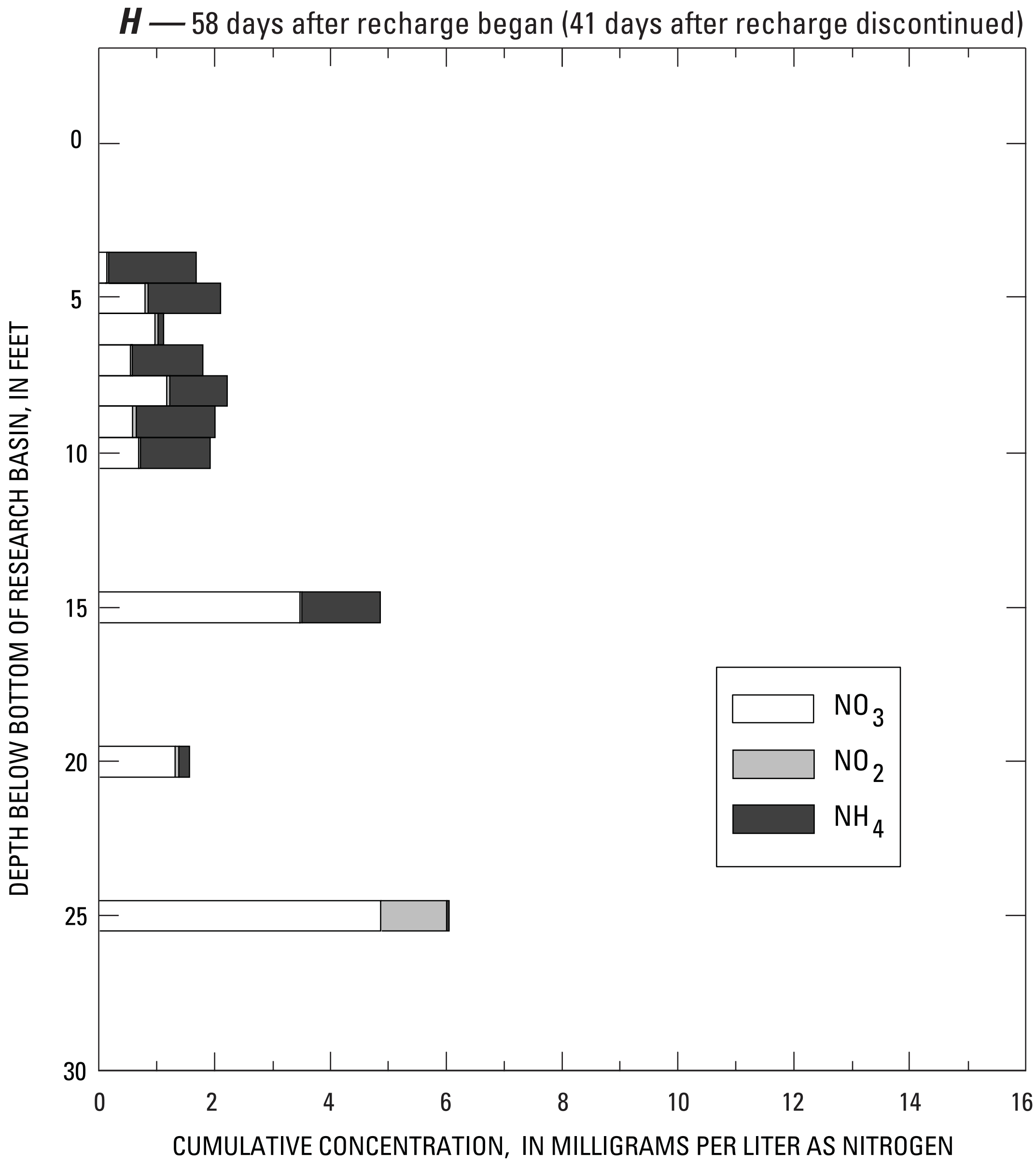

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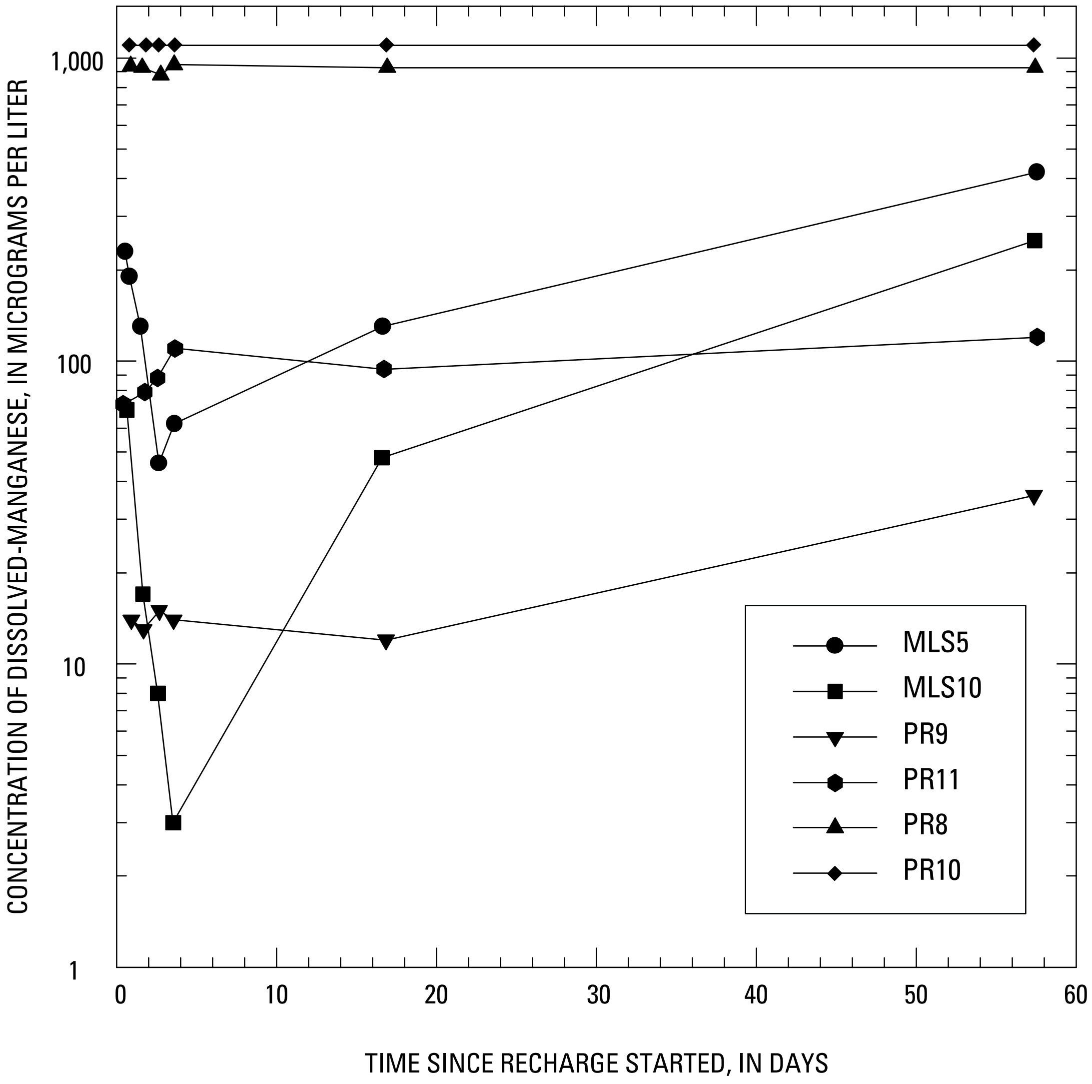


Figure 19. Changes in dissolved-manganese concentration beneath the research basin, Montebello Forebay, Los Angeles County, California, during recharge with recycled water (MLS, multilevel sampler at indicated depths in feet; piezometers above, PR9 and PR11, and below, PR8 and PR10, the clay lens).

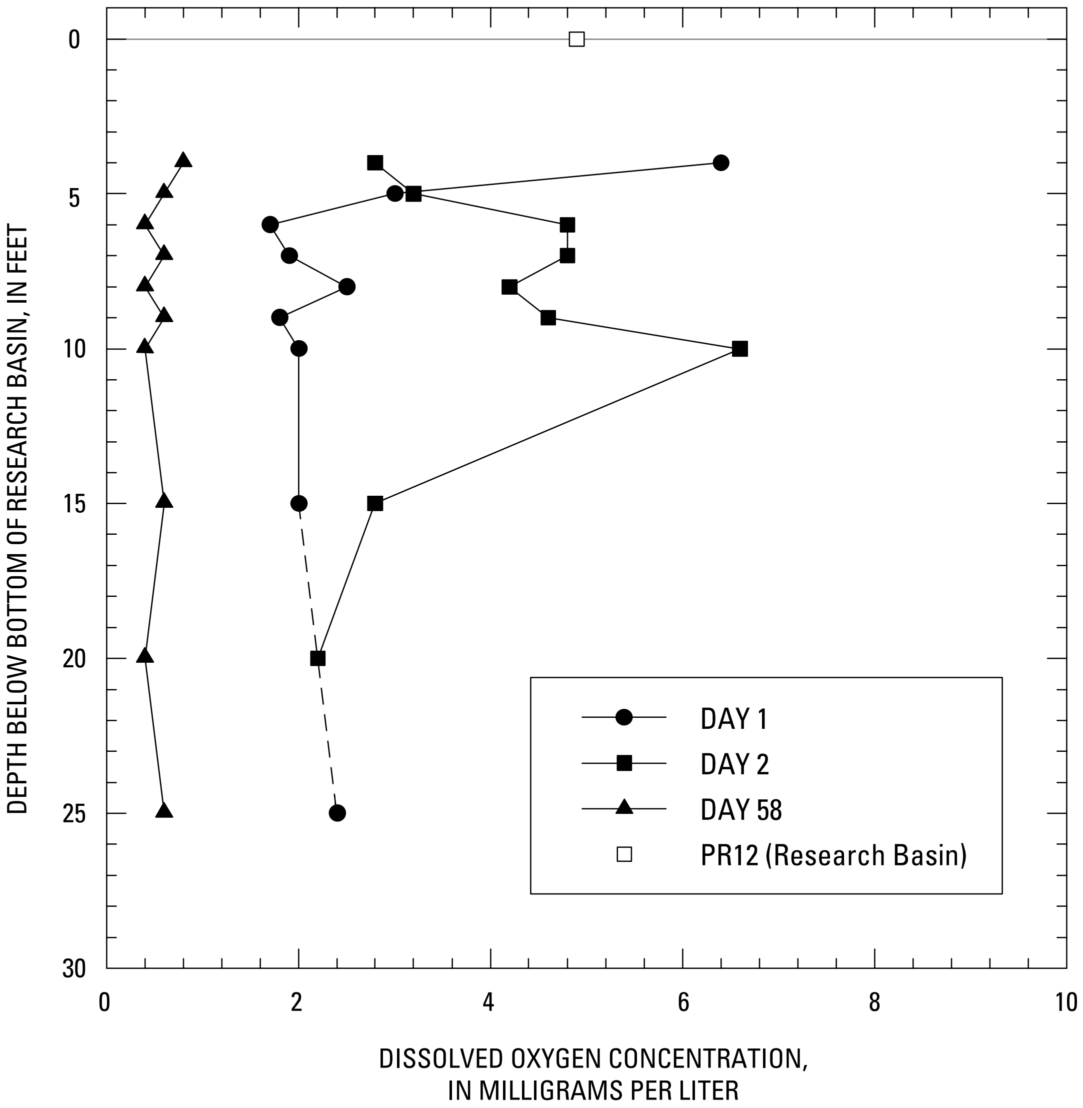


Figure 20. Changes in dissolved-oxygen concentration beneath the research basin, Montebello Forebay, Los Angeles County, California, at selected times during the recharge experiment.

Table 9. Nitrogen-isotope data for nitrate in water below research basin, Montebello Forebay, Los Angeles County, California, during April–June 1994 recharge experiment

[Refer to text for description of “formal” methodology to calculate fractionation between days 0 and 2; mg/L, milligrams per liter; per mil, parts per thousand; MLS, multilevel sampler; —, no data]

Sample identifier	Nitrate-N (mg/L)			N-15 (per mil)			Isotope separation factor (per mil)	
	Day 0	Day 2	Day 58	Day 0	Day 2	Day 58	Day 0/2	Day 2/58
MLS10	2.38	8.95	0.66	40.4	7.6	65.3	–24.76	–22.13
MLS9	2.47	8.53	.58	39.3	8.1	66.7	–25.17	–21.80
MLS8	1.66	6.47	1.07	41.7	9.5	54.3	–23.67	–24.90
MLS7	2.8	7.21	.53	31.5	10.2	60.9	–22.52	–19.42
MLS6	2.97	7.81	.89	31.5	9	52.6	–23.27	–20.07
MLS5	2.05	7.51	.77	37.8	10.9	52.6	–20.72	–18.31
PR8	1.48	1.49	1.4	41.2	41.8	—	—	—
Average					9.22[a]		–23.35	–21.11
Standard deviation					1.25[a]		1.62	2.35

[a] Data for PR8 not used in calculation.

In this case, the initial values are those obtained during the second day of recharge on April 6, and final values are those obtained long after recharge ceased on June 1. The calculation yields an isotope-separation factor (ε) of –23.3 ± 1.6 $^{o}/_{oo}$, a value close to the more negative (larger magnitude) end of the range from –30 to –5 $^{o}/_{oo}$ reported in the literature for fractionation during denitrification in a variety of ground-water environments (Schroeder and others, 1993, and references therein).

Although analytical data do not exist for initial conditions before April 4, a hypothetical value for ε can be formally calculated by assuming that concentration and isotope data from April 6 are representative of “initial” values for earlier recharge. Note that this calculation yields a very similar value (–21.1 ± 2.4 $^{o}/_{oo}$), even though the initial conditions are actually some undetermined combination of input from the first recharge experiment in August 1993, natural recharge during the intervening winter, and regional spreading operations at the adjacent San Gabriel River Coastal Spreading Grounds. This result, as well as the increase in manganese concentration and relative enrichment in reduced nitrogen species, by the last day that effluent was added to the research basin on April 21, indicates that the redox environment for denitrification during recharge itself is present throughout recharge, particularly during the latter period of recharge, and not only during the interval between recharge events. In addition, two high values for δ^{15}N (>41 $^{o}/_{oo}$) in the piezometer below the clay lens (PR8), which is unaffected by recharge experiments in the research basin, argue strongly that denitrification may have a larger areal extent than just at the research basin itself.

Other Possible Mechanisms for Nitrogen Removal

Other possible mechanisms for reduction of aqueous nitrogen (reduced species only) concentration include:

1. Volatilization of ammonia from the water in the research basin or from the moist soil surface as the floor of the research basin dries,

2. Cation exchange of ammonia on soil beneath the research basin, and

3. Sorption or incorporation within the organic-rich, fine-grained layer that accumulates in a thin infiltration zone on the floor of the research basin.

Although it would be difficult to quantify the importance of each of these mechanisms, some theoretical considerations described herein can yield plausible arguments for or against them.

Volatilization

The direction of ammonia transport across an air/water interface is determined by relative concentrations of the (un-ionized) gas in the water and atmosphere and the rate of exchange is dependent on such environmental factors as windspeed. The pK_a (pH at which the ammonium ion and un-ionized ammonia are present in equal concentrations) of the ammonium ion is 9.3 in dilute solution and varies with salinity and temperature. For environmental conditions at the study site, equilibrium geochemical calculations indicate that about 10 percent of total dissolved ammonia plus ammonium is in the un-ionized ammonia form (R. Seiler, USGS, written commun., 2002) that is susceptible to loss by volatilization. However, analysis of air samples collected immediately above the water surface in the research basin did not find ammonia concentrations to be higher than outside the basin (T.F. Rees, USGS, oral commun., 1996), although differentiation based on these analyses is poor due to high ambient (background) ammonia concentrations in the region. Loss by volatilization of ammonia probably is negligible, although a definitive conclusion is not possible.

Ion Exchange

Certain clay minerals have the ability to exchange cations through ion exchange in aqueous solutions with which they are in contact. Cation-exchange capacity, which is an indication of this ability, was measured by equilibration of soil from selected depths beneath the research basin with a 1N ammonium acetate solution. The results, on a dry mineral-weight basis, average about 3 meq/100 g (milliequivalents per 100 grams of soil) between 0.5 and 3 ft below the research basin and increase to about 5 meq/100 g in the more clay-rich infiltration zone extending from the research-basin floor to a depth of 0.5 ft (Anders, 1997). Converting the cation-exchange capacity of 3 meq/100 g to a pore-volume solution basis by using a mineral-weight density of 2.6 g/cm^3 and porosity of 0.24 yields an average value of about 250 meq/L for soil more than 0.5 ft beneath the research basin. Ammonia present in the research basin during the first few days of the second recharge experiment averaged 4.74 mg/L as nitrogen, which equates to 0.34 meq/L. Hence, the basin's soil has the capacity to remove, by cation exchange, more than 1,000 void-space volumes of recycled water if all of the major cations are exchanged for the ammonium ion. Because about 50 ft, equivalent to 12.5 acre-ft, of recycled water was delivered to the research basin during the second experiment, percolation through less than an inch of soil would be sufficient to remove all the ammonium ion if all the exchangeable sites were replaced with ammonium!

These results seem to indicate a major capacity for ammonium removal by cation exchange, but there are some limitations to this conclusion. Ion exchange is a competitive process among ammonium and the other major cations, and thus only a small fraction of the total capacity actually is available for ammonium-ion exchange. Reequilibration between the soil and water takes place each time the relative cation concentrations change in the soil moisture that is in contact with the ion-exchangeable clays. Recharge with oxygenated water probably leads initially to removal of any ammonium from the soil and its subsequent microbial oxidation to nitrate. Then the less oxic conditions that prevail during the latter stages of recharge, and especially during stagnation after recharge is discontinued, reverse the equilibrium to favor exchange of ammonium back onto the soil. As long as any oxygen at all is present in the subsurface, it would seem that this cyclic process could continue indefinitely without any long-term increase in exchangeable ammonium in the soil.

The behavior of three minor-element cations, barium (Ba^{2+}), strontium (Sr^{2+}), and lithium (Li^+), where concentrations are at least 100 times less than the concentration of ammonium on an equivalents basis, can be used to investigate the ion-exchange process—and thereby infer the effect this process may have on ammonium (NH_4^+), for which susceptibility to biological transformation confounds interpretation. To interpret the data for all three cations, it is helpful to recall that divalent ions are bound more tightly to clays than are monovalent ions (Berner, 1971), hence the pattern for Li^+ is expected to more closely mimic NH_4^+. The computer program WATEQ4F (Plummer and others, 1984) was used to confirm undersaturation with respect to formation of sulfate and carbonate minerals, except for barium for which the ion-activity product slightly exceeds the solubility product of barite (barium sulfate).

For all three minor ions, there was no temporal trend in concentration below the clay lens throughout the 17-day recharge experiment in April 1994 (data in appendix 3), as would be expected if percolating water does not move beneath the clay lens. However, trends are discernible between the research-basin floor and the top of the clay lens (fig. 21). For barium, concentration in the research basin (PR12) is much less, at 41 µg/L (0.60 µeq/L), than is concentration in the soil moisture before recharge, at about 150 µg/L. There is little, if any, decrease in concentration during recharge, even in a band of somewhat higher (>200 µg/L) concentrations between 15 and 20 ft beneath the research-basin floor. This result implies that sufficient barium is available to desorb from the soil and maintain high aqueous concentrations during recharge, despite replacement of water in the pore spaces as many as several (but less than10) times over. For strontium, concentrations are about the same in the research basin (519 µg/L, or 11.8 µeq/L) and in soil moisture to a depth of 10 ft beneath the research basin, and therefore do not change during recharge. Between 15 and 25 ft, concentrations range from 800 to 900 µg/L before recharge, and do not decrease during the first 3 days of recharge. However, there is a noticeable decrease of about 230 µg/L (about 5 µeq/L) across this deeper zone between the 3rd and 17th day of recharge. Lithium concentrations of about 17 µg/L (2.4 µeq/L) in the research basin are about double those below the research basin before recharge. After the first 4 days of recharge, lithium concentrations increase about 3 µg/L (0.4 µeq/L) to a depth of 20 ft. No further increase occurs over the remaining 13 days of recharge, despite the fact that concentrations still are about 5 µg/L less than in the recycled water from the research basins.

The patterns described above strongly suggest kinetic limitations to the establishment of complete ion-exchange equilibrium as recycled water percolates through the soil column. As with lithium, the effects of ion exchange for ammonium are likely to manifest themselves to a depth extending at least several feet beneath the research-basin floor (the entire percolation zone), and perhaps almost to the clay lens itself, rather than be confined to the top few inches (the infiltration zone).

Sorption

The final process considered for organic carbon and nitrogen removal is sorption, or incorporation with soil on the floor of, and possibly immediately below, the research basin itself. Because the concentration of organic matter, and trace constituents as well, is typically about three orders of magnitude less in water than in the solid phase with which the water is in contact, even complete removal from the percolating water is unlikely to be discernible solely from soil analyses, unless such removal is confined to the top few inches beneath the research-basin floor, given the volume delivered and concentrations in the recycled water. Removal within such a thin infiltration zone is a likely possibility. However, as with ion-exchange, the long-term implications are less certain during repeated cycles of recharge and desiccation because some of this organic carbon and nitrogen undoubtedly is mineralized between successive recharge events.

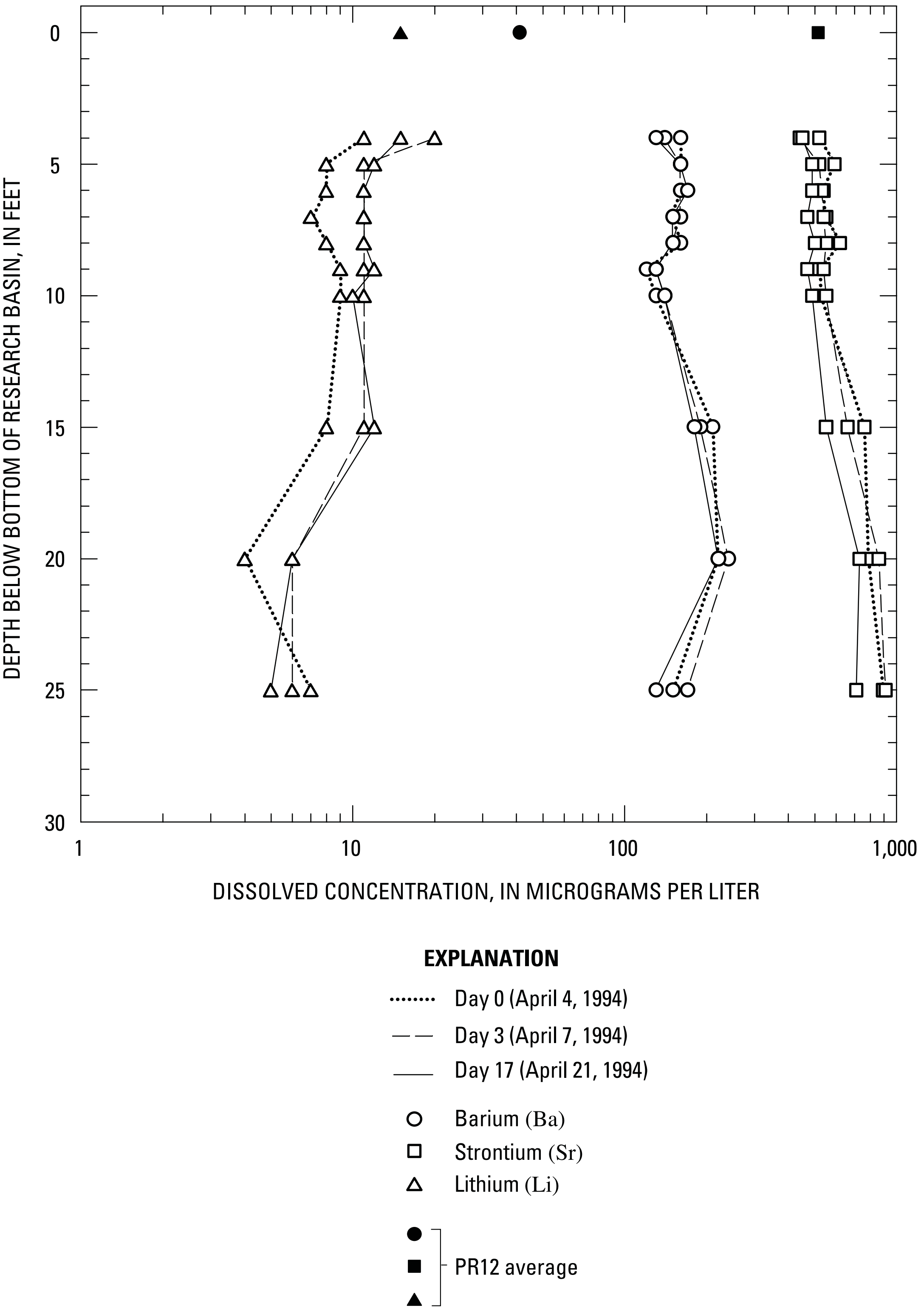


Figure 21. Progress toward reequilibration of dissolved barium (Ba), strontium (Sr), and lithium (Li) beneath the research basin, Montebello Forebay, Los Angeles County, California, on the 3rd (April 7, 1994) and 17th (April 21) days of recharge with recycled water.

As was done for ion exchange, a surrogate, orthophosphate (PO_4) in this case, was chosen to illustrate possible effects of sorption during recharge. Phosphate was calculated (Plummer and others, 1984) to be oversaturated with respect to apatite minerals (especially fluorapatite), but formation of these minerals is slow. Phosphate is readily sorbed onto particle surfaces, including organic and hydrous ferromanganese oxide coatings that are commonly present in soils, and this is more likely to control concentrations over the short time of a recharge experiment. Phosphate as phosphorus (PO_4-P) concentration decreased from about 2 mg/L in the research basin to a “near-equilibrium” (steady-state) concentration of about 1.2 mg/L to a depth of 15 ft beneath the basin as recharge continued (fig. 22). The concentration at 4 ft was already 1.2 mg/L before recharge, and remained at that level throughout recharge. Concentrations below 4 ft also were elevated, although they were less than 1.2 mg/L before recharge began, reflecting the influence of prior recharge to either the research basin or the adjacent spreading grounds. The pattern described suggests saturation of sorption sites and implies that some removal occurs, perhaps through incorporation as insoluble organophosphorous compounds, on or just beneath the basin floor. If so, the decrease is similar in magnitude to that observed for organic carbon. However, unlike organic carbon, for which mineralization can lead to removal (as carbon dioxide or alkalinity), mineralization of organophosphorous in the subsurface yields inorganic phosphate, which can remain behind to establish the depth-related profile observed. It would seem that eventually this pattern of decreasing phosphate concentration with increasing depth will disappear as additional recharge experiments are done unless phosphate is removed through some slow precipitation (mineral formation) process. The fact that the profile for dissolved organic carbon in figure 15 is much less steep than is the profile for orthophosphate in figure 22 indicates that sorptive removal, once the recycled water has penetrated more than a few feet beneath the basin floor, is comparatively less important for organic carbon.

Relative Importance of Oxygen and Nitrate as Electron Acceptors

Microbial oxidation of organic carbon can be represented by two idealized (for carbohydrates) reactions:

$$CH_2O + O_2 \rightarrow CO_2 + H_2O$$

and

$$4NO_3^- + 5(CH_2O) \rightarrow 2N_2 + CO_2 + 3H_2O + 4HCO_3^-,$$

representing oxygen and nitrate (denitrification) as electron acceptors, respectively. On the basis of the stoichiometry for these model reactions, the mass ratio of carbon oxidation to oxidant required is 0.375 mg C/mg O and 1.07 mg C/mg N. These values could be used to quantify the relative importance of each process to organic carbon removal during percolation through the soil column if all chemical transformations and physical processes were known with certainty. They are not, and therefore the best that can be done is a plausible relative ranking of importance.

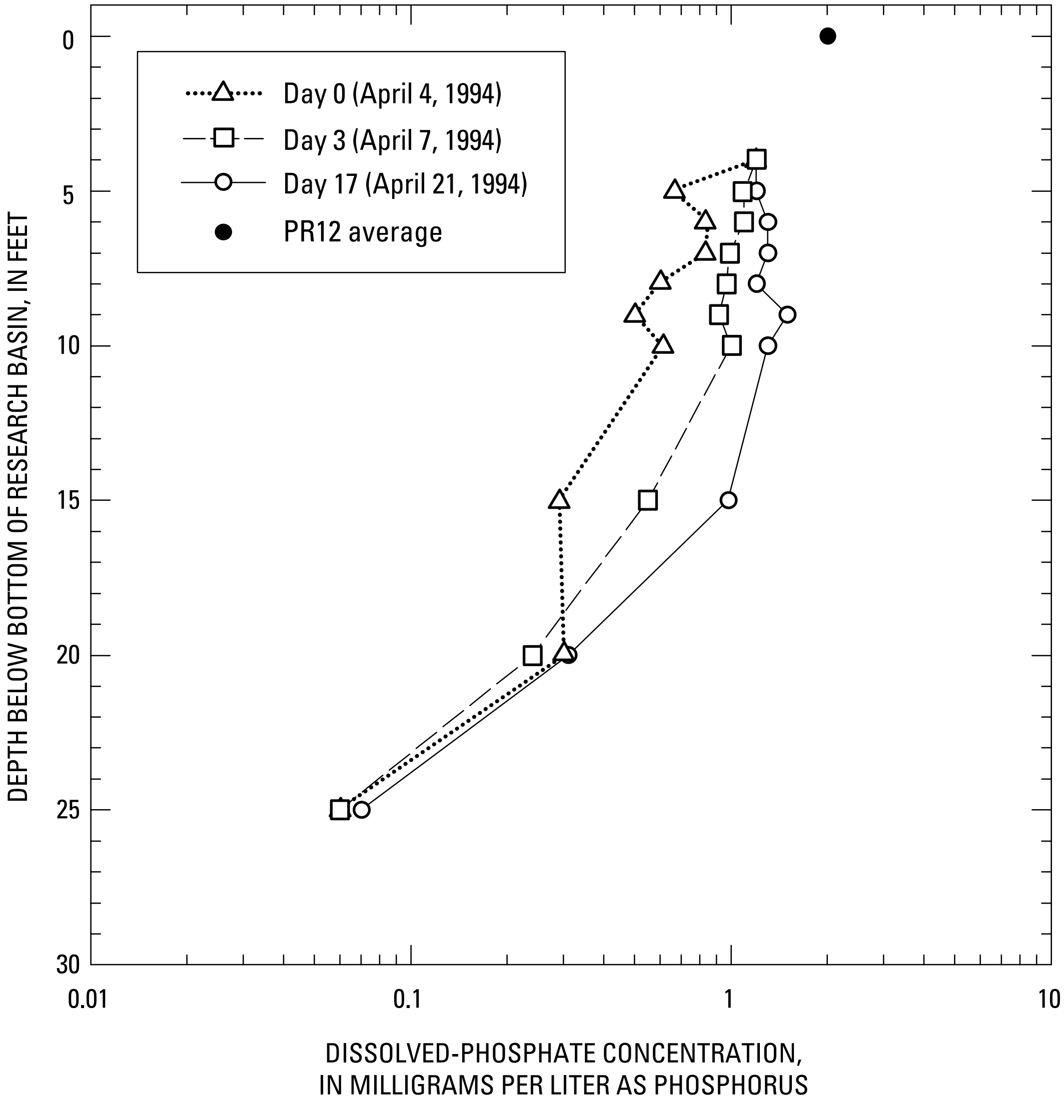


Figure 22. Removal of orthophosphate from recycled water beneath the research basin, Montebello Forebay, Los Angeles County, California, on the 3rd (April 7, 1994) and 17th (April 21) days of recharge.

As discussed in the “Nitrogen” section in this chapter, by the 17th day of the second recharge experiment, total nitrogen had declined in the multilevel sampler by about 60 percent, representing a reduction of about 7 mg/L. The decline in organic carbon was about 35 percent after 2 days of recharge, representing a reduction of a little more than 3 mg/L. The average highest dissolved-oxygen concentration (fig. 20 and data in appendix 3), attained during the first few days of recharge, in the multilevel sampler was 5.0 mg/L (range from 2.4 mg/L at the 20-foot depth to 6.6 mg/L at the 10-foot depth). Even if this oxygen were entirely consumed by oxidation of only dissolved organic carbon, to the exclusion of all other reduced constituents (especially nitrogen), it would yield a removal of slightly less than 2 mg/L in the dissolved organic carbon. This would seem to imply that denitrification is about an equally important mechanism for removal of organic carbon. The fact that the average highest nitrate plus nitrite (as nitrogen) concentration, also attained during the first few days of recharge, in the multilevel sampler was 8.5 mg/L (range from 6.3 to 9.7 mg/L) certainly indicates that there is more than enough oxidized nitrogen available to effect a further reduction in dissolved organic carbon. In fact, the question for which a satisfactory answer is not available is why does there appear to be less organic carbon than required to explain the observed decrease in nitrogen of about 7 mg/L if removal is entirely from heterotrophic (carbon as electron donor) denitrification. The implication is that a substantial part of the apparent removal represents temporary storage of reduced nitrogen on ion-exchangeable clays or in sorbed organic nitrogen and (or) reduction by electron donors other than just organic carbon.

An important caution should be noted in these conclusions. These mass-balance calculations are based on the assumption that the subsurface system is closed to the atmosphere during recharge. Although this may be a valid assumption when little or no unsaturated zone exists, as in the first two recharge experiments, recharge through a thick unsaturated zone could induce incorporation of additional atmospheric oxygen into the percolating water, especially during early stages of recharge before water has a chance to completely fill void (pore) spaces in the soil.

And another limitation, which may have an even more important implication for the long-term and net changes in ground water chemical composition at downgradient production wells, is the extent to which removal of aqueous constituents is from actual degradation and from permanent incorporation with the solid phase rather than simply temporary storage on the soil.

PART II

CHAPTER 6: HIERARCHAL APPROACH TO ORGANIC MATTER CHARACTERIZATION

By Jerry A. Leenheer *and* Larry B. Barber

The characterization of dissolved organic matter (DOM) is a complex endeavor requiring a hierarchal analytical approach (Leenheer and Huffman, 1976; Barber, 1992) that measures, among other things: (1) total, particulate, colloidal, and dissolved carbon, (2) operationally defined dissolved organic carbon (DOC) fractions, (3) molecular-weight characteristics, (4) compound classes and functional-group characteristics, and (5) specific organic compounds. A hierarchal approach was designed to comprehensively characterize organic matter in reclaimed water that might be transported into the subsurface environment during artificial recharge. Particulate organic matter was removed from reclaimed-water and ground-water samples by glass-fiber filtration in the field through 25-µm and 0.3-µm cartridge filters in series (Leenheer and Noyes, 1984), and colloids were then isolated from the filtrate by tangential flow ultrafiltration using regenerated cellulose membranes with 0.005-µm pore size (Leenheer and others, 1989; Rostad and others, 1998). Colloids recovered from the membranes were characterized separately from the dissolved organic matter in the membrane permeate.

The DOC was characterized at various hierarchal levels (fig. 23). The classification basis and the percentage that can be characterized at each of the levels are shown in figure 23. At the first three levels of this hierarchy, all of the carbon in certain samples was characterized by DOC fractionation analyses. Analyses of compound classes (level 4) required isolation of the DOC fractions for spectra characterizations by ^{13}C-nuclear magnetic resonance (^{13}C-NMR) spectrometry, infrared (IR) spectrometry, and ultraviolet-visible (UV/VIS) spectrometry. The greatest potential to obtain new research information on DOC characterization is at level 4 owing to recent improvements in fraction isolation and spectral characterization techniques. Lastly, certain specific compounds that are indicative of sewage wastewater and disinfection by-products were analyzed by gas chromatography-mass spectrometry (GC/MS). The following chapters of this report are presented in order of increasing molecular specificity as determined by the hierarchal analytical approach. The chemical structures of selected organic constituents discussed are shown in figure 24.

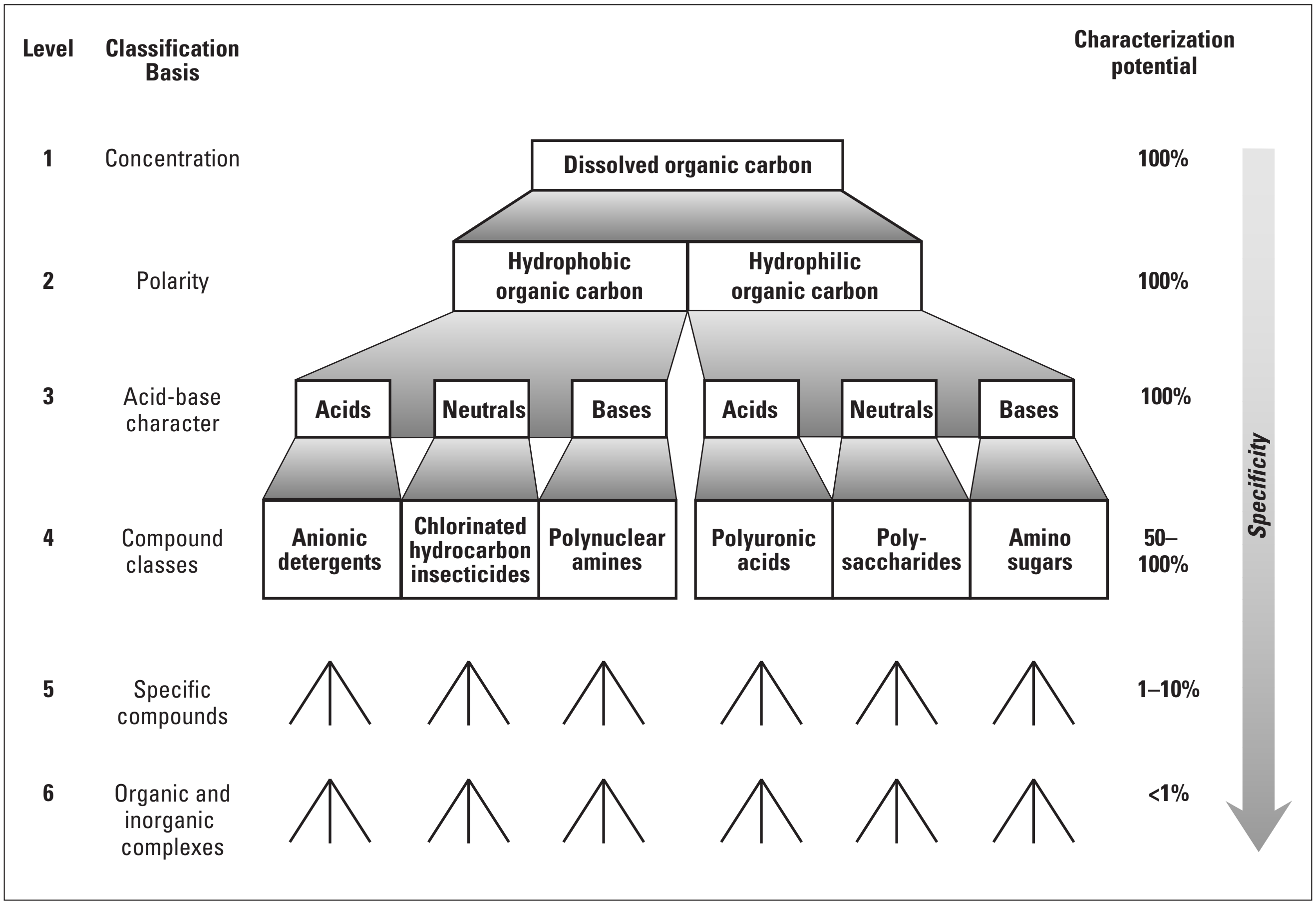
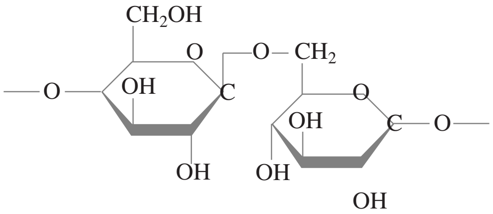


Figure 23. Hierarchal classification of dissolved organic carbon (<, less than).

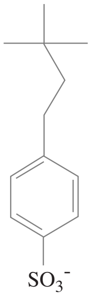
1. Aetal, Hemiacetal Carbons



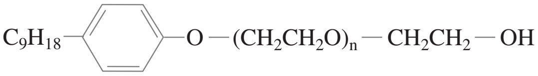
2. Acid R-COOH

3. Alcohol R-OH

4. Alkyl benzene sulfonate

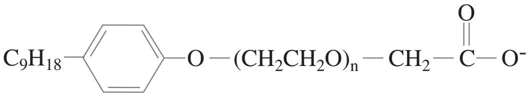


5. Alklyphenol polyethoxylate (APEO)



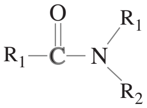
$C_9H_{18}-C_6H_4-O-(CH_2CH_2O)_n-CH_2CH_2-OH$

6. Alklyphenol polyethoxy carboxylate (APEC)



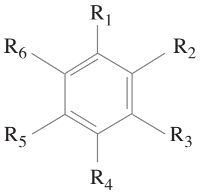
$C_9H_{18}-C_6H_4-O-(CH_2CH_2O)_n-CH_2-C(=O)-O^-$

7. Amide carbons

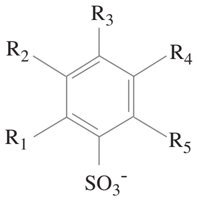


$R_1-\overset{O}{\overset{\|}{C}}-N(R_1)(R_2)$

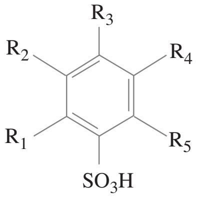
8. Aromatic carbons



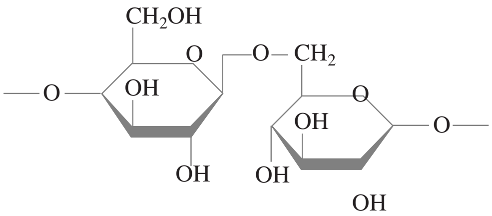
9. Aromatic sulfonate



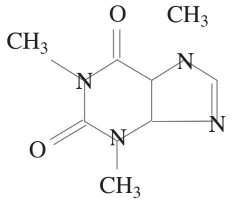
10. Aromatic sulfonic acid



11. Carbohydrate carbons



12. Caffeine



13. Dialkyltetraline sulfonate (DATS)

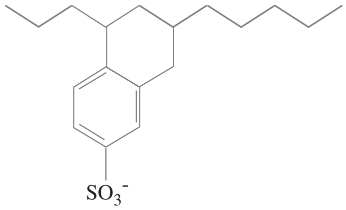
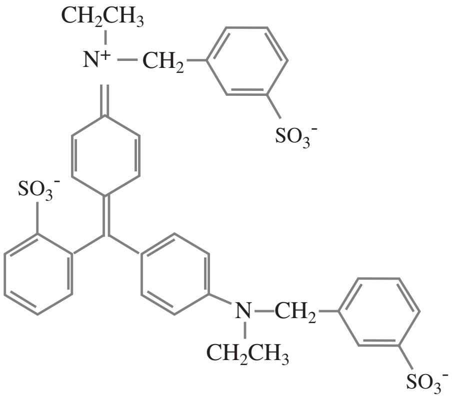


Figure 24. Chemical structure of selected organic compounds and functional groups.

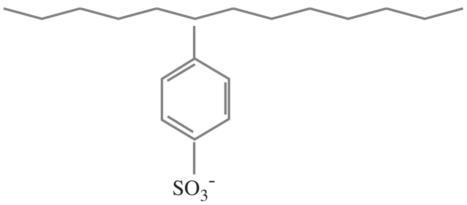
14. Direct Blue Dye (Erioglaucine)



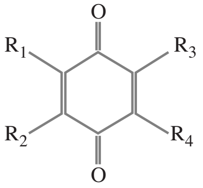
15. Ether R_1COOR_2

16. Ether R_1-O-R_2

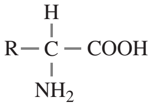
17. Linear alkylbenzene sulfonate (LAS)



18. Ketone/Quinone



19. Methine carbons of amino acids

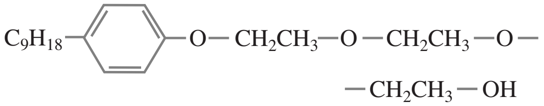


$$R - \overset{H}{\underset{NH_2}{C}} - COOH$$

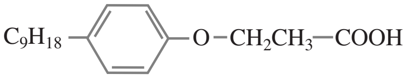
20. Methyl carbons -CH_3

21. Methylene carbons —CH_{2-}—

22. Nonylphenol 1-3-ethoxylate

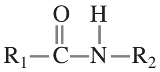


23. Nonylphenol 1-ethoxylate carboxylic acid



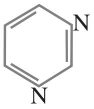
24. Olefinic carbons R_1—C=C—R_2

25. Peptide linkage

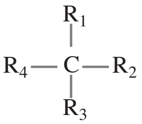


$$R_1 - \overset{O}{\overset{\|}{C}} - \overset{H}{\overset{|}{N}} - R_2$$

26. Pyrimidine



27. Quarternary carbons



$$R_4 - \overset{R_1}{\underset{R_3}{C}} - R_2$$

28. Sulfophenyl carboxylate (SPC)

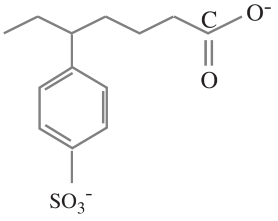


Figure 24.—Continued.

CHAPTER 7: ISOLATION AND CHARACTERIZATION OF COLLOIDS

By Kevin A. Thorn, Colleen E. Rostad, *and* Ted I. Noyes

Among particles present in the environment, colloids are smaller in diameter than the particulate phase and larger than the humic phase. Although the transition from particulate to colloid to humic phases seems to involve a gradual decrease in size and concurrent increase in organic carbon content, the composition of their organic carbon may be distinctly different. The organic composition of ground-water colloids is unknown. The nature of this mobile phase in the aquifer is of concern in the recharge of aquifers with sewage effluent (recycled water). In this study, the colloid phase was characterized by elemental composition and multinuclear (carbon-13, nitrogen-15, and phosphorus-31) nuclear magnetic resonance (NMR) spectrometry.

Sampling and Methods

Colloid Isolation Procedures

During the April 1994 recharge experiment, the colloid phase was isolated from water samples collected from PR13 (wastewater effluent), MLS4 and MLS7 (multilevel sampler at depths of 4 and 7 ft beneath the research-basin floor), and well PR9 (25 ft beneath the research-basin floor). During the September 1994 recharge experiment, the colloid phase was isolated from water samples from PR12 (research basin) and PR9. Water samples were pumped onsite through Balston DH (25-µm) and AH (0.3-µm) glass-fiber prefilters to remove the larger particulate matter. Colloids were isolated from the prefiltered solution by ultrafiltration using a Series L Dorr-Oliver tangential-flow ultrafiltration system (Amicon Div. W.R. Grace, Beverly, Massachusetts), which had been modified by replacing all plumbing with Teflon pipe, and using an air-driven, double-diaphragm Teflon-bellows pump for solution circulation (Rostad, 1996; Rostad and others, 1998). Colloids on the ultrafilter membranes were placed in PFA Teflon bags, and resuspended by gently massaging the membrane from the outside of the Teflon bag. Colloids in aqueous suspension were then transferred to a 2-L Teflon bottle, preserved with two drops of chloroform, refrigerated, and transported on ice to the laboratory. Four mL of this liquid colloid concentrate was transferred to a glass vial and refrigerated for future analyses. The retentates from the ultrafilters, designated as the colloid phase, were freeze-dried. Advantages of these particle-isolation techniques include minimal introduction of sampling artifacts by the isolation equipment, and the ease of sample retrieval. A colloid sample similarly isolated from Thoreau's Bog, a pristine bog in Concord, Massachusetts, was provided by Dr. James Ranville, Colorado School of Mines, as a commonly used standard for comparison to the colloids isolated from the recharge basin.

Analytical Methods

The colloid samples were characterized by elemental analysis and by multinuclear (^{13}C, ^{15}N, and ^{31}P) solid-state cross polarization/magic angle spinning (CP/MAS) nuclear magnetic resonance (NMR) spectrometry. Elemental analyses were performed by Huffmann Laboratories, Golden, Colorado (Huffman and Stuber, 1985). Solid-state CP/MAS NMR spectra were recorded on a Chemagnetics CMX-200 NMR spectrometer at carbon, nitrogen, and phosphorus resonant frequencies of 50.3, 20.3, and 80.9 megahertz (MHz), respectively, using a 7.5-mm ceramic probe (zirconium pencil rotors). Acquisition parameters for the ^{13}C NMR spectra included a 30,000 Hz spectral window, 17.051-ms acquisition time, 2.0-ms contact time, 1.0-s pulse delay, and spinning rate of 5 kHz. Spectra were referenced to hexamethylbenzene. Acquisition parameters for the ^{15}N NMR spectra included a 30,000 Hz spectral window, 17.051-ms acquisition time, 2.0-ms contact time, 1.0-s pulse delay, and spinning rate of 3.5 kHz. Chemical shifts were referenced to glycine, taken as 32.6 parts per million (ppm). Acquisition parameters for the ^{31}P NMR spectra included a 30,000 Hz spectral window, 34.1-ms acquisition time, 2.0-ms contact time, 2.0-s pulse delay, and spinning rate of 3.5 kHz. Chemical shifts were referenced to ammonium dihydrogen phosphate, taken as 0.81 ppm.

Results and Discussion

Colloid Concentration and Changes in Elemental Composition

The total amounts of colloids and colloidal organic carbon content, elemental analyses on moisture-free basis, elemental analyses on moisture- and ash-free basis, and elemental mass-ratios during recharge experiments are given in tables 10–13, respectively. Comparison with data elsewhere in this report shows that colloidal organic carbon constitutes about 10 to 20 percent of the total (or dissolved) organic carbon; the percentage is highest in recycled water and lowest in percolating water beneath the research basin (table 11). For the April 1994 experiment, the concentration of colloid isolated from MLS4 (4 ft below the floor of the research basin) is approximately one-half the concentration isolated from the effluent (PR13). These data indicate that a significant proportion of the colloidal material is filtered out as the water percolates through sediments beneath the research basin. Likewise, data in table 10 for the September 1994 experiment indicate that a significant proportion of the colloidal material is filtered out in the soil beneath the research basin; the concentration of colloid isolated from PR9 (25 ft beneath the basin) is approximately one-third that of the research basin (PR12).

In addition to removal, the composition of the colloids also changes with transport from the effluent (PR13) or research basin (PR12) through the sediment (PR9) during both the experiments (table 11). In the April experiment, the total-ash content of the recycled-water effluent increases from 37.2 percent to more than 50 percent for samples from MLS4, MLS7, and PR9. In the September experiment, the increase in total-ash content (mineral matter that remains after combustion) is from 26.9 percent in the research basin itself to 43.8 percent in PR9. Thus, the total-ash content of colloids increases and their organic content decreases as recycled water percolates beneath the research basin. This shift could be due to preferential filtration during percolation, sloughing of mineral matter from the soil, and (or) (most likely) organic decomposition.

Organic carbon content of colloids ranged from 5.5 percent at PR9 in April 1994 to 27.2 percent at PR12 in September 1994 (table 11). By comparison, the organic content of river-water colloids isolated with this same technique ranged from 6.9 to 26.23 percent in summer, 5.02 to 30.85 percent in autumn, and 4.59 to 27.06 percent in spring (Rostad, 1996; Rostad and others, 1994). For the river-water colloids, seasonal averages were 16.46 percent in summer, 16.09 percent in autumn and 12.99 percent in spring (Rostad, 1996; Rostad and others, 1994). For the two recharge experiments in this study, average organic carbon content was higher, 25 percent, in recycled water and lower, 9 percent, in water beneath the research basin.

For the most part, nitrogen and organic carbon content of the colloids analyzed for this study are positively correlated—as also is the case for river colloids. Nitrogen content of colloids ranged from 1.6 to 4.3 percent and, as with organic carbon, is somewhat higher in recycled water than in soil water beneath the research basin. The range from 1.6 to 2.6 percent beneath the research basin is about the same as values reported for river colloids, which averaged 2.19 percent in summer, 1.79 percent in autumn, and 1.54 percent during spring runoff, with an overall average of 1.8 percent (Rostad, 1996; Rostad and others, 1998).

The H/C, O/C, and N/C elemental mass ratios in table 13 indicate that the organic matter associated with the colloids is composed primarily of the undegraded biochemical constituents of bacteria or algae, and not of humic substances. The range of H/C values for the colloids, 0.14–0.33, is much less then the range of 0.80–1.50 reported for soil and aquatic fulvic and humic acids (Steelink, 1985). The range of O/C values for the colloids, 1.2–5.6, also differs from the range of 0.28–0.74 reported for soil and aquatic fulvic and humic acids. Finally, the range of N/C values for the colloids, 0.15–0.29, is higher than the range of 0.01–0.09 reported for the humic substances. The colloids are enriched in nitrogen and oxygen and depleted in hydrogen in comparison with fulvic and humic acids, as would be expected if they were composed of bacterial, fungal, or algal matter.

Table 10. Amounts of colloid isolated from the research basin, Montebello Forebay, Los Angeles County, California, during recharge experiments

[L, liter; g, gram; mg/L, milligrams per liter; mg C/L, milligrams carbon per liter]

Sample identifier	Date	Volume of water sampled (L)	Yield of colloid (g)	Concentration of colloid (mg/L)	Colloidal carbon concentration (mg C/L)
MLS7	04-06-94	220	1.0	4.5	0.5
MLS4	04-05-94	220	1.2	5.5	.5
PR9	04-07-94	220	.9	4.1	.3
PR13 (effluent)	04-06-94	110	1.2	10.9	2.5
PR9	09-22-94	400	.7	1.7	.3
PR12 (pond)	09-19-94	240	1.3	5.2	1.5

Table 11. Elemental analyses, on moisture-free basis, of colloids from the research basin, Montebello Forebay, Los Angeles County, California

[Concentrations in percent on moisture-free basis; C, carbon; H, hydrogen; O, oxygen; N, nitrogen; S, sulfur; P, phosphorus]

Sample identifier	Date	C (total)	C (carbonate)	C (organic)	H	O	N	S	P	Ash
PR13	04-94	23.3	1.40	21.9	3.2	29.5	3.2	4.1	0.6	37.2
MLS4	04-94	9.0	1.62	7.4	1.8	25.1	1.9	4.6	.2	57.4
MLS7	04-94	10.8	2.10	8.7	2.0	28.6	1.9	5.6	.2	50.9
PR9	04-94	7.9	2.39	5.51	1.8	30.9	1.6	6.4	.1	51.4
PR12	09-94	28.2	.98	27.2	4.3	32.5	4.3	3.0	.8	26.9
PR9	09-94	14.9	1.80	13.1	2.5	30.9	2.6	5.0	.3	43.8

Table 12. Elemental analyses of colloids, on moisture- and ash-free basis, from the research basin, Montebello Forebay, Los Angeles County, California

[These values are calculated on a mineral-free basis from values in table 11; concentrations in percent on moisture- and ash-free basis; C, carbon; H, hydrogen; O, oxygen; N, nitrogen; S, sulfur; P, phosphorus]

Sample identifier	Date	C	H	O	N	S	P
PR13	04-94	34.9	5.1	47.0	5.1	6.5	1.0
MLS4	04-94	17.4	4.2	58.9	4.5	10.8	.5
MLS7	04-94	17.7	4.1	58.2	3.9	11.4	.4
PR9	04-94	11.3	3.7	63.6	3.3	13.2	.2
PR12	09-94	37.2	5.9	44.5	5.9	4.1	1.1
PR9	09-94	23.3	4.4	55.0	4.6	8.9	.5

Table 13. Selected elemental mass ratios in colloids from the research basin, Montebello Forebay, Los Angeles County, California

[C, carbon; H, hydrogen; O, oxygen; N, nitrogen]

Sample identifier	Date	H/C	O/C	N/C	C/N
PR13	04-94	0.14	1.35	0.15	6.84
MLS4	04-94	.24	3.40	.26	3.88
MLS7	04-94	.23	3.29	.22	4.58
PR9	04-94	.33	5.61	.29	3.44
PR12	09-94	.16	1.19	.16	6.33
PR9	09-94	.19	2.36	.20	5.04

Although the colloid phase approaches humic materials in organic carbon content, its organic carbon composition is distinctly different. The C/N ratios of the ground-water colloids ranged from 3.4 to 6.8, and averaged 5.0. The C/N ratio of 6.6 (average of PR12 and PR13) in recycled water decreases to 4.2 in the subsurface (table 13). These colloid C/N ratios are much lower than those in various types of soils, humic materials, or plants (Rostad, 1996). They are even lower than the comparatively low C/N ratios of river colloids, which average about 8. Aquatic colloids commonly are compared to, equated with, or related to aquatic fulvic acids (Shinozuka and Nihei, 1994; Tombacz and Regdon, 1994), but their much higher C/N ratios indicate a substantial difference in organic material composition. The colloid C/N ratios in this study are more similar to those of biomass, such as bacteria (3–5), algae (5.6), and microbial cells (6) (Rostad, 1996; Rostad and others, 1998), indicating cellular material that has not yet undergone substantial diagenesis (degradation).

Nuclear Magnetic Resonance Spectrometry

The solid-state CP/MAS NMR spectra (figs. 25*A–L*) provide further evidence that the organic matter associated with the colloids is derived from the biochemical constituents of bacteria or algae. Several observations can be made on the spectra of colloids collected from the research basin (PR12) in September 1994. Major peaks in the ^{13}C CP/MAS spectrum (fig. 25*E*) occur at 24.4 ppm (methyl carbons), 32.6 ppm (methylene carbons), 56.0 ppm (methine carbons of amino acids), 72.3 ppm (carbohydrate carbons), 102.7 ppm (anomeric carbons of carbohydrates), 131.1 ppm (aromatic carbons; for example, in aromatic side chains of amino acids) and 175.2 ppm (carboxylic acid and amide carbons). The dipolar dephased ^{13}C CP/MAS NMR spectrum (fig. 25*I*) aids in the confirmation of these assignments. When a dipolar dephasing time of 40 µs is employed, almost all signal intensities from methine and methylene carbons are removed from the spectrum, whereas signals from quaternary and methyl carbons are retained. The disappearance of the peaks at 131.1, 102.7, 72.3, and 56.0 ppm is consistent with the assignment of these as methine carbons, whereas the retention of the signals near 175.2 and 24.4 ppm is consistent with the assignments of these as quaternary and methyl carbons, respectively. The attenuation of the signal near 32.6 ppm is consistent with the assignment of these carbons as methylenes.

Comparison of the CP/MAS ^{13}C NMR spectrum in the effluent (PR13) and the research basin (PR12) to the spectrum of the Thoreau's Bog (a commonly-used standard for comparison) colloid provides a further indication that the organic matter of colloids in recycled wastewater is fundamentally different from humic material. The peaks in the spectra for this study (figs. 25*A–F*) are sharper and their resolution is closer to baseline than in the spectrum of the Thoreau's Bog colloid (fig. 25*J*), which is composed predominantly of more structurally heterogeneous humic material. In addition, the ketone/quinone peak at 180 to 220 ppm in the Thoreau's Bog spectrum that is characteristic of humic substances is absent in colloids from this study.

The solid state CP/MAS ^{15}N NMR spectra of effluent (PR13) and recycled water in the research basin (PR12) have sharp secondary amide peaks (amino acid nitrogens involved in peptide linkages) at 117–120 ppm (figs. 25*G*, *H*). The line-width and the relatively short acquisition time required to achieve the intensity of the signal are consistent with these nitrogens representing intact proteinaceous material.

The solid-state CP/MAS ^{31}P NMR spectra of colloids in the research basin (PR12) and in percolating water 25 ft beneath the floor of the research basin (PR9) exhibit major peaks centered at approximately –2.6 ppm (figs. 25*K*, *L*). These peaks would encompass both orthophosphate inorganic P and orthophosphate monoester organic P (Condron and others, 1997).

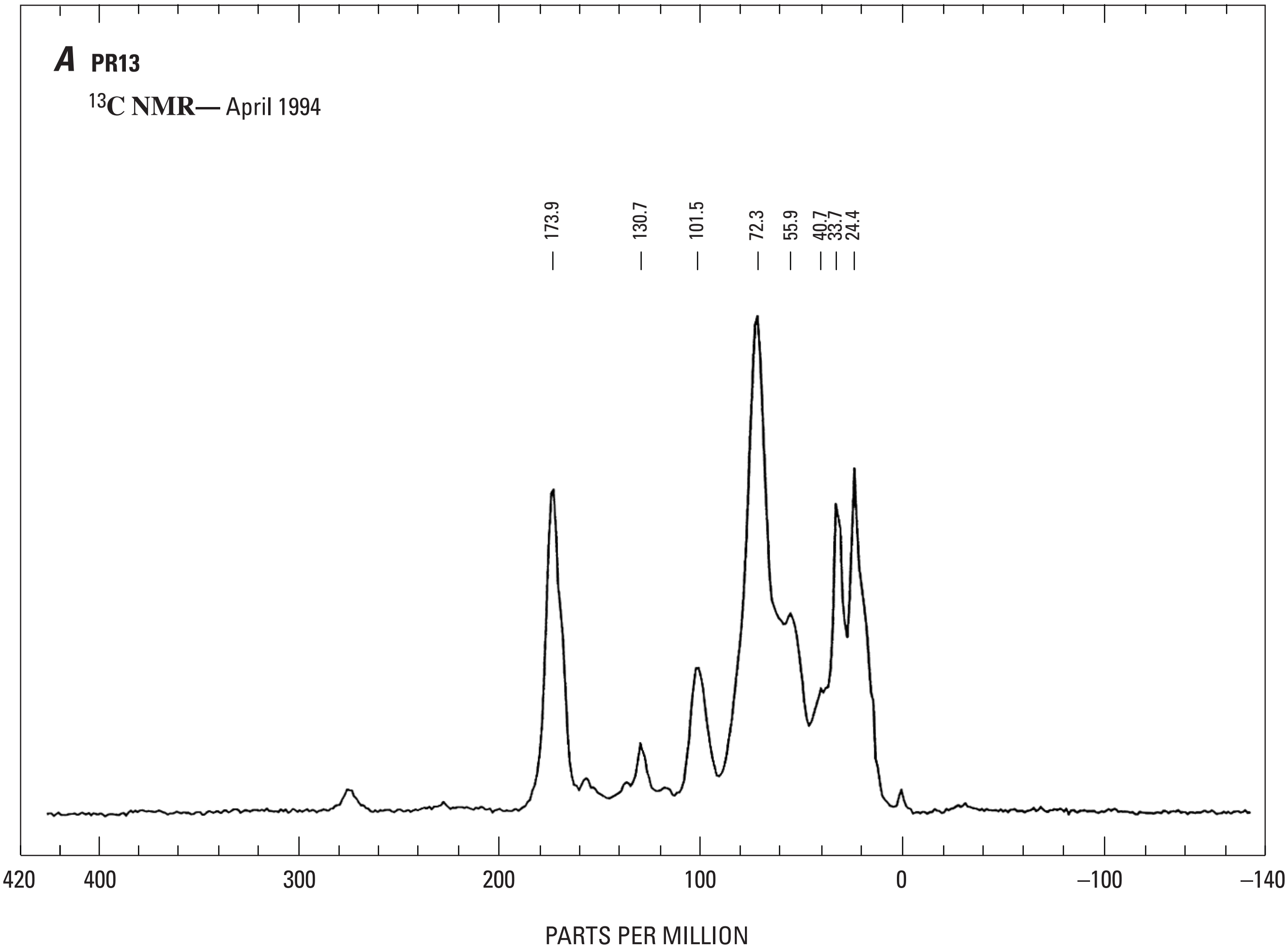


Figure 25*A*. Carbon-13 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid collected from PR13, April 1994.

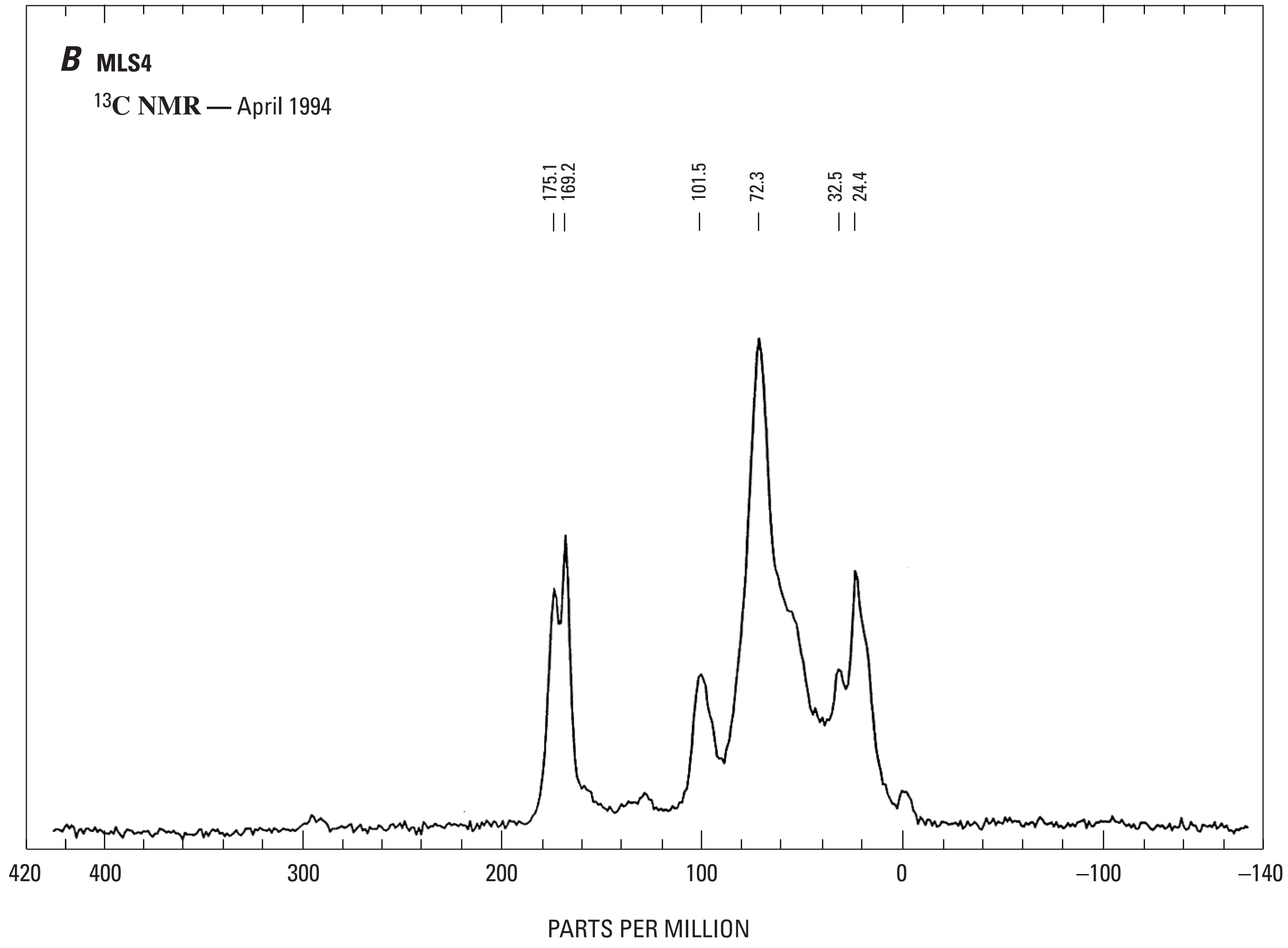


Figure 25*B*. Carbon-13 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid collected from MLS4, April 1994.

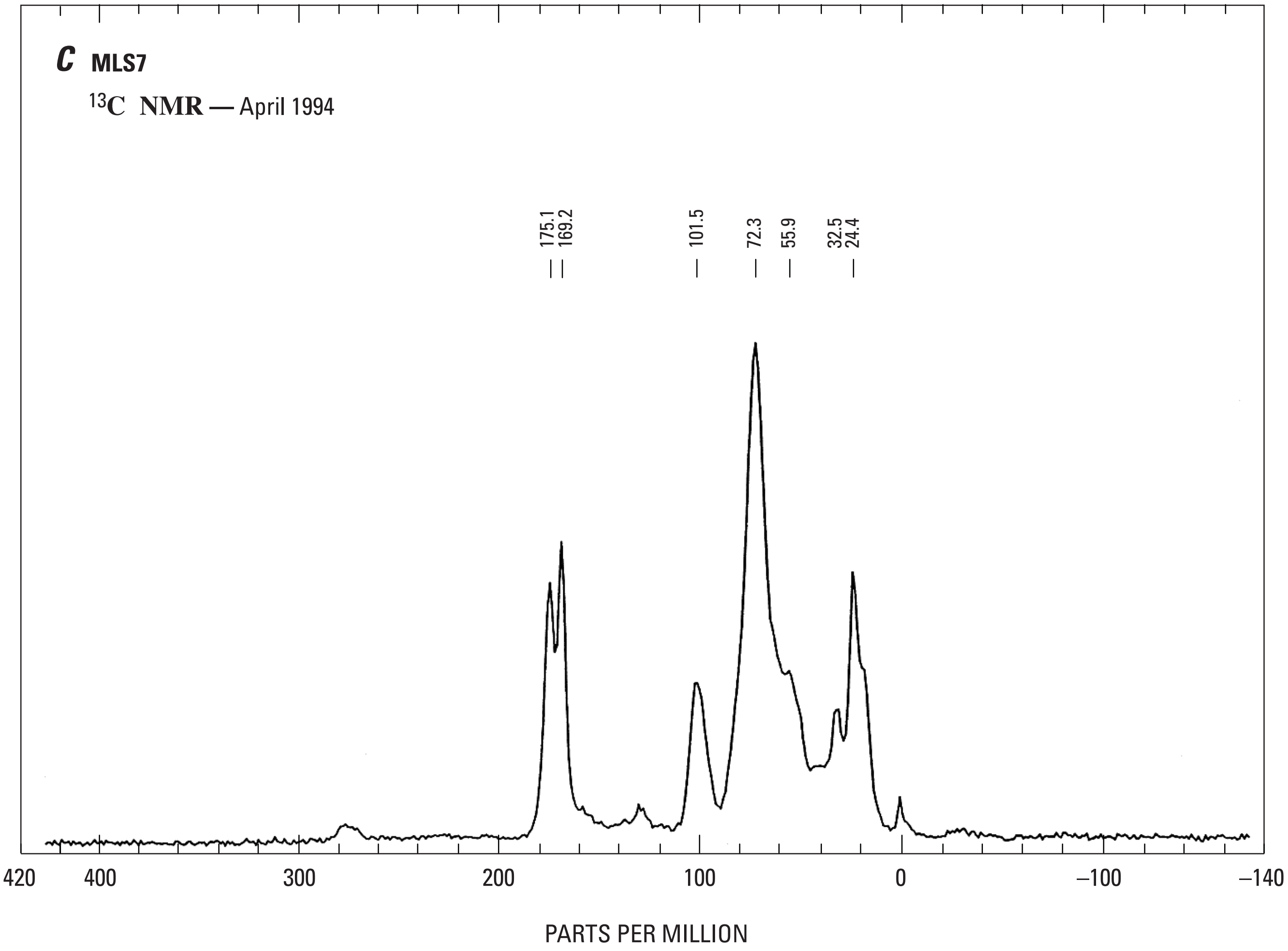


Figure 25*C*. Carbon-13 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid collected from MLS7, April 1994.

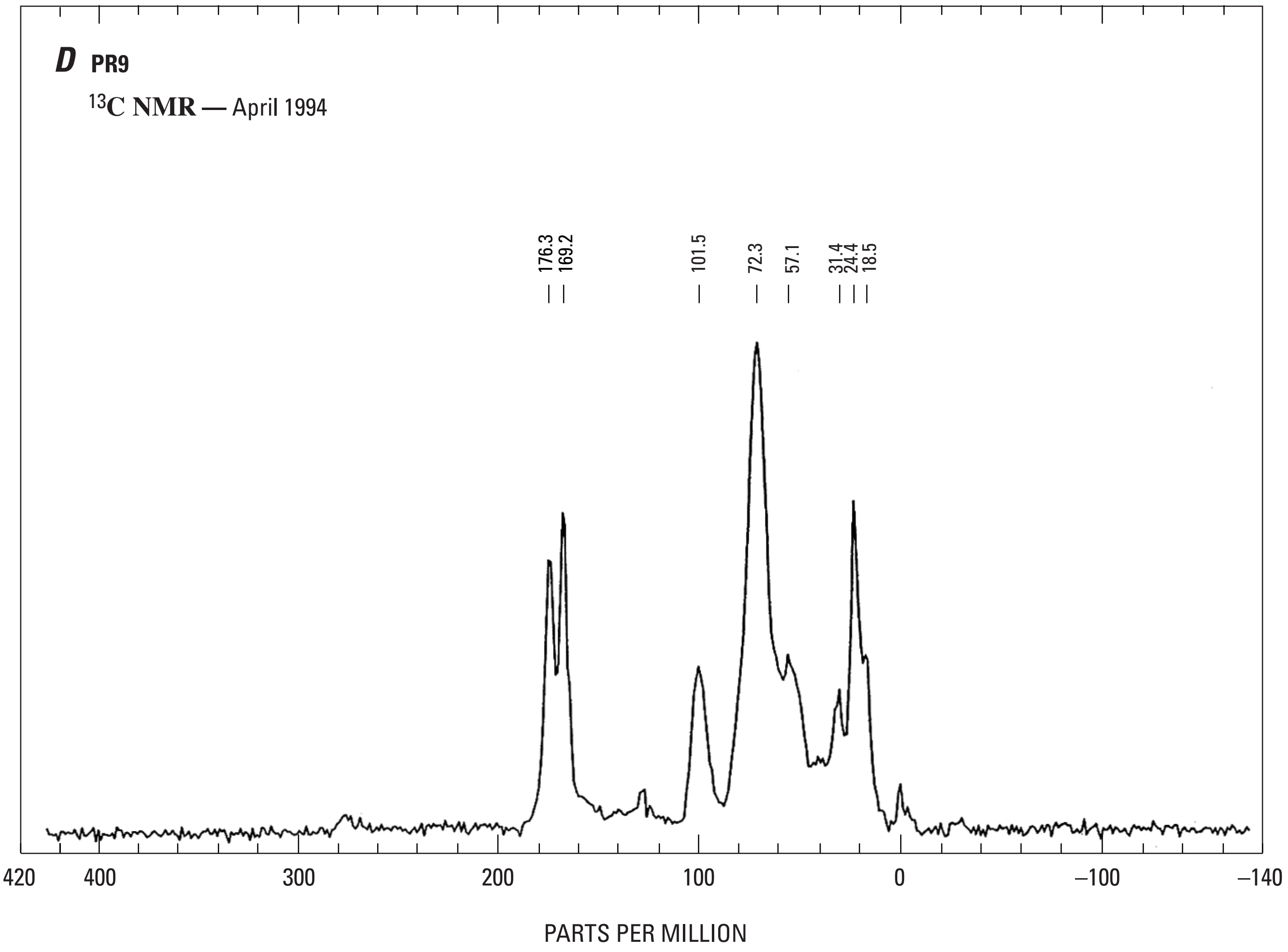


Figure 25*D*. Carbon-13 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid collected from PR9, April 1994.

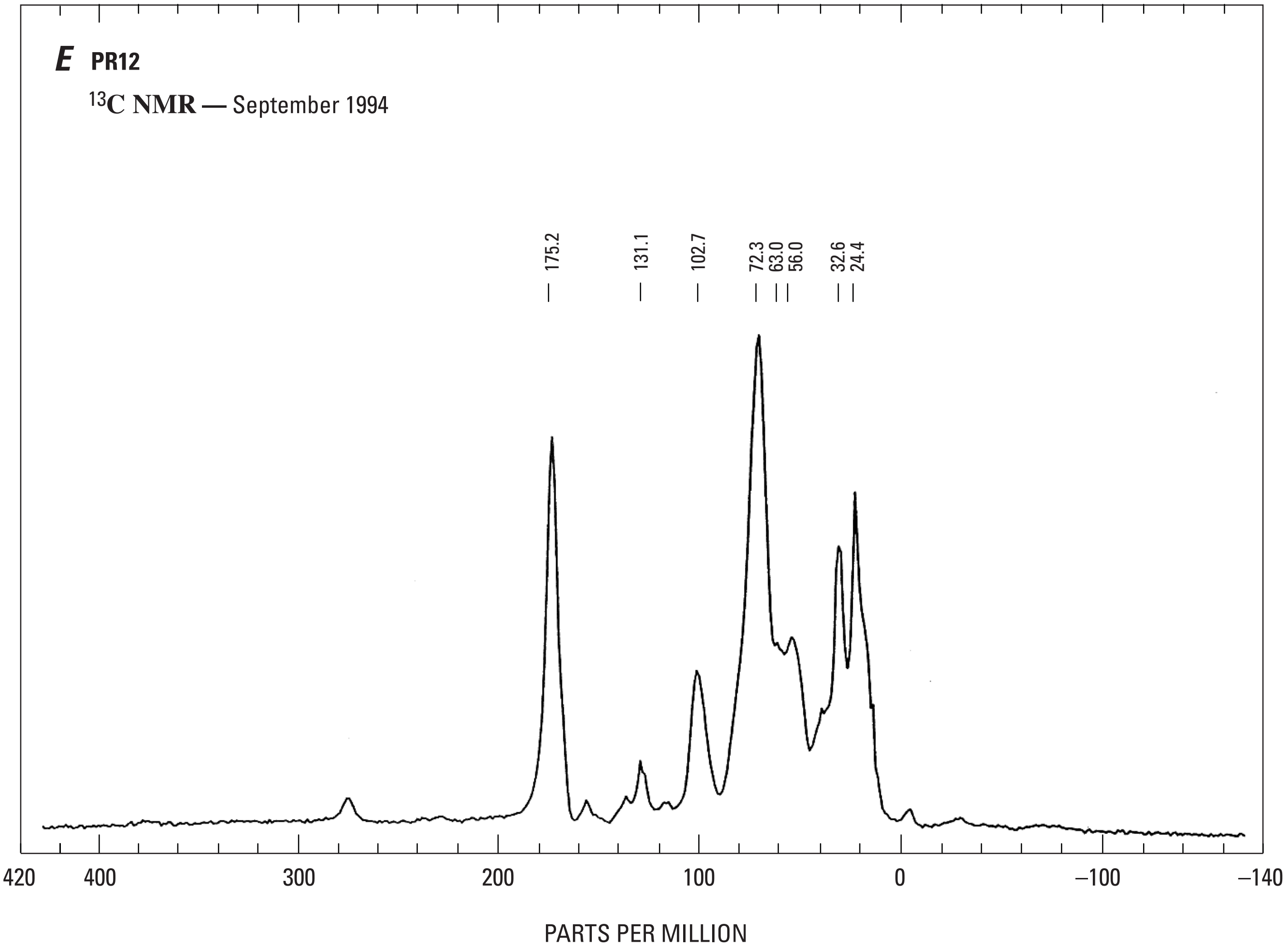


Figure 25*E*. Carbon-13 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid collected from PR12, September 1994.

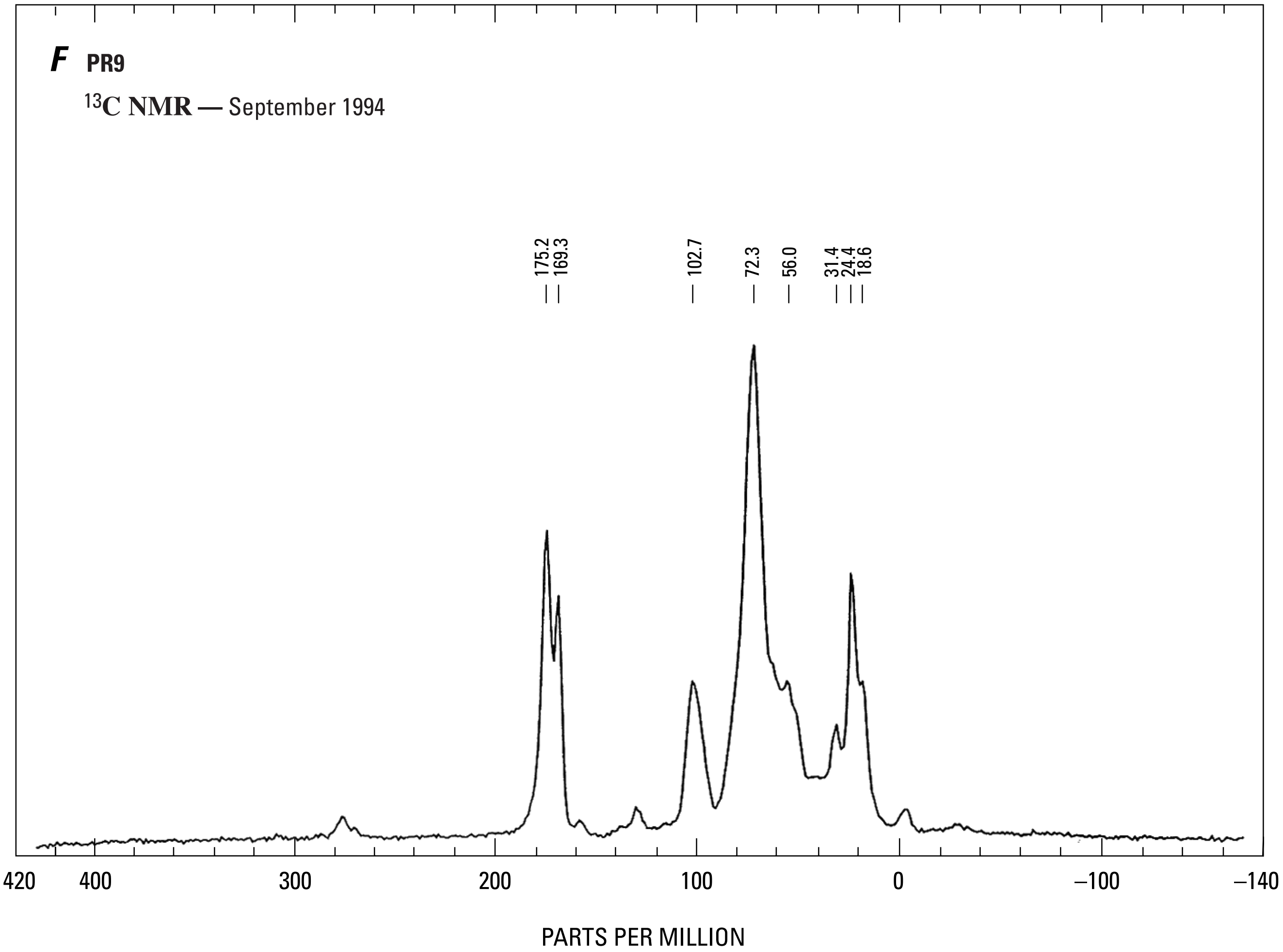


Figure 25*F*. Carbon-13 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid collected from PR9, September 1994.

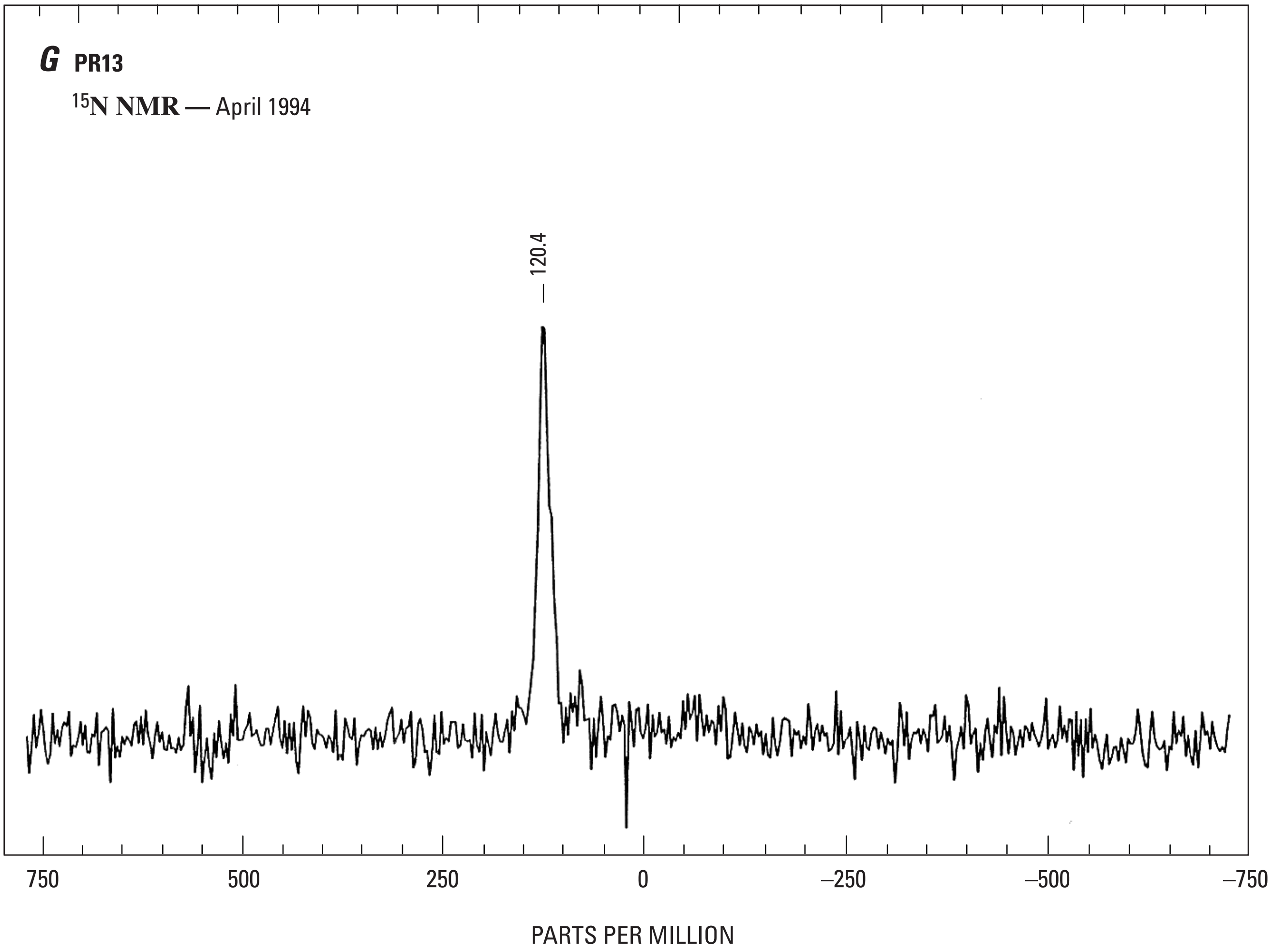


Figure 25*G*. Nitrogen-15 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid collected from PR13, April 1994.

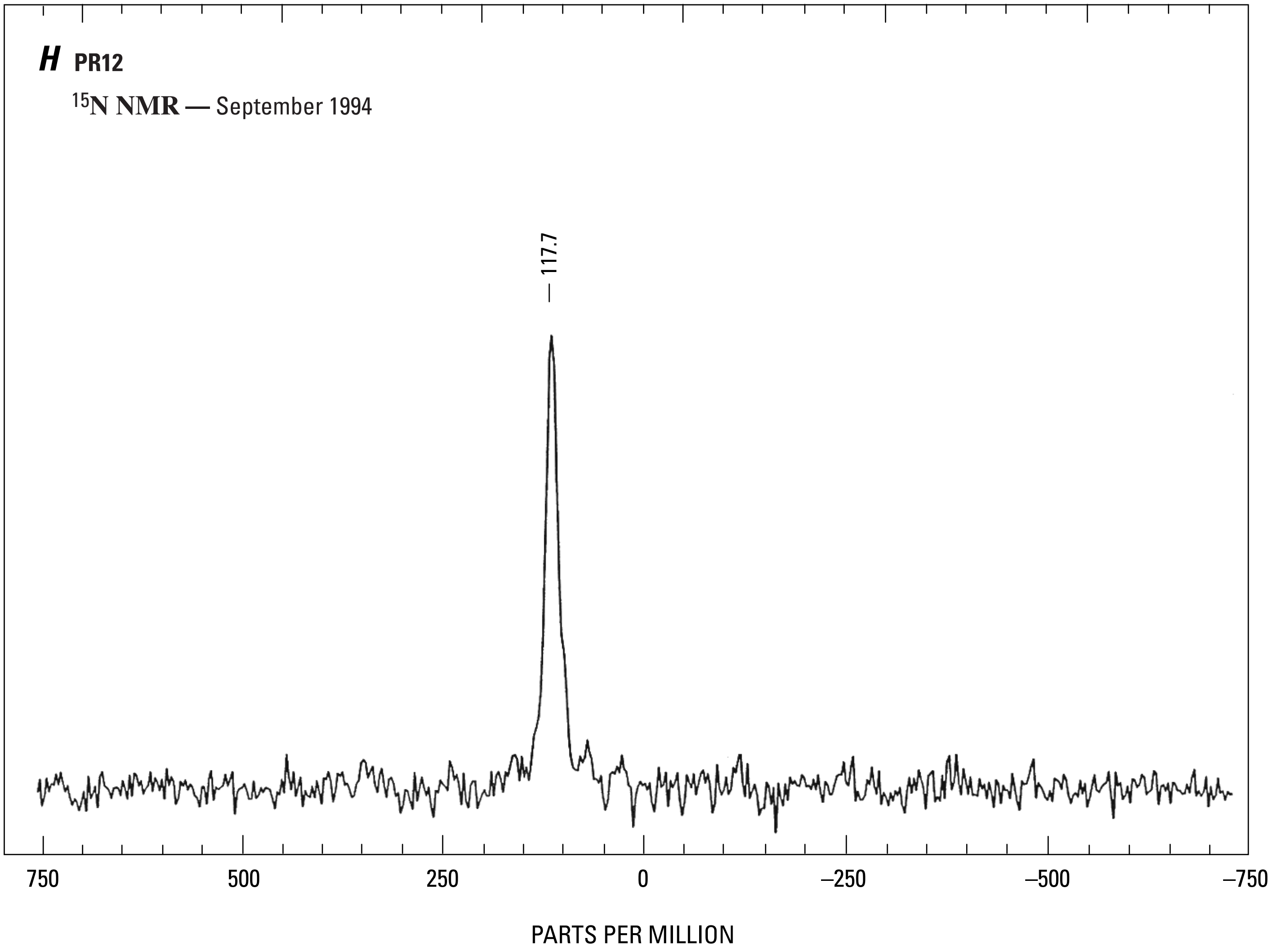


Figure 25*H*. Nitrogen-15 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid collected from PR12, September 1994.

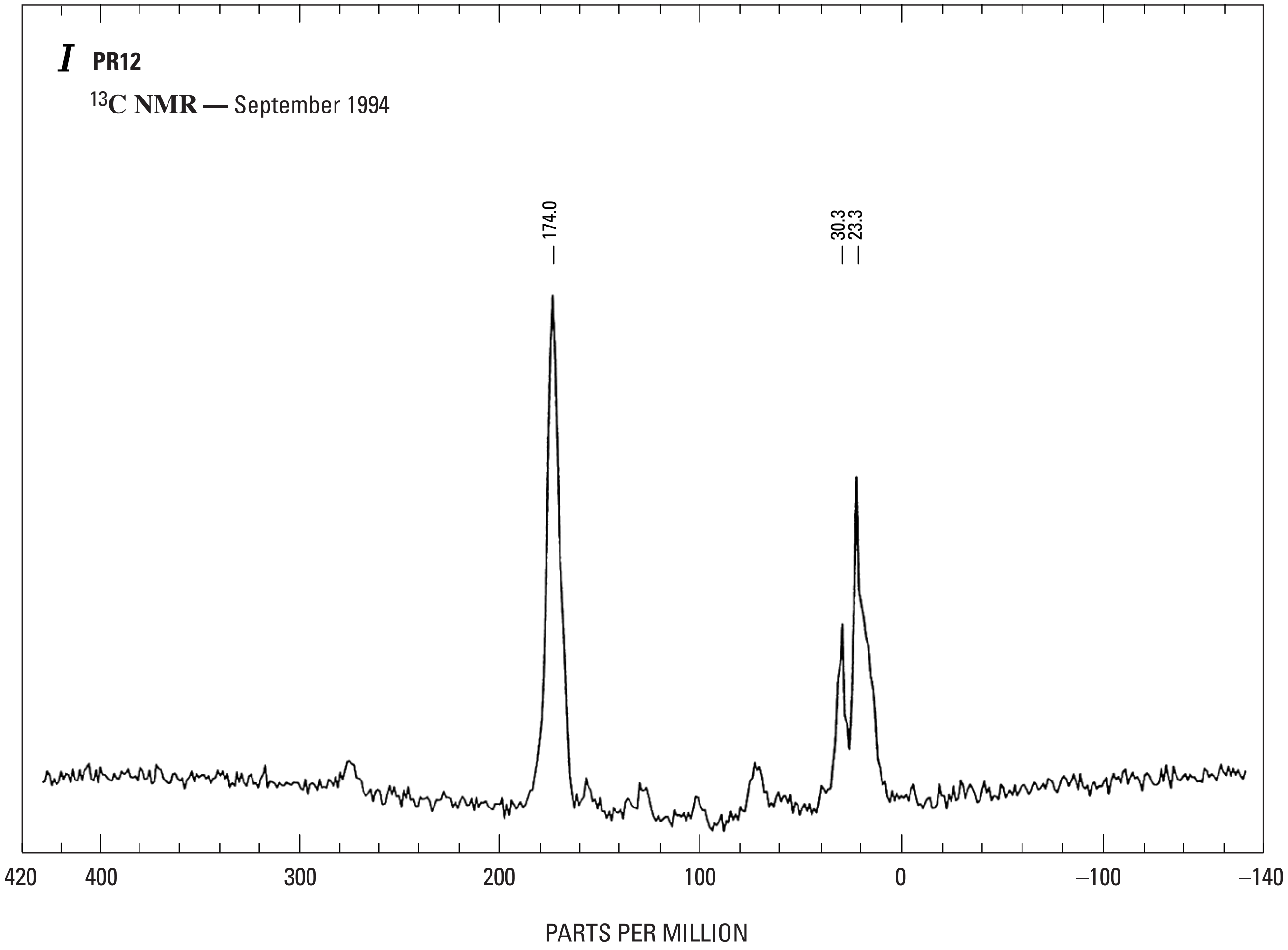


Figure 25*I*. Dipolar dephased carbon-13 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid collected from PR12, September 1994.

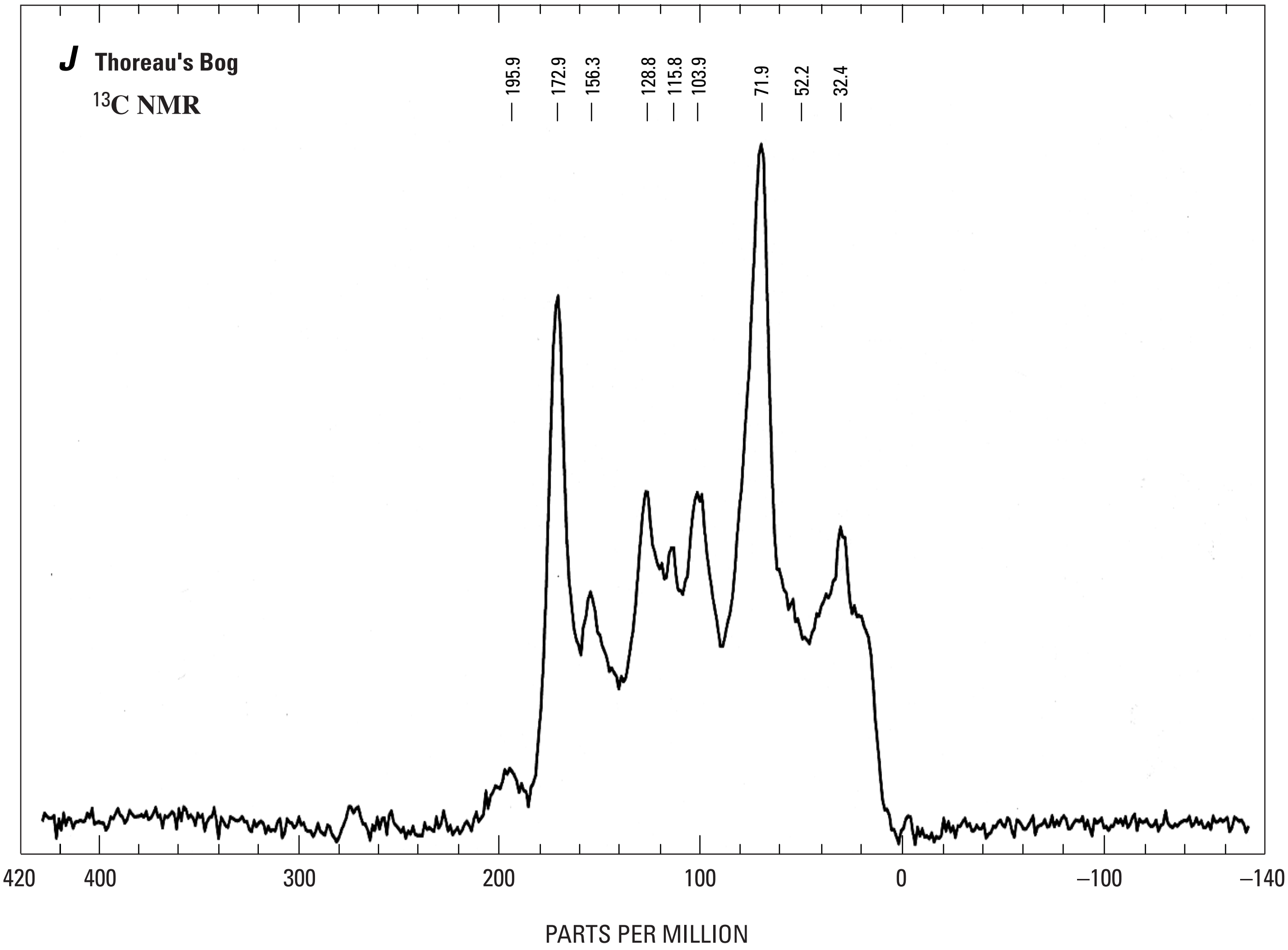


Figure 25*J*. Carbon-13 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid from Thoreau's Bog.

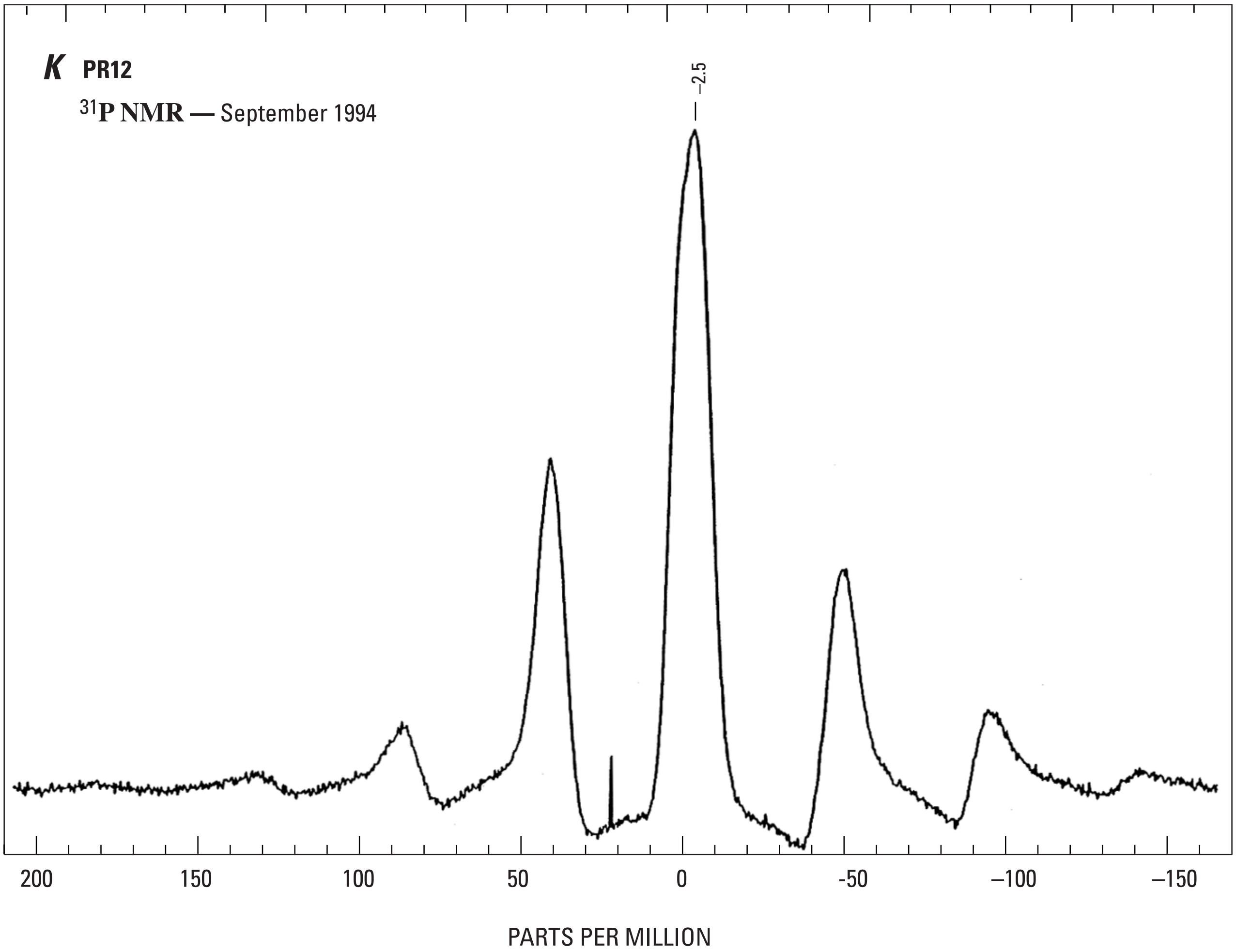


Figure 25*K*. Phosphorus-31 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid collected from PR12, September 1994.

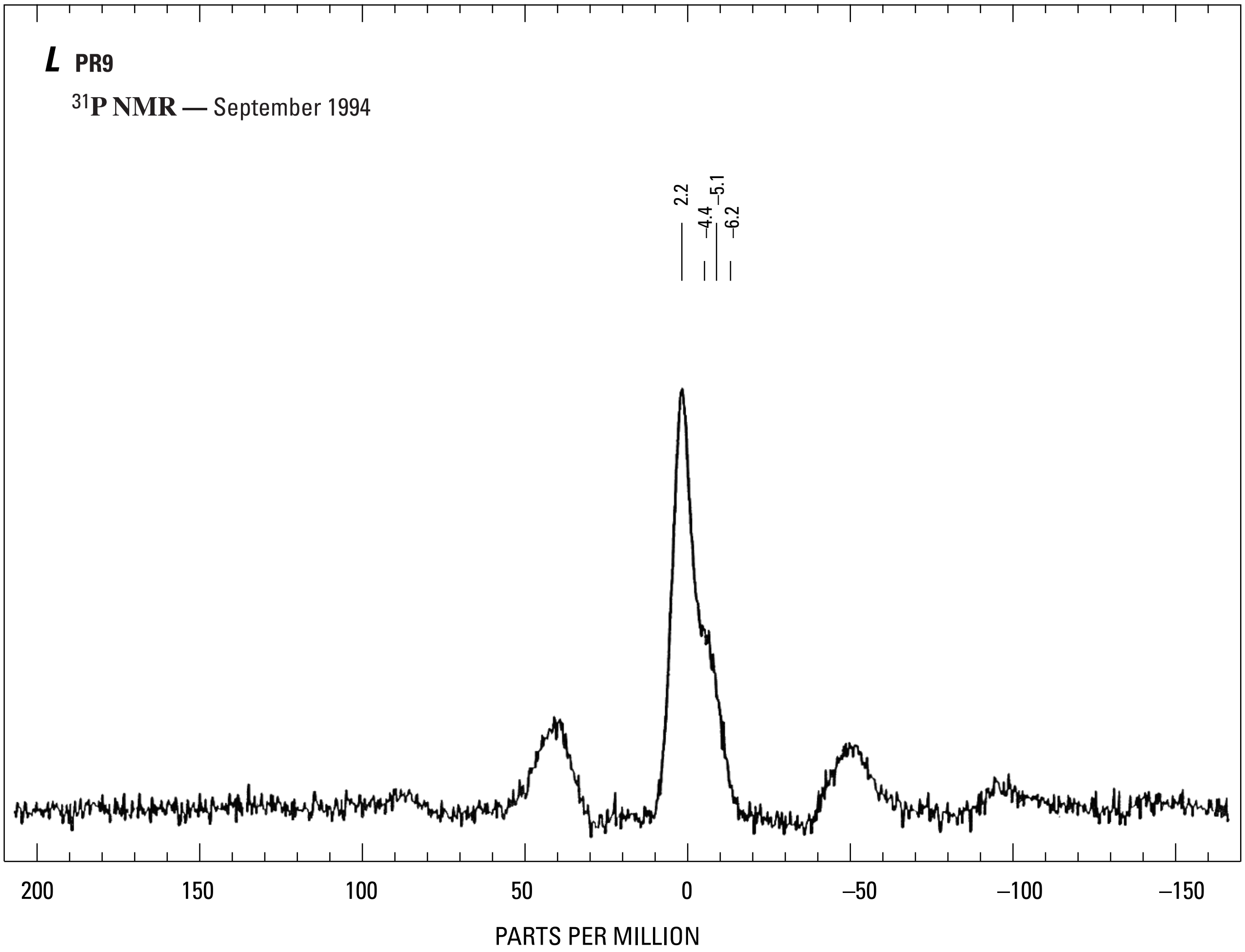


Figure 25*L*. Phosphorus-31 cross polarization/magic-angle spinning nuclear magnetic resonance spectometry of colloid collected from PR9, September 1994.

Differences between colloids in recycled water before recharge and during recharge beneath the research basin are illustrated by the ^{13}C CP/MAS NMR spectra. For example, compare spectra from the September 1994 sampling in figures 25*E* and *F*. There is a splitting of the carboxylic acid/amide peak in the spectrum from PR9, with maximums at 175.2 and 169.3 ppm, and a relative decrease in the signal intensity of the methylene carbons (31.4 ppm) with respect to the methyl carbons (24.4 ppm). These same differences also exist for the April 1994 recharge experiment between the effluent (PR13) (fig. 25*A*) and recharged water beneath the research basin at MLS4, MLS7, and PR9 (figs. 25*B*, *C*, *D*). The peaks at 169 ppm in the spectra of samples from below the bottom of the basin represent carbonate carbon. The resolution of the carbonate signal in these spectra corresponds to an increase in the ratio of inorganic to organic carbon in these samples compared to the colloids from the effluent and the research basin. One possible explanation is that the changes in spectra during recharge reflect the filtering out of algal material as the recycled water percolates through the bottom sediment. In other words, whereas the organic matter of colloids in the research basin and recycled water itself may be derived from a combination of algae and bacteria, the organic matter of colloids in recharged water beneath the research basin is derived mainly from bacteria. The decrease in C/N ratios of colloids during recharge, as shown in table 13, is consistent with this hypothesis insofar as C/N ratios of algae (5.6) tend to be higher than those of bacteria (3–5) (Rostad and others, 1997). It also is consistent with observations of bacterial transport reported in Chapter 4 on microbiological changes and with visual (greenish color) observations of algal transport, albeit to lesser depths, in these same samples for microbiological analyses.

CHAPTER 8: CHARACTERIZATION OF DISSOLVED ORGANIC MATTER BY CONCENTRATION, FRACTIONATION, AND MOLECULAR WEIGHT DETERMINATIONS

By Larry B. Barber

The concentrations and characteristics of DOC (dissolved organic carbon) and sewage-derived organic compounds are of concern in the recharge of aquifers with recycled water. Both natural and synthetic organic matter are important due to possible direct health effects and the formation of disinfection byproducts by reactions that take place during water treatment. Municipal wastewaters are mixtures containing thousands of dissolved and particulate organic compounds of varying chemical structures and molecular weights, and their characterization can be an important part of evaluating possible health effects.

The fate of DOC during aquifer recharge with recycled water depends on a number of hydrogeologic and biogeochemical processes, including dispersion and dilution, biodegradation, and sorption. Both rate and extent of removal during infiltration is affected by the composition, which varies with the origin of the organic matter (domestic or industrial), the level of pretreatment received, and the operation dynamics of the infiltration process.

In this study, the fate of DOC during three wastewater-infiltration events was evaluated by comparing concentrations and characteristics in samples collected from wells and multilevel samplers beneath and near the research basin with those in recycled water used in recharging the basin.

Methods

Sample Collection and Field Processing

Dissolved organic carbon was characterized in water collected during all three recharge experiments described in previous chapters. Samples were analyzed for total organic carbon (TOC), DOC, and total inorganic carbon (TIC) concentration, DOC fractionation (DOC_f), and DOC molecular-weight characterization (DOC_{mw}). One-liter samples for DOC, DOC_f, and DOC_{mw} analysis were pressure filtered (20–30 lb/in^2) through 0.45-µm silver membranes and collected in precleaned amber glass bottles. Unfiltered samples were collected in 40-mL amber glass bottles for TOC and TIC analysis.

Independent field measurements were made at the time of sampling for organic characterization measurement, and these data are reported in appendix 9. Specific conductance was measured using a temperature-compensated conductivity meter (Orion model 124) calibrated daily against standard reference solutions. Dissolved oxygen (DO) was measured using a temperature- and pressure-compensated DO meter (Orion model 820) calibrated daily against air. Sample pH was measured using an Orion 250 meter and an Orion model 9107 Triode pH electrode. The electrode was calibrated daily using pH 4, 7, and 10 standards. The samples used for detailed organic characterization were collected virtually concurrently—but by different personnel (in many cases)—with samples for microbiological and inorganic analyses. All field data are included in appendix 9 for each of the three recharge experiments. Some differences exist between these data and the field data described in the previous chapters on water-quality changes and given in the earlier appendixes, but these differences are generally minor.

Analytical Methods

Total and Dissolved Organic and Inorganic Carbon Concentration

Total and dissolved organic and inorganic carbon were measured by heated persulfate oxidation using an Oceanographic International Model 700 Carbon Analyzer. This method involves acidifying a 1-mL water sample with phosphoric acid to convert inorganic carbon to carbon dioxide (CO_2) and sparging with nitrogen (N_2) gas. The N_2 passes through a molecular sieve wherein the CO_2 is trapped. The trapped CO_2 is thermally desorbed and measured using an IR (infrared) detector. After removal of inorganic carbon, sodium persulfate is added and the sample is heated to oxidize the organic carbon to CO_2, which is then measured in the same way as is inorganic carbon. Each sample was analyzed in duplicate, and concentrations were calculated using a 6-point calibration curve. Distilled-water blanks and quality-assurance standards were analyzed approximately every 10 samples. The detection limit for this method is about 0.1 mg/L.

Dissolved Organic Carbon Fractionation

Samples were analyzed by an automated DOC_f method that is based on the method described by Leenheer and Huffman (1976, 1979), Leenheer (1981), and Barber and others (2001). This method is based on chromatographic separation, using macroreticular resins, of the DOC into six fractions using reverse- and normal-phase sorption and differences in aqueous elution characteristics.

A variety of macroreticular sorption resins were used in the DOC_f method. The reverse-phase adsorbent used in the method was Supelite DAX-8 (Supelco), an acrylic ester copolymer, or Amberchrom CG-71m (Supelco), a moderately polar polymethacrylate polymer with a smaller particle size than that of DAX-8. This material is equivalent to the XAD-8 resin used elsewhere in this report. Values obtained using both resins are reported for several samples from the second and third recharge experiments. The ion-exchange resins that were used are based on a cross-linked styrene divinylbenzene copolymer. The anion-exchange resin was BIO-RAD AG MP 1, a Type I strong-base anion-exchange resin (in Cl^- form) with quaternary ammonium basic functional groups or Amberlite IRA 910 (Rhom and Hass), which has Type II dimethylethanolamine basic functional groups. The cation-exchange resin was BIO-RAD AG MP 50 or Amberlite 200 (Rhom and Hass); both are Type I strong-acid cation-exchange resins with sulfonic acid functional groups (in H^+ form). The resins were custom packed by Waters Chromatography (Medford, Massachusetts) into long-body SepPak cartridges using radial compression technology.

The DOC_f method was automated using a Waters Millilab 1A solid-phase extraction robotics workstation. Each cartridge (pore volume approximately 1 mL) was conditioned immediately prior to use at flow rates through the cartridges of 1–4 mL/min.

This method separates the DOC into six fractions. The filtered water is passed through a DAX-8 or GC-71m (reverse-phase) column at neutral pH, and the effluent is collected. Under these conditions, the hydrophobic neutral (HPO_n) and the hydrophobic base (HPO_b) fractions are sorbed to the resin. The HPO_b fraction is then isolated by extracting the resin with 0.1 N sulfuric acid, leaving the HPO_n fraction to be determined by mass difference. The column effluent from the original sample is acidified to pH 2 using sulfuric acid, passed through the reverse-phase column again, and collected. The hydrophobic acid (HPO_a) fraction is then determined by mass difference between the column influent and effluent. The DOC that passes through the reverse-phase column at pH 2 is considered to be hydrophilic (HPI). The HPI DOC is further separated into a base (HPI_b) fraction by passing the sample through cation-exchange resin and into an acid fraction (HPI_a) by passing the cation-exchange column effluent through an anion-exchange resin. The final effluent from the ion-exchange resins that has passed through all of the sorbents is then the hydrophilic neutral fraction (HPI_n).

By following this entire procedure for each DOC_f sample, one obtains 13 subsamples for DOC analysis consisting of blanks, cartridge influents, cartridge effluents, and extracts. Each set of subsamples is analyzed as a group and includes a water blank and two DOC standards containing 1 and 5 mg/L carbon. Analyses of the various fractions were performed by persulfate oxidation as described in the preceding section. Examples of types or classes of organic compounds that could be present in each of the six DOC fractions are shown in figure 24.

Dissolved Organic Carbon Molecular-Weight Characterization

Aliquots from samples filtered through the silver membrane were fractionated by ultrafiltration to determine the molecular-weight characteristics of the DOC. Fractionation involved passing the sample through a parallel set of membranes (Diaflo Ultrafilters, Amicon, Beverly, Massachusetts) with nominal pore sizes that result in nominal molecular-weight cutoffs at 100,000 da (daltons) (YM100 filter), 30,000 da (YM30 filter), and 3,000 da (YM3 filter). An 80-mL sample was placed in a stirred filtration chamber containing the appropriate ultrafilter, the chamber was pressurized with N_2 to 60–70 lb/in^2, the first 20 mL of sample to pass through the filter was discarded, and the next 14 mL was collected and analyzed for DOC as described above. The percentage of DOC with molecular weights less than the three selected size cutoffs is determined by dividing the DOC of the filtrate by the initial DOC of the sample.

Results and Discussion

First Recharge Experiment

As was noted in descriptions in previous chapters of the hydrologic conditions at the research basin during the first recharge experiment in August 1993, the addition of very little recycled water was required to maintain the water level in the basin once it had been initially filled (the initial filling required less than 2 days). The slow infiltration was attributed to concurrent delivery of recycled water to the adjacent spreading grounds, which resulted in ground-water levels above the floor of the research basin (fig. 9). The result is that even 13 days after delivery of recycled water to the research basin began on August 10, the water had percolated only to a depth of about 10 ft below the basin floor, as evidenced by specific-conductance data given in appendix 8.

Organic Carbon Concentration

The results of DOC concentration analysis for samples collected August 23, 1993, are given in table 14. The data indicate about a 30-percent reduction in DOC concentration between the research basin (PR12) and soil water to a depth of 10 ft (MLS4–10) beneath the research-basin floor, an interval over which specific conductance is nearly constant.

Dissolved Organic Carbon Fractionation

Results of the DOC_f analysis are summarized in table 14 and are illustrated on “stiff-type” diagrams (Stiff, 1951) in figure 26. Because the analytical method was not yet fully developed at the time of this sampling, the DOC_f analysis was done by Huffman Laboratories, Denver, Colorado. Although there are some minor differences between the methods they used and those used by the USGS for the next two recharge experiments, the principles are the same and results are therefore considered comparable.

Some readily apparent differences (shown in fig. 26) occur in relative proportions of the six different fractions among the various samples. However, in assessing possible changes in composition during recharge, one must exclude from consideration data from more than 10 ft below the research-basin floor because percolation of recharge at the research basin did not extend beyond this depth during the August 1993 experiment. The diagrams seem to indicate a slight shift from hydrophobic predominance in the effluent (PR13) to hydrophilic predominance in the subsurface (MLS4). This shift is accompanied by an increase in the acid (HPO_a and HPI_a) and decrease in the neutral (HPO_n and HPI_n) components of the hydrophobic and hydrophilic fractions, respectively. However, even such modest differences in composition are no longer discernible when comparisons are extended to include data in table 14 from the research basin itself (PR12) and from depths below 4 ft (MLS5–10).

Table 14. Dissolved organic carbon (DOC) fractionation data for samples collected August 23, 1993, at the research basin, Montebello Forebay, Los Angeles County, California

[mg/L, milligrams per liter; <, less than; samples analyzed by Huffman Laboratories, Denver, Colorado]

Sample identifier	Total DOC (mg/L)	Hydrophobic fractions (percent)				Hydrophilic fractions (percent)			
		Total	Acid	Base	Neutral	Total	Acid	Base	Neutral
PR13	7.2	53	18	1	35	47	15	8	24
PR12 at surface	7.5	34	21	<1	14	66	48	11	8
PR12 at bottom	7.8	37	19	<1	18	63	42	9	12
MLS4	5.8	40	26	<1	14	60	47	13	<1
MLS5	5.4	35	22	<1	11	65	50	13	2
MLS6	5.4	46	20	<1	26	54	28	13	15
MLS7	6.1	41	16	<1	26	59	26	7	25
MLS8	5.2	42	21	2	19	58	42	4	10
MLS10	3.6	28	17	<1	11	72	44	17	11
MLS11	3.7	54	8	<1	46	46	22	16	8
PR9	2.0	40	35	<1	5	60	15	10	30
PR8	2.3	52	4	<1	48	48	4	9	35

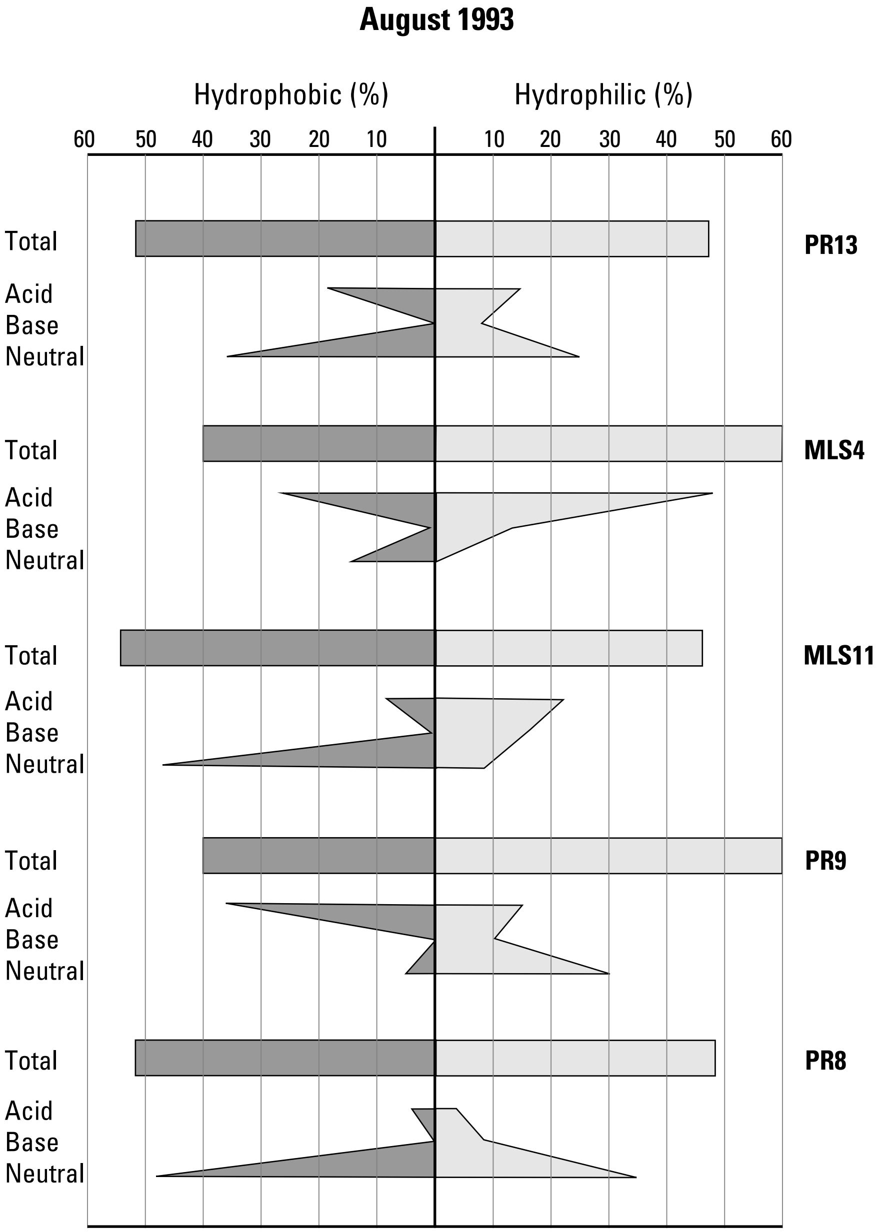


Figure 26. Relative proportions of six dissolved organic carbon fractions at the research basin, Montebello Forebay, Los Angeles County, California, during the August 1993 recharge experiment.

Second Recharge Experiment

The second recharge event started at 20:00 April 4, 1994, and ended at 17:00 April 21, 1994. During the 17 days of infiltration 12.5 acre-ft of effluent was recharged through the research basin. A total of 42 samples were collected from the wastewater effluent, the infiltration basin, wells, and MLS ports for organic analysis. Samples were collected 1 day before discharge to the basin, and 1, 2, 3, 4, and 58 days after infiltration began. The day 58 sample was collected 41 days after filling of the basin stopped.

Field measurements obtained on samples collected during the second recharge experiment for organic carbon characterization are consistent with the pattern described previously in Chapter 5 on water-quality changes. For example, chloride data in figure 12 show that by the second day of recharge, April 6, 1994, recharged water had completely, or nearly completely, displaced preexisting water in the soil to a depth of about 20 ft. There was also substantial, though less complete, displacement at a depth of 25 ft (PR9)—unlike in August 1993. Specific-conductance data (appendix 9) on the samples collected April 7, 1994, for organic carbon characterization yield a similar result; conductance values were nearly constant in the upper 19 ft and decreased slightly at 20 (MLS20) and 25 ft (PR9). A DO maximum, centered at a depth of 11 ft beneath the basin according to the data in appendix 9, also is confirmed in figure 20. The pH was slightly above 7 in the research basin and slightly below 7 beneath it; the difference was only about 0.2 pH unit. Such a decrease is consistent with ammonia oxidation (nitrification)—which, on the basis of the nitrogen profiles in figure 18, seems to be occurring—during the first few days of recharge. And finally, there is only a very slight decrease in temperature with increasing depth beneath the research basin as recycled water with a temperature near 24°C displaces cooler preexisting soil moisture having a temperature near 22°C.

Organic Carbon Concentration

Measurements of DOC and TOC concentration on selected samples indicate that only1 percent, or less, of the aqueous organic carbon beneath the research basin is present as particles larger than 0.45 µm (table 15). This finding can be compared with data in Chapter 7 that showed that the colloidal contribution, though minor relative to total and dissolved (0.45-µm) organic carbon, is about an order of magnitude greater than the contribution from particles larger than 0.45 µm. As expected, the effluent itself has a higher particulate organic carbon concentration (POC) at about 5 percent, most of which apparently does not infiltrate intact beneath the research basin during recharge experiments. The upgradient background well (-7J1) and a well 2,500 ft south of the research basin (-19C1) also had measurable quantities of POC, but because these wells are only infrequently sampled, the POC could be artifacts caused by sloughing of material from the soil during pumping to collect the sample.

The DOC concentration data (table 16) beneath the research basin indicate that concentration increases rapidly on successive days, with some temporal and spatial variability in the early stages, from 1.5 to 2.2 mg/L before recharge to a nearly uniform level of about 6 mg/L 3 days after recharge began. The concentration after 3 days represents about a one-third reduction in DOC concentration in comparison with the approximately 9 to 10 mg/L present in the recycled water itself. The DOC concentrations then declined after the recharge experiment was discontinued, although even 41 days later, on June 1, concentrations still exceeded those that existed before the recharge experiment began. This subsequent decline was attributed, on the basis of information shown in figure 12*B*, to partial replacement of the high-DOC recycled water with lower-DOC ambient ground water after recharge is discontinued.

Table 15. Selected organic and inorganic carbon data and analytical precision information for samples collected during the April and September 1994 recharge experiments at the research basin, Montebello Forebay, Los Angeles County, California

[Data for April 7 except as noted; DOC, dissolved organic carbon; TOC, total organic carbon; POC, particulate organic carbon; TIC, total inorganic carbon; mg/L, milligrams per liter; <, less than; —, no data]

Sample identifier	DOC[1] (mg/L)	TOC (mg/L)	POC (percent)	TIC (mg/L)
PR13 (April 5)	9.7	10.2	5.2	49.9
PR12 (April 6)	9.2	9.1	1.2	52.3
MLS4 (April 6)	3.6	3.6	.6	37.1
MLS7	4.1	4.1	.5	44.0
MLS10	5.8	5.9	1.9	47.2
MLS15	5.9	5.7	3.3	44.0
MLS20	4.4	4.2	4.1	42.5
PR11	2.5	2.5	.8	43.3
PR10	2.1	2.1	.9	41.6
PR9 (April 5)	2.5	2.5	.0	44.5
PR9	4.5	—	—	45.9
PR8	2.3	—	—	43.6
2S/11W-19C1	3.5	4.2	18.2	46.7
2S/11W-18P1	3.6	3.6	.8	46.7
2S/11W-7J1	1.6	1.7	6.0	59.7
Field blank	—	.1	—	—
Filter blank	—	.1	—	—
Effluent from Bolston Filter				
PR12	8.4	—	—	—
MLS4	4.8	—	—	—
MLS7	5.9	—	—	—
PR9	5.3	—	—	—
Effluent from Amicon Ultrafilter				
PR12	7.9	—	—	—
MLS4	4.9	—	—	—
MLS7	5.6	—	—	—
PR9	4.7	—	—	—
September 1994				
PR13	8.0	8.3	<1	45.0
MLS15	5.4	5.3	2	
PR9	5.5	5.5	<1	48.2
PR11	5.4	5.4	<1	48.3
WP5	4.0	4.1	<1	44.3
2S/11W-7J1	1.4	1.9	<1	61.3

[1] Precision ranges from <0.1 to 0.3 based on replicate anayses.

Table 16. Dissolved (DOC) and total (TOC) organic carbon concentrations before (April 4), during, and after (June 1) the 17-day recharge experiment in April 1994 at the research basin, Montebello Forebay, Los Angeles County, California

[April 7 data are for TOC, all other data are for DOC; —, no data]

Sample identifier	Organic carbon concentration, in milligrams per liter					
	April 4	April 5	April 6	April 7	April 8	June 1
PR13	—	9.7	9.2	—	8.3	—
MLS4	1.8	3.6	—	6.3	6.3	7.8
MLS5	1.8	—	—	6.0	5.0	4.1
MLS6	1.7	—	—	5.6	5.0	4.1
MLS7	1.7	—	4.1	5.5	4.6	3.4
MLS8	2.0	—	—	5.6	4.8	3.6
MLS9	1.5	—	—	5.9	5.7	2.2
MLS10	1.8	—	5.8	6.1	5.9	2.5
MLS11	—	—	—	5.8	—	—
MLS12	—	—	—	6.0	—	—
MLS13	—	—	—	5.8	—	—
MLS14	—	—	—	5.9	—	—
MLS15	2.0	—	5.9	5.9	—	3.6
MLS16	—	—	—	5.4	—	—
MLS17	—	—	—	5.9	—	—
MLS18	—	—	—	5.5	—	—
MLS19	—	—	—	5.5	—	—
MLS20	2.2	—	4.4	4.2	—	2.8
PR9	1.9	2.5	—	4.5	2.3	3.6

The fairly uniform pattern described does not exist, however, at very shallow depths, especially at 4 ft (MLS4), where DOC concentration actually increased to 7.8 mg/L on June 1. Such a high concentration could indicate desorption from the solid to the aqueous phase. Even the chloride concentration at 142 mg/L in MLS4 on June 1 exceeds the concentration (range 125 to 139 mg/L) in the research basin (PR12) during the period April 4–21 when effluent was being delivered to the research basin (appendix 3). The high chloride level is consistent with concentration by partial evaporation during the drying cycle that follows recharge.

Molecular Weight of Dissolved Organic Carbon

The molecular-weight characterization data in table 17 indicate that the concentration of nearly all DOC beneath the basin, and in the background well (-7J1), is less than 30,000 da (equivalent to 0.005-µm filter pore size). There is some evidence for preferential removal of higher-molecular-weight DOC during recharge as the proportion less than 3,000 da increases from about 70 percent in the effluent (PR13) to about 80 percent beneath the research basin.

Table 17. Dissolved organic carbon (DOC) molecular-weight distribution for samples collected at the research basin, Montebello Forebay, Los Angeles County, California, in April and September 1994

[mg/L, milligrams per liter; SRFA, Suwannee River fulvic acid; KHP, potassium hydrogen phthalate standard; —. no data]

Sample identifier	Total DOC (mg/L)	DOC content in percent size fraction less than		
		3,000 daltons	30,000 daltons	100,000 daltons
		April 1994		
PR13	8.2	69	82	—
MLS4	3.2	81	93	95
MLS10	5.1	78	93	95
MLS15	5.3	79	93	93
MLS20	3.8	81	100	98
PR9 (April 5)	2.4	70	99	101
PR9 (April 7)	3.9	85	104	98
PR8	2.2	108	96	93
		September 1994		
PR13	8.2	58	79	85
MLS15	5.2	69	98	97
PR9	5.9	75	91	89
PR11	5.5	75	94	93
WP5	4.2	77	97	101
2S/11W-7J1	1.3	57	102	103
SRFA	3.6	8	75	97
KHP	5.2	23	82	100

Dissolved Organic Carbon Fractionation

The results of DOC fractionation during the second recharge experiment are presented in table 18 and in depth-related profiles in figure 27. Patterns are more easily discernible than during the first recharge experiment—in part because more data were collected, but also because the recycled water penetrated to a greater depth beneath the research basin than during the first experiment. This is evident from the change in relative concentrations at the 25-ft depth (PR9) between April 5 and April 7, when increasing amounts of recycled water reach this depth. (Note only the April 5 data are shown in figure 27—if the April 7 data were plotted instead, the difference [shift in profile] from shallower depths would appear to be less marked than depicted in the figure). The data in table 18 suggest a slight decrease in the hydrophilic component during recharge from 66 percent in the research basin (PR12) to about 60 percent beneath the basin. However, this small difference is less than the average difference obtained by using two different resins (CG-71m or DAX-8) for dual sets of values on seven samples included in table 18 and is therefore not significant.

The profiles to a depth of 25 ft, the depth to which recycled water penetrated, show a general decrease with increasing depth in both the hydrophilic acid (HPI_a) and hydrophilic base (HPI_b) fractions. This pattern is matched by a rather uniform increase in the hydrophobic neutral (HPO_n) and hydrophobic acid (HPO_a) fractions, as would be expected if there were preferential removal of the hydrophilic component from the DOC. Also, it is clear, upon comparison of the fractionation data in these profiles with results at the 50-foot depth, that recycled water during the recharge experiment does not penetrate beneath the clay lens that is present between the deeper (PR8 and PR10) and shallower (PR9 and PR11) piezometers (table 18 and fig. 27).

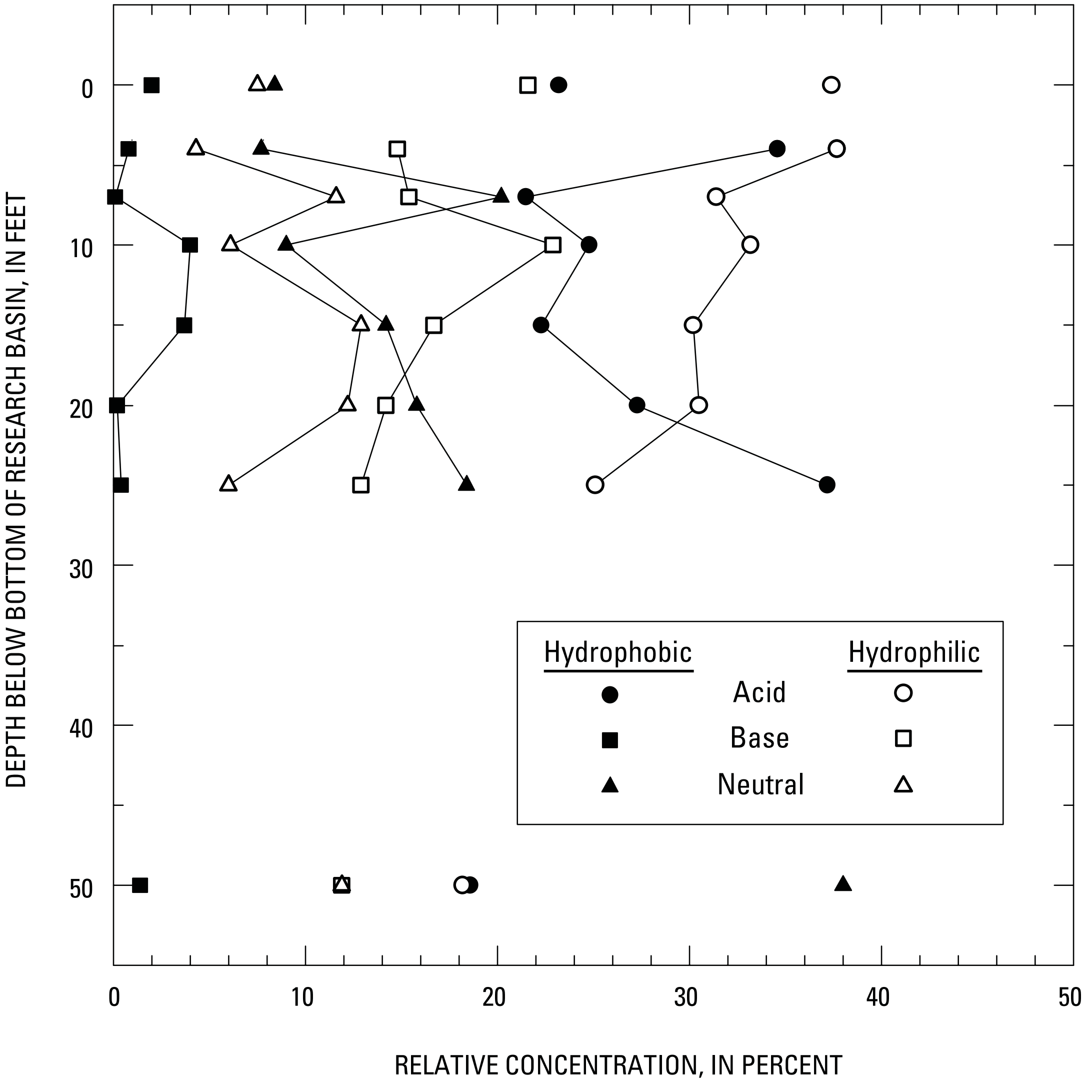


Figure 27. Relative concentrations of six dissolved organic carbon fractions in PR13 (effluent depicted as zero depth) and beneath the research basin during the April 1994 recharge experiment, Montebello Forebay, Los Angeles County, California.

Table 18. Dissolved organic carbon (DOC) fractionation data for samples collected at the research basin, Montebello Forebay, Los Angeles County, California, April 1994

[A, data obtained using CG-71m resin; B, data obtained using DAX-8 resin; mg/L, milligrams per liter; SRFA, Suwannee River fulvic acid; <, less than; —, no data]

Sample identifier	Total DOC (mg/L)	Hydrophobic fractions (percent)				Hydrophilic fractions (percent)			
		Total	Acid	Base	Neutral	Total	Acid	Base	Neutral
PR13 A	9.1	38	23	4	11	62	32	26	4
PR13 B	8.3	47	19	2	26	53	26	18	9
PR12 A	—	—	—	—	—	—	—	—	—
PR12 B	7.8	34	23	2	8	66	37	22	7
MLS4 A	3.1	43	35	1	8	57	38	15	4
MLS4 B	—	—	—	—	—	—	—	—	—
MLS7 A	3.6	42	21	<1	20	58	31	15	12
MLS7 B	3.5	40	32	<1	7	60	35	15	10
MLS10 B	5.1	38	25	4	9	62	33	23	6
MLS15 B	5.4	40	22	4	14	60	30	17	13
MLS20 B	3.9	43	27	<1	16	57	31	14	12
PR9 (April 5) B	2.5	56	37	<1	18	44	25	13	6
PR9 (April 7) A	3.9	39	25	4	10	61	30	18	13
PR9 (April 7) B	3.8	36	17	4	15	64	32	20	12
PR8 B	2.5	58	19	1	38	42	18	12	12
PR10 B	2.4	54	17	2	34	46	20	16	10
PR11 A	2.4	63	29	<1	35	37	4	2	31
PR11 B	2.3	45	27	<1	17	55	7	8	40
2S/11W-19C1 B	3.0	41	31	<1	9	59	20	12	27
2S/11W-18P1 B	3.1	38	19	6	13	62	16	8	37
2S/11W-7J1 B	1.4	25	25	<1	<1	75	34	18	23
SRFA A	4.7	71	46	4	20	29	22	7	<1
SRFA B	4.6	64	44	3	17	36	27	2	7

Third Recharge Experiment

At the time of the last of the three recharge experiments, in September 1994, ground-water levels were much lower than during the first two experiments, with an approximately 10- to 15-foot unsaturated zone existing beneath the research basin (fig. 9). Hence, recycled water was able to infiltrate rapidly and displace preexisting moisture beneath the research basin. The profile for specific conductance was constant at about 1,090 µS/cm to a depth of 25 ft, a confirmation of virtually complete displacement (shown by data in appendixes 4 and 9), when sampled about 2 weeks after recharge had begun.

Organic Carbon Concentration

The decrease in DOC from 8.2 mg/L in the effluent (PR13) to 5.2–5.9 at depths of 15 and 25 ft (MLS15, PR9, and PR11) beneath the research basin (table 17) represents a 32-percent reduction in aqueous DOC concentration. The value is nearly identical to those calculated from the first two recharge experiments and suggests that reduction in DOC (also TOC) concentration during recharge is independent (within the sensitivity of the experimental results) of unsaturated-zone thickness and independent, as well, of environmental properties such as redox potential that do affect nitrogen removal.

Molecular Weight of Dissolved Organic Carbon

The results of molecular-weight characterization for the DOC during the third recharge experiment, when a substantial unsaturated zone existed, are similar to those from the second recharge experiment, when almost no unsaturated zone was present. There is some slight evidence that movement through an unsaturated zone is less effective in removing (presumably by sorption) higher-molecular-weight DOC; this evidence is based on the observation that the proportion of DOC greater than 3,000 da beneath the research basin increases from about 20 percent in the second recharge experiment to about 30 percent in the third experiment (percentages calculated from data in table 17). A comparison with the Suwannee River fulvic acid (a standard commonly used for comparison), where 92 percent of the DOC is greater than 3,000 da, confirms the expected finding that ground-water DOC at the study site is of lower molecular weight than is typical for natural organic carbon in surface water (Barber and others, 1995a, b).

Dissolved Organic Carbon Fractionation

The analytical method was modified slightly from the second recharge experiment by using a smaller-particle-size resin for initial isolation of the hydrophobic component. This change results in a slightly higher HPO_a fraction. The data in table 19 indicate nearly equal amounts of hydrophobic and hydrophilic DOC in the effluent (PR13), whereas the hydrophilic component was slightly greater in the second recharge experiment (table 18). Proportions of the six fractions beneath the research basin were generally about the same in both experiments; however, data from too few depths (15 and 25 ft only) were collected in the third experiment to reliably assign differences.

A rather large difference was observed between the April and September samples in the relative proportion of the six fractions at the background well (-7J1). Predominance shifted from hydrophilic (75 percent in table 18) in the second recharge experiment to hydrophobic (64 percent in table 19) in the third experiment. This shift was accompanied by a large increase in the HPO_a fraction and decreases in the HPI_a and HPI_b fractions. Such large variations in such a short time suggest that this background (or upgradient) monitoring well may be subject to seasonal changes that affect natural recharge and water levels, and perhaps even operations at the spreading grounds itself.

Table 19. Dissolved organic carbon (DOC) fractionation data for samples collected at the research basin, Montebello Forebay, Los Angeles County, California, September 1994

[mg/L, milligrams per liter; A, data obtained using CG-71m resin; B, data obtained using DAX-8 resin]

Sample identifier	Total DOC (mg/L)	Hydrophobic fractions (percent)				Hydrophilic fractions (percent)			
		Total	Acid	Base	Neutral	Total	Acid	Base	Neutral
PR13	7.6	50	35	1	13	50	25	17	8
MLS15	4.8	47	34	1	13	53	27	13	12
PR9 A	5.5	23	8	1	13	77	46	19	12
PR9 B	5.2	48	39	1	8	52	27	14	12
PR 11	5.1	48	36	1	11	52	29	14	10
WP5	3.9	48	38	1	9	52	27	10	15
2S/11W-7J1	1.5	64	38	1	26	36	2	5	28

CHAPTER 9: CHARACTERIZATION OF DISSOLVED ORGANIC MATTER BY INFRARED AND ULTRAVIOLET/VISIBLE SPECTROMETRY

By Jerry A. Leenheer *and* Ted I. Noyes

Infrared spectrometry is especially useful for determining oxygen, nitrogen, and sulfur functional groups in organic-matter isolates, and methyl and methylene groups in hydrocarbon structures. However, interpreting IR spectra can be more complex than interpreting ^{13}C-NMR spectra. Purity of the isolates is a more important requirement for IR than for ^{13}C-NMR owing to IR spectral interferences from ammonium, nitrate, nitrite, phosphate, silica, sulfate, and water. Large concentrations of ammonium, nitrate, and phosphate in recycled water made necessary the development of specific fractionation and isolation methods that are not normally required for natural waters. Therefore, the primary objective for the April and September 1994 samplings was to develop methods for comprehensive fractionation, isolation, and IR characterization of DOC; a secondary objective was to apply these methods to observe water-quality changes during infiltration of reclaimed water from the research basin into the subsurface.

Fractionation and Isolation Methods

For the ultrafiltered water samples (method described in Chapter 6) obtained during the April 4–7, 1994, sampling, the preparative DOC fractionation approach (Leenheer and Noyes, 1984) using Amberlite XAD-8, MSC-1H, and Duolite A-7 resin columns in series was used with the following modifications:

(1) The 20-L ultrafiltered sample was adjusted to pH 4 and vacuum-evaporated to 0.5 L. The evaporation under acidic conditions eliminates carbonates and maintains ammonium in the cationic form to minimize ammonia reactions with organic matter.

(2) Hydrophobic DOC was adsorbed from the sample concentrate on a 150-mL bed-volume column of XAD-8 resin. The low ratio of sample concentrate volume to resin volume enabled greater recoveries of hydrophobic solutes with column-capacity factors (k') that are lower than those from earlier methods.

(3) Most of the inorganic salts in the hydrophilic DOC fraction that did not sorb to XAD-8 resin were removed by zeotrophic distillation with acetic acid (Aiken and Leenheer, 1993). Removal of these salts allowed the sorption of hydrophilic bases on the MSC-1H resin (100-mL column) and hydrophilic acids on the A-7 resin (100-mL column) using much smaller volumes of these ion-exchange resins than if salts had not been removed.

(4) The final desalting of both the hydrophobic and hydrophilic base fractions was done on Amberlite XAD-4 resin using water volumes that recovered solutes with k' values greater than 4. A 75-percent acetonitrile/25-percent water (volume ratio) mixture was used for elution of the base fractions.

(5) Nitrate, phosphate, and sulfate were major salt interferants in the hydrophilic acid fraction eluted with dilute sodium hydroxide (NaOH) from the A-7 resin. Phosphate was removed by precipitation as magnesium ammonium phosphate (Fischer, 1961), and nitrate and sulfate were precipitated as their barium salts, insoluble in acetic acid (Audrieth and Kleinberg, 1953), after removal of water by zeotrophic distillation.

Additional changes in fractionation and isolation methods were made for samples collected during September 19–22, 1994. The main objective of these methods changes was to separate and characterize discrete compound-class contaminants such as alkylphenol polyethyoxy carboxylates (APECs), aromatic sulfonates, alkylsulfates and arylsulfates, and a blue dye, from organic matter of natural origin such as carbohydrates, fulvic acid, and proteins.

Special care was taken during the processing of these samples to prevent exposure to extremes of low pH and heat that would hydrolyze alkylsulfates and arylsulfates that might be present from sulfate-ester surfactants. The 20-L samples were vacuum-rotary evaporated without pH adjustment to 0.5 L. The concentrates were then acidified to pH 3, and purged with nitrogen to remove carbonates. The pH of the samples was adjusted to 7 and the samples were vacuum-evaporated to 50 mL. These concentrates were reacidified to pH 2 and extracted using 200 mL of diethylether to remove the APEC contaminants and other extractable acids. The aqueous phase was neutralized to pH 8 and passed through a sodium-saturated MSC-1 column to remove divalent and trivalent cations. The samples were evaporated to dryness and the salts were extracted using methanol, an optimum solvent for sodium salts of sulfate esters (Paulson, 1976). The extract was evaporated to dryness and redissolved in water. Both the methanol-insoluble salts and the methanol-soluble salts were then fractionated using the same procedure as for the previous samples. This procedure was verified using sodium methyl sulfate and sodium dodecysulfate to minimize sulfate ester hydrolysis.

Hydrophobic acid fractions were subfractionated by readsorbing the acid form of these fractions on a 20-mL column of silica gel and sequentially eluting with methylene chloride, ethyl acetate, acetone, 75-percent acetone/25-percent 2-propanol, methanol, 75-percent acetonitrile/25-percent water, and 0.3 M oxalic acid. The $HPO_{a,n}$ fraction that contained a blue dye was similarly applied to the silica gel column and eluted with 50-percent acetone/50-percent 2-propanol, 50-percent acetonitrile/50-percent 2-propanol, and 75-percent acetonitrile/25-percent water. The blue dye eluted with the final fraction.

Not all of these procedures were applied to each sample of the September 1994 sampling. The procedures evolved and were modified as findings from each previous sample became known.

Infrared Spectral Characterizations

Infrared spectra of 2–5 mg of sample-fraction isolates in KBr pellets were determined on a Perkin Elmer Model 580 IR Spectrometer with dispersive optics and a thermocouple detector. A few spectra of organic standards were determined on a Perkin Elmer System 2000 Fourier Transform Infrared Spectrometer using a pulsed-laser source and deuterated triglycine sulfate detector.

The sulfophenyl carboxylate-8 (SPC-8) and dialkyltetraline- and dialkylindane-sulfonate (DATS) standards were obtained from M. L. Trehey of Monsanto. The neutral alkylphenol polyethoxylate surfactant (Triton X-100) was obtained from Rohm and Haas, and the anionic aromatic sulfonate surfactant was obtained from Alconox. The nonylphenol 1-3-ethyoxylate (Aldrich Chemical) and the nonylphenol-1-ethoxy carboxylic acid (Kolb Chemical) were obtained from J.C. Field of Oregon State University.

Twenty liters of ultrafiltered water from the effluent source (PR13) of the reclaimed water that is delivered to the research basin was sampled April 5, 1994. The masses and fraction percentages of dissolved organic matter obtained from the preparative DOC fractionation of this water are presented in table 20. The total recovered DOC of 10.92 mg/L in table 20 compares well with the measured DOC of 9.69 mg/L, considering uncertainties in the percentage-carbon values of the fractions. Therefore, the fractionation and isolation are comprehensive in terms of mass recovery.

Table 20. Preparative dissolved organic carbon (DOC) fractionating data for reclaimed-water effluent (PR13) collected at the research basin, Montebello Forebay, Los Angeles County, California, April 5, 1994

[mg, milligram]

Fraction	Weight (mg)	Percen-tage	Dissolved organic carbon
Hydrophobic neutrals (HPO_n)	58.7	13.4	1.46
Hydrophobic acids (HPO_a)	209.8	48.0	5.24
Hydrophobic bases (HPO_b)	19.1	4.4	.48
Hydrophilic acids (HPI_a)	64.0	14.6	1.60
Hydrophilic bases (HPI_b)	14.9	3.4	.37
Hydrophilic neutrals (HPI_n)	71.0	16.2	1.77
Total	437.5	100	10.92

Infrared spectra of the DOC fractions given in table 20 are shown in figure 28. The hydrophobic fractions (spectra A, B, and C) have much stronger peaks for the hydrocarbon stretching frequencies at 3,000–2,860 cm^{-1} and bending frequencies at 1,440–1,380 cm^{-1} than are found for the hydrophilic fractions (spectra D, E, and F). The acid fractions (spectra B and D) are dominated by the carboxylic acid peak at 1,720 cm^{-1}, but aromatic sulfonic acids also are important components, as indicated by sharply defined peaks at 1,040 and 1,012 cm^{-1}. The base fractions (spectra C and E) are highly proteinaceous, as indicated by the amide-1 peak at 1,660 cm^{-1} and amide 2 peak at 1,550 cm^{-1}. Lesser amounts of these amide peaks are found in the HPO_n (spectra A), HPI_a (spectra D), and HPI_n (spectra F) fractions. The HPI_n fraction is dominated by carbohydrates, as indicated by the strong carbonyl-oxygen (C-O) stretch band from 1,150 to 1,050 cm^{-1}, but the broad C-O stretch band centered at 1,720 cm^{-1} is indicative of acids, esters, and amides that exist as neutral species by themselves or possibly in complexed forms with borate or silica. Peaks that indicate inorganic species are absent in these spectra—with the exception of the HPO_n fraction, which contains a small quantity of silicic acid as indicated by peaks at 1,130, 960, and 470 cm^{-1}.

The reclaimed-water effluent was resampled from the research basin September 21, 1994, and fractionated to obtain additional compound-class information. The IR spectra of DOC fractions from this sample are shown in figure 29. This fractionation detected only trace amounts of organic sulfate esters in spectra B and E; note the peak at 1,065 cm^{-1}, which is indicative of sulfate esters (Paulson, 1976). The sharp peak at 1,513 cm^{-1} was fractionated almost completely into the ether-extract fraction (spectrum A) and was tentatively identified from comparison of standard IR spectra (Pouchert, 1985) as an aromatic-ring vibration that is strong in 1,4-substituted alkoxy compounds. This peak may be indicative of APEC metabolites from neutral surfactant degradation. In the hydrophobic neutral fractions (spectra B and D), the strong amide-1 peak at 1,650 cm^{-1} is accompanied by a weak amide-2 peak at 1,550 cm^{-1} and a peak of medium intensity at 1,410 cm^{-1}. This amide peak pattern is found for cyclic secondary amides (Pouchert, 1985) such as pyrimidines found in nucleic acids. Pyrimidines previously have been reported in municipal sewage effluents (Pitt and others, 1975). Sulfonic acids were again found as major components of the acid fractions, as indicated by the peak at 1,040 cm^{-1} (spectra C and F), but the absence of the 1,012 cm^{-1} peak in the hydrophilic acids of spectra F indicates that these sulfonic acids are not 1,4-substituted sulfonic acids.

A water sample collected from well PR11 on September 19, 1994, was subjected to the most extensive hydrophobic DOC fractionation in an attempt to separate specific contaminant classes in infiltrated reclaimed water from non-specific fulvic acids. The IR spectra of the major hydrophobic fractions of this sample are shown in figure 30. The ether-extractable acids (spectrum A) contain the APEC contaminants, tentatively identified by the sharp peak at 1,513 cm^{-1}. The sharp peak at 1,385 cm^{-1} in this spectrum is nitrate. Aromatic sulfonic acids are a major component of spectrum D and a minor component of spectrum C, as indicated by peaks at 1,185, 1,130, 1,040, 1,012, 625, and 585 cm^{-1}.

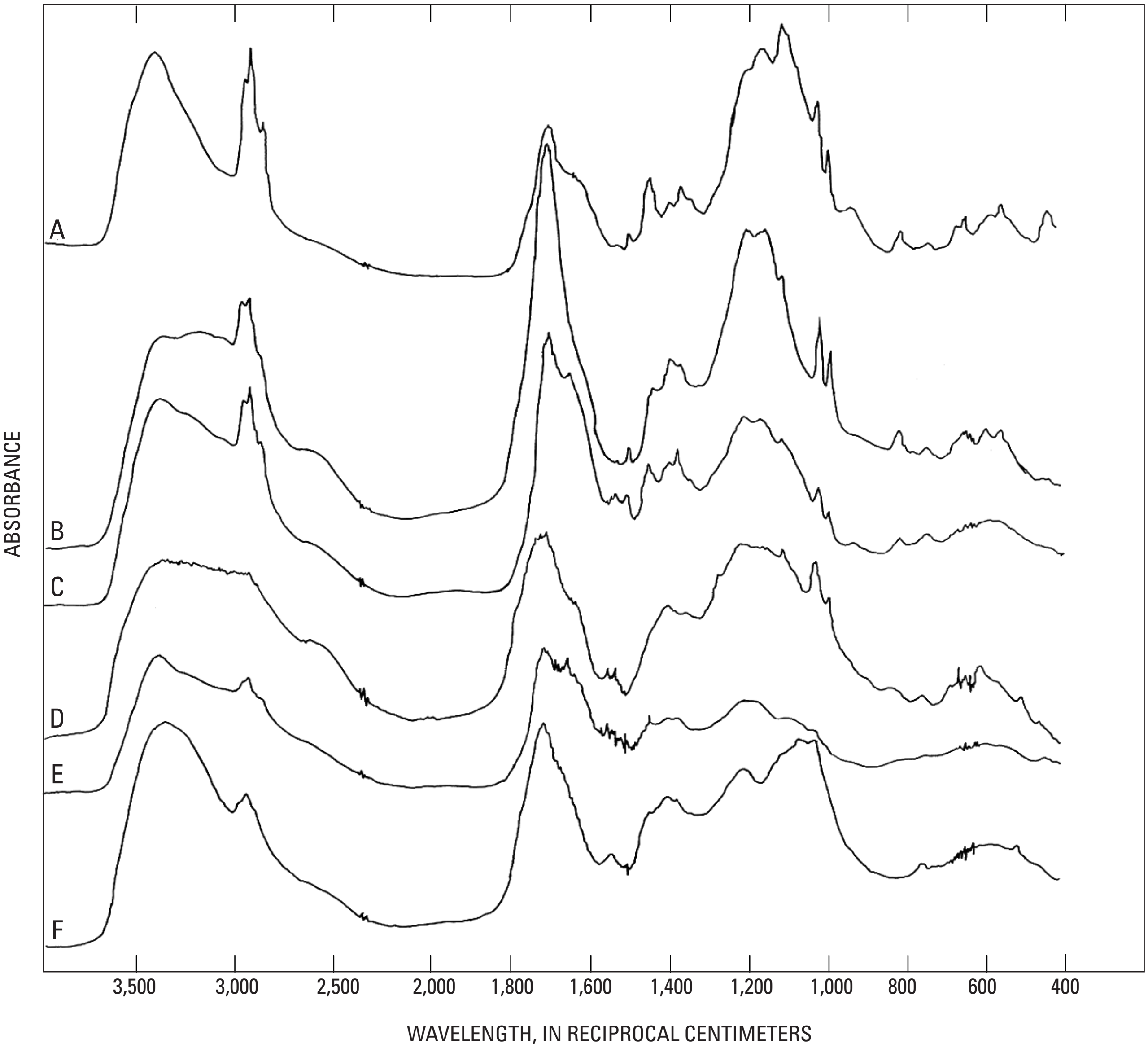


Figure 28. Infrared spectra of dissolved organic carbon (DOC) fractions from reclaimed-water effluent (PR13) sampled April 5, 1994, at the research basin, Montebello Forebay, Los Angeles County, California: hydrophobic neutral fraction (spectrum A); hydrophobic acid fraction (spectrum B); hydrophobic base fraction (spectrum C); hydrophilic acid fraction (spectrum D); hydrophilic base fraction (spectrum E); and hydrophilic neutral fraction (spectrum F).

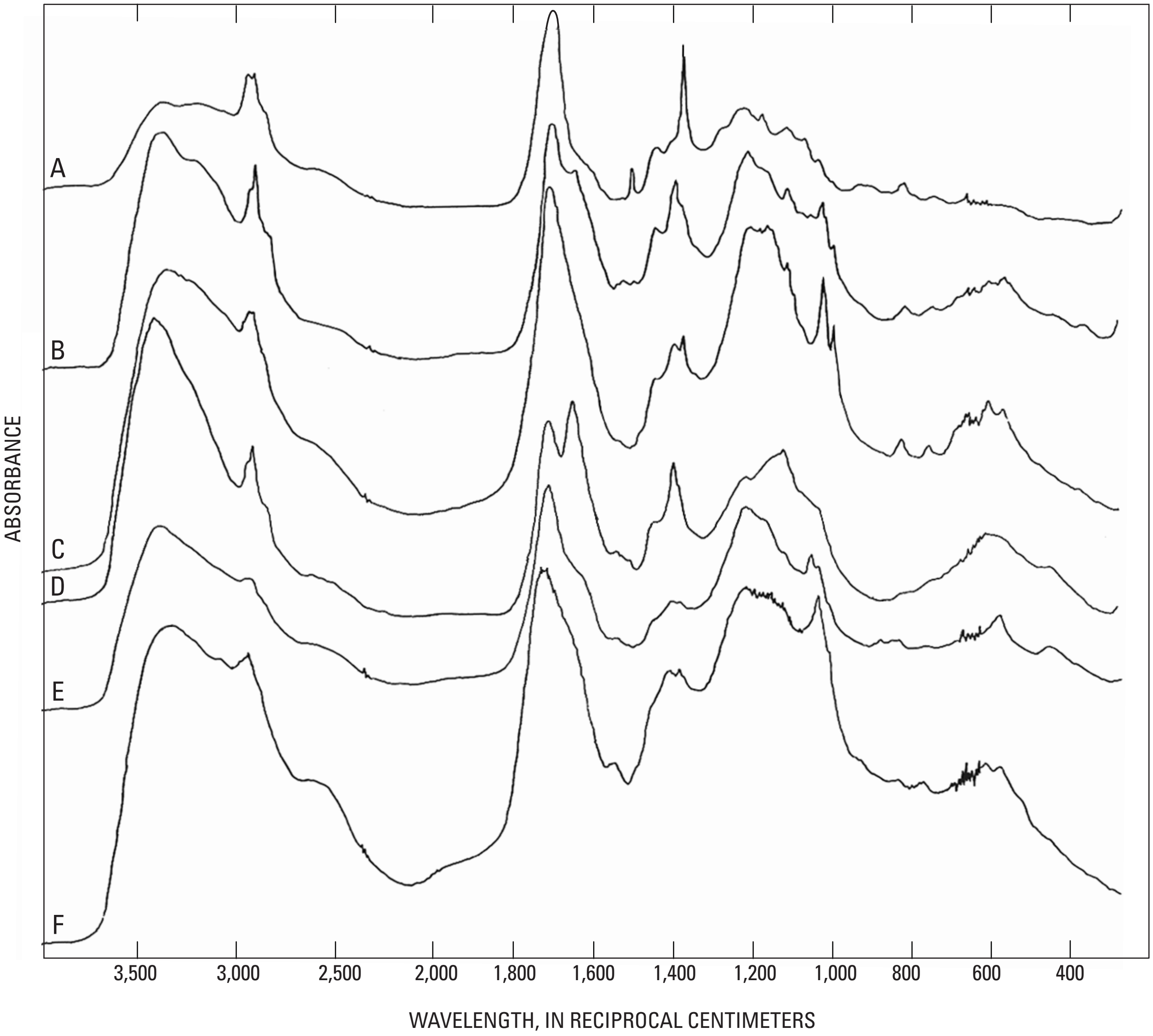


Figure 29. Infrared spectra of dissolved organic carbon (DOC) fractions in reclaimed water sampled from the research basin (PR12) September 21, 1994, Montebello Forebay, Los Angeles County, California: ether-extractable acids (spectrum A); hydrophobic neutral fraction of methanol-soluble extract (spectrum B); hydrophobic acid fraction of methanol-soluble extract (spectrum C); hydrophobic neutral fraction of methanol-insoluble extract (spectrum D); hydrophobic acid fraction of methanol-insoluble extract (spectrum E); and hydrophilic acid fraction of methanol-insoluble extract (spectrum F).

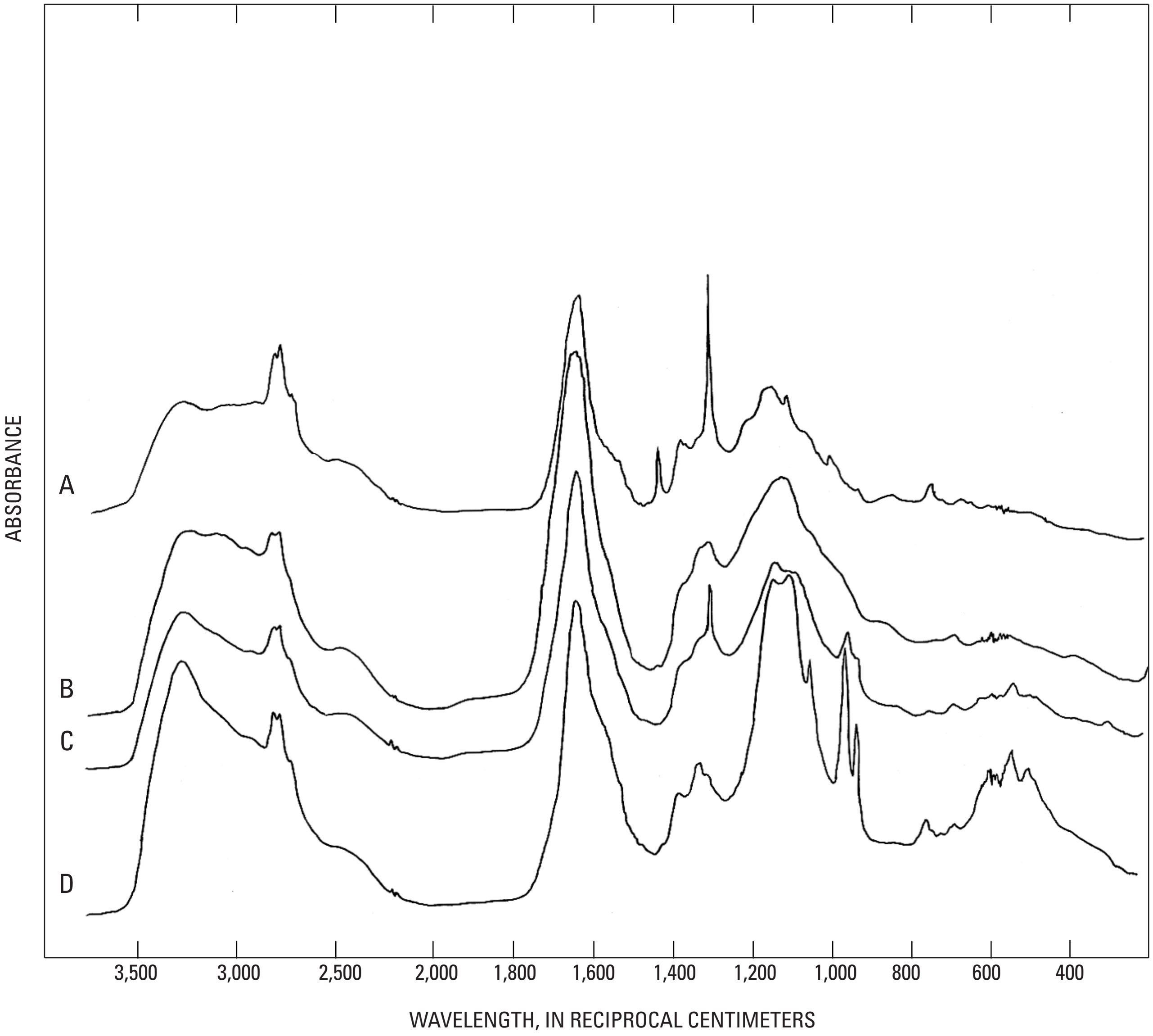


Figure 30. Infrared spectra of dissolved organic carbon (DOC) fractions from water sampled from well PR11 September 19, 1994, at the research basin, Montebello Forebay, Los Angeles County, California: ether-extractable acids (spectrum A); hydrophobic fraction, ethyl acetate fraction from silica gel (spectrum B); hydrophobic fraction, acetone extract from silica gel (spectrum C); and hydrophobic fraction, 75 percent acetone, 25 percent 2-propanol extraction from silica gel (spectrum D).

The fractions represented by spectra B and C are primarily fulvic acids; however, a major peak in fulvic acids derived from tannins and lignins at 1,600 to 1,630 cm^{-1} is absent. According to Stevenson (1982), this peak can be attributed to aromatic C=C stretching vibrations, and hydrogen-bonded (by phenol) conjugated ketones. This peak is the best indicator in IR spectra of polyphenolic aromatics in humic substances that are reactive with halides. The fulvic-acid fractions in this water sample appear to be predominantly aliphatic carboxylic acids with lesser amounts of alcohol, ester, and ether functional groups. Fractions B and C represent 55 percent of the nonextractable hydrophobic fraction and fraction D represents 30 percent. The remaining 15 percent is distributed among four minor fractions that have proteins and pyrimidines in the IR spectra.

The tentative compound-class assignments given to DOC fractions in the reclaimed-water effluent were confirmed by IR spectra of various standard materials. Spectra of the Suwannee River fulvic acid (SRFA) derived from polyphenolic tannin and lignin, protein, and a pyrimidine are shown in figure 31. As mentioned previously, the polyphenolic indicator peak at 1,626 cm^{-1} for fulvic acid is not significant for humic substances fractionated from this reclaimed-water effluent (fig. 31, spectra B and C). The defining peak for proteins is the amide-2 peak, a broad peak from 1,520 to 1,560 cm^{-1}, and for pyrimidines, a number of medium-intensity peaks from 1,400 to 1,430 cm^{-1} (fig. 31). Although the peaks indicative of protein and pyrimidine structures are not the most intense peaks of these substances, these diagnostic peaks occur in spectra regions where there are no major interferences from other peaks.

For neutral surfactants of the alkylphenol polyethoxylate class, the most intense peak of the parent surfactants is at 1,111 cm^{-1}, which is the C–O stretch of the ether groups in the polyethoxylate chain (fig. 32). The loss of most of the polyethoxylate chain by microbial degradation produces short-chain alkylphenol polyethoxylate (APEO) and APEC metabolites, and therefore this ether peak is reduced, and an aromatic C=C stretching peak at 1,513 cm^{-1} becomes the most intense and defining peak of the spectrum (fig. 32).

Infrared spectra of a commercial anionic detergent formulation of linear alkylbenzene sulfonate (LAS) surfactants, the DATS component of this surfactant (resistant to complete biodegradation), and a sulfophenyl carboxylate (SPC) metabolite of LAS degradation are shown in figure 33. The spectra of LAS and SPC are characterized by a sharply defined peak indicative of 1,4-substituted aromatic rings at 1,012 cm^{-1}, which is absent in DATS because the aromatic ring has a 1,3,4-substitution pattern. The intensity ratio of the sulfonic acid peak near 1,040 cm-^{1} to the 1,012 cm^{-1} peak is a general indicator of the proportions of 1,4-substituted aromatic sulfonates (LAS and SPC) and aromatic sulfonates with greater ring substitution patterns (DATS, DATS carboxylates, sulfonated optical brighteners, and sulfonated textile dyes).

Water-quality changes in DOC fractions during infiltration of reclaimed water were detected during the April 1994 sampling. Shown in figure 34 are HPO$_n$ fraction IR spectra of water samples collected April 5, 1994, from the research basin (PR12) (spectrum A) and from well MLS4 (spectrum B), and a water sample collected April 8 from well PR9 (spectrum C). The research basin contained large amounts of polyethoxylates from nonionic surfactants as indicated by peaks at 1,350, 1,110, and 950 cm^{-1} in spectrum A, whereas most of these polyethoxylates are diminished by the time the water had infiltrated 4 ft in MLS4 (spectrum B). Short-chain APEO and APEC metabolites of nonionic polyethoxylate surfactants are indicated by the peak at 1,513 cm^{-1} in the 25-ft well (PR9) in spectrum C. Conversely, anionic aromatic sulfonates are progressively enriched as water infiltrates to deeper levels, as indicated by changes in the 1,040 and 1,012 cm^{-1} peaks in spectra A to C. Thus, nonionic surfactant polyethoxylates are probably metabolized or adsorbed during infiltration, whereas anionic aromatic sulfonates (particularly DATS) are selectively preserved and enriched in this fraction as other components are depleted (Field and others, 1992a, b).

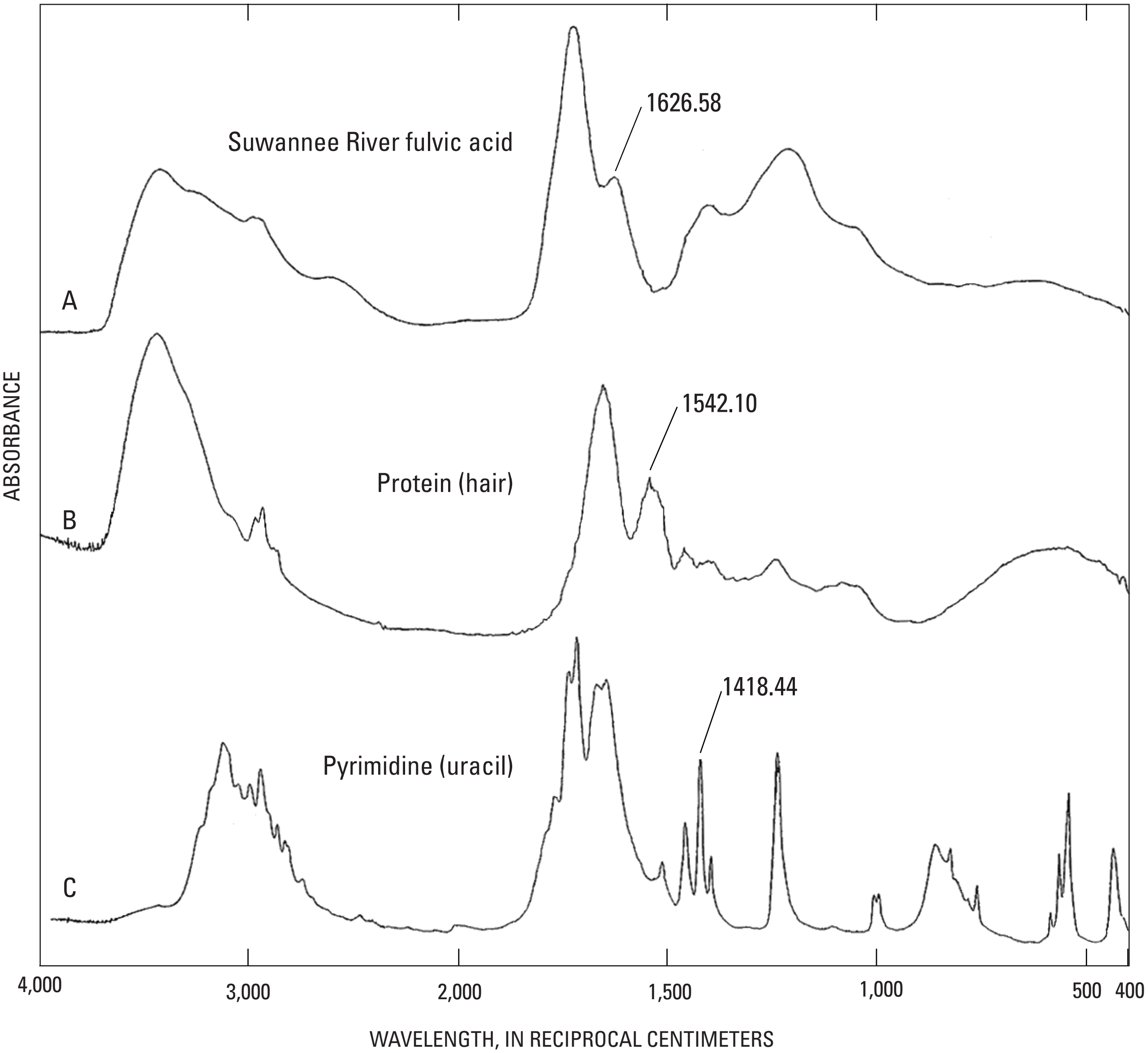


Figure 31. Infrared spectra of natural fulvic acid, protein, and pyrimidine.

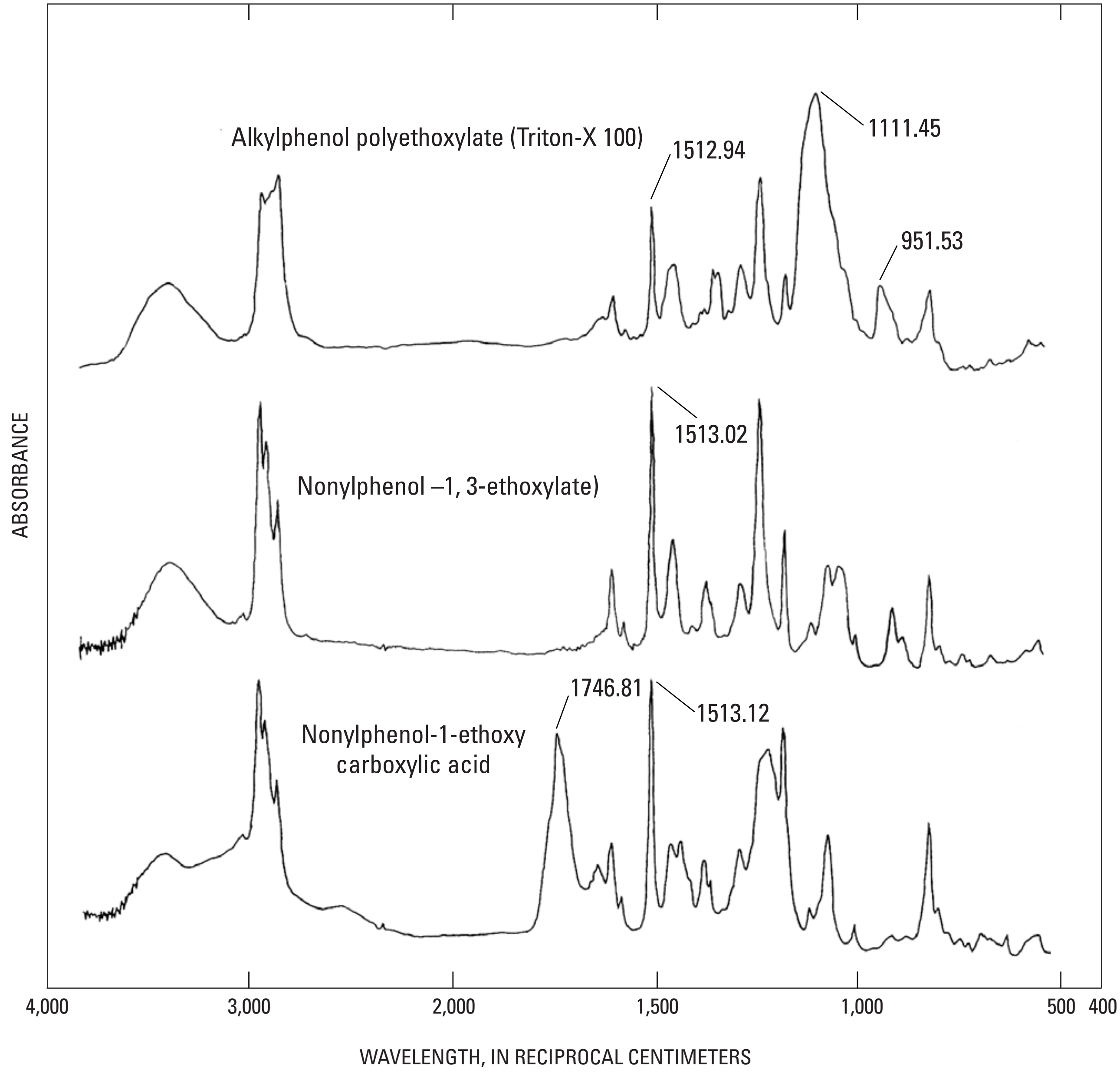


Figure 32. Infrared spectra of synthetic aromatic sulfonate surfactants and a sulfophenyl carboxylate (SPC) metabolite.

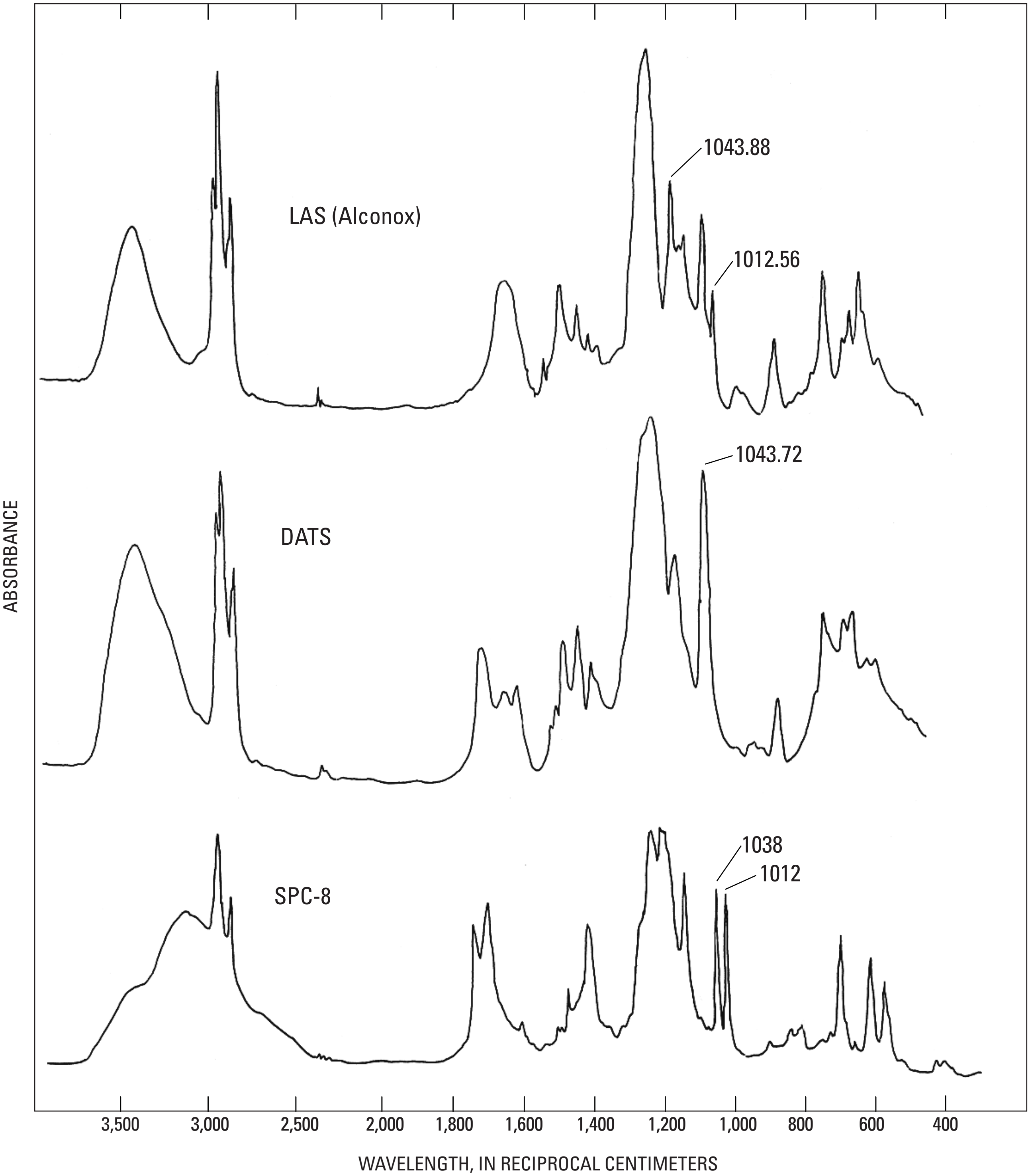


Figure 33. Infrared spectra of synthetic alkylphenol polyethoxylate surfactants and certain metabolites. (Refer to figure 24 for compound's structure.)

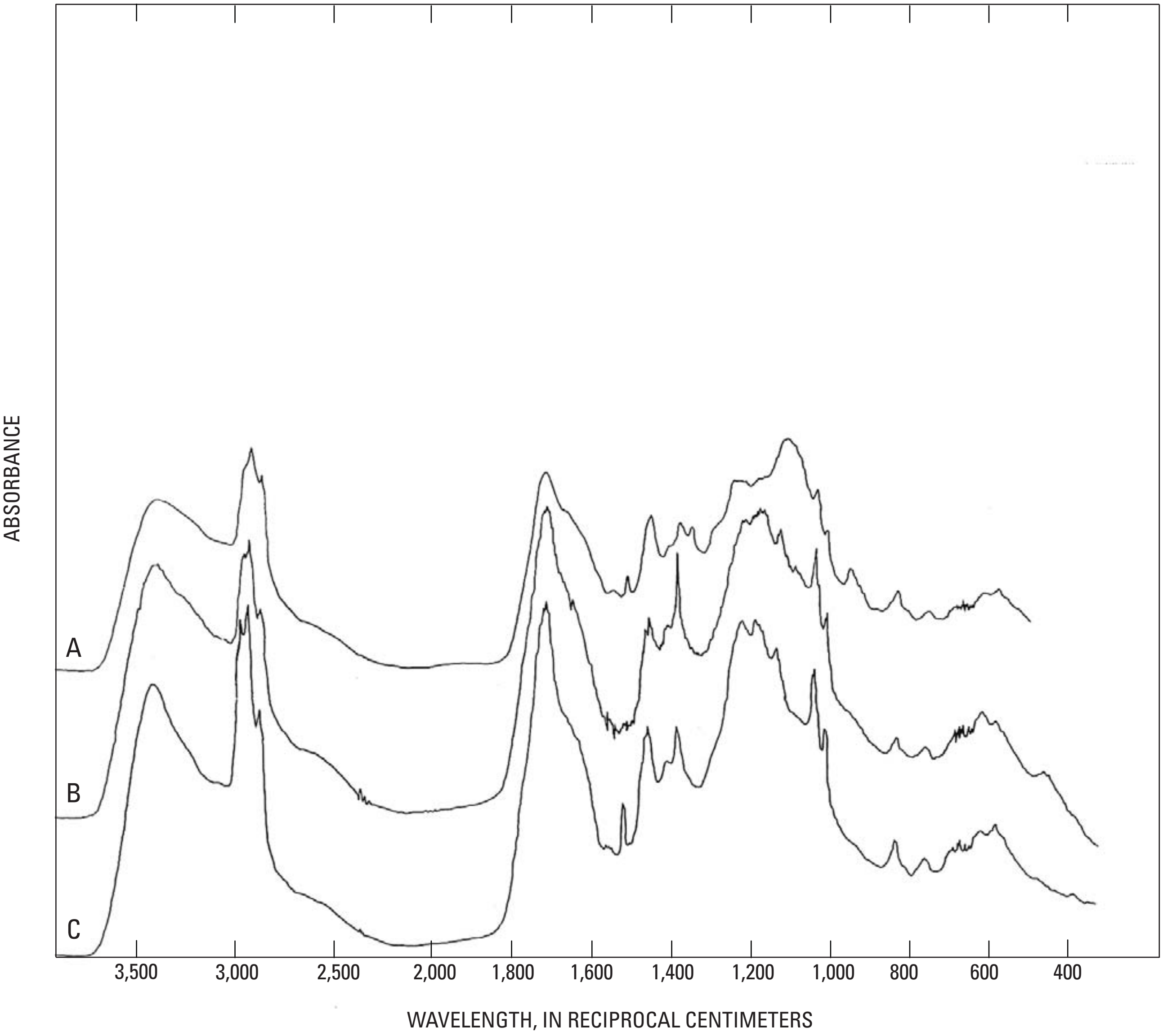


Figure 34. Infrared spectra of hydrophobic neutral fractions for samples collected April 5, 1994, from the research basin (PR12); April 5 from MLS4; and April 8 from well PR9 (spectra A to C, respectively), Montebello Forebay, Los Angeles County, California.

In the HPI_b fraction of these wells, the protein component, as measured by the amide-1 and amide-2 peaks, appears to be depleted, and the pyrimidine component, as measured by the 1,410 cm^{-1} peak, appears to be enriched. Both changes in the HPO_n fraction and the HPI_b fractions are consistent with changes in DOC fractionation patterns discussed previously in this report. No readily discerned changes in IR spectra were observed in any other fractions.

In the background well 2S/11W-7J1 sampled September 21, 1994, trace amounts of APEC were detected in the ether-extract fraction, and trace amounts of aromatic sulfonates were detected in the hydrophobic fractions by IR measurement of indicator peaks of these fractions. Apparently, this well is slightly contaminated by infiltration of sewage wastewater of unknown origin—a suggestion also made in Chapter 8 on the basis of large fluctuations in hydrophilic and hydrophobic DOC fractions.

In summary, IR analyses of DOC fractions in the reclaimed-water effluent revealed a complex mixture of natural aliphatic fulvic acid, proteins, and pyrimidines, and synthetic APEO, DATS, and LAS surfactants and their metabolites that was very different than the DOC composition of natural waters. Infiltration of this effluent resulted in loss of proteins and parent APEO and LAS surfactants, while the proportion of APEC, DATS, and LAS metabolites and pyrimidines were enriched. The surfactant composition of this reclaimed water, and changes during infiltration and transport in ground water, is similar to that observed previously by Field and others (1992a, b) at Cape Cod, Massachusetts.

Ultraviolet/Visible Spectrometry

The ultraviolet/visible (UV/VIS) spectrum of the blue dye subfraction isolated from the HPO_n fraction of well PR9 sampled September 20, 1994, was determined on a Perkin-Elmer Lambda 4B UV/VIS Spectrophotometer. Most of this subfraction (about 3 mg) was used for an IR spectrum, but a small residue from the freeze-dry vessel was used to generate the UV/VIS spectrum shown in figure 35. The sample was analyzed in water at pH 6.6 in a 1-cm light-path quartz cell. The peak shown in the visible part of the spectrum has a spectral maximum at 628 nanometers (nm). The IR spectrum showed the presence of aromatic sulfonates, but it is unlikely that the IR spectrum represented a pure dye. The blue dye has been identified by mass spectrometry in a similar reclaimed-water effluent sample from Phoenix, Arizona, as erioglaucine (or Brilliant Blue), a water-soluble sulfonated triphenylmethane dye that is extensively used in food colorings and toilet-cleaning products (Rostad and Leenheer, 2000). The blue dye was noted in all the reclaimed-water samples and infiltrated ground-water samples collected near the research basin for both the April and September 1994 samplings. The blue dye was not detected in the background-well sample (-7J1).

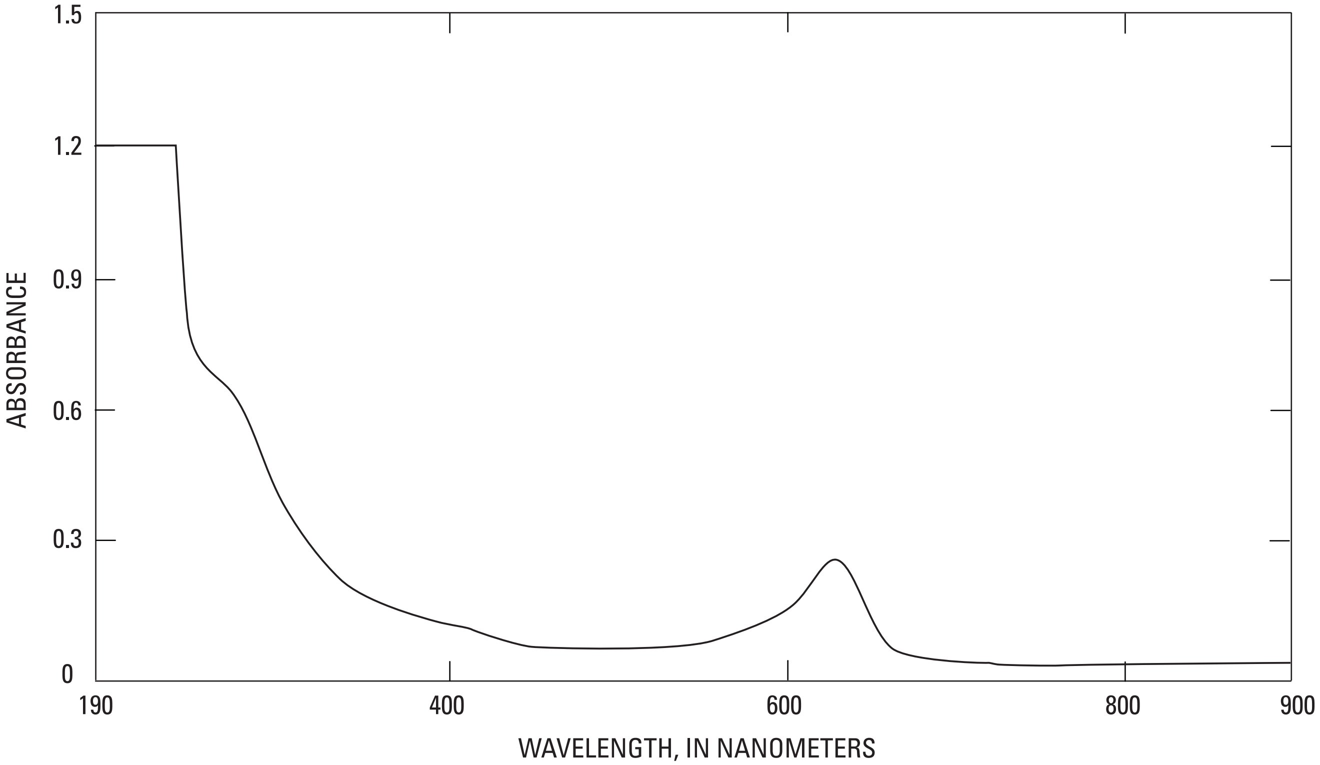


Figure 35. Ultraviolet/visible (UV/VIS) spectrum of blue dye subfraction isolated from a sample collected September 20, 1994, from well PR9, research basin, Montebello Forebay, Los Angeles County, California.

CHAPTER 10: CHARACTERIZATION OF DISSOLVED ORGANIC MATTER BY NUCLEAR MAGNETIC RESONANCE (NMR) SPECTROMETRY

By Kevin A. Thorn *and* Steven J. Younger

Dissolved organic matter (DOM) was characterized by NMR spectrometric methods analogous to those used to characterize colloidal organic carbon in Chapter 7.

Sampling

During the April 1994 recharge experiment, water samples were collected from PR13 (effluent), PR12 (research basin), multilevel sampling ports MLS4 and MLS7, and well PR9. During the September 1994 recharge experiment, water samples were collected from PR12 (research basin) and well PR9. Water samples were pumped onsite through Balston DH (25-µm) and AH (0.3-µm) glass fiber filters, and then through AMICON 30,000-molecular-weight (0.005 µm) regenerated cellulose membrane filters, using tangential flow ultrafiltration (Rostad, 1996; Rostad and others, 1998), as was also described in Chapter 7. Filtered water samples were chilled on ice and transported to the laboratory.

The filtered water samples were then acidified to pH 2 using concentrated HCl and passed through a two-column array of XAD-8 and XAD-4 resins to isolate the major fractions of DOC (Aiken and others, 1992). Fulvic acids and hydrophobic neutrals were eluted from the XAD-8 resins with dilute NaOH and 100-percent acetonitrile, respectively. Hydrophilic acids and hydrophilic neutrals were eluted from the XAD-4 resins with dilute NaOH and 100-percent acetonitrile, respectively.

The DOC fractions were characterized by liquid phase ^{13}C NMR spectrometry; Fourier transform infrared spectroscopy (FTIR). (Sufficient sample quantities were not available for element and molecular-weight analyses.) Liquid-phase ^{13}C NMR spectra of DOC fractions were recorded on a Varian XL300 NMR spectrometer at a carbon resonant frequency of 75.4 MHz using a 10-mm broadband probe. Acquisition parameters included a 30,000 Hz spectral window, 45-degree pulse angle, 0.2-s acquisition time, 1.0-s pulse delay, and continuous WALTZ decoupling. These conditions do not eliminate differential T_1 (spin lattice relaxation time) effects and differential nuclear Overhauser enhancement (NOE) effects. The peak areas in the liquid phase ^{13}C NMR spectra therefore do not represent a quantitative distribution of ^{13}C nuclei in the samples.

Results

The continuous decoupled liquid-phase ^{13}C NMR spectra of the fulvic-acid fraction from the April 1994 research-basin sample (PR12) and a sample of pristine ground water in Minnesota (Thorn and Aiken, 1998) are shown for comparison in figure 36. The spectrum of the Minnesota ground water has the six major broad peaks characteristic of humic substances listed below:

• 0–60 ppm	Aliphatic carbons (sp^3 hybridized) bonded primarily to other carbons, but also to nitrogen and sulfur
• 60–90 ppm	Hetero-aliphatic carbons: sp^3 hybridized carbons bonded to oxygens, including alcohols, ethers, and carbohydrates
• 90–110 ppm	Acetal and hemiacetal carbons, anomeric carbons of carbohydrates, and protonated aromatic carbons
• 110–160 ppm	Aromatic and olefinic carbons
• 160–180 ppm	Carboxylic acid, ester, and amide carbons
• 180–220 ppm	Ketone and quinone carbons

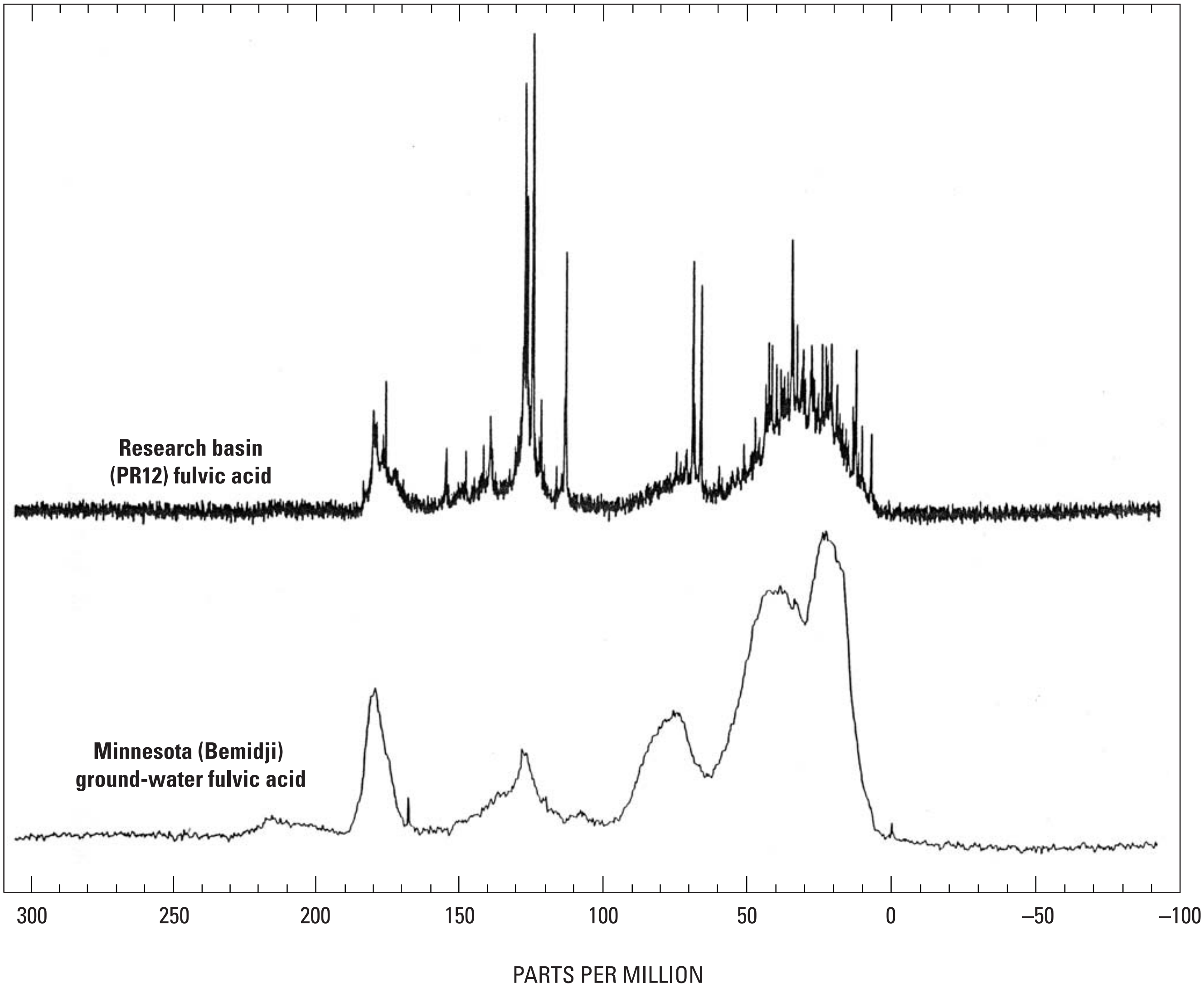


Figure 36. Continuous decoupled liquid-phase carbon-13 nuclear magnetic resonance spectra of April 1994 PR12 fulvic-acid fraction and Minnesota ground-water fulvic-acid fraction (Thorn and Aiken, 1998).

The spectrum of the fulvic-acid fraction in the research-basin sample is distinguishable from that of the Minnesota fulvic acid in that sharp peaks are superimposed over the broad underlying peaks of the fulvic-acid material. The sharp peaks in the spectrum of the research-basin fulvic acid correspond to LAS surfactants and their SPC degradation products (sulfophenyl carboxylates), as well as to the APEO (alkylphenol polyethoxylate) surfactants and their APEC (alkylphenol polyethoxy carboxylate) degradation products, and to dialkyltetraline sulfonates (DATS). Some of the major assignments for these surfactants and surfactant degradation products are illustrated in figure 37. For example, the peaks from 60 to 70 ppm correspond to the polyethoxylate carbons of APEOs and APECs. The peaks at approximately 128 ppm correspond to the protonated aromatic carbons in the benzene rings of the SPCs, APECs, DATS, and the corresponding degradation products. The peaks at approximately 115 ppm correspond to the protonated aromatic carbons ortho to the polyethoxylate chains on the benzene rings of the APECs. The peak at 142 ppm corresponds to the aromatic carbons bonded to the sulfonate groups in the benzene rings of LAS and SPCs. More detailed interpretations of the surfactant spectra are given by Thurman and others (1987) and Field and others (1992c). The ^{13}C NMR spectrum of the fulvic-acid fraction isolated from PR9 during the April experiment (fig. 38) is virtually identical to the research-basin spectrum. Thus, there is no discernible qualitative attenuation of the constituents that co-isolate in the fulvic-acid fraction on XAD-8 resin as the reclaimed water infiltrates to a depth of 25 ft. [Shortening of ethoxylate chain lengths in the APEO and APEC materials recovered in the acetonitrile eluates from the XAD-8 resins between the research-basin water (PR12) and the MLS4 water was observed; spectra not shown.] The results observed in the spectra of the fulvic-acid fractions from the April experiment are replicated in the September experiment (figs. 39, 40). Again, the LAS, surfactants, SPCs, APEOs, and APECs persist in the fulvic acid fraction as the pond water infiltrates to a depth of 25 ft.

The detection of surfactants and surfactant degradation products in the fulvic-acid fractions is consistent with the IR and GC/MS analyses presented in Chapters 9 and 12.

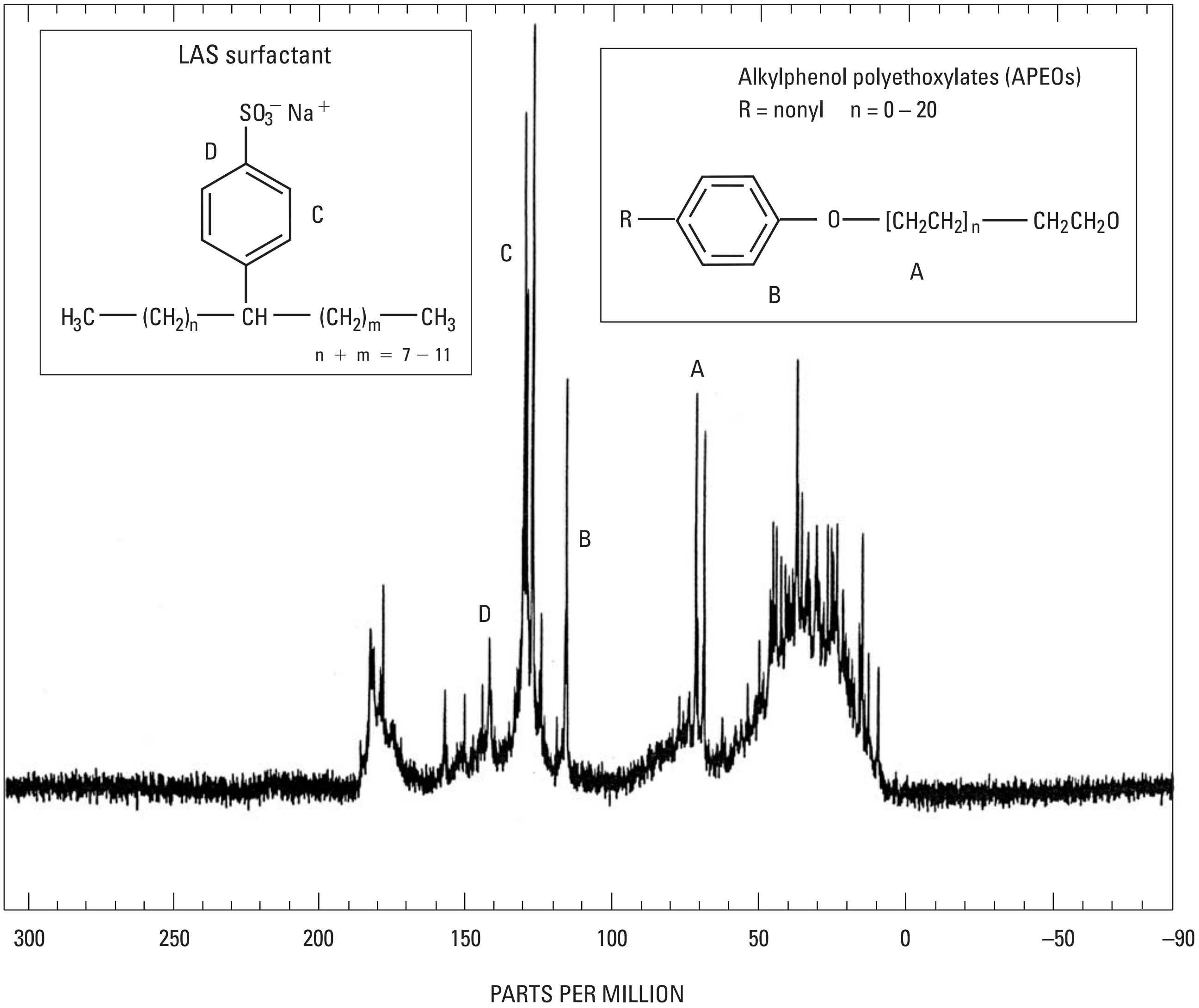


Figure 37. Continuous decoupled liquid-phase carbon-13 nuclear magnetic resonance spectrum of April 1994 PR12 fulvic-acid fraction showing chemical shift assignments of surfactants.

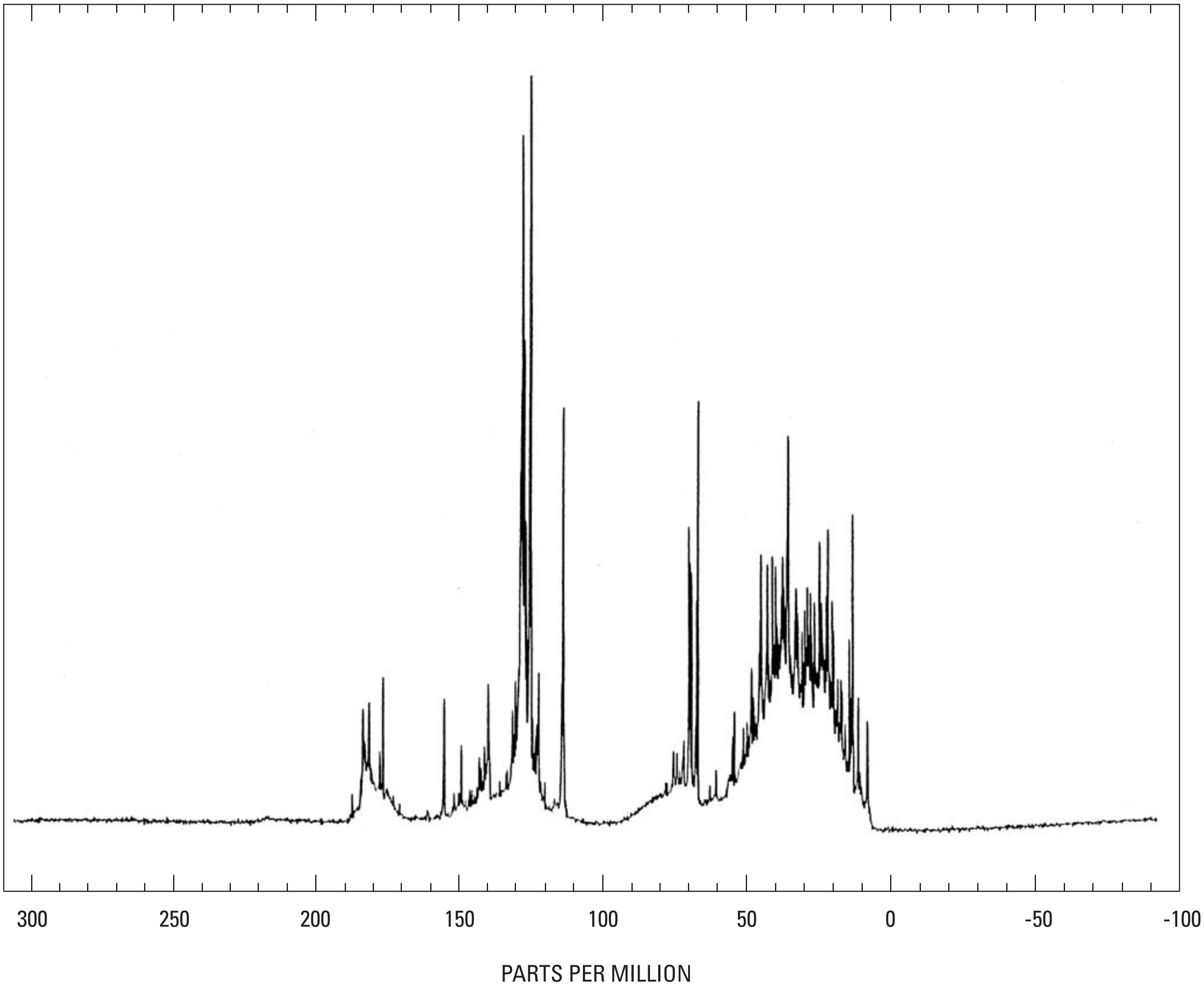


Figure 38. Continuous decoupled liquid-phase carbon-13 nuclear magnetic resonance spectrum of April 1994 PR9 fulvic-acid fraction.

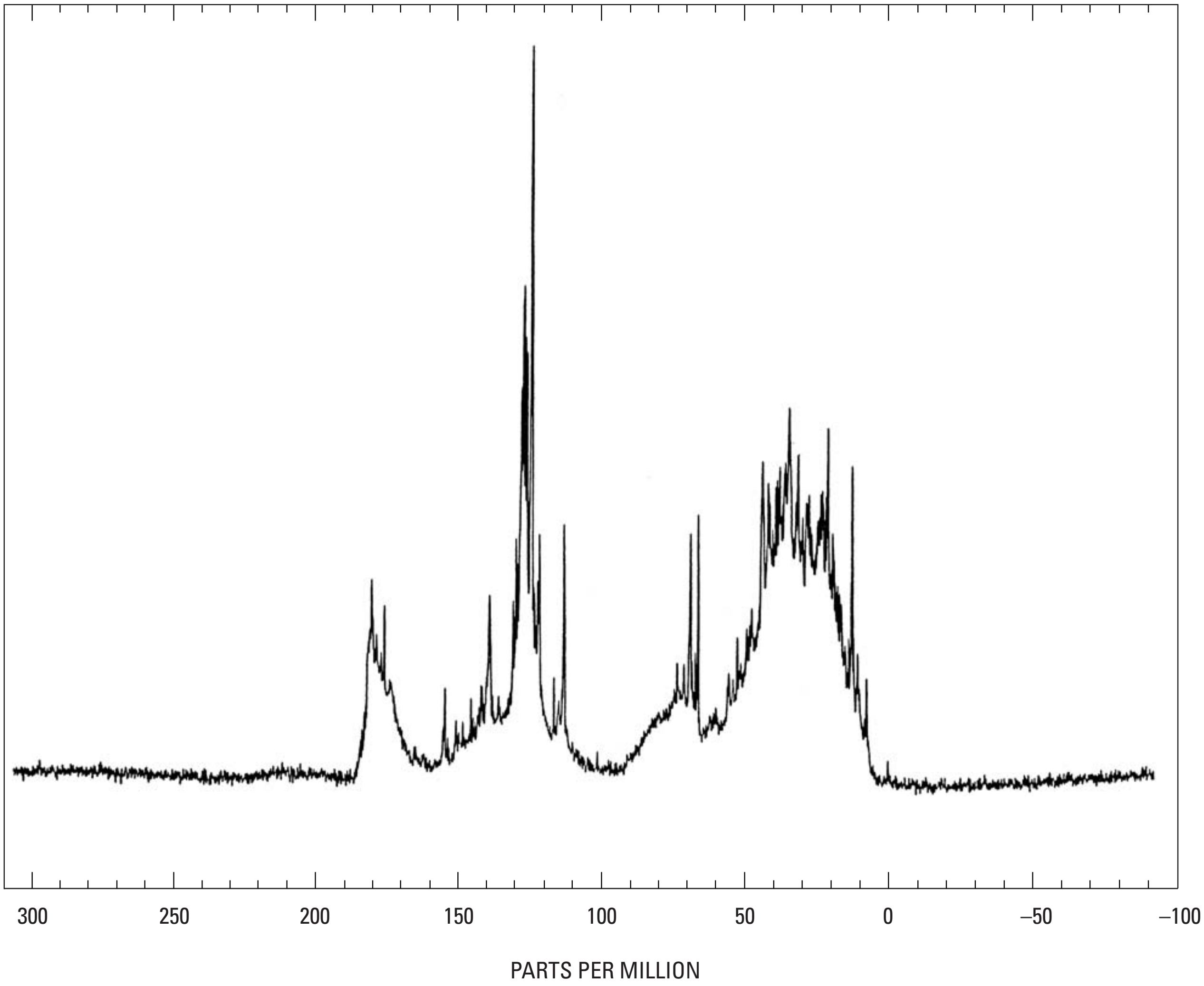


Figure 39. Continuous decoupled liquid-phase carbon-13 nuclear magnetic resonance spectrum of September 1994 PR12 fulvic-acid fraction.

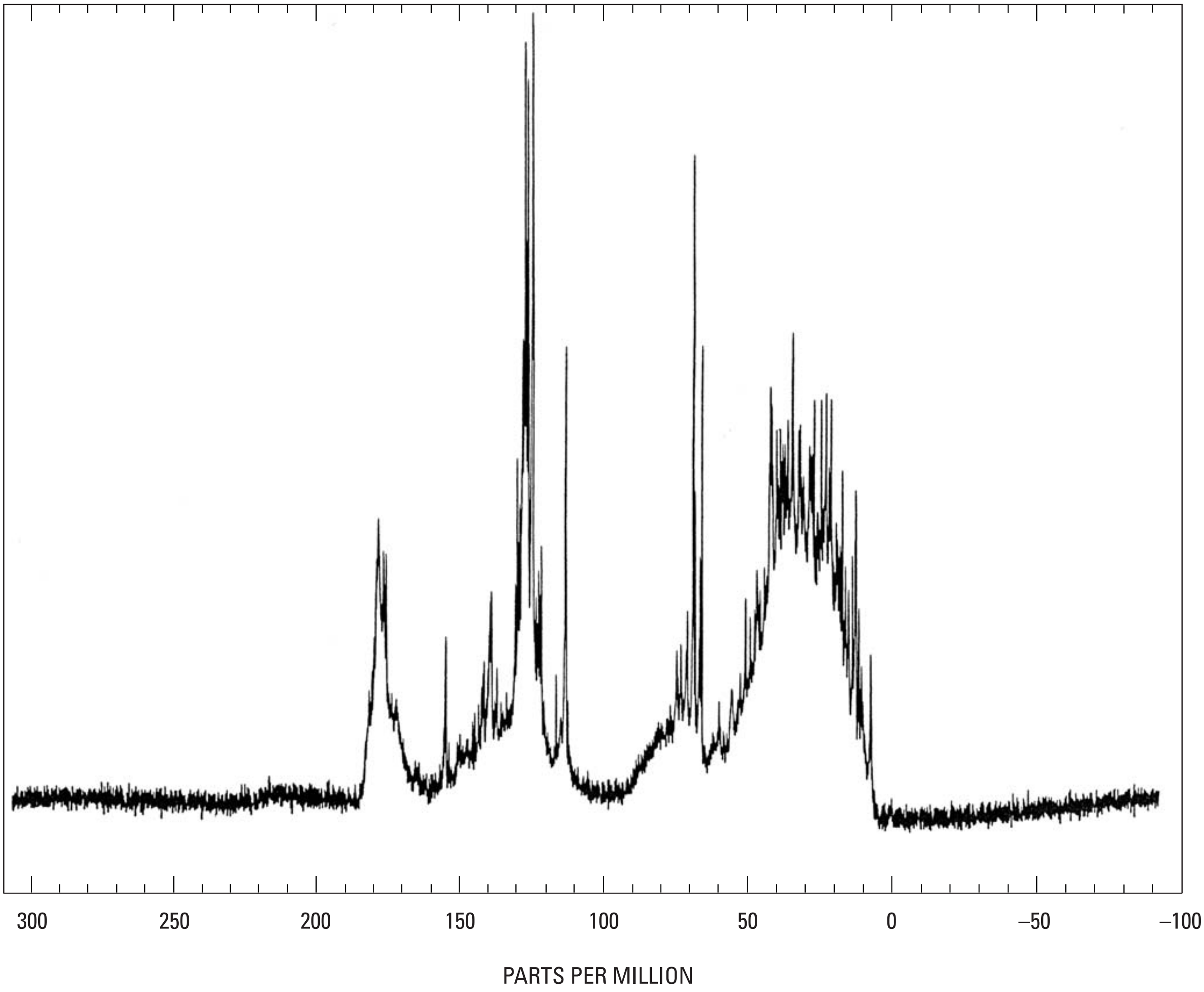


Figure 40. Continuous decoupled liquid-phase carbon-13 nuclear magnetic resonance spectrum of September 1994 PR9 fulvic-acid fraction.

CHAPTER 11: DISTRIBUTIONS OF HALOGENATED ORGANIC COMPOUNDS

By Colleen E. Rostad *and* Ronald E. Rathbun

Understanding the dominant geochemical factors involved in degradation or alteration of dissolved organic carbon (DOC) at soil-aquifer treatment sites is critical to reliably predict the potential for DOC degradation, migration, and fate. One water-quality characteristic of concern is total organic halogen or halide (TOX)—a collective term encompassing halogenated organic compounds in the water, many of which are toxic, carcinogenic, or mutagenic, and includes those compounds that comprise the trihalomethanes (THMs). These contaminants result from the disinfection of water using chlorine and are formed by reaction of the chlorine with the DOC. The nature and the extent of the TOX and THMs so generated vary with the nature and reactivity of the DOC. Initial studies indicated that THMs and DOC that infiltrate into an aquifer decrease downgradient, whereas TOX is unaffected by aquifer passage (Roberts, and others, 1982). In more-recent studies, TOX decreased concurrently with DOC during soil-aquifer treatment (Wilson and others, 1995). Factors that affect the fate of TOX and THM during artificial recharge with reclaimed wastewater are complex. The research basin was sampled in April and September 1994 to determine whether TOX and THM are attenuated beneath the research basin under different hydraulic conditions. Samples were taken a few days after delivery of recycled water to the research basin commenced, and thus "steady-state" conditions had been established.

Methods

Samples collected in April and September 1994 at the research basin were analyzed for THMs by solvent-extraction procedure Standard Method 6232B (AWWA, 1992) or the equivalent U.S. Environmental Protection Agency (U.S. EPA) Method 501.2 (CFR, 1994), with slight modifications. A trace of sodium sulfite added to the 40-mL amber glass vial in which the samples were collected scavenged any free chlorine present and eliminated further THM formation. Samples were collected with no head-space and chilled or refrigerated until extracted. Until analysis, sample vials were stored, at 4°C, upside down to preclude losses through the septum cap during storage. Sample extractions using pentane were done directly in the sample vials to avoid sample transfer of volatile constituents. The extraction step consisted of removing and discarding 4.5 mL of sample using an adjustable pipetter, adding 4.0 mL of ultra-high-purity THM-grade pentane with a Class A pipet, and shaking the vial for 1.5 minutes. Vials were weighed at each step to determine the precise amounts of sample removed and pentane added. Pentane extracts were analyzed by gas chromatography with electron-capture detection (GC-ECD). The extracts were injected splitless at 200°C on a 12-m, 0.2-mm i.d., cross-linked surface-bonded 1-percent dimethylpolysiloxane capillary GC column, at 30°C for 8 minutes. Standard samples covering the expected range of sample concentrations were prepared by injecting microliter quantities of primary standards into the background-well (2S/11W-7J1) water contained in the vials. Background-well water was used as the standard matrix to eliminate effects of the water chemistry on the efficiency of the extraction procedure. Standard samples were then treated in exactly the same way as were the study samples.

Silver-membrane field-filtered samples were analyzed for TOX by Standard Method 5320 (AWWA, 1992) as described briefly herein. Samples were collected into 125-mL amber glass bottles, to which a small amount of sodium sulfite preservative had been added, and were acidified to pH 2 using reagent-grade nitric acid when received in the laboratory. The TOX compounds were adsorbed from the water sample onto granular activated carbon packed in glass columns. Adsorption occurred on two columns placed in series. The columns were washed with 2 mL of 0.08 M potassium nitrate solution to remove inorganic halides. The granular carbon was transferred to a quartz sample boat in the Dohrmann DX-20A TOX analyzer with an AD-3 adsorption module and analyzed. Samples were analyzed in duplicate to compensate for the inherent variability of the analytical procedure.

Results

Concentrations of the THM and TOX in samples collected near the research basin are shown for April 1994 in table 21 and for September 1994 in table 22. When the research basin was sampled in April 1994, THM concentrations ranged from greater than 15 µg/L to non-detectable (<0.01 µg/L) levels. Concentrations were highest in the effluent (PR13) and ponded water in the research basin (PR12) and were lower beneath the research basin, as shown in figure 41. The decrease could be due largely to dilution by antecedent soil moisture much lower in THM and TOX as it was partly displaced by the recycled water percolating downward from the research basin. The high THM concentrations found in the effluent and research basin were markedly reduced (to 3 µg/L) in the shallowest multilevel sampler at a depth of 4 ft. The low THM concentration at 4 ft then appears to increase (to almost 10 µg/L) with increasing depth to 25 ft (PR9 sample on April 7). Concentrations were below detection at 50 ft below the research-basin floor (PR8) and also next to the basin at a depth of 25 ft below the basin floor (PR11). The fact that THM concentrations in the recycled water appear to decrease soon after infiltration and then increase again with increasing depth suggests possible formation of compounds during downward percolation. Further support for this hypothesis is provided by the observation that THM concentration rises from a non-detectable level on April 5 to about 9 µg/L on April 7 in PR9, presumably as newly recycled water reaches this depth. Caution is advised, however, as the amount of data is scant and even the DOC concentration in MLS4 seems to be anomalously low. The pattern for TOX is generally the same as that of THM, although TOX concentrations are higher (fig. 41).

The THM concentration of about 17 µg/L for recycled water in the research basin during the September 1994 recharge event was slightly higher than the concentration during the April 1994 experiment (compare data in tables 21 and 22). For comparison with wastewater from other cities, THM concentrations, in micrograms per liter, in wastewater after secondary biological treatment were 1.5 for Washington, D.C., 4.1 in Phoenix, Arizona, 2.7 in Denver, Colorado, and 13.3 in Palo Alto, California (McCarty, 1990). Although higher than in these cities, THM concentrations in the research basin were still much lower than concentrations in most chlorinated drinking water. Median values, in micrograms per liter, of total THMs in drinking water from 35 treatment facilities varied seasonally and were 34 in spring, 44 in summer, 40 in autumn, and 30 in winter (Krasner and others, 1989). A much broader survey reported similar median THM concentrations from 727 water-supply utilities nationwide at 40 in spring, 44 in summer, 36 in autumn and 30 in winter (McGuire and Meadow, 1988).

The pattern of both THM and TOX concentrations was similar in April and September with one important difference—elevated concentrations were observed deeper (compare data from 50 ft in figs. 41 and 42) and farther offsite in September 1994. This could be a consequence of differing hydraulic conditions, as described in Chapter 3, "Geologic and Hydrologic Setting," allowing the contaminants to migrate farther when the water table was much lower in September. However, it could also be caused by seasonal differences in the way stormwater and recycled water are supplied to the adjacent large spreading grounds. Antecedent water beneath the clay lens in April 1994 would be expected to have been replaced by a greater percentage of stormwater following the wet season, whereas the deep water in September could have been flushed by a greater percentage of recycled water recharged during the summer dry season.

Concentrations of TOX in the effluent (PR13) and in the research basin (PR12) during both sampling times were generally a little higher than is typical of concentrations in wastewater from other places. Concentrations in wastewater after secondary biological treatment ranged from 85 µg/L in Washington, D.C., 87 µg/L in Phoenix, Arizona, 131 µg/L in Orange County, California, to 192 µg/L in Palo Alto, California (McCarty, 1990). The TOX concentrations in finished drinking water from five selected water utilities in 1983–84 were 152, 298, 319, 460, and 549 µg/L, respectively (Singer and Chang, 1989)—notably higher than TOX concentrations typical of wastewater. As expected, TOX concentrations are much lower in surface water than in treated wastewater, averaging 15.2 µg/L for the Mississippi River, 8.64 µg/L for the Missouri River, and 12.14 µg/L for the Ohio River (Rathbun and Bishop, 1993, 1994; Rathbun, 1995).

Table 21. Concentrations of trihalomethanes (THMs), total organic halides (TOX), and dissolved organic carbon (DOC), and ratios of THM/TOX and TOX/DOC, in samples collected at the research station, Montebello Forebay, Los Angeles County, California, April 7, 1994 (except where noted)

[mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; —, no data]

Sample	THM (µg/L)	TOX (µg/L)	DOC (mg/L)	THM as percent of TOX	TOX as percent of DOC
MLS20	5.95	94	4.35	6.33	2.16
MLS15	9.07	136	5.88	6.65	2.32
MLS10	9.74	126	5.76	7.76	2.18
MLS7	5.61	103	4.12	5.46	2.49
MLS4	2.72	46	3.59	5.87	1.29
PR8	<.01	29	2.26	.01	1.28
PR9 (April 5)	<.01	48	2.46	.01	1.96
PR9 (April 7)	9.08	113	4.47	8.04	2.53
PR10	—	24	2.14	—	1.13
PR11	<.01	20	2.51	.02	.80
PR12	15.43	175	9.18	8.84	1.90
PR13	14.06	224	9.69	6.27	2.31
2S/11W-18P1	—	73	3.61	—	2.02
2S/11W-19C1	5.06	58	3.47	8.75	1.67
2S/11W-7J1	<.01	—	1.56	—	—
Deionized water blank	—	.20	—	—	—
Balston blank	—	1.76	.10	—	1.76

Table 22. Concentrations of trihalomethanes (THMs), total organic halogens (TOX), and dissolved organic carbon (DOC), and ratios of THM/TOX and TOX/DOC, in samples collected at the research basin, Montebello Forebay, Los Angeles County, California, September 1994

[mg/L, milligrams per liter; µg/L, micrograms per liter; —, no data]

Sample	THM (µg/L)	TOX (µg/L)	DOC (mg/L)	THM as percent of TOX	TOX as percent of DOC
MLS15	5.89	115	5.30	5.12	2.17
PR8	9.23	87	—	10.63	—
PR9	7.51	131	5.50	5.74	2.38
PR10	6.30	73	—	8.57	—
PR11	9.82	110	5.40	8.90	2.04
PR12	17.24	156	8.30	11.06	1.88
WP5	4.12	74	4.10	5.57	1.81
2S/11W-18P1	.53	36	—	1.47	—
2S/11W-19C1	.94	32	—	2.88	—
2S/11W-7J1	2.16	19	1.90	11.54	.98

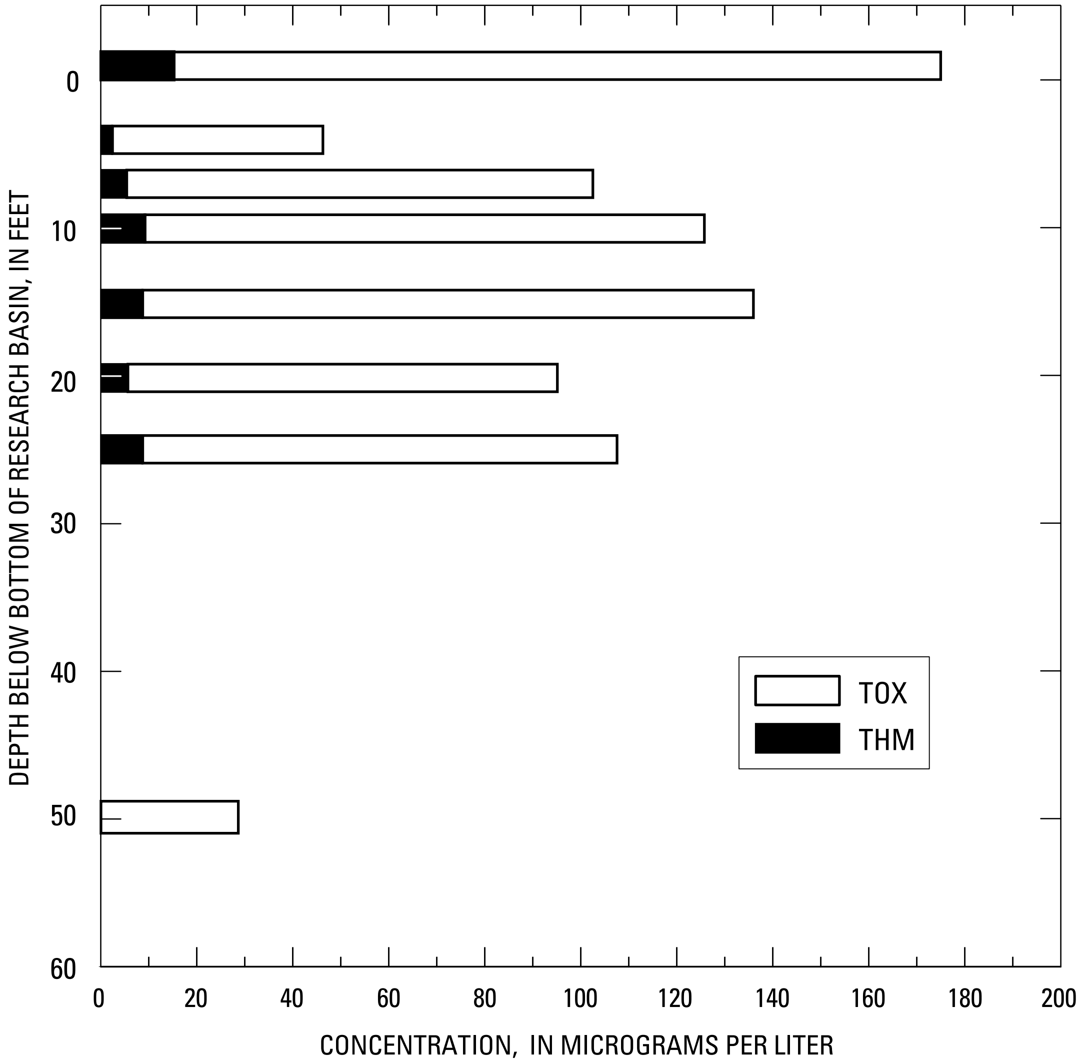


Figure 41. Concentrations of trihalomenthane (THM) and total organic halides (TOX) for selected samples collected in April 1994 at the research basin, Montebello Forebay, Los Angeles County, California.

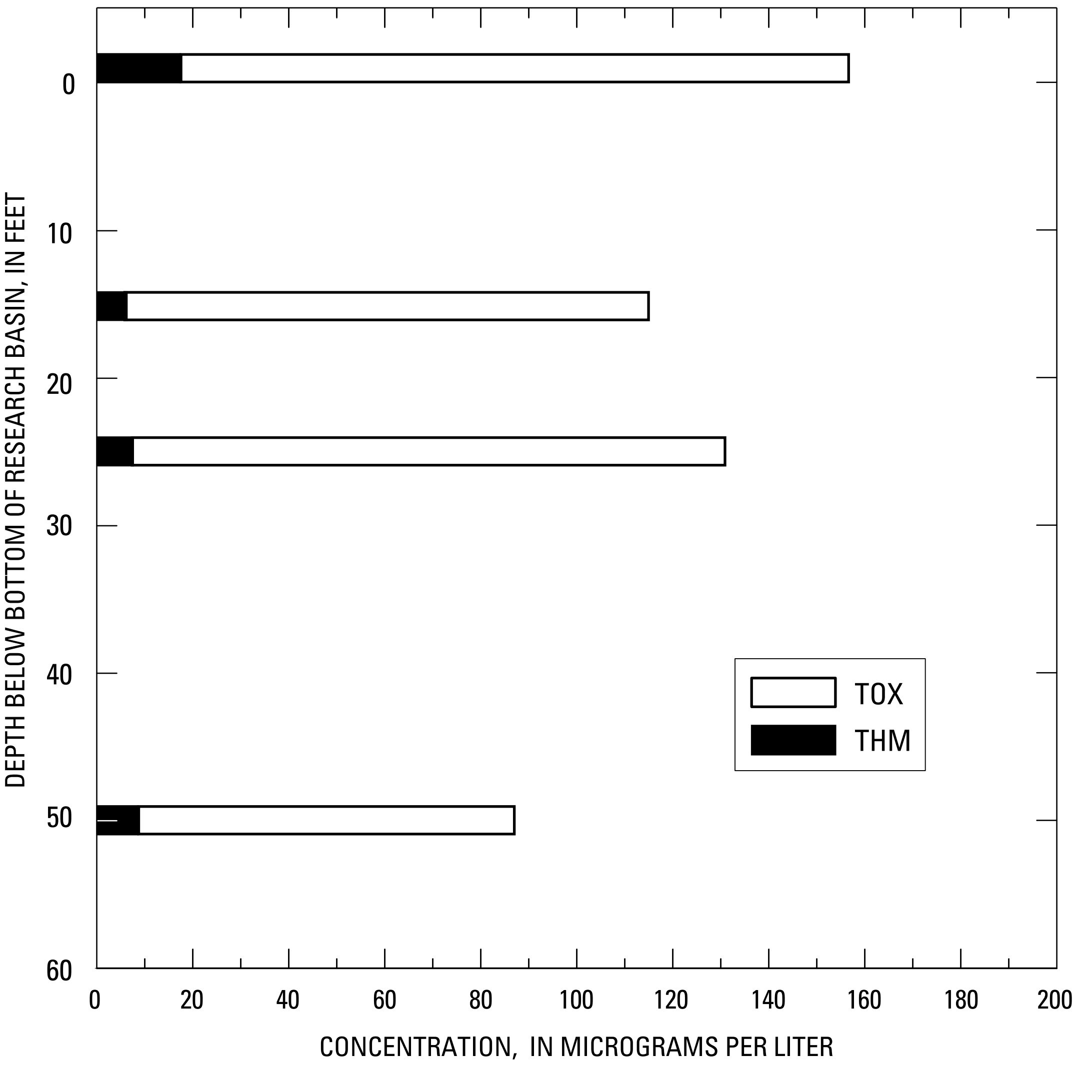


Figure 42. Concentrations of trihalomenthane (THM) and total organic halides (TOX) for selected samples collected in September 1994 at the research basin, Montebello Forebay, Los Angeles County, California.

Mass ratios for TOX to THM of 3 to 10, depending on treatment conditions, have been found in water from various sources (Singer and Chang, 1989). In surface water treated for drinking water, the TOX to THM ratio averaged about 3.4 (Singer and Chang, 1989). In the study area, the ratio ranged from 11 to 18 in April 1994, and from 9 to 20 in September 1994—if ratios in which THM concentrations near limits of detection are eliminated (calculated from data tables 21 and 22). These high TOX to THM ratios indicate that complex halogenated compounds, rather than THM, are a large component of the complex halogenated compounds at this site.

Low levels of THMs at some of the sample sites produce wide variation in the TOX to THM ratio, and the percentage of THM in the TOX was compared for each site (listed for April 1994 in table 21 and for September 1994 in table 22). Changes in this percentage during infiltration may indicate preferential degradation or sorption of either THM or TOX during recharge. In April (fig. 43) and in September (table 22), the percentage of THM in the TOX ranged from 5 to 9 and did not show any discernible vertical trend between 5 and 25 ft beneath the basin floor. The percentage of THM in the TOX was a little higher in the research basin than beneath the research basin, suggesting preferential removal of the simpler THM compounds, or preferential generation of the more complex TOX compounds, during infiltration. The percentage of THM in the TOX at 50 ft below the research basin (PR8 and PR10) was near zero in April 1994 but high in September 1994. Since recycled water from the recharge experiments in the research basin is known not to reach this depth, this seasonal variation must be indicative of larger regional factors, as noted earlier. It is likely that the ground water at this depth contains a high proportion of the prior winter's stormwater in April, whereas in September it contains a high proportion of recycled water from the spreading grounds or unlined reaches of the San Gabriel River following several months of negligible rainfall.

The percentage of TOX with respect to DOC measured here, at about 1 to 2 percent, is much lower than percentages for formation potentials reported in surface water from other areas (Rathbun and Bishop, 1993, 1994; Rathbun, 1995) In order to determine whether TOX was changing with respect to DOC during recharge, the TOX as a percent of DOC was evaluated from data for April 1994 in table 21 (and fig. 43) and for September 1994 in table 22. The data do not provide clear evidence for preferential removal or enrichment in TOX with respect to DOC. Although the proportion as TOX is lower in the 50-foot wells (PR8 and PR10) than at shallower depths for the samples collected in April, as noted already, this deeper ground water may have contained a high proportion of antecedent stormwater at that time. No samples from either well were obtained in September, when more wastewater and less stormwater might have been present as discussed above.

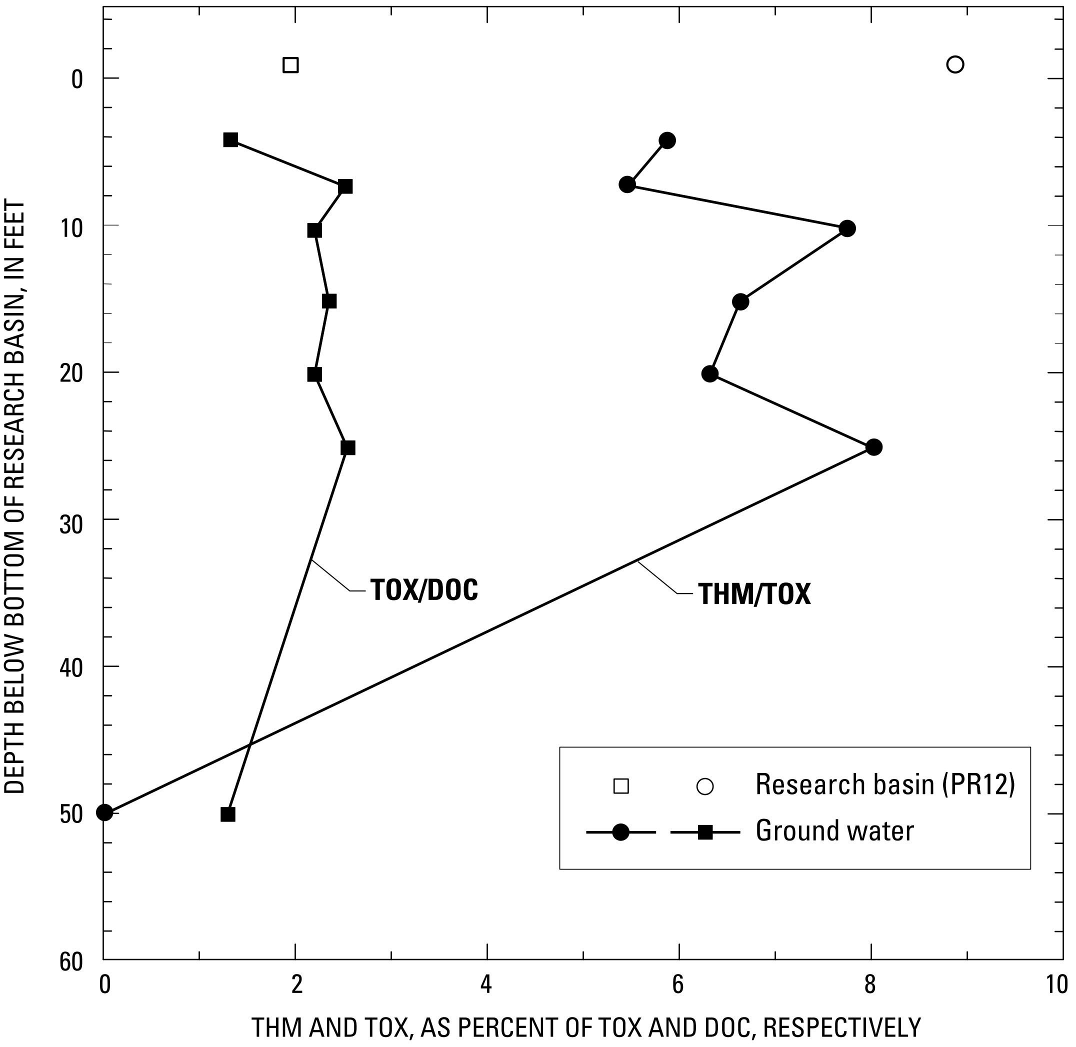


Figure 43. Trihalomethane to total organic halide ratios (THM/TOX) and total organic halide to dissolved organic carbon ratios (TOX/DOC) for selected samples collected in April 1994 at the research basin, Montebello Forebay, Los Angeles County, California.

CHAPTER 12: SPECIFIC ORGANIC CONTAMINANTS

By Larry B. Barber *and* Colleen E. Rostad

Anionic surfactants and their metabolites are a major group of dissolved organic contaminants found in reclaimed water (Barber, 1992; Swisher, 1987). Caffeine has also been found to be a useful indicator to distinguish domestic-wastewater inputs from industrial-wastewater inputs elsewhere (Barber and others, 1995 a, b). Therefore, water samples collected during the April and September 1994 recharge experiments were analyzed for anionic aromatic sulfonate surfactants, certain aromatic sulfonate metabolites, and caffeine. Samples of reclaimed water also were analyzed for specific volatile organic compounds.

Sampling

Samples for specific compound analyses were collected during two sampling trips: April 4–7 and September 19–22, 1994. Treated-wastewater effluent and ground water were sampled for methylene blue active substances (MBAS), linear alkylbenzene sulfonate (LAS), caffeine, and volatile organic compound (VOC) analyses. Raw water samples were collected without head-space in 40-mL amber glass bottles for VOC analyses. Samples for MBAS, LAS, and caffeine analyses were pressure-filtered through 1-µm glass-fiber filters and preserved with 2-percent formalin. All samples were stored in the dark at 4°C until analyzed.

Analytical Methods

Methylene Blue Active Substances

Methylene blue active substance (MBAS) analysis is a measure of total anionic surfactants, and includes linear- and branch-chained alkylbenzene sulfonic acids (LAS and ABS), sulfophenyl carboxylic acid (SPC) degradation products of LAS and ABS, dialkyltetralin sulfonates and dialkylindane sulfonates (DATS), which are impurities in LAS and ABS formulations, alkylsulfates, and other natural and synthetic strong-acid hydrophobic compounds. Filtered formalin-preserved samples were analyzed for MBAS using a miniaturized version of the method described by Wershaw and others (1983). This method involves (1) acidifying a 5-mL water sample to pH <2 using sulfuric acid, (2) adding an aqueous methylene blue solution to form an ion pair with anionic compounds in the acidified water sample, and (3) extracting the methylene blue ion pair into chloroform. The amount of extracted anionic surfactant is measured by absorbance at 635 nm on a UV/VIS spectrophotometer. The acidification step removes interferences from weak organic acids that become protonated, and the chloroform extraction isolates the hydrophobic organic ion pairs and removes interferences from inorganic anions. Quantification was based on a 4-point standard curve. Each set of samples included a distilled water blank and from one to three quality-assurance standards. Replicate analysis was performed on selected samples. The detection limit for this method is about 20 µg/L.

Anionic Surfactants

Samples collected in April 1994 were analyzed for LAS and related compounds using a modification of the solid-phase extraction (SPE), derivatization, gas chromatography/mass spectrometry (GC/MS) method of Trehy and others (1990). Details of this method are given by Barber and others (1995a, b). The SPE isolation was performed by a Waters Millilab 1A robotics workstation. Octadecyl surface-modified-silica (C_{18}) SepPak cartridges (1g) were used for reverse-phase isolation.

The C_{18} cartridges were conditioned with methanol prior to processing the 1-L samples. The samples were passed through the cartridges at a flow rate of 20 mL/min. The C_{18} cartridge was eluted with 5 mL of acetonitrile followed by 5 mL of methylene chloride, and the combined eluant was evaporated to dryness under a stream of N_2. The LAS in the C_{18} extracts was derivatized by reacting the residue with phosphorous pentachloride followed by trifluoroethanol to form the trifluoroethyl esters of LAS.

The derivatized extracts were analyzed by electron-impact GC/MS using a Hewlett Packard 5890 GC with a 5970 Mass Selective Detector in both the full-scan and selected-ion monitoring (SIM) modes. The conditions for the analysis are: column, Hewlett Packard Ultra II, 25 m by 0.2-mm i.d., 20-µm film thickness; carrier gas, ultra-high-purity helium, 27 cm/s; source temperature, 250°C; source pressure, 1×10^{-5} torr; ionization energy, 70 electron volts; scan range, 45 to 550 atomic mass unit (AMU); scan time, 1 scan/s; splitless mode, purge valve on at 0.75 min; injector temperature, 280°C; MS interface temperature, 250°C; initial oven temperature, 110°C; initial hold time, 1 min; ramp rate, 8°C/min; final temperature, 300°C; final hold time, 5 min. Selected ion-monitoring data were collected for the molecular ions [M^+] of the trifluoroethyl ester derivatives of the individual LAS homologs (*m/z* 352 for C_8, 366 for C_9, 380 for C_{10}, 394 for C_{11}, 408 for C_{12}, 422 for C_{13}, and 436 for C_{14}) and for their base peaks (*m/z* 253 and 267).

Several quality-assurance and quantitation standards were used, including: C_{10}–C_{14} LAS (Vista Chemical), C_8-LAS (Aldrich), and C_9-LAS (Procter and Gamble Company). The C_9-LAS surrogate standard was added to the aqueous sample prior to SPE isolation to evaluate the whole-method recovery, and the C_8-LAS was added to the extract after isolation to evaluate derivatization. The C_{10}–C_{14} LAS standard was spiked into distilled water and processed through the entire procedure in the same manner as were field samples. Quantitation of LAS was based on the C_9-LAS molecular-ion peak area (SIM mode) and the peak areas of the individual isomers and homologs of C_{10}–C_{14} LAS. The detection limit for individual homologs that comprise the total LAS was about 0.1 µg/L.

Samples collected in September were analyzed for LAS by a different method (Field and others, 1992c, 1994). Additional details of the method are described by Barber and others (1999). This method involves injection-port derivatization using tetrabutylammonium hydrogen sulfate (TBA) in chloroform. Water samples (1 L) were isolated on C_{18} silica cartridges using the Waters Millilab 1A robotics system after ionic-strength adjustment using sodium chloride. After isolation, the cartridges were eluted with TBA/chloroform, dried over sodium sulfate, and concentrated to a final volume of 200 µL.

The extracts were analyzed by GC/MS using the same conditions described above with the following changes: split mode, 10:1 split ratio; injection-port temperature, 300°C; initial oven temperature, 110°C; initial time, 0 min; ramp rate, 20°C/min to 200°C followed by 6°C/min to 300°C; final hold time, 5 min. Selected ion-monitoring data were collected for the [M^+–55] ions (molecular ion minus loss of the butyl functional group) of the butylated esters of the individual homologs (*m/z* 271 for C_8, 285 for C_9, 299 for C_{10}, 313 for C_{11}, 327 for C_{12}, 341 for C_{13}, and 355 for C_{14}) and for their base peaks (*m/z* 91, 171, and 185). Concentrations were calculated relative to the C_9-LAS surrogate standard using response factors determined from a 4-point calibration curve. The detection limit for this method was about 0.1 µg/L for each homolog.

Caffeine

Samples were analyzed for caffeine by SPE sorption, followed by GC/MS analysis, as described by Barber and others (1995 a, b). Caffeine was extracted from 1 L of formalin-preserved water samples using C_{18} SepPak cartridges and the Millilab 1A workstation. The water samples were spiked with C_{13} caffeine (Cambridge Isotopes), passed through the C_{18} cartridge, and eluted with ethyl acetate or TBA/chloroform. The switch was made from ethyl acetate to TBA/chloroform to allow the simultaneous measurement of caffeine and LAS. The recovery of caffeine is about the same for both eluting solvents. The solvent extract is dried over sodium sulfate and its volume is reduced to 100 µL.

The extracts were analyzed in the full-scan and SIM modes by GC/MS using the splitless conditions described above, with the following changes: injection-port temperature, 280°C; initial oven temperature, 60°C; initial time, 1 min; ramp rate, 8°C/min; final temperature, 300°C; final hold time, 0 min. Selected ion-monitoring data were collected for the [M^+] of caffeine and the C_{13} caffeine surrogate standard (*m/z* 194 and 197, respectively) and for the base peaks of the compounds (*m/z* 109 and 180, respectively). Quantitation of caffeine was based on the molecular-ion peak area of the C_{13} caffeine surrogate standard and response factors determined from a 4-point calibration curve, or from the molecular-ion peak area of caffeine and a 4-point external standard calibration curve. The detection limit for this method is about 0.01 µg/L.

Volatile Organic Compounds

In order to ascertain the potential for specific volatile organic compound (VOC) input to the ground water due to recharge using reclaimed water, a sample from the research basin (PR12) taken in September 1994 was analyzed for VOCs by purge-and-trap capillary GC/MS (Rose and Schroeder, 1995), which is similar to U.S. EPA Method 524.2 (Eichelburger and Budde, 1989).

Results

April 1994 Sampling

Methylene Blue Active Substances

Methylene blue active substances (MBAS) were measured as an indicator of anionic surfactants (table 23). Concentrations ranged from 840 µg/L in the sewage effluent (PR13) to 230 µg/L in the 50-foot well (PR8). There was a 46-percent decrease in MBAS concentration between the effluent (PR13) and the research basin (PR12), followed by an additional 51-percent decrease during the first 4 ft of infiltration, below which the variation in MBAS concentrations remains within analytical precision in the multilevel sampler (MLS) samples. Concentrations of MBAS in all of the samples beneath the research basin to a depth of 25 ft were elevated with respect to concentrations in samples from 50 ft (PR8 and PR10).

Linear Alkylbenzene Sulfonate

Specific anionic surfactant (LAS) was measured and concentrations are given in table 23. Linear alkylbenzene sulfonate is a complex mixture consisting of 26 separate isomers and homologs. Each isomer has a different rate of biodegradation. The process of biodegradation results in the selective removal of the more biodegradable components (Tabor and Barber, 1996).

The isomeric composition of the LAS in the effluent and ground water beneath the research basin was enriched in the more biologically resistant internal isomers. The concentration of LAS (table 23, fig. 44) accounts for only 5 percent of the total MBAS response in the effluent (PR13) and for even less in the ground-water samples. In addition to LAS, MBAS also is a partial measure of the impurities and metabolites of LAS (Field and Leenheer, 1988), which are not included in the reported LAS values. Results of the GC/MS analysis indicate the presence of SPC and DATS in the effluent and ground water. These compounds have been shown to be recalcitrant to biodegradation and thus are preferentially preserved (Field and others, 1992a, b). However, these compounds were not quantified. The MBAS method also is susceptible to positive interferences from elevated nitrate and chloride concentrations (Burkhardt and others, 1995), which are an additional source of error.

The concentration of total LAS decreased by 83 percent between the effluent (PR13) and the research basin (PR12), a greater removal than was observed for MBAS. Although there is considerable scatter in the data (perhaps because differences in the time of sampling wherein steady-state conditions had not yet been established at all depths), additional removal of LAS with increasing depth is apparent. With the exception of the second sample, collected at PR9 on April 7, after recycled water likely had reached this depth, no LAS was detected below 20 ft.

Caffeine

Caffeine was measured in the research basin (PR12) and at a few depths beneath the research basin (table 23). Concentrations for all samples were near the detection limit (0.05 µg/L), and there was no apparent trend with depth. Low caffeine concentration in the recycled water could be an indication of the effectiveness of treatment by the wastewater-treatment plants in this area.

September 1994 Sampling

Linear Alkylbenzene Sulfonate

Concentrations of LAS for the September 1994 sampling are given in table 24. Concentrations in the effluent (PR13), which were determined by the method of Field and others (1992c, 1994), were about the same in April (40.6 µg/L) and September (36.6 µg/L). In contrast to the April sampling, the results from September show a much lower removal rate with increasing depth. During both recharge events, LAS was detected in the 25-foot well (PR9), and the LAS mixture was enriched in the more biologically resistant internal isomers.

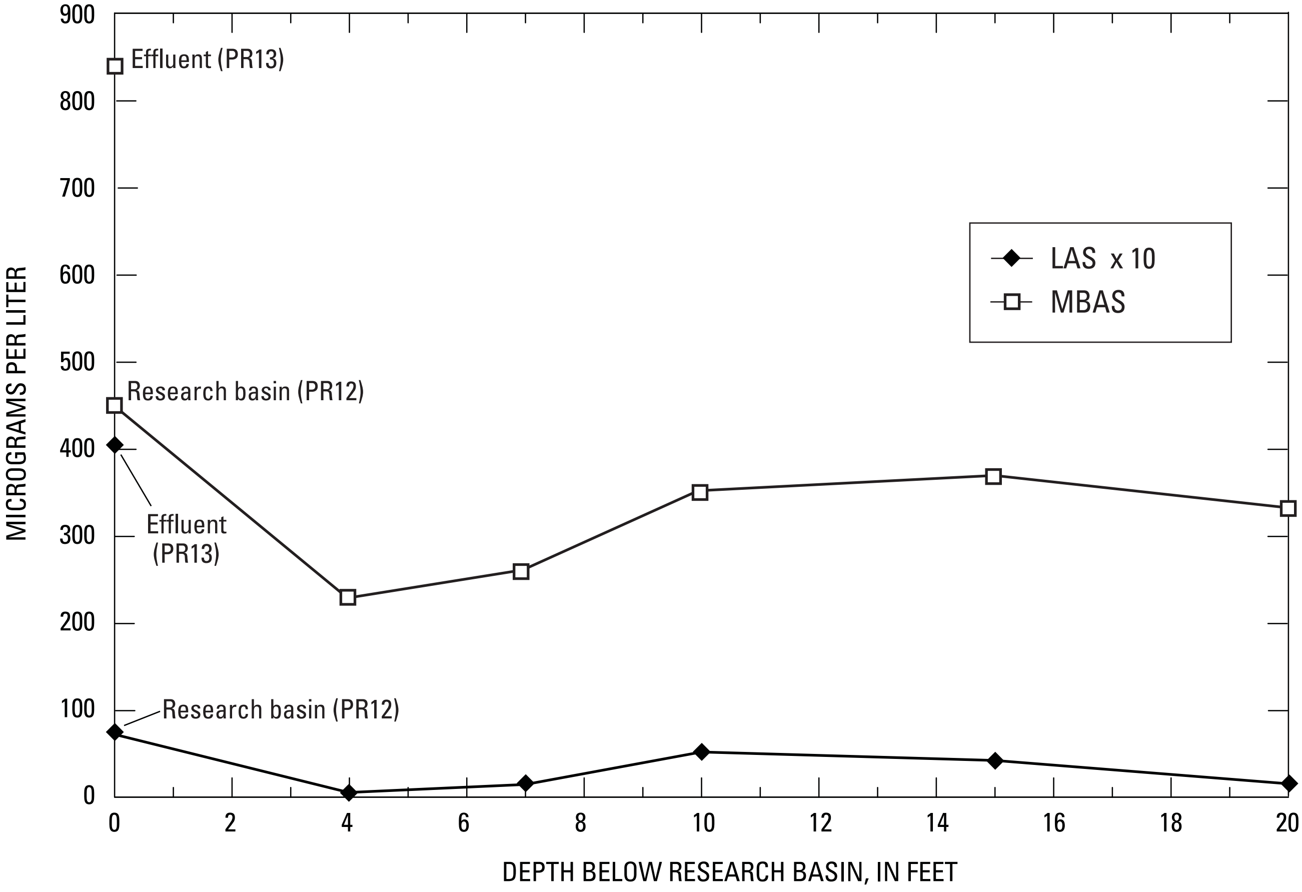


Figure 44. Attenuation of anionic surfactant concentrations (LAS and MBAS) with depth below research basin during infiltration of reclaimed water, April 1994, Montebello Forebay, Los Angeles County, California.

Table 23. Concentrations of methylene blue active substances (MBAS), linear alkylbenzene sulfonate (LAS), and caffeine for samples collected at the research basin, Montebello Forebay, Los Angeles County, California, April 1994

[µg/L, micrograms per liter; <, less than; —, not analyzed]

Sample	MBAS (µg/L)	LAS (µg/L)	Caffeine (µg/L)
PR13	840	40.6	—
PR12	450	7.1	0.05
MLS4	220	.5	—
MLS7	260	1.4	.11
MLS10	350	5.2	.07
MLS15	370	4.4	—
MLS20	330	1.4	.05
PR11	230	<.5	—
PR10	200	<.5	—
PR9 (April 5)	220	<.5	—
PR9 (April 7)	320	3.6	—
PR8	230	<.5	—
2S/11W-19C1	280	—	—
2S/11W-18P1	280	—	—
2S/11W-7J1S	—	—	—
Field blank	10	<.5	—

Table 24. Concentrations of methylene blue active substances (MBAS), linear alkylbenzene sulfonate (LAS), and caffeine concentrations for samples collected at the research basin, Montebello Forebay, Los Angeles County, California, September 1994

[µg/L, micrograms per liter; <, less than; —, not analyzed]

Sample	MBAS (µg/L)	LAS (µg/L)	Caffeine (µg/L)
PR13	—	36.6	0.08
MLS15	—	21.7	.08
PR9	—	9.5	.08
PR11	—	<1.0	.08
WP5	—	5.1	<.05
2S/11W-7J1S	—	1.0	<.05

Caffeine

Results from caffeine analysis (table 24) indicate that concentrations in all samples were near the detection limit (0.05 µg/L), as they were in April. These results confirm that caffeine concentrations are too low for it to be a useful tracer of recycled water at this site.

Volatile Organic Compounds

Twenty-two of seventy-seven volatile target compounds measured were detected in a sample of recycled water from the research basin (PR12). Concentrations of the compounds that were detected are given in table 25. Compounds that were not detected are listed in table 26. The sample was not spiked with surrogates in the field when collected. In addition, the sample was preserved by addition of sodium sulfite, rather than ascorbic acid and hydrochloric acid typically used in the USGS National Water Quality Laboratory (NWQL) in Denver (Rose and Schroeder, 1995). The sample was analyzed slightly beyond the typical 14-day holding time. Concentrations, therefore, should be considered minimum values and could explain why the summed concentration for individual compounds at about 9 µg/L is less than the THM concentration of 17 µg/L reported using methods described in the previous chapter (table 22). In spite of these limitations, the enhanced detection limits of the NWQL, where the analysis was done, provided detections as low as 0.02 µg/L.

Most of the compounds detected are disinfection byproducts or common industrial solvents. None of the detected compounds were near Action or Maximum Contaminant Levels (Landsman and Fisher, 1991). For methylene chloride, the California Department of Health Services Action Level is 40 µg/L; concentration in the research basin was only 1 µg/L. The Maximum Contaminant Level under the current Drinking Water Standard for methylene chloride is 5 µg/L (U.S. Environmental Protection Agency, 1996). Toluene was found in the research basin at a concentration of only 0.06 µg/L. The Action Level for toluene is 100 µg/L, and the California Department of Health Services Detection Limit for purposes of reporting is 10.0 µg/L. The Maximum Contaminant Level under the current Drinking Water Standard for toluene is 1,000 µg/L (U.S. Environmental Protection Agency, 1996).

Table 25. Concentrations of volatile organic compounds (VOCs) identified by purge and trap gas chromatography-mass spectrometry (GC/MS) in recycled water from the research basin (PR12), Montebello Forebay, Los Angeles County, September 1994

[Compounds listed in order of GC retention time; µg/L, micrograms per liter]

Compound	Concentration (µg/L)
Chloromethane	0.04
Trichlorofluoromethane	.02
Methylene chloride	1.01
Methyl-t-butyl ether	.51
1,1-Dichloroethane	.10
Bromochloromethane	.08
Chloroform	6.10
1,1,1-Trichloroethane	6.51
Carbon tetrachloride	.01
1,2-Dichloroethane	.05
Trichloroethene	.03
Dibromomethane	.08
Bromodichloromethane	1.93
Toluene	.06
Tetrachloroethene	1.51
Dibromochloromethane	.72
Ethylbenzene	.02
m- and p-Xylene	.01
o-Xylene	.03
Bromoform	.13
1,4-Dichlorobenzene	.62
1,2-Dichlorobenzene	.09

Table 26. Volatile organic compounds (VOCs) not detected by purge and trap gas chromatography-mass spectrometry (GC/MS) in recycled water from the research basin (PR12), Montebello Forebay, Los Angeles County, California, September 1994

[Compounds listed in order of GC retention time]

VOCs
Dichlorodifluoromethane
Vinyl chloride
Bromomethane
Chloroethane
Acrolein
1,1-Dichloroethene
1,1,2-Trichloro-l,2,2-trifluoroethane
Acrylonitrile
trans-1,2-Dichloroethene
2,2-Dichloropropane
cis-1,2-Dichloroethene
1,1-Dichloropropene
Benzene
1,2-Dichloropropane
2-Chloroethylvinylether
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
1,1,2-Trichloroethane
1,3-Dichloropropane
1,2-Dibromoethane
Chlorobenzene
1,1,1,2-Tetrachloroethane
Styrene
Isopropylbenzene
Bromobenzene
1,1,2,2-Tetrachloroethane
1,2,3-Trichloropropane
n-Propylbenzene
2-Chlorotoluene
4-Chlorotoluene
1,3,5-Trimethylbenzene
2-Ethyl toluene
tert-Butylbenzene
1,2,4-Trimethylbenzene
sec-Butylbenzene
1,3-Dichlorobenzene
p-Isopropyltoluene
1,2,3-Trimethylbenzene
n-Butylbenzene
1,2-Dibromo-3-chloropropane
1,2,3,4-Tetramethylbenzene
1,2,3,5-Tetramethylbenzene
1,2,4-Trichlorobenzene
Hexachlorobutadiene
Naphthalene
1,2,3-Tichlorobenzene
Acetone
Iodomethane
Diethylether
Carbon disulfide
Vinyl acetate
4-Methyl-2-pentanone
2-Butanone
2-Hexanone
trans-1,4-Dichloro-2-butene

REFERENCES CITED

Aiken, G.R., and Leenheer, J.A., 1993, Isolation and chemical characterization of dissolved and colloidal organic matter: Chemistry and Ecology, v. 8, p. 135–151.

Aiken, G.R., McKnight, D.M., Thorn, K.A., and Thurman, E.M., 1992, Isolation of hydrophilic organic acids from water using nonionic macroporous resins: Organic Geochemistry, v. 18, p. 567–573.

Anders, R., 1997, Water-quality changes during artificial recharge with reclaimed water: M.S. thesis, San Diego State University, California, 110 p.

Anders, Robert, and Schroeder, R.A., 1997, Water-quality changes during recharge with recycled water at a research basin in the Montebello Forebay, Los Angeles County, California, *in* Kendall, D.W., ed., Proceedings of the AWRA Symposium Conjunctive Use of Water Resources: Aquifer Storage and Recovery, American Water Resources Association 33rd National Meeting, Long Beach, California, October 19–23, 1997: Herndon, Virginia, American Water Resources Association, TPS-97-2, p. 285–296.

Arya, L.M., and Paris, J.F., 1981, A physicoempirical model to predict the soil moisture characteristics from particle size distributions and bulk density data: Soil Science Society of America Journal, v. 45, p. 1023–1030.

Audrieth, L. F., and Kleinberg, J., 1953, Non-aqueous solvents: New York, John Wiley, p. 148–151.

AWWA (American Water Works Association), 1992, Standard Methods for the Examination of Water and Wastewater, 18th Edition, Washington, D.C.

Barber, L.B., II, 1992, Hierarchical analytical approach to evaluating the transport and biogeochemical fate of organic compounds in sewage-contaminated groundwater, Cape Cod, Massachusetts: Chapter 4, *in* Lesage, S., and Jackson, R.E., eds., Groundwater Contamination and Analysis at Hazardous Waste Sites: New York, Marcel Dekker, Inc., p. 73–120.

Barber, L.B., II, Brown, G.K., Kennedy, K.R., Leenheer, J.A., Noyes, T.I., Rostad, C.E., and Thorn, K.A., 1997, Water quality at production wells near artificial-recharge basins in Montebello Forebay, Los Angeles County, *in* Kendall, D.W., ed., Proceedings of the AWRA Symposium Conjunctive Use of Water Resources: Aquifer Storage and Recovery, American Water Resources Association 33rd National Meeting, Long Beach, California, October 19–23, 1997: Herndon, Virginia, American Water Resources Association, TPS-97-2, p. 261–272.

Barber, L.B., II, Leenheer, J.A., Noyes, T.I., and Stiles, E.A., 2001, Nature and transformation of dissolved organic matter in treatment wetlands: Environmental Science and Technology, v. 35, p. 4805–4816.

Barber, L. B., II, Leenheer, J.A., Noyes, T.I., and Stiles, E.A., 1999, Transformation of dissolved organic matter in constructed wetlands: Final report for U.S. Geological Survey/Bureau of Reclamation Interagency Agreement No. 1425-3-AA-81-18180, Bureau of Reclamation, Denver, Colorado, 101 p.

Barber, L.B., II, Leenheer, J.A., Pereira, W.E., Noyes, T.I., Brown, G.K., Tabor, C.F., and Writer, J.H., 1995a, Organic contamination of the Mississippi River from municipal and industrial wastewater, *in* Meade, R. H., ed., Contaminants in the Mississippi River, 1987–1992. U.S. Geological Survey Circular 1133, p. 115–135.

Barber, L.B., II, Leenheer, J.A., Tabor, C.F., Jr., Brown, G.K., Noyes, T.I., and Norieaga, M.C., 1995b, Organic compounds and sewage-derived contaminants: Chapter 5, *in* Moody, J.A., ed., Chemical data for water samples collected during four upriver cruises on the Mississippi River between New Orleans, Louisiana, and Minneapolis, Minnesota, May 1990–April 1992: U.S. Geological Survey Open-File Report 94-523, p. 221–233.

Barclay's California Code of Regulations, 1978, Ground water recharge: Title 26, Sect. 22.60320 (loose leaf).

Berner, R.A., 1971, Principles of chemical sedimentology: New York, McGraw-Hill, 240 p.

Britton, L.J., and Greeson, P.E., eds., 1987, Methods for collection and analysis of aquatic biological and microbiological samples: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter A4, 363 p.

Burkhardt, M.R., Cinotto, P.J., Frahm, G.W., Woodworth, M.T., and Pritt, J.W., 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of methylene blue active substances by spectrophotometry: U.S. Geological Survey Open-File Report 95-189, 16 p.

California Department of Health Services, 1978, Wastewater reclamation criteria, an excerpt from the California Administrative Code, Title 22, Division 4, Environmental Health: Engineering Section, Berkeley Calif. (loose leaf).

California Department of Water Resources, Southern District, 1961, Planned utilization of the ground water basins of the coastal plain of Los Angeles County, Appendix A—Ground Water Geology: Bulletin 104, 150 p.

California State Water Resources Control Board, 1987, Report of the scientific advisory panel on groundwater recharge with reclaimed waste water, 29 p.

CFR (Code of Federal Regulations), 1994, Title 40, Part 141, Subpart C, Appendix C, Part II, Analysis of trihalomethanes in drinking water by liquid/liquid extraction (EPA Method 501.2), p. 713–721.

Condron, L.M., Frossard, E., Newman, R.H., Tekely, P., and Morel, J-L, 1997, Use of ^{31}P NMR in the study of soils and the environment, *in* Nanny, M.A., Minear, R.A., and Leenheer, J.A., eds., Nuclear Magnetic Resonance spectroscopy in environmental chemistry: New York, Oxford University Press, p. 247–271.

Coplen, T.B., 1988, Normalization of oxygen and hydrogen isotope data: Chemical Geology (Isotope Geoscience Section), v. 72, p. 293–297.

Craig, H., 1961a, Isotope variations in meteoric waters: Science, v. 133, p. 1702–1703.

_______1961b, Standard for reporting concentrations of deuterium and oxygen-18 in natural waters: Science, v. 133, p. 1833–1834.

Dazzo, F.B., and Rothwell, D.F., 1974, Evaluation of porcelain cup water samplers for bacterial samplings: Applied Microbiology, v. 27, p. 1172–1174.

Eichelburger, J.W., and Budde, W.L., 1989, Method 524.2, Revision 3.0: Cincinnati, Ohio, Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency.

Epstein, S., and Mayeda, T., 1953, Variations of the ^{18}O content of waters from natural sources: Geochimica et Cosmochimica Acta, v. 4, p. 213–224.

Fetter, C.W., 1988, Journal of Hydrology: Columbus, Ohio, Merrill Publishing Company, 592 p.

Field, J.A., Barber, L.B., II, Thurman, E.M., Moore, B.L., Lawrence, D.L., and Peake, D.A., 1992a, Fate of alkylbenzene sulfonates and dialkyltetralinsulfonates in sewage-contaminated groundwater: Environmental Science and Technology, v. 26, p. 1140–1148.

Field, J.A., Field, T.M., Polger, T., and Giger, W., 1994, Determination of secondary alkane sulfonates in sewage wastewaters by solid-phase extraction and injection port derivatization gas chromatography/mass spectrometry: Environmental Science and Technology, v. 28, p. 497–503.

Field, J.A., and Leenheer, J.A., 1988, Response of anionic detergents and their carboxylated degradation products to the methylene-blue-active substances test: U.S. Geological Survey Water-Resources Investigations Report 88-4220, p. 614–615.

Field, J.A., Leenheer, J.A., Thorn, K A., Barber, L.B., II, Rostad, C., Macalady, D.L., and Daniel, S.R., 1992b, Identification of persistent anionic surfactant-derived chemicals in sewage effluent and groundwater: Journal of Contaminant Hydrology, v. 9, p. 55–78.

Field, J.A., Miller, D.J., Field, T.M., Hawthorne, S.B., and Giger, W., 1992c, Quantitative determination of sulfonated aliphatic and aromatic surfactants in sewage sludge by ion-pair/supercritical fluid extraction and derivatization gas chromatography/mass spectrometry: Analytical Chemistry, v. 64, p. 3161–3167.

Fischer, R.B., 1961, Quantitative chemical analysis, Second Edition: Philadelphia, W. B. Saunders Co., p. 145–148.

Fishman, M.J., and Friedman, L.C., eds., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter A1, 545 p.

Goddard, E.N., Trask, F.D., De Ford, R.K., Rove, O.N., Singewald, J.T., Jr., and Overback, R.M., 1948, Rock-color chart: Geological Society of America, reprinted 1984.

Guy, H.P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter C1, 58 p.

Huffman, E.W.D., Jr., and Stuber, H., 1985, Analytical methodology for elemental analysis of humic substances, *in* Aiken, G.R., McKnight, D.M., Wershaw, R.L., and MacCarthy, P., eds., Humic substances in soil, sediment, and water: New York, John Wiley, p. 433–455.

Kendall, C., and Coplen, T.B., 1985, Multisample conversion of water to hydrogen by zinc for stable isotope determination: Analytical Chemistry, v. 57, p. 1437–1440.

Krasner, S.W., McGuire, M.J., Jacangelo, J.G., Patania, N.L., Reagan, K.M., and Aieta, E.M., 1989, The occurrence of disinfection by-products in U.S. drinking water: Journal of American Water Works Association, v. 81 no. 8, p. 41–53.

Land, Michael, Everett, R.R., and Crawford, S.M., 2002, Geologic, hydrologic, and water-quality data from multiple-well monitoring sites in the Central and West Coast Basins, Los Angeles County, California, 1995–2000: U.S. Geological Survey Open-File Report 01-277, 178 p.

Landsman, S.H., and Fisher, S.M., 1991, Annual report for the fiscal year, July 1, 1990, to June 30, 1991: The Metropolitan Water District of Southern California.

LeBlanc, D.R., Garabedian, S.P., Hess, K.M., Gelhar, L.W., Quadri, R.D., Stollenwerk, K.G., and Wood, W.W., 1991, Large-scale natural gradient tracer test in sand and gravel, Cape Cod, Massachusetts—1. Experimental design and observed tracer movement. Water Resources Research, v. 27, p. 895–910.

Leenheer, J.A., 1981, Comprehensive approach to preparative isolation and fractionation of dissolved organic carbon from natural waters and wastewaters: Environmental Science and Technology, v. 15, p. 578–587.

Leenheer, J.A., and Huffman, E.W.D., Jr., 1976, Classification of organic solutes in water by using macroreticular resins: U.S. Geological Survey, Journal of Research, v. 4, no. 6, p. 737–751.

Leenheer, J.A., and Huffman, E.W.D., Jr., 1979, Analytical method for dissolved-organic carbon fractionation: U.S. Geological Survey Water-Resources Investigations 79-4, 16 p.

Leenheer, J.A., Meade, R.H., Taylor, H.E., and Pereira, W.E., 1989, Sampling, fractionation, and dewatering of suspended sediment from the Mississippi River for geochemical and trace-contaminant analysis, *in* Mallard, G.E., and Ragone, S.E., eds, U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Phoenix, Arizona, September 26–30, 1988: U.S. Geological Survey Water-Resources Investigations Report 88-4220, p. 501–512.

Leenheer, J.A., and Noyes, T.I., 1984, A filtration and column-adsorption system for onsite concentration and fractionation of organic substances from large volumes of water: U.S. Geological Survey Water-Supply Paper 2230, 16 p.

Leenheer, J.A., Rostad, C.E., Barber, L.B., Schroeder, R.A., Anders, Robert, and Davisson, M.L., 2001, Nature and chlorine reactivity of organic constituents from reclaimed water in groundwater, Los Angeles County, California: Environmental Science and Technology, v. 35, p. 3869–3876.

McCarty, P. L., 1990, Volatile organic chemicals and intentional water reuse, Chapter 8 *in* Ram, N.M., Christman, R.F., and Cantor, K.P., eds., Significance and treatment of volatile organic compounds in water supplies: Boca Raton, Florida, Lewis Publishers, p. 127–138..

McGuire, M.J., and Meadow, R.G., 1988, AWWARF [American Water Works Association Research Foundation] trihalomethane survey, Journal of American Water Works Association, v. 80, no. 1, p. 61–68.

Nikkel, M., Mueller, T., Thompson, K., and Rechard, P., 1989, Assessment of the adequacy of the ground water monitoring program for artificial recharge of aquifers in the Los Angeles area, California, *in* Johnson, A.I., and Finlayson, D.J., eds., Artificial recharge of ground water, Anaheim, California, August 23–27, 1988, Proceedings of the International Symposium: American Society of Civil Engineers, New York, p. 396–404.

Paulson, G.D., 1976, Sulfate ester conjugates—Their synthesis, purification, hydrolysis, and chemical and spectral properties, *in* Kaufman, D.D., Still, G.G., Paulson, G.D., and Bandal S.K., eds, Bound and conjugated pesticide residues: American Chemical Society Symposium Series 29, Chapter 6, Washington, D.C., American Chemical Society, p. 86–102.

Peters, C.A., and Healy, R.W., 1988, The representativeness of pore water samples collected from the unsaturated zone using pressure-vacuum lysimeters: Ground-Water Monitoring Review, v. 8, p. 96–101.

Pitt, W.W., Jr., Jolley, R.L., and Scott, C.D., 1975, Determination of trace organics in municipal sewage effluents and natural waters by high-resolution ion-exchange chromatography: Environmental Science and Technology, v. 9, p. 1068–1073.

Plummer, L.N., Jones, B.F., and Truesdell, A.H., 1984, WATEQF-a Fortran IV version of WATEQ, a computer program for calculating chemical equilibrium in natural waters: U.S. Geological Survey Water-Resources Investigations 76-13, 70 p.

Pouchert, C.J., 1985, The Aldrich Library of FT-IR spectra, Volumes 1 and 2: Milwaukee, Wisconsin, Aldrich Chemical Company, 2,958 p.

Rathbun, R. E., 1995, Trihalomethane and nonpurgeable total organic-halide formation potentials for the Mississippi River and some of its tributaries, March–April 1992: U.S. Geological Survey Open-File Report 94-336, 55 p.

Rathbun, R. E., and Bishop, L.M., 1993, Trihalomethane and nonpurgeable total organic-halide formation potentials for the Mississippi River and some of its tributaries, June–August 1991, U.S. Geological Survey Open-File Report 93-158, 57 p.

Rathbun, R. E., and Bishop, L.M., 1994, Trihalomethane and nonpurgeable total organic-halide formation potentials for the Mississippi River and some of its tributaries, September–October 1991, U.S. Geological Survey Open-File Report 94-36, 53 p.

Reichard, E.G., Land, Michael, Crawford, S.M., Johnson, Tyler, Everett, R.R., Kulshan, Trayle, Ponti, D.J., Halford, K.L., Johnson, T.A., Paybins, K.S., and Nishikawa, Tracy, 2003, Geohydrology, geochemistry, and ground-water simulation-optimization of the Central and West Coast Basins, Los Angeles County, California: U.S. Geological Survey Water-Resources Investigations Report 03-4065, 56 p, available online at the following URL:http://pubs.water.usgs.gov/wri34065/

Roberts, P.V., Schreiner, J., and Hopkins, G.D., 1982, Field study of organic water quality changes during groundwater recharge in the Palo Alto Baylands: Water Resources, v. 16, p. 1025–1035.

Rose, D.L., and Schroeder, M.P., 1995, Methods of analysis by the U.S. Geological Survey, National Water Quality Laboratory—Determination of volatile organic compounds in water by purge and trap capillary gas chromatography/mass spectrometry: U.S. Geological Survey Open-File Report, 94-708, 26 p.

Rostad, C.E., 1996, Partitioning of lipophilic organic contaminants among suspended particulate, colloid, and dissolved phases in the Mississippi River: Golden, Colorado, Colorado School of Mines, Ph.D. thesis 4477, 210 p.

Rostad, C.E., Leenheer, J.A., and Daniel, S.R., 1997, Organic carbon and nitrogen content associated with colloids and suspended particulates form the Mississippi River and some of its tributaries: Environmental Science and Technology, v. 31, p. 3218–3225.

Rostad, C.E., and Leenheer, J.A., 2000, Identification of erioglaucine (Brilliant Blue) as a wastewater marker by liquid chromatography/electrospray mass spectrometry, *in* 47th Annual ASMS Conference on Mass Spectrometry and Allied Topics, Long Beach, California, June 11–15, 2000: American Society for Mass Spectrometry, Abstract no. 266.

Rostad, C.E., Pereira, W.E., and Leiker, T.J., 1994, Distribution and transport of selected anthropogenic organic compounds on Mississippi River suspended sediment, May–June 1988: Journal of Contaminant Hydrology, v. 16, p. 175–199.

Rostad, C.E., Rees, T.F., and Daniel, S.R., 1998, Colloid particle sizes in the Mississippi River and some of its tributaries, from Minneapolis to below New Orleans: Hydrological Processes, v. 12, p. 25–41.

Schroeder, R.A., 1995, Potential for chemical transport beneath a storm-runoff recharge (retention) basin for an industrial catchment in Fresno, California: U.S. Geological Survey Water-Resources Investigations Report 93-4140, 38 p.

Schroeder, R.A., Anders, Robert, Böhlke, J.K., Michel, R.L., and Metge, D.W., 1997, Water quality at production wells near artificial-recharge basins in Montebello Forebay, Los Angeles County, *in* Kendall, D.W., ed., Proceedings of the AWRA Symposium Conjunctive Use of Water Resources: Aquifer Storage and Recovery, American Water Resources Association 33rd National Meeting, Long Beach, California, October 19–23, 1997: Herndon, Virginia, American Water Resources Association, TPS-97-2, p. 273–284.

Schroeder, R. A., and Anders, Robert, 2002, Transport and fate of water-quality indicators after 40 years of artificial recharge with treated municipal wastewater to the Central Ground-Water Basin in Los Angeles County, in Aiken, G. R., and Kuniansky, E. L., eds., 2002, U.S. Geological Survey Artificial Recharge Workshop Proceedings, Sacramento, California, April 2–4, 2002: U.S.Geological Survey Open-File Report 02-89, p. 42–46, available at the following URL: http:water.usgs.gov/ogw/pubs/ofr0289/

Schroeder, R.A., Martin, Peter, and Bohlke, J.K., 1993, Chemical, isotopic, and microbiological evidence for denitrification during transport of domestic wastewater through a thick unsaturated zone in the Mojave Desert, San Bernardino County, California: U.S. Geological Survey Open-File Report 93-414, 11 p.

Shinozuka, N., and Nihei, Y., 1994, Size of aqueous solutions studied by light scattering, *in* Senesi, N., and Miano, T.M., eds., Humic substances in the global environment and implications on human health: New York, Elsevier Science, p. 889–894.

Singer, P.C., and Chang, S.D., 1989, Correlations between trihalomethanes and total organic halides formed during water treatment: Journal of American Work Works Association v. 81, p. 61–65.

Sloss, E.M., Geschwind, S.A., McCaffrey, D.F., and Ritz, B.R., 1996, Groundwater recharge with reclaimed water—an epidemiologic assessment in Los Angeles County, 1987–1991: Rand report prepared for the Water Replenishment District of Southern California, Rand Report ISBN: 0-8330-2385-3, Santa Monica, California, 124 p.

Steelink, C., 1985, Implications of elemental characteristics of humic substances, *in* Aiken, G.R., McKnight, D.M., Wershaw, R.L., and MacCarthy, P., eds., Humic substances in soil, sediment, and water: New York, John Wiley, p. 457–476.

Stevenson, F.J., 1982, Spectroscopic approaches, Chapter 11, *in* Humus chemistry: genesis, composition, reactions: New York, John Wiley, p. 264–284.

Stiff, H.A., Jr., 1951, The interpretation of chemical water analysis by means of patterns: Journal of Petroleum Technology, v. 3, p. 15–17.

Swisher, R.D., 1987, Surfactant biodegradation (second edition): New York, Marcel Dekker, 1,085 p.

Tabor, C.F., and Barber, L.B., II, 1996, Fate of linear alkylbenzene sulfonate in the Mississippi River: Environmental Science and Technology, v. 30, p. 161–171.

Thorn, K.A., and Aiken, G.R., 1998, Biodegration of crude oil into nonvolatile organic acids in a contaminated aquifer near Bemidji, Minnesota: Organic Geochemistry, v. 29, p. 909–931.

Thurman, E.M., Willoughby, T., Barber, L.B., II, and Thorn, K.A., 1987, Determination of alkylbenzene sulfonate surfactants in groundwater using macroreticular resins and carbon-13 nuclear magnetic resonance spectrometry: Analytical Chemistry, v. 59, p. 1798–1802.

Timme, P.J., 1994, National Water Quality Laboratory 1994 services catalog: U.S. Geological Survey Open-file Report 94-304, 103 p.

Tombacz, E., and Regdon, I., 1994, Humic substances as various colloidal systems, *in* Senesi, N., and Miano, T.M., eds., Humic substances in the global environment and implications on human health: New York, Elsevier Science, p. 139–144.

Trehy, M.L., Gledhill, W.E., and Orth, R.G., 1990, Determination of linear alkylbenzenesulfonates and dialkyltetralinsulfonates in water and sediment by gas chromatography/mass spectrometry: Analytical Chemistry, v. 62, p. 2581–2586.

Troxler Electronic Laboratories, Inc., 1983, Instruction manual, depth moisture gages, Research Triangle Park, North Carolina, 55 p.

_______1992, Sentry 200-AP user's manual, Research Triangle Park, North Carolina, 5 chapters and appendixes A–F.

Umari, A.M.J., Martin, P., Schroeder, R.A., Duell, L.F.W., Jr., and Fay, R.G., 1995, Potential for ground-water contamination from movement of wastewater through the unsaturated zone, upper Mojave River Basin, California: U.S. Geological Survey Water-Resources Investigations Report 93-4137, 83 p.

U.S. Environmental Protection Agency, Office of Water, 1996, Drinking water regulations and health advisories, EPA 822-B-96-002, 11 p.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., 1983, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Laboratory Analysis, Chapter A3, 173 p.

Wilson, L.G., Amy, G.L., Gerba, C.P., Gordon, H., Johnson, B., and Miller, J., 1995, Water quality changes during soil aquifer treatment of tertiary effluent: Water Environmental Research, v. 67, p. 371–376.

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APPENDIXES

Appendix 1. Periodic water-level measurements made near the research basin, Montebello Forebay, Los Angeles County, California, between January 1993 and December 1995

[Water level: altitude, in feet above sea level; local identifier for wells near research basin in parentheses; —, no data]

State well No. (Local identifier)	Date	Water level	State well No.	Date	Water level	State well No.	Date	Water level
2S/11W-18L27	04-16-93	162.51		09-27-94	144.13		06-01-94	158.74
(PR8)	08-10-93	161.51		10-11-94	157.18		07-06-94	158.63
	08-11-93	160.78		04-11-95	162.80		08-18-94	148.03
	08-12-93	160.46		05-04-95	163.74		08-30-94	148.64
	08-13-93	160.27		06-27-95	161.67		09-06-94	146.37
	08-16-93	160.03		07-18-95	161.66		09-07-94	151.18
	08-23-93	158.82		07-28-95	161.97		09-09-94	151.73
	08-24-93	158.47		07-30-95	163.24		09-12-94	150.97
	08-28-93	159.15		07-31-95	162.74		09-14-94	150.60
	08-29-93	159.06		08-08-95	161.59		09-16-94	150.17
	08-30-93	159.07		09-08-95	158.63		09-19-94	149.74
	11-17-93	157.50		09-11-95	157.38		09-20-94	149.56
	03-10-94	156.36		09-19-95	159.16		09-21-94	149.36
	03-24-94	157.71		09-29-95	155.81		09-22-94	149.16
	04-04-94	159.48		10-04-95	152.40		09-23-94	149.01
	04-05-94	159.46	2S/11W-18L28	04-16-93	162.61		09-27-94	144.43
	04-06-94	160.19	(PR9)	08-10-93	161.59		10-11-94	157.02
	04-07-94	160.29		08-11-93	160.98		11-16-94	160.14
	04-08-94	160.26		08-12-93	160.80		04-11-95	162.95
	04-21-94	159.86		08-13-93	160.47		05-04-95	163.74
	06-01-94	158.65		08-16-93	160.19		06-27-95	161.71
	07-06-94	158.52		08-23-93	158.95		07-18-95	161.78
	08-18-94	147.93		08-24-93	158.90		07-28-95	162.07
	08-30-94	148.46		08-28-93	159.21		07-30-95	164.42
	09-06-94	146.24		08-29-93	159.21		07-31-95	164.48
	09-07-94	147.81		08-30-93	160.16		08-08-95	161.66
	09-09-94	148.54		11-17-93	157.73		09-06-95	158.74
	09-12-94	148.28		03-10-94	156.39		09-11-95	157.44
	09-14-94	148.06		03-24-94	157.66		09-19-95	160.43
	09-16-94	147.81		04-04-94	159.52		09-29-95	156.43
	09-19-94	147.71		04-05-94	159.90		10-04-95	152.56
	09-20-94	147.62		04-06-94	161.16	2S/11W-18L29	04-16-93	162.06
	09-21-94	147.18		04-07-94	161.31	(PR10)	08-10-93	161.32
	09-22-94	147.04		04-08-94	161.29		08-11-93	160.42
	09-23-94	146.90		04-21-94	160.09		08-12-93	160.15

Appendix 1. Periodic water-level measurements made near the research basin, Montebello Forebay, Los Angeles County, California, between January 1993 and December 1995—Continued

State well No.	Date	Water level	State well No.	Date	Water level	State well No.	Date	Water level
	08-13-93	159.97		07-30-95	162.75		09-21-94	147.99
	08-16-93	159.32		07-31-95	162.40		09-22-94	147.82
	08-23-93	158.35		08-08-95	161.41		09-23-94	147.65
	08-24-93	158.26		09-06-95	158.24		09-27-94	144.18
	08-28-93	158.62		09-11-95	156.99		10-11-94	156.72
	08-29-93	158.55		09-19-95	158.36		11-16-94	160.02
	08-30-93	158.54		09-29-95	155.10		04-11-95	162.75
	11-17-93	156.79		10-04-95	152.03		05-04-95	163.60
	03-10-94	155.93	2S/11W-18L30	04-16-93	162.35		06-27-95	161.43
	04-04-94	159.34	(PR11)	08-10-93	160.84		07-18-95	161.98
	04-05-94	159.34		08-11-93	160.71		07-28-95	162.04
	04-06-94	159.76		08-12-93	160.28		07-30-95	163.79
	04-07-94	159.81		08-16-93	159.60		07-31-95	162.97
	04-08-94	159.73		08-23-93	158.63		08-08-95	161.60
	04-21-94	159.71		08-24-93	158.55		09-06-95	158.52
	06-01-94	157.93		08-28-93	159.25		09-11-95	157.21
	07-06-94	158.18		08-29-93	158.91		09-19-95	159.62
	08-18-94	147.72		08-30-93	158.88		09-29-95	156.18
	08-30-94	148.22		11-17-93	157.16		10-04-95	152.33
	09-06-94	145.97		03-10-94	156.16	2S/11W-18L31	11-16-94	160.17
	09-07-94	147.04		04-04-94	159.49	(WP1)	04-11-95	162.98
	09-09-94	147.66		04-05-94	159.78		05-04-95	163.72
	09-12-94	147.42		04-06-94	160.53		06-27-95	161.71
	09-14-94	147.20		04-07-94	160.63		07-18-95	161.73
	09-16-94	146.94		04-08-94	160.57		07-28-95	162.07
	09-19-94	146.57		04-21-94	159.98		07-30-95	164.84
	09-20-94	146.48		06-01-94	158.15		07-31-95	163.40
	09-21-94	146.35		07-06-94	157.43		08-08-95	161.64
	09-22-94	146.21		08-18-94	147.84		09-19-95	160.85
	09-23-94	146.06		08-30-94	148.45		10-04-95	—
	09-27-94	143.84		09-06-94	146.13	2S/11W-18L32	11-16-94	159.74
	10-11-94	156.22		09-07-94	148.85	(WP2)	04-11-95	162.57
	11-16-94	159.59		09-09-94	149.90		05-04-95	163.31
	04-11-95	162.42		09-12-94	149.45		06-27-95	161.30
	05-04-95	163.39		09-14-94	149.12		07-18-95	161.35
	06-27-95	161.05		09-16-94	148.75		07-28-95	161.67
	07-18-95	161.37		09-19-94	148.30		07-30-95	164.31
	07-28-95	161.79		09-20-94	148.18		07-31-95	162.97

Appendix 1. Periodic water-level measurements made near the research basin, Montebello Forebay, Los Angeles County, California, between January 1993 and December 1995—Continued

State well No.	Date	Water level	State well No.	Date	Water level	State well No.	Date	Water level
	08-08-95	161.25		09-19-95	138.05		11-23-92	127.02
	09-19-95	160.33		09-29-95	134.25		12-09-92	127.31
	09-29-95	156.73	2S/11W-19E1	04-21-94	145.08		01-20-93	137.13
	10-04-95	152.18		06-02-94	137.98		02-19-93	142.51
2S/11W-18L33	07-18-95	162.31		07-06-94	139.42		04-12-93	142.01
(WP3)	09-19-95	157.64		04-11-95	150.46		11-17-93	137.04
	09-29-95	—		05-04-95	148.55		03-10-94	131.48
	10-04-95	—		06-27-95	145.53		04-04-94	139.17
2S/11W-18L34	07-18-95	161.67		07-31-95	148.52		04-05-94	138.92
(WP4)	09-19-95	157.62		09-11-95	136.40		04-07-94	137.73
	09-29-95	155.91		09-19-95	132.99		04-21-94	137.31
	10-04-95	153.08	2S/11W-19C1	07-20-92	141.06		06-01-94	137.47
2S/11W-18L35	07-18-95	162.11		08-14-92	136.66		07-06-94	138.19
(WP5)	09-19-95	157.61		09-30-92	129.04		04-11-95	144.22
	09-29-95	154.46		11-23-92	137.66		05-04-95	141.21
	10-04-95	151.48		12-09-92	143.42		06-27-95	141.52
2S/11W-18P1	07-20-92	141.80		01-20-93	148.35		07-31-95	143.57
	08-14-92	137.85		02-19-93	150.67		09-19-95	131.43
	09-30-92	132.08		04-12-93	146.71		09-29-95	126.98
	11-23-92	136.81		11-17-93	139.95	2S/12W-25Q1	07-20-92	95.50
	12-09-92	147.31		03-10-94	136.96		08-14-92	92.15
	01-20-93	150.15		04-04-94	149.86		09-30-92	87.70
	02-19-93	153.67		04-05-94	148.96		11-23-92	100.14
	04-12-93	148.75		04-07-94	147.81		12-09-92	99.91
	11-17-93	139.10		04-21-94	149.39		02-19-93	113.36
	03-10-94	139.71		06-02-94	145.68		04-12-93	115.07
	04-04-94	151.88		07-06-94	144.20		11-17-93	102.70
	04-05-94	151.19		04-11-95	148.05		03-10-94	113.64
	04-07-94	149.54		05-04-95	151.81		04-04-94	109.50
	04-21-94	152.74		06-27-95	144.23		04-05-94	109.82
	06-02-94	142.33		07-31-95	151.55		04-07-94	109.16
	07-06-94	143.49		09-11-95	141.61		04-21-94	109.66
	04-11-95	149.17		09-19-95	139.85		06-02-94	105.76
	05-04-95	155.60		09-29-95	134.35		07-06-94	111.68
	06-27-95	143.04	2S/12W-24R1	07-20-92	130.76		04-11-95	117.00
	07-31-95	155.33		08-14-92	125.54		05-04-95	113.01
	09-11-95	139.48		09-30-92	115.38		06-27-95	113.10
							07-31-95	109.44

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen—alkalinity

[See table 1 for explanation of local identifier listed under station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; µS/cm, microsiemens per centimeter; °C, degrees Celsius; ft, feet below basin floor or land surface; mg/L, milligrams per liter; —, no data; CR, ceramic-cup lysimeter; SS, stainless steel lysimeter; TF, Teflon lysimeter; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conductance, field (µS/cm) (00095)	Water temperature, (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
2S/11W-18L10LYS	08/10/93	2110	—	—	—	—	190	54	14	4.4	76	—
(CR-RED at 50 ft)	08/11/93	1900	—	—	—	—	200	56	14	4.4	77	—
	08/12/93	1655	—	—	—	—	210	58	15	1.8	80	—
	08/13/93	1020	—	—	—	—	210	58	15	4.6	79	—
	08/16/93	1050	—	—	—	—	210	58	15	4.8	81	—
	08/23/93	1054	—	—	—	—	200	57	15	4.5	81	—
	08/24/93	1800	—	—	—	—	180	50	14	4.7	77	—
	08/28/93	1900	—	—	—	—	200	57	14	5	78	—
	08/29/93	1800	—	—	—	—	220	62	15	4.5	74	—
	08/30/93	1118	—	—	—	—	200	56	15	4.7	73	—
2S/11W-18L11LYS	08/10/93	2135	—	—	—	—	170	47	13	3.4	90	—
(CR-ORG at 25 ft)	08/11/93	1905	—	—	—	—	180	49	13	3.6	91	—
	08/12/93	1700	—	—	—	—	180	52	13	.6	90	—
	08/13/93	1025	—	—	—	—	180	51	13	3.7	91	—
	08/16/93	1055	—	—	—	—	190	53	13	4	91	—
	08/23/93	1109	—	—	—	—	190	53	13	3.8	92	—
	08/24/93	1800	—	—	—	—	180	49	13	3.9	89	—
	08/28/93	1900	—	—	—	—	190	54	14	4.3	90	—
	08/29/93	1800	—	—	—	—	200	55	14	3.7	88	—
	08/30/93	1115	—	—	—	—	190	54	13	4	85	—
2S/11W-18L13LYS	08/10/93	2140	—	—	—	—	250	73	17	9.2	120	—
(CR-BLU at 13.5 ft)	08/11/93	1910	—	—	—	—	240	69	16	9.4	120	—
	08/12/93	1710	—	—	—	—	240	70	16	.8	120	—
	08/13/93	1030	—	—	—	—	250	71	17	9	120	—
	08/16/93	1100	—	—	—	—	250	72	16	9.8	130	—
	08/23/93	1112	—	—	—	—	240	70	16	9.7	120	—

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conduc-tance, field (µS/cm) (00095)	Water tempera-ture, (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Mag-nesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	08/24/93	1800	—	—	—	—	230	65	16	10	120	—
	08/28/93	1900	—	—	—	—	240	69	16	11	130	—
	08/29/93	1800	—	—	—	—	250	72	16	9.4	130	—
	08/30/93	1120	—	—	—	—	210	59	16	9.6	120	—
2S/11W-18L14A	08/10/93	2110	1.4	7.3	800	20.1	200	58	13	4.6	87	—
(MLS20)	08/11/93	2000	—	7.3	756	20.3	180	52	12	4.5	85	150
	08/12/93	2000	—	7.2	774	19.5	200	57	13	3.3	87	160
	08/13/93	1920	—	7.1	809	19.7	190	55	13	4.5	87	160
	08/16/93	1855	.4	7.3	860	19.5	220	62	15	5.2	89	160
	08/23/93	1900	.2	7.1	843	19.5	220	61	16	5.3	92	160
	08/24/93	1700	—	7.1	832	—	220	62	15	4.8	89	170
	08/28/93	1730	—	7.1	802	21.4	200	56	14	4.4	84	160
	08/29/93	1635	—	7	791	21.7	190	55	13	4.7	81	160
	08/30/93	1730	.4	7.2	778	20	200	56	14	4.6	85	150
2S/11W-18L14B	08/10/93	2040	1.4	7.2	901	20.8	240	66	17	7	92	180
(MLS19)	08/11/93	1930	—	7.2	769	20.6	180	54	12	5.2	88	160
	08/12/93	1920	—	7.2	926	19.7	260	73	19	7.2	97	190
	08/13/93	1845	—	7.1	938	20.9	240	67	17	7.2	94	190
	08/16/93	1818	.4	7.3	916	20.5	230	64	16	7.6	94	170
	08/23/93	1830	.4	7.2	918	20	240	66	17	7.2	93	170
	08/24/93	1650	—	7.1	914	—	250	70	18	7.2	97	170
	08/28/93	1715	—	7.2	895	22.6	230	63	17	6.7	88	180
	08/29/93	1620	—	7.2	890	21.7	240	66	17	6.7	94	170
	08/30/93	1715	.6	7.3	885	20	240	66	17	7.1	90	170
2S/11W-18L14C	08/10/93	2005	1.2	7.2	952	21.5	260	74	19	7.9	94	190
(MLS18)	08/11/93	1900	—	7.2	951	21.1	250	72	18	8.1	94	190
	08/12/93	1845	—	7.2	931	20.9	250	70	18	8.4	94	200
	08/13/93	1800	—	7.1	929	21.6	230	64	17	7.6	94	190
	08/16/93	1745	0.4	7.2	931	21	230	65	16	8	95	170

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conduc- tance, field (μS/cm) (00095)	Water tempera- ture, (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Mag- nesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	08/23/93	1815	.4	7.2	917	20.5	240	66	18	7.9	94	170
	08/24/93	1615	—	7.1	916	22.9	250	72	18	7.6	94	160
	08/28/93	1655	—	7.1	903	23.5	230	64	17	6.9	87	180
	08/29/93	1600	—	7.1	894	22.2	240	67	18	7.4	87	170
	08/30/93	1630	.4	7.3	895	20.5	250	70	17	7.3	85	170
2S/11W-18L14D	08/10/93	1930	—	7.4	964	21.6	270	76	19	8.8	100	190
(MLS17)	08/11/93	1830	—	7.3	952	21.2	—	—	—	—	—	200
	08/12/93	1800	—	7.3	946	21.6	240	68	17	7.9	90	210
	08/13/93	1745	—	7.2	952	22	240	69	17	8.2	100	200
	08/16/93	1705	.4	7.3	973	21	240	67	17	9.2	100	180
	08/23/93	1800	.4	7.3	984	21	260	73	19	10	99	180
	08/24/93	1550	—	7.2	981	23.2	260	73	19	8.6	99	170
	08/28/93	1640	—	7.1	952	23.3	240	67	18	7.7	93	190
	08/29/93	1540	—	7.1	951	23.3	250	71	18	8.5	93	190
	08/30/93	1600	.4	7.3	952	21	250	72	18	8.4	95	180
2S/11W-18L14E	08/10/93	1915	1.4	7.3	877	21.2	250	69	18	7.1	91	170
(MLS16)	08/11/93	1745	—	7.3	874	22.1	230	67	16	8.1	88	170
	08/12/93	1700	—	7.2	871	21.8	240	68	17	6.8	89	180
	08/13/93	1720	—	7.2	878	21.1	220	63	16	6.9	89	180
	08/16/93	1620	.6	7.2	927	21	230	64	17	8	97	170
	08/23/93	1710	.4	7.1	952	21	260	73	19	7.9	93	160
	08/24/93	1525	—	7.1	955	23.1	280	79	20	7.2	88	160
	08/28/93	1620	—	7.1	900	23.1	240	67	18	6.8	81	170
	08/29/93	1510	—	7	904	23.3	250	69	18	7.2	80	170
	08/30/93	1540	.4	7.2	904	21	250	72	18	7.5	82	160
2S/11W-18L14F	08/10/93	1755	1.4	7.2	839	21.7	230	64	17	7.2	84	160
(MLS15)	08/11/93	1700	—	7.1	851	22.3	—	—	—	—	—	160
	08/12/93	1620	—	7.1	858	21.7	250	70	18	6.5	78	150

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conductance, field (μS/cm) (00095)	Water temperature, (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	08/13/93	1700	—	7	836	21.1	240	66	17	7.1	77	150
	08/16/93	1530	0.4	7.1	914	21.5	270	75	20	8.4	80	150
	08/23/93	1700	.6	7	940	21.5	290	81	20	8.1	75	150
	08/24/93	1450	—	7	940	—	290	82	21	8	78	150
	08/28/93	1600	—	6.9	892	23.2	270	74	20	7.2	70	150
	08/29/93	1450	—	6.9	912	22.9	280	79	20	8.3	74	150
	08/30/93	1440	.4	7.1	878	21	270	78	19	7.6	69	140
2S/11W-18L14G	08/10/93	1710	1.2	7.3	855	22.3	250	70	18	7.8	74	150
(MLS14)	08/11/93	1610	—	7	856	23.1	250	72	18	7.1	77	160
	08/12/93	1500	—	7.1	880	22.5	260	71	19	8.1	72	150
	08/13/93	1645	—	7.1	912	21.3	270	75	20	8.1	74	170
	08/16/93	1550	.4	7.1	972	22	290	82	21	9	78	160
	08/23/93	1630	.6	7.1	950	22	290	82	21	9.8	80	150
	08/24/93	1430	—	6.9	935	—	290	83	21	7.7	78	150
	08/28/93	1500	—	7	923	22.8	270	75	20	8	75	150
	08/29/93	1250	—	7	934	21.9	280	78	20	8.2	79	150
	08/30/93	1430	.4	7	949	21	290	81	20	7.9	80	160
2S/11W-18L14H	08/10/93	1625	1.2	7.1	895	22.6	270	78	19	7.8	72	150
(MLS13)	08/11/93	1545	—	7	909	22.5	290	81	20	9.1	74	160
	08/12/93	1445	—	7	932	23.6	290	83	21	7.1	73	160
	08/13/93	1620	—	7	955	21.8	290	81	20	7.6	77	170
	08/16/93	1430	.6	7.1	1,010	23.5	270	78	19	8.5	97	160
	08/23/93	1600	.4	7.1	972	22.5	280	80	20	8.8	85	160
	08/24/93	1315	—	7.1	970	24.5	300	86	21	7.6	90	160
	08/28/93	1515	—	6.9	957	23.4	270	78	19	8.1	80	160
	08/29/93	1235	—	7	952	22	300	85	20	7.5	82	160
	08/30/93	1310	.4	7.1	950	21.5	290	81	20	7.3	79	160
2S/11W-18L14I	08/10/93	1525	1.6	7.1	898	23.4	290	85	19	6.9	72	140
(MLS12)	08/11/93	1520	—	7	917	22.5	—	—	—	—	—	150

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conduc- tance, field (µS/cm) (00095)	Water tempera- ture, (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Mag- nesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	08/12/93	1315	—	7	932	22.7	300	86	20	7.2	73	160
	08/13/93	1530	—	7	965	22	300	85	21	7.3	81	180
	08/16/93	1250	0.4	7.1	1,020	24	250	73	17	7.8	110	160
	08/23/93	1520	.6	7.1	990	23	290	82	21	8.6	87	170
	08/24/93	1220	—	7.1	983	24.5	290	83	20	7.4	88	160
	08/28/93	1335	—	7	965	23.4	280	80	20	8.2	79	160
	08/29/93	1220	—	7.1	957	22.3	290	83	20	7.1	78	160
	08/30/93	1230	.4	7.1	950	22	300	85	20	7.3	78	150
2S/11W-18L14J (MLS11)	08/10/93	1500	1.4	7	922	22.7	290	84	20	7.1	76	150
	08/11/93	1240	—	6.9	914	22.8	300	87	20	6.8	77	150
	08/12/93	1250	—	7	956	22.6	300	87	21	7.2	77	180
	08/13/93	1500	—	7.1	993	22.5	270	79	18	6.9	93	190
	08/16/93	1245	.6	7.3	1,040	24.5	240	68	16	7.9	120	170
	08/23/93	1500	.4	7.1	1,000	23	290	82	20	9	89	170
	08/24/93	1200	—	7.1	993	24	300	85	20	7.8	92	170
	08/28/93	1315	—	6.9	974	24	290	82	20	8	79	170
	08/29/93	1200	—	7	970	23	300	87	21	7	79	160
	08/30/93	1215	.4	7.1	965	22.5	310	88	21	7.3	84	160
2S/11W-18L14K (MLS10)	08/10/93	1415	1.4	7.1	952	23.8	300	82	22	10	83	170
	08/11/93	1210	—	7	931	22.4	300	89	19	8.9	79	160
	08/12/93	1220	—	7.1	989	22.5	310	88	21	8.2	85	220
	08/13/93	1300	—	7.2	1,010	21.8	260	74	17	8	110	190
	08/16/93	1200	.6	7.4	1,050	25.5	230	67	16	9.2	120	170
	08/23/93	1230	.4	7.3	1,040	24	270	77	19	9.6	110	190
	08/24/93	1105	—	7.1	1,030	—	280	79	20	9.8	110	—
	08/28/93	1250	—	7	1,010	23.8	300	85	21	9.2	84	180
	08/29/93	1125	—	7.1	1,000	23.1	310	90	21	8.2	84	180
	08/30/93	1150	.4	7.1	990	23	310	89	21	7.8	84	170

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conductance, field (μS/cm) (00095)	Water temperature, (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
2S/11W-18L14L	08/10/93	1345	1.4	7	938	23	290	82	20	7.8	78	160
(MLS9)	08/11/93	1115	—	7.1	951	22.7	300	85	21	9.6	81	160
	08/12/93	1130	—	7.2	1,020	22.9	300	84	22	10	83	220
	08/13/93	1230	—	7.2	1,030	22.4	240	66	18	10	110	190
	08/16/93	1130	.6	7.4	1,060	25.5	230	64	17	11	120	180
	08/23/93	1210	.4	7.4	1,070	24	260	69	20	12	120	200
	08/24/93	1045	—	7.4	1,060	—	250	70	19	—	120	200
	08/28/93	1230	—	7.2	1,090	23.9	300	81	23	13	100	220
	08/29/93	1105	—	7.2	1,070	23.1	310	87	23	11	98	220
	08/30/93	1130	.4	7.2	1,050	23	300	81	23	11	95	200
2S/11W-18L14M	08/10/93	1230	1.4	7.3	1,000	23.6	240	69	17	10	100	210
(MLS8)	08/11/93	1030	—	7.3	1,010	22.6	250	72	17	9.8	100	210
	08/12/93	1100	—	7.3	1,000	23.5	270	76	19	9.5	110	230
	08/13/93	1150	—	7.4	1,000	22.3	240	66	17	9.1	110	220
	08/16/93	1100	.4	7.4	1,030	25.5	240	68	16	10	110	190
	08/23/93	1145	.6	7.4	1,030	24.5	240	68	18	7.9	120	190
	08/24/93	1020	—	7.3	1,030	24.1	250	69	18	9.8	110	180
	08/28/93	1120	—	7.2	1,010	24.4	240	67	17	11	110	230
	08/29/93	1050	—	7.3	1,010	23	250	72	18	8.8	110	200
	08/30/93	1050	.4	7.3	995	23.5	260	74	18	8.9	100	200
2S/11W-18L14N	08/10/93	1115	.4	7.5	1,090	24.6	230	64	18	12	130	250
(MLS7)	08/11/93	1000	—	7.5	1,080	23.5	240	65	18	12	130	250
	08/12/93	1030	—	7.5	1,050	24	230	62	18	12	130	250
	08/13/93	1040	—	7.5	1,050	22.6	220	60	17	11	120	230
	08/16/93	1015	.4	7.5	1,070	26	220	60	17	13	130	190
	08/23/93	1100	.4	7.5	1,060	24.5	230	64	18	10	120	200
	08/24 /93	0930	—	7.5	1,060	—	230	62	18	2.5	120	190
	08/28/93	1050	—	7.5	1,040	24.6	220	59	17	12	120	220
	08/29/93	1030	—	7.5	1,030	24.2	230	64	18	11	120	240

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conduc-tance, field (μS/cm) (00095)	Water tempera-ture, (ºC) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Mag-nesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	08/30/93	1030	0.4	7.6	1,040	24.5	240	65	18	10	120	230
2S/11W-18L14O	08/10/93	1010	.2	7.5	1,080	19.5	240	65	18	.1	130	250
(MLS6)	08/11/93	0930	—	7.4	1,050	23.1	220	61	16	2.2	120	230
	08/12/93	0930	—	7.4	1,040	24	230	63	17	13	110	260
	08/13/93	1015	—	7.5	1,060	22.3	230	64	17	10	120	240
	08/16/93	1000	.6	7.5	1,060	26	230	63	17	11	120	200
	08/23/93	1050	.4	7.6	1,050	25	240	66	18	10	120	200
	08/24/93	0850	—	7.4	1,050	24.1	230	64	18	—	120	200
	08/28/93	1020	—	7.5	1,030	23.9	240	65	18	12	120	210
	08/29/93	1015	—	7.5	1,030	24.3	240	65	18	11	120	220
	08/30/93	1000	.4	7.4	1,020	24.5	240	67	18	9.8	110	220
2S/11W-18L14P	08/10/93	0846	.4	7.6	1,060	24.2	230	67	16	11	120	250
(MLS5)	08/11/93	0900	—	7.4	1,040	23.6	230	66	16	9.2	120	250
	08/12/93	0900	—	7.3	1,030	23.6	240	66	17	9.9	110	260
	08/13/93	0845	—	7.4	1,050	22.1	220	61	16	10	120	280
	08/16/93	0900	.6	7.6	1,060	25.5	240	66	17	13	120	230
	08/23/93	0945	.4	7.7	1,050	25	230	63	18	14	130	220
	08/24/93	0830	—	7.4	1,050	24.1	230	63	17	—	120	210
	08/28/93	0930	—	7.5	1,040	24.7	220	62	16	12	120	220
	08/29/93	0930	—	7.6	1,030	24.6	230	63	17	11	120	240
	08/30/93	0920	.4	7.5	1,020	25	230	65	17	10	120	240
2S/11W-18L14Q	08/10/93	0845	.4	7.4	1,050	23.3	220	62	16	1.1	130	270
(MLS4)	08/11/93	0845	—	7.4	1,060	23.9	200	57	15	9.4	130	290
	08/12/93	0845	—	7.5	1,050	24.6	220	61	16	11	130	270
	08/13/93	0810	—	7.4	1,070	22.8	210	59	15	9.7	130	240
	08/16/93	0845	.4	7.6	1,080	25.5	220	62	15	11	130	220
	08/23/93	0920	.6	7.8	1,070	25	220	64	15	10	130	220
	08/24/93	0815	—	7.3	1,060	24.3	230	66	15	9.7	130	210

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conductance, field (µS/cm) (00095)	Water temperature, (ºC) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	08/28/93	0930	—	7.4	1,050	24.8	220	63	15	11	120	230
	08/29/93	0910	—	7.6	1,040	24.6	220	63	15	10	130	250
	08/30/93	0820	0.4	7.5	1,030	25	220	64	15	10	130	250
2S/11W-18L15LYS	08/10/93	1955	—	—	—	—	140	33	13	4.4	70	—
(SS-RED at 49 ft)	08/11/93	1815	—	—	—	—	140	35	13	4.2	73	—
	08/12/93	1550	—	—	—	—	140	37	12	.7	71	—
	08/13/93	0905	—	—	—	—	140	36	12	3.9	71	—
	08/16/93	0750	—	—	—	—	150	39	12	4.3	71	—
	08/23/93	0850	—	—	—	—	150	40	13	4.3	80	—
	08/24/93	1800	—	—	—	—	—	—	—	—	—	—
	08/28/93	1900	—	—	—	—	140	37	12	4.8	77	—
	08/29/93	1800	—	—	—	—	160	40	14	4.4	83	—
	08/30/93	0900	—	—	—	—	160	42	13	4.4	79	—
2S/11W-18L16LYS	08/10/93	2015	—	—	—	—	51	15	3.1	3.6	93	—
(SS-ORG at 25 ft)	08/11/93	1835	—	—	—	—	82	25	4.7	3.5	110	—
	08/12/93	1555	—	—	—	—	140	42	8	.1	96	—
	08/13/93	0915	—	—	—	—	150	46	9.3	4	92	—
	08/16/93	0755	—	—	—	—	170	51	9.7	4.4	93	—
	08/23/93	0851	—	—	—	—	100	28	7.8	4.7	96	—
	08/24/93	1800	—	—	—	—	75	20	5.9	3.9	92	—
	08/28/93	1900	—	—	—	—	120	32	9.4	4.9	89	—
	08/29/93	1800	—	—	—	—	110	30	9.1	3.9	88	—
	08/30/93	0900	—	—	—	—	270	75	19	4.2	85	—
2S/11W-18L17LYS	08/10/93	2025	—	—	—	—	170	51	9.3	6.5	110	—
(SS-YEL at 15 ft)	08/11/93	1830	—	—	—	—	170	52	9.5	6.5	110	—
	08/12/93	1610	—	—	—	—	190	57	12	5	89	—
	08/13/93	0920	—	—	—	—	200	58	13	6.7	88	—
	08/16/93	0800	—	—	—	—	230	68	15	6.9	90	—
	08/23/93	0853	—	—	—	—	210	60	15	6.9	92	—

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conductance, field (μS/cm) (00095)	Water temperature, (ºC) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	08/24/93	1800	—	—	—	—	190	52	14	6.9	92	—
	08/28/93	1900	—	—	—	—	240	65	18	8.6	86	—
	08/29/93	1800	—	—	—	—	220	61	17	7	86	—
	08/30/93	0900	—	—	—	—	250	70	19	7.2	80	—
2S/11W-18L18LYS	08/10/93	2100	—	—	—	—	180	49	15	8.4	110	—
(SS-GRE at 10 ft)	08/11/93	1840	—	—	—	—	240	72	15	9.4	110	—
	08/12/93	1615	—	—	—	—	230	67	16	2.6	100	—
	08/13/93	0925	—	—	—	—	250	71	18	8.9	94	—
	08/16/93	0805	—	—	—	—	260	74	19	9.6	100	—
	08/23/93	0854	—	—	—	—	230	64	17	9.5	120	—
	08/24/93	1800	—	—	—	—	—	—	—	—	—	—
	08/28/93	1900	—	—	—	—	220	63	16	10	120	—
	08/29/93	1800	—	—	—	—	230	65	16	8.7	120	—
	08/30/93	0900	—	—	—	—	250	70	19	8.8	110	—
2S/11W-18L19LYS	08/10/93	2110	—	—	—	—	—	—	—	3.5	—	—
(SS-BLU at 5 ft)	08/11/93	1845	—	—	—	—	140	40	8.7	6.1	180	—
	08/12/93	1620	—	—	—	—	150	45	8.7	2.9	180	—
	08/13/93	0930	—	—	—	—	130	43	6.1	5.2	180	—
	08/16/93	0810	—	—	—	—	150	47	7.3	5.7	170	—
	08/23/93	0855	—	—	—	—	100	33	5.3	5.5	180	—
	08/24/93	1800	—	—	—	—	72	24	2.8	4.9	190	—
	08/28/93	1900	—	—	—	—	110	37	5.3	6.5	180	—
	08/29/93	1800	—	—	—	—	—	—	—	.2	—	—
	08/30/93	0900	—	—	—	—	120	38	6.1	5.8	170	—
2S/11W-18L20LYS	08/10/93	2107	—	—	—	—	280	77	21	9.4	76	—
(CR-YEL at 15 ft)	08/11/93	1855	—	—	—	—	270	75	20	9.2	70	—
	08/12/93	1645	—	—	—	—	300	83	22	0.1	76	—
	08/13/93	0940	—	—	—	—	280	77	21	9.2	73	—

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conductance, field (µS/cm) (00095)	Water temperature, (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	08/16/93	0925	—	—	—	—	320	90	23	10	83	—
	08/23/93	0902	—	—	—	—	290	80	21	9.8	89	—
	08/24/93	1800	—	—	—	—	280	76	21	9.2	88	—
	08/28/93	1900	—	—	—	—	300	84	21	9.1	87	—
	08/29/93	1800	—	—	—	—	320	92	22	7.6	87	—
	08/30/93	1022	—	—	—	—	300	83	22	8	84	—
2S/11W-18L21LYS	08/10/93	2145	—	—	—	—	—	—	—	—	—	—
(CR-GRE at 9 ft)	08/11/93	1850	—	—	—	—	150	40	11	4.5	190	—
	08/12/93	1635	—	—	—	—	190	51	14	4	160	—
	08/13/93	0935	—	—	—	—	190	51	14	5.6	160	—
	08/16/93	0920	—	—	—	—	190	54	14	6.1	160	—
	08/23/93	0903	—	—	—	—	170	47	12	5.8	170	—
	08/24/93	1800	—	—	—	—	140	37	11	4.8	180	—
	08/28/93	1900	—	—	—	—	190	52	14	6.7	170	—
	08/29/93	1800	—	—	—	—	180	50	14	5.1	180	—
	08/30/93	1020	—	—	—	—	190	51	15	6	160	—
2S/11W-18L23LYS	08/10/93	2200	—	—	—	—	—	—	—	—	—	—
(TF-ORG at 25 ft)	08/11/93	1915	—	—	—	—	260	74	18	9.8	98	—
	08/16/93	1205	—	—	—	—	170	50	12	4.2	75	—
	08/23/93	0936	—	—	—	—	170	49	12	4.2	76	—
	08/24/93	1800	—	—	—	—	—	—	—	—	—	—
	08/30/93	1515	—	—	—	—	180	49	13	4.6	76	—
2S/11W-18L25LYS	08/10/93	2205	—	—	—	—	—	—	—	—	—	—
(TF-GRE at 10 ft)												
2S/11W-18L26LYS	08/10/93	2110	—	—	—	—	—	—	—	—	—	—
(TF-BLU at 5 ft)	08/23/93	0940	—	—	—	—	—	—	—	—	—	—
	08/24/93	1800	—	—	—	—	—	—	—	—	—	—
2S/11W-18L27	08/10/93	1835	—	7.3	687	19.7	180	49	13	4	78	150
(PR8 at 49 ft)	08/11/93	1730	—	7.3	700	21.1	170	47	13	4.4	76	150

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conduc-tance, field (µS/cm) (00095)	Water tempera-ture, (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Mag-nesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	08/12/93	1730	—	7.3	695	20.8	180	49	13	.9	72	150
	08/13/93	1820	—	7.2	714	20	170	48	13	4	75	150
	08/16/93	1650	0.2	7.3	707	19	180	51	13	4.3	72	150
	08/23/93	1530	.2	7.2	700	19	180	49	14	4.5	74	140
	08/24/93	1305	—	7.3	696		180	50	13	4	77	140
	08/28/93	1350	—	7.2	718	21	190	51	14	4.1	79	140
	08/29/93	1305	—	7.2	717	21	180	50	14	4.1	77	150
	08/30/93	1450	.2	7.2	720	20	190	52	14	4.1	76	140
2S/11W-18L28	08/10/93	2145	.8	6.9	683	18.8	170	48	13	4.2	71	140
(PR9 at 25 ft)	08/11/93	1500	—	7.1	695	21	170	48	13	4.8	74	140
	08/12/93	1600	—	7	702	20.8	180	50	14	4.4	74	140
	08/13/93	1600	—	7.1	716	19.6	180	48	14	4.3	74	140
	08/16/93	1910	.2	7	732	19	190	53	14	4.6	72	140
	08/23/93	1730	.2	7	770	19	200	55	16	4.7	81	130
	08/24/93	1510	—	7	772	—	210	57	16	4.5	80	130
	08/28/93	1530	—	7.1	764	20.9	200	56	15	4.6	80	140
	08/29/93	1535	—	7	759	21.5	200	54	15	4.2	75	140
	08/30/93	1620	.2	7	753	19	200	56	15	4.6	78	140
2S/11W-18L29	08/10/93	1100	1	7	779	21	220	63	16	5.5	66	130
(PR10 at 60 ft)	08/11/93	1045	—	7.3	651	19.4	160	46	12	4	75	140
	08/12/93	0945	—	7.3	661	18.5	160	45	12	.1	69	140
	08/13/93	1120	—	7.3	669	19	160	44	12	4.1	73	140
	08/16/93	1035	.2	7.2	673	18	170	47	13	4.3	75	150
	08/23/93	1250	.2	7.2	690	18.5	170	48	13	4.7	74	140
	08/24/93	0720	—	7.3	694	—	170	47	13	4.3	78	140
	08/28/93	1000	—	7.2	727	19.9	170	48	13	4.2	77	150
	08/29/93	1140	—	7.2	724	19.5	180	49	14	4.5	80	150
	08/30/93	1250	0.2	7.2	730	19	190	52	14	4.6	79	140

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conduc-tance, field (µS/cm) (00095)	Water tempera-ture, (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Mag-nesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
2S/11W-18L30	08/10/93	1550	1.2	7.2	651	20.8	160	45	12	4.1	74	140
(PR11 at 36 ft)	08/11/93	1300	—	6.9	761	20.7	230	65	16	6.4	67	130
	08/12/93	1200	—	6.9	758	20	240	66	17	5.8	69	130
	08/13/93	1330	—	7	752	20	210	59	16	5.1	67	130
	08/16/93	1450	.2	6.9	761	19	210	60	15	5.6	68	140
	08/23/93	1015	.2	6.9	782	18.5	220	62	16	6	73	—
	08/24/93	1130	—	6.9	766	20.5	210	59	15	5.3	76	130
	08/28/93	1215	—	6.9	787	20.3	210	58	15	5.1	74	140
	08/29/93	0955	—	7	797	19.2	220	61	16	5.1	78	140
	08/30/93	1100	.2	6.9	812	19	230	66	16	5.5	75	130
POND AT PICO	08/10/93	2200	2.8	9.7	1040	23.8	230	61	19	1.3	130	190
(PR12)	08/11/93	2100	—	8	1060	24.1	230	62	19	8.8	130	170
	08/12/93	2030	—	8.9	1040	24.5	220	58	19	13	120	170
	08/13/93	0910	—	8.1	1070	26	230	59	19	11	120	170
	08/16/93	1940	—	9.1	1030	26	230	60	19	13	120	160
	08/23/93	1920	6	8.1	1040	25	230	60	20	11	120	160
	08/23/93	1930	2.8	7.9	1050	25.5	240	63	20	13	120	160
	08/23/93	1950	1	7.7	1050	25.5	230	61	19	12	130	170
	08/23/93	2030	—	8.9	1030	25	230	58	20	13	130	—
	08/24/93	1720	—	8.7	1030	25.5	240	61	20	—	130	160
	08/28/93	1745	—	8.8	1030	25.7	220	57	19	11	120	170
	08/29/93	1700	—	8.8	1030	25.6	220	58	19	12	120	180
	08/30/93	1745	7	8.8	1030	26	230	60	19	10	120	170
SEWAGE EFFLUENT	08/10/93	2245	1	7.3	1050	24.3	230	60	19	7.1	120	180
(PR13)	08/11/93	2045	—	7.5	1090	25.5	230	59	19	8.7	120	200
	08/12/93	1950	—	7.5	1100	24.4	220	58	18	1.9	110	200
	08/13/93	1900	—	7.5	1130	24.2	220	57	18	10	120	210
	08/16/93	2000	5	7.5	1120	26	220	58	18	13	110	210
	08/23/93	2010	—	7.4	1080	24.5	220	56	19	13	110	210

Appendix 2A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conduc-tance, field (μS/cm) (00095)	Water tempera-ture, (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) 00915)	Mag-nesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	08/24/93	1750	—	7.3	1100	26.5	220	60	18	—	110	200
	08/28/93	1805	—	7.4	1130	27.4	220	57	18	11	110	220
	08/29/93	1720	—	7.4	1110	26.6	230	59	19	11	120	190
	08/30/93	1810	3.2	7.4	1130	28	230	61	18	11	120	210

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus

[See table 1 for explanation of local identifier listed below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; mg/L, milligrams per liter; <, actual value less than value shown; —, no data; CR, ceramic-cup lysimeter; SS, stainless steel lysimeter; TF, Teflon lysimeter; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, orthophosphate, dissolved (mg/L as P) (00671)
2S/11W-18L10LYS	08/10/93	2110	—	—	—	20	—	—	0.03	0.07	0.092	0.02	0.23
(CR-RED at 50 ft)	08/11/93	1900	—	—	—	20	—	—	.03	.04	.06	.02	.25
	08/12/93	1655	—	—	—	21	—	—	.04	—	<.050	.01	.25
	08/13/93	1020	—	—	—	21	—	—	.01	—	<.050	<.010	.26
	08/16/93	1050	—	—	—	20	—	—	.04	—	<.050	<.010	.26
	08/23/93	1054	—	—	—	19	—	—	.03	—	<.050	<.010	.26
	08/24/93	1800	—	—	—	20	—	—	.03	—	.24	<.010	.26
	08/28/93	1900	—	—	—	21	—	—	.01	—	.33	<.010	.27
	08/29/93	1800	—	—	—	21	—	—	.04	—	.22	<.010	.29
	08/30/93	1118	—	—	—	20	—	—	.02	—	.19	<.010	.28
2S/11W-18L11LYS	08/10/93	2135	—	—	—	28	—	—	.03	.27	.29	.02	.17
(CR-ORG at 25 ft)	08/11/93	1905	—	—	—	25	—	—	.03	.26	.27	.01	.17
	08/12/93	1700	—	—	—	27	—	—	.04	.23	.24	.01	.17
	08/13/93	1025	—	—	—	27	—	—	.02	—	.2	<.010	.18
	08/16/93	1055	—	—	—	27	—	—	.03	.16	.18	.02	.17
	08/23/93	1109	—	—	—	26	—	—	.02	—	.11	<.010	.15
	08/24/93	1800	—	—	—	27	—	—	.02	—	<.050	.03	.04
	08/28/93	1900	—	—	—	27	—	—	.01	—	<.050	<.010	.15
	08/29/93	1800	—	—	—	27	—	—	.02	—	<.050	<.010	.15
	08/30/93	1115	—	—	—	26	—	—	.02	—	<.050	<.010	.16
2S/11W-18L13LYS	08/10/93	2140	—	—	—	35	—	—	1.1	.03	.058	.03	.72
(CR-BLU at 13.5 ft)	08/11/93	1910	—	—	—	31	—	—	1.3	—	<.050	<.010	.81
	08/12/93	1710	—	—	—	33	—	—	1.3	—	<.050	<.010	.86
	08/13/93	1030	—	—	—	34	—	—	1.3	—	<.050	<.010	.84
	08/16/93	1100	—	—	—	34	—	—	1.4	—	<0.050	<0.010	0.91

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, orthophosphate, dissolved (mg/L as P) (00671)
	08/23/93	1112	—	—	—	35	—	—	1.4	—	<.050	<.010	.96
	08/24/93	1800	—	—	—	34	—	—	1.3	—	<.050	<.010	.94
	08/28/93	1900	—	—	—	34	—	—	1.4	—	<.050	<.010	.98
	08/29/93	1800	—	—	—	35	—	—	1.5	—	<.050	<.010	1
	08/30/93	1120	—	—	—	—	—	—	1.5	—	<.050	<.010	1
2S/11W-18L14A	08/10/93	2110	0.1	83	0.4	22	120	—	.34	0.59	.61	.02	.41
(MLS20)	08/11/93	2000	—	—	—	22	—	—	.23	.67	.69	.02	.38
	08/12/93	2000	—	—	—	22	—	—	.2	.83	.85	.02	.33
	08/13/93	1920	—	—	—	21	—	—	.2	1.08	1.1	.02	.33
	08/16/93	1855	—	—	—	21	—	—	.2	1.27	1.3	.03	.33
	08/23/93	1900	—	—	—	22	—	—	.18	1.27	1.3	.03	.35
	08/24/93	1700	—	—	—	22	—	—	.17	.94	.98	.04	.32
	08/28/93	1730	—	—	—	21	—	—	.16	.71	.74	.03	.33
	08/29/93	1635	—	—	—	21	—	—	.15	.39	.41	.02	.3
	08/30/93	1730	—	—	—	22	—	—	.14	.22	.23	.01	.31
2S/11W-18L14B	08/10/93	2040	—	—	—	22	—	—	.9	1.18	1.2	.02	.69
(MLS19)	08/11/93	1930	—	—	—	22	—	—	.27	.54	.56	.02	.44
	08/12/93	1920	—	—	—	24	—	—	1.1	1.19	1.2	.01	.84
	08/13/93	1845	—	—	—	23	—	—	1.1	.92	.93	.01	.82
	08/16/93	1818	—	—	—	23	—	—	1.1	.22	.23	.01	.89
	08/23/93	1830	—	—	—	23	—	—	—	—	—	—	—
	08/24/93	1650	—	—	—	24	—	—	.96		.62	<.010	.76
	08/28/93	1715	—	—	—	22	—	—	.94	.44	.45	.01	.89
	08/29/93	1620	.14	96	.4	23	140	558	.84	1.19	1.2	.01	.87
	08/30/93	1715	—	—	—	23	—	—	.87	.32	.33	.01	.91
2S/11W-18L14C	08/10/93	2005	—	—	—	22	—	—	1.1	2.47	2.5	.03	.82
(MLS18)	08/11/93	1900	—	—	—	23	—	—	1.2	1.68	1.7	0.02	0.89

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, orthophosphate, dissolved (mg/L as P) (00671)
	08/12/93	1845	—	—	—	23	—	—	1.3	.78	.8	.02	.97
	08/13/93	1800	—	—	—	23	—	—	1.2	.36	.38	.02	.89
	08/16/93	1745	—	—	—	23	—	—	1.2	—	<.050	<.010	.99
	08/23/93	1815	—	—	—	23	—	—	1.2	—	<.050	<.010	.92
	08/24/93	1615	—	—	—	24	—	—	1.2	—	.052	<.010	.89
	08/28/93	1655	—	—	—	22	—	—	1.1	—	.09	<.010	1
	08/29/93	1600	—	—	—	22	—	—	.97	—	.077	<.010	.96
	08/30/93	1630	—	—	—	23	—	—	.98	—	.074	<.010	.99
2S/11W-18L14D	08/10/93	1930	—	—	—	24	—	—	1.6	1.19	1.2	.01	1.1
(MLS17)	08/11/93	1830	—	—	—	—	—	—	1.6	—	.7	<.010	1.1
	08/12/93	1800	—	—	—	23	—	—	1.7	.29	.3	.01	1.2
	08/13/93	1745	—	—	—	24	—	—	1.6	—	<.050	<.010	1.1
	08/16/93	1705	—	—	—	24	—	—	1.5	—	<.050	<.010	1.2
	08/23/93	1800	—	—	—	23	—	—	1.6	—	<.050	<.010	1.1
	08/24/93	1550	—	—	—	23	—	—	1.4	—	<.050	<.010	1
	08/28/93	1640	—	—	—	23	—	—	1.5	—	.096	<.010	1.3
	08/29/93	1540	—	—	—	23	—	—	1.4	—	.063	<.010	1.3
	08/30/93	1600	—	—	—	23	—	—	1.4	—	<.050	<.010	1.3
2S/11W-18L14E	08/10/93	1915	—	—	—	23	—	—	.82	—	1.2	<.010	.67
(MLS16)	08/11/93	1745	—	—	—	23	—	—	.88	—	.72	<.010	.69
	08/12/93	1700	—	—	—	23	—	—	.94	—	.22	<.010	.72
	08/13/93	1720	—	—	—	23	—	—	.91	—	<.050	<.010	.76
	08/16/93	1620	—	—	—	23	—	—	1.2	—	.063	<.010	.94
	08/23/93	1710	0.13	110	0.4	23	170	600	1	—	<.050	<.010	.81
	08/24/93	1525	—	—	—	23	—	—	.75	—	<.050	<.010	.64
	08/28/93	1620	—	—	—	22	—	—	.97	—	.056	<.010	.9
	08/29/93	1510	—	—	—	22	—	—	0.99	—	<0.050	<0.010	0.91

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, ortho-phosphate, dissolved (mg/L as P) (00671)
	08/30/93	1540	—	—	—	23	—	—	.96	—	<.050	<.010	.88
2S/11W-18L14F	08/10/93	1755	—	—	—	21	—	—	.63	—	2.2	<.010	.47
(MLS15)	08/11/93	1700	—	—	—	—	—	—	.67	—	1.2	<.010	.49
	08/12/93	1620	—	—	—	22	—	—	.76	—	.052	<.010	.53
	08/13/93	1700	—	—	—	21	—	—	.74	—	<.050	<.010	.52
	08/16/93	1530	—	—	—	21	—	—	.79	—	<.050	<.010	.48
	08/23/93	1700	—	—	—	22	—	—	.83	—	<.050	<.010	.48
	08/24/93	1450	—	—	—	22	—	—	.8	—	<.050	<.010	.47
	08/28/93	1600	—	—	—	21	—	—	.77	—	<.050	<.010	.49
	08/29/93	1450	—	—	—	21	—	—	.8	—	<.050	<.010	.53
	08/30/93	1440	—	—	—	22	—	—	.74	—	<.050	<.010	.48
2S/11W-18L14G	08/10/93	1710	—	—	—	21	—	—	.76	—	.58	<.010	.62
(MLS14)	08/11/93	1610	—	—	—	22	—	—	.8	—	.34	<.010	.64
	08/12/93	1500	—	—	—	21	—	—	.92	—	<.050	<.010	.65
	08/13/93	1645	—	—	—	21	—	—	1.1	—	<.050	<.010	.68
	08/16/93	1550	—	—	—	21	—	—	1.1	—	.14	<.010	.69
	08/23/93	1630	—	—	—	21	—	—	1.1	—	<.050	<.010	.64
	08/24/93	1430	—	—	—	22	—	—	.76	—	<.050	<.010	.45
	08/28/93	1500	—	—	—	20	—	—	.9	—	<.050	<.010	.63
	08/29/93	1250	—	—	—	20	—	—	.85	—	<.050	<.010	.61
	08/30/93	1430	—	—	—	21	—	—	.92	—	<.050	<.010	.7
2S/11W-18L14H	08/10/93	1625	—	—	—	20	—	—	.92	—	<.050	<.010	.64
(MLS13)	08/11/93	1545	—	—	—	21	—	—	.87	—	<.050	<.010	.64
	08/12/93	1445	—	—	—	20	—	—	.89	—	<.050	<.010	.64
	08/13/93	1620	—	—	—	20	—	—	.86	—	<.050	<.010	.63
	08/16/93	1430	—	—	—	21	—	—	.78	—	.25	<.010	.73
	08/23/93	1600	—	—	—	19	—	—	0.66	—	<0.05	<0.01	0.68

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, orthophosphate, dissolved (mg/L as P) (00671)
	08/24/93	1315	—	—	—	20	—	—	.6	—	<.050	<.010	.64
	08/28/93	1515	—	—	—	19	—	—	.6	—	<.050	<.010	.65
	08/29/93	1235	—	—	—	20	—	—	.57	—	<.050	<.010	.61
	08/30/93	1310	—	—	—	19	—	—	.56	—	<.050	<.010	.59
2S/11W-18L14I	08/10/93	1525	—	—	—	20	—	—	.45	—	<.050	<.010	.54
(MLS12)	08/11/93	1520	—	—	—	—	—	—	.49	—	<.050	<.010	.56
	08/12/93	1315	—	—	—	20	—	—	.49	—	.059	<.010	.56
	08/13/93	1530	0.12	120	0.5	20	140	590	.58	—	<.050	<.010	.63
	08/16/93	1250	—	—	—	21	—	—	.49	—	.13	<.010	.71
	08/23/93	1520	—	—	—	20	—	—	.49	—	<.050	<.010	.72
	08/24/93	1220	.15	110	.6	20	170	600	.42	—	<.050	<.010	.728
	08/28/93	1335	—	—	—	19	—	—	.37	—	<.050	<.010	.65
	08/29/93	1220	—	—	—	19	—	—	.39	—	<.050	<.010	.65
	08/30/93	1230	—	—	—	20	—	—	.33	—	<.050	<.010	.62
2S/11W-18L14J	08/10/93	1500	—	—	—	20	—	—	.41	—	<.050	<.010	.54
(MLS11)	08/11/93	1240	.15	100	.3	20	180	588	.41	—	.43	<.010	.53
	08/12/93	1250	—	—	—	20	—	—	.41	—	.3	<.010	.57
	08/13/93	1500	—	—	—	22	—	—	.46	—	<.050	<.010	.71
	08/16/93	1245	—	—	—	21	—	—	.57	—	<.050	<.010	1.1
	08/23/93	1500	—	—	—	20	—	—	.59	—	<.050	<.010	.84
	08/24/93	1200	—	—	—	21	—	—	.58	—	<.050	<.010	.81
	08/28/93	1315	—	—	—	19	—	—	.31	—	<.050	<.010	.65
	08/29/93	1200	—	—	—	19	—	—	.28	—	<.050	<.010	.63
	08/30/93	1215	—	—	—	20	—	—	.25	—	<.050	<.010	.61
2S/11W-18L14K	08/10/93	1415	—	—	—	21	—	—	1.7	—	<.050	<.010	.92
(MLS10)	08/11/93	1210	—	—	—	21	—	—	.8	—	<.050	<.010	.7
	08/12/93	1220	—	—	—	22	—	—	0.94	—	0.97	<0.010	0.81

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, ortho-phosphate, dissolved (mg/L as P) (00671)
	08/13/93	1300	—	—	—	24	—	—	.89	—	<.050	<.010	.94
	08/16/93	1200	—	—	—	22	—	—	1.1	—	<.050	<.010	1.5
	08/23/93	1230	—	—	—	24	—	—	1.5	—	.27	<.010	1.3
	08/24/93	1105	—	—	—	24	—	—	1.5	—	.25	<.010	1.2
	08/28/93	1250	—	—	—	21	—	—	.84	—	.7	<.010	.91
	08/29/93	1125	—	—	—	21	—	—	.74	—	.48	<.010	.83
	08/30/93	1150	—	—	—	21	—	—	.63	—	.3	<.010	.8
2S/11W-18L14L	08/10/93	1345	—	—	—	19	—	—	.68	—	.064	<.010	.61
(MLS9)	08/11/93	1115	—	—	—	22	—	—	1.5	—	<.050	<.010	.95
	08/12/93	1130	—	—	—	22	—	—	2.1	—	2	<.010	1.1
	08/13/93	1230	—	—	—	24	—	—	2.1	—	<.050	<.010	1.2
	08/16/93	1130	—	—	—	22	—	—	2.1	—	<.050	<.010	1.8
	08/23/93	1210	—	—	—	24	—	—	2.1	—	.22	<.010	1.5
	08/24/93	1045	—	—	—	25	—	—	2.1	—	.2	<.010	1.5
	08/28/93	1230	—	—	—	25	—	—	2	—	1.1	<.010	1.4
	08/29/93	1105	—	—	—	25	—	—	2	—	.95	<.010	1.2
	08/30/93	1130	0.17	110	0.4	24	170	655	2	—	2.9	<.010	1.3
2S/11W-18L14M	08/10/93	1230	—	—	—	23	—	—	2.2	—	.26	<.010	1.3
(MLS8)	08/11/93	1030	—	—	—	24	—	—	2.3	—	.18	<.010	1.4
	08/12/93	1100	—	—	—	25	—	—	2.3	—	.51	<.010	1.5
	08/13/93	1150	—	—	—	24	—	—	2.3	—	.057	<.010	1.5
	08/16/93	1100	—	—	—	24	—	—	2.2	—	<.050	<.010	1.4
	08/23/93	1145	—	—	—	24	—	—	2.2	—	<.050	<.010	1.5
	08/24/93	1020	—	—	—	25	—	—	2.3	—	<.050	<.010	1.5
	08/28/93	1120	—	—	—	24	—	—	2	—	.1	<.010	1.6
	08/29/93	1050	.1	120	.6	25	140	634	1.9	—	2	<.010	1.6
	08/30/93	1050	—	—	—	24	—	—	1.6	—	0.093	<0.010	1.4

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, orthophosphate, dissolved (mg/L as P) (00671)
2S/11W-18L14N	08/10/93	1115	0.07	130	0.8	25	110	652	3.5	—	.15	<.010	1.9
(MLS7)	08/11/93	1000	—	—	—	25	—	—	3.7	—	<.050	<.010	2.1
	08/12/93	1030	.05	140	.7	26	82	631	3.8	—	<.050	<.010	2.1
	08/13/93	1040	—	—	—	26	—	—	3.6	—	<.050	<.010	2
	08/16/93	1015	—	—	—	26	—	—	3.5	—	<.050	<.010	2
	08/23/93	1100	—	—	—	25	—	—	3.3	—	<.050	<.010	1.8
	08/24/93	0930	—	—	—	25	—	—	3.5	—	<.050	<.010	2
	08/28/93	1050	—	—	—	24	—	—	2.7	—	<.050	<.010	2.3
	08/29/93	1030	—	—	—	24	—	—	2.4	—	<.050	<.010	2.4
	08/30/93	1030	—	—	—	25	—	—	2.3	—	<.050	<.010	2.5
2S/11W-18L14O	08/10/93	1010	—	—	—	24	—	—	3.4	—	.064	<.010	1.9
(MLS6)	08/11/93	0930	—	—	—	25	—	—	3.5	—	<.050	<.010	2
	08/12/93	0930	—	—	—	25	—	—	3.4	—	<.050	<.010	2.1
	08/13/93	1015	—	—	—	28	—	—	3.4	—	<.050	<.010	2
	08/16/93	1000	—	—	—	26	—	—	3.3	—	<.050	<.010	2
	08/23/93	1050	—	—	—	24	—	—	3	—	<.050	<.010	1.7
	08/24/93	0850	—	—	—	24	—	—	3.1	—	<.050	<.010	1.8
	08/28/93	1020	.08	130	.7	25	120	630	2.7	—	.051	<.010	2.1
	08/29/93	1015	—	—	—	24	—	—	2.6	—	<.050	<.010	2.2
	08/30/93	1000	—	—	—	24	—	—	2.3	—	<.050	<.010	2.1
2S/11W-18L14P	08/10/93	0846	—	—	—	25	—	—	3.3	—	<.050	<.010	2
(MLS5)	08/11/93	0900	—	—	—	26	—	—	3.3	—	<.050	<.010	2.2
	08/12/93	0900	—	—	—	26	—	—	3.2	—	<.050	<.010	2.2
	08/13/93	0845	—	—	—	27	—	—	3.6	—	<.050	<.010	2.3
	08/16/93	0900	.04	130	.8	29	120	644	3.3	—	<.050	<.010	2.2
	08/23/93	0945	—	—	—	27	—	—	3.1	—	<.050	<.010	2.2
	08/24/93	0830	—	—	—	27	—	—	3.4	—	<0.050	<0.010	2.2

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, ortho-phosphate, dissolved (mg/L as P) (00671)
	08/28/93	0930	—	—	—	26	—	—	2.9	—	<.050	<.010	2.4
	08/29/93	0930	—	—	—	26	—	—	3	—	<.050	<.010	2.5
	08/30/93	0920	—	—	—	26	—	—	2.8	—	<.050	<.010	2.5
2S/11W-18L14Q (MLS4)	08/10/93	0845	—	—	—	27	—	—	3.2	—	<.050	<.010	2.5
	08/11/93	0845	—	—	—	27	—	—	3.3	—	<.050	<.010	2.7
	08/12/93	0845	—	—	—	31	—	—	3.2	—	<.050	<.010	2.7
	08/13/93	0810	—	—	—	30	—	—	3	—	<.050	<.010	2.7
	08/16/93	0845	—	—	—	28	—	—	2.8	—	<.050	<.010	2.7
	08/23/93	0920	—	—	—	30	—	—	2.8	—	<.050	<.010	2.7
	08/24/93	0815	0.07	130	0.8	31	120	641	2.8	—	<.050	<.010	2.5
	08/28/93	0930	—	—	—	29	—	—	2.8	—	<.050	<.010	2.8
	08/29/93	0910	—	—	—	28	—	—	2.6	—	<.050	<.010	2.8
	08/30/93	0820	—	—	—	28	—	—	2.9	—	<.050	<.010	2.8
2S/11W-18L15LYS (SS-RED at 49 ft)	08/10/93	1955	—	—	—	21	—	—	.04	0.54	.65	.11	.02
	08/11/93	1815	—	—	—	20	—	—	.02	.52	.63	.11	<.010
	08/12/93	1550	—	—	—	22	—	—	.04	.44	.49	.05	.01
	08/13/93	0905	—	—	—	21	—	—	.02	.37	.43	.06	.01
	08/16/93	0750	—	—	—	22	—	—	.04	.27	.32	.05	.02
	08/23/93	0850	—	—	—	20	—	—	.02	—	<.050	<.010	.02
	08/24/93	1800	—	—	—		—	—	.02	.13	.16	.03	.01
	08/28/93	1900	—	—	—	21	—	—	.03	—	<.050	.01	.02
	08/29/93	1800	—	—	—	21	—	—	.03	.04	.056	.02	.02
	08/30/93	0900	—	—	—	21	—	—	.03	.05	.069	.02	.02
2S/11W-18L16LYS (SS-ORG at 25 ft)	08/10/93	2015	—	—	—	29	—	—	.03	.29	.49	.2	.09
	08/11/93	1835	—	—	—	24	—	—	.03	—	<.050	.02	.13
	08/12/93	1555	—	—	—	24	—	—	.05	—	<.050	.03	.14
	08/13/93	0915	—	—	—	24	—	—	0.04	—	<0.050	0.02	0.12

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, orthophosphate, dissolved (mg/L as P) (00671)
	08/16/93	0755	—	—	—	27	—	—	.04	—	<.050	<.010	.07
	08/23/93	0851	0.12	59	0.3	25	120	—	.01	—	<.050	<.010	.05
	08/24/93	1800	—	—	—	22	—	—	.02	—	<.050	<.010	.15
	08/28/93	1900	—	—	—	24	—	—	.04	—	<.050	<.010	.04
	08/29/93	1800	—	—	—	22	—	—	.02	—	<.050	.02	.05
	08/30/93	0900	.14	61	.3	23	120	—	.02	—	<.050	.02	.06
2S/11W-18L17LYS	08/10/93	2025	—	—	—	42	—	—	.07	0.08	.21	.13	.33
(SS-YEL at 15 ft)	08/11/93	1830	.13	77	.3	35	130	—	.29	—	<.050	<.010	.02
	08/12/93	1610	—	—	—	25	—	—	.42	.03	.12	.09	.32
	08/13/93	0920	—	—	—	24	—	—	.46	.01	.07	.06	.3
	08/16/93	0800	—	—	—	27	—	—	.4	.03	.1	.07	.28
	08/23/93	0853	—	—	—	23	—	—	.36	—	<.050	<.010	.25
	08/24/93	1800	—	—	—	21	—	—	.1	—	<.050	<.010	.23
	08/28/93	1900	—	—	—	24	—	—	.48	—	<.050	<.010	.22
	08/29/93	1800	—	—	—	23	—	—	.39	—	<.050	<.010	.25
	08/30/93	0900	—	—	—	25	—	—	.38	—	<.050	<.010	.24
2S/11W-18L18LYS	08/10/93	2100	—	—	—	—	—	—	.03	—	1.3	<.010	.54
(SS-GRE at 10 ft)	08/11/93	1840	—	—	—	25	—	—	1	—	<.050	<.010	.62
	08/12/93	1615	—	—	—	24	—	—	1.1	—	<.050	<.010	.59
	08/13/93	0925	—	—	—	24	—	—	1.2	—	<.050	<.010	.55
	08/16/93	0805	—	—	—	26	—	—	1.4	—	<.050	<.010	.56
	08/23/93	0854	—	—	—	25	—	—	.86	—	<.050	<.010	.58
	08/24/93	1800	—	—	—	—	—	—	.25	—	<.050	<.010	.56
	08/28/93	1900	—	—	—	24	—	—	.3	—	<.050	<.010	.58
	08/29/93	1800	—	—	—	23	—	—	.56	—	<.050	<.010	.53
	08/30/93	0900	—	—	—	23	—	—	.51	—	<.050	<.010	.55
2S/11W-18L19LYS	08/10/93	2110	—	—	—	—	—	—	0.16	—	<0.050	0.01	0.92

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, orthophosphate, dissolved (mg/L as P) (00671)
(SS-BLU at 5 ft)	08/11/93	1845	—	—	—	130	—	—	.1	—	<.050	.02	.97
	08/12/93	1620	—	—	—	97	—	—	.13	—	<.050	.03	.94
	08/13/93	0930	—	—	—	55	—	—	.15	—	<.050	<.010	.77
	08/16/93	0810	—	—	—	53	—	—	—	—	—	—	—
	08/23/93	0855	—	—	—	58	—	—	.13	—	<.050	.02	.83
	08/24/93	1800	—	—	—	54	—	—	.25	—	<.050	<.010	.78
	08/28/93	1900	—	—	—	51	—	—	.13	—	<.050	<.010	.87
	08/29/93	1800	—	—	—	—	—	—	.27	—	<.050	<.010	.75
	08/30/93	0900	—	—	—	47	—	—	.28	—	<.050	<.010	.73
2S/11W-18L20LYS	08/10/93	2107	—	—	—	—	—	—	1.5	0.06	.081	.02	.78
(CR-YEL at 15 ft)	08/11/93	1855	—	—	—	19	—	—	1.3	—	<.050	<.010	.76
	08/12/93	1645	—	—	—	21	—	—	1.4	—	<.050	<.010	.74
	08/13/93	0940	—	—	—	19	—	—	1.4	—	<.050	<.010	.78
	08/16/93	0925	—	—	—	21	—	—	1.3	—	<.050	<.010	.77
	08/23/93	0902	—	—	—	19	—	—	1.1	—	<.050	<.010	.8
	08/24/93	1800	—	—	—	19	—	—	.67	—	<.050	<.010	.73
	08/28/93	1900	—	—	—	20	—	—	.6	—	<.050	<.010	.73
	08/29/93	1800	—	—	—	20	—	—	.53	—	<.050	<.010	.67
	08/30/93	1022	—	—	—	—	—	—	.51	—	<.050	<.010	.66
2S/11W-18L21LYS	08/10/93	2145	—	—	—	—	—	—	.36	—	.059	<.010	1.3
(CR-GRE at 9 ft)	08/11/93	1850	—	—	—	69	—	—	.91	—	<.050	<.010	.97
	08/12/93	1635	—	—	—	58	—	—	1.1	—	<.050	<.010	.96
	08/13/93	0935	—	—	—	57	—	—	1	—	<.050	<.010	.98
	08/16/93	0920	—	—	—	60	—	—	1.1	—	<.050	<.010	1
	08/23/93	0903	—	—	—	68	—	—	.95	—	<.050	<.010	1.1
	08/24/93	1800	—	—	—	71	—	—	.79	—	<.050	<.010	1.1
	08/28/93	1900	—	—	—	68	—	—	0.96	—	<0.050	<0.010	1.1

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, orthophosphate, dissolved (mg/L as P) (00671)
	08/29/93	1800	—	—	—	70	—	—	.87	—	<.050	<.010	1.1
	08/30/93	1020	—	—	—	—	—	—	.97	—	<.050	<.010	1
2S/11W-18L23LYS (TF-ORG at 25 ft)	08/10/93	2200	—	—	—	—	—	—	.03	1.44	1.6	.16	.07
	08/11/93	1915	—	—	—	24	—	—	.02	1.38	1.4	.02	.07
	08/16/93	1205	—	—	—	23	—	—	.03	—	1.8	<.010	.07
	08/23/93	0936	—	—	—	21	—	—	.03	—	1.1	<.010	.07
	08/24/93	1800	—	—	—	—	—	—	.02	—	.89	<.010	.08
	08/30/93	1515	—	—	—	21	—	—	.02	—	.63	<.010	.08
2S/11W-18L25LYS (TF-GRE at 10 ft)	08/10/93	2205	—	—	—	—	—	—	.03	.8	.86	.06	1.7
2S/11W-18L26LYS (TF-BLU at 5 ft)	08/10/93	2110	—	—	—	—	—	—	.04	1.77	2.7	.93	.44
	08/23/93	0940	—	—	—	—	—	—	.05	.13	.25	.12	.41
	08/24/93	1800	—	—	—	—	—	—	.02	.22	.26	.04	.42
2S/11W-18L27 (PR8 at 49 ft)	08/10/93	1835	—	—	—	21	—	—	.03	—	.7	<.010	.15
	08/11/93	1730	—	—	—	21	—	—	.02	—	.65	<.010	.15
	08/12/93	1730	—	—	—	20	—	—	.04	—	.62	<.010	.15
	08/13/93	1820	—	—	—	21	—	—	.03	—	.56	<.010	.15
	08/16/93	1650	—	—	—	20	—	—	.03	—	.56	<.010	.14
	08/23/93	1530	—	—	—	21	—	—	.02	—	.59	<.010	.15
	08/24/93	1305	—	—	—	21	—	—	.02	—	.59	<.010	.16
	08/28/93	1350	—	—	—	21	—	—	.03	—	.6	<.010	.15
	08/29/93	1305	—	—	—	20	—	—	.03	—	.61	<.010	.16
	08/30/93	1450	—	—	—	21	—	—	.02	—	.63	<.010	.16
2S/11W-18L28 (PR9 at 25 ft)	08/10/93	2145	—	—	—	20	—	—	.03	—	.82	<.010	.06
	08/11/93	1500	—	—	—	21	—	—	.02	—	.8	<.010	.05
	08/12/93	1600	0.14	57	0.3	21	120	426	.03	—	.77	<.010	.06
	08/13/93	1600	—	—	—	20	—	—	0.03	—	0.7	<0.010	0.07

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, orthophosphate, dissolved (mg/L as P) (00671)
	08/16/93	1910	—	—	—	20	—	—	.03	—	.57	<.010	.06
	08/23/93	1730	—	—	—	21	—	—	.04	—	.46	<.010	.06
	08/24/93	1510	—	—	—	22	—	—	.02	—	.43	<.010	.05
	08/28/93	1530	0.15	77	0.3	21	140	481	.03	—	.38	<.010	.05
	08/29/93	1535	—	—	—	21	—	—	.22	2.67	3	.33	1.4
	08/30/93	1620	—	—	—	21	—	—	.03	—	.38	<.010	.05
2S/11W-18L29	08/10/93	1100	.16	82	.4	20	140	476	.04	—	.18	<.010	.6
(PR10 at 60 ft)	08/11/93	1045	—	—	—	21	—	—	.02	—	.34	<.010	.09
	08/12/93	0945	—	—	—	20	—	—	.05	—	.36	<.010	.1
	08/13/93	1120	—	—	—	20	—	—	.03	—	.34	<.010	.1
	08/16/93	1035	.12	55	.4	21	110	416	.04	—	.36	<.010	.09
	08/23/93	1250	—	—	—	20	—	—	.02	—	.39	<.010	.09
	08/24/93	0720	—	—	—	21	—	—	.03	—	.36	<.010	.1
	08/28/93	1000	—	—	—	20	—	—	.02	—	.24	<.010	.09
	08/29/93	1140	—	—	—	20	—	—	.03	—	.25	<.010	.1
	08/30/93	1250	—	—	—	21	—	—	.02	—	.23	.01	.1
2S/11W-18L30	08/10/93	1550	—	—	—	21	—	—	.03	—	.35	<.010	.1
(PR11 at 36 ft)	08/11/93	1300	—	—	—	20	—	—	.02	—	.26	<.010	.61
	08/12/93	1200	—	—	—	21	—	—	.03	—	.32	<.010	.59
	08/13/93	1330	—	—	—	20	—	—	.03	—	.34	<.010	.59
	08/16/93	1450	—	—	—	20	—	—	.04	—	2	<.010	.57
	08/23/93	1015	—	—	—	20	—	—	.01	—	1.6	<.010	.55
	08/24/93	1130	—	—	—	21	—	—	.03	—	1.2	<.010	.56
	08/28/93	1215	—	—	—	20	—	—	.02	—	.46	<.010	.55
	08/29/93	0955	—	—	—	20	—	—	.03	—	.36	<.010	.55
	08/30/93	1100	—	—	—	20	—	—	.02	—	.31	<.010	.52
POND AT PICO	08/10/93	2200	—	—	—	23	—	—	0.05	—	<0.050	<0.010	0.2

Appendix 2B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, bromide–phosphorus—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorus, orthophosphate, dissolved (mg/L as P) (00671)
(PR12)	08/11/93	2100	—	—	—	22	—	—	1.4	3.9	5.2	1.3	1.9
	08/12/93	2030	—	—	—	21	—	—	.34	3.8	5.3	1.5	1.2
	08/13/93	0910	—	—	—	21	—	—	.35	3.5	5.3	1.8	1.8
	08/16/93	1940	—	—	—	21	—	—	.2	3.8	6.5	2.7	1.2
	08/23/93	1920	—	—	—	20	—	—	.18	4.94	5.2	.26	1.7
	08/23/93	1930	—	—	—	21	—	—	.35	5.04	5.3	.26	1
	08/23/93	1950	0.06	130	0.6	21	150	652	.52	4.57	4.8	.23	1.7
	08/23/93	2030	—	—	—	20	—	—	.3	4.9	5.2	.3	1.4
	08/24/93	1720	—	—	—	22	—	—	.19	4.56	4.8	.24	1.5
	08/28/93	1745	—	—	—	20	—	—	.19	3.09	3.4	.31	1.4
	08/29/93	1700	—	—	—	20	—	—	.03	—	.39	<.010	.05
	08/30/93	1745	—	—	—	21	—	—	.28	2.38	2.7	.32	1.4
SEWAGE EFFLUENT	08/10/93	2245	—	—	—	20	—	—	5.3	5	6.6	1.6	2.2
(PR13)	08/11/93	2045	.05	120	.7	20	150	719	12	15.3	17	1.7	3.5
	08/12/93	1950	—	—	—	19	—	—	12	3.3	5.3	2	2.1
	08/13/93	1900	—	—	—	20	—	—	12	3.9	6.1	2.2	2
	08/16/93	2000	—	—	—	20	—	—	13	2.8	4.6	1.8	3.6
	08/23/93	2010	—	—	—	20	—	—	13	3.1	4.7	1.6	3.8
	08/24/93	1750	—	—	—	21	—	—	14	3.2	5	1.8	2.3
	08/28/93	1805	—	—	—	20	—	—	16	1.7	3.6	1.9	2
	08/29/93	1720	—	—	—	20	—	—	11	4.7	6.4	1.7	1.5
	08/30/93	1810	—	—	—	21	—	—	16	2.1	3.9	1.8	2.1

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt

[See table 1 for explanation of local identifier listed under station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; <, actual value less than value shown; —, no data; CR, ceramic-cup lysimeter; SS, stainless steel lysimeter; TF, Teflon lysimeter; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Arsenic, dissolved (µg/L as As) (01000)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
2S/11W-18L10LYS	08/10/93	2110	13	100	<0.5	<1	<1	2
(CR-RED at 50 ft)	08/11/93	1900	15	100	<.5	<1	<1	2
	08/12/93	1655	13	110	<.5	<1	<1	2
	08/13/93	1020	—	110	<.5	<1	<1	2
	08/16/93	1050	15	110	<.5	<1	<1	2
	08/23/93	1054	14	100	<.5	<1	<1	3
	08/24/93	1800	15	97	<.5	<1	<5	3
	08/28/93	1900	15	100	<.5	<1	<1	3
	08/29/93	1800	15	100	<.5	<1	<1	2
	08/30/93	1118	15	110	<.5	<1	<1	3
2S/11W-18L11LYS	08/10/93	2135	—	81	<.5	<1	<1	<1
(CR-ORG at 25 ft)	08/11/93	1905	6	85	<.5	<1	<1	<1
	08/12/93	1700	5	89	<.5	<1	<1	<1
	08/13/93	1025	6	88	<.5	<1	<1	<1
	08/16/93	1055	6	90	<.5	<1	<1	<1
	08/23/93	1109	5	92	<.5	<1	<1	1
	08/24/93	1800	5	90	<.5	<1	<5	<3
	08/28/93	1900	5	96	<.5	<1	<1	1
	08/29/93	1800	5	96	<.5	<1	<1	<1
	08/30/93	1115	5	93	<.5	<1	<1	1
2S/11W-18L13LYS	08/10/93	2140	—	120	<.5	<1	<1	5
(CR-BLU at 13.5 ft)	08/11/93	1910	—	120	<.5	<1	1	3
	08/12/93	1710	14	120	<.5	<1	<1	4
	08/13/93	1030	—	130	<.5	<1	<1	4
	08/16/93	1100	17	120	<.5	<1	<1	4
	08/23/93	1112	17	120	<.5	<1	<1	4
	08/24/93	1800	16	120	<.5	<1	<5	<3
	08/28/93	1900	—	120	<.5	<1	250	5

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt—Continued

Station name (Local identifier)	Date	Time	Arsenic, dissolved (µg/L as As) (01000)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
	08/29/93	1800	17	120	<0.5	1	<1	3
	08/30/93	1120	—	—	—	<1	<1	4
2S/11W-18L14A (MLS20)	08/10/93	2110	10	140	<.5	1	<.5	<3
	08/11/93	2000	6	130	<.5	<1	<.5	<3
	08/12/93	2000	6	140	<.5	<1	<.5	<3
	08/13/93	1920	5	140	<.5	<1	<.5	<3
	08/16/93	1855	7	150	<.5	<1	<.5	<3
	08/23/93	1900	8	170	<.5	<1	<.5	<3
	08/24/93	1700	6	150	<.5	1	<.5	<3
	08/28/93	1730	8	150	<.5	<1	<.5	<3
	08/29/93	1635	7	140	<.5	<1	<.5	<3
	08/30/93	1730	6	150	<.5	<1	<.5	<3
2S/11W-18L14B (MLS19)	08/10/93	2040	9	170	<.5	<1	<.5	<3
	08/11/93	1930	10	140	<.5	<1	<.5	<3
	08/12/93	1920	10	180	<.5	<1	<.5	<3
	08/13/93	1845	9	170	<.5	<1	<.5	<3
	08/16/93	1818	11	150	<.5	1	<.5	<3
	08/23/93	1830	10	160	<.5	<1	<.5	<3
	08/24/93	1650	10	170	<.5	<1	<.5	<3
	08/28/93	1715	11	160	<.5	1	<.5	<3
	08/29/93	1620	10	160	<.5	1	<.5	<3
	08/30/93	1715	10	160	<.5	<1	<.5	<3
2S/11W-18L14C (MLS18)	08/10/93	2005	9	170	<.5	1	<.5	<3
	08/11/93	1900	9	170	<.5	<1	<.5	<3
	08/12/93	1845	11	160	<.5	<1	<.5	3
	08/13/93	1800	10	160	<.5	<1	<.5	<3
	08/16/93	1745	13	150	<.5	<1	<.5	<3
	08/23/93	1815	11	160	<.5	<1	<.5	<3
	08/24/93	1615	12	160	<.5	<1	<.5	<3
	08/28/93	1655	11	160	<.5	<1	<.5	<3
	08/29/93	1600	11	160	<.5	<1	<5	<3

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt—Continued

Station name (Local identifier)	Date	Time	Arsenic, dissolved (µg/L as As) (01000)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
	08/30/93	1630	12	160	<0.5	1	<5	<3
2S/11W-18L14D	08/10/93	1930	12	160	<.5	<1	<5	<3
(MLS17)	08/11/93	1830	—	—	—	—	—	—
	08/12/93	1800	13	150	<.5	2	<5	5
	08/13/93	1745	14	160	<.5	<1	<5	<3
	08/16/93	1705	16	150	<.5	<1	<5	<3
	08/23/93	1800	13	160	<.5	<1	<5	3
	08/24/93	1550	14	160	<.5	<1	<5	<3
	08/28/93	1640	14	160	<.5	<1	<5	<3
	08/29/93	1540	15	160	<.5	<1	<5	<3
	08/30/93	1600	15	150	<.5	<1	<5	<3
2S/11W-18L14E	08/10/93	1915	8	160	<.5	<1	<5	<3
(MLS16)	08/11/93	1745	8	160	<.5	1	<5	<3
	08/12/93	1700	9	160	<.5	<1	<5	<3
	08/13/93	1720	11	160	<.5	<1	<5	<3
	08/16/93	1620	15	160	<.5	<1	<5	<3
	08/23/93	1710	11	170	<.5	2	<5	<3
	08/24/93	1525	10	190	<.5	<1	<5	<3
	08/28/93	1620	11	170	<.5	<1	<5	<3
	08/29/93	1510	11	170	<.5	<1	<5	<3
	08/30/93	1540	11	180	<.5	<1	<5	<3
2S/11W-18L14F	08/10/93	1755	9	170	<.5	<1	<5	<3
(MLS15)	08/11/93	1700	—	—	—	—	—	—
	08/12/93	1620	13	180	<.5	<1	<5	<3
	08/13/93	1700	15	180	<.5	<1	<5	<3
	08/16/93	1530	14	200	<.5	<1	<5	<3
	08/23/93	1700	9	210	<.5	<1	<5	<3
	08/24/93	1450	10	210	<.5	2	<5	<3
	08/28/93	1600	10	210	<.5	<1	<5	<3
	08/29/93	1450	10	210	<.5	<1	<5	<3
	08/30/93	1440	9	210	<.5	1	<5	<3

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt—Continued

Station name (Local identifier)	Date	Time	Arsenic, dissolved (µg/L as As) (01000)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
2S/11W-18L14G	08/10/93	1710	10	160	<0.5	<1	<5	<3
(MLS14)	08/11/93	1610	10	170	<.5	<1	<5	<3
	08/12/93	1500	13	160	<.5	<1	<5	<3
	08/13/93	1645	11	180	<.5	<1	<5	<3
	08/16/93	1550	11	190	<.5	<1	<5	<3
	08/23/93	1630	12	190	<.5	<1	<5	<3
	08/24/93	1430	9	210	<.5	<1	<5	<3
	08/28/93	1500	10	180	<.5	<1	<5	<3
	08/29/93	1250	10	190	<.5	<1	<5	<3
	08/30/93	1430	11	190	<.5	<1	<5	<3
2S/11W-18L14H	08/10/93	1625	9	170	<.5	1	<5	<3
(MLS13)	08/11/93	1545	10	180	<.5	<1	<5	<3
	08/12/93	1445	10	180	<.5	1	<5	<3
	08/13/93	1620	10	190	<.5	<1	<5	<3
	08/16/93	1430	9	170	<.5	<1	<5	<3
	08/23/93	1600	9	180	<.5	<1	<5	<3
	08/24/93	1315	10	180	<.5	<1	<5	<3
	08/28/93	1515	9	170	<.5	<1	<5	<3
	08/29/93	1235	9	180	<.5	<1	<5	<3
	08/30/93	1310	9	180	<.5	1	<5	<3
2S/11W-18L14I	08/10/93	1525	7	160	<.5	<1	<5	<3
(MLS12)	08/11/93	1520	—	—	—	—	—	—
	08/12/93	1315	7	160	<.5	1	<5	<3
	08/13/93	1530	9	160	<.5	1	<5	3
	08/16/93	1250	8	150	<.5	<1	<5	<3
	08/23/93	1520	9	160	<.5	<1	<5	<3
	08/24/93	1220	9	160	<.5	<1	<5	<3
	08/28/93	1335	7	160	<.5	<1	<5	<3
	08/29/93	1220	8	160	<.5	<1	<5	<3
	08/30/93	1230	7	160	<.5	<1	<5	<3
2S/11W-18L14J	08/10/93	1500	7	150	<.5	<1	<5	<3

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt—Continued

Station name (Local identifier)	Date	Time	Arsenic, dissolved (μg/L as As) (01000)	Barium, dissolved (μg/L as Ba) (01005)	Beryllium, dissolved (μg/L as Be) (01010)	Cadmium, dissolved (μg/L as Cd) (01025)	Chromium, dissolved (μg/L as Cr) (01030)	Cobalt, dissolved (μg/L as Co) (01035)
(MLS11)	08/11/93	1240	6	150	<0.5	<1	<5	<3
	08/12/93	1250	5	150	<.5	<1	<5	<3
	08/13/93	1500	10	140	<.5	<1	<1	<3
	08/16/93	1245	11	130	<.5	<1	<1	<3
	08/23/93	1500	8	150	<.5	<1	<1	4
	08/24/93	1200	8	150	<.5	<1	<1	<3
	08/28/93	1315	6	150	<.5	<1	<1	<3
	08/29/93	1200	6	150	<.5	<1	<1	<3
	08/30/93	1215	6	160	<.5	<1	<1	<3
2S/11W-18L14K	08/10/93	1415	8	160	<.5	<1	<1	<3
(MLS10)	08/11/93	1210	7	160	<.5	<1	<1	<3
	08/12/93	1220	6	160	<.5	<1	<1	<3
	08/13/93	1300	11	140	<.5	<1	<1	<3
	08/16/93	1200	13	130	<.5	<1	<1	<3
	08/23/93	1230	9	150	<5	<1	<1	<3
	08/24/93	1105	10	150	<.5	<1	<1	<3
	08/28/93	1250	6	160	<.5	<1	<1	<3
	08/29/93	1125	6	160	<.5	<1	<1	<3
	08/30/93	1150	6	160	<.5	1	<1	<3
2S/11W-18L14L	08/10/93	1345	6	150	<.5	<1	<1	<3
(MLS9)	08/11/93	1115	8	160	<.5	<1	<1	<3
	08/12/93	1130	7	160	<.5	<1	<1	<3
	08/13/93	1230	12	140	<.5	<1	<1	<3
	08/16/93	1130	15	130	<.5	<1	<1	3
	08/23/93	1210	10	140	<.5	<1	<1	<3
	08/24/93	1045	10	140	<.5	<1	<1	3
	08/28/93	1230	8	160	<.5	<1	<1	<3
	08/29/93	1105	8	170	<.5	<1	<1	<3
	08/30/93	1130	7	170	<.5	<1	<1	<3
2S/11W-18L14M	08/10/93	1230	14	150	<.5	1	<1	<3
(MLS8)	08/11/93	1030	15	160	<.5	<1	<1	<3

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt—Continued

Station name (Local identifier)	Date	Time	Arsenic, dissolved (µg/L as As) (01000)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
	08/12/93	1100	16	160	<0.5	<1	<5	4
	08/13/93	1150	15	150	<.5	<1	<5	<3
	08/16/93	1100	18	140	<.5	1	<5	4
	08/23/93	1145	18	150	<.5	1	<5	<3
	08/24/93	1020	18	140	<.5	<1	<5	4
	08/28/93	1120	16	150	<.5	<1	<5	4
	08/29/93	1050	17	160	<.5	<1	<5	3
	08/30/93	1050	5	150	<.5	2	<5	<3
2S/11W-18L14N	08/10/93	1115	14	150	<.5	<1	<5	<3
(MLS7)	08/11/93	1000	16	150	<.5	1	<5	5
	08/12/93	1030	18	140	<.5	<1	<5	3
	08/13/93	1040	17	130	<.5	<1	<5	5
	08/16/93	1015	18	140	<.5	<1	<5	3
	08/23/93	1100	17	140	<.5	<1	<5	<3
	08/24/93	0930	17	130	<.5	<1	<5	5
	08/28/93	1050	18	130	<.5	<1	<5	5
	08/29/93	1030	19	130	<.5	<1	<5	3
	08/30/93	1030	20	130	<.5	<1	<5	<3
2S/11W-18L14O	08/10/93	1010	15	150	<.5	1	<5	4
(MLS6)	08/11/93	0930	20	150	<.5	<1	<5	4
	08/12/93	0930	21	140	<.5	<1	<5	5
	08/13/93	1015	22	150	<.5	<1	<5	3
	08/16/93	1000	21	150	<.5	<1	<5	<3
	08/23/93	1050	17	150	<.5	<1	<5	4
	08/24/93	0850	18	150	<.5	<1	<5	<3
	08/28/93	1020	20	150	<.5	<1	<5	<3
	08/29/93	1015	23	140	<.5	<1	<5	<3
	08/30/93	1000	21	150	<.5	<1	<5	<3
2S/11W-18L14P	08/10/93	0846	19	140	<.5	1	<5	<3
(MLS5)	08/11/93	0900	22	140	<.5	<1	<5	4
	08/12/93	0900	20	140	<.5	1	<5	4

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt—Continued

Station name (Local identifier)	Date	Time	Arsenic, dissolved (µg/L as As) (01000)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
	08/13/93	0845	24	140	<0.5	<1	<5	<3
	08/16/93	0900	22	140	<.5	<1	<5	4
	08/23/93	0945	22	150	<.5	<1	<5	<3
	08/24/93	0830	24	130	<.5	1	<5	4
	08/28/93	0930	25	130	<.5	<1	<5	<3
	08/29/93	0930	26	130	<.5	<1	<5	3
	08/30/93	0920	29	130	<.5	1	<5	<3
2S/11W-18L14Q	08/10/93	0845	21	150	<.5	<1	<5	<3
(MLS4)	08/11/93	0845	24	140	<.5	1	<5	4
	08/12/93	0845	27	140	<.5	<1	<5	3
	08/13/93	0810	27	140	<.5	2	<5	4
	08/16/93	0845	24	140	<.5	1	<5	<3
	08/23/93	0920	23	140	<.5	<1	<5	<3
	08/24/93	0815	25	140	<.5	<1	<5	6
	08/28/93	0930	24	130	<.5	1	<5	<3
	08/29/93	0910	25	130	<.5	2	<5	4
	08/30/93	0820	26	130	<.5	<1	<5	<3
2S/11W-18L15LYS	08/10/93	1955	2	120	<.5	<1	<1	2
(SS-RED at 49 ft)	08/11/93	1815	1	120	<.5	<1	1	1
	08/12/93	1550	1	120	<.5	<1	<1	1
	08/13/93	0905	1	110	<.5	<1	<1	2
	08/16/93	0750	1	120	<.5	<1	<1	2
	08/23/93	0850	3	110	<.5	<1	<1	2
	08/24/93	1800	—	—	—	—	—	—
	08/28/93	1900	2	110	<.5	<1	<1	2
	08/29/93	1800	3	110	.5	<1	<1	2
	08/30/93	0900		120	<.5	<1	<1	2
2S/11W-18L16LYS	08/10/93	2015	28	45	<.5	<1	<1	2
(SS-ORG at 25 ft)	08/11/93	1835	35	66	<.5	<1	1	<1
	08/12/93	1555	20	100	<.5	<1	<1	<1
	08/13/93	0915	21	110	<.5	<1	<1	<1

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt—Continued

Station name (Local identifier)	Date	Time	Arsenic, dissolved (µg/L as As) (01000)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
	08/16/93	0755	17	140	<0.5	<1	<1	<1
	08/23/93	0851	19	100	<10	<1	<1	<1
	08/24/93	1800	23	73	<.5	<1	<5	<3
	08/28/93	1900	19	120	<.5	<1	<1	1
	08/29/93	1800	21	93	<.5	<1	<1	<1
	08/30/93	0900	17	140	<.5	<1	<1	<1
2S/11W-18L17LYS (SS-YEL at 15 ft)	08/10/93	2025	10	140	<.5	<1	<1	3
	08/11/93	1830	7	120	<.5	<1	60	1
	08/12/93	1610	7	130	<.5	<1	10	1
	08/13/93	0920	8	130	<.5	<1	4	<1
	08/16/93	0800	8	140	<.5	<1	2	<1
	08/23/93	0853	8	130	<.5	<1	2	<1
	08/24/93	1800	9	120	<.5	<1	6	<3
	08/28/93	1900	9	150	<.5	<1	7	<1
	08/29/93	1800	7	130	<.5	<1	<1	<1
	08/30/93	0900	8	140	<.5	<1	1	<1
2S/11W-18L18LYS (SS-GRE at 10 ft)	08/10/93	2100	—	100	<10	<1		1
	08/11/93	1840	—	150	<.5	<1	1	<1
	08/12/93	1615	10	150	<.5	<1	<1	<1
	08/13/93	0925	10	150	<.5	<1	<1	<1
	08/16/93	0805	11	160	<.5	<1	<1	<1
	08/23/93	0854	11	140	<.5	<1	2	2
	08/24/93	1800	—	—	—	—	—	—
	08/28/93	1900	9	140	<.5	<1	2	1
	08/29/93	1800	9	130	<.5	<1	<1	<1
	08/30/93	0900	9	150	<.5	<1	<1	<1
2S/11W-18L19LYS (SS-BLU at 5 ft)	08/10/93	2110	—	—	—	<1	<1	3
	08/11/93	1845	37	160	<.5	1	22	5
	08/12/93	1620		130	<.5	<1	22	5
	08/13/93	0930	38	63	<.5	<1	1	3
	08/16/93	0810	33	62	<.5	<1	<1	3

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt—Continued

Station name (Local identifier)	Date	Time	Arsenic, dissolved (µg/L as As) (01000)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
	08/23/93	0855	34	70	<0.5	<1	5	4
	08/24/93	1800	37	39	<.5	<1	<5	<3
	08/28/93	1900	34	53	<.5	<1	<1	4
	08/29/93	1800	—	—	—	<1	<1	2
	08/30/93	0900	32	51	<.5	<1	<1	4
2S/11W-18L20LYS	08/10/93	2107	—	100	<10	—	<1	—
(CR-YEL at 15 ft)	08/11/93	1855	—	140	<.5	<1	<1	<1
	08/12/93	1645	10	160	.5	<1	1	<1
	08/13/93	0940	7	150	<.5	<1	<5	<3
	08/16/93	0925		170	<.5	<1	1	1
	08/23/93	0902	9	150	<.5	<1	<1	3
	08/24/93	1800	9	150	<.5	<1	<5	<3
	08/28/93	1900	9	150	<.5	<1	<1	<1
	08/29/93	1800	7	160	<.5	<1	<1	<1
	08/30/93	1022	—	—	—	<1	<1	<1
2S/11W-18L21LYS	08/10/93	2145	—	—	—	—	—	—
(CR-GRE at 9 ft)	08/11/93	1850	23	55	<.5	<1	<1	<1
	08/12/93	1635	19	69	<.5	<1	<1	<1
	08/13/93	0935	20	71	<.5	<1	<1	2
	08/16/93	0920	20	74	<.5	<1	<1	2
	08/23/93	0903	19	65	<.5	<1	<1	2
	08/24/93	1800	22	56	<.5	<1	<5	<3
	08/28/93	1900	19	70	<.5	<1	<1	2
	08/29/93	1800	19	65	<.5	<1	<1	1
	08/30/93	1020	—	—	—	1	<1	1
2S/11W-18L23LYS	08/10/93	2200	—	—	—	—	—	—
(TF-ORG at 25 ft)	08/11/93	1915	13	160	<.5	<1	<5	<3
	08/16/93	1205	3	85	<.5	<1	<1	<1
	08/23/93	0936	2	84	<.5	<1	1	<1
	08/24/93	1800	—	—	—	—	—	—
	08/30/93	1515	3	87	<.5	<1	<1	<1

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt—Continued

Station name (Local identifier)	Date	Time	Arsenic, dissolved (μg/L as As) (01000)	Barium, dissolved (μg/L as Ba) (01005)	Beryllium, dissolved (μg/L as Be) (01010)	Cadmium, dissolved (μg/L as Cd) (01025)	Chromium, dissolved (μg/L as Cr) (01030)	Cobalt, dissolved (μg/L as Co) (01035)
2S/11W-18L25LYS	08/10/93	2205	—	—	—	—	—	—
(TF-GRE at 10 ft)								
2S/11W-18L26LYS	08/10/93	2110	—	—	—	—	—	—
(TF-BLU at 5 ft)	08/23/93	0940	—	—	—	—	—	—
	08/24/93	1800	—	—	—	—	—	—
2S/11W-18L27	08/10/93	1835	8	86	<0.5	<1	<5	5
(PR8 at 49 ft)	08/11/93	1730	8	87	<.5	<1	<5	4
	08/12/93	1730	8	84	<.5	<1	<5	4
	08/13/93	1820	7	88	<.5	<1	<5	<3
	08/16/93	1650	7	85	<.5	<1	<5	5
	08/23/93	1530	8	88	<.5	<1	<5	4
	08/24/93	1305	8	85	<.5	<1	<5	4
	08/28/93	1350	9	93	<.5	<1	<5	3
	08/29/93	1305	8	92	<.5	<1	<5	4
	08/30/93	1450	8	92	<.5	<1	<5	<3
2S/11W-18L28	08/10/93	2145	3	91	<.5	<1	<5	<3
(PR9 at 25 ft)	08/11/93	1500	3	95	<.5	<1	<5	<3
	08/12/93	1600	3	97	<.5	<1	<5	<3
	08/13/93	1600	2	95	<.5	<1	<5	<3
	08/16/93	1910	3	98	<.5	<1	<5	<3
	08/23/93	1730	3	110	<.5	<1	<5	<3
	08/24/93	1510	3	110	<.5	<1	<5	<3
	08/28/93	1530	3	110	<.5	<1	<5	<3
	08/29/93	1535	3	100	<.5	<1	<5	<3
	08/30/93	1620	3	110	<.5	<1	<5	<3
2S/11W-18L29	08/10/93	1100	21	120	<.5	<1	<5	<3
(PR10 at 60 ft)	08/11/93	1045	5	82	<.5	<1	<5	<3
	08/12/93	0945	6	76	<.5	<1	<5	<3
	08/13/93	1120	5	82	<.5	<1	<5	<3
	08/16/93	1035	5	83	<.5	<1	<5	<3
	08/23/93	1250	6	86	<.5	<1	<5	<3

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt—Continued

Station name (Local identifier)	Date	Time	Arsenic, dissolved (µg/L as As) (01000)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
	08/24/93	0720	6	85	<0.5	<1	<5	<3
	08/28/93	1000	6	92	<.5	<1	<5	3
	08/29/93	1140	5	94	<.5	<1	<5	<3
	08/30/93	1250	6	94	<.5	<1	<5	<3
2S/11W-18L30	08/10/93	1550	6	79	<.5	2	<5	<3
(PR11 at 36 ft)	08/11/93	1300	19	120	<.5	2	<5	<3
	08/12/93	1200	22	120	<.5	<1	<5	<3
	08/13/93	1330	20	120	<.5	<1	<5	<3
	08/16/93	1450	19	110	<.5	<1	<5	<3
	08/23/93	1015	19	120	<.5	<1	<5	<3
	08/24/93	1130	18	110	<.5	<1	<5	<3
	08/28/93	1215	18	120	<.5	<1	<5	<3
	08/29/93	0955	18	120	<.5	1	<5	<3
	08/30/93	1100	18	120	<.5	<1	<5	<3
POND AT PICO	08/10/93	2200	4	34	<.5	<1	<5	<3
(PR12)	08/11/93	2100	3	43	<.5	<1	<5	<3
	08/12/93	2030	3	38	<.5	<1	<5	<3
	08/13/93	0910	2	44	<.5	<1	<5	<3
	08/16/93	1940	3	38	<.5	<1	<5	<3
	08/23/93	1920	3	42	<.5	<1	<5	<3
	08/23/93	1930	3	42	<.5	<1	<5	<3
	08/23/93	1950	2	41	<.5	<1	<5	<3
	08/23/93	2030	3	39	<.5	<1	<5	<3
	08/24/93	1720	3	41	<.5	<1	<5	<3
	08/28/93	1745	3	40	<.5	<1	<5	<3
	08/29/93	1700	3	38	<.5	<1	<5	<3
	08/30/93	1745	3	39	<.5	<1	<5	<3
SEWAGE EFFLUENT	08/10/93	2245	3	42	<.5	<1	<5	<3
(PR13)	08/11/93	2045	4	46	<.5	<1	<5	<3
	08/12/93	1950	2	45	<.5	<1	<5	<3
	08/13/93	1900	1	44	<.5	<1	<5	<3

Appendix 2C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, arsenic–cobalt—Continued

Station name (Local identifier)	Date	Time	Arsenic, dissolved (µg/L as As) (01000)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
	08/16/93	2000	2	41	<0.5	<1	<5	<3
	08/23/93	2010	3	42	<.5	<1	<5	<3
	08/24/93	1750	2	43	<.5	<1	<5	<3
	08/28/93	1805	3	48	<.5	<1	<5	<3
	08/29/93	1720	2	49	<.5	<1	<5	<3
	08/30/93	1810	2	48	<.5	<1	<5	<3

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese

[See table 1 for explanation of local identifier listed under station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; <, actual value less than value shown; —, no data; CR, ceramic-cup lysimeter; SS, stainless steel lysimeter; TF, Teflon lysimeter; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
2S/11W-18L10LYS	08/10/93	2110	2	53	<1	<4	910
(CR-RED at 50 ft)	08/11/93	1900	2	3	1	<4	930
	08/12/93	1655	2	3	1	<4	970
	08/13/93	1020	3	8	3	<4	970
	08/16/93	1050	<1	8	2	<4	990
	08/23/93	1054	2	<3	4	<4	960
	08/24/93	1800	<10	4	10	<4	860
	08/28/93	1900	6	9	3	<4	950
	08/29/93	1800	4	<3	<1	<4	1,000
	08/30/93	1118	4	5	1	<4	980
2S/11W-18L11LYS	08/10/93	2135	4	6	2	<4	460
(CR-ORG at 25 ft)	08/11/93	1905	3	4	2	5	460
	08/12/93	1700	3	5	2	9	460
	08/13/93	1025	5	<3	2	4	440
	08/16/93	1055	2	19	3	10	450
	08/23/93	1109	2	3	2	5	460
	08/24/93	1800	<10	5	<10	7	460
	08/28/93	1900	3	5	2	6	490
	08/29/93	1800	3	5	<1	4	510
	08/30/93	1115	3	8	2	4	470
2S/11W-18L13LYS	08/10/93	2140	9	44	<1	10	1,100
(CR-BLU at 13.5 ft)	08/11/93	1910	10	21	<1	16	890
	08/12/93	1710	10	14	<1	<4	760
	08/13/93	1030	9	16	<1	11	720
	08/16/93	1100	3	21	1	10	700
	08/23/93	1112	2	46	1	9	700
	08/24/93	1800	<10	39	<10	10	750
	08/28/93	1900	4	1,200	<1	10	990

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
	08/29/93	1800	5	27	<1	9	840
	08/30/93	1120	7	—	<1	—	—
2S/11W-18L14A (MLS20)	08/10/93	2110	<10	170	<10	6	2,400
	08/11/93	2000	<10	140	<10	6	2,000
	08/12/93	2000	<10	140	<10	11	2,000
	08/13/93	1920	<10	130	<10	<4	1,900
	08/16/93	1855	<10	150	<10	10	2,100
	08/23/93	1900	<10	160	<10	6	2,200
	08/24/93	1700	<10	110	10	7	2,100
	08/28/93	1730	<10	120	<10	8	1,900
	08/29/93	1635	<10	110	<10	<4	1,800
	08/30/93	1730	<10	120	<10	4	1,800
2S/11W-18L14B (MLS19)	08/10/93	2040	<10	24	<10	6	770
	08/11/93	1930	<10	150	<10	5	2,100
	08/12/93	1920	<10	21	<10	11	750
	08/13/93	1845	<10	21	<10	7	710
	08/16/93	1818	<10	15	<10	11	700
	08/23/93	1830	<10	28	<10	10	710
	08/24/93	1650	<10	9	<10	10	720
	08/28/93	1715	<10	18	<10	10	660
	08/29/93	1620	<10	18	20	8	690
	08/30/93	1715	<10	17	<10	7	660
2S/11W-18L14C (MLS18)	08/10/93	2005	<10	39	<10	6	760
	08/11/93	1900	<10	31	<10	6	720
	08/12/93	1845	<10	25	<10	11	670
	08/13/93	1800	<10	25	<10	7	630
	08/16/93	1745	<10	19	<10	12	630
	08/23/93	1815	<10	37	<10	10	680
	08/24/93	1615	<10	10	20	12	680
	08/28/93	1655	<10	26	<10	9	660
	08/29/93	1600	<10	23	<10	9	670

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
	08/30/93	1630	<10	21	<10	5	660
2S/11W-18L14D	08/10/93	1930	<10	81	<10	11	920
(MLS17)	08/11/93	1830	—	—	—	—	—
	08/12/93	1800	<10	30	<10	12	730
	08/13/93	1745	<10	56	<10	8	760
	08/16/93	1705	<10	18	<10	8	780
	08/23/93	1800	<10	62	<10	13	870
	08/24/93	1550	<10	17	<10	11	770
	08/28/93	1640	<10	62	<10	10	820
	08/29/93	1540	<10	63	<10	7	790
	08/30/93	1600	<10	53	<10	7	770
2S/11W-18L14E	08/10/93	1915	<10	32	<10	10	720
(MLS16)	08/11/93	1745	<10	24	10	7	660
	08/12/93	1700	<10	18	<10	11	630
	08/13/93	1720	<10	21	10	8	600
	08/16/93	1620	<10	20	<10	7	660
	08/23/93	1710	<10	24	<10	11	780
	08/24/93	1525	<10	9	20	11	720
	08/28/93	1620	<10	22	<10	10	690
	08/29/93	1510	<10	23	10	6	660
	08/30/93	1540	<10	26	<10	7	670
2S/11W-18L14F	08/10/93	1755	<10	6	<10	6	190
(MLS15)	08/11/93	1700	—	—	—	—	—
	08/12/93	1620	<10	<3	<10	12	170
	08/13/93	1700	<10	4	10	9	170
	08/16/93	1530	<10	5	<10	9	230
	08/23/93	1700	<10	5	<10	7	280
	08/24/93	1450	<10	<3	<10	13	270
	08/28/93	1600	<10	5	10	12	260
	08/29/93	1450	<10	3	10	10	240
	08/30/93	1440	<10	6	<10	8	250

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
2S/11W-18L14G	08/10/93	1710	<10	7	<10	9	240
(MLS14)	08/11/93	1610	<10	7	<10	9	250
	08/12/93	1500	<10	5	<10	13	230
	08/13/93	1645	<10	8	<10	11	230
	08/16/93	1550	<10	7	<10	15	250
	08/23/93	1630	<10	9	<10	16	310
	08/24/93	1430	<10	4	10	13	290
	08/28/93	1500	<10	9	<10	12	270
	08/29/93	1250	<10	8	<10	12	270
	08/30/93	1430	<10	7	<10	9	250
2S/11W-18L14H	08/10/93	1625	<10	8	20	9	360
(MLS13)	08/11/93	1545	<10	8	<10	10	290
	08/12/93	1445	<10	5	<10	13	280
	08/13/93	1620	<10	8	<10	10	290
	08/16/93	1430	20	10	<10	11	320
	08/23/93	1600	<10	8	<10	13	310
	08/24/93	1315	<10	5	<10	15	300
	08/28/93	1515	<10	9	<10	13	270
	08/29/93	1235	<10	11	10	10	320
	08/30/93	1310	<10	8	<10	10	310
2S/11W-18L14I	08/10/93	1525	<10	7	<10	8	180
(MLS12)	08/11/93	1520	—	—	—	—	—
	08/12/93	1315	<10	4	<10	15	170
	08/13/93	1530	<10	8	<10	12	180
	08/16/93	1250	20	13	<10	12	230
	08/23/93	1520	<10	6	<10	14	230
	08/24/93	1220	<10	4	<10	13	220
	08/28/93	1335	<10	9	<10	13	240
	08/29/93	1220	<10	9	<10	9	240
	08/30/93	1230	<10	10	<10	11	240
2S/11W-18L14J	08/10/93	1500	<10	6	<10	9	200

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
(MLS11)	08/11/93	1240	<10	5	<10	11	200
	08/12/93	1250	<10	<3	<10	14	180
	08/13/93	1500	<10	5	<10	10	170
	08/16/93	1245	10	6	<10	11	220
	08/23/93	1500	<10	4	<10	15	260
	08/24/93	1200	<10	3	<10	14	260
	08/28/93	1315	<10	6	10	13	260
	08/29/93	1200	<10	7	10	9	270
	08/30/93	1215	<10	9	10	14	280
2S/11W-18L14K	08/10/93	1415	<10	5	<10	12	290
(MLS10)	08/11/93	1210	<10	7	<10	8	290
	08/12/93	1220	<10	10	<10	13	270
	08/13/93	1300	<10	8	<10	9	240
	08/16/93	1200	<10	7	<10	10	290
	08/23/93	1230	<10	6	<10	13	400
	08/24/93	1105	<10	5	<10	11	400
	08/28/93	1250	<10	7	<10	13	400
	08/29/93	1125	<10	6	<10	9	410
	08/30/93	1150	<10	6	<10	10	380
2S/11W-18L14L	08/10/93	1345	<10	7	<10	8	290
(MLS9)	08/11/93	1115	<10	5	10	10	290
	08/12/93	1130	<10	<3	<10	15	270
	08/13/93	1230	<10	4	<10	9	230
	08/16/93	1130	<10	7	<10	11	300
	08/23/93	1210	<10	4	<10	11	420
	08/24/93	1045	<10	3	<10	11	400
	08/28/93	1230	<10	9	20	12	450
	08/29/93	1105	<10	5	<10	9	490
	08/30/93	1130	<10	<3	<10	10	470
2S/11W-18L14M	08/10/93	1230	<10	74	<10	10	1,000
(MLS8)	08/11/93	1030	<10	77	<10	9	1,000

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
	08/12/93	1100	<10	51	<10	14	960
	08/13/93	1150	<10	49	<10	7	810
	08/16/93	1100	<10	54	<10	13	850
	08/23/93	1145	<10	66	<10	10	920
	08/24/93	1020	<10	61	<10	12	850
	08/28/93	1120	<10	48	<10	11	840
	08/29/93	1050	<10	63	<10	8	860
	08/30/93	1050	<10	59	<10	7	790
2S/11W-18L14N (MLS7)	08/10/93	1115	<10	11	<10	6	830
	08/11/93	1000	<10	15	<10	7	790
	08/12/93	1030	<10	10	<10	25	720
	08/13/93	1040	<10	15	<10	8	660
	08/16/93	1015	<10	16	<10	8	710
	08/23/93	1100	<10	14	<10	12	800
	08/24/93	0930	<10	18	<10	9	720
	08/28/93	1050	<10	18	<10	10	690
	08/29/93	1030	<10	20	20	7	710
	08/30/93	1030	<10	17	<10	5	670
2S/11W-18L14O (MLS6)	08/10/93	1010	<10	18	<10	10	900
	08/11/93	0930	<10	17	<10	9	890
	08/12/93	0930	<10	17	<10	14	840
	08/13/93	1015	<10	19	<10	7	840
	08/16/93	1000	<10	24	<10	12	840
	08/23/93	1050	<10	24	<10	11	900
	08/24/93	0850	<10	16	<10	8	860
	08/28/93	1020	<10	25	10	9	880
	08/29/93	1015	<10	19	<10	7	840
	08/30/93	1000	<10	20	<10	5	800
2S/11W-18L14P (MLS5)	08/10/93	0846	<10	17	<10	5	790
	08/11/93	0900	<10	35	<10	8	780
	08/12/93	0900	<10	18	<10	13	690

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
	08/13/93	0845	<10	19	<10	6	730
	08/16/93	0900	<10	20	<10	14	740
	08/23/93	0945	<10	47	<10	7	710
	08/24/93	0830	<10	18	<10	8	720
	08/28/93	0930	<10	23	<10	9	690
	08/29/93	0930	<10	21	10	6	730
	08/30/93	0920	<10	13	<10	5	680
2S/11W-18L14Q	08/10/93	0845	<10	6	<10	9	740
(MLS4)	08/11/93	0845	<10	7	20	8	650
	08/12/93	0845	<10	11	<10	11	630
	08/13/93	0810	<10	18	<10	7	640
	08/16/93	0845	<10	13	<10	12	640
	08/23/93	0920	<10	13	<10	12	690
	08/24/93	0815	<10	18	<10	10	690
	08/28/93	0930	<10	16	<10	10	600
	08/29/93	0910	<10	11	20	8	610
	08/30/93	0820	<10	14	<10	5	550
2S/11W-18L15LYS	08/10/93	1955	<1	70	<1	<4	430
(SS-RED at 49 ft)	08/11/93	1815	<1	120	<1	<4	610
	08/12/93	1550	<1	78	<1	<4	660
	08/13/93	0905	<1	53	<1	<4	610
	08/16/93	0750	<1	95	<1	<4	660
	08/23/93	0850	<1	21	<1	<4	580
	08/24/93	1800	—	—	—	—	—
	08/28/93	1900	<1	99	<1	<4	710
	08/29/93	1800	<1	94	<1	<4	660
	08/30/93	0900	<1	89	<1	<4	770
2S/11W-18L16LYS	08/10/93	2015	<1	43	<1	<4	10
(SS-ORG at 25 ft)	08/11/93	1835	<1	13	<1	<4	44
	08/12/93	1555	<1	41	<1	<4	260
	08/13/93	0915	<1	33	<1	<4	420

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
	08/16/93	0755	<1	67	<1	<4	250
	08/23/93	0851	<1	30	<1	<10	110
	08/24/93	1800	<10	14	<10	10	40
	08/28/93	1900	<1	67	<1	<4	150
	08/29/93	1800	<1	20	<1	<4	170
	08/30/93	0900	<1	5	<1	9	79
2S/11W-18L17LYS	08/10/93	2025	8	3,700	9	4	95
(SS-YEL at 15 ft)	08/11/93	1830	4	1,800	5	4	76
	08/12/93	1610	<1	380	<1	<4	120
	08/13/93	0920	<1	260	<1	7	140
	08/16/93	0800	<1	150	<1	6	200
	08/23/93	0853	<1	310	<1	4	87
	08/24/93	1800	<10	360	<10	5	100
	08/28/93	1900	<1	880	1	7	180
	08/29/93	1800	<1	230	<1	5	150
	08/30/93	0900	<1	230	<1	<4	220
2S/11W-18L18LYS	08/10/93	2100	3	—	2	—	—
(SS-GRE at 10 ft)	08/11/93	1840	2	6	<1	11	17
	08/12/93	1615	1	6	<1	13	58
	08/13/93	0925	2	26	<1	18	240
	08/16/93	0805	<1	420	<1	15	290
	08/23/93	0854	3	790	4	9	160
	08/24/93	1800	—	—	—	—	—
	08/28/93	1900	1	380	1	10	150
	08/29/93	1800	1	310	<1	9	150
	08/30/93	0900	<1	120	<1	14	210
2S/11W-18L19LYS	08/10/93	2110	1	—	<1	—	—
(SS-BLU at 5 ft)	08/11/93	1845	23	13,000	47	14	250
	08/12/93	1620	18	8,800	33	9	180
	08/13/93	0930	2	390	2	<4	35
	08/16/93	0810	<1	81	<1	8	33

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (μg/L as Cu) (01040)	Iron, dissolved (μg/L as Fe) (01046)	Lead, dissolved (μg/L as Pb) (01049)	Lithium, dissolved (μg/L as Li) (01130)	Manganese, dissolved (μg/L as Mn) (01056)
	08/23/93	0855	7	2,000	10	<4	65
	08/24/93	1800	<10	800	<10	<4	34
	08/28/93	1900	<1	280	1	<4	22
	08/29/93	1800	<1	—	<1	—	—
	08/30/93	0900	<1	87	<1	<4	21
2S/11W-18L20LYS	08/10/93	2107	—	—	—	—	—
(CR-YEL at 15 ft)	08/11/93	1855	5	5	1	8	140
	08/12/93	1645	6	14	2	7	160
	08/13/93	0940	<10	10	<10	10	150
	08/16/93	0925	4	18	2	6	170
	08/23/93	0902	2	15	2	10	170
	08/24/93	1800	<10	25	<10	11	170
	08/28/93	1900	7	13	1	11	180
	08/29/93	1800	8	15	<1	8	180
	08/30/93	1022	8	—	2	—	—
2S/11W-18L21LYS	08/10/93	2145	—	—	—	—	—
(CR-GRE at 9 ft)	08/11/93	1850	5	17	5	31	86
	08/12/93	1635	4	16	3	23	130
	08/13/93	0935	3	10	3	21	150
	08/16/93	0920	4	33	4	26	160
	08/23/93	0903	2	27	3	25	140
	08/24/93	1800	<10	21	10	30	110
	08/28/93	1900	3	27	4	25	170
	08/29/93	1800	4	19	4	24	160
	08/30/93	1020	4	—	4	—	—
2S/11W-18L23LYS	08/10/93	2200	—	—	—	—	—
(TF-ORG at 25 ft)	08/11/93	1915	<10	60	10	7	860
	08/16/93	1205	2	9	1	<4	130
	08/23/93	0936	3	<3	1	<4	130
	08/24/93	1800	—	—	—	—	—
	08/30/93	1515	3	8	<1	<4	140

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
2S/11W-18L25LYS	08/10/93	2205	—	—	—	—	—
(TF-GRE at 10 ft)							
2S/11W-18L26LYS	08/10/93	2110	—	—	—	—	—
(TF-BLU at 5 ft)	08/23/93	0940	—	—	—	—	—
	08/24/93	1800	—	—	—	—	—
2S/11W-18L27	08/10/93	1835	<10	<3	<10	<4	520
(PR8 at 49 ft)	08/11/93	1730	<10	<3	<10	<4	520
	08/12/93	1730	<10	<3	<10	8	530
	08/13/93	1820	<10	7	<10	<4	540
	08/16/93	1650	<10	<3	<10	8	550
	08/23/93	1530	<10	<3	<10	5	560
	08/24/93	1305	<10	<3	<10	6	540
	08/28/93	1350	<10	<3	20	<4	580
	08/29/93	1305	<10	<3	<10	<4	580
	08/30/93	1450	<10	<3	<10	<4	580
2S/11W-18L28	08/10/93	2145	<10	4	<10	<4	13
(PR9 at 25 ft)	08/11/93	1500	<10	<3	<10	5	13
	08/12/93	1600	<10	<3	<10	9	13
	08/13/93	1600	<10	<3	<10	<4	13
	08/16/93	1910	<10	<3	<10	8	14
	08/23/93	1730	<10	<3	<10	6	14
	08/24/93	1510	<10	6	<10	7	15
	08/28/93	1530	<10	<3	20	7	14
	08/29/93	1535	<10	4	<10	4	14
	08/30/93	1620	<10	3	<10	5	14
2S/11W-18L29	08/10/93	1100	<10	<3	<10	9	66
(PR10 at 60 ft)	08/11/93	1045	<10	<3	<10	<4	530
	08/12/93	0945	<10	<3	<10	10	520
	08/13/93	1120	<10	<3	<10	<4	520
	08/16/93	1035	<10	<3	<10	10	560
	08/23/93	1250	<10	<3	<10	6	580

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
	08/24/93	0720	<10	<3	<10	<4	570
	08/28/93	1000	<10	<3	<10	7	600
	08/29/93	1140	<10	<3	10	<4	610
	08/30/93	1250	<10	5	<10	<4	620
2S/11W-18L30 (PR11 at 36 ft)	08/10/93	1550	<10	<3	<10	5	530
	08/11/93	1300	<10	3	<10	9	67
	08/12/93	1200	<10	<3	<10	14	69
	08/13/93	1330	<10	<3	<10	8	64
	08/16/93	1450	<10	<3	<10	13	65
	08/23/93	1015	<10	4	<10	14	67
	08/24/93	1130	<10	<3	<10	13	63
	08/28/93	1215	<10	4	<10	12	61
	08/29/93	0955	<10	6	20	10	65
	08/30/93	1100	<10	<3	<10	8	68
POND AT PICO (PR12)	08/10/93	2200	<10	<3	<10	14	3
	08/11/93	2100	<10	15	<10	16	7
	08/12/93	2030	<10	6	<10	20	4
	08/13/93	0910	<10	9	<10	17	1
	08/16/93	1940	<10	4	<10	21	5
	08/23/93	1920	<10	4	<10	20	1
	08/23/93	1930	<10	<3	<10	22	1
	08/23/93	1950	<10	5	<10	21	3
	08/23/93	2030	<10	4	<10	17	1
	08/24/93	1720	<10	3	20	20	2
	08/28/93	1745	<10	4	<10	20	4
	08/29/93	1700	<10	<3	10	15	2
	08/30/93	1745	<10	4	<10	17	2
SEWAGE EFFLUENT (PR13)	08/10/93	2245	<10	41	<10	19	12
	08/11/93	2045	<10	31	<10	17	16
	08/12/93	1950	<10	23	<10	19	14
	08/13/93	1900	<10	33	<10	17	14

Appendix 2D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
	08/16/93	2000	<10	24	<10	21	15
	08/23/93	2010	<10	27	<10	17	12
	08/24/93	1750	<10	18	<10	19	13
	08/28/93	1805	<10	27	<10	19	15
	08/29/93	1720	<10	20	20	17	15
	08/30/93	1810	<10	25	<10	16	15

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; <, actual value less than value shown; —, no data; CR, ceramic-cup lysimeter; SS, stainless steel lysimeter; TF, Teflon lysimeter; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)
2S/11W-18L10LYS	08/10/93	2110	<10	2	<1	530	—	15
(CR-RED at 50 ft)	08/11/93	1900	<10	2	<1	510	—	10
	08/12/93	1655	<10	2	<1	550	—	10
	08/13/93	1020	<10	4	<1	530	—	53
	08/16/93	1050	10	2	<1	550	—	25
	08/23/93	1054	<10	7	<1	530	—	68
	08/24/93	1800	<10	<10	<1	500	9	33
	08/28/93	1900	20	65	<1	510	—	57
	08/29/93	1800	<10	9	<1	530	—	31
	08/30/93	1118	<10	5	<1	540	6	20
2S/11W-18L11LYS	08/10/93	2135	20	3	<1	430	—	35
(CR-ORG at 25 ft)	08/11/93	1905	20	3	<1	440	—	15
	08/12/93	1700	20	3	<1	460	—	14
	08/13/93	1025	<10	5	<1	450	—	31
	08/16/93	1055	30	2	<1	460	—	40
	08/23/93	1109	<10	6	<1	460	—	42
	08/24/93	1800	20	<10	<1	470	<6	21
	08/28/93	1900	<10	5	<1	490	—	46
	08/29/93	1800	<10	4	<1	490	—	30
	08/30/93	1115	30	3	<1	460	—	22
2S/11W-18L13LYS	08/10/93	2140	60	11	<1	590	—	21
(CR-BLU at 13.5 ft)	08/11/93	1910		11	<1	560	—	8
	08/12/93	1710	50	10	<1	570	—	9
	08/13/93	1030	<10	13	<1	570	—	14
	08/16/93	1100	60	15	<1	560	—	18
	08/23/93	1112	30	14	<1	540	—	28
	08/24/93	1800	40	<10	<1	550	<6	15
	08/28/93	1900	—	12	<1	550	—	25

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)
	08/29/93	1800	50	14	<1	550	—	16
	08/30/93	1120	—	11	<1	—	—	—
2S/11W-18L14A (MLS20)	08/10/93	2110	20	<10	3	520	<6	9
	08/11/93	2000	10	<10	<1	480	<6	<3
	08/12/93	2000	20	<10	<1	530	<6	3
	08/13/93	1920	20	<10	<1	530	<6	<3
	08/16/93	1855	10	<10	<1	600	<6	<3
	08/23/93	1900	20	<10	1	630	<6	<3
	08/24/93	1700	10	<10	1	600	<6	5
	08/28/93	1730	<10	<10	2	560	<6	4
	08/29/93	1635	<10	<10	<1	540	<6	<3
	08/30/93	1730	20	<10	<1	550	<6	6
2S/11W-18L14B (MLS19)	08/10/93	2040	<10	<10	<1	610	<6	18
	08/11/93	1930	20	10	<1	500	<6	<3
	08/12/93	1920	20	<10	<1	670	<6	22
	08/13/93	1845	20	<10	<1	610	<6	22
	08/16/93	1818	20	<10	<1	580	<6	18
	08/23/93	1830	10	<10	<1	600	<6	15
	08/24/93	1650	20	<10	<1	630	6	23
	08/28/93	1715	10	<10	<1	580	<6	14
	08/29/93	1620	<10	<10	2	620	<6	14
	08/30/93	1715	<10	<10	<1	580	<6	14
2S/11W-18L14C (MLS18)	08/10/93	2005	<10	<10	<1	640	<6	24
	08/11/93	1900	<10	<10	<1	630	<6	23
	08/12/93	1845	10	<10	2	610	<6	22
	08/13/93	1800	<10	<10	<1	570	<6	26
	08/16/93	1745	10	<10	<1	570	<6	22
	08/23/93	1815	20	<10	1	610	<6	11
	08/24/93	1615	10	<10	1	600	8	29
	08/28/93	1655	<10	<10	1	570	<6	18
	08/29/93	1600	<10	<10	<1	590	<6	10

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)
	08/30/93	1630	10	<10	<1	580	<6	16
2S/11W-18L14D (MLS17)	08/10/93	1930	<10	<10	<1	630	<6	32
	08/11/93	1830	—	—	—	—	—	—
	08/12/93	1800	20	<10	3	540	<6	24
	08/13/93	1745	<10	10	<1	560	<6	27
	08/16/93	1705	20	10	<1	550	<6	47
	08/23/93	1800	10	<10	<1	590	<6	15
	08/24/93	1550	10	<10	<1	600	8	39
	08/28/93	1640	<10	<10	<1	550	<6	16
	08/29/93	1540	10	<10	<1	560	<6	15
	08/30/93	1600	<10	<10	<1	550	<6	17
2S/11W-18L14E (MLS16)	08/10/93	1915	<10	<10	<1	650	<6	18
	08/11/93	1745	<10	<10	<1	610	<6	19
	08/12/93	1700	<10	<10	<1	620	<6	19
	08/13/93	1720	10	<10	<1	590	<6	17
	08/16/93	1620	10	<10	<1	610	<6	18
	08/23/93	1710	<10	<10	<1	690	<6	18
	08/24/93	1525	<10	10	<1	710	9	35
	08/28/93	1620	<10	<10	<1	620	<6	14
	08/29/93	1510	<10	<10	<1	610	<6	10
	08/30/93	1540	<10	<10	<1	630	<6	32
2S/11W-18L14F (MLS15)	08/10/93	1755	<10	<10	<1	630	6	5
	08/11/93	1700	—	—	—	—	—	—
	08/12/93	1620	<10	<10	<1	700	7	7
	08/13/93	1700	<10	<10	<1	650	7	9
	08/16/93	1530	<10	<10	<1	770	<6	8
	08/23/93	1700	<10	<10	<1	770	<6	10
	08/24/93	1450	<10	<10	<1	780	8	10
	08/28/93	1600	<10	<10	<1	730	<6	6
	08/29/93	1450	<10	<10	<1	750	<6	5
	08/30/93	1440	<10	<10	<1	720	<6	9

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (μg/L as Mo) (01060)	Nickel, dissolved (μg/L as Ni) (01065)	Silver, dissolved (μg/L as Ag) (01075)	Strontium, dissolved (μg/L as Sr) (01080)	Vanadium, dissolved (μg/L as V) (01085)	Zinc, dissolved (μg/L as Zn) (01090)
2S/11W-18L14G	08/10/93	1710	<10	<10	<1	610	<6	11
(MLS14)	08/11/93	1610	<10	<10	<1	630	<6	17
	08/12/93	1500	<10	<10	<1	630	<6	14
	08/13/93	1645	10	<10	<1	650	<6	13
	08/16/93	1550	<10	<10	<1	710	<6	14
	08/23/93	1630	10	<10	2	700	9	15
	08/24/93	1430	<10	<10	<1	790	7	11
	08/28/93	1500	<10	<10	<1	670	6	21
	08/29/93	1250	20	<10	<1	690	<6	16
	08/30/93	1430	<10	<10	<1	670	<6	7
2S/11W-18L14H	08/10/93	1625	<10	<10	<1	610	<6	6
(MLS13)	08/11/93	1545	<10	<10	<1	640	<6	6
	08/12/93	1445	<10	<10	1	670	<6	7
	08/13/93	1620	<10	<10	<1	660	<6	17
	08/16/93	1430	10	<10	<1	620	<6	13
	08/23/93	1600	<10	<10	<1	650	7	5
	08/24/93	1315	<10	<10	<1	650	<6	13
	08/28/93	1515	<10	<10	2	610	7	3
	08/29/93	1235	<10	<10	<1	640	<6	4
	08/30/93	1310	<10	<10	<1	620	<6	7
2S/11W-18L14I	08/10/93	1525	<10	<10	<1	590	<6	5
(MLS12)	08/11/93	1520	—	—	—	—	—	—
	08/12/93	1315	<10	<10	2	640	<6	7
	08/13/93	1530	<10	<10	<1	650	6	12
	08/16/93	1250	20	10	<1	550	<6	15
	08/23/93	1520	10	<10	<1	640	7	6
	08/24/93	1220	10	<10	<1	630	<6	23
	08/28/93	1335	<10	<10	1	610	<6	7
	08/29/93	1220	<10	<10	<1	610	<6	5
	08/30/93	1230	<10	<10	<1	620	<6	5
2S/11W-18L14J	08/10/93	1500	<10	<10	<1	600	<6	4

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (μg/L as Mo) (01060)	Nickel, dissolved (μg/L as Ni) (01065)	Silver, dissolved (μg/L as Ag) (01075)	Strontium, dissolved (μg/L as Sr) (01080)	Vanadium, dissolved (μg/L as V) (01085)	Zinc, dissolved (μg/L as Zn) (01090)
(MLS11)	08/11/93	1240	<10	<10	<1	610	<6	<3
	08/12/93	1250	<10	<10	2	630	<6	5
	08/13/93	1500	20	<10	<1	560	<6	8
	08/16/93	1245	30	10	<1	500	7	9
	08/23/93	1500	<10	<10	3	590	9	<3
	08/24/93	1200	<10	<10	<1	600	<6	6
	08/28/93	1315	<10	<10	2	590	7	3
	08/29/93	1200	<10	<10	<1	610	<6	<3
	08/30/93	1215	<10	<10	2	650	6	<3
2S/11W-18L14K	08/10/93	1415	<10	<10	<1	620	<6	7
(MLS10)	08/11/93	1210	<10	<10	<1	610	<6	10
	08/12/93	1220	10	<10	1	630	7	9
	08/13/93	1300	20	<10	<1	510	<6	13
	08/16/93	1200	30	10	<1	490	6	16
	08/23/93	1230	10	<10	<1	550	7	9
	08/24/93	1105	<10	<10	<1	570	<6	11
	08/28/93	1250	<10	<10	<1	600	<6	8
	08/29/93	1125	<10	<10	<1	610	<6	9
	08/30/93	1150	10	<10	<1	600	<6	4
2S/11W-18L14L	08/10/93	1345	<10	<10	<1	600	<6	6
(MLS9)	08/11/93	1115	10	<10	1	610	<6	7
	08/12/93	1130	10	<10	1	610	<6	8
	08/13/93	1230	20	<10	<1	500	6	11
	08/16/93	1130	20	10	<1	470	6	25
	08/23/93	1210	20	<10	1	540	7	4
	08/24/93	1045	10	<10	<1	510	7	8
	08/28/93	1230	<10	<10	<1	600	7	9
	08/29/93	1105	<10	10	<1	610	6	6
	08/30/93	1130	<10	<10	<1	620	<6	<3
2S/11W-18L14M	08/10/93	1230	10	<10	1	550	<6	19
(MLS8)	08/11/93	1030	<10	10	<1	540	<6	25

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)
	08/12/93	1100	20	<10	2	560	<6	20
	08/13/93	1150	<10	<10	<1	510	<6	22
	08/16/93	1100	20	10	<1	510	<6	35
	08/23/93	1145	20	<10	<1	550	<6	13
	08/24/93	1020	20	<10	<1	510	<6	18
	08/28/93	1120	<10	<10	<1	520	<6	18
	08/29/93	1050	<10	<10	1	560	<6	15
	08/30/93	1050	10	<10	<1	550	<6	13
2S/11W-18L14N (MLS7)	08/10/93	1115	20	<10	<1	480	<6	9
	08/11/93	1000	30	10	<1	460	<6	6
	08/12/93	1030	20	10	<1	450	<6	5
	08/13/93	1040	20	<10	<1	430	<6	3
	08/16/93	1015	30	10	<1	440	<6	10
	08/23/93	1100	20	<10	<1	460	<6	8
	08/24/93	0930	20	<10	<1	440	<6	10
	08/28/93	1050	<10	<10	2	420	<6	5
	08/29/93	1030	<10	<10	<1	440	<6	10
	08/30/93	1030	<10	<10	<1	430	<6	4
2S/11W-18L14O (MLS6)	08/10/93	1010	20	10	<1	500	<6	8
	08/11/93	0930	20	<10	<1	450	<6	11
	08/12/93	0930	20	<10	2	440	<6	11
	08/13/93	1015	20	<10	<1	460	<6	12
	08/16/93	1000	20	10	<1	460	<6	18
	08/23/93	1050	20	<10	<1	500	<6	9
	08/24/93	0850	10	<10	<1	460	<6	10
	08/28/93	1020	<10	<10	<1	490	<6	10
	08/29/93	1015	<10	<10	<1	450	<6	8
	08/30/93	1000	20	<10	<1	460	<6	8
2S/11W-18L14P (MLS5)	08/10/93	0846	20	10	<1	510	<6	8
	08/11/93	0900	20	10	<1	470	<6	13
	08/12/93	0900	10	<10	<1	460	<6	14

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (μg/L as Mo) (01060)	Nickel, dissolved (μg/L as Ni) (01065)	Silver, dissolved (μg/L as Ag) (01075)	Strontium, dissolved (μg/L as Sr) (01080)	Vanadium, dissolved (μg/L as V) (01085)	Zinc, dissolved (μg/L as Zn) (01090)
	08/13/93	0845	<10	10	<1	450	<6	21
	08/16/93	0900	30	20	<1	480	<6	15
	08/23/93	0945	20	10	<1	510	<6	11
	08/24/93	0830	10	<10	<1	450	<6	10
	08/28/93	0930	<10	<10	<1	440	<6	10
	08/29/93	0930	<10	<10	<1	430	<6	10
	08/30/93	0920	<10	<10	<1	440	<6	8
2S/11W-18L14Q (MLS4)	08/10/93	0845	20	10	<1	460	<6	12
	08/11/93	0845	<10	20	<1	420	<6	6
	08/12/93	0845	20	<10	<1	440	<6	8
	08/13/93	0810	20	<10	<1	410	<6	9
	08/16/93	0845	20	20	<1	430	<6	12
	08/23/93	0920	20	<10	<1	440	<6	4
	08/24/93	0815	20	10	1	460	<6	11
	08/28/93	0930	10	<10	<1	420	<6	8
	08/29/93	0910	<10	10	<1	430	<6	11
	08/30/93	0820	<10	<10	<1	430	<6	7
2S/11W-18L15LYS (SS-RED at 49 ft)	08/10/93	1955	<10	8	<1	530	—	<3
	08/11/93	1815	<10	8	<1	500	—	9
	08/12/93	1550	20	6	<1	470	—	4
	08/13/93	0905	<10	5	<1	450	—	5
	08/16/93	0750	<10	7	<1	450	—	3
	08/23/93	0850	<10	11	<1	480	—	<3
	08/24/93	1800	—	—	—	—	—	—
	08/28/93	1900	20	6	<1	470	—	7
	08/29/93	1800	<10	5	<1	510	—	3
	08/30/93	0900	10	7	<1	520	—	6
2S/11W-18L16LYS (SS-ORG at 25 ft)	08/10/93	2015	20	8	<1	310	—	<3
	08/11/93	1835	10	5	<1	380	—	8
	08/12/93	1555	<10	3	<1	560	—	<3
	08/13/93	0915	<10	4	<1	600	—	6

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)
	08/16/93	0755	10	5	<1	710	—	<3
	08/23/93	0851	16	12	<1	550	<1	<10
	08/24/93	1800	20	<10	<1	420	<6	4
	08/28/93	1900	20	6	<1	590	—	7
	08/29/93	1800	<10	10	<1	470	—	<3
	08/30/93	0900	20	10	<1	630	<1	4
2S/11W-18L17LYS	08/10/93	2025	30	110	3	510	—	32
(SS-YEL at 15 ft)	08/11/93	1830	<10	62	4	520	1	24
	08/12/93	1610	<10	11	<1	600	—	5
	08/13/93	0920	<10	10	<1	610	—	<3
	08/16/93	0800	<10	11	<1	670	—	<3
	08/23/93	0853	10	13	<1	640	—	<3
	08/24/93	1800	<10	<10	1	590	<6	7
	08/28/93	1900	20	16	<1	710	—	7
	08/29/93	1800	<10	18	<1	640	—	<3
	08/30/93	0900	20	21	<1	700	—	<3
2S/11W-18L18LYS	08/10/93	2100	—	5	<1	—	—	—
(SS-GRE at 10 ft)	08/11/93	1840	<10	4	<1	630	—	5
	08/12/93	1615	<10	3	<1	600	—	<3
	08/13/93	0925	20	4	<1	600	—	9
	08/16/93	0805	20	4	<1	620	—	6
	08/23/93	0854	<10	9	<1	550	—	8
	08/24/93	1800	—	—	—	—	—	—
	08/28/93	1900	<10	7	<1	550	—	8
	08/29/93	1800	20	5	<1	540	—	8
	08/30/93	0900	10	4	<1	600	—	<3
2S/11W-18L19LYS	08/10/93	2110	—	15	<1	—	—	—
(SS-BLU at 5 ft)	08/11/93	1845	10	82	2	370	—	110
	08/12/93	1620	40	60	3	400	—	69
	08/13/93	0930	20	14	<1	360	—	7
	08/16/93	0810	70	10	<1	390	—	11

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)
	08/23/93	0855	40	27	<1	300	—	26
	08/24/93	1800	30	10	<1	250	<6	8
	08/28/93	1900	40	11	<1	340	—	7
	08/29/93	1800	—	12	<1	—	—	—
	08/30/93	0900	30	9	<1	320	—	4
2S/11W-18L20LYS	08/10/93	2107	—	—	—	—	—	—
(CR-YEL at 15 ft)	08/11/93	1855	<10	3	<1	540	—	52
	08/12/93	1645	10	4	<1	610	—	55
	08/13/93	0940	30	<10	<1	570	<6	57
	08/16/93	0925	<10	5	<1	630	—	120
	08/23/93	0902	10	9	<1	550	—	50
	08/24/93	1800	10	20	<1	580	<6	56
	08/28/93	1900	20	9	<1	590	—	59
	08/29/93	1800	<10	7	<1	620	—	51
	08/30/93	1022	—	6	<1	—	—	—
2S/11W-18L21LYS	08/10/93	2145	—	—	—	—	—	—
(CR-GRE at 9 ft)	08/11/93	1850	<10	10	<1	310	—	29
	08/12/93	1635	<10	9	<1	380	—	25
	08/13/93	0935	<10	9	<1	380	—	7
	08/16/93	0920	<10	16	<1	380	—	38
	08/23/93	0903	10	15	<1	340	—	34
	08/24/93	1800	30	10	<1	300	<6	20
	08/28/93	1900	<10	12	<1	370	—	35
	08/29/93	1800	30	13	<1	350	—	21
	08/30/93	1020	—	13	<1	—	—	—
2S/11W-18L23LYS	08/10/93	2200	—	—	—	—	—	—
(TF-ORG at 25 ft)	08/11/93	1915	10	<10	<1	590	<6	28
	08/16/93	1205	<10	2	<1	560	—	10
	08/23/93	0936	<10	2	<1	550	—	<3
	08/24/93	1800	—	—	—	—	—	—
	08/30/93	1515	10	2	<1	570	—	<3

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)
2S/11W-18L25LYS	08/10/93	2205	—	—	—	—	—	—
(TF-GRE at 10 ft)								
2S/11W-18L26LYS	08/10/93	2110	—	—	—	—	—	—
(TF-BLU at 5 ft)	08/23/93	0940	—	—	—	—	—	—
	08/24/93	1800	—	—	—	—	—	—
2S/11W-18L27	08/10/93	1835	20	<10	<1	500	<6	<3
(PR8 at 49 ft)	08/11/93	1730	<10	<10	<1	490	<6	<3
	08/12/93	1730	10	<10	2	480	<6	<3
	08/13/93	1820	<10	<10	<1	490	<6	<3
	08/16/93	1650	10	<10	<1	490	<6	<3
	08/23/93	1530	10	<10	<1	510	<6	<3
	08/24/93	1305	<10	<10	<1	490	<6	<3
	08/28/93	1350	<10	<10	1	520	<6	<3
	08/29/93	1305	<10	<10	<1	510	<6	5
	08/30/93	1450	<10	<10	<1	510	<6	7
2S/11W-18L28	08/10/93	2145	<10	<10	<1	530	<6	<3
(PR9 at 25 ft)	08/11/93	1500	<10	<10	<1	560	<6	<3
	08/12/93	1600	<10	<10	1	580	<6	4
	08/13/93	1600	<10	<10	<1	560	<6	4
	08/16/93	1910	<10	<10	<1	600	<6	<3
	08/23/93	1730	<10	<10	<1	660	<6	<3
	08/24/93	1510	10	<10	<1	640	<6	<3
	08/28/93	1530	<10	<10	<1	660	<6	<3
	08/29/93	1535	<10	<10	<1	610	<6	<3
	08/30/93	1620	<10	<10	<1	620	<6	4
2S/11W-18L29	08/10/93	1100	<10	<10	<1	540	7	8
(PR10 at 60 ft)	08/11/93	1045	20	<10	<1	460	<6	<3
	08/12/93	0945	20	<10	2	440	<6	<3
	08/13/93	1120	<10	<10	<1	450	<6	3
	08/16/93	1035	20	<10	<1	470	<6	4
	08/23/93	1250	20	<10	2	490	<6	<3

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)
	08/24/93	0720	10	<10	<1	480	<6	4
	08/28/93	1000	<10	<10	<1	500	<6	<3
	08/29/93	1140	10	<10	<1	520	<6	4
	08/30/93	1250	10	<10	<1	510	<6	5
2S/11W-18L30 (PR11 at 36 ft)	08/10/93	1550	20	<10	<1	460	<6	<3
	08/11/93	1300	<10	<10	<1	540	7	<3
	08/12/93	1200	10	<10	<1	560	6	<3
	08/13/93	1330	<10	<10	<1	510	7	4
	08/16/93	1450	<10	<10	<1	510	7	<3
	08/23/93	1015	<10	<10	1	520	8	<3
	08/24/93	1130	<10	<10	<1	500	7	<3
	08/28/93	1215	<10	<10	<1	500	7	<3
	08/29/93	0955	<10	<10	<1	540	7	4
	08/30/93	1100	<10	<10	<1	540	<6	<3
POND AT PICO (PR12)	08/10/93	2200	10	<10	<1	510	<6	10
	08/11/93	2100	20	10	<1	540	<6	35
	08/12/93	2030	20	<10	2	510	<6	29
	08/13/93	0910	10	10	<1	530	<6	36
	08/16/93	1940	20	<10	<1	520	<6	28
	08/23/93	1920	20	<10	<1	540	<6	46
	08/23/93	1930	10	<10	<1	540	<6	50
	08/23/93	1950	10	<10	<1	530	<6	44
	08/23/93	2030	20	10	<1	550	<6	36
	08/24/93	1720	20	<10	<1	540	<6	38
	08/28/93	1745	<10	<10	<1	520	<6	32
	08/29/93	1700	10	<10	<1	510	<6	31
	08/30/93	1745	20	<10	<1	520	<6	48
SEWAGE EFFLUENT (PR13)	08/10/93	2245	30	<10	<1	540	<6	60
	08/11/93	2045	<10	<10	<1	540	<6	58
	08/12/93	1950	10	10	<1	530	<6	49
	08/13/93	1900	<10	<10	<1	510	<6	42

Appendix 2E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)
	08/16/93	2000	10	10	<1	510	<6	45
	08/23/93	2010	20	<10	2	530	<6	51
	08/24/93	1750	20	<10	<1	520	<6	55
	08/28/93	1805	20	<10	<1	510	<6	51
	08/29/93	1720	10	10	<1	540	<6	55
	08/30/93	1810	10	<10	<1	520	<6	52

Appendix 3A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, oxygen–alkalinity

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; µS/cm, microsiemens per centimeter; °C, degrees Celsius; ft, feet below basin floor or land surface; mg/L, milligrams per liter; —, no data; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field, (standard units) (00400)	Specific conductance, field (µS/cm) (00095)	Water temperature (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) (00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
2S/11W-18L14A	04/04/94	1940	—	7.1	936	—	260	73	19	84	160
(MLS20)	04/05/94	1205	—	7	927	21.8	270	77	19	81	160
	04/05/94	1800	2	7	925	21.7	270	76	19	81	160
	04/06/94	1400	2.4	7.1	923	21.9	260	72	19	82	160
	04/07/94	0900	2.2	7	1,020	22	290	81	20	88	160
	04/08/94	0825	2.2	7	1,050	21.8	280	79	21	100	170
	04/21/94	0915	—	7.1	1,060	23	230	64	17	120	180
	06/01/94	1455	.4	7.1	1,000	23	230	64	16	110	170
2S/11W-18L14C	04/07/94	0915	3.8	7.1	1,090	22.3	250	72	18	110	180
(MLS18)	04/08/94	0830	2.8	7.1	1,130	22.3	260	73	19	130	180
2S/11W-18L14F	04/04/94	1930	—	7	958	—	280	76	21	83	160
(MLS15)	04/05/94	1145	1.8	6.9	940	21.9	280	79	20	81	160
	04/05/94	1750	2.2	7	925	21.8	270	76	20	81	160
	04/06/94	1350	5.8	7.1	1,080	21.3	270	73	20	110	170
	04/07/94	0945	2.8	7	1,100	22.6	250	71	18	120	180
	04/08/94	0845	4.8	7	1,200	22.1	310	85	23	130	170
	04/21/94	0945	—	7.1	1,040	23	210	59	16	120	170
	06/01/94	1435	.6	7.1	1,050	22	240	67	17	120	180
2S/11W-18L14K	04/04/94	1855	.6	7.2	919	—	230	64	17	91	170
(MLS10)	04/05/94	1123	1.8	7.1	924	21.4	250	70	18	91	170
	04/05/94	1740	2.2	7.2	926	21.2	250	71	18	90	180
	04/06/94	1145	5.2	7.1	1,100	20.3	270	75	20	120	180
	04/07/94	1000	6.6	7.1	1,130	22.7	250	73	17	120	180
	04/08/94	0910	4.6	7.1	1,120	22.7	250	71	17	120	180
	04/21/94	1000	—	7.1	1,040	23	220	61	16	120	180

Appendix 3A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field, (standard units) (00400)	Specific conductance, field (μS/cm) (00095)	Water temperature (ºC) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) (00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	06/01/94	1350	.4	7.2	1,030	20.5	290	78	22	94	180
2S/11W-18L14L	04/04/94	1835	0.8	7.2	920	—	240	66	17	90	170
(MLS9)	04/05/94	1100	.6	7	929	21.2	260	73	18	90	180
	04/05/94	1645	3	7.1	920	20.9	250	72	18	88	170
	04/06/94	1125	6	7.1	1,100	20.2	280	77	20	110	170
	04/07/94	1018	4.6	7	1,120	23	240	69	17	120	180
	04/08/94	0945	1.8	7.1	1,110	22.9	250	71	17	120	180
	04/21/94	1020	—	7.1	1,030	23	220	59	17	120	170
	06/01/94	1315	.6	7	1,030	20	290	78	23	91	180
2S/11W-18L14M	04/04/94	1750	1.2	7	942	—	250	71	18	88	160
(MLS8)	04/05/94	1046	2	7	947	21.3	270	75	19	91	160
	04/05/94	1635	3	7	943	21.3	270	75	19	90	160
	04/06/94	1045	4.6	7.1	1,060	20.7	280	78	20	100	170
	04/07/94	1040	4.2	7.1	1,120	23	250	71	18	120	180
	04/08/94	0930	4.6	7.1	1,200	22.4	290	83	21	130	180
	04/21/94	1040	—	7.2	1,050	23	230	62	17	120	180
	06/01/94	1210	.4	7.2	1,040	21	260	71	19	110	190
2S/11W-18L14N	04/04/94	1730	1	7.1	937	—	250	70	19	90	160
(MLS7)	04/05/94	1010	1	7	925	20.6	250	71	18	87	170
	04/05/94	1540	2.8	7.1	928	20.8	250	71	18	89	170
	04/06/94	1000	2.8	7.1	1,070	21	280	78	20	100	170
	04/07/94	1100	4.8	7	1,120	23	250	69	18	120	180
	04/08/94	0950	2.6	7.1	1,150	22.7	270	76	19	130	180
	04/21/94	1050	—	7.2	1,050	23	210	58	16	120	180
	06/01/94	1100	.6	7.2	1,040	20.5	250	67	19	110	190
2S/11W-18L14O	04/04/94	1715	1.8	7.1	907	—	240	67	18	88	160
(MLS6)	04/05/94	0950	1.2	7	929	20.7	260	72	19	88	160
	04/05/94	1532	2.2	7.1	945	20.6	270	75	19	89	160

Appendix 3A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field, (standard units) (00400)	Specific conduc- tance, field (µS/cm) (00095)	Water tem- perature (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) (00915)	Mag- nesium, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	04/06/94	0950	3.8	7.1	1,090	21.2	270	75	20	110	170
	04/07/94	1120	4.8	7.1	1,120	22.9	250	71	17	120	180
	04/08/94	1045	3.2	7.1	1,150	22.7	270	75	19	130	180
	04/21/94	1105	—	7.1	1,050	23	220	60	17	120	180
	06/01/94	1040	.4	7.2	1,060	21	230	64	18	110	210
2S/11W-18L14P	04/04/94	1630	1.2	7.2	936	—	250	69	18	86	160
(MLS5)	04/05/94	0900	2.8	7	933	20.8	250	72	18	87	160
	04/05/94	1505	3.2	7	979	20.8	280	77	20	91	160
	04/06/94	0818	4.6	7.1	1,080	21	270	73	20	110	170
	04/07/94	1130	3.2	7.1	1,130	22.9	240	68	17	130	180
	04/08/94	1055	3	7.1	1,170	22.4	270	74	20	130	180
	04/21/94	1135	—	7.2	1,050	23	220	61	17	120	180
	06/01/94	0935	.6	7.2	1,050	21	250	68	20	110	200
2S/11W-18L14Q	04/04/94	1605	—	7.1	1,040	—	260	69	20	110	140
(MLS4)	04/05/94	0830	6.4	7	1,120	19.5	280	77	21	120	140
	04/05/94	1450	6.4	7	1,210	19.7	350	95	26	120	140
	04/06/94	0820	5	7.1	1,130	21.9	220	59	17	140	180
	04/07/94	1144	2.8	7.2	1,150	23	210	58	16	150	190
	04/08/94	1125	2	7.1	1,150	22.7	270	75	19	130	180
	04/21/94	1145	—	7.5	1,070	23	200	53	16	140	180
	06/01/94	0915	.8	7.3	1,090	22	220	59	18	140	240
2S/11W-18L27	04/04/94	1905	—	7.1	910	—	290	81	21	74	160
(PR8 at 49 ft)	04/05/94	1700	—	7.1	897	—	290	80	21	73	160
	04/06/94	1030	1.6	7.1	911	20.6	280	78	20	71	160
	04/07/94	1425	—	7.2	910	—	270	76	20	71	160
	04/08/94	1040	4	7.1	923	20.2	290	81	21	74	160
	04/21/94	1740	—	7.1	927	20.4	300	83	22	75	160
	06/01/94	1330	—	7	920	22	280	78	20	78	160

Appendix 3A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field, (standard units) (00400)	Specific conductance, field (µS/cm) (00095)	Water temperature (ºC) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) (00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
2S/11W-18L28	04/04/94	1720	1.6	7	933	—	290	80	21	72	150
(PR9 at 25 ft)	04/05/94	1805	2.4	6.9	928	—	280	80	20	75	150
	04/06/94	1205	2.8	6.9	958	22.8	280	77	21	79	160
	04/07/94	1200	—	6.9	1,030	22.7	290	82	21	88	160
	04/08/94	1000	1.4	6.9	1,060	21.9	300	82	22	100	160
	04/21/94	1625	—	7	1,060	—	220	61	17	120	170
	06/01/94	1515	.6	6.9	1,050	24	260	71	19	110	—
2S/11W-18L29	04/04/94	2000	—	7.1	957	—	320	88	23	69	170
(PR10 at 50 ft)	04/05/94	1405	—	7.1	952	—	320	88	23	71	170
	04/06/94	1550	—	7.2	952	20.7	300	83	22	72	170
	04/07/94	1030	—	7.1	951	19.7	300	84	21	69	170
	04/07/94	1200	—	7.1	951	19.7	—	—	—	—	170
	04/08/94	1200	3.4	7.1	956	—	310	85	23	72	170
	04/21/94	1445	—	7	933	21	310	85	23	70	160
	06/01/94	1130	—	7	937	21	300	83	22	73	160
2S/11W-18L30	04/04/94	1550	—	7	914	22.8	250	71	18	85	160
(PR11 at 36 ft)	04/05/94	1550	2	7	911	—	250	70	18	84	160
	04/06/94	1445	—	6.9	922	22.4	250	70	18	85	160
	04/07/94	0930	1.6	6.9	947	22	260	76	18	83	150
	04/07/94	0931		6.9	945	22	270	78	19	87	150
	04/08/94	1200	1.6	6.8	1,040	22	300	87	21	91	160
	04/21/94	1315	—	7	1,050	22.5	230	65	17	120	170
	06/01/94	1015	—	6.8	984	—	240	69	17	100	160
POND AT PICO	04/05/94	0845	—	7.3	1,100	22.8	230	62	19	120	190
(PR12)	04/05/94	0943	—	7.3	1,100	21.5	230	61	18	120	190
	04/05/94	1055	—	7.3	1,110	—	240	63	19	120	190
	04/05/94	1154	—	7.3	1,100	—	240	63	19	120	190
	04/05/94	1421	—	7.3	1,080	—	230	61	19	120	180
	04/05/94	1607	—	7.3	1,100	—	230	62	19	120	190

Appendix 3A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field, (standard units) (00400)	Specific conduc-tance, field (µS/cm) (00095)	Water tem-perature (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) (00915)	Mag-nesium, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	04/05/94	1714	—	7.4	1,120	—	240	63	19	120	190
	04/05/94	1830	—	7.3	1,130	24.2	240	64	19	120	180
	04/06/94	0745	—	7.3	1,130	—	230	60	19	130	190
	04/07/94	0800	4.6	7.2	1,150	22.3	230	61	18	130	190
	04/07/94	0805	5.6	7.2	1,150	22.3	240	63	19	130	190
	04/07/94	0810	5.4	7.2	1,150	22.1	220	60	18	130	190
	04/07/94	1430	4.8	7.3	1,130	23.1	230	61	18	120	190
	04/07/94	1530	4.6	7.3	1,120	23.4	230	61	18	120	180
	04/07/94	1540	5	7.3	1,130	23	230	61	18	120	190
	04/07/94	1825	5	7.3	1,130	23.1	230	63	18	120	190
	04/07/94	1830	5	7.3	1,130	22.9	230	61	18	120	190
	04/07/94	1845	4.6	7.2	1,130	22.9	220	59	18	120	190
	04/08/94	1130	—	7.2	1,140	22.4	240	63	19	130	190
	04/21/94	0800	—	7.3	1,180	21.9	230	60	19	120	180
	04/21/94	0815	—	7.2	1,070	23	230	60	19	120	170
	04/21/94	0820	—	7.2	1,070	21.4	220	57	18	120	170
	04/21/94	0825	—	7.2	1,070	21.4	230	61	18	120	180
SEWAGE EFFLUENT (PR13)	04/05/94	0915	—	7.3	1,090	—	220	60	18	120	—
	04/05/94	1020	—	7.3	1,100	—	230	61	19	120	190
	04/05/94	1105	—	7.3	1,060	—	230	61	18	120	180
	04/05/94	1210	—	7.3	1,060	—	230	60	19	120	180
	04/05/94	1420	—	7.3	1,110	—	240	64	19	120	180
	04/05/94	1545	—	7.3	1,150	—	240	63	19	120	190
	04/05/94	1650	—	7.5	1,160	—	240	64	19	120	190
	04/05/94	1835	—	7.2	1,160	21.7	230	62	19	120	190
	04/06/94	1215	—	7.5	1,080	23.3	230	61	18	130	190
	04/07/94	1215	6.8	7.3	1,060	23.4	220	59	18	120	180
	04/08/94	1215	7	7.3	1,100	23.3	230	59	19	130	210

Appendix 3A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field, (standard units) (00400)	Specific conduc- tance, field (μS/cm) (00095)	Water tem- perature (ºC) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) (00915)	Mag- nesium, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field, (mg/L as $CaCO_3$) (39036)
	04/21/94	1530	—	7.3	1,110	24	220	59	18	120	190

Appendix 3B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, bromide–phosphorus

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; mg/L, milligrams per liter; <, actual value less than value shown; —, no data; MLS, multilevel sampler]

Station name (Local Identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved, mg/L as N (00613)	Phosphorus, ortho phosphate, dissolved (mg/L as P) (00671)
2S/11W-18L14A	04/04/94	1940	—	102	—	24	158	0.23	0.87	0.89	0.02	0.3
(MLS20)	04/05/94	1205	—	104	—	25	162	.21	.97	.99	.02	.24
	04/05/94	1800	—	101	—	25	158	.2	.95	.97	.02	.25
	04/06/94	1400	—	—	—	23	—	.14	2.07	2.1	.03	.21
	04/07/94	0900	—	119	—	24	157	.16	4.75	5.3	.55	.24
	04/08/94	0825	—	127	—	23	154	.16	5.75	6.3	.55	.23
	04/21/94	0915	—	129	—	21	147	.19	3.2	4.4	1.2	.31
	06/01/94	1455	—	108	—	22	152	.15	1.36	1.4	.04	.32
2S/11W-18L14C	04/07/94	0915	—	129	—	22	147	.1	7.17	7.8	.63	.71
(MLS18)	04/08/94	0830	—	133	—	22	163	.33	7.15	7.8	.65	.88
2S/11W-18L14F	04/04/94	1930	—	112	—	22	162	.02	1.26	1.3	.04	.29
(MLS15)	04/05/94	1145	—	118	—	23	172	.03	1.36	1.4	.04	.28
	04/05/94	1750	—	104	—	21	160	.02	1.68	1.7	.02	.29
	04/06/94	1350	—	135	—	20	154	.02	7.2	8.3	1.1	.35
	04/07/94	0945	—	133	—	21	150	.03	7.1	8.2	1.1	.55
	04/08/94	0845	—	133	—	22	208	.05	9.63	9.7	.07	.64
	04/21/94	0945	—	129	—	20	144	1.9	2.27	2.3	.03	.98
	06/01/94	1435	—	121	—	20	143	1.3	3.28	3.3	.02	.79
2S/11W-18L14K	04/04/94	1855	—	93	—	19	154	.02	2.38	2.4	.02	.61
(MLS10)	04/05/94	1123	—	92	—	19	154	.04	2.47	2.5	.03	.59
	04/05/94	1740	—	90	—	19	155	—	—	—	—	—
	04/06/94	1145	—	132	—	21	155	.02	8.95	9.1	.15	.75
	04/07/94	1000	—	136	—	21	153	.04	7.86	8.2	.34	1
	04/08/94	0910	—	136	—	20	149	.04	7.22	7.9	.68	1.1
	04/21/94	1000	—	128	—	20	144	1.5	2.69	2.7	.01	1.3

Appendix 3B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, bromide–phosphorus—Continued

Station name (Local Identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved, mg/L as N (00613)	Phos-phorus, ortho phosphate, dissolved (mg/L as P) (00671)
	06/01/94	1350	—	112	—	16	162	1.2	.66	.68	.02	.93
2S/11W-18L14L	04/04/94	1835	—	91	—	18	152	0.04	2.47	2.5	0.03	0.5
(MLS9)	04/05/94	1100	—	91	—	19	153	.02	2.58	2.6	.02	.56
	04/05/94	1645	—	88	—	19	155	.02	3.09	3.1	.01	.49
	04/06/94	1125	—	131	—	21	158	.02	8.53	8.8	.27	.86
	04/07/94	1018	—	138	—	20	151	.03	7.4	8.2	.8	.92
	04/08/94	0945	—	136	—	20	146	.19	6.1	7.6	1.5	1.1
	04/21/94	1020	—	127	—	19	141	1.5	3.69	3.7	.01	1.5
	06/01/94	1315	—	112	—	16	167	1.4	.58	.59	.01	.98
2S/11W-18L14M	04/04/94	1750	—	99	—	22	162	.12	1.66	1.7	.04	.6
(MLS8)	04/05/94	1046	—	96	—	22	169	.1	2.15	2.2	.05	.63
	04/05/94	1635	—	94	—	21	168	.08	2.46	2.5	.04	.59
	04/06/94	1045	—	124	—	21	158	.09	6.47	6.9	.43	.57
	04/07/94	1040	—	134	—	21	156	.12	7.34	7.8	.46	.97
	04/08/94	0930	—	135	—	22	199	.18	8.3	8.7	.4	.97
	04/21/94	1040	—	128	—	21	146	1.6	2.05	2.1	.05	1.2
	06/01/94	1210	—	116	—	19	149	1.2	1.07	1.1	.03	1
2S/11W-18L14N	04/04/94	1730	—	86	—	21	181	.1	2.8	2.9	.1	.83
(MLS7)	04/05/94	1010	—	91	—	20	163	.06	2.77	2.8	.03	.76
	04/05/94	1540	—	91	—	20	162	.05	2.77	2.8	.03	.71
	04/06/94	1000	—	121	—	21	168	.05	7.21	7.7	.49	.8
	04/07/94	1100	—	134	—	21	151	.05	7.55	8.1	.55	.99
	04/08/94	0950	—	135	—	21	172	.2	7.84	8.4	.56	1.1
	04/21/94	1050	—	128	—	19	143	1.5	2.72	3	.28	1.3
	06/01/94	1100	—	115	—	20	148	1.2	.53	.55	.02	1.3
2S/11W-18L14O	04/04/94	1715	—	86	—	20	165	.03	2.97	3	.03	.84
(MLS6)	04/05/94	0950	—	92	—	20	166	.06	2.56	2.6	.04	.8
	04/05/94	1532	—	90	—	20	177	.03	3.28	3.3	.02	.71

Appendix 3B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, bromide–phosphorus—Continued

Station name (Local Identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved, mg/L as N (00613)	Phos-phorus, ortho phosphate, dissolved (mg/L as P) (00671)
	04/06/94	0950	—	126	—	21	162	—	—	—	—	—
	04/07/94	1120	—	136	—	21	153	0.08	7.81	8.4	0.59	1.1
	04/08/94	1045	—	136	—	21	169	.34	7.41	8.2	.79	1.2
	04/21/94	1105	—	130	—	20	146	1.8	2.27	2.4	.13	1.3
	06/01/94	1040	—	120	—	20	139	1.4	.89	.92	.03	1.4
2S/11W-18L14P	04/04/94	1630	—	95	—	20	167	.04	2.05	2.1	.05	.65
(MLS5)	04/05/94	0900	—	96	—	21	162	.04	2.16	2.2	.04	.63
	04/05/94	1505	—	90	—	21	191	.04	3.38	3.4	.02	.68
	04/06/94	0818	—	119	—	21	175	.03	7.51	7.9	.39	.89
	04/07/94	1130	—	141	—	21	160	.25	7.25	8.1	.85	1.1
	04/08/94	1055	—	136	—	22	178	.95	7.57	8.4	.83	1.1
	04/21/94	1135	—	128	—	20	146	1.8	2.18	2.3	.12	1.2
	06/01/94	0935	—	121	—	19	137	1.3	.77	0.8	.03	1.3
2S/11W-18L14Q	04/04/94	1605	—	76	—	21	256	.02	—	5.7	<.010	1.2
(MLS4)	04/05/94	0830	—	74	—	22	308	.02	7.18	7.2	.02	1.1
	04/05/94	1450	—	88	—	20	339	.03	7.46	7.8	.34	.95
	04/06/94	0820	—	127	—	21	166	.07	7.9	9	1.1	1
	04/07/94	1144	—	135	—	21	153	.86	6.7	8	1.3	1.2
	04/08/94	1125	—	137	—	21	169	.36	7.37	8.2	.83	1.2
	04/21/94	1145	—	128	—	21	149	2	1.87	2.1	.23	1.2
	06/01/94	0915	—	142	—	22	95	1.5	.17	.19	.02	2.3
2S/11W-18L27	04/04/94	1905	0.14	97	0.3	22	150	.03	1.48	1.5	.02	.16
(PR8 at 49 ft)	04/05/94	1700	.14	100	.3	22	150	—	—	1.4	—	—
	04/06/94	1030	—	99	—	21	151	.03	1.49	1.5	.01	.17
	04/07/94	1425	—	98	—	21	149	.02	—	1.5	<.010	.17
	04/08/94	1040	—	102	—	22	151	.02	—	1.7	<.010	.16
	04/21/94	1740	.14	96	.3	22	150	.02	2.17	2.2	.03	.15
	06/01/94	1330	.15	94	.4	21	150	.03	1.38	1.4	.02	.18
2S/11W-18L28	04/04/94	1720	—	107	—	23	158	.01	—	1.3	<.010	.06

Appendix 3B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, bromide–phosphorus—Continued

Station name (Local Identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved, mg/L as N (00613)	Phos-phorus, ortho phosphate, dissolved (mg/L as P) (00671)
(PR9 at 25 ft)	04/05/94	1805	—	107	—	23	156	0.02	1.49	1.5	0.01	0.06
	04/06/94	1205	—	109	—	23	159	.02	2.48	2.6	.12	.06
	04/07/94	1200	—	123	—	22	156	.02	5.9	6.9	1	.06
	04/08/94	1000	—	130	—	22	152	.02	6.2	7.7	1.5	.06
	04/21/94	1625	—	123	—	20	140	.03	6.4	8.2	1.8	.07
	06/01/94	1515	—	123	—	21	142	.03	4.8	6	1.2	.08
2S/11W-18L29	04/04/94	2000	—	109	—	22	158	.02	1.28	1.3	.02	.1
(PR10 at 50 ft)	04/05/94	1405	—	109	—	22	157	.03	1.28	1.3	.02	.11
	04/06/94	1550	—	109	—	21	156	.03	1.28	1.3	.02	.11
	04/07/94	1030	—	108	—	21	155	.02	1.39	1.4	.01	.1
	04/07/94	1200	—	—	—	—	—	—	—	—	—	—
	04/08/94	1200	—	109	—	22	157	.03	—	1.5	<.010	.12
	04/21/94	1445	—	103	—	21	—	.02	1.49	1.5	.01	.1
	06/01/94	1130	—	101	—	21	154	.02	1.68	1.7	.02	.1
2S/11W-18L30	04/04/94	1550	—	99	—	21	156	.03	—	1.4	<.010	.48
(PR11 at 36 ft)	04/05/94	1550	—	99	—	21	156	.03	1.39	1.4	.01	.46
	04/06/94	1445	—	102	—	21	158	.02	—	1.5	<.010	.41
	04/07/94	0930	—	105	—	22	158	.02	2.7	2.8	.1	.38
	04/07/94	0931	0.15	100	0.4	22	160	.03	2.7	2.8	.1	.38
	04/08/94	1200	—	130	—	22	—	.02	5.7	6.9	1.2	.35
	04/21/94	1315	—	125	—	20	140	.02	4.9	7.2	2.3	.35
	06/01/94	1015	—	108	—	21	146	.01	4.09	4.5	.41	.32
POND AT PICO	04/05/94	0845	—	131	—	20	150	4.7	5.3	6.8	1.5	1.9
(PR12)	04/05/94	0943	—	130	—	20	149	4.7	5.4	6.9	1.5	1.8
	04/05/94	1055	—	129	—	20	151	4.7	5.2	6.7	1.5	2
	04/05/94	1154	—	128	—	20	150	4.3	5.4	6.8	1.4	1.8
	04/05/94	1421	—	125	—	20	149	3.2	6	7.2	1.2	2
	04/05/94	1607	—	129	—	20	147	3.9	6.2	7.4	1.2	1.9

Appendix 3B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, bromide–phosphorus—Continued

Station name (Local Identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved, mg/L as N (00613)	Phos-phorus, ortho phosphate, dissolved (mg/L as P) (00671)
	04/05/94	1714	—	131	—	20	150	4.6	6.3	7.5	1.2	2.2
	04/05/94	1830	—	134	—	20	150	5.3	6.6	7.8	1.2	2.2
	04/06/94	0745	—	133	—	20	149	6	5.9	7.3	1.4	2.2
	04/07/94	0800	—	137	—	20	146	5.1	6.1	7.7	1.6	2
	04/07/94	0805	—	137	—	20	147	5.2	6.3	7.9	1.6	2
	04/07/94	0810	—	138	—	20	148	5.2	6.1	7.8	1.7	2
	04/07/94	1430	—	135	—	20	144	4.5	6	7.6	1.6	2
	04/07/94	1530	—	137	—	20	145	4.5	6.2	7.8	1.6	2
	04/07/94	1540	—	136	—	20	144	4.5	6	7.7	1.7	2
	04/07/94	1825	—	139	—	20	145	5	6.3	7.9	1.6	2
	04/07/94	1830	—	138	—	20	145	5.1	6.1	7.8	1.7	2
	04/07/94	1845	—	137	—	20	144	—	—	—	—	—
	04/08/94	1130	0.04	130	0.7	20	140	5.6	12.3	14	1.7	2
	04/21/94	0800	—	129	—	20	140	2.6	6.3	7.2	.9	1.9
	04/21/94	0815	—	129	—	20	140	2.5	4.6	7.1	2.5	1.8
	04/21/94	0820	—	129	—	19	138	2.6	6.12	7	.88	1.9
	04/21/94	0825	—	129	—	20	139	2.6	6.1	7	.9	1.9
SEWAGE EFFLUENT (PR13)	04/05/94	0915	—	127	—	20	141	4.9	4.7	6.3	1.6	1.7
	04/05/94	1020	—	131	—	20	149	2.8	6	7	1	2.1
	04/05/94	1105	—	123	—	20	142	3.4	5.3	6.8	1.5	1.5
	04/05/94	1210	—	120	—	20	148	—	—	—	—	—
	04/05/94	1420	—	134	—	20	149	3.3	6.8	7.9	1.1	2.1
	04/05/94	1545	—	141	—	20	148	6.6	6.6	7.8	1.2	2.3
	04/05/94	1650	—	140	—	20	148	8	6.9	8.1	1.2	2.3
	04/05/94	1835	—	140	—	19	148	9	7.9	9.2	1.3	2.4
	04/06/94	1215	.1	120	.5	20	150	2.5	8.4	9.5	1.1	2.1
	04/07/94	1215	—	124	—	20	140	2.9	5.7	6.8	1.1	1.7
	04/08/94	1215	—	118	—	20	142	3	6.5	7.7	1.2	1.7
	04/21/94	1530	—	136	—	20	134	8	4.3	5.4	1.1	2.1

Appendix 3C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, barium–cobalt

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; <, actual value less than value shown; —, no data; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
2S/11W-18L14A	04/04/94	1940	220	<0.5	<1	<5	6
(MLS20)	04/05/94	1205	210	<.5	1	<5	8
	04/05/94	1800	210	<.5	<1	<5	5
	04/06/94	1400	220	<.5	<1	<5	5
	04/07/94	0900	240	<.5	<1	<5	5
	04/08/94	0825	250	<.5	<1	<5	<3
	04/21/94	0915	220	<.5	<1	<5	<3
	06/01/94	1455	190	<.5	<1	<5	<3
2S/11W-18L14C	04/07/94	0915	190	<.5	3	<5	<3
(MLS18)	04/08/94	0830	190	<.5	<1	<5	<3
2S/11W-18L14F	04/04/94	1930	210	<.5	<1	<5	5
(MLS15)	04/05/94	1145	200	1.1	1	<5	4
	04/05/94	1750	190	1.1	1	<5	4
	04/06/94	1350	210	<.5	<1	<5	<3
	04/07/94	0945	190	<.5	<1	<5	<3
	04/08/94	0845	230	<.5	<1	<5	<3
	04/21/94	0945	180	<.5	2	<5	<3
	06/01/94	1435	180	<.5	<1	<5	<3
2S/11W-18L14K	04/04/94	1855	130	<.5	<1	<5	<3
(MLS10)	04/05/94	1123	130	1.1	2	<5	<3
	04/05/94	1740	130	<.5	1	<5	<3
	04/06/94	1145	150	<.5	1	<5	<3
	04/07/94	1000	140	<.5	<1	<5	4
	04/08/94	0910	130	<.5	<1	<5	<3
	04/21/94	1000	140	<.5	2	<5	<3
	06/01/94	1350	150	<.5	1	<5	<3
2S/11W-18L14L	04/04/94	1835	120	<.5	<1	<5	<3
(MLS9)	04/05/94	1100	120	1.2	<1	<5	<3

Appendix 3C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, barium–cobalt—Continued

Station name (Local identifier)	Date	Time	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
	04/05/94	1645	120	1.2	1	<5	<3
	04/06/94	1125	140	<.5	2	<5	<3
	04/07/94	1018	130	<.5	<1	<5	<3
	04/08/94	0945	130	<.5	1	<5	<3
	04/21/94	1020	130	<.5	<1	<5	<3
	06/01/94	1315	150	<.5	<1	<5	<3
2S/11W-18L14M	04/04/94	1750	160	<.5	<1	<5	<3
(MLS8)	04/05/94	1046	160	1.2	1	<5	<3
	04/05/94	1635	160	1.3	1	<5	<3
	04/06/94	1045	170	<.5	1	<5	<3
	04/07/94	1040	150	<.5	<1	<5	<3
	04/08/94	0930	180	<.5	<1	<5	<3
	04/21/94	1040	150	<.5	<1	<5	<3
	06/01/94	1210	160	<.5	<1	<5	<3
2S/11W-18L14N	04/04/94	1730	150	<.5	1	<5	<3
(MLS7)	04/05/94	1010	150	1.2	2	<5	<3
	04/05/94	1540	150	<.5	1	<5	3
	04/06/94	1000	170	<.5	<1	<5	<3
	04/07/94	1100	160	<.5	<1	<5	<3
	04/08/94	0950	170	<.5	2	<5	<3
	04/21/94	1050	150	<.5	2	<5	<3
	06/01/94	1100	160	<.5	<1	<5	3
2S/11W-18L14O	04/04/94	1715	160	<.5	2	<5	<3
(MLS6)	04/05/94	0950	150	1.1	<1	<5	<3
	04/05/94	1532	160	1.1	1	<5	<3
	04/06/94	0950	180	<.5	<1	<5	4
	04/07/94	1120	160	<.5	<1	<5	<3
	04/08/94	1045	180	<.5	5	<5	<3
	04/21/94	1105	170	<.5	<1	<5	<3
	06/01/94	1040	160	<.5	<1	<5	<3

Appendix 3C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, barium–cobalt—Continued

Station name (Local identifier)	Date	Time	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
2S/11W-18L14P	04/04/94	1630	160	<0.5	1	<5	<3
(MLS5)	04/05/94	0900	160	1	<1	<5	4
	04/05/94	1505	170	1	<1	<5	<3
	04/06/94	0818	170	<.5	<1	<5	<3
	04/07/94	1130	160	<.5	<1	<5	<3
	04/08/94	1055	180	<.5	<1	<5	<3
	04/21/94	1135	160	<.5	<1	<5	<3
	06/01/94	0935	160	<.5	<1	<5	<3
2S/11W-18L14Q	04/04/94	1605	160	<.5	<1	<5	<3
(MLS4)	04/05/94	0830	170	<.5	<1	<5	<3
	04/05/94	1450	190	<.5	<1	<5	<3
	04/06/94	0820	140	<.5	<1	<5	<3
	04/07/94	1144	140	<.5	<1	<5	<3
	04/08/94	1125	180	<.5	3	<5	<3
	04/21/94	1145	130	<.5	<1	<5	<3
	06/01/94	0915	140	<.5	1	<5	3
2S/11W-18L27	04/04/94	1905	140	<.5	1	<5	11
(PR8 at 49 ft)	04/05/94	1700	140	<.5	<1	<5	12
	04/06/94	1030	140	<.5	<1	<5	13
	04/07/94	1425	140	<.5	<1	<5	10
	04/08/94	1040	150	<.5	<1	<5	9
	04/21/94	1740	140	<.5	2	<5	13
	06/01/94	1330	140	<.5	<1	<5	14
2S/11W-18L28	04/04/94	1720	150	<.5	1	<5	6
(PR9 at 25 ft)	04/05/94	1805	150	1	<1	<5	5
	04/06/94	1205	150	<.5	<1	<5	4
	04/07/94	1200	170	<.5	<1	<5	5
	04/08/94	1000	170	<.5	<1	<5	<3
	04/21/94	1625	130	<.5	<1	<5	<3
	06/01/94	1515	150	<.5	<1	<5	<3

Appendix 3C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, barium–cobalt—Continued

Station name (Local identifier)	Date	Time	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
2S/11W-18L29	04/04/94	2000	150	<0.5	<1	<5	8
(PR10 at 50 ft)	04/05/94	1405	150	1	2	<5	10
	04/06/94	1550	150	<.5	<1	<5	12
	04/07/94	1030	150	<.5	2	<5	11
	04/07/94	1200	—	—	—	—	—
	04/08/94	1200	160	<.5	<1	<5	10
	04/21/94	1445	150	<.5	<1	<5	14
	06/01/94	1130	150	<.5	<1	<5	10
2S/11W-18L30	04/04/94	1550	140	<.5	3	<5	4
(PR11 at 36 ft)	04/05/94	1550	130	<.5	<1	<5	5
	04/06/94	1445	140	<.5	<1	<5	<3
	04/07/94	0930	150	<.5	2	<5	6
	04/07/94	0931	150	<.5	2	<5	4
	04/08/94	1200	170	<.5	3	<5	<3
	04/21/94	1315	140	<.5	<1	<5	<3
	06/01/94	1015	140	<.5	<1	<5	<3
POND AT PICO	04/05/94	0845	42	1.3	<1	<5	<3
(PR12)	04/05/94	0943	40	1.1	<1	<5	<3
	04/05/94	1055	40	1.2	1	<5	<3
	04/05/94	1154	41	1.2	<1	<5	<3
	04/05/94	1421	40	<.5	<1	<5	<3
	04/05/94	1607	41	<.5	<1	<5	<3
	04/05/94	1714	42	<.5	2	<5	<3
	04/05/94	1830	43	1.1	<1	<5	<3
	04/06/94	0745	43	<.5	<1	<5	<3
	04/07/94	0800	42	<.5	<1	<5	<3
	04/07/94	0805	41	1.3	<1	<5	<3
	04/07/94	0810	42	<.5	3	<5	<3
	04/07/94	1430	41	<.5	<1	<5	<3
	04/07/94	1530	41	<.5	2	<5	<3
	04/07/94	1540	39	<.5	<1	<5	<3

Appendix 3C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, barium–cobalt—Continued

Station name (Local identifier)	Date	Time	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)
	04/07/94	1825	40	<0.5	2	<5	3
	04/07/94	1830	41	<.5	4	<5	<3
	04/07/94	1845	41	<.5	<1	<5	<3
	04/08/94	1130	41	<.5	2	<5	<3
	04/21/94	0800	41	<.5	<1	<5	<3
	04/21/94	0815	42	<.5	<1	<5	<3
	04/21/94	0820	40	<.5	1	<5	<3
	04/21/94	0825	41	<.5	1	<5	<3
SEWAGE EFFLUENT (PR13)	04/05/94	0915	38	<.5	2	<5	<3
	04/05/94	1020	39	<.5	2	5	<3
	04/05/94	1105	35	1.2	<1	<5	<3
	04/05/94	1210	39	<.5	<1	<5	<3
	04/05/94	1420	40	1.1	2	<5	<3
	04/05/94	1545	41	<.5	<1	<5	<3
	04/05/94	1650	42	1.1	<1	<5	<3
	04/05/94	1835	43	<.5	<1	<5	<3
	04/06/94	1215	38	<.5	<1	<5	<3
	04/07/94	1215	38	<.5	<1	<5	<3
	04/08/94	1215	40	<.5	<1	<5	<3
	04/21/94	1530	43	<.5	<1	<5	<3

Appendix 3D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, copper–manganese

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; <, actual value less than value shown; —, no data; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
2S/11W-18L14A	04/04/94	1940	<10	330	<10	<4	2,700
(MLS20)	04/05/94	1205	<10	310	<10	7	2,600
	04/05/94	1800	<10	320	<10	6	2,600
	04/06/94	1400	<10	190	<10	6	2,000
	04/07/94	0900	<10	170	10	6	2,000
	04/08/94	0825	10	110	<10	6	1,900
	04/21/94	0915	20	86	10	6	1,700
	06/01/94	1455	<10	68	<10	<4	1,600
2S/11W-18L14C	04/07/94	0915	10	11	<10	11	170
(MLS18)	04/08/94	0830	20	9	<10	12	140
2S/11W-18L14F	04/04/94	1930	<10	5	<10	8	220
(MLS15)	04/05/94	1145	<10	6	<10	13	220
	04/05/94	1750	<10	10	<10	12	190
	04/06/94	1350	10	11	<10	8	78
	04/07/94	0945	10	14	<10	11	42
	04/08/94	0845	20	11	<10	11	30
	04/21/94	0945	20	10	<10	12	82
	06/01/94	1435	20	9	<10	10	150
2S/11W-18L14K	04/04/94	1855	<10	<3	<10	9	77
(MLS10)	04/05/94	1123	<10	<3	<10	12	69
	04/05/94	1740	<10	<3	<10	11	64
	04/06/94	1145	10	14	<10	10	17
	04/07/94	1000	10	13	<10	11	8
	04/08/94	0910	10	9	<10	12	3
	04/21/94	1000	20	12	10	10	48
	06/01/94	1350	<10	3	10	10	250
2S/11W-18L14L	04/04/94	1835	<10	<3	20	9	31
(MLS9)	04/05/94	1100	<10	6	<10	13	22

Appendix 3D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
	04/05/94	1645	<10	<3	<10	14	18
	04/06/94	1125	20	12	<10	9	8
	04/07/94	1018	10	10	<10	11	2
	04/08/94	0945	10	12	10	14	3
	04/21/94	1020	20	11	<10	12	53
	06/01/94	1315	<10	<3	<10	11	190
2S/11W-18L14M	04/04/94	1750	<10	65	<10	8	530
(MLS8)	04/05/94	1046	<10	68	<10	12	490
	04/05/94	1635	<10	60	<10	12	440
	04/06/94	1045	10	42	<10	8	370
	04/07/94	1040	10	23	20	11	220
	04/08/94	0930	20	28	<10	11	240
	04/21/94	1040	20	40	<10	11	330
	06/01/94	1210	<10	39	<10	9	530
2S/11W-18L14N	04/04/94	1730	<10	5	<10	7	760
(MLS7)	04/05/94	1010	<10	8	10	12	640
	04/05/94	1540	<10	7	<10	11	620
	04/06/94	1000	<10	13	10	8	600
	04/07/94	1100	20	17	<10	11	150
	04/08/94	0950	20	10	<10	10	160
	04/21/94	1050	10	12	<10	11	250
	06/01/94	1100	10	3	<10	8	480
2S/11W-18L14O	04/04/94	1715	<10	<3	<10	8	230
(MLS6)	04/05/94	0950	<10	5	<10	12	680
	04/05/94	1532	<10	4	<10	14	160
	04/06/94	0950	10	17	<10	8	79
	04/07/94	1120	10	15	<10	11	38
	04/08/94	1045	20	13	<10	10	51
	04/21/94	1105	20	13	<10	11	110
	06/01/94	1040	10	<3	<10	10	380

Appendix 3D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
2S/11W-18L14P	04/04/94	1630	<10	11	<10	8	260
(MLS5)	04/05/94	0900	<10	6	<10	12	230
	04/05/94	1505	<10	4	<10	14	190
	04/06/94	0818	10	25	30	11	130
	04/07/94	1130	20	16	<10	11	46
	04/08/94	1055	20	14	<10	13	62
	04/21/94	1135	20	16	<10	12	130
	06/01/94	0935	10	6	<10	8	420
2S/11W-18L14Q	04/04/94	1605	<10	6	<10	11	16
(MLS4)	04/05/94	0830	<10	<3	<10	13	21
	04/05/94	1450	<10	7	10	14	45
	04/06/94	0820	10	16	20	18	32
	04/07/94	1144	10	16	<10	20	16
	04/08/94	1125	20	12	<10	10	48
	04/21/94	1145	20	10	<10	15	69
	06/01/94	0915	10	3	<10	8	360
2S/11W-18L27	04/04/94	1905	<10	<3	<10	6	960
(PR8 at 49 ft)	04/05/94	1700	<10	<3	<10	6	940
	04/06/94	1030	<10	<3	<10	<4	930
	04/07/94	1425	<10	5	<10	5	880
	04/08/94	1040	<10	<3	<10	<4	950
	04/21/94	1740	<10	<3	<10	6	930
	06/01/94	1330	<10	6	20	<4	930
2S/11W-18L28	04/04/94	1720	<10	<3	<10	7	15
(PR9 at 25 ft)	04/05/94	1805	<10	<3	<10	10	14
	04/06/94	1205	<10	5	<10	6	13
	04/07/94	1200	10	7	<10	6	15
	04/08/94	1000	20	11	<10	6	14
	04/21/94	1625	20	10	20	5	12
	06/01/94	1515	20	7	<10	7	36

Appendix 3D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
2S/11W-18L29	04/04/94	2000	<10	<3	<10	6	1,100
(PR10 at 50 ft)	04/05/94	1405	<10	<3	<10	8	1,100
	04/06/94	1550	<10	7	<10	4	1,100
	04/07/94	1030	<10	<3	<10	<4	1,100
	04/07/94	1200	—	—	—	—	—
	04/08/94	1200	<10	<3	10	<4	1,100
	04/21/94	1445	<10	4	<10	<4	1,100
	06/01/94	1130	<10	<3	<10	<4	1,100
2S/11W-18L30	04/04/94	1550	<10	<3	<10	8	74
(PR11 at 36 ft)	04/05/94	1550	<10	<3	10	11	72
	04/06/94	1445	<10	4	<10	9	79
	04/07/94	0930	<10	4	30	10	88
	04/07/94	0931	<10	6	<10	13	90
	04/08/94	1200	10	9	<10	10	110
	04/21/94	1315	20	12	<10	9	94
	06/01/94	1015	10	5	<10	7	120
POND AT PICO	04/05/94	0845	<10	35	<10	19	23
(PR12)	04/05/94	0943	<10	28	<10	19	22
	04/05/94	1055	<10	37	<10	19	18
	04/05/94	1154	<10	19	<10	19	16
	04/05/94	1421	<10	18	<10	18	14
	04/05/94	1607	<10	17	10	18	15
	04/05/94	1714	<10	18	<10	18	14
	04/05/94	1830	<10	16	<10	19	14
	04/06/94	0745	<10	32	<10	16	12
	04/07/94	0800	<10	24	<10	16	11
	04/07/94	0805	<10	28	<10	19	11
	04/07/94	0810	<10	26	<10	16	11
	04/07/94	1430	<10	21	<10	15	11
	04/07/94	1530	<10	20	<10	15	10
	04/07/94	1540	<10	22	<10	15	11

Appendix 3D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, copper–manganese—Continued

Station name (Local identifier)	Date	Time	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
	04/07/94	1825	<10	26	<10	14	11
	04/07/94	1830	<10	19	<10	16	10
	04/07/94	1845	<10	19	20	15	10
	04/08/94	1130	<10	32	<10	19	12
	04/21/94	0800	<10	25	<10	14	15
	04/21/94	0815	<10	36	<10	15	15
	04/21/94	0820	<10	23	<10	15	13
	04/21/94	0825	<10	25	<10	14	15
SEWAGE EFFLUENT (PR13)	04/05/94	0915	<10	36	<10	17	13
	04/05/94	1020	<10	34	<10	19	11
	04/05/94	1105	<10	29	<10	18	11
	04/05/94	1210	<10	30	<10	18	10
	04/05/94	1420	<10	27	<10	19	10
	04/05/94	1545	<10	23	<10	18	9
	04/05/94	1650	<10	25	<10	20	10
	04/05/94	1835	<10	26	<10	18	13
	04/06/94	1215	<10	32	<10	17	13
	04/07/94	1215	<10	31	<10	15	11
	04/08/94	1215	<10	37	10	16	8
	04/21/94	1530	<10	32	<10	13	13

Appendix 3E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, molybdenum–strontium

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; <, actual value less than value shown; —, no data; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium , dissolved (µg/L as Sr) (01080)
2S/11W-18L14A	04/04/94	1940	<10	<10	<1	790
(MLS20)	04/05/94	1205	20	<10	<1	810
	04/05/94	1800	<10	10	<1	800
	04/06/94	1400	<10	<10	<1	810
	04/07/94	0900	<10	10	<1	860
	04/08/94	0825	<10	<10	1	890
	04/21/94	0915	20	<10	1	730
	06/01/94	1455	30	<10	<1	670
2S/11W-18L14C	04/07/94	0915	10	<10	<1	650
(MLS18)	04/08/94	0830	10	<10	<1	650
2S/11W-18L14F	04/04/94	1930	<10	<10	<1	760
(MLS15)	04/05/94	1145	<10	<10	<1	740
	04/05/94	1750	<10	<10	<1	720
	04/06/94	1350	20	<10	<1	730
	04/07/94	0945	<10	<10	<1	660
	04/08/94	0845	<10	<10	<1	800
	04/21/94	0945	20	<10	2	550
	06/01/94	1435	20	<10	<1	600
2S/11W-18L14K	04/04/94	1855	20	<10	<1	520
(MLS10)	04/05/94	1123	20	<10	<1	540
	04/05/94	1740	20	<10	<1	560
	04/06/94	1145	<10	<10	<1	620
	04/07/94	1000	<10	<10	<1	550
	04/08/94	0910	10	<10	<1	550
	04/21/94	1000	30	<10	<1	490
	06/01/94	1350	30	<10	<1	610
2S/11W-18L14L	04/04/94	1835	<10	<10	<1	520
(MLS9)	04/05/94	1100	10	<10	<1	540

Appendix 3E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, molybdenum–strontium—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium , dissolved (µg/L as Sr) (01080)
	04/05/94	1645	20	<10	2	530
	04/06/94	1125	20	<10	<1	610
	04/07/94	1018	<10	<10	<1	540
	04/08/94	0945	10	<10	1	530
	04/21/94	1020	10	<10	<1	470
	06/01/94	1315	10	<10	<1	610
2S/11W-18L14M	04/04/94	1750	<10	<10	<1	620
(MLS8)	04/05/94	1046	<10	<10	<1	620
	04/05/94	1635	20	<10	<1	620
	04/06/94	1045	30	<10	2	650
	04/07/94	1040	<10	<10	<1	550
	04/08/94	0930	20	<10	<1	670
	04/21/94	1040	20	<10	<1	500
	06/01/94	1210	30	10	<1	570
2S/11W-18L14N	04/04/94	1730	20	<10	<1	550
(MLS7)	04/05/94	1010	10	<10	<1	520
	04/05/94	1540	20	<10	<1	540
	04/06/94	1000	<10	<10	<1	590
	04/07/94	1100	<10	<10	<1	540
	04/08/94	0950	10	<10	<1	570
	04/21/94	1050	30	<10	<1	470
	06/01/94	1100	20	<10	<1	540
2S/11W-18L14O	04/04/94	1715	20	<10	<1	540
(MLS6)	04/05/94	0950	<10	<10	<1	540
	04/05/94	1532	10	<10	<1	560
	04/06/94	0950	<10	<10	<1	600
	04/07/94	1120	<10	<10	<1	530
	04/08/94	1045	30	<10	<1	580
	04/21/94	1105	20	<10	<1	490
	06/01/94	1040	20	<10	1	520

Appendix 3E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, molybdenum–strontium—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (μg/L as Mo) (01060)	Nickel, dissolved (μg/L as Ni) (01065)	Silver, dissolved (μg/L as Ag) (01075)	Strontium , dissolved (μg/L as Sr) (01080)
2S/11W-18L14P	04/04/94	1630	<10	<10	<1	590
(MLS5)	04/05/94	0900	10	<10	<1	580
	04/05/94	1505	<10	<10	<1	590
	04/06/94	0818	<10	<10	<1	600
	04/07/94	1130	<10	<10	<1	520
	04/08/94	1055	20	<10	<1	610
	04/21/94	1135	30	<10	<1	490
	06/01/94	0935	30	<10	<1	570
2S/11W-18L14Q	04/04/94	1605	<10	<10	<1	520
(MLS4)	04/05/94	0830	10	<10	<1	560
	04/05/94	1450	10	<10	<1	700
	04/06/94	0820	<10	<10	<1	460
	04/07/94	1144	20	<10	1	440
	04/08/94	1125	30	<10	<1	580
	04/21/94	1145	10	<10	<1	450
	06/01/94	0915	40	10	<1	490
2S/11W-18L27	04/04/94	1905	20	<10	2	780
(PR8 at 49 ft)	04/05/94	1700	10	<10	<1	770
	04/06/94	1030	<10	<10	2	770
	04/07/94	1425	<10	<10	<1	760
	04/08/94	1040	10	<10	1	800
	04/21/94	1740	10	<10	<1	810
	06/01/94	1330	<10	<10	<1	750
2S/11W-18L28	04/04/94	1720	<10	10	<1	890
(PR9 at 25 ft)	04/05/94	1805	<10	<10	<1	850
	04/06/94	1205	<10	<10	<1	870
	04/07/94	1200	10	10	<1	910
	04/08/94	1000	<10	<10	1	920
	04/21/94	1625	10	<10	<1	710
	06/01/94	1515	20	<10	<1	810

Appendix 3E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, molybdenum–strontium—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium , dissolved (µg/L as Sr) (01080)
2S/11W-18L29	04/04/94	2000	<10	<10	<1	860
(PR10 at 50 ft)	04/05/94	1405	10	<10	1	840
	04/06/94	1550	<10	<10	<1	850
	04/07/94	1030	<10	<10	<1	820
	04/07/94	1200	—	—	—	—
	04/08/94	1200	20	<10	<1	860
	04/21/94	1445	10	<10	<1	840
	06/01/94	1130	10	<10	<1	810
2S/11W-18L30	04/04/94	1550	30	<10	<1	640
(PR11 at 36 ft)	04/05/94	1550	30	10	<1	630
	04/06/94	1445	<10	<10	<1	650
	04/07/94	0930	20	<10	<1	660
	04/07/94	0931	10	<10	<1	690
	04/08/94	1200	20	<10	<1	760
	04/21/94	1315	20	<10	<1	610
	06/01/94	1015	20	<10	<1	640
POND AT PICO	04/05/94	0845	10	<10	<1	520
(PR12)	04/05/94	0943	20	<10	<1	520
	04/05/94	1055	20	<10	<1	520
	04/05/94	1154	10	<10	<1	520
	04/05/94	1421	20	<10	<1	520
	04/05/94	1607	20	<10	<1	530
	04/05/94	1714	10	<10	<1	520
	04/05/94	1830	10	10	<1	540
	04/06/94	0745	<10	<10	<1	540
	04/07/94	0800	20	10	<1	520
	04/07/94	0805	20	<10	<1	530
	04/07/94	0810	30	10	<1	520
	04/07/94	1430	20	<10	<1	510
	04/07/94	1530	10	<10	<1	510
	04/07/94	1540	<10	<10	<1	510

Appendix 3E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, molybdenum–strontium—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (μg/L as Mo) (01060)	Nickel, dissolved (μg/L as Ni) (01065)	Silver, dissolved (μg/L as Ag) (01075)	Strontium , dissolved (μg/L as Sr) (01080)
	04/07/94	1825	<10	<10	<1	510
	04/07/94	1830	10	10	<1	520
	04/07/94	1845	10	<10	<1	520
	04/08/94	1130	20	<10	1	530
	04/21/94	0800	<10	<10	<1	510
	04/21/94	0815	20	<10	1	510
	04/21/94	0820	20	<10	<1	500
	04/21/94	0825	20	<10	<1	510
SEWAGE EFFLUENT (PR13)	04/05/94	0915	20	<10	2	500
	04/05/94	1020	30	<10	2	520
	04/05/94	1105	20	<10	<1	490
	04/05/94	1210	20	<10	<1	520
	04/05/94	1420	10	<10	1	540
	04/05/94	1545	20	<10	<1	540
	04/05/94	1650	10	<10	<1	550
	04/05/94	1835	10	10	<1	540
	04/06/94	1215	10	<10	<1	520
	04/07/94	1215	<10	<10	<1	500
	04/08/94	1215	40	10	<1	520
	04/21/94	1530	<10	<10	<1	510

Appendix 3F. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, vanadium–oxygen-18/16

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; per mil, part per thousand; <, actual value less than value shown; —, no data; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Vanadium, dissolved (µg/L as V) (01085)	Zinc , dissolved (µg/L as Zn) (01090)	Hydrogen-2/1 (per mil) (82082)	Nitrogen-15/14, ammonium fraction (per mil) (82691)	Nitrogen-15/14, nitrate fraction, (per mil) (82690)	Oxygen-18/16, (per mil) (82085)
2S/11W-18L14A	04/04/94	1940	<6	<3	–57.6	—	47.1	–7.94
(MLS20)	04/05/94	1205	<6	8	—	—	—	—
	04/05/94	1800	<6	11	—	—	—	—
	04/06/94	1400	<6	10	—	—	—	—
	04/07/94	0900	<6	7	—	—	—	—
	04/08/94	0825	<6	8	—	—	—	—
	04/21/94	0915	<6	<3	—	—	—	—
	06/01/94	1455	<6	14	—	—	—	—
2S/11W-18L14C	04/07/94	0915	8	56	—	—	—	—
(MLS18)	04/08/94	0830	11	120	—	—	—	—
2S/11W-18L14F	04/04/94	1930	<6	7	–57.7	—	53.3	–7.99
(MLS15)	04/05/94	1145	<6	8	—	—	—	—
	04/05/94	1750	6	9	—	—	—	—
	04/06/94	1350	<6	13	—	—	—	—
	04/07/94	0945	10	23	—	—	—	—
	04/08/94	0845	9	11	—	—	—	—
	04/21/94	0945	11	16	—	—	—	—
	06/01/94	1435	<6	18	—	—	—	—
2S/11W-18L14K	04/04/94	1855	6	<3	–55.3	—	40.4	–7.79
(MLS10)	04/05/94	1123	<6	7	—	—	—	—
	04/05/94	1740	7	4	—	—	—	—
	04/06/94	1145	6	34	–62.7	—	7.6	–8.59
	04/07/94	1000	9	33	—	—	—	—
	04/08/94	0910	7	15	—	—	—	—
	04/21/94	1000	9	<3	—	—	—	—
	06/01/94	1350	<6	15	–55.0	—	65.3	–7.68

Appendix 3F. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, vanadium–oxygen 16/18—Continued

Station name (Local identifier)	Date	Time	Vanadium, dissolved (μg/L as V) (01085)	Zinc , dissolved (μg/L as Zn) (01090)	Hydrogen-2/1 (per mil) (82082)	Nitrogen-15/14, ammonium fraction (per mil) (82691)	Nitrogen-15/14, nitrate fraction, (per mil) (82690)	Oxygen-18/16, (per mil) (82085)
2S/11W-18L14L	04/04/94	1835	<6	<3	–55.5	—	39.3	–7.74
(MLS9)	04/05/94	1100	<6	<3	—	—	—	—
	04/05/94	1645	<6	5	—	—	—	—
	04/06/94	1125	<6	17	–61.5	—	8.1	–8.57
	04/07/94	1018	8	20	—	—	—	—
	04/08/94	0945	7	16	—	—	—	—
	04/21/94	1020	9	5	—	—	—	—
	06/01/94	1315	<6	11	–55.0	—	66.7	–7.72
2S/11W-18L14M	04/04/94	1750	<6	14	–56.5	—	41.7	–7.81
(MLS8)	04/05/94	1046	<6	18	—	—	—	—
	04/05/94	1635	<6	15	—	—	—	—
	04/06/94	1045	7	23	–61.8	—	9.5	–8.38
	04/07/94	1040	11	73	—	—	—	—
	04/08/94	0930	10	58	—	—	—	—
	04/21/94	1040	10	24	—	—	—	—
	06/01/94	1210	<6	36	–55.6	—	54.3	–7.63
2S/11W-18L14N	04/04/94	1730	<6	5	–55.1	—	31.5	–7.62
(MLS7)	04/05/94	1010	<6	9	—	—	—	—
	04/05/94	1540	7	15	—	—	—	—
	04/06/94	1000	6	13	–60.9	—	10.2	–8.38
	04/07/94	1100	12	34	—	—	—	—
	04/08/94	0950	11	20	—	—	—	—
	04/21/94	1050	11	16	—	—	—	—
	06/01/94	1100	7	7	–54.5	—	60.9	–7.28
2S/11W-18L14O	04/04/94	1715	7	5	–54.4	—	31.5	–7.7
(MLS6)	04/05/94	0950	<6	11	—	—	—	—
	04/05/94	1532	8	15	—	—	—	—
	04/06/94	0950	11	22	–61.3	—	9	–8.45
	04/07/94	1120	11	43	—	—	—	—
	04/08/94	1045	11	27	—	—	—	—

Appendix 3F. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, vanadium–oxygen 16/18—Continued

Station name (Local identifier)	Date	Time	Vanadium, dissolved (µg/L as V) (01085)	Zinc , dissolved (µg/L as Zn) (01090)	Hydrogen-2/1 (per mil) (82082)	Nitrogen-15/14, ammonium fraction (per mil) (82691)	Nitrogen-15/14, nitrate fraction, (per mil) (82690)	Oxygen-18/16, (per mil) (82085)
	04/21/94	1105	14	18	—	—	—	—
	06/01/94	1040	11	16	–54.0	—	52.6	–7.16
2S/11W-18L14P	04/04/94	1630	8	30	–55.3	—	37.8	–7.76
(MLS5)	04/05/94	0900	7	22	—	—	—	—
	04/05/94	1505	7	35	—	—	—	—
	04/06/94	0818	9	36	–61.3	—	10.9	–8.32
	04/07/94	1130	14	47	—	—	—	—
	04/08/94	1055	12	31	—	—	—	—
	04/21/94	1135	13	18	—	—	—	—
	06/01/94	0935	9	29	–54.2	—	52.6	–7.16
2S/11W-18L14Q	04/04/94	1605	14	<3	–50.6	—	22.9	–7.15
(MLS4)	04/05/94	0830	10	4	—	—	—	—
	04/05/94	1450	10	19	—	—	—	—
	04/06/94	0820	11	30	–61.8	—	—	–8.50
	04/07/94	1144	13	34	—	—	—	—
	04/08/94	1125	9	34	—	—	—	—
	04/21/94	1145	13	15	—	—	—	—
	06/01/94	0915	10	26	–45.4	28.8		–5.03
2S/11W-18L27	04/04/94	1905	9	4	—	—	41.2	—
(PR8 at 49 ft)	04/05/94	1700	10	<3	—	—		—
	04/06/94	1030	6	9	–57.8	—	41.8	–7.96
	04/07/94	1425	<6	<3	—	—	—	—
	04/08/94	1040	<6	6	—	—	—	—
	04/21/94	1740	9	<3	—	—	—	—
	06/01/94	1330	<6	20	—	—	—	—
2S/11W-18L28	04/04/94	1720	<6	<3	–56.8	—	50.9	–7.99
(PR9 at 25 ft)	04/05/94	1805	<6	4	—	—	—	—
	04/06/94	1205	<6	6	—	—	—	—
	04/07/94	1200	7	<3	—	—	—	—
	04/08/94	1000	7	4	—	—	—	—

Appendix 3F. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, vanadium–oxygen 16/18—Continued

Station name (Local identifier)	Date	Time	Vanadium, dissolved (µg/L as V) (01085)	Zinc , dissolved (µg/L as Zn) (01090)	Hydrogen-2/1 (per mil) (82082)	Nitrogen-15/14, ammonium fraction (per mil) (82691)	Nitrogen-15/14, nitrate fraction, (per mil) (82690)	Oxygen-18/16, (per mil) (82085)
	04/21/94	1625	<6	5	—	—	—	—
	06/01/94	1515	<6	4	—	—	—	—
2S/11W-18L29	04/04/94	2000	<6	<3	—	—	—	—
(PR10 at 50 ft)	04/05/94	1405	<6	9	—	—	—	—
	04/06/94	1550	6	10	—	—	—	—
	04/07/94	1030	<6	<3	—	—	—	—
	04/07/94	1200	—	—	—	—	—	—
	04/08/94	1200	<6	4	—	—	—	—
	04/21/94	1445	<6	<3	—	—	—	—
	06/01/94	1130	<6	14	—	—	—	—
2S/11W-18L30	04/04/94	1550	7	7	—	—	—	—
(PR11 at 36 ft)	04/05/94	1550	9	<3	—	—	—	—
	04/06/94	1445	9	<3	—	—	—	—
	04/07/94	0930	9	<3	—	—	—	—
	04/07/94	0931	11	<3	—	—	—	—
	04/08/94	1200	7	<3	—	—	—	—
	04/21/94	1315	9	<3	—	—	—	—
	06/01/94	1015	6	17	—	—	—	—
POND AT PICO	04/05/94	0845	<6	48	—	—	—	—
(PR12)	04/05/94	0943	<6	42	—	—	—	—
	04/05/94	1055	<6	42	—	—	—	—
	04/05/94	1154	<6	42	—	—	—	—
	04/05/94	1421	<6	43	—	—	—	—
	04/05/94	1607	<6	41	—	—	—	—
	04/05/94	1714	<6	51	—	—	—	—
	04/05/94	1830	<6	52	—	—	—	—
	04/06/94	0745	<6	58	—	—	9.4	—
	04/07/94	0800	<6	50	—	—	—	—
	04/07/94	0805	<6	55	—	—	—	—
	04/07/94	0810	<6	47	—	—	—	—

Appendix 3F. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994, vanadium–oxygen 16/18—Continued

Station name (Local identifier)	Date	Time	Vanadium, dissolved (µg/L as V) (01085)	Zinc , dissolved (µg/L as Zn) (01090)	Hydrogen-2/1 (per mil) (82082)	Nitrogen-15/14, ammonium fraction (per mil) (82691)	Nitrogen-15/14, nitrate fraction, (per mil) (82690)	Oxygen-18/16, (per mil) (82085)
	04/07/94	1430	<6	50	—	—	—	—
	04/07/94	1530	<6	39	—	—	—	—
	04/07/94	1540	<6	49	—	—	—	—
	04/07/94	1825	<6	58	—	—	—	—
	04/07/94	1830	<6	45	—	—	—	—
	04/07/94	1845	<6	58	—	—	—	—
	04/08/94	1130	<6	59	—	—	—	—
	04/21/94	0800	6	56	—	—	—	—
	04/21/94	0815	<6	57	—	—	—	—
	04/21/94	0820	<6	44	—	—	—	—
	04/21/94	0825	<6	57	—	—	—	—
SEWAGE EFFLUENT (PR13)	04/05/94	0915	<6	47	—	—	—	—
	04/05/94	1020	7	48	—	—	—	—
	04/05/94	1105	<6	45	—	—	—	—
	04/05/94	1210	<6	55	—	—	—	—
	04/05/94	1420	<6	49	—	—	—	—
	04/05/94	1545	<6	52	—	—	—	—
	04/05/94	1650	<6	44	—	—	—	—
	04/05/94	1835	<6	44	—	—	—	—
	04/06/94	1215	<6	52	–62.7	—	14.9	–8.65
	04/07/94	1215	7	47	—	—	—	—
	04/08/94	1215	<6	48	—	—	—	—
	04/21/94	1530	<6	38	—	—	—	—

Appendix 4A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, oxygen–alkalinity

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; µS/cm, microsiemens per centimeter; °C, degrees Celsius; ft, feet below basin floor or land surface; mg/L, milligrams per liter; —, no data; MLS, multilevel sampler]

Station name (Local identifier)	**Date**	**Time**	**Oxygen, dissolved (mg/L) (00300)**	**pH, water, whole, field (standard units) (00400)**	**Specific conductance, field (µS/cm) (00095)**	**Water temperature (°C) (00010)**	**Hardness, total (mg/L as $CaCO_3$) (00900)**	**Calcium, dissolved (mg/L as Ca) (00915)**	**Magnesium, dissolved (mg/L as Mg) (00925)**	**Sodium, dissolved (mg/L as Na) (00930)**	**Alkalinity, fixed endpoint, field (mg/L as $CaCO_3$) (39036)**
2S/11W-18L14 A (MLS20)	09/06/94	1530	0.4	7.2	1,080	21.6	—	—	—	—	160
	09/07/94	0915	2.4	7	1,180	23.6	—	—	—	—	170
	09/09/94	1030	.4	7.2	1,090	28.2	—	—	—	—	170
	09/12/94	0845	.4	7.2	1,060	27.8	—	—	—	—	180
	09/16/94	0830	—	7.2	1,090	27.7	—	—	—	—	190
	09/19/94	1425	.4	7.2	1,070	27.9	—	—	—	—	180
	09/22/94	0915	.6	7.2	1,070	27.5	—	—	—	—	180
2S/11W-18L14E (MLS16)	09/06/94	1325	.2	7.1	1,150	21.3	—	—	—	—	170
2S/11W-18L14F (MLS15)	09/07/94	1035	6	7	1,070	27.5	—	—	—	—	170
	09/09/94	1000	.4	7.2	1,100	28.2	—	—	—	—	180
	09/12/94	0850	.4	7.2	1,020	27.8	—	—	—	—	180
	09/16/94	0900		7.2	1,100	27.6	—	—	—	—	190
	09/19/94	1430	.4	7.1	1,050	27.9	—	—	—	—	170
	09/21/94	1145	1.2	7.2	1,090	27.5	230	62	18	120	180
	09/22/94	0920	.6	7.2	1,090	27.3	—	—	—	—	180
2S/11W-18L14I (MLS12)	09/16/94	1000	—	7.2	1,090	27.8	—	—	—	—	190
	09/19/94	1545	1	7.1	1,040	27.9	—	—	—	—	180
2S/11W-18L14J (MLS11)	09/07/94	1215	6	7	1,070	27.9	—	—	—	—	180
	09/12/94	1040	.4	7.2	1,010	27.4	—	—	—	—	180
2S/11W-18L14K (MLS10)	09/09/94	1230	.8	7.1	1,080	28.7	—	—	—	—	180
2S/11W-18L27 (PR8 at 49 ft)	09/06/94	1440	.4	7.1	996	21.8	—	—	—	—	150
	09/07/94	1150	.4	7.1	997	21.9	—	—	—	—	150
	09/09/94	1330	.6	7.1	1,020	22.1	—	—	—	—	150

Appendix 4A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, water, whole, field (standard units) (00400)	Specific conductance, field (µS/cm) (00095)	Water temperature (ºC) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) (00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field (mg/L as $CaCO_3$) (39036)
	09/12/94	1320	.6	7.1	1,040	21.4	—	—	—	—	160
	09/16/94	1150	—	7.1	1,040	24.3	—	—	—	—	170
	09/19/94	2005	2	7	1,080	23.8	—	—	—	—	180
	09/22/94	1215	.6	7	1,040	26.3	—	—	—	—	180
2S/11W-18L28	09/06/94	1210	.6	7	1,060	21.5	—	—	—	—	150
(PR9 at 25 ft)	09/07/94	0945	3.6	7.1	1,050	26.2	—	—	—	—	170
	09/09/94	1045	.8	7.1	1,090	29.2	—	—	—	—	180
	09/12/94	1430	.4	7.1	1,020	28.5	—	—	—	—	180
	09/16/94	1325	—	7	1,100	28.2	—	—	—	—	190
	09/19/94	1815	.6	7.1	1,060	27.4	230	61	18	110	170
	09/22/94	1330	.6	7.2	1,090	28.4	—	—	—	—	180
2S/11W-18L29	09/06/94	1620	.8	7.1	940	22.2	—	—	—	—	170
(PR10 at 60 ft)	09/07/94	1435	.4	7.1	942	21.9	—	—	—	—	160
	09/09/94	1530	.4	7.1	938	22.1	—	—	—	—	160
	09/12/94	1000	.6	7.1	943	20.6	—	—	—	—	160
	09/16/94	1055	—	7.1	999	20.8	—	—	—	—	150
	09/19/94	1415	.4	7.1	1,040	20.6	—	—	—	—	150
	09/22/94	0930	.6	7	1,050	20.7	—	—	—	—	160
2S/11W-18L30	09/06/94	1835	.8	7	1,060	20.5	—	—	—	—	120
(PR11 at 36 ft)	09/07/94	1630	.4	7	1,090	20.9	—	—	—	—	170
	09/09/94	1700	3.6	7.1	1,080	28.3	—	—	—	—	170
	09/12/94	1100	—	7.1	1,050	27.8	—	—	—	—	170
	09/16/94	0925	—	7.1	1,100	27.5	—	—	—	—	190
	09/19/94	1600	.6	7.1	1,060	27.9	230	65	17	120	160
	09/22/94	1115	.6	7.2	1,080	27.7	—	—	—	—	180
POND AT PICO	09/07/94	1515	6	7.3	1,160	29.7	—	—	—	—	190
(PR12)	09/09/94	1625	—	7.4	1,170	29.4	—	—	—	—	180

Appendix 4A. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, oxygen–alkalinity—Continued

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, water, whole, field (standard units) (00400)	Specific conductance, field (µS/cm) (00095)	Water temperature (ºC) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) (00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field (mg/L as $CaCO_3$) (39036)
	09/12/94	1415	6.4	7.3	1,010	28.9	—	—	—	—	170
	09/16/94	1030	—	7.2	1,080	27.9	—	—	—	—	190
	09/19/94	1845	4.6	7.1	1,080	27.6	—	—	—	—	160
	09/22/94	1345	3	7.2	1,080	28.3	—	—	—	—	180
	09/23/94	1145	7	7.1	1,100	27.8	220	60	18	120	170

Appendix 4B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, bromide–nitrogen

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; mg/L, milligrams per liter; <, actual value less than value shown; —, no data; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Chlorine, total residual (mg/L) (50060)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved, (mg/L as N) (00613)
2S/11W-18L14A	09/06/94	1530	<0.2	106	—	0.2	—	224	—	0.67	—	<0.020
(MLS20)	09/07/94	0915	<.2	133	3.6	.3	—	195	—	8.74	—	1.26
	09/09/94	1030	.5	139	5.6	.5	—	136	—	4.84	—	2.45
	09/12/94	0845	<.2	119	3.4	.3	—	134	—	5.67	—	1.98
	09/16/94	0830	1.4	134	—	.3	—	134	—	2.89	—	<1.28
	09/19/94	1425	<.2	124	1.6	.4	—	137	—	5.86	—	.78
	09/22/94	0915	<.2	130	.4	.5	—	135	—	4.31	—	.3
2S/11W-18L14E	09/06/94	1325	.6	117	—	.3	—	193	—	10.3	—	.07
(MLS16)												
2S/11W-18L14F	09/07/94	1035	<.2	129	3.6	<.6	—	142	—	4.53	—	1.78
(MLS15)	09/09/94	1000	<.2	139	5.6	<.2	—	136	—	4.54	—	2.75
	09/12/94	0850	<.2	112	2.8	.4	—	131	—	5.88	—	1.81
	09/16/94	0900	.7	132	—	.37	—	133	—	3.56	—	.15
	09/19/94	1430	<.2	119	—	.5	—	137	—	6.64	—	.03
	09/21/94	1145	.11	130	—	.6	22	130	2.9	—	4.8	<.010
	09/22/94	0920	<.2	134	—	.4	—	135	—	4.78	—	<.020
2S/11W-18L14I	09/16/94	1000	.4	129	—	.2	—	134	—	4.4	—	.86
(MLS12)	09/19/94	1545	<.2	115	1	.4	—	134	—	6.5	—	.53
2S/11W-18L14J	09/07/94	1215	.2	123	6.4	.5	—	147	—	3.86	—	2.37
(MLS11)	09/12/94	1040	.4	111	2.8	.5	—	134	—	5.49	—	1.82
2S/11W-18L14K	09/09/94	1230	<.2	131	5.2	.4	—	140	—	3.49	—	2.49
(MLS10)												
2S/11W-18L27	09/06/94	1440	.3	105	—	.3	—	194	—	.83	—	<.020
(PR8 at 49 ft)	09/07/94	1150	<.2	107	—	.2	—	199	—	.84	—	<.020
	09/09/94	1330	<.2	106	—	<.2	—	210	—	.64	—	<.020
	09/12/94	1320	<.2	121	5.6	.2	—	164	—	3.1	—	1.47

Appendix 4B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, bromide–nitrogen—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Chlorine, total residual (mg/L) (50060)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved, (mg/L as N) (00613)
	09/16/94	1150	<0.2	124	—	0.3	—	146	—	5.12	—	2.51
	09/19/94	2005	<.2	130	0.4	.2	—	138	—	4.31	—	2.04
	09/22/94	1215	<.2	126	4	.3	—	134	—	4.27	—	1.82
2S/11W-18L28	09/06/94	1210	<.2	108	—	.2	—	226	—	.17	—	<.020
(PR9 at 25 ft)	09/07/94	0945	.5	127	5.2	.5	—	140	—	3.81	—	1.95
	09/09/94	1045	<.2	140	6.8	.5	—	134	—	4.86	—	3.37
	09/12/94	1430	<.2	112	5.6	.3	—	130	—	5.59	—	2.54
	09/16/94	1325	<.2	134	—	.5	—	134	—	3.29	—	2.55
	09/19/94	1815	.09	120	4	.7	22	130	2.5	6	8	2
	09/22/94	1330	<.2	133	3.2	.4	—	135	—	4.34	—	1.68
2S/11W-18L29	09/06/94	1620	<.2	102	—	.2	—	160	—	1.02	—	<.020
(PR10 at 60 ft)	09/07/94	1435	<.2	100	—	.2	—	160	—	1.02	—	<.020
	09/09/94	1530	1.2	102	—	.3	—	171	—	1.02	—	<.020
	09/12/94	1000	<.2	98	—	.2	—	168	—	1.43	—	.01
	09/16/94	1055	<.2	108	—	.3	—	189	—	1.33	—	.33
	09/19/94	1415	<.2	111	.8	.2	—	199	—	2.44	—	.5
	09/22/94	0930	<.2	129	3	.3	—	168	—	3.98	—	1.72
2S/11W-18L30	09/06/94	1835	<.2	120	—	.5	—	183	—	3.86	—	<.02
(PR11 at 36 ft)	09/07/94	1630	<.2	125	3.2	.4	—	168	—	6.09	—	1.22
	09/09/94	1700	.3	137	9.6	.5	—	132	—	4.9	—	3.21
	09/12/94	1100	.1	120	4.6	.5	—	139	—	6.52	—	2.77
	09/16/94	0925	.4	134	—	.4	—	137	—	3.05	—	2.58
	09/19/94	1600	.06	120	1	.7	22	130	1.7	6.1	7.9	1.8
	09/22/94	1115	.2	132	2	.4	—	136	—	4.1	—	.93
POND AT PICO	09/07/94	1515	<.2	149	4	.4	—	133	—	5.11	—	1.66
(PR12)	09/09/94	1625	<.2	148	4.6	.3	—	138	—	6.62	—	1.81
	09/12/94	1415	<.2	111	4.6	.4	—	133	—	6.19	—	1.95
	09/16/94	1030	<.2	125	—	.4	—	137	—	4.39	—	2.34
	09/19/94	1845	.2	121	5.6	.3	—	138	—	7.07	—	2.64

Appendix 4B. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, bromide–nitrogen—Continued

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Chlorine, total residual (mg/L) (50060)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, nitrate, dissolved (mg/L as N) (00618)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved, (mg/L as N) (00613)
	09/22/94	1345	<0.2	129	6	0.5	—	136	—	5.8	—	2.43
	09/23/94	1145	.04	130	7	.7	22	130	4.1	5.4	7.8	2.4

Appendix 4C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, phosphorus–chromium

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; mg/L, milligrams per liter; µg/L, micrograms per liter; <, actual value less than value shown; —, no data; MLS, multilevel sampler]

Station name (Local identifier)	**Date**	**Time**	**Phosphorus ortho-phosphate, dissolved (mg/L as P) (00671)**	**Barium, dissolved (µg/L as Ba) (01005)**	**Beryllium, dissolved (µg/L as Be) (01010)**	**Boron, dissolved (µg/L as B) (01020)**	**Cadmium, dissolved (µg/L as Cd) (01025)**	**Chromium, dissolved (µg/L as Cr) (01030)**
2S/11W-18L14A (MLS20)	09/06/94	1530	0.5	—	—	—	—	—
	09/07/94	0915	<.4	—	—	—	—	—
	09/09/94	1030	.5	—	—	—	—	—
	09/12/94	0845	1.2	—	—	—	—	—
	09/16/94	0830	1.2	—	—	—	—	—
	09/19/94	1425	1.6	—	—	—	—	—
	09/22/94	0915	1.1	—	—	—	—	—
2S/11W-18L14E (MLS16)	09/06/94	1325	1.1	—	—	—	—	—
2S/11W-18L14F (MLS15)	09/07/94	1035	.7	—	—	—	—	—
	09/09/94	1000	1.3	—	—	—	—	—
	09/12/94	0850	1.1	—	—	—	—	—
	09/16/94	0900	1.3	—	—	—	—	—
	09/19/94	1430	.9	—	—	—	—	—
	09/21/94	1145	1.9	170	<0.5	430	<1	<5
	09/22/94	0920	1.5	—	—	—	—	—
2S/11W-18L14I (MLS12)	09/16/94	1000	1.8	—	—	—	—	—
	09/19/94	1545	1.7	—	—	—	—	—
2S/11W-18L14J (MLS11)	09/07/94	1215	.8	—	—	—	—	—
	09/12/94	1040	1.7	—	—	—	—	—
2S/11W-18L14K (MLS10)	09/09/94	1230	1.5	—	—	—	—	—
2S/11W-18L27 (PR8 at 49 ft)	09/06/94	1440	1	—	—	—	—	—
	09/07/94	1150	.3	—	—	—	—	—
	09/09/94	1330	1.3	—	—	—	—	—
	09/12/94	1320	.2	—	—	—	—	—
	09/16/94	1150	.4	—	—	—	—	—

Appendix 4C. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, phosphorus–chromium—Continued

Station name (Local identifier)	Date	Time	Phosphorus ortho-phosphate, dissolved (mg/L as P) (00671)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Boron, dissolved (µg/L as B) (01020)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)
	09/19/94	2005	0.3	—	—	—	—	—
	09/22/94	1215	<.4	—	—	—	—	—
2S/11W-18L28	09/06/94	1210	1.1	—	—	—	—	—
(PR9 at 25 ft)	09/07/94	0945	<.4	—	—	—	—	—
	09/09/94	1045	<.4	—	—	—	—	—
	09/12/94	1430	1.7	—	—	—	—	—
	09/16/94	1325	1.1	—	—	—	—	—
	09/19/94	1815	1.5	150	<0.5	430	<1	<5
	09/22/94	1330	1.4	—	—	—	—	—
2S/11W-18L29	09/06/94	1620	<.4	—	—	—	—	—
(PR10 at 60 ft)	09/07/94	1435	<.4	—	—	—	—	—
	09/09/94	1530	1.4	—	—	—	—	—
	09/12/94	1000	<.4	—	—	—	—	—
	09/16/94	1055	.6	—	—	—	—	—
	09/19/94	1415	2.4	—	—	—	—	—
	09/22/94	0930	.4	—	—	—	—	—
2S/11W-18L30	09/06/94	1835	<.4	—	—	—	—	—
(PR11 at 36 ft)	09/07/94	1630	.6	—	—	—	—	—
	09/09/94	1700	1.9	—	—	—	—	—
	09/12/94	1100	1.6	—	—	—	—	—
	09/16/94	0925	3.3	—	—	—	—	—
	09/19/94	1600	1.6	150	<.5	410	<1	<5
	09/22/94	1115	1.2	—	—	—	—	—
POND AT PICO	09/07/94	1515	.8	—	—	—	—	—
(PR12)	09/09/94	1625	11.4	—	—	—	—	—
	09/12/94	1415	1.5	—	—	—	—	—
	09/16/94	1030	1.7	—	—	—	—	—
	09/19/94	1845	1.7	—	—	—	—	—
	09/22/94	1345	—	—	—	—	—	—
	09/23/94	1145	2	43	<.5	450	<1	<5

Appendix 4D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, cobalt–manganese

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; <, actual value less than value shown; —, no data; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Cobalt, dissolved (µg/L as Co) (01035)	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, Dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
2S/11W-18L14A	09/06/94	1530	—	—	—	—	—	—
(MLS20)	09/07/94	0915	—	—	—	—	—	—
	09/09/94	1030	—	—	—	—	—	—
	09/12/94	0845	—	—	—	—	—	—
	09/16/94	0830	—	—	—	—	—	—
	09/19/94	1425	—	—	—	—	—	—
	09/22/94	0915	—	—	—	—	—	—
2S/11W-18L14E	09/06/94	1325	—	—	—	—	—	—
(MLS16)								
2S/11W-18L14F	09/07/94	1035	—	—	—	—	—	—
(MLS14)	09/09/94	1000	—	—	—	—	—	—
	09/12/94	0850	—	—	—	—	—	—
	09/16/94	0900	—	—	—	—	—	—
	09/19/94	1430	—	—	—	—	—	—
	09/21/94	1145	<3	10	17	<10	19	87
	09/22/94	0920	—	—	—	—	—	—
2S/11W-18L14I	09/16/94	1000	—	—	—	—	—	—
(MLS12)	09/19/94	1545	—	—	—	—	—	—
2S/11W-18L14J	09/07/94	1215	—	—	—	—	—	—
(MLS11)	09/12/94	1040	—	—	—	—	—	—
2S/11W-18L14K	09/09/94	1230	—	—	—	—	—	—
(MLS10)								
2S/11W-18L27	09/06/94	1440	—	—	—	—	—	—
(PR8 at 49 ft)	09/07/94	1150	—	—	—	—	—	—
	09/09/94	1330	—	—	—	—	—	—
	09/12/94	1320	—	—	—	—	—	—
	09/16/94	1150	—	—	—	—	—	—
	09/19/94	2005	—	—	—	—	—	—

Appendix 4D. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, cobalt–manganese—Continued

Station name (Local identifier)	Date	Time	Cobalt, dissolved (µg/L as Co) (01035)	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, Dissolved (µg/L as Li) (01130)	Manganese, dissolved (µg/L as Mn) (01056)
	09/22/94	1215	—	—	—	—	—	—
2S/11W-18L28	09/06/94	1210	—	—	—	—	—	—
(PR9 at 25 ft)	09/07/94	0945	—	—	—	—	—	—
	09/09/94	1045	—	—	—	—	—	—
	09/12/94	1430	—	—	—	—	—	—
	09/16/94	1325	—	—	—	—	—	—
	09/19/94	1815	<3	<10	9	30	15	110
	09/22/94	1330	—	—	—	—	—	—
2S/11W-18L29	09/06/94	1620	—	—	—	—	—	—
(PR10 at 60 ft)	09/07/94	1435	—	—	—	—	—	—
	09/09/94	1530	—	—	—	—	—	—
	09/12/94	1000	—	—	—	—	—	—
	09/16/94	1055	—	—	—	—	—	—
	09/19/94	1415	—	—	—	—	—	—
	09/22/94	0930	—	—	—	—	—	—
2S/11W-18L30	09/06/94	1835	—	—	—	—	—	—
(PR11 at 36 ft)	09/07/94	1630	—	—	—	—	—	—
	09/09/94	1700	—	—	—	—	—	—
	09/12/94	1100	—	—	—	—	—	—
	09/16/94	0925	—	—	—	—	—	—
	09/19/94	1600	<3	10	10	20	13	96
	09/22/94	1115	—	—	—	—	—	—
POND AT PICO	09/07/94	1515	—	—	—	—	—	—
(PR12)	09/09/94	1625	—	—	—	—	—	—
	09/12/94	1415	—	—	—	—	—	—
	09/16/94	1030	—	—	—	—	—	—
	09/19/94	1845	—	—	—	—	—	—
	09/22/94	1345	—	—	—	—	—	—
	09/23/94	1145	<3	<10	35	40	16	16

Appendix 4E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, molybdenum–zinc

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; <, actual value less than value shown; —, no data; MLS, multilevel sampler]

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)
2S/11W-18L14 A (MLS20)	09/06/94	1530	—	—	—	—	—	—
	09/07/94	0915	—	—	—	—	—	—
	09/09/94	1030	—	—	—	—	—	—
	09/12/94	0845	—	—	—	—	—	—
	09/16/94	0830	—	—	—	—	—	—
	09/19/94	1425	—	—	—	—	—	—
	09/22/94	0915	—	—	—	—	—	—
2S/11W-18L14E (MLS16)	09/06/94	1325	—	—	—	—	—	—
2S/11W-18L14F (MLS15)	09/07/94	1035	—	—	—	—	—	—
	09/09/94	1000	—	—	—	—	—	—
	09/12/94	0850	—	—	—	—	—	—
	09/16/94	0900	—	—	—	—	—	—
	09/19/94	1430	—	—	—	—	—	—
	09/21/94	1145	30	<10	2	500	12	28
	09/22/94	0920	—	—	—	—	—	—
2S/11W-18L14I (MLS12)	09/16/94	1000	—	—	—	—	—	—
	09/19/94	1545	—	—	—	—	—	—
2S/11W-18L14J (MLS11)	09/07/94	1215	—	—	—	—	—	—
	09/12/94	1040	—	—	—	—	—	—
2S/11W-18L14K (MLS10)	09/09/94	1230	—	—	—	—	—	—
2S/11W-18L27 (PR8 at 49 ft)	09/06/94	1440	—	—	—	—	—	—
	09/07/94	1150	—	—	—	—	—	—
	09/09/94	1330	—	—	—	—	—	—
	09/12/94	1320	—	—	—	—	—	—
	09/16/94	1150	—	—	—	—	—	—
	09/19/94	2005	—	—	—	—	—	—
	09/22/94	1215	—	—	—	—	—	—
2S/11W-18L28	09/06/94	1210	—	—	—	—	—	—

Appendix 4E. Water-quality data for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994, molybdenum–zinc—Continued

Station name (Local identifier)	Date	Time	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)
(PR9 at 25 ft)	09/07/94	0945	—	—	—	—	—	—
	09/09/94	1045	—	—	—	—	—	—
	09/12/94	1430	—	—	—	—	—	—
	09/16/94	1325	—	—	—	—	—	—
	09/19/94	1815	50	20	1	560	16	14
	09/22/94	1330	—	—	—	—	—	—
2S/11W-18L29	09/06/94	1620	—	—	—	—	—	—
(PR10 at 60 ft)	09/07/94	1435	—	—	—	—	—	—
	09/09/94	1530	—	—	—	—	—	—
	09/12/94	1000	—	—	—	—	—	—
	09/16/94	1055	—	—	—	—	—	—
	09/19/94	1415	—	—	—	—	—	—
	09/22/94	0930	—	—	—	—	—	—
2S/11W-18L30	09/06/94	1835	—	—	—	—	—	—
(PR11 at 36 ft)	09/07/94	1630	—	—	—	—	—	—
	09/09/94	1700	—	—	—	—	—	—
	09/12/94	1100	—	—	—	—	—	—
	09/16/94	0925	—	—	—	—	—	—
	09/19/94	1600	60	10	2	620	17	10
	09/22/94	1115	—	—	—	—	—	—
POND AT PICO	09/07/94	1515	—	—	—	—	—	—
(PR12)	09/09/94	1625	—	—	—	—	—	—
	09/12/94	1415	—	—	—	—	—	—
	09/16/94	1030	—	—	—	—	—	—
	09/19/94	1845	—	—	—	—	—	—
	09/22/94	1345	—	—	—	—	—	—
	09/23/94	1145	30	10	3	490	<6	51

Appendix 5. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993

[See table 1 for explanation of local identifier below station name; ft, feet below basin floor or land surface; mg/L, milligrams per liter; <, actual value less than value shown; —, no data; CR, ceramic-cup lysimeter; SS, stainless steel lysimeter; MLS, multilevel sampler; samples differing by one minute represent duplicate analyses]

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L10LYS	08-10-93	2130	120	68	<1	—	—	—
(CR-RED at 50 ft)	08-11-93	1900	115	72	<1	0.1	<0.1	<3
	08-12-93	1655	127	76	<1	<.1	<.1	<3
	08-13-93	1020	129	76	<1	<.1	<.1	<3
	08-16-93	1050	135	77	<1	<.1	<.1	<3
	08-23-93	1054	120	67	<1	<.1	<.1	<3
	08-24-93	1800	118	64	<1	.08	<.01	<3
	08-28-93	1900	117	62	<1	.26	<.01	<3
	08-29-93	1800	125	65	<1	.34	<.01	<3
	08-30-93	1118	134	68	<1	.25	<.01	<3
2S/11W-18L11LYS	08-10-93	2135	120	64	<1	.2	<.1	<3
(CR-ORG at 25 ft)	08-11-93	1905	121	66	<1	.2	<.1	<3
	08-12-93	1700	122	68	<1	.2	<.1	<3
	08-13-93	1025	123	69	<1	.1	<.1	<3
	08-16-93	1055	124	69	<1	.1	<.1	<3
	08-23-93	1109	—	65	<1	.15	<.01	<3
	08-24-93	1800	122	68	<1	.06	<.01	<3
	08-28-93	1900	118	64	<1	.05	<.01	<3
	08-29-93	1800	120	65	<1	.05	<.01	<3
	08-30-93	1115	121	64	<1	.08	<.01	<3
2S/11W-18L13LYS	08-10-93	2140	112	134	<1	<.1	.1	<3
(CR-BLU at 13.5 ft)	08-11-93	1910	109	135	<1	<.1	.1	<3
	08-12-93	1710	93	138	<1	<.1	<.1	<3
	08-13-93	1030	105	137	<1	<.1	<.1	<3
	08-16-93	1100	97	137	<1	<.1	<.1	<3
	08-23-93	1112	80	131	<1	<.01	<.01	<3
	08-24-93	1800	102	131	<1	<.01	<.01	<3
	08-28-93	1900	100	123	<1	<.01	<.01	<3
	08-29-93	1800	110	124	<1	<.01	<.01	<3
	08-30-93	1120	104	122	<1	<.01	<.01	<3

Appendix 5. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L14A	08-10-93	2110	117	82	<1	0.6	<0.1	<3
(MLS20)	08-11-93	2000	119	73	<1	.7	<.1	<3
		2001	119	73	<1	.7	<.1	<3
	08-12-93	2000	118	77	<1	.8	<.1	<3
	08-13-93	1920	120	83	<1	1.2	<.1	<3
	08-16-93	1855	124	93	<1	1.3	<.1	<3
	08-23-93	1900	127	87	<1	1.3	.02	<3
	08-24-93	1700	110	74	<1	.88	.02	<3
	08-28-93	1730	113	75	<1	.7	<.01	<3
	08-29-93	1635	118	72	<1	.4	.01	<3
	08-30-93	1730	123	69	<1	.26	<.01	<3
2S/11W-18L14B	08-10-93	2040	125	103	<1	1.3	<.1	<3
(MLS19)	08-11-93	1930	107	68	<1	.5	<.1	<3
	08-12-93	1920	119	111	<1	1.3	<.1	<3
	08-13-93	1845	125	110	<1	.9	<.1	<3
	08-16-93	1818	135	105	<1	.1	<.1	<3
	08-23-93	1830	130	98	<1	.62	<.01	<3
	08-24-93	1650	124	95	<1	.61	<.01	<3
	08-28-93	1715	114	94	<1	.44	<.01	<3
		1716	114	92	<1	.46	<.01	<3
	08-29-93	1620	119	92	<1	.39	.01	<3
		1621	120	92	<1	.39	.01	<3
	08-30-93	1715	107	97	<1	.33	<.01	<3
2S/11W-18L14C	08-10-93	2005	130	110	<1	2.7	<.1	<3
(MLS18)	08-11-93	1900	126	109	<1	1.9	<.1	<3
	08-12-93	1845	118	111	<1	.8	<.1	<3
	08-13-93	1800	121	107	<1	.3	<.1	<3
	08-16-93	1745	121	101	<1	<.1	<.1	<3
	08-23-93	1815	127	95	<1	.06	<.01	<3
	08-24-93	1615	111	91	<1	.09	<.01	<3
	08-28-93	1655	122	99	<1	.11	<.01	<3
	08-29-93	1600	118	91	<1	.09	<.01	<3
	08-30-93	1630	117	95	<1	.12	<.01	<3
		1631	112	93	<1	.11	<.01	<3

Appendix 5. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L14D	08-10-93	1930	131	111	<1	1.3	<0.1	<3
(MLS17)	08-11-93	1830	121	107	<1	.6	<.1	<3
	08-12-93	1800	112	115	<1	.2	<.1	<3
	08-13-93	1745	118	114	<1	<.1	<.1	<3
	08-16-93	1705	140	119	<1	<.1	<.1	<3
	08-23-93	1800	135	107	<1	.04	<.01	<3
	08-24-93	1550	144	111	<1	.08	<.01	<3
	08-28-93	1640	124	107	<1	.11	<.01	<3
	08-29-93	1540	123	103	<1	.07	<.01	<3
	08-30-93	1600	111	100	<1	.09	<.01	<3
2S/11W-18L14E	08-10-93	1915	131	92	<1	1.4	<.1	<3
(MLS16)	08-11-93	1745	130	94	<1	.7	<.1	<3
	08-12-93	1700	124	99	<1	.2	<.1	<3
	08-13-93	1720	125	98	<1	<.1	<.1	<3
	08-16-93	1620	140	108	<1	<.1	<.1	<3
	08-23-93	1710	146	104	<1	.06	<.01	<3
		1711	143	102	<1	.06	<.01	<3
	08-24-93	1525	145	103	<1	.09	<.01	<3
	08-28-93	1620	126	98	<1	.09	<.01	<3
	08-29-93	1510	122	93	<1	.07	<.01	<3
	08-30-93	1540	118	93	<1	.09	<.01	<3
2S/11W-18L14F	08-10-93	1755	136	85	<1	2.5	<.1	<3
(MLS15)	08-11-93	1700	137	90	<1	1.3	<.1	<3
	08-12-93	1620	141	95	<1	<.1	<.1	<3
	08-13-93	1700	134	92	<1	<.1	<.1	<3
	08-16-93	1530	159	102	<1	<.1	<.1	<3
	08-23-93	1700	157	97	<1	.07	<.01	<3
	08-24-93	1450	171	101	<1	.12	<.01	<3
	08-28-93	1600	133	92	<1	.09	<.01	<3
	08-29-93	1450	146	96	<1	.09	<.01	<3
	08-30-93	1440	137	92	<1	.11	<.01	<3

Appendix 5. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L14G	08-10-93	1710	140	91	<1	0.7	<0.1	<3
(MLS14)	08-11-93	1610	138	94	<1	<.1	<.1	<3
	08-12-93	1500	123	101	<1	<.1	<.1	<3
	08-13-93	1645	153	105	<1	<.1	<.1	<3
	08-16-93	1550	156	119	<1	<.1	<.1	<3
	08-23-93	1630	159	98	<1	.79	<.01	<3
	08-24-93	1430	182	100	<1	.12	<.01	<3
	08-28-93	1500	154	99	<1	.1	<.01	<3
	08-29-93	1250	159	97	<1	.1	<.01	<3
	08-30-93	1430	160	103	<1	.12	<.01	<3
2S/11W-18L14H	08-10-93	1625	152	101	<1	<.1	<.1	<3
(MLS13)	08-11-93	1545	157	104	<1	<.1	<.1	<3
	08-12-93	1445	167	108	<1	<.1	<.1	<3
	08-13-93	1620	151	111	<1	<.1	<.1	<3
	08-16-93	1430	140	125	<1	.2	<.1	<3
	08-23-93	1600	157	101	<1	.07	<.01	<3
	08-24-93	1315	190	105	<1	.1	<.01	<3
	08-28-93	1515	162	99	<1	.09	<.01	<3
	08-29-93	1235	166	102	<1	.1	<.01	<3
	08-30-93	1310	161	99	<1	.11	<.01	<3
2S/11W-18L14I	08-10-93	1525	132	103	<1	<.1	<.1	<3
(MLS12)	08-11-93	1520	146	105	<1	<.1	<.1	<3
	08-12-93	1315	145	98	<1	<.1	<.1	<3
	08-13-93	1530	132	118	<1	<.1	<.1	<3
	08-16-93	1250	149	132	<1	<.1	<.1	<3
	08-23-93	1520	169	105	<1	.07	<.01	<3
	08-24-93	1220	148	108	<1	.09	<.01	<3
		1221	149	101	<1	.1	<.01	<3
		1222	170	109	<1	.1	<.01	<3
		1223	152	105	<1	.07	<.01	<3
	08-28-93	1335	157	101	<1	.1	<.01	<3
	08-29-93	1220	170	108	<1	.11	<.01	<3
	08-30-93	1230	153	100	<1	.11	<.01	<3

Appendix 5. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L14J	08-10-93	1500	169	107	<1	—	—	—
(MLS11)	08-11-93	1240	167	104	<1	<0.1	<0.1	<3
	08-12-93	1250	153	114	<1	<.1	<.1	<3
	08-13-93	1500	114	133	<1	.3	<.1	<3
	08-16-93	1245	150	136	<1	<.1	<.1	8.2
	08-23-93	1500	167	107	<1	<.1	<.1	<3
	08-24-93	1200	163	110	<1	.1	<.01	<3
	08-28-93	1315	160	102	<1	.12	<.01	<3
	08-29-93	1200	167	105	<1	.12	<.01	<3
	08-30-93	1215	149	97	<1	.11	<.01	<3
2S/11W-18L14K	08-10-93	1415	172	109	<1	<.1	<.1	<3
(MLS10)	08-11-93	1210	165	105	<1	<.1	<.1	<3
	08-12-93	1220	120	125	<1	<.1	<.1	<3
	08-13-93	1300	108	135	<1	<.1	<.1	<3
	08-16-93	1200	149	135	<1	<.1	<.1	<3
	08-23-93	1230	150	115	<1	.3	<.01	<3
	08-24-93	1105	144	110	<1	.29	<.01	<3
		1106	156	116	<1	.3	<.01	<3
	08-28-93	1250	160	104	<1	.73	<.01	<3
		1251	162	107	<1	.74	<.01	<3
	08-29-93	1125	163	105	<1	.54	<.01	<3
	08-30-93	1150	166	106	<1	.39	<.01	<3
2S/11W-18L14L	08-10-93	1345	172	107	<1	.9	<.1	<3
(MLS9)		1346	172	107	<1	.9	<.1	<3
	08-11-93	1115	165	105	<1	<.1	<.1	<3
	08-12-93	1130	123	126	<1	2.2	<.1	<3
	08-13-93	1230	133	135	<1	<.1	<.1	<3
	08-16-93	1130	148	135	<1	<.1	<.1	<3
	08-23-93	1210	129	124	<1	.2	<.01	<3
	08-24-93	1045	121	116	<1	.2	<.01	<3
	08-28-93	1230	139	113	<1	1.1	<.01	<3
	08-29-93	1105	160	109	<1	.95	<.01	<3
	08-30-93	1130	143	105	<1	.9	<.01	<3
		1131	145	105	<1	.9	<.01	<3
		1132	152	102	<1	.91	<.01	<3
		1133	134	100	<1	.87	<.01	<3

Appendix 5. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L14M	08-10-93	1230	130	118	<1	0.2	<0.1	<3
(MLS8)	08-11-93	1030	126	118	<1	<.1	<.1	<3
	08-12-93	1100	105	125	<1	.4	<.1	<3
	08-13-93	1150	102	127	<1	<.1	<.1	<3
	08-16-93	1100	129	130	<1	<.1	<.1	<3
	08-23-93	1145	131	120	<1	.01	<.01	<3
	08-24-93	1020	133	122	<1	.07	<.01	<3
	08-28-93	1120	121	118	<1	.12	<.01	<3
	08-29-93	1050	118	113	<1	.05	<.01	<3
		1051	120	116	<1	.05	<.01	<3
		1052	125	117	<1	.06	<.01	<3
		1053	119	118	<1	.05	<.01	<3
	08-30-93	1050	119	107	<1	.12	<.01	<3
2S/11W-18L14N	08-10-93	1115	109	137	<1	<.1	<.1	<3
(MLS7)	08-11-93	1000	101	136	<1	<.1	<.1	<3
	08-12-93	1030	76	143	<1	<.1	<.1	<3
	08-13-93	1040	93	135	<1	<.1	<.1	3.1
	08-16-93	1015	134	128	<1	<.1	<.1	3.5
	08-23-93	1100	121	125	<1	<.01	<.01	<3
	08-24-93	0930	113	124	<1	.01	<.01	<3
	08-28-93	1050	92	124	<1	<.01	<.01	<3
	08-29-93	1030	99	126	<1	<.01	<.01	<3
	08-30-93	1030	88	125	<1	<.01	<.01	<3
2S/11W-18L14O	08-10-93	1010	110	135	<1	<.1	<.1	<3
(MLS6)	08-11-93	0930	93	134	<1	<.1	<.1	<3
	08-12-93	0930	70	138	<1	<.1	<.1	<3
	08-13-93	1015	90	131	<1	<.1	<.1	<3
	08-16-93	1000	116	123	<1	<.1	<.1	<3
	08-23-93	1050	132	131	<1	<.01	<.01	<3
		1051	131	131	<1	<.01	<.01	<3
		1052	128	129	<1	.03	<.01	<3
		1053	133	129	<1	.03	<.01	<3
	08-24-93	0850	114	121	<1	<.01	<.01	<3
	08-28-93	1020	100	121	<1	.04	<.01	<3
	08-29-93	1015	102	122	<1	<.01	<.01	<3
	08-30-93	1000	97	118	<1	.02	<.01	<3

Appendix 5. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L14P	08-10-93	0846	92	128	<1	<0.1	<0.1	<3
(MLS5)	08-11-93	0900	77	132	<1	<.1	<.1	3.6
	08-12-93	0900	59	138	<1	<.1	<.1	<3
	08-13-93	0845	50	136	<1	<.1	<.1	<3
	08-16-93	0900	109	136	<1	<.1	<.1	<3
	08-23-93	0945	115	132	<1	<.01	<.01	<3
	08-24-93	0830	96	119	<1	<.01	<.01	<3
	08-28-93	0930	91	125	<1	.01	<.01	<3
	08-29-93	0930	77	121	<1	<.01	<.01	<3
	08-30-93	0920	73	119	<1	<.01	<.01	<3
2S/11W-18L14Q	08-10-93	0845	75	128	<1	<.1	<.1	<3
(MLS4)	08-11-93	0845	44	126	<1	<.1	<.1	<3
	08-12-93	0845	59	139	<1	<.1	<.1	3.5
	08-13-93	0810	105	132	<1	<.1	<.1	<3
	08-16-93	0845	104	123	<1	<.1	<.1	<3
	08-23-93	0920	105	118	<1	<.01	<.01	<3
	08-24-93	0815	105	120	<1	<.01	<.01	<3
	08-28-93	0930	93	122	<1	<.01	<.01	<3
	08-29-93	0910	80	122	<1	<.01	<.01	<3
	08-30-93	0820	83	125	<1	<.01	<.01	<3
2S/11W-18L15LYS	08-10-93	1955	83	39	<1	.5	.1	<3
(SS-RED at 49 ft)	08-11-93	1815	88	42	<1	.5	.1	<3
	08-12-93	1550	91	46	<1	.4	<.1	<3
	08-13-93	0905	89	47	<1	.3	<.1	<3
	08-16-93	0750	96	52	<1	.1	<.1	<3
	08-23-93	0850	94	54	<1	.02	<.01	<3
	08-24-93	1800	87	48	<1	.15	.02	<3
	08-28-93	1900	92	51	<1	.03	<.01	<3
	08-29-93	1800	93	51	<1	.05	<.01	<3
	08-30-93	0900	101	54	<1	.06	<.01	<3
2S/11W-18L16LYS	08-10-93	2015	82	54	<1	<.1	.1	<3
(SS-ORG at 25 ft)	08-11-93	1835	108	63	<1	<.1	<.1	<3
	08-12-93	1555	107	64	<1	<.1	<.1	<3
	08-13-93	0915	111	64	<1	<.1	<.1	<3
	08-16-93	0755	109	64	<1	<.1	<.1	<3
	08-23-93	0851	106	59	<1	.04	<.01	<3
	08-24-93	1800	93	53	<1	.01	<.01	<3
	08-28-93	1900	101	57	<1	.04	<.01	<3
	08-29-93	1800	90	51	<1	.02	<.01	<3
	08-30-93	0900	100	54	<1	.03	<.01	<3

Appendix 5. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L27	08-10-93	1835	112	60	<1	0.8	<0.1	<3
(PR8 at 49 ft)	08-11-93	1730	113	61	<1	.6	<.1	<3
	08-12-93	1730	119	63	<1	.6	<.1	<3
	08-13-93	1820	120	64	<1	.6	<.1	<3
	08-16-93	1650	121	63	<1	.6	<.1	<3
	08-23-93	1530	106	57	<1	.58	<.01	<3
	08-24-93	1305	106	58	<1	.59	<.01	<3
	08-28-93	1350	103	58	<1	.62	<.01	<3
	08-29-93	1305	109	60	<1	.58	<.01	<3
	08-30-93	1450	105	58	<1	.6	<.01	<3
2S/11W-18L28	08-10-93	2145	114	62	<1	.9	<.1	<3
(PR9 at 25 ft)	08-11-93	1500	116	64	<1	.8	<.1	<3
	08-12-93	1600	115	67	<1	.8	<.1	<3
	08-13-93	1600	117	67	<1	.7	<.1	<3
	08-16-93	1910	119	73	<1	.6	<.1	<3
	08-23-93	1730	119	72	<1	.45	<.01	<3
	08-24-93	1510	121	76	<1	.48	<.01	<3
	08-28-93	1530	123	73	<1	.43	<.01	<3
		1531	123	73	<1	.43	<.01	<3
	08-29-93	1535	116	67	<1	.38	<.01	<3
	08-30-93	1620	123	69	<1	.41	<.01	<3
2S/11W-18L29	08-10-93	1100	135	82	<1	.2	<.1	<3
(PR10 at 60 ft)	08-11-93	1045	95	50	<1	.3	<.1	<3
	08-12-93	0945	98	53	<1	.3	<.1	<3
	08-13-93	1120	108	58	<1	.3	<.1	<3
	08-16-93	1035	111	59	<1	.3	<.1	<3
		1036	108	59	<1	.3	<.1	<3
		1037	118	63	<1	.4	<.1	<3
		1038	111	59	<1	.3	<.1	<3
	08-23-93	1250	108	57	<1	.4	<.01	<3
	08-24-93	0720	113	60	<1	.4	<.01	<3
	08-28-93	1000	117	62	<1	.29	<.01	<3
	08-29-93	1140	114	60	<1	.25	<.01	<3
	08-30-93	1250	112	59	<1	.24	<.01	<3

Appendix 5. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during August 1993—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L30	08-10-93	1550	112	54	<1	0.3	<0.1	<3
(PR11 at 36 ft)	08-11-93	1300	133	80	<1	.3	<.1	<3
	08-12-93	1200	112	73	<1	.3	<.1	<3
	08-13-93	1330	129	77	<1	.3	<.1	<3
	08-16-93	1450	121	78	<1	2.2	<.1	<3
	08-23-93	1015	112	73	<1	1.5	<.01	<3
	08-24-93	1130	112	75	<1	1.2	<.01	<3
	08-28-93	1215	122	80	<1	.55	<.01	<3
	08-29-93	0955	115	77	<1	.38	<.01	<3
	08-30-93	1100	118	79	<1	.36	<.01	<3
	08-10-93	2200	145	144	<1	<.1	<.1	<3
	08-11-93	2100	144	133	<1	4.3	1.3	<3
	08-12-93	2030	145	136	<1	4	1.7	<3
		2031	145	136	<1	4.1	1.5	<3
		2032	145	137	<1	4	1.7	<3
		2033	148	135	<1	4.1	1.5	4
POND AT PICO	08-13-93	0910	145	136	<1	4.1	1.5	<3
(PR12)	08-16-93	1940	140	138	<1	4.1	2.6	<3
	08-23-93	1920	127	123	<1	4.5	.29	<3
	08-23-93	1930	118	119	<1	4.7	.25	<3
	08-23-93	1950	126	113	<1	4.4	.22	<3
	08-23-93	2030	136	122	<1	4.4	.23	<3
	08-24-93	1720	124	126	<1	4.4	.23	<3
	08-28-93	1745	126	126	<1	2.9	.28	<3
	08-29-93	1700	116	114	<1	2.2	.26	<3
	08-30-93	1745	120	119	<1	2.1	.25	<3
SEWAGE	08-10-93	2245	148	120	<1	5.8	1.6	<3
EFFLUENT	08-11-93	2045	140	124	<1	4	1.6	3
(PR13)	08-12-93	1950	132	134	<1	3.7	1.9	3
		1951	132	135	<1	3.7	1.9	<3
	08-13-93	1900	135	139	<1	4.5	2.1	<3
	08-16-93	2000	130	135	<1	3.1	1.8	4
	08-23-93	2010	120	108	<1	3	1.4	<3
	08-24-93	1750	114	127	<1	3.1	1.6	<3
	08-28-93	1805	119	132	<1	1.8	1.8	<3
	08-29-93	1720	121	135	<1	4.3	1.5	—
	08-30-93	1810	109	126	<1	1.9	1.5	<3

Appendix 6. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994

[See table 1 for explanation of local identifier below station name; ft, feet below basin floor or land surface; mg/L, milligrams per liter; <, actual value less than value shown; —, no data; MLS, multilevel sampler; samples differing by one minute represent duplicate analyses]

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L14A	04-04-94	1940	158	102	<0.2	0.85	<0.01	<0.2
(MLS20)	04-05-94	1205	162	104	<.2	.97	<.01	<.2
	04-05-94	1800	158	101	<.2	.94	<.01	.5
	04-06-94	1400	157	99	<.2	2.06	.03	<.2
	04-07-94	0900	157	119	<.2	4.84	.55	<.2
	04-08-94	0825	154	127	<.2	5.83	.54	<.2
	04-21-94	0915	147	129	<.2	3.06	1.20	<.2
		0916[1]	144	129	<.2	3.03	1.20	.4
	06-01-94	1455	152	108	.2	1.34	.03	<.2
2S/11W-18L14C	04-07-94	0915	155	130	<.2	7.26	.63	.3
(MLS18)	04-08-94	0830	163	133	<.2	7.16	.65	.6
2S/11W-18L14F	04-04-94	1930	162	112	.3	1.27	.04	.2
(MLS15)		1931[1]	158	111	.2	1.26	.04	.2
	04-05-94	1145	172	118	.2	1.48	.03	<.2
	04-05-94	1750	160	104	.3	1.70	<.01	.2
	04-06-94	1350	154	135	.2	7.38	1.07	<.2
	04-07-94	0945	150	133	<.2	7.08	1.04	<.2
	04-08-94	0845	208	133	.3	9.48	.06	<.2
	04-21-94	0945	144	129	<.2	2.43	<.013	.5
	06-01-94	1435	143	121	.3	3.21	<.01	.5
2S/11W-18L14K	04-04-94	1855	154	93	<.2	2.27	<.01	.2
(MLS10)	04-05-94	1123	154	92	.8	2.40	<.01	<.2
	04-05-94	1740	155	90	<.2	2.87	<.01	<.2
		1741[1]	156	91	<.2	2.90	<.01	.2
	04-06-94	1145	155	132	<.2	8.55	.14	.2
	04-07-94	1000	153	136	.2	7.73	.34	.5
	04-08-94	0910	149	136	.3	7.22	.67	1.0
	04-21-94	1000	144	128	.5	3.03	.01	1.0
	06-01-94	1350	162	112	.3	.70	<.01	.4
2S/11W-18L14L	04-04-94	1835	152	91	<.2	2.47	<.01	.4
(MLS9)	04-05-94	1100	153	91	<.2	2.49	<.01	.3
	04-05-94	1645	155	88	.2	3.05	<.01	<.2
	04-06-94	1125	158	131	.9	8.41	.26	.5
	04-07-94	1018	151	138	<.2	7.28	.78	.6
	04-08-94	0945	146	136	.4	6.17	1.48	1.1
	04-21-94	1020	141	127	<.2	3.74	<.01	1.1
	06-01-94	1315	167	112	.3	.54	<.01	.6

See footnote at end of table.

Appendix 6. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L14L	04-04-94	1835	152	91	<0.2	2.47	<0.01	0.4
(MLS9)	04-05-94	1100	153	91	<.2	2.49	<.01	.3
	04-05-94	1645	155	88	.2	3.05	<.01	<.2
	04-06-94	1125	158	131	.9	8.41	.26	.5
	04-07-94	1018	151	138	<.2	7.28	.78	.6
	04-08-94	0945	146	136	.4	6.17	1.48	1.1
	04-21-94	1020	141	127	<.2	3.74	<.01	1.1
	06-01-94	1315	167	112	.3	.54	<.01	.6
2S/11W-18L14M	04-04-94	1750	162	99	<.2	1.69	.03	.2
(MLS8)	04-05-94	1046	169	96	<.2	2.10	.03	<.2
	04-05-94	1635	168	94	<.2	2.41	.02	<.2
	04-06-94	1045	158	124	<.2	6.45	.44	<.2
	04-07-94	1040	156	134	<.2	7.38	.46	.5
	04-08-94	0930	199	135	.3	8.37	.39	<.2
		0931[1]	199	135	<.2	8.29	.39	<.2
	04-21-94	1040	146	128	<.2	2.17	.04	.9
	06-01-94	1210	149	116	.3	1.02	.02	.7
		1211[1]	150	117	.2	1.13	.02	.6
2S/11W-18L14N	04-04-94	1730	181	86	<.2	2.73	.09	<.2
(MLS7)	04-05-94	1010	163	91	<.2	2.71	.02	.4
	04-05-94	1540	162	91	.3	2.70	<.01	.4
	04-06-94	1000	168	121	<.2	7.10	.50	.6
	04-07-94	1100	151	134	<.2	7.64	.51	.7
	04-08-94	0950	172	135	<.2	7.73	.55	.8
	04-21-94	1050	143	128	<.2	2.69	.27	1.2
	06-01-94	1100	148	115	.3	.57	<.01	.9
2S/11W-18L14O	04-04-94	1715	165	86	<.2	2.93	.03	.4
(MLS6)	04-05-94	0950	166	92	<.2	2.57	.03	.6
		0951[1]	164	90	<.2	2.56	.03	.4
	04-05-94	1532	177	90	.2	3.22	<.01	.4
		1533[1]	176	90	<.2	3.20	<.01	.6
	04-06-94	0950	162	126	1.6	7.52	.58	<.2
	04-07-94	1120	153	136	<.2	7.69	.56	.6
	04-08-94	1045	169	136	<.2	7.40	.77	.5
	04-21-94	1105	146	130	<.2	2.48	.12	.3
	06-01-94	1040	139	120	.6	.81	.02	.9

See footnote at end of table.

Appendix 6. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L14P	04-04-94	1630	167	95	0.3	2.08	0.04	0.2
(MLS5)	04-05-94	0900	162	96	<.2	2.15	.03	.5
	04-05-94	1505	191	90	<.2	3.22	<.01	.2
	04-06-94	0818	175	119	<.2	7.26	.38	1.0
		0819[1]	173	120	<.2	7.26	.38	.6
	04-07-94	1130	160	141	<.2	7.60	.88	.6
	04-08-94	1055	178	136	<.2	7.52	.82	.5
		1056[1]	177	136	.2	7.52	.82	.8
	04-21-94	1135	146	128	<.2	2.36	.11	1.1
		1136[1]	145	128	<.2	2.36	.11	1.3
	06-01-94	0935	137	121	.4	.76	.03	1.1
2S/11W-18L14Q	04-04-94	1605	256	76	.2	5.75	<.01	.9
(MLS4)	04-05-94	0830	308	74	.7	7.00	<.01	.4
	04-05-94	1450	339	88	.4	7.23	.34	.8
	04-06-94	0820	166	127	<.2	7.76	1.08	.6
	04-07-94	1144	153	135	<.2	6.71	1.25	.6
	04-08-94	1125	169	137	<.2	7.43	.84	.8
	04-21-94	1145	149	128	.2	2.02	.23	.8
	06-01-94	0915	95	142	.5	.24	<.012	1.8
2S/11W-18L27	04-04-94	1905	151	99	<.2	1.44	<.01	<.2
(PR8 at 49 ft)		1906[1]	152	102	<.2	1.48	<.01	<.2
		1907[1]	153	100	<.2	1.47	<.01	.4
	04-05-94	1805	156	107	<.2	1.40	<.01	<.2
	04-06-94	1205	159	109	.2	2.37	.11	<.2
		1206[1]	160	108	.2	2.36	.11	<.2
	04-07-94	1425	149	98	<.2	1.49	<.01	<.2
	04-08-94	1040	151	102	<.2	1.82	<.01	<.2
	04-21-94	1740	153	100	.3	2.21	.02	<.2
		1741[1]	153	101	<.2	2.23	.02	<.2
		1742[1]	154	101	<.2	2.20	.02	<.2
	06-01-94	1330	147	95	.2	1.32	<.01	<.2
		1331	147	95	.5	1.31	<.014	.2
		1332	148	96	.4	1.32	<.013	<.2

See footnote at end of table.

Appendix 6. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L28	04-04-94	1720	158	107	<0.2	1.27	<0.01	<0.2
(PR9 at 25 ft)		1721[1]	157	107	<.2	1.27	<.01	<.2
	04-05-94	1700	149	98	.2	1.43	<.01	<.2
		1701[1]	150	99	.7	1.44	<.01	<.2
		1702[1]	151	100	.3	1.45	<.01	<.2
	04-06-94	1030	151	99	<.2	1.50	<.01	<.2
	04-07-94	1200	156	123	<.2	5.80	.95	<.2
	04-08-94	1000	152	130	<.2	6.14	1.41	<.2
	04-21-94	1625	140	123	<.2	6.53	1.79	<.2
	06-01-94	1515	142	123	<.2	4.78	1.21	<.2
2S/11W-18L29	04-04-94	2000	158	109	.3	1.28	<.01	.4
(PR10 at 60 ft)	04-05-94	1405	157	109	.4	1.27	<.01	<.2
	04-06-94	1550	156	109	<.2	1.29	<.01	<.2
	04-07-94	1030	155	108	<.2	1.32	<.01	<.2
		1031[1]	157	109	<.2	1.34	<.01	<.2
	04-08-94	1200	157	109	<.2	1.53	<.011	<.2
	04-21-94	1445	—	103	—	1.64	<.01	—
	06-01-94	1130	154	101	.2	1.74	.02	<.2
2S/11W-18L30	04-04-94	1550	156	99	<.2	1.42	<.01	<.2
(PR11 at 36 ft)	04-05-94	1550	154	99	.3	1.40	<.01	.2
	04-06-94	1445	156	102	<.2	1.51	<.01	<.2
	04-07-94	0930	158	105	.2	2.75	.09	<.2
		0931[1]	158	105	<.2	2.68	.10	<.2
		0932[1]	158	106	.3	2.69	.10	<.2
		0933[1]	159	105	.2	2.70	.10	<.2
	04-08-94	1200	147	130	.2	5.89	1.11	.4
	04-21-94	1315	140	125	<.2	5.22	2.23	<.2
	06-01-94	1015	146	108	<.2	3.63	.39	.2

See footnote at end of table.

Appendix 6. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during April and June 1994—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
POND AT PICO	04-05-94	0845	150	131	.3	5.43	1.46	1.7
(PR12)	04-05-94	0943	149	130	.2	5.28	1.48	1.5
	04-05-94	1055	151	129	<.2	5.16	1.46	1.6
	04-05-94	1154	150	128	<.2	5.24	1.37	1.7
	04-05-94	1155	149	127	<.2	5.22	1.37	1.5
	04-05-94	1421	149	125	.2	5.98	1.18	1.6
	04-05-94	1607	147	129	<.2	6.17	1.17	1.3
	04-05-94	1714	150	131	<.2	6.27	1.18	1.6
	04-05-94	1830	150	134	<.2	6.48	1.21	1.5
	04-06-94	0745	149	133	.3	5.97	1.36	1.7
	04-07-94	0800	146	137	.3	6.25	1.58	1.5
	04-07-94	0805	147	137	.2	6.31	1.59	1.3
	04-07-94	0810	148	138	<.2	6.31	1.60	1.8
	04-07-94	1430	144	135	<.2	5.98	1.59	1.5
	04-07-94	1530	145	137	<.2	6.26	1.60	1.5
	04-07-94	1540	144	136	<.2	6.06	1.59	2.0
	04-07-94	1825	145	139	.4	6.40	1.62	1.6
	04-07-94	1830	145	138	<.2	6.28	1.60	1.4
	04-07-94	1845	144	137	.2	6.29	1.61	1.8
	04-08-94	1130[1]	145	136	<.2	5.95	1.73	1.6
		1131[1]	144	135	<.2	5.98	1.72	1.9
		1132[1]	145	134	.7	5.93	1.71	1.9
	04-21-94	0800	140	129	<.2	4.74	2.43	1.3
	04-21-94	0815	140	129	<.2	4.77	2.48	1.6
	04-21-94	0820	138	129	<.2	4.81	2.45	1.2
	04-21-94	0825	139	129	<.2	5.02	2.44	1.3
SEWAGE	04-05-94	0915	141	127	<.2	4.81	1.54	1.3
EFFLUENT	04-05-94	1020	149	131	.3	4.96	1.42	1.5
(PR13)	04-05-94	1105	142	123	<.2	5.22	1.42	1.0
	04-05-94	1210	148	120	<.2	6.07	1.02	1.7
	04-05-94	1420	149	134	.2	6.89	1.08	2.0
	04-05-94	1545	148	141	.4	6.56	1.19	1.6
	04-05-94	1650	148	140	<.2	—	—	1.5
	04-05-94	1835	148	140	<.2	7.70	1.30	1.9
	04-06-94	1215	151	121	<.2	5.59	1.12	1.6
	04-07-94	1215	140	124	<.2	5.51	1.11	1.0
	04-08-94	1215	142	118	<.2	6.47	1.14	1.4
	04-21-94	1530	134	136	<.2	4.31	1.06	1.7

[1] Replicate analyses

Appendix 7. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994

[See table 1 for explanation of local identifier below station name; ft, feet below basin floor or land surface; mg/L, milligrams per liter; <, actual value less than value shown; —, no data; MLS, multilevel sampler; samples differing by one minute represent duplicate analyses]

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L14A	940906	1530	224	106	<0.2	0.67	<0.02	0.5
(MLS20)	940907	0915	195	133	<.2	8.74	1.26	<.4
	940909	1030	136	139	.5	4.84	2.45	.5
	940912	0845	134	119	<.2	5.67	1.98	1.2
	940916	0830	134	134	1.4	2.89	1.28	1.2
	940919	1925	137	124	<.2	5.86	.78	1.6
	940922	0915	135	130	<.2	4.31	.30	1.1
2S/11W-18L14E	940906	1330	193	117	.6	10.27	.07	1.1
(MLS16)		1331	201	121	.2	10.38	.04	2.3
2S/11W-18L14F	940907	1035	142	129	<.2	4.53	1.78	.7
(MLS15)	940909	1000	136	139	<.2	4.54	2.75	1.3
	940912	0850	131	112	<.2	5.88	1.81	1.1
	940916	0900	133	132	.7	3.56	.15	1.3
	940919	1430	137	119	<.2	6.64	.03	.9
	940921	1145	137	133	<.2	4.85	<.02	2.5
	940922	0920	135	134	<.2	4.78	<.02	1.5
2S/11W-18L14I	940916	1000	134	129	.4	4.40	.86	1.8
(MLS12)	940919	1545	134	115	<.2	6.50	.53	1.7
2S/11W-18L14J	940907	1215	147	123	.2	3.86	2.37	.8
(MLS11)	940912	1040	134	111	.4	5.49	1.82	1.7
2S/11W-18L14K	940909	1230	140	131	<.2	3.49	2.49	1.5
(MLS10)								
2S/11W-18L27	940906	1440	194	105	.3	0.83	<.02	1.0
(PR8 at 49 ft)	940907	1150	199	107	<.2	.84	<.02	.3
	940909	1315	210	106	<.2	.64	<.02	1.3
	940912	1320	164	121	<.2	3.10	1.47	.2
	940916	1150	146	124	<.2	5.12	2.51	.4
	940919	2005	138	130	<.2	4.31	2.04	.3
	940922	1215	134	126	<.2	4.27	1.82	<.4

Appendix 7. Water-quality data from analyses done in San Diego Geochemical Laboratory for samples collected near the research basin, Montebello Forebay, Los Angeles County, California, during September 1994—Continued

Station name (Local identifier)	Date	Time	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Nitrogen, nitrate dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)	Ortho-phosphate, dissolved (mg/L as P)
2S/11W-18L28	940906	1210	226	108	<0.2	0.17	<0.02	1.1
(PR9 at 25 ft)	940907	0945	140	127	.5	3.81	1.95	<.4
	940909	1045	134	140	<.2	4.86	3.37	<.4
	940912	1430	130	112	<.2	5.59	2.54	1.7
	940916	1325	134	134	<.2	3.29	2.55	1.1
	940919	1815	135	120	.5	6.34	2.00	1.0
	940922	1330	135	133	<.2	4.34	1.68	1.4
2S/11W-18L29	940906	1615	160	102	<.2	1.02	<.02	<.4
(PR10 at 60 ft)	940907	1435	160	100	<.2	1.02	<.02	<.4
	940909	1530	171	102	1.2	1.02	<.02	1.4
	940912	1000	168	98	<.2	1.43	.01	<.4
	940916	1055	189	108	<.2	1.33	.33	.6
	940919	1415	199	111	<.2	2.44	.50	2.4
	940922	0930	168	129	<.2	3.98	1.72	.4
2S/11W-18L30	940906	1835	183	120	<.2	3.86	<.02	<.4
(PR11 at 36 ft)	940907	1520	168	125	<.2	6.09	1.22	.6
	940909	1700	132	137	.3	4.90	3.21	1.9
	940912	1100	139	120	.1	6.52	2.77	1.6
	940916	0925	137	134	.4	3.05	2.58	3.3
	940919	1600	135	121	.3	6.12	1.77	—
		1601	133	122	<.2	6.09	1.73	3.4
	940922	1115	136	132	.2	4.10	.93	1.2
POND AT PICO	940907	1515	133	149	<.2	5.11	1.66	.8
(PR12)	940909	1625	138	148	<.2	6.62	1.81	1.4
	940912	1415	133	111	<.2	6.19	1.95	1.5
	940916	1030	137	125	<.2	4.39	2.34	1.7
	940919	1845	138	121	.2	7.07	2.64	1.7
	940922	1345	136	129	<.2	5.80	2.43	—
	940923	1145	137	130	<.2	5.57	2.34	1.8

Appendix 8A. Water-quality data from selected production and monitoring wells, collected near the research basin, Montebello Forebay, Los Angeles County, California, oxygen–alkalinity

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; ft, feet below basin floor or land surface; mg/L, milligrams per liter; —, no data]

Station name (Local identifier)	Date	Time	Oxygen, dissolved (mg/L) (00300)	pH, field (standard units) (00400)	Specific conductance, field (µS/cm) (00095)	Water temperature (°C) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) (00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Sodium dissolved (mg/L as Na) (00930)	Alkalinity, fixed endpoint, field (mg/L as $CaCO_3$) (39036)
2S/12W-24R1	04/07/94	1625	—	7.2	778	—	180	50	13	85	150
2S/11W-19E1	04/07/94	1710	—	6.8	1,030	21.3	220	57	18	120	160
2S/11W-19C1	04/06/94	1845	—	7	1,030	—	240	64	19	110	170
	09/23/94	1340	2.4	7	1,060	22.4	—	—	—	—	150
2S/11W-18P1	04/06/94	1745	—	6.9	1,030	20.2	220	59	18	120	160
	09/23/94	1200	2.4	7	1,070	24.7	—	—	—	—	180
2S/11W-18L35 (WPS at 20.6 ft)	09/21/94	1500	8.4	7.5	1,070	28.4	260	70	20	110	170
2S/11W-7J1	04/07/94	1510	5.6	7.6	1,060	20.3	370	110	22	80	210
	09/12/94	1100	9	7.3	1,150	19.9	—	—	—	—	220
	09/21/94	1030	8	7.2	1,140	19.8	400	120	25	83	220

Appendix 8B. Water-quality data from selected production and monitoring wells, collected near the research basin, Montebello Forebay, Los Angeles County, California, bromide–phosphorus

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; mg/L, milligrams per liter; <, actual value less than value shown; —, no data]

Station name (Local identifier)	Date	Time	Bromide, dissolved (mg/L as Br) (71870)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Nitrogen ammonia, dissolved (mg/L as N) (00608)	Nitrogen nitrate, dissolved (mg/L as N) (00618)	Nitrogen nitrite plus nitrate dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved, (mg/L as N) (00613)	Ortho-phosphate, dissolved (mg/L as P) (00671)
2S/12W-24R1	04/07/94	1625	—	—	—	16	—	0.02	—	9.9	<0.010	1.3
2S/11W-19E1	04/07/94	1710	—	—	—	21	—	.49	2.49	2.5	.01	2.3
2S/11W-19C1	04/06/94	1845	—	—	—	18	—	.03	5.38	5.4	.02	1.5
	09/23/94	1340	<0.2	117	0.4	—	192	—	1.27		<.020	.7
2S/11W-18P1	04/06/94	1745	—	—	—	20	—	.18	—	5	<.010	1.8
	09/23/94	1200	<.2	140	.4	—	138	—	2.1	—	<.020	3.4
2S/11W-18L35 (WPS at 20.6 ft)	09/21/94	1500	.12	130	.7	23	140	.03	4	6	2	1.2
2S/11W-7J1	04/07/94	1510	—	86	—	19	212	.01	—	3.3	<.010	.02
	09/12/94	1100	<.2	89	.3	—	245	—	2.36		<.020	<.4
	09/21/94	1030	.28	90	.3	20	240	<.010	—	2.7	<.010	.01

Appendix 8C. Water-quality data from selected production and monitoring wells, collected near the research basin, Montebello Forebay, Los Angeles County, California, barium–chromium

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; <, actual value less than value shown; —, no data]

Station name (Local identifier)	Date	Time	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Boron, dissolved (µg/L as B) (01020)	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)
2S/12W-24R1	04/07/94	1625	97	<0.5	—	<1	<5
2S/11W-19E1	04/07/94	1710	100	<.5	—	<1	<5
2S/11W-19C1	04/06/94	1845	160	<.5	—	<1	5
	09/23/94	1340	—	—	—	—	—
2S/11W-18P1	04/06/94	1745	140	<.5	—	<1	<5
	09/23/94	1200	—	—	—	—	—
2S/11W-18L35 (WPS at 20.6 ft)	09/21/94	1500	200	<.5	470	<1	<5
2S/11W-7J1	04/07/94	1510	77	<.5	—	<1	<5
	09/12/94	1100	—	—	—	—	—
	09/21/94	1030	86	<.5	250	<1	<5

Appendix 8D. Water-quality data from selected production and monitoring wells, collected near the research basin, Montebello Forebay, Los Angeles County, California, cobalt–lithium

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; <, actual value less than value shown; —, no data]

Station name (Local identifier)	Date	Time	Cobalt , dissolved (µg/L as CO) (01035)	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)
2S/12W-24R1	04/07/94	1625	<3	<10	6	20	9
2S/11W-19E1	04/07/94	1710	<3	10	7	<10	16
2S/11W-19C1	04/06/94	1845	5	10	31	<10	16
	09/23/94	1340	—	—	—	—	—
2S/11W-18P1	04/06/94	1745	<3	10	11	<10	14
	09/23/94	1200	—	—	—	—	—
2S/11W-18L35 (WPS at 20.6 ft)	09/21/94	1500	<3	20	8	<10	16
2S/11W-7J1	04/07/94	1510	<3	<10	6	<10	<4
	09/12/94	1100	—	—	—	—	—
	09/21/94	1030	<3	<10	7	<10	5

Appendix 8E. Water-quality data from selected production and monitoring wells, collected near the research basin, Montebello Forebay, Los Angeles County, California, manganese–silver

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; <, actual value less than value shown; -—, no data]

Station name (Local identifier)	Date	Time	Manganese, dissolved (µg/L as Mn) (01056)	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Silver, dissolved (µg/L as Ag) (01075)
2S/12W-24R1	04/07/94	1625	38	20	<10	<1
2S/11W-19E1	04/07/94	1710	2	20	<10	<1
2S/11W-19C1	04/06/94	1845	460	30	<10	<1
	09/23/94	1340	—	—	—	—
2S/11W-18P1	04/06/94	1745	60	20	<10	<1
	09/23/94	1200	—	—	—	—
2S/11W-18L35 (WPS at 20.6 ft)	09/21/94	1500	800	30	<10	2
2S/11W-7J1	04/07/94	1510	4	<10	<10	<1
	09/12/94	1100	—	—	—	—
	09/21/94	1030	6	<10	<10	2

Appendix 8F. Water-quality data from selected production and monitoring wells, collected near the research basin, Montebello Forebay, Los Angeles County, California, strontium–oxygen 18/16

[See table 1 for explanation of local identifier below station name; number below the compound is the data parameter code, which is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property; ft, feet below basin floor or land surface; µg/L, micrograms per liter; per mil, parts per thousand; <, actual value less than value shown; —, no data]

Station name (Local identifier)	Date	Time	Strontium, dissolved (µg/L as Sr) (01080)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)	Hydrogen-2/1 (per mil) (82082)	Oxygen-18/16 (per mil) (82085)
2S/12W-24R1	04/07/94	1625	360	<6	3	—	—
2S/11W-19E1	04/07/94	1710	470	8	14	—	—
2S/11W-19C1	04/06/94	1845	500	6	<3	—	—
	09/23/94	1340	—	—	—	—	—
2S/11W-18P1	04/06/94	1745	470	6	6	—	—
	09/23/94	1200	—	—	—	—	—
2S/11W-18L35 (WPS at 20.6 ft)	09/21/94	1500	560	10	360	—	—
2S/11W-7J1	04/07/94	1510	620	<6	7	–57.5	–7.90
	09/12/94	1100	—	—	—	—	—
	09/21/94	1030	690	<6	<3	—	—

Appendix 9. Selected field measurements on samples collected for organic characterization near the research basin, Montebello Forebay, Los Angeles County, California

[SC, specific conductance; µS/cm, microsiemens per centimeter at 25ºC; ºC, degrees Celsius; mg/L, milligrams per liter; ft, foot; —, no data]

Sample identifier	Date	Time	SC (µS/cm)	pH (standard units)	Temperature, water (ºC)	Oxygen, dissolved (mg/L)
First recharge experiment						
MLS4	08-23-93	0920	970	7.4	—	—
MLS5	08-23-93	0945	960	7.7	—	—
MLS6	08-23-93	1050	948	7.3	—	—
MLS7	08-23-93	1100	976	7.5	—	—
MLS8	08-23-93	1145	950	7.2	—	—
MLS10	08-23-93	1210	958	7.4	—	—
MLS11	08-23-93	1500	916	7.3	—	—
PR8	08-23-93	1530	643	7.5	—	—
PR9	08-23-93	1730	708	7.3	—	—
PR12 (6 ft depth)	08-23-93	1920	954	7.6	—	—
PR12 (surface)	08-23-93	1950	955	7.5	—	—
PR13	08-23-93	2010	958	7.2	—	—
Second recharge experiment						
PR13	04-05-94	0730	1,100	7.1	23.3	4.6
MLS4	04-05-94	1300	1,133	6.9	20.1	5.5
PR10	04-05-94	1400	—	—	—	—
PR11	04-05-94	1530	930	6.9	22.5	.5
PR9	04-05-94	1700	918	7.0	20.9	.7
PR8	04-05-94	1900	953	6.8	21.5	.7
MLS7	04-06-94	0900	1,084	7.0	20.7	2.3
MLS10	04-06-94	1100	1,112	7.0	20.7	5.1
MLS15	04-06-94	1200	1,087	7.0	22.1	3.9
PR12	04-06-94	1500	1,145	7.1	24.2	4.4
2S/11W-18P1	04-06-94	1730	1,047	6.7	20.2	1.2
2S/11W-19C1	04-06-94	1900	1,051	6.9	19.2	1.4
MLS20	04-07-94	0945	1,041	6.89	21.7	2.4
PR9	04-07-94	1200	1,045	6.76	22.4	.8
2S/11W-7J1	04-07-94	1430	1,082	7.12	20.4	5.6
MLS4	04-07-94	1700	1,165	6.98	22.8	.8
MLS5	04-07-94	1705	1,153	6.93	23.0	1.4
MLS6	04-07-94	1710	1,147	6.92	23.0	1.9
MLS7	04-07-94	1715	1,137	6.89	22.9	2.2
MLS8	04-07-94	1720	1,142	6.94	22.9	2.4
MLS9	04-07-94	1725	1,134	6.89	22.9	2.4
MLS10	04-07-94	1730	1,147	6.92	22.7	4.3
MLS11	04-07-94	1735	1,149	6.95	22.6	5.1
MLS12	04-07-94	1740	1,148	6.96	22.4	4.3
MLS13	04-07-94	1745	1,137	6.92	22.5	2.2
MLS14	04-07-94	1750	1,138	6.92	22.7	2.5
MLS15	04-07-94	1755	1,136	6.97	22.3	2.3
MLS16	04-07-94	1800	1,114	6.92	22.4	2.3

Appendix 9. Selected field measurements on samples collected for organic characterization, near the research basin, Montebello Forebay, Los Angeles County, California—Continued

Sample identifier	Date	Time	SC (µS/cm)	pH (standard units)	Temperature, water (°C)	Oxygen, dissolved (mg/L)
MLS17	04-07-94	1805	1,132	6.93	22.3	2.3
MLS18	04-07-94	1810	1,127	6.92	21.9	2.4
MLS19	04-07-94	1815	1,113	6.89	21.9	1.7
MLS20	04-07-94	1820	1,047	6.94	21.7	1.9
Third recharge experiment						
PR9	09-19-94	1815	1,065	7.1	27.4	0.6
2S/11W-7J1	09-21-94	1030	1,144	7.2	19.8	8.0
MLS15	09-21-94	1145	1,090	7.2	27.5	1.2
WP5	09-21-94	1500	1,068	7.5	28.4	8.4
PR11	09-22-94	1115	1,075	7.2	27.7	.6
PR13	09-22-94	1345	1,084	7.2	28.3	3.0