REM IV

Remedial Planning Activities at Selected Uncontrolled Hazardous Waste Sites–Zone II

Environmental Protection Agency
Hazardous Site Control Division
Contract No. 68-01-7251

PUBLIC REVIEW DRAFT
BASINWIDE TECHNICAL PLAN
REPORT

VOLUME ONE
SAN GABRIEL BASIN
LOS ANGELES, CALIFORNIA

April 17, 1990

CH2M HILL
Black & Veatch
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PRC
Ecology and Environment

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1.0 INTRODUCTION

The San Gabriel Basinwide Technical Planning Report presents a long-term plan for remediation of groundwater contaminated with volatile organic compounds (VOCs) in the San Gabriel Basin. Based on an assessment of the consequences of continuing present water management practices on the migration of VOC contamination in the basin, it is clear that the remedial process already initiated must continue in a direct and steadfast manner.

This plan presents a strategy built upon an integration of remedial objectives, remedial investigation (RI) needs, source identification and control, and institutional concerns. Priorities identified in this integrated strategy are used to evaluate a variety of actions for incorporation into an incremental and sequential approach to remediating the groundwater contamination problem that presently exists within the San Gabriel Basin. Although specific recommendations regarding the implementation of remedial and investigative actions are made, the plan should be considered more general and broad in scope than a feasibility study or design-level document. Additionally, the plan focuses on the technical aspects of remediation and source control; EPA state and local agencies are currently involved in discussions concerning funding and basinwide management consideration.

1.1 BACKGROUND

Groundwater contaminated with VOCs was first detected in 1979 in the San Gabriel Basin during environmental monitoring activities conducted by Aerojet Electrosystems near their facility in Azusa. In May 1984, four broad areas of contamination within the basin were listed as San Gabriel Areas 1-4 on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL). The four areas were defined based on water quality data available at the time of listing. Subsequent water quality sampling has shown that VOC contamination is pervasive throughout much of the San Gabriel Basin; EPA currently manages all of the San Gabriel Basin as one, albeit large, site, because all of the sites are within a single groundwater basin in which actions in one area may significantly affect other areas.

To provide some remediation planning flexibility and to facilitate cost recovery actions, the entire San Gabriel Basin has been subdivided into seven RI areas that include the NPL Areas 1-4. The location of these seven areas is shown in Figure 1-1. Groundwater contamination in each of these areas is

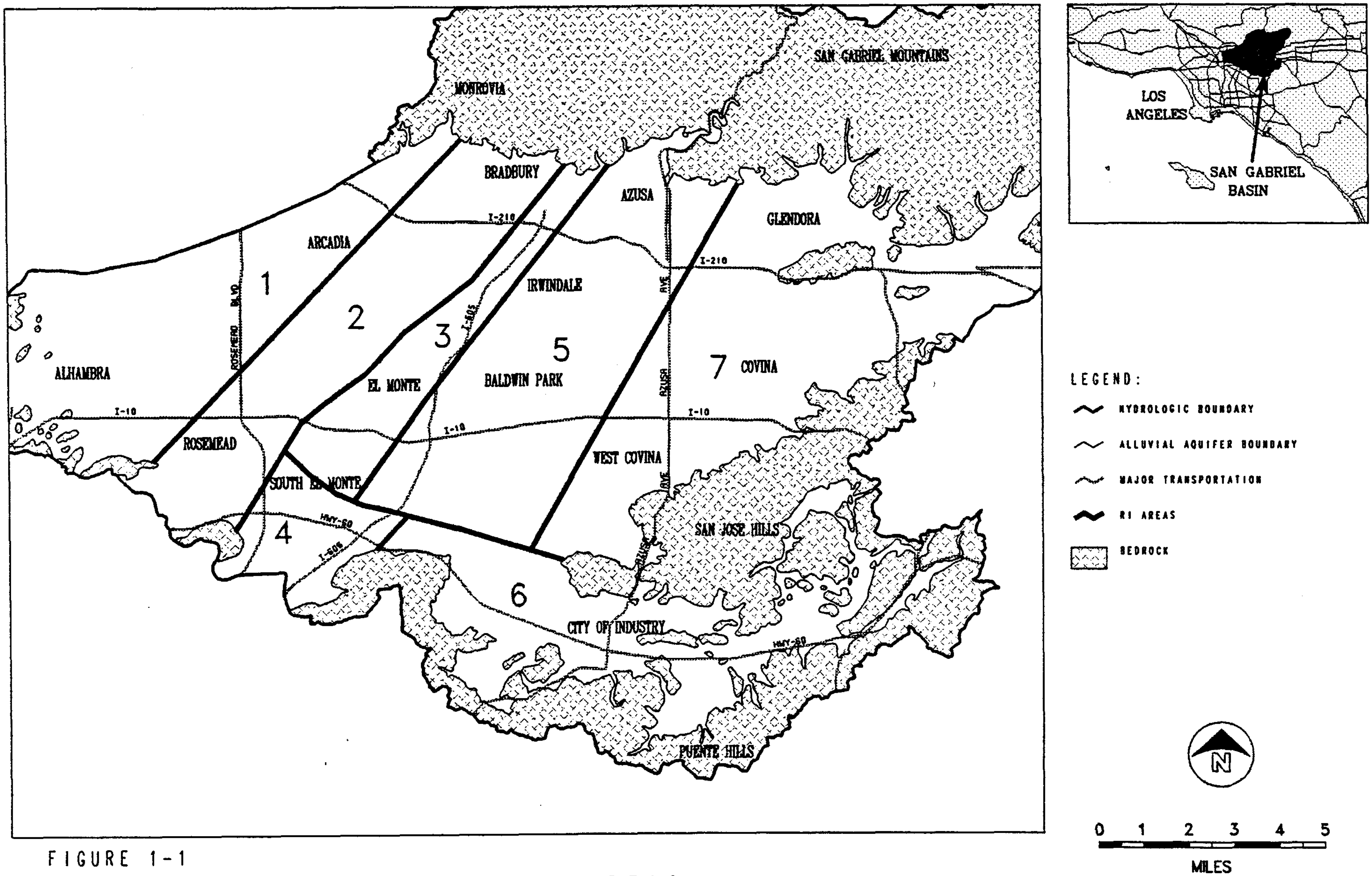

FIGURE 1-1

THE SAN GABRIEL BASIN - RI AREAS

Draft Basinwide Technical Plan
San Gabriel Basin

distinguished from that in other areas by extent and types of organic contaminants. The physical properties of the aquifer itself are also distinguishable by RI Area. When these areas were originally defined, contamination above federal and state drinking water standards, referred to as maximum contaminant levels (MCLs), was wholly contained within them. Although subsequent data indicate otherwise, the seven areas remain as a convenient framework for describing conditions in the basin and planning discrete remedial actions may be developed.

Forty-five private and municipal water purveyors sell water on a wholesale or retail basis in the San Gabriel Basin. About 240,000 acre-feet of groundwater are extracted annually for domestic, municipal, and industrial use. Based on the latest data available during the preparation of this report, groundwater contaminated above MCLs occurs in almost 20 percent[1] of the basin area. To ensure that public health is protected and an adequate supply of water is provided, purveyors have responded to this problem by removing wells from service, operating the wells on an intermittent basis, blending contaminated water with water from another source, or installing treatment systems.

Although the purveyor's actions were often necessary as an immediate response and have been successful in solving the short-term groundwater contamination problem, continued use of these approachs will most likely not be adequate to address this problem over the long term. Removal of contaminated wells from service has the effect of letting contamination that would otherwise be extracted from the aquifer remain and migrate further within the groundwater system. This effect may be compounded by the practice of replacing contaminated wells with new wells located in "clean" areas, or completing contaminated wells to greater depths to avoid shallow contamination. Therfore, a new approach to the management of the water resources of the San Gabriel Basin must be developed.

Because all sources of contamination have not been identified or cleaned up, contaminants can be assumed to continue to enter the groundwater, adding to the VOC load within the system. The effect of delayed remedial actions is the continued migration of contaminants within the basin. This suggests that significantly greater costs be associated with delayed groundwater remediation than would be the case with relatively near-term remedial actions. Simply providing treatment to wells that become contaminated provides little or no measure of migration control and, as contamination continues to spread, additional wells will eventually require treatment. Failure to implement remedial actions may lead to extensive contamination throughout most of the

[1]The approximate lateral extent of contamination is not necessarily an indicator of the percentage of total volume of groundwater contaminated. Descriptions of the uncertainty in the vertical extent of contamination and various estimates of total volume of contaminated water are contained in the Draft Report of Remedial Investigations (EPA, 1989b).

areas of the basin currently used for groundwater production. Areas presently affected by groundwater contaminated with VOCs are shown in Figure 1-2.

EPA involvement in the San Gabriel Basin to date has essentially followed an three-phase approach that incorporates (1) planning and implementation of discrete operable units, (2) basinwide remedial planning and remedial investigations, and (3) planning for cost recovery and enforcement actions. These three components have continued concurrently and are intended to support and complement each other. The specific activities associated with each of these components are collectively considered Stage I activities; the actions described in this plan will form part of Stages II through V. Stage I activities are summarized in the following three sections.

1.1.1 PREVIOUS AND ONGOING OPERABLE UNIT ACTIVITIES

In accordance with the National Contingency Plan, operable units may be defined address specific identifiable and discrete portions of a larger contamination problem. Operable units have been identified within the San Gabriel Basin that allow remediation of parts of the basin to proceed with consistent, manageable, and discreet actions within the context of overall basinwide remedial planning. Operable units implemented to date or in the process of implementation are summarized below and are shown in Figure 1-3.

1.1.1.1 El Monte Mutuals

The Richwood Mutual operable unit was initiated as an Interim Remedial Measure (IRM) to respond to VOC contaminant levels greater than MCLs in the two Richwood supply wells. The Richwood remedial action consists of a granular activated carbon adsorption treatment system, with distribution of the treated water to the Mutual members.

Remedial actions was also planned for the Rurban Homes Mutual wells, located in the vicinity of the Richwood wells. Although initial sampling of water from these wells indicated contamination above MCLs, subsequent sampling prior to design of a treatment system revealed contamination had declined to within standards. Consequently, no action has been initiated at the Rurban Homes wells.

1.1.1.2 Suburban Water Systems

The Suburban Water Systems Bartolo Well Field Operable Unit Feasibility Study (OUFS) was completed in June 1988, and the EPA Record of Decision (ROD) was signed in September 1988 (EPA, 1988a, 1988b). The purpose of the operable unit at Suburban Water Systems' Bartolo Well Field is to avert a threat to the public health posed by rising concentrations of VOCs in the Bartolo Well

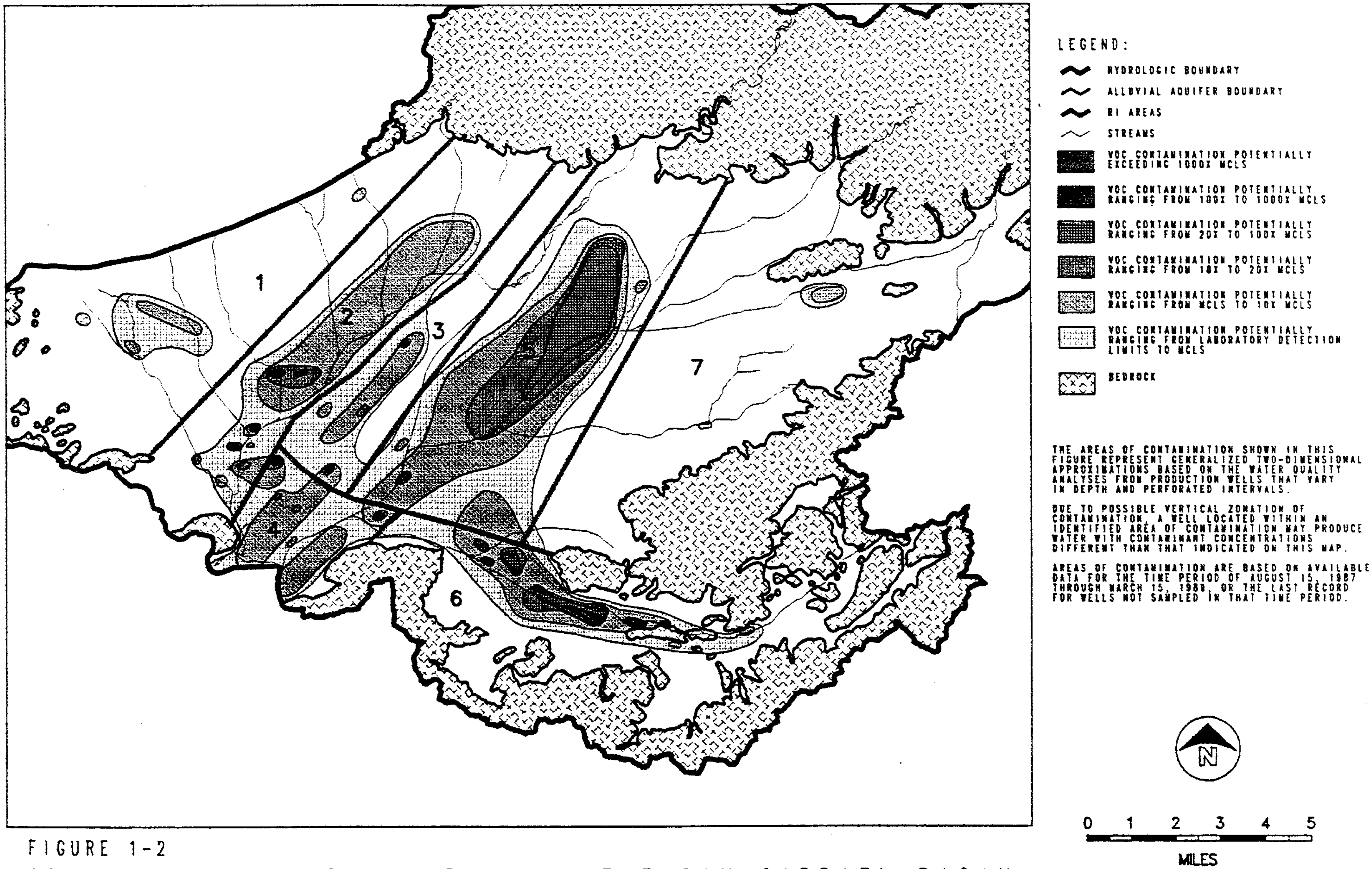

FIGURE 1-2

GROUNDWATER CONTAMINATION IN THE SAN GABRIEL BASIN

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San Gabriel Basin

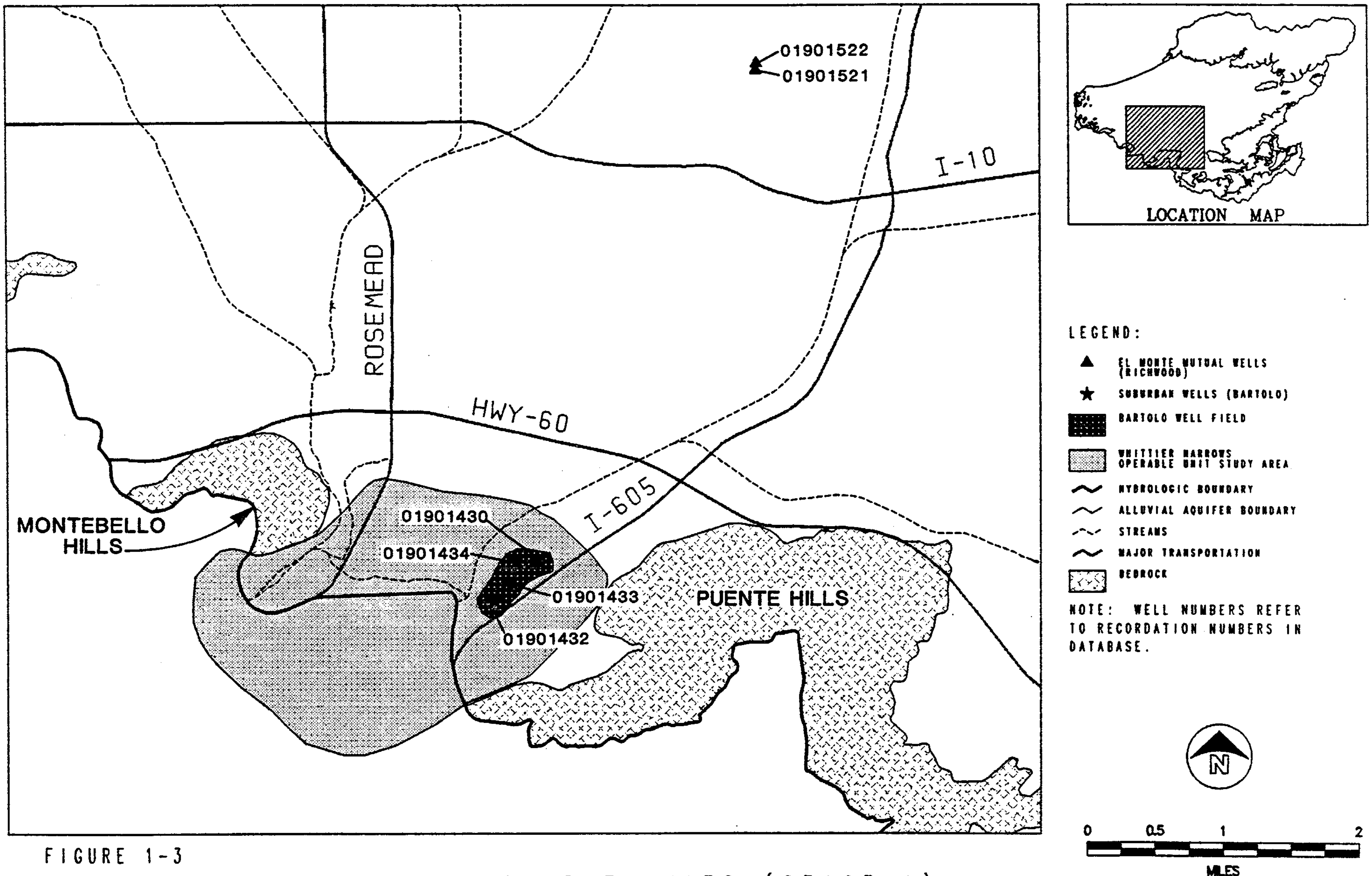


FIGURE 1-3

PREVIOUS AND ONGOING OPERABLE UNITS (STAGE 1)

Draft Basinwide Technical Plan
San Gabriel Basin

to the public health posed by rising concentrations of VOCs in the Bartolo Well Field water supply wells and to assist in the control of contaminant migration in the Whittier Narrows area. These wells are located in the Whittier Narrows flood control basin and within the Whittier Narrows area. The selected remedial alternative includes air stripping with carbon off-gas treatment for the four Bartolo wells, with disposition of the treated water directly to the Suburban water supply system. Design of the system is currently underway, with construction expected to start in early 1991.

1.1.1.3 Whittier Narrows

The purpose of the Whittier Narrows Operable Unit is to control interbasin contaminant migration from the San Gabriel Basin to the Central Basin (EPA, 1989a). The operable unit is located in Whittier Narrows, an approximately 1-and-1/2-mile-wide gap between the Puente Hills and the Montebello Hills (Figure 1-3). Whittier Narrows is the only area where significant groundwater and surface water outflow from the San Gabriel Basin occurs.

The Whittier Narrows OUFS identifies and evaluates a variety of potential remedial actions, including groundwater extraction, and treatment and disposition of the treated water (EPA, 1989a). Under the potential remedial actions, contaminant migration will be monitored and controlled by existing production wells, possibly augmented with new extraction wells. Potential treatment alternatives include air stripping, carbon adsorption, and ozone-peroxide oxidation. Treated groundwater may be discharged directly to existing domestic distribution systems, artificial recharge basins, injection wells, or a combination of these alternatives. The ROD selecting the remedy for the Whittier Narrows Operable Unit is expected to be signed within the next year.

1.1.1.4 Other Activities

Other operable-unit-related activities performed to date include an evaluation to determine if assistance to individual water purveyors would be appropriate to assure provision of adequate water supplies until basinwide groundwater contamination could be addressed. Based on preliminary groundwater modeling by EPA (1986a), 20 water purveyors in the San Gabriel Basin were identified whose water supplies were projected to be impacted in the near term by groundwater contamination. These water purveyors were informed of the modeling results and requested to provide additional information on their well operations, supply system, water supply quality, and potential impacts of reduced capacity. Eight purveyors responded to the request. An analysis of each of the eight purveyors need for EPA assistance was performed. The results of this analysis highlighted differences in the severity of contamination problems in different portions of the basin. These analyses will be described in Section 4.2.3, General Geographic Priorities.

1.1.2 BASINWIDE REMEDIAL INVESTIGATIONS

Remedial investigations in the San Gabriel Basin that are ongoing or have been completed to date include the following:

- Geologic, hydrogeologic, water quality, and groundwater pumping information was collected, compiled, and reviewed to develop a conceptual hydrogeologic model of the entire basin, described in the Supplemental Sampling Program (SSP) Report (EPA, 1986a). Investigations described in the SSP include a preliminary numerical model of groundwater flow in the basin. The results of the SSP investigations provided much of the basis for planning of the interim remedial investigations in the basin described below.

- An existing well monitoring program was developed and implemented to complement the efforts of the ongoing California Assembly Bill 1803 (AB 1803) sampling program. EPA performed four rounds of basinwide well sampling.

- Soil-gas sampling was undertaken in the vicinity of Whittier Narrows to identify potential source areas and evaluate the application of this technology elsewhere in the basin.

- A surface water sampling program was developed and implemented to assess the extent and magnitude of surface water contamination in the San Jose Creek and, to a lesser extent, Whittier Narrows. This sampling program also evaluated surface water-groundwater interactions and the potential for surface drainage systems to provide pathways for contaminant migration.

- Well logging and depth-specific sampling of seven production wells in Whittier Narrows were undertaken to better define the vertical distribution of contamination in the vicinity of existing wells.

- A review of about 1,000 lithologic logs from the entire basin was used to develop an enhanced understanding of the geology of the alluvial aquifer.

- An investigation of the types of surface water-groundwater interactions suspected to occur in the basin was undertaken to refine estimates of the magnitude of groundwater discharge to rivers and discharge from rivers to the water table.

- A calibrated numerical model of basinwide groundwater flow and contaminant migration was developed with the Coupled Fluid, Energy, and Solute Transport (CFEST) code. Additional modeling of advective flowpaths and solute transport was performed in support of the Whittier Narrows Operable Unit.

- o An existing well monitoring program was developed and performed in the Whittier Narrows area to specifically support the Whittier Narrows OUFS, and two rounds of sampling were performed throughout Whittier Narrows.

- o Two well clusters and one multiport well were constructed and sampled in the western portion of Whittier Narrows to support the Whittier Narrows OUFS (EPA, 1989a).

- o Well logging and depth-specific sampling were performed in the Azusa and Park Hills areas (RI Area 5 in Figure 1-1) in anticipation of future remedial activities.

The results of all RI activities performed after the SSP are summarized and interpreted in the Draft Report of Remedial Investigations (EPA, 1989b). Information from these investigations is used in this report where appropriate.

1.1.3 COST RECOVERY AND ENFORCEMENT ACTIONS

EPA, the State Water Resources Control Board (SWRCB), the Regional Water Quality Control Board (RWQCB), and California Department of Health Services (CDHS) are coordinating their efforts to identify and investigate contaminant sources. SWRCB and RWQCB will continue to identify potential source sites in their Well Investigation Program, and will coordinate their efforts with the location and timing of EPA's remedial actions. SWRCB and RWQCB conduct several other programs to investigate and regulate specific categories of potential sources. These programs include the Solid Waste Assessment Test (SWAT) program to investigate landfills, the Underground Storage Tank program to control past and current dischrages from underground tanks, and the Toxic Pits Cleanup Act program to regulate discharges from surface impoundments. CDHS and EPA will support source identification efforts through their existing Resource Conservation and Recovery Act (RCRA) Treatment, Storage, and Disposal (TSD) facility permitting and inspection programs. EPA has begun to compile data gathered during the RWQCB investigations into the basinwide data base and will use the data in support of enforcement and cost recovery actions with Potentially Responsible Parties (PRPs). In addition, EPA will continue to investigate historical sources of contamination through the use of historical areal photographs; searches of historical EPA, state, and local agency files; and information requests to companies that currently or historically operated within the valley. Activities to recover costs for previous and ongoing operable units, as well as future enforcement activities to support the actions described in this plan, are described in Section 4.2.4.

1.2 PURPOSE AND OBJECTIVES

The overall objective of this report is to present an incremental and sequential plan to address the problem of VOC contamination in groundwater throughout the San Gabriel Basin. An appraisal of the potential consequences of continuing present water management practices in the basin and not implementing remedial actions (Section 2.0) is followed by an assessment of the general approaches available to alleviate the contamination problem (Section 3.0). Specific remedial objectives, discussed in Section 4.0, include the following:

1. Remove contaminated groundwater
2. Control migration of contaminated groundwater
3. Protect natural resources
4. Maintain an adequate water supply
5. Prevent exposure of the public to contaminated groundwater

The plan will describe manageable, discrete actions that incorporate and integrate (1) operable- unit-based remedial actions, (2) remedial investigations, and (3) source investigation, cost recovery and enforcement actions. Given the uncertainty regarding the physical characteristics of the basin, including the lateral and vertical extent of contamination, the level of effort required to achieve many of these objectives cannot yet be determined. The sequential approach followed in the proposed plan allows initial actions that address less aggressive objectives to be followed by more comprehensive actions based on data acquired in the interim.

Investigations that have been undertaken in the basin are described in the Draft Report of Remedial Investigations (EPA, 1989b). The results of these investigations and implications regarding the continued spread of groundwater contamination form the basis of the strategic plan presented in this report.

1.2.1 INSTITUTIONAL CONSIDERATIONS

It is anticipated that funding for efforts to address groundwater contamination beyond those already initiated (including the Whittier Narrows Operable Unit) will be obtained through an enforcement-lead process. EPA has determined that the magnitude and complexity of the contamination problem in the basin requires a high level of long-term management and financial support: cooperation and resource commitments from federal, state, and local agencies and the local water community are essential. However, EPA has undertaken the initial basinwide investigation of the problem and has used the information gained from this investigation in the development of this technical plan and a Draft

Report of Remedial Investigations (EPA, 1989b). As such, these documents are intended to satisfy the objectives described below:

1. Outline a long-term technical approach to remediation of groundwater contamination in the San Gabriel Basin

2. Generally describe the apparent feasibility and duration of this undertaking

3. Describe the complexities of multiple-source, stratified zones of groundwater contaminated with a variety of contaminants above federal and state drinking water standards

4. Underscore the need to bring all institutional players together to provide the funds and managerial framework required to implement the actions described in this plan.

EPA actions beyond Stage I will be implemented within an "enforcement-lead" framework in which PRPs will be expected to provide funds required for remediation of contamination for which they are considered responsible. These PRPs will be identified through a series of technical and demographic investigations. In this report, these actions will be considered primarily in terms of their effects on the timing of implementation of remedial actions.

1.2.2 ENVIRONMENT OF MULTIPLE OBJECTIVES

Because of an incomplete understanding of hydrogeologic conditions and the vertical and horizontal extent of contamination within the San Gabriel Basin, the feasibility of attaining ambitious basinwide objectives, such as contaminant migration control or removal, cannot be determined in any but very approximate and uncertain terms. Thus, selection of a technical approach focused on a single objective and a related concentrated effort--for example, to contain migration, or, more simply, maintain an adequate supply of potable water--cannot be accomplished at this time.

The problem of groundwater contamination in the San Gabriel Basin is dynamic and continues to worsen with time. To obtain the information required to identify, evaluate, and select an ambitious basinwide remedial scheme might allow conditions to deteriorate and increase the difficulty of eventual remediation. However, an incremental operable-unit approach allows some actions to be initiated to provide a short-term measure of remediation by maintaining the supply of potable water and slowing the deterioration of conditions throughout the basin. Therefore, this basinwide plan offers a solution that is intended to accomplish the following purposes:

- Integrate actions designed to achieve a variety of objectives within

- a sequential and incremental framework, that permits

- initial implementation of actions and investigations that will produce results and data that allow subsequent implementation of more ambitious and aggressive remedial actions.

These potentially feasible, ambitious and aggressive actions will ultimately provide a satisfactory degree of containment and remove groundwater contaminants in the basin.

1.3 SCOPE AND APPROACH

The development of a strategy for remediation of a large and complex area of contaminated groundwater must be focused on the past and present factors that contributed to the current problem and must now play a part in its solution. Considerable effort has been expended in developing an understanding of the natural characteristics of the basin and in defining the extent of VOC contamination to the degree possible given the level of information available (EPA, 1989b). The first part of this report presents an evaluation of the effects of institutional factors on the groundwater system and an attempt to evaluate the possible results of allowing existing practices to continue without initiation of remedial location. This evaluation is followed by a description of issues requiring consideration of the timing of remedial actions that are then integrated into a composite strategy. A wide variety of potential remedial actions is subsequently identified along with associated remedial investigations. To properly evaluate the potential benefits of implementing these actions and estimate their relative cost-effectiveness, a series of evaluations is presented for a subset of representative potential operable units. Finally, the results of these evaluations are considered along with the composite strategy to identify the components of a long-range plan.

More specifically, the scope of work described in this report includes the following tasks:

- Evaluate the potential consequences of allowing existing groundwater contamination to continue to migrate without implementing actions to control or decrease the extent of contamination

- Identify a wide range of potential remedial actions

- Identify and prioritize remedial objectives, basinwide remedial investigation needs, cost recovery efforts, source control actions, and the needs of different portions of the basin, and develop an integrated basinwide strategy

- o Identify a subset of representative operable units from the larger list of potential remedial actions

- o Evaluate the potential effects of the representative subset of operable units on groundwater flow and contaminant migration

- o Estimate the potential implications of implementing the representative subset of operable units on existing water supply and distribution systems, and describe how potential problems may be reduced

- o Estimate the cost associated with the actions identified in the subset of representative operable units

- o Organize previously identified actions associated with remediation, remedial investigation, and cost recovery into a staged, long-term plan for basinwide remediation of VOC contamination in the San Gabriel Basin

It should be noted at the outset that the solution offered in this plan is designed to primarily address relatively deep groundwater contamination in the basin. This contamination has been characterized for the most part based on data from production wells and represents the largest portion of the threat to the drinking water supply in the basin. However, ongoing investigations near the surface of the basin continue to identify high-level contamination in the shallow portions of the aquifer. This shallow contamination, if allowed to migrate unchecked, will continue to contribute to contamination in the water-producing portions of the aquifer. Because of the relative infancy of source investigation efforts, it is premature to include near-surface actions at this time. Instead, these actions must be incorporated as additional information regarding the total extent of near-surface contamination becomes available. This information will be obtained during the course of implementing those actions described herein that address contamination throughout deeper portions of the aquifer.

2.0 EVALUATION OF POTENTIAL EFFECTS OF NO REMEDIAL ACTION

The direction and magnitude of groundwater flow and contaminant migration in the San Gabriel Basin are dominated by groundwater extraction. Thus, a modification of water resource management practices in the basin is important to minimizing the future migration of contaminants into presently uncontaminated areas. Continuation of these practices may aggravate the future migration of contaminants into presently uncontaminated areas. This section (1) reviews the circumstances which led to the current groundwater resource management structure within the San Gabriel Basin, (2) summarizes today's water management practices, (3) evaluates possible effects of continuing these practices, and (4) describes the need for a coordinated water quality management policy to control the spread of contamination in the basin.

2.1 DEVELOPMENT OF THE CURRENT WATER RESOURCE MANAGEMENT STRUCTURE

The current water resource management structure in the basin has been developed through the last half of this century and has had to respond to drastic changes in population and land use. The following section summarizes that development.

2.1.1 HISTORICAL USE AND MANAGEMENT OF WATER IN THE BASIN

World War II initiated a period of significant industrial and residential growth in the San Gabriel Valley, an area previously populated predominantly by citrus growers and other agricultural interests. Ranchers owned most of the original wells and water rights. As development increased, so did demands on the local groundwater and surface water resources. Mutual water companies were formed to serve residential needs. Water utilities were established when the demand grew even larger. The water resources were further stressed when the transition from septic tanks to centralized sewage treatment plants resulted in the export of water previously recharged into the groundwater basin.

By the 1950s, the population in the San Gabriel Valley grew to almost 750,000, and water interests in the Central Basin became concerned that the San Gabriel Basin consumption would begin to limit the groundwater and surface water flow through Whittier Narrows and, thus, affect the Central Basin water supply.

Two lawsuits related to water use in the San Gabriel Valley were settled in the 1960s and 1970s. The first, commonly known as the Long Beach Judgement, established an agreement in 1964 between the San Gabriel Basin and the Central Basin to assure that an average of 98,415 acre-feet of useable water would be delivered to the Central Basin each year. The San Gabriel River Watermaster was appointed to administer this interbasin agreement. The second judgement, entered in 1973, defined the intrabasin allocation of water rights in the San Gabriel Basin. The Main San Gabriel Basin Watermaster (Watermaster) was then established to administer this second agreement, which includes an assessment on those water purveyors who pump more than their annual allocation so that water can be imported for basin replenishment.

Thus, the degree of control over water use in the San Gabriel Valley evolved as development in the valley increased, and competition for the resource has become more keen. The San Gabriel groundwater basin is a significant resource for the valley, the Southern California region, and the State of California as a whole--as both a renewable drinking water resource for a population in excess of one million and as a natural underground water storage reservoir.

2.1.2 CURRENT WATER MANAGEMENT STRUCTURE

Day-to-day management of water in the San Gabriel Basin is a complex undertaking and involves a multitude of independent, yet loosely associated parties. The 2 watermasters, 3 municipal water districts, 45 water purveyors, and 105 individual water-right holders all play a role in managing the groundwater resource.

The three municipal water districts in the basin, which include the San Gabriel Valley Municipal Water District (SGVMWD), the Upper San Gabriel Valley Municipal Water District (USGVMWD), and the Three Valleys Municipal Water District (TVMWD), are shown in Figure 2-1. USGVMWD and TVMWD obtain water from the Metropolitan Water District of Southern California (MWD) to supplement local groundwater supplies. SGVMWD, which covers the four cities of Azusa, Alhambra, Monterey Park, and Sierra Madre, is not a member agency of MWD and, instead, contracts directly with the State Water Project to obtain a supplemental supply of imported water.

Of the water purveyors, some are investor-owned utilities, others are run by special districts or city governments, and still others are small mutual water companies. Figure 2-2 shows the service areas of the water purveyors. Joint decisionmaking occurs primarily through Watermaster or, more informally, through the Upper San Gabriel Valley Water Association. Other involved parties include MWD (a water wholesaler), the Los Angeles County Department of Public Works (LACDPW, formerly the Los Angeles County Flood Control District), and the Los Angeles Regional Water Quality Control Board with state-mandated water quality responsibilities.

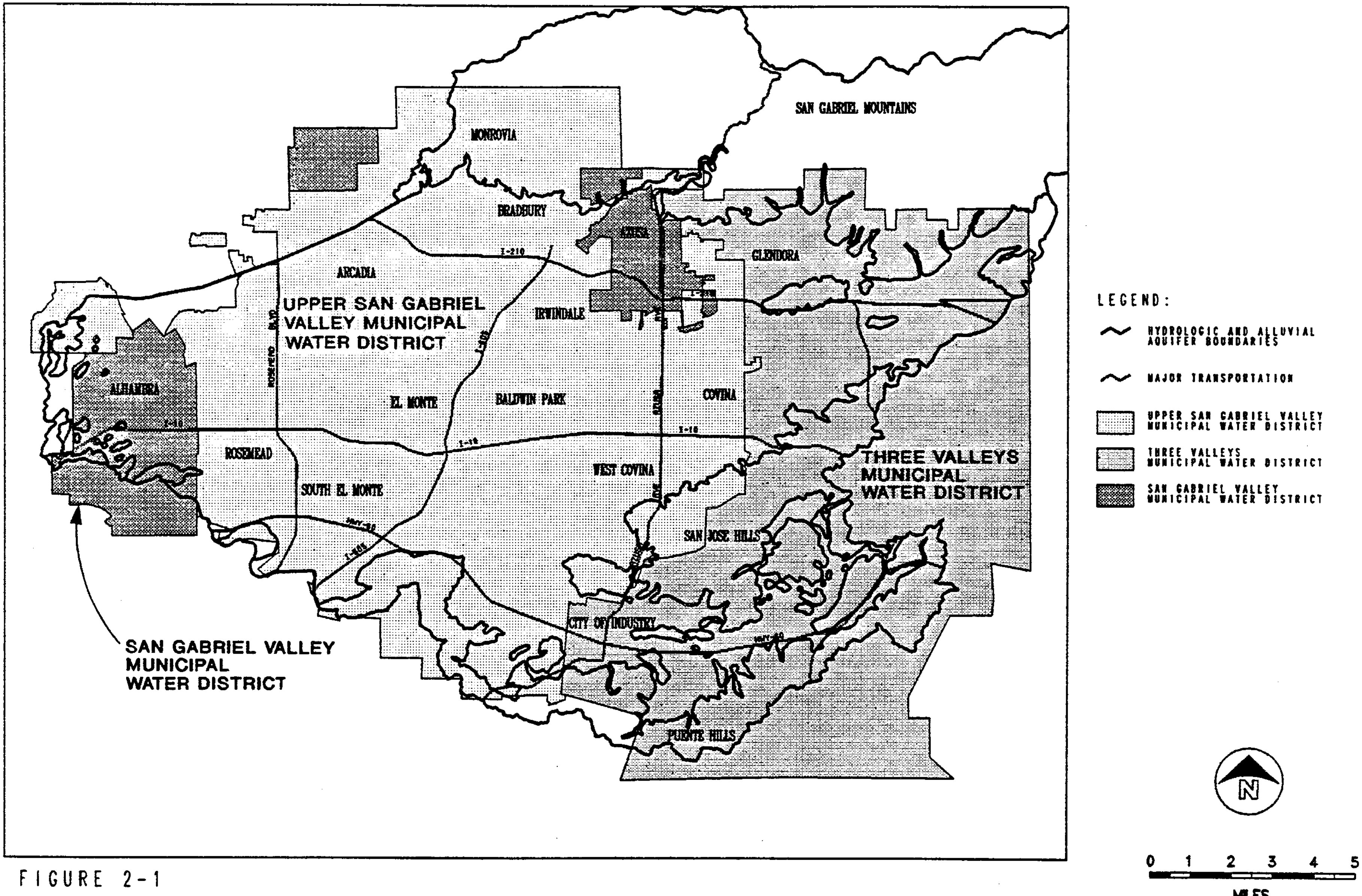


FIGURE 2-1
MUNICIPAL WATER DISTRICTS IN THE SAN GABRIEL BASIN

A four-party agreement was recently signed by Watermaster, SGVMWD, USGVMWD, and the Upper San Gabriel Valley Water Association. This agreement expresses an intention to establish Watermaster as the entity to coordinate local involvement in the federal, state, and regional efforts to preserve and restore the quality of groundwater within the Main San Gabriel Basin. However, funding, staff resources, and legal authorities for this effort have not yet been fully committed or adopted.

2.2 CURRENT WATER RESOURCE MANAGEMENT PRACTICES

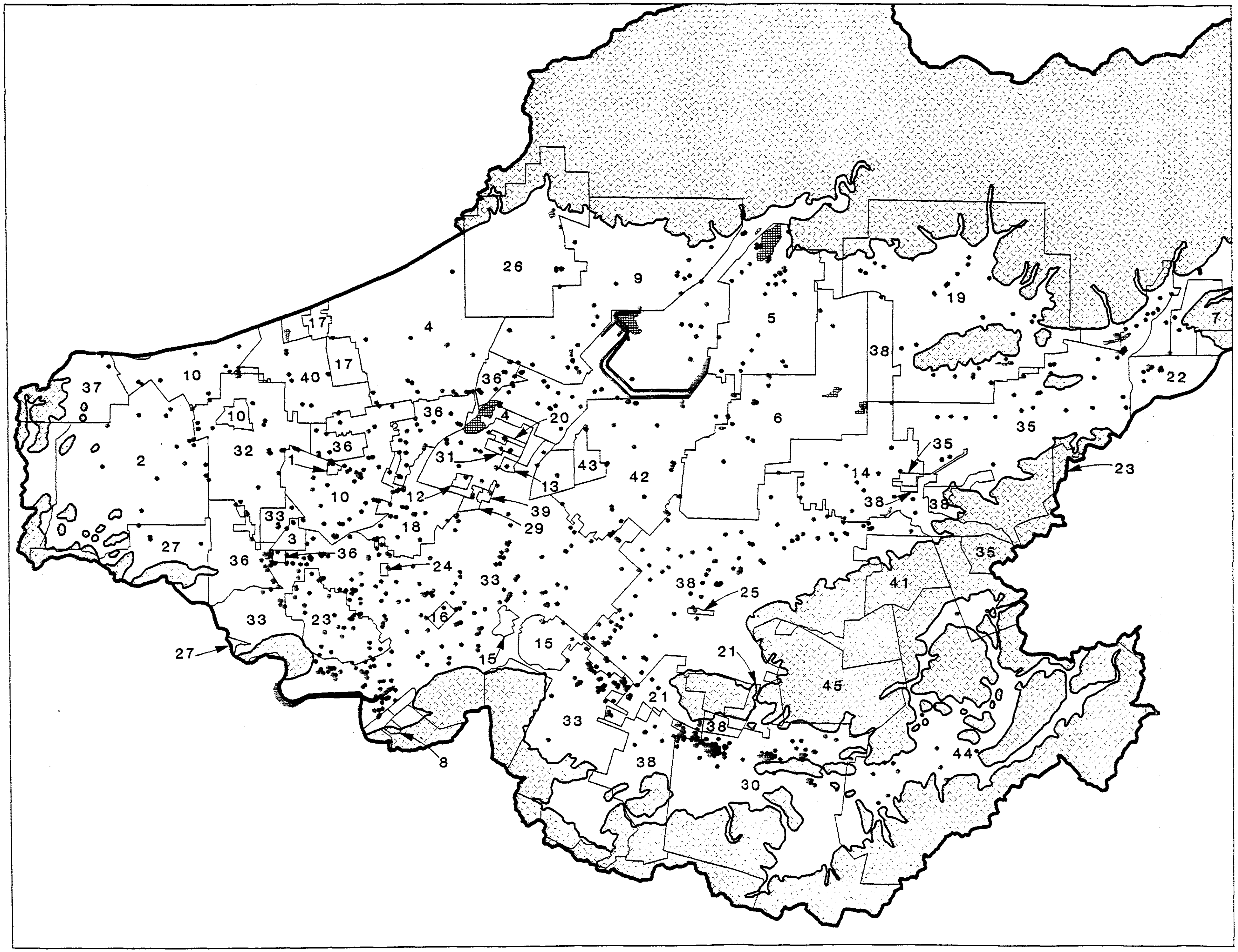
Current water resource management practices in the basin affect both water quantity and quality. The autonomy of the individual water purveyors and the infancy of the efforts to identify and control sources of contamination are key factors in understanding current management practices that affect water quantity and quality.

2.2.1 WATER QUANTITY MANAGEMENT

Water management within the San Gabriel Basin and between the San Gabriel Basin and the Central Basin is subject to the terms of the judgements in two court cases: Board of Water Commissioners of the City of Long Beach et al., vs San Gabriel Valley Water Company et al., Case Number 722647, Los Angeles County and Upper San Gabriel Valley Municipal Water District vs City of Alhambra, et al., Case Number 924128, Los Angeles County. In these judgements, the rights to water from the San Gabriel Basin for the Central Basin, the San Gabriel Basin, and users within the San Gabriel Basin are defined. The administrative bodies responsible for administering the judgements are also delineated.

The terms of the Long Beach Judgement involve a physical solution whereby the Lower Area is guaranteed an average annual useable supply of San Gabriel River water through Whittier Narrows. The useable water is comprised of three categories: (1) surface flow that passes through Whittier Narrows, (2) subsurface flow through Whittier Narrows, and (3) a portion of the exported water (water produced in the Upper Area and exported to the Lower Area by pipeline). The entitlement of water guaranteed annually varies from year to year, depending upon the previous 10-year average annual rainfall. When less than the guaranteed quantity of water is received by the Lower Area, the Upper Area is required to deliver makeup water to the Lower Area. The Long Beach Judgement also provides for a three-member, court-appointed Watermaster to administer the judgement (i.e., San Gabriel River Watermaster).

Watermaster was created to administer the terms of the second judgement. Watermaster establishes the Operating Safe Yield (OSY) in May of each year for



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MILES

LEGEND:

- HYDROLOGIC BOUNDARY
- ALLUVIAL AQUIFER BOUNDARY
- WATER PURVEYOR BOUNDARY
- DAM
- PRODUCTION WELL
- SPREADING BASIN
- BEDROCK

CODE	PRODUCER'S NAME
1	ADAMS RANCH MUTUAL WATER COMPANY
2	CITY OF ALHAMBRA
3	AMARILLO MUTUAL WATER COMPANY
4	CITY OF ARCADIA
5	CITY OF AZUZSA
6	AZUSA VALLEY WATER COMPANY
7	BASELINE WATER COMPANY
8	BEVERLY ACRES MUTUAL WATER COMPANY
9	CALIFORNIA-AMERICAN WATER COMPANY-DUARTE SYSTEM
10	CALIFORNIA-AMERICAN WATER COMPANY-SAN MARINO SYSTEM
11	CALIFORNIA DOMESTIC WATER COMPANY
12	CEDAR AVENUE MUTUAL WATER COMPANY
13	CHAMPION MUTUAL WATER COMPANY
14	CITY OF COVINA
15	CITY OF INDUSTRY WATERWORKS SYSTEM
16	DEL RIO MUTUAL WATER COMPANY
17	EAST PASADENA WATER COMPANY
18	CITY OF EL MONTE
19	CITY OF GLENDORA
20	HEMLOCK MUTUAL WATER COMPANY
21	LA PUENTE VALLEY COUNTY WATER DISTRICT
22	CITY OF LA VERNE
23	COUNTY OF LOS ANGELES
24	LOS FLORES MUTUAL WATER COMPANY
25	MAPLE WATER COMPANY
26	CITY OF MONROVIA
27	CITY OF MONTEREY PARK
28	CITY OF PASADENA
29	RICHWOOD MUTUAL WATER COMPANY
30	ROWLAND AREA COUNTY WATER DISTRICT
31	RURBAN HOMES MUTUAL WATER COMPANY
32	SAN GABRIEL COUNTY WATER DISTRICT
33	SAN GABRIEL VALLEY WATER COMPANY
34	CITY OF SIERRA MADRE
35	SOUTHERN CALIFORNIA WATER COMPANY-SAN DIMAS DISTRICT
36	SOUTHERN CALIF. WATER CO.-SAN GABRIEL VALLEY DISTRICT
37	CITY OF SOUTH PASADENA
38	SUBURBAN WATER SYSTEMS
39	STERLING MUTUAL WATER COMPANY
40	SUNNY SLOPE WATER COMPANY
41	VALENCIA HEIGHTS WATER COMPANY
42	VALLEY COUNTY WATER DISTRICT
43	VALLEY VIEW MUTUAL WATER COMPANY
44	WALNUT VALLEY WATER DISTRICT
45	CITY OF WEST COVINA

SOURCE: UNPUBLISHED MAP OF PURVEYOR DATA STETSON ENGINEERS INC., APRIL 1988.

FIGURE 2-2

PURVEYOR SERVICE AREAS

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San Gabriel Basin

the ensuing fiscal year and estimates OSYs for the following 4 years, based principally on natural water supply conditions. Prescriptive groundwater rights were adjudicated to the purveyors of the basin (i.e., all groundwater producers have an equal right to their share). This has resulted in a specific quantity in acre-feet appointed to each producer. Each year, producers are allowed to extract free of replacement water assessments their share of the OSY and other rights to extractions that they may have acquired. Any producer can extract all of the water needed for beneficial use, but the portion that exceeds his share of OSY is assessed a fee by the Watermaster at a rate that will purchase one acre-foot of imported supplemental water for each acre-foot of excess production.[1] The Watermaster uses the fee to contract with USGVMWD and SGVMWD to buy recharge water from MWD or the State Water Project to replenish the basin.

Purveyors can pump all the water required for beneficial use, as long as they comply with the provisions of the judgement. In the event Watermaster determines it desirable to restrict pumping in a specific area and force purveyors to procure water from another source in lieu of pumping, Watermaster will reimburse any associated cost differences.

To maintain water supplies during drought conditions and to save water during times of surplus, Watermaster also uses the basin as an underground storage reservoir. LACDPW operates several artificial recharge basins in the Valley (Figure 2-2). "Local" surface water from rains and snow melt is diverted into the recharge basins or this water is allowed to percolate through the San Gabriel River channel bottom. Imported replenishment water is also recharged at these sites. Watermaster is evaluating a plan that involves using reclaimed wastewater from the San Jose Reclamation Plant (near the confluence of San Jose Creek and San Gabriel River) as a source of replenishment water. An average of about 7,500 acre-feet per year could be pumped from the plant to the downstream edge of Santa Fe Dam and allowed to recharge through the San Gabriel River (Stetson, 1987).

In addition, Watermaster has cyclic storage agreements with USGVMWD/MWD and with SGVMWD. Currently, USGVMWD/MWD can store up to 142,000 acre-feet and SGVMWD can store up to 25,000 acre-feet at any one time. This saved water can be credited to future purchases of replenishment water. Recharge of imported water is limited, therefore, water levels do not get high enough to hamper gravel-quarry operations. Water levels monitored by LACDPW are used by Watermaster to establish the OSY for purveyor pumping and the locations where recharge of imported water can occur.

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[1]Purveyors may pump at any rate and at any location, subject to the terms of the judgement.

Existing cyclic storage practices are only intended to affect the use of water within the San Gabriel Valley. However, as a natural reservoir, the entire San Gabriel Basin has an extraordinary value to the entire Southern California water community. The ability to provide such a large volume of storage is a great asset to a region where seasonally varying demands are difficult to satisfy with the present erratic, unpredictable supplies. The economic benefits of natural storage in the San Gabriel Basin may be clearly illustrated by the comparative cost of building concrete reservoirs to equal this volume: more than 500 large (100-million-gallon or 307-acre-feet) concrete reservoirs would cost on the order of $10 million each.

MWD and USGVMWD are evaluating plans to increase the operating range of these cyclic storage programs. One plan involves increasing MWD's storage limit by about 400,000 acre-feet (although the feasibility of this is currently being evaluated) and installing new wells to pump out the stored water during drought. Under this conceptual plan, MWD would extract water for local use or export from the basin during drought years in an emergency, while providing surplus water for aquifer recharge during wet years when the supply of imported water is plentiful.

2.2.2 WATER QUALITY MANAGEMENT

EPA, CDHS, RWQCB, and individual water purveyors currently play large water quality management roles in the basin.

2.2.2.1 Regulatory Agencies

EPA's San Gabriel Superfund Project, since the listing of the four sites on the NPL in 1984, has focused on: (1) acting for the protection of public health (through interim remedial measures, such as Richwood - EPA, 1983), (2) containing the contamination within the basin at Whittier Narrows (EPA, 1989a), (3) continuing the field work needed to better define the nature and extent of contamination (EPA, 1989b), (4) integrating the data generated by CDHS' state-mandated water supply well sampling program (AB 1803) with the project data base, (5) working with State Water Resources (SWRCB) and RWQCB to identify and control potential sources of contamination, and (6) using the information created by these activities to develop and evaluate a basinwide strategy.

However, because of the San Gabriel Basin's size (almost 200 square miles); the unknown number of facilities that have contributed to contamination (probably hundreds); and the fact that some may still be contributing, identifying and controlling potential sources is a major effort. Identification, confirmation, and subsequent control of those sources is currently only in the beginning stages; technical, logistic, and legal complexities of these efforts will require years of continuous effort.

The projected effort needed to immediately identify sources, conduct negotiations with PRPs, and begin facility-specific investigations and remedial actions throughout the basin is beyond the staffing and funding currently available to the project from EPA and RWQCB. Moreover, it may require decades to complete this effort in all areas of the basin. Existing contaminant sources may, therefore, continue to contribute contamination into the groundwater basin for some time. New storage and handling regulations should lessen future contributions from new sources, but contaminants already below the surface, in either the unsaturated zone or below the water table, may continue to contribute to the overall groundwater problem. In fact, it is likely that a large percentage of the contamination already introduced into the aquifer has not yet been dissolved in the groundwater. Residual contaminants probably remain concentrated near their source, and pools of completely undissolved VOCs may continue to dissolve and increase groundwater contamination for an undefinable, though probably considerable, length of time. Subsurface or secondary sources of contamination of this type are discussed further in Section 2.3.4.3.

In addition to the magnitude of the VOC problem, nitrate contamination in groundwater represents a serious drinking water quality and supply problem. The nitrate contamination is probably largely due to agricultural practices in the valley. Such contamination, caused by the normal application of fertilizer, is not covered by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). In this plan, nitrates are assumed to be treated when encountered in wells at operable units to assure treated water complies with state and federal MCLs, but are not considered in the strategic approach to remediation of VOC contamination. However, a complimentary plan developed by state and local agencies to control nitrate contamination is considered essential. The extent of the current nitrate contamination will be summarized in Section 2.4, Nitrate Contamination, a more detailed evaluation of the historical and present nitrate contamination is contained in the Draft Report of Remedial Investigations (EPA, 1989b).

2.2.2.2 Purveyor Decision Making

During the last 10 years, the water purveyors of the San Gabriel Basin have successfully continued to provide an adequate supply of potable water to over a million people, despite the contamination. As their wells have become contaminated, these purveyors have responded in a variety of ways to remain in compliance with state and federal drinking water standards. Unfortunately, as the problem has worsened, individual actions by the numerous parties involved have not prevented the worsening of conditions basinwide, and require some incentive to do so in the future. In fact, as discussed below, these actions may be contributing to the spread of contamination. The reasons for this reflect each purveyor's efforts to remain in business and continue to service their clientele by dealing with contamination problems in the ways described below. Each purveyor acts to deal with different individual circumstances, including:

- o The imminence and seriousness of the contamination threat to their wells
- o Their financial capability to invest in treatment, connections to alternate sources, or new wells
- o Legal or political access to alternative water supplies

To meet his short-term needs, and to meet his obligations to his water consumers, the individual chooses the most cost-effective of the following alternatives:

- o Blending contaminated water with water from other wells such that the blended water remains within standards
- o Shutting down contaminated wells
- o Developing new wells in clean areas of the basin or in deeper parts of the aquifer
- o Buying supplemental water supplies from outside the basin or from purveyors not yet affected by the contamination
- o Installing some form of treatment system for pumped water

Although each of these options may provide an immediate source of potable water, only treatment provides a long-term solution to the purveyors' problems; however,s none of these options provide a solution to the basinwide contamination problem. Blending, for example, is only feasible while the water is not contaminated substantially above MCLs. Treatment in of itself, on the other hand, will not ensure that the portions of the aquifer from which water below MCLs is currently produced remains uncontaminated. Shutting down contaminated wells and either installing new ones in uncontaminated areas or purchasing imported water is likely to decrease containment of contamination in that area; installing new wells may extend areas of contamination into previously uncontaminated areas.

The purveyor's choices may also be made independently from a consideration of how his action will contribute to or conflict with basinwide remediation objectives. The purveyors frequently decide to either (1) develop new wells, which can result in "pulling" the contamination toward areas or zones that may previously have been "clean" or (2) pump from greater depths, which can have the same effect. Figure 2-3 shows the locations of wells whose pumping in 1987 changed by more than 1,000 gallons per minute (gpm)--or about 1,600 acre-feet per year--compared with pumping in 1978, the year before VOCs were first detected in water supply wells. Purveyors apparently stopped pumping from several wells within the areas of contamination and increased pumping from wells located on the edges of the contaminated areas. Figure 2-4 shows the trend toward pumping from deeper parts of the alluvial aquifer. The pumping from wells with screened intervals below 400 feet has increased from 36 percent of basinwide pumping in 1978 to 51 percent in 1987. In addition, purveyors increased the amount of pumping from wells deeper than 1,000 feet from less than 2 percent of basinwide pumping in 1978 to over 5 percent in 1987--an increase of about 200 percent.

Any efforts to affect the migration of contaminants must include measures to control and manage the location and rate of pumping on a basinwide scale. To this end, financial or regulatory incentives may be required to influence the decisions of individual purveyors.

Section 2.3, Possible Effects of Continuing Current Water Resource management Practices, discusses the possible effects, on regional and local scales, of these changes in purveyor pumping during (1) the last 10 years, and (2) the future potential effects should these water quality management practices continue.

2.2.2.3 Existing Water Quality Management Issues

The San Gabriel water purveyors have, to date, successfully dealt with rapid changes in their environments and service areas and the rapidly worsening contamination problem. This has been accomplished through various independent actions that have managed to maintain adequate supplies of potable water throughout the basin. However, independent actions by the purveyors provide short-term solutions that do not address the basinwide problem; coordinated efforts are now required to assure that adequate supplies of water will continue to be available and to allow the basin to play a part in the larger scale management of the future water resources of Southern California.

In addition to basinwide coordination of water purveyors, extensive resources are required to identify and control the possible sources of contamination. Figure 2-5 shows the commercial and industrial areas of the San Gabriel Valley. The potential sources of contamination within these areas are numerous: possibly thousands of both abandoned and currently operating facilities. These many above ground and associated below ground sources may still be leaking contamination into the groundwater basin. Because the number of potential sources is great, the resources required to adequately address this problem are beyond those of any of the current water quality managers.

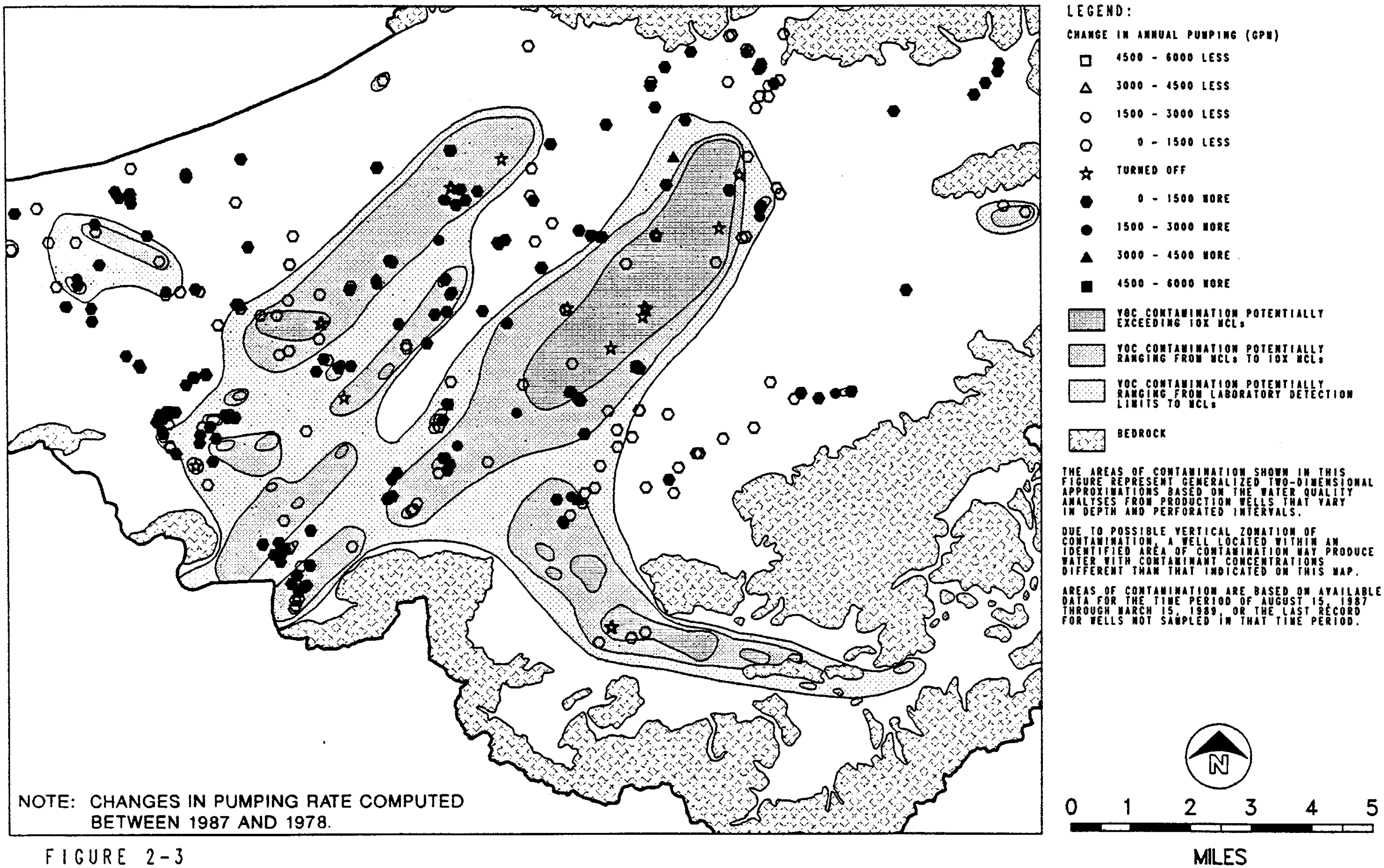


FIGURE 2-3

RECENT CHANGES IN PUMPING RATE AT PRODUCTION WELLS

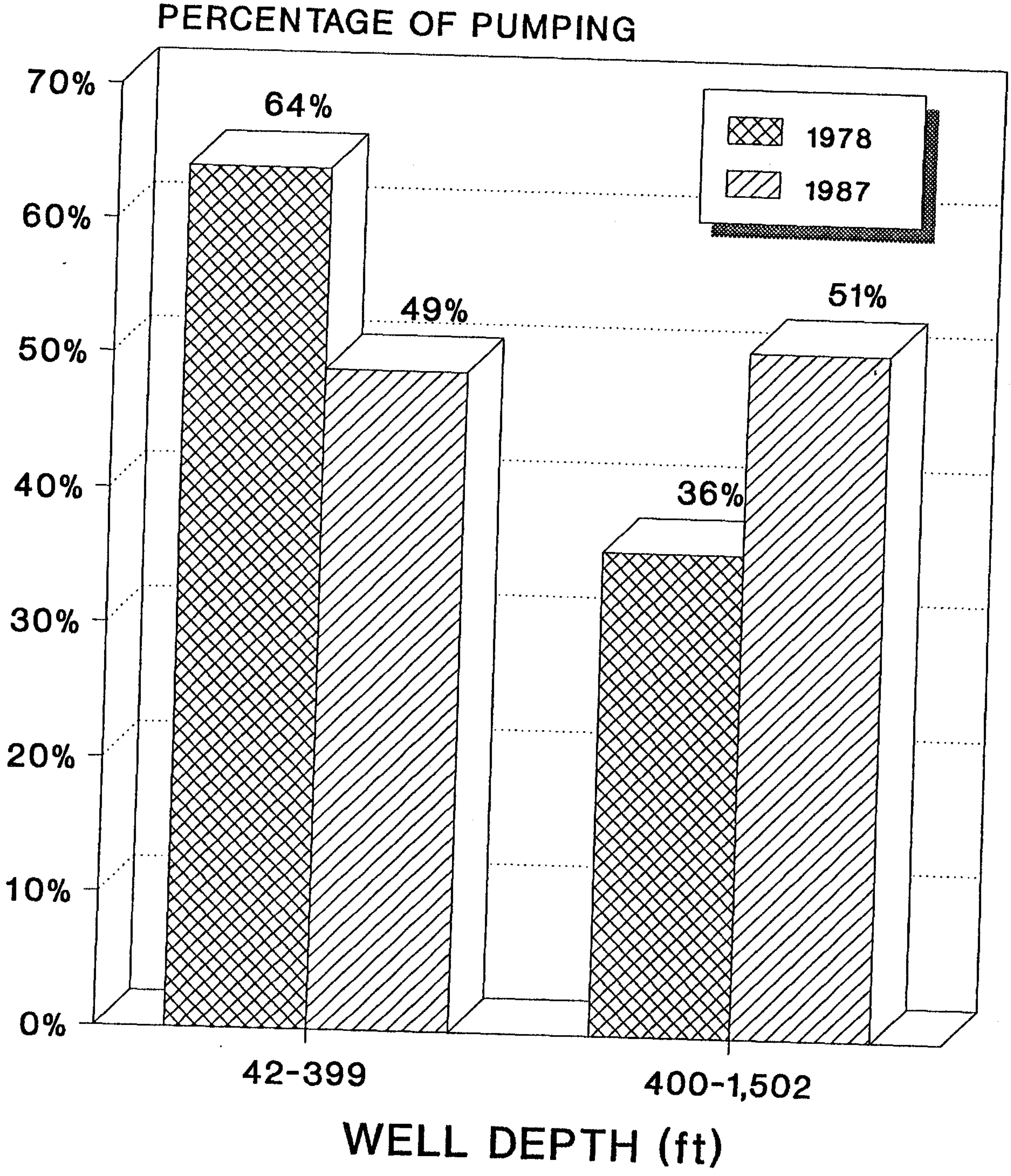


FIGURE 2-4
CHANGING PUMPING PATTERNS
DRAFT BASINWIDE TECHNICAL PLAN
SAN GABRIEL BASIN

F:\FIGURES\LA062440.TP\FIG2-4.DWG 01/09/90

A necessary step toward solving these problems will be the institution of a central entity to coordinate actions between the multitude of individual organizations involved. Support for these efforts will be provided through the cooperation of federal, state, and local organizations. This plan provides for both the technical basis for establishing the appropriate institutional structure, and the opportunity to bring the numerous players together. EPA and involved state and local agencies have already initiated discussions concerning the institutional and funding issues associated with establishing coordinated basinwide water quality management.

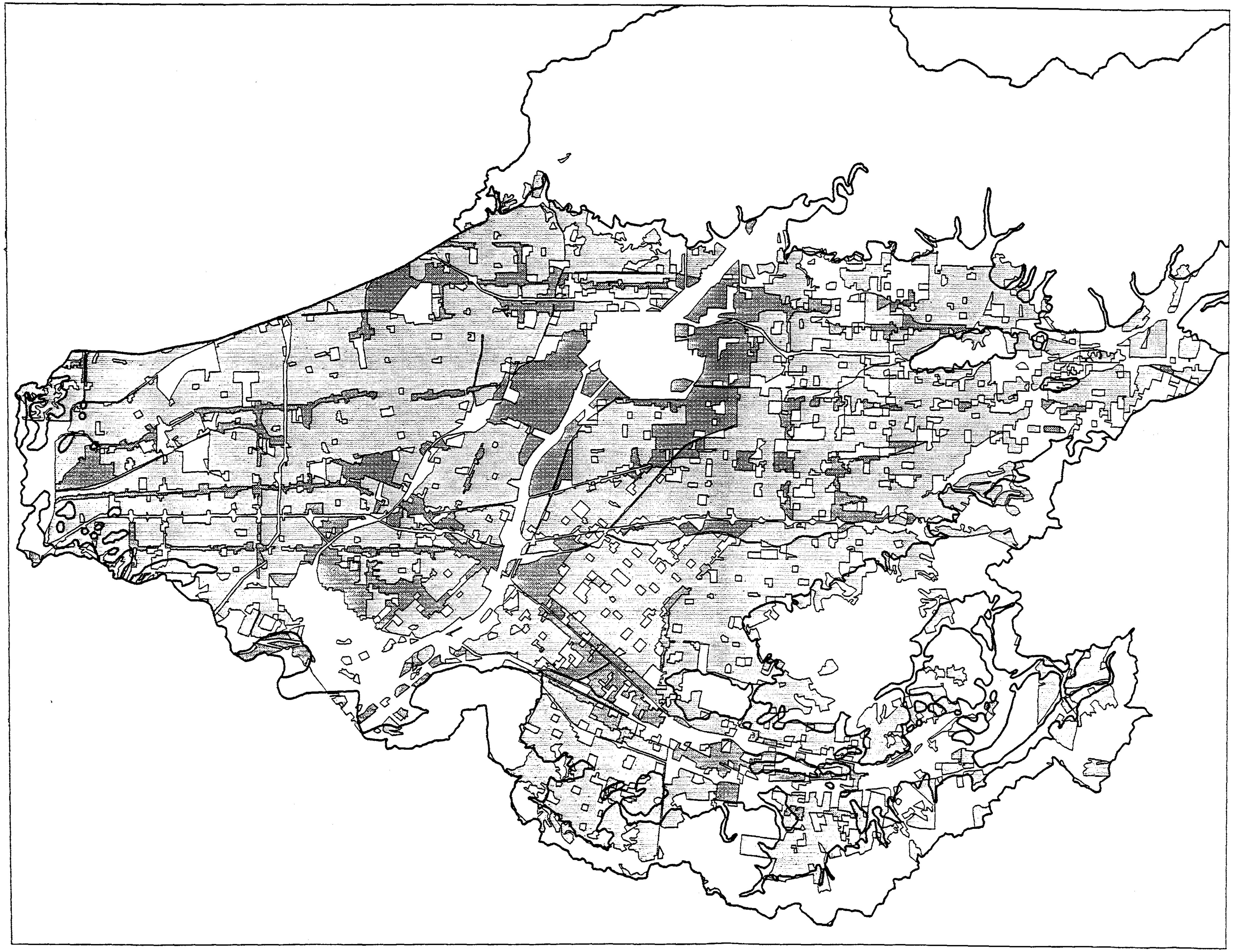
2.3 POSSIBLE EFFECTS OF NOT IMPLEMENTING REMEDIAL ACTIONS

This section presents an assessment of the magnitude of the effects of current water resource management practices on the extent of contamination in the San Gabriel Basin. This assessment includes: (1) a review of the technical approach and limitations of the analyses, (2) an estimate of the possible increase in the extent of contamination between 1979 and 1989 attributable to water management practices, (3) an evaluation of the extent of potential contamination in 1999 and 2009 if current practices continue, and (4) a description of other consequences of not controlling contaminant migration in the basin.

2.3.1 TECHNICAL APPROACH

The regional effects of continuing existing practices have been estimated using a three-dimensional numerical model of groundwater flow and transport (EPA, 1989b). To test the ability of the model to reproduce natural conditions of contaminant migration in the basin, simulations of contaminant transport over the last 9 years were compared with observed conditions in the basin. This procedure involved defining "sources" of continued contaminant introduction, as well as interpretations of the extent of magnitude of contamination in 1980. Calibration of the model using assumptions of this kind is discussed more fully in Appendix C, along with the evaluations of potential operable units, and is briefly summarized below.

There are numerous parameters that require definition in a model of this type and sophistication. These include numbers that both define the physical characteristics of the aquifer as well as the nature and extent of contamination. To simulate the response of the groundwater system to changes in the inflow and outflow of water over the last 9 years, these parameters were iteratively varied until the results of the numerical model were in agreement with what has been observed. However, conditions of groundwater contamination in 1980 are not completely known, and the characteristics of the aquifer are only known in the immediate vicinity of wells at which measurements have been taken. Despite the combination of parameters used in the model are not considered



N

0 1 2 3 4 5

MILES

LEGEND:

HYDROLOGIC AND ALLUVIAL AQUIFER BOUNDARIES

COMMERCIAL AND INDUSTRIAL

RESIDENTIAL

AGRICULTURAL, OPEN, AND UNCLASSIFIED

Data originally compiled from 1978-1980 Southern California Edison Land Use Inventory.

SUMMARY OF 1978-1980
LAND USE DATA:

TYPE	PERCENT
AGRICULTURE	2.5
COMMERCIAL	3.6
INDUSTRIAL	5.8
OPEN	43.5
RESIDENTIAL	34.2
UNCLASSIFIED	10.2
WATER	0.2

FIGURE 2-5

GENERALIZED LAND USE

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completely accurate, the fact that the model can reproduce what is known of the historical behavior of the groundwater system suggests it is a reasonable tool with which to estimate the response of the system to different pumping patterns. Consequently, it has been used to analyze the effects of various real and hypothetical pumping scenarios, including estimates of: (1) the extent of contaminant migration between 1980 and 1989, (2) how much the purveyors' water quality management practices may have exacerbated the problem, and (3) the possible extent of contamination in 1999 and 2009 if no remedial actions are implemented. In later sections, the model will be used to evaluate potential remedial actions.

2.3.2 POSSIBLE EFFECTS OF EXISTING MANAGEMENT PRACTICES (1980-1989)

Model results suggest that the areal extent of contamination may have increased by 9 square miles since 1980 and that 40 wells may have become contaminated above MCLs. These results are based on the actual pumping records for that period. However, it is illustrative to examine what the current situation might be if pumping patterns had been otherwise.

Figure 2-6 shows what the areal extent of contamination might have looked like in a portion of the basin in 1989 if the 1977-1980 pumping patterns had remained in effect through 1989, i.e., if purveyors had not shut down contaminated wells and started pumping near the peripheries of the contaminated areas. The figure also shows new wells drilled or turned on between 1980 and 1982. New pumping in the southeast part of Area 5, north of the mouth of Puente Valley, apparently accelerated the movement of the Puente Valley contaminants out of the valley. The new pumping in the south-central part of Area 5 also appears to have limited the downgradient migration of the above-MCL contamination.

On a regional scale however, these practices may have increased the areal extent of contamination by one square mile, over 10 percent of the total increase in the extent of contamination thought to have occurred since 1980. Although this is a small increase relative to the areal extent of above-MCL contamination throughout the basin, if these practices continue for the next several decades, the effects may become more pronounced.

The degree to which the continued pumping of wells in Area 5 would have affected the amount of contamination presently in the groundwater can be more simply estimated based on the capacity of the wells and the concentrations of contaminants surrounding them. These data are used in Appendix A to estimate the potential for contaminant withdrawal at wells throughout the basin (Table A-1). Over 17,000 pounds per year could have been withdrawn by only nine of the wells in the area. If it is assumed that they were all shut down at the same time in 1983, well over 100,000 pounds (about 51 tons) of contaminants would have been removed if these wells had been pumped throughout the intervening time.

The ability to recognize the effects of historical water management practices--as well as those of most other factors affecting groundwater flow--on the migration of contaminants has been developed to a large degree on the basis of data compiled and investigations performed in recent years. Ten years ago, there were no such tools with which to foresee the effects of changes in pumping patterns. It is the current level of understanding of groundwater conditions that has allowed a reevaluation of historical conditions and the development of this Basinwide Plan.

2.3.3 POSSIBLE EFFECTS OF NOT IMPLEMENTING REMEDIAL ACTIONS (1989-2009)

Starting with the interpreted extent of contamination in 1989, shown in Figure 1-2, the model has been used to simulate contaminant transport for 20 years using the same flow fields and the same sources assumed for the 1980-1989 period. Figures 2-7 and 2-8 show what the extent of shallow and deep contamination, may be respectively in 1999 if the existing pumping patterns are allowed to continue. The limited number of continuing sources of contamination in this simulation causes the higher levels of contamination to decrease as the mass of contaminants in these areas spreads out vertically and horizontally. However, the above-MCL area may increase by about 15 square miles; and an additional 40 to 50 wells might be located in areas above MCLs within the next 10 years.

Because of the limited number of very deep wells and the correspondingly poor understanding of present conditions at depth, initial conditions in the model do not include substantial contamination in the deeper portions of the basin. Nonetheless, the simulated future conditions indicate considerable contamination at depths greater than 1,000 feet (Figure 2-7) in only 10 years. Without any form of groundwater extraction at depth, contamination can be expected to continue to accumulate at depth and affect the rest of the aquifer.

Figures 2-7 and 2-8 show what the extent of shallow and deep contamination may be in 2009 if the existing pumping patterns continue. The area above MCLs in the upper portion of the aquifer may be about 62 square miles in 2009. An additional 15 to 20 wells may then be above MCLs. Concentrations over 10 to 20 times MCLs will probably have reached the pumping center north of Puente Valley. According to the model, contamination at depth (Figure 2-8)

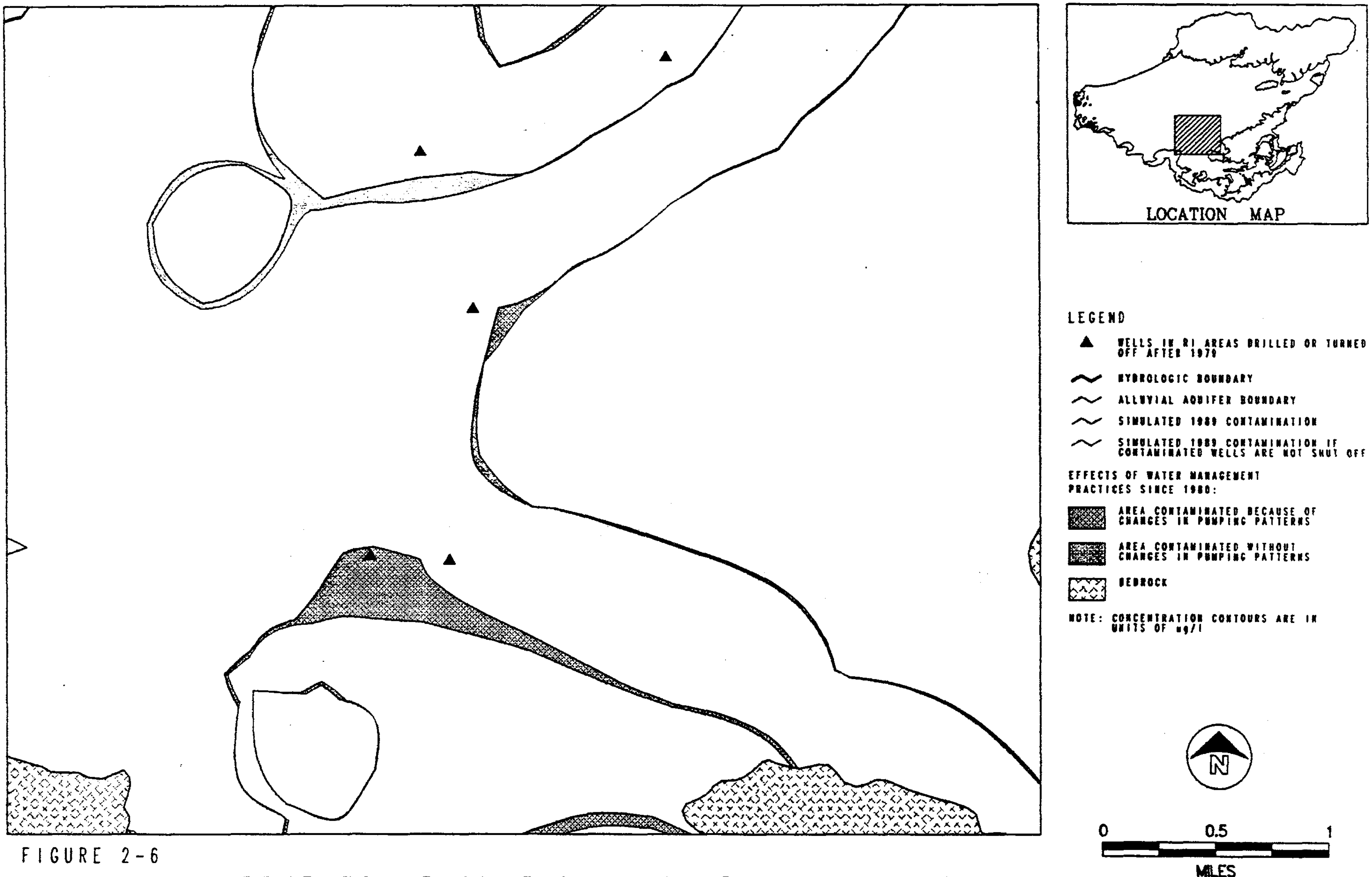

FIGURE 2-6

EXAMPLE OF EFFECTS OF SHUT-DOWN CONTAMINATED WELLS

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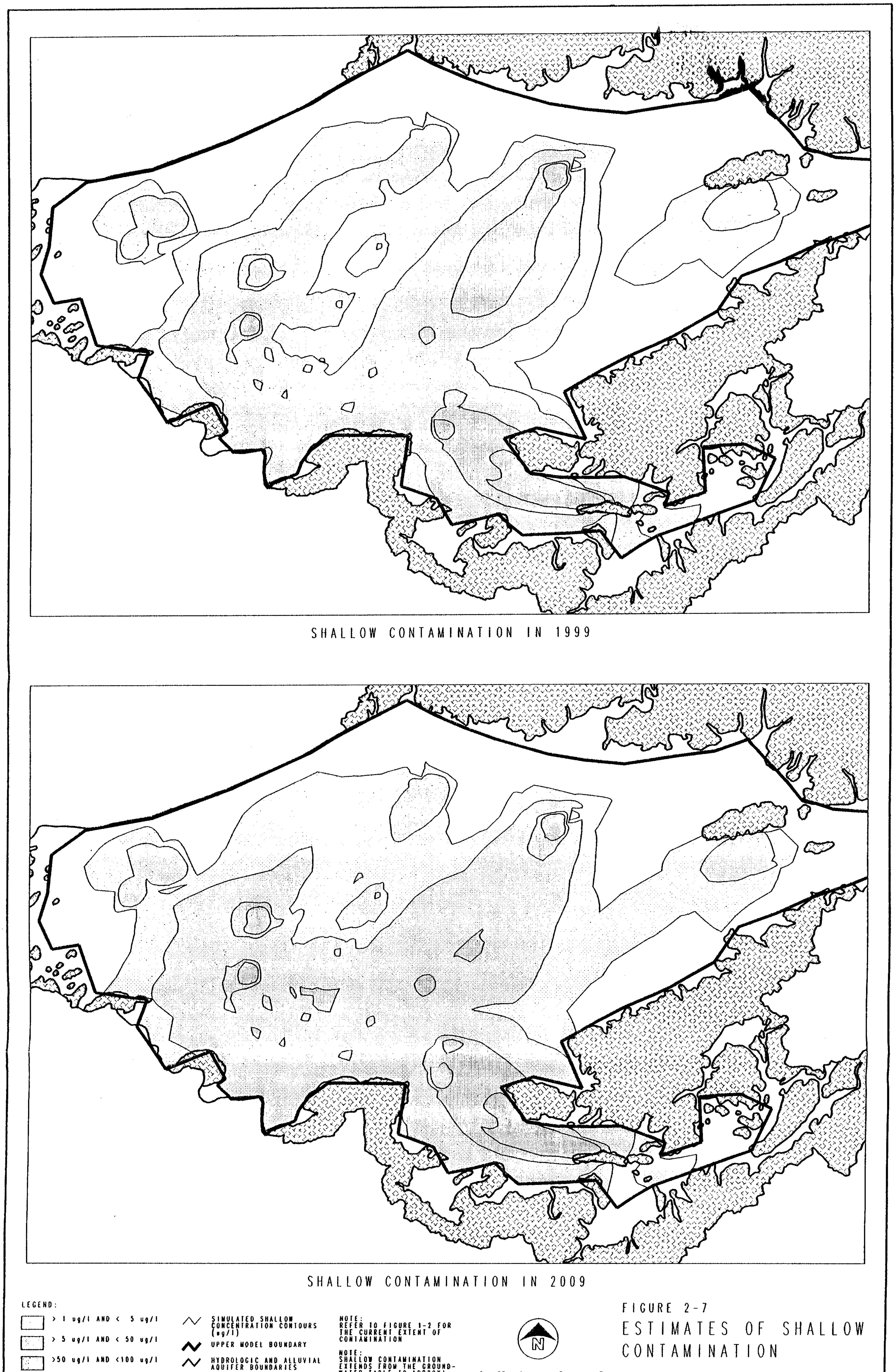

FIGURE 2-7
ESTIMATES OF SHALLOW CONTAMINATION

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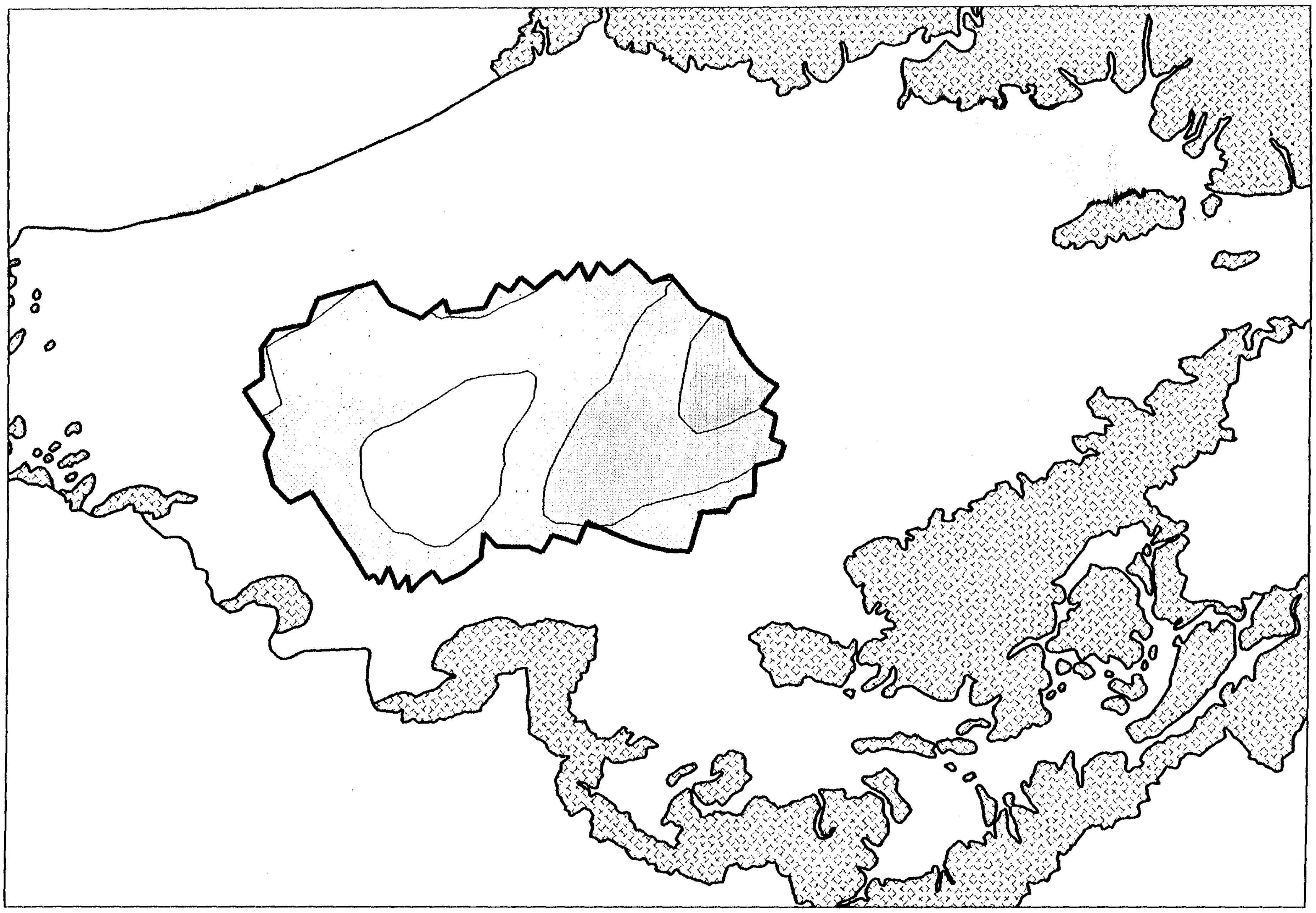
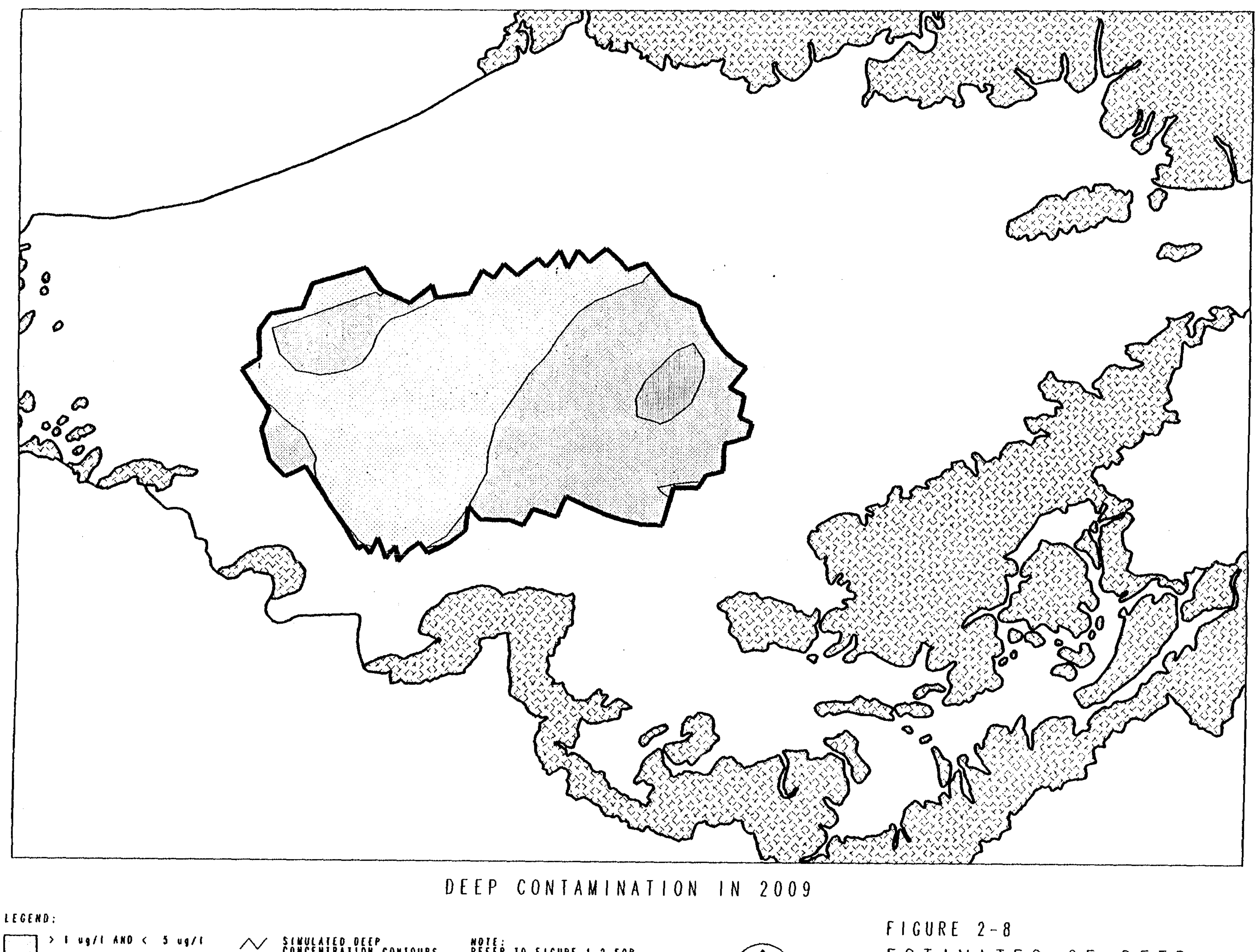
San Gabriel Basin



DEEP CONTAMINATION IN 1999



DEEP CONTAMINATION IN 2009

LEGEND:

- > 1 ug/l AND < 5 ug/l
- > 5 ug/l AND < 50 ug/l
- >50 ug/l AND <100 ug/l
- >100 ug/l
- SIMULATED DEEP CONCENTRATION CONTOURS (ug/l)
- LAYER 4 MODEL BOUNDARY
- HYDROLOGIC AND ALLUVIAL AQUIFER BOUNDARIES
- BEDROCK

NOTE:
REFER TO FIGURE 1-2 FOR THE CURRENT EXTENT OF CONTAMINATION

NOTE:
DEEP CONTAMINATION EXTENDS FROM APPROXIMATELY 1000 FEET TO 1400 FEET BELOW THE WATER TABLE.

0 0.5 1 2 3
MILES

FIGURE 2-8
ESTIMATES OF DEEP CONTAMINATION

Draft Technical Basinwide Plan
San Gabriel Basin

will have exceeded MCLs throughout almost all of the deep portion of the aquifer in 20 years.

Several factors suggest that the results of these simulations may be conservative estimates of what may actually occur if existing practices continue. For example, the practice of relocating pumping to the peripheries of the spreading contaminated areas will accelerate the migration of contaminants into uncontaminated areas. The model presently assumes that pumping patterns observed over the last 10 years will continue unchanged into the future. Model results are also limited by the relatively small number of continuing sources of contamination.

As explained in Appendix C, sources were incorporated into the model at nodes (representing discrete areas) in a manner consistent with the reconstruction of present conditions based on assumed conditions in 1980. The resulting distribution of source nodes in the model should be considered to represent the minimum required; it is considered likely that additional sources of contamination--both direct sources at the surface and residual sources in the subsurface--are more abundant in the natural system than in the numerical model.

2.3.4 OTHER POSSIBLE CONSEQUENCES OF NOT IMPLEMENTING REMEDIAL ACTIONS

Other possible consequences of continuing the existing practices include: (1) increasing the cost of expanded cyclic storage programs, (2) allowing the subsurface VOC contamination to degrade to more toxic breakdown products, (3) allowing more VOCs to enter the groundwater system through unidentified and uncontrolled sources, and (4) increasing amounts of VOCs moving through other pathways (e.g., discharging to surface water or gas-phase diffusion through the unsaturated zone and conceivably to the surface) (Ziemba, 1988). These potential consequences are discussed below.

2.3.4.1 Increasing the Cost of Expanded Cyclic Storage Programs

Without an aggressive, coordinated effort to contain migration within the basin, over the next few decades the extent of contaminant migration may be similar to the estimates shown in Figures 2-7 and 2-8. Under such circumstances, USGVMWD, SGVMWD, and MWD might find cyclic storage or conjunctive use a less attractive alternative because of the increased cost of treating the stored water before it can be used as an additional supply of water. Alternatively, the degree to which the basin's storage capacity is utilized, is decreased as the cost of stored water increases because of the need for treatment. For example, additional use of the basin's storage capacity to meet infrequent "peak" demands for water supply may become less economical if extraction and use of the water requires large capital investment in treatment facilities that would be used infrequently. In addition to the complication of more widespread areal contamination, the rising groundwater levels caused by expanded recharge operations could dissolve residual-VOC contamination in the unsaturated zone above the water table, thereby increasing concentrations of VOCs in the groundwater.

As discussed in Section 2.2, USGVMWD, SGVMWD, and MWD currently have agreements to store up to 167,000 acre-feet in the basin and are evaluating the feasibility of almost doubling this amount. This option would create large water storage to meet peak demands and for emergency situations in which alternative sources are cut off. In addition to saving the cost of building storage ($10 million for 1/500th of the cyclic storage agreement), this option could make developing additional supplies for Southern California unnecessary. This represents a tremendous potential savings. Based on MWD's current prices for a noninterruptible supply of treated water, the cost of replacing a 200,000 acre-foot resource (assuming that it could be found) might be on the order of $46 million per year. Additionally, the potential savings related to adverse impacts to the environment elsewhere, that might result from providing this alternate source of water, is incalculable.

2.3.4.2 Toxic Breakdown Products

A considerable and growing body of scientific literature suggests that VOCs such as trichloroethylene (TCE), tetrachloroethylene (PCE), and carbon tetrachloride (CTC) may by transformed in soil and groundwater by biologic and chemical processes. Degradation products from PCE and TCE include 1,1-dichloroethylene (1,1-DCE), cis-1,2-dichloroethylene (cis-1,2-DCE), trans-1,2-dichloroethylene (trans-1,2-DCE), and vinyl chloride (VC). CTC breakdown products may include chloroform and carbon dioxide. VOC degradation is discussed in more detail in the Draft Report of Remedial Investigations (EPA, 1989b).

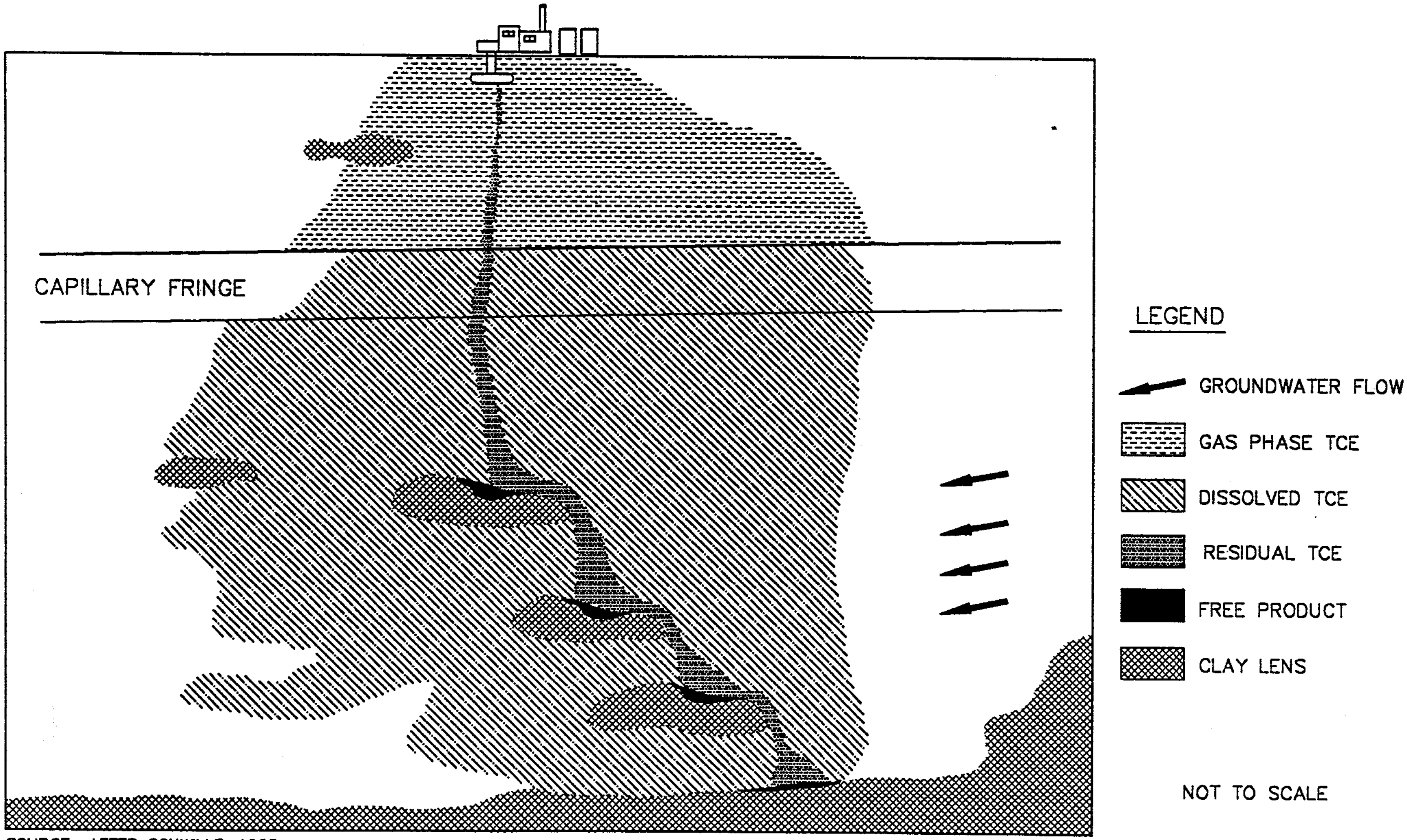
The possible degradation of PCE and TCE to vinyl chloride is significant because: (1) VC is known to be a human carcinogen, but TCE and PCE are only considered probable human carcinogens because the weight of evidence is not as strong and (2) based on oral cancer potency factors, EPA considers VC to be over 200 times more potent a carcinogen than TCE and about 45 times more potent than PCE (EPA, 1989b). The presence and rate of TCE and PCE degradation to VC depends on factors such as the presence or absence of certain types of microbes, nutrients, and competing substrate. However, Sampling of water supply and monitoring wells in the basin indicates the breakdown products listed above are already present in the San Gabriel aquifer.

VC was found in three water supply wells at levels of up to 19 micrograms per liter (ug/l) (the state MCL for VC is 0.5 ug/l). If the VC in these wells comes from degradation of parent products, VC may become more widespread in the future. This will increase the risk to public health associated with groundwater contamination and complicate treatment of contaminated groundwater (because of the difficulty in controlling air emissions associated with treatment of VC-contaminated groundwater). In addition, because the state MCL is an order of magnitude less than that for TCE and PCE, additional wells may exceed MCLs as degradation occurs.

2.3.4.3 Possible Effects of Unidentified and Uncontrolled Sources

In Section 2.3, the magnitude of the efforts needed to identify and control sources of contamination was reviewed. Modeling results suggest that if only a few sources persist, the high concentrations of contamination may decline, although the areal extent of above-MCL contamination will probably continue to increase. However, the chemical parameters that determine behavior of VOC's in the subsurface suggest that VOC contaminants in the subsurface can continue to act as sources of aqueous phase contamination in groundwater for years or even decades (EPA, 1989b). This is illustrated as follows.

Figure 2-9 illustrates a hypothetical leak of TCE from an underground storage tank. The liquid TCE flows downward, under the influence of gravity. As it drops through the unsaturated zone, some of the TCE may be left behind and sorbed to the aquifer material. This is called residual contamination. Meanwhile, from this liquid subsurface source, gas phase TCE may spread horizontally through the unsaturated zone by gaseous diffusion, thereby a vapor cloud that decreases in concentration away from the spill. If enough TCE is spilled overcome the retention capacity of the soil, the stream of free product may continue to the water table, still leaving a trail of residual contamination behind. Just above the water table, at the capillary fringe, TCE may be detained because of the differences in surface tension between TCE and water. If enough TCE is spilled to overcome this barrier, the free product may move into the saturated zone and sink (because the density of TCE is greater than the density of water), thereby leaving a small amount of residual behind. Upon encountering low permeability layers that it cannot penetrate, small pools of TCE may form. Because TCE is almost 50 percent more dense than water, the forces that drive its movement (gravity and pressure gradients) act differently on the nonaqueous phase TCE than they do on the groundwater. Thus, the nonaqueous phase TCE can move in a direction different than the groundwater; it can even move upgradient if, for example, it encounters a clay lens that slopes upgradient as shown in Figure 2-9. As illustrated by this hypothetical case, there may be up to four means whereby pollutants may continue to contribute to subsurface groundwater contamination: (1) infiltrating rainwater passing through residual contaminants in the unsaturated zone may dissolve



SOURCE: AFTER SCHWILLE, 1988

FIGURE 2-9
HYPOTHETICAL SUBSURFACE SOURCES

and carry TCE to the water table, (2) infiltrating rainwater passing through the gas phase cloud may dissolve and carry TCE to the water table, (3) groundwater flowing past the residual contamination in the saturated zone may slowly dissolve the residual and carry it downgradient in a plume, and (4) groundwater flowing over a pool of free product slowly dissolves the TCE and adds it to the plume.

2.3.4.4 Other Contaminant Migration Pathways

The focus of this section has been on groundwater flow as the principal contaminant pathway. However, EPA investigations (1989b) have identified two other pathways contaminants could take: (1) groundwater discharge to surface water and (2) air emissions.

EPA (1989b) sampled surface water in San Jose Creek and Whittier Narrows and found VOCs in concentrations over MCLs in some areas. These concentrations were typically quickly reduced to below MCLs by mixing and volatilization. However, allowing the continued migration of contaminants in Puente Valley and toward Whittier Narrows, where groundwater discharge to rivers may be occurring, could increase the levels of VOCs found in these surface waters. Much of the surface water discharging through Whittier Narrows recharges groundwater in the Central Basin. Thus, contaminated surface water leaving the San Gabriel Basin could contaminate Central Basin aquifers. If this were to occur, remedial actions may have to be expanded to include surface water treatment.

Finally, investigations have also indicated that gas phase movement of VOCs can potentially lead to air emissions from (1) contaminated soils, (2) contaminated groundwater, and (3) contaminated surface water (Ziemba, 1988; EPA, 1989b). Although preliminary calculations suggest these emissions would be low compared with other air emissions in the valley, public awareness of this fact should underscore the need to address the problem of subsurface contamination.

2.4 NITRATE CONTAMINATION

Although VOC contamination in the groundwater of the basin was not discovered until 1979, high concentrations of nitrate in the groundwater have been known to occur for many years. Data from the early 1950s indicate nitrate concentrations ranging up to 130 milligrams per liter (mg/l) as nitrate NO_3, and wells from several portions of the basin have reportedly produced water exceeding the current federal and state primary drinking water standard of 45 mg/l as NO_3 (CDWR, 1977).

Purveyors of drinking water are required to have their wells tested for nitrates at least once every 3 years. Since 1973, these data have been compiled by the Main San Gabriel Basin Watermaster and summarized in annual reports. An interpretation of the approximate current magnitude and extent of nitrate contamination, based on data from 1985 to 1988, is shown in Figure 2-10.

Potential sources of nitrate contamination include both historical and current activities within the basin. Ranching and agriculture were probably the predominant historical sources of nitrates within the basin, because they involved the application of nitrogen fertilizer to crops and orchards and grazing livestock. Early in the 20th century, however, the San Gabriel Basin began changing from a predominantly rural, ranching, and agricultural community to a residential and commercial complex. An increase in groundwater extraction has accompanied this change.

Until recently, sewage disposal in the basin typically occurred in cesspools, septic tanks, and local wastewater treatment facilities. Currently, disposal directly to the ground is only allowed over approximately 10 percent of the basin at existing sites and in areas, where sewers are not available such as along the foothills. These areas in which disposal to the ground is permitted are potential continuing sources of nitrate contamination.

Although nitrates continue to be introduced to a relatively small percentage of the basin's area, the nitrates introduced by historical agricultural practices probably continue to be the primary source of nitrate to the groundwater system. Data available from the upper Santa Ana River Basin indicate that citrus crops utilize only 20 to 30 percent of the nitrogen applied as fertilizers at the surface (Kearney Foundation, 1973). The remaining nitrogen accumulates in the ground above the water table. Some of this nitrogen is carried to the water table by precipitation. Additionally, as the water table fluctuates in response to pumping and precipitation, residual nitrate is dissolved and allowed to flow away with the groundwater. Although a quantitative estimate of the effect of nitrates still present above the water table cannot be made, it is clear that nitrate contamination may continue to be introduced to the groundwater for a very long time.

A comparison of historical and current information on nitrate contamination in the groundwater of the basin, presented in the Draft San Gabriel RI Report (EPA, 1989b), indicates that the extent of areas with high concentrations of nitrate continues to grow at a substantial rate. This suggests that continuing sources of nitrate contamination still exist in the basin. As shown in Figure 2-10, nitrates are presently found in practically every portion of the basin. Although numerical simulations of nitrate contamination have not been performed as part of this analysis, it is clear that nitrate migration is affected by the same types of processes that affect VOC contamination in groundwater.

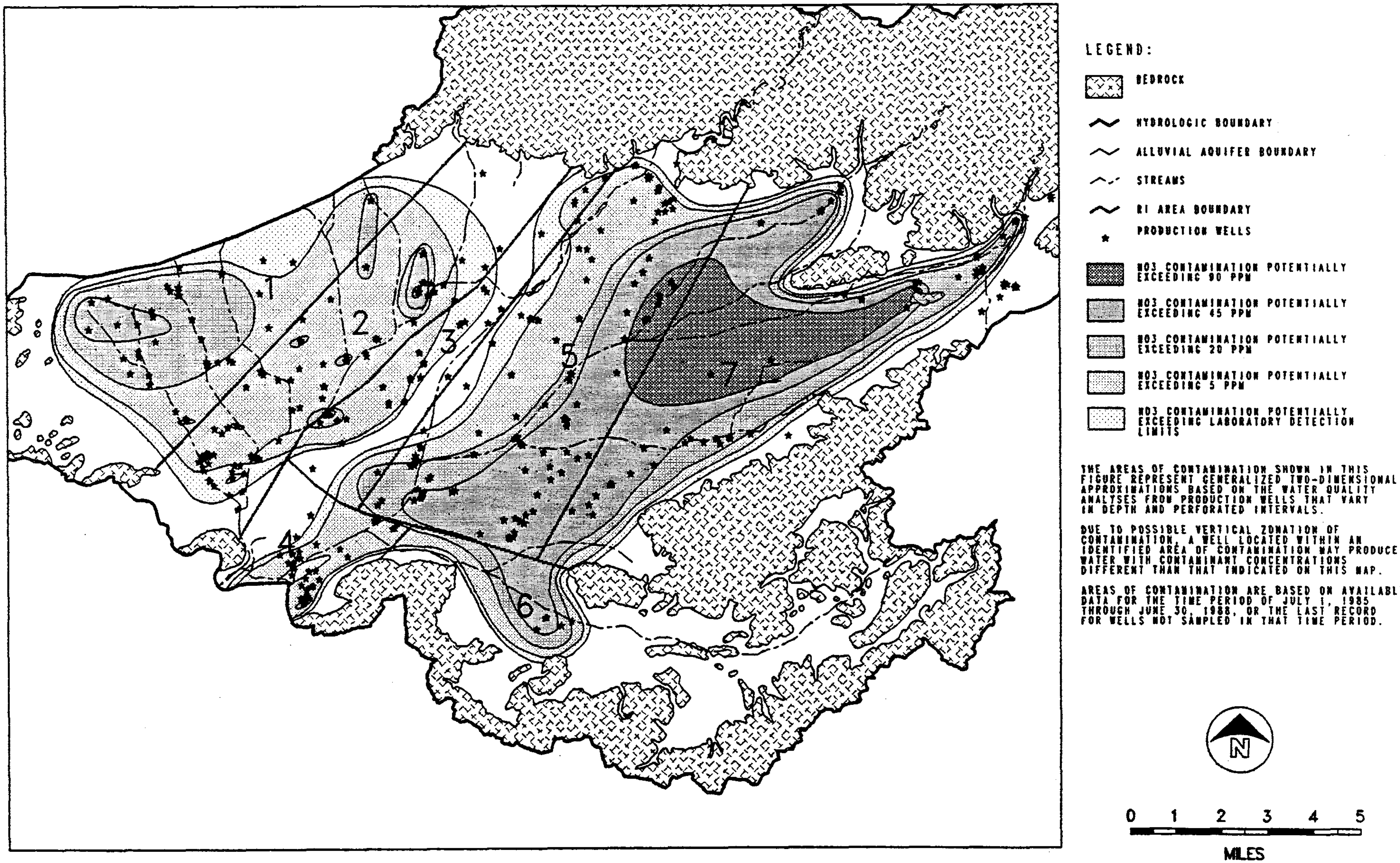


FIGURE 2-10

ESTIMATED AREAL EXTENT OF NITRATE CONTAMINATION

1985-1988

Draft Technical Basinwide Plan
San Gabriel Basin

In addition, continuing sources of nitrate contamination are probably more extensive areally than the types of VOC sources described Section 2.3.4.3.

Blending, the primary method used by purveyors to ensure that drinking water remains below the 45 mg/l standard for nitrates, requires a source of good-quality water. Water suitable for blending with high-nitrate water is currently relatively abundantly available from wells outside of the areas with high concentrations of nitrates, as well as from imported sources. Eliminating or curtailing production in nitrate areas and maximizing production in clean areas is possibly less of a factor affecting nitrate migration than it is for VOC migration because of the widespread use of blending. Nonetheless, nitrate contamination is clearly very widespread and continues to expand toward pumping centers. Sources of good-quality water for blending will most likely become progressively more limited in the basin, and large amounts of imported water will eventually be required for blending purposes alone if no action is undertaken to manage the nitrate problem.

As mentioned previously, this plan does not directly address remediating the basin's nitrate contamination. Nonetheless, the costs and schedules presented as part of this plan include nitrate treatment where it is considered likely to exceed MCLs at operable units within the next 10 years. Although the specific actions described in this plan are not expressly designed to address nitrates, removal and treatment of nitrates at operable unit wells (instead of blending with water from production wells in clean areas) should provide a reasonable measure of remediation. However, nitrate treatment is costly and complex, and it is likely that a considerable portion of blending will continue to be used to supplement treatment, as long as action is taken to ensure that both VOC and nitrate contamination is prevented from spreading throughout the basin. As suggested earlier, the nitrate issue merits further evaluation and may be best dealt with by incorporating additional actions aimed more directly at remediating nitrate contamination to those described in this plan.

2.5 CONCLUSIONS REGARDING THE CONSEQUENCES OF NOT INSTITUTING REMEDIAL ACTIONS

The extent of VOC (and nitrate) contamination in the San Gabriel Basin is spreading and will continue to spread if existing water management practices continue. Although the current water management structure in the basin has led to progressive and proactive water quantity management, there is no coordinated effort to control migration within the basin. Individual purveyor actions, while meeting short-term water quality needs, may be making the problem worse by inadvertently accelerating the spread of contamination. Given the situation described above, meeting the ultimate, aggressive basinwide objectives of remediation of groundwater contamination, described in Section

1.0, requires long-term coordination among the individual purveyors. This may require active financial or regulatory incentives. A central authority with the appropriate funding mechanisms and sufficient staff resources would greatly facilitate this coordinated effort. In fact, most of the operable units described in later chapters as part of the proposed long-term technical plan for remediation of VOC contamination in the basin cannot be implemented without a central authority with the ability to coordinate extraction and treatment of contaminated groundwater, shut down or reduce pumping from exiting wells, distribute treated groundwater over large areas, and recharge groundwater.

The magnitude and complexity of the program necessary to remediate the groundwater contamination requires resources that are beyond the capabilities of the federal Superfund program. The funding and staffing needs of this project must be balanced against the needs of hundreds of other Superfund sites across the United States. If only EPA resources are committed to the project, many important actions will not proceed in a timely manner.

EPA and state and local agencies involved with groundwater supply and quality issues have been working to resolve the technical, institutional, and resource issues associated with the San Gabriel Basin groundwater contamination problem. The State Water Resources Control Board (SWRCB) held a hearing focused generally on these issues in El Monte, California, on June 28 and 29, 1988. A resolution was adopted by SWRCB on October 20, 1988, encouraging the formation of a water quality authority for the basin or a water quality management group that would exercise the powers of existing agencies through joint agreements. In addition, the resolution directed the Main San Gabriel Basin Watermaster to either assume the lead role for coordinating the activities of local, state, and federal agencies in addressing groundwater quality problems, or indicate the agency it preferred to assume this role. A joint resolution was signed by the Main San Gabriel Basin Watermaster, the San Gabriel and Upper San Gabriel Valley Municipal Water Districts, and the San Gabriel Valley Water Association. This joint resolution identified Watermaster as the agency to assume the lead role in coordinating local, state, and federal activities.

More recently, SWRCB has facilitated a series of meetings between EPA, the Los Angeles Regional Water Quality Control Board (RWQCB), the California Department of Health Services (CDHS), the Department of Water Resources) (DWR), the Main San Gabriel Basin Watermaster (Watermaster), the Metropolitan Water District of Southern California (MWD), and the Los Angeles County Department of Public Works (LACDPW) to develop a workable approach to developing a local groundwater management entity with the resources and specific legal authorities necessary to take on basinwide water quality management responsibilities.

Containing or remediating groundwater contamination in the San Gabriel Basin requires a large-scale, long-term commitment of resources. A coordinated effort on the part of federal, state, and local agencies will be necessary if basinwide remedial objectives are to be achieved. Without active water quality management, groundwater in the basin could eventually degrade to the point that no areas remain available for producing drinking water without substantial treatment.

3.0 GENERAL BASINWIDE APPROACH AND OBJECTIVES

3.1 EPA'S BASINWIDE OBJECTIVES

Because the San Gabriel Valley Sites are listed on the NPL, EPA is required to meet certain mandates for investigating and remediating groundwater contamination in the San Gabriel Basin. These mandates are based on provisions in the (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA). EPA implements these provisions by way of specific requirements in the National Contingency Plan; the Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites; the Groundwater Protection Strategy; and the various other statutes, regulations, and policy directives relevant to groundwater use and remediation.

Generally, CERCLA and SARA require EPA to select and implement remedial actions that address the following objectives:

- Protect human health and the environment
- Attain Applicable or Relevant and Appropriate Requirements (ARARs) of federal and state environmental laws (waivers of these requirements are only possible in specific circumstances)
- Are cost-effective
- Use treatment or remedial technologies to the maximum extent possible
- Achieve permanent solutions
- Preferentially employ treatment that permanently and significantly reduces the mobility, toxicity, or volume of the hazardous substances

CERCLA also requires periodic review of remedial actions. These performance evaluations, or 5-year reviews, are required as long as contaminant concentrations at the site exceed drinking water standards. This requirement implies a preference for restoration of the aquifer as a long-term goal.

As stated in the EPA's Guidance for Remedial Actions, Superfund policy is to use the Groundwater Protection Strategy as a guide in determining appropriate remediation for groundwater contamination. Under the Groundwater Protection Strategy, EPA established guidelines for classifying groundwater resources based on use, value, and vulnerability to contamination. Aquifers that are vulnerable to contamination and that provide an irreplaceable source of drinking water are accorded the highest priority (Class I) for protection and/or remediation. This strategy states a preference against further degradation of aquifers like the San Gabriel Basin, which are currently sources of drinking water, and a preference for remediating contamination in such aquifers so that ambient concentrations do not exceed drinking water standards. The San Gabriel Basin can be classified as a Class I aquifer because it meets the criteria of being easily contaminated and is an irreplaceable source of drinking water.

The most significant ARARs for the San Gabriel Project are the drinking water standards established under provisions of the Safe Drinking Water Act (SDWA, the federal statute that regulates the quality of public drinking water supplies) and California state law. Under the SDWA, EPA promulgates drinking water standards called Maximum Contaminant Levels (MCLs), which are based both on the protection of health and on the economic and technological feasibility of achieving the standard. The California Department of Health Services (CDHS) uses a similar process to promulgate state MCLs, many of which are lower than federal MCLs. Both federal- and state- promulgated MCLs are considered ARARs for the San Gabriel Project. In general, EPA's long-term cleanup goal is to reduce the concentration of contaminants in groundwater so that MCLs are not exceeded.

Collectively, then, these legislative mandates and policies clearly indicate an overall goal of protecting human health and the environment by taking action to remediate contamination in the groundwater. The goals to strive for at individual Superfund sites include:

- Preventing human exposure to contaminated groundwater
- Protecting uncontaminated groundwater for current and future use
- Restoring currently contaminated groundwater for future use
- Protecting the environment from exposure to the contaminated groundwater (i.e., "biological receptors that may be affected at the groundwater discharge point")

3.2 ALTERNATIVE APPROACHES FOR THE SAN GABRIEL PROJECT

Remediation of the San Gabriel Valley Superfund Sites is unlike to that of most Superfund sites for a multitude of reasons. The basin is unusually large approximately 170 square miles. The aquifer is also unusually deep--probably up to 4,000 feet. The basin's groundwater provides approximately 90 percent of the domestic water supply for more than one million people. The potential migration of contamination from the San Gabriel Basin into the Central Basin could affect the water supply of the Los Angeles metropolitan area, which supports significantly more than one million people. Based on the current MWD rates, the water annually extracted from the San Gabriel Basin (about 200,000 acre-feet per year) is worth approximately $45 million per year.

The combination of these factors with the institutional complexities and source control problems described in Section 2.0 causes the San Gabriel project to stretch the capabilities of more traditional approaches to remediating Superfund sites. Obviously, a traditional remedial investigation/feasibility study (RI/FS) in the San Gabriel Basin would be extremely costly and time-consuming. The cost of remediation toward the goal of complete restoration could potentially be astronomical. Indeed, the feasibility of ever actually achieving complete restoration is doubtful at any cost. It is likely that continuation of existing practices, including simply providing treatment at existing wells and terminating production in areas that become contaminated, will eventually allow contamination to permeate most of the aquifer.

3.2.1 REPLACING THE BASIN WITH AN ALTERNATE WATER SUPPLY

Because of the anticipated high cost of remediation, EPA investigated the feasibility of replacing the water supply now provided by the basin with water imported from outside the basin. So far, approximately 30 percent of the basin's average total annual groundwater extraction capacity (which could represent about 64,000 acre-feet of water) has been affected by the VOC contamination. Groundwater is defined as affected by VOC contamination when well contamination has been measured at least once at concentrations above the state drinking water standard. Based on the 1985-86 MWSs price for a continuous supply of treated water ($225 per acre-foot), an alternate 64,000 acre-foot supply from MWD to replace that already contaminated would cost approximately $14 million per year. This figure does not include the costs associated with constructing additional distribution facilities to allow widespread use of MWD surface water supplies (only 10 purveyors in the basin now have service connections to MWD). Because typical costs for groundwater extraction in the basin vary between $30 and $60 per acre-foot, $225 per acre-foot for water from MWD represents a substantial increase in cost.

In addition to the high cost and logistical difficulties of replacing the contaminated groundwater with surface water supplies, the amount of imported surface water potentially needed may not be available at any cost. MWD already projects a shortfall in the availability of water necessary to meet anticipated future water demands. Less water will be available from the Colorado River when the Central Arizona Project begins diverting its full allocation. The State Water Project is also expected to be unable to provide an adequate amount of water to meet projected delivery requests from State water contractors. The potential shortfall would be especially critical during drought years. In addition, potential outcomes of pending litigation over City of Los Angeles water rights in the Mono Basin and Owens Valley threaten to increase competition for other existing surface water supplies. Thus, the loss of even part of the San Gabriel Basin groundwater supply would exacerbate an already serious water supply problem.

In addition to prohibitive costs and the lack of available alternative water supplies, there is a history of politically-charged decisionmaking associated with the development of new water supplies in California. Given these impediments, the option of replacing the basin's groundwater supply with an imported supply is likely to be infeasible and would be, at best, extremely uncertain.

3.2.2 NECESSITY FOR REMEDIATION

Because of the unlikelihood of replacing groundwater extraction in the San Gabriel Basin with an alternate water supply, EPA began developing a remediation strategy to approach the long-term goal of removing contamination from the San Gabriel Basin groundwater to meet state and federal MCLs.

In early 1987, EPA conducted a preliminary assessment of remedial action responses to regional groundwater contamination in the San Gabriel Basin. In that assessment, six remedial action objectives and five conceptual remedial action approaches were identified. The remedial objectives range from the minimum required by CERCLA/SARA (protect public health) up to the maximum technically achievable[1] (more complete restoration of the basin). The preliminary remedial objectives identified by EPA in the 1986 assessment are listed below:

1. Protect residents in the San Gabriel Valley from exposure to contaminated groundwater

2. Allow continued use of groundwater as a water supply in the San Gabriel Basin

3. Prevent contamination from spreading into other groundwater basins, namely the Central Basin, to prevent exposure and allow continued use of the groundwater

4. Prevent contamination from spreading within the San Gabriel Basin, thus preventing expansion of existing plumes

5. Partially remediate the groundwater within the basin by removing high-level contamination and partially shrinking the size of the existing plumes

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[1]Technical constraints on achieving total restoration are discussed in Section 4.2.

6. Remediate the groundwater within the basin more completely by removing both high-level and low-level contaminants and substantially shrinking the size of the plumes

To address these objectives, EPA developed five very general remedial action approaches. These approaches range from treatment at existing wells (which would address the fewest objectives) to extraction, treatment, and reinjection (which addresses all the objectives). The five remedial action approaches[2] are:

A. <u>Wellhead treatment</u> either at existing extraction facilities or at new centralized facilities

B. <u>Containment at Whittier Narrows</u> by extraction, treatment, and reinjection in the Whittier Narrows area

C. <u>Containment Within the Basin and at Whittier Narrows</u> by extraction and treatment at the downgradient ends of existing plumes and, potentially, reinjection at upgradient wells to help flush the contamination; thus, existing plumes would not spread further

D. <u>Partial Restoration and Containment at Whittier Narrows</u> by extraction and treatment of groundwater in areas where the contamination is especially high and reinjection upgradient to help dilute and flush the contamination

E. <u>More Complete Restoration and Containment at Whittier Narrows</u> by extraction and treatment of the groundwater contamination in both high- and low-level areas and reinjection the treated water upgradient

Table 3-1 on the following page shows the relationship of the six objectives and the five remedial approaches.

EPA also evaluated the estimated costs and schedules for implementing each approach. EPA concluded, based on the information available for this evaluation, that implementation of an aggressive, intensive basinwide remediation program could cost up to $800 million and take up to 28 years. The RI/FS to support the more complete restoration approach could cost up to $50 million and take up to 10 years. Table 3-2 shows the estimated costs and durations for the five remedial action approaches. None of these costs include efforts to control the sources of contamination in the basin, although such efforts are essential for the long-term success of any approach.

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[2]The remedial objectives and remedial action approaches are discussed in detail in Section 4.0 and Appendix A.

TABLE 3-1

REMEDIAL ACTION APPROACH RELATED TO REMEDIAL OBJECTIVES

		REMEDIAL RESPONSE OBJECTIVES: PROTECT THE PUBLIC FROM EPOSURE TO CONTAMINATED GROUNDWATER	ALLOW CONTINUED USE OF GROUNDWATER AS A WATER SUPPLY IN SAN GABRIEL BASIN	PREVENT CONTAMINATION FROM SPREADING INTO OTHER GROUNDWATER BASINS	PREVENT CONTAMINATION FROM SPREADING WITHIN THE SAN GABRIEL BASIN	PROVIDE PARTIAL REMEDIATION OF GROUNDWATER WITHIN BASIN BY REMOVING HIGH-LEVEL CONTAMINANTS & SHARING PLUME SIZE TO SOME DEGREE	PROVIDE MORE COMPLETE REMEDIATION OF GROUNDWATER WITHIN BASIN BY REMOVING HIGH-LEVEL & LOW-LEVEL CONTAMINANTS & SHRINKING PLUME SIZES SUBSTANTIALLY	COMMENTS/ISSUES
A	**REMEDIAL ACTION APPROACH** WELLHEAD TREATMENT USE OF EXISTING SYSTEMS ONLY	√	√					• CONTAMINATION SPREADS INTO CENTRAL BASIN, WITH POPULATION OVER 1 MILLION POTENTIALLY AFFECTED
	CENTRALIZED APPROACH	√	√					
B	**CONTAINMENT AT WHITTIER NARROWS** A + EXTRACTION, TREATMENT, + INJECTION AT WHITTIER NARROWS	√	√	√				• POTENTIALLY CONTAMINATED SURFACE WATER IS NOT CONTROLLED
C	**CONTAINMENT WITHIN THE BASIN** B + EXTRACTION & TREATMENT AT DOWNGRADIENT END OF PLUME AREAS	√	√	√	√			• PROVIDES SOME CONTROL OF POTENTIALLY CONTAMINATED SURFACE WATER • ALLOWS CONTINUED SPREAD OF HIGH LEVELS OF CONTAMINATION
	WITH UPGRADIENT INJECTION WELLS	√	√	√	√			• POTENTIAL FOR SPREADING CONTAMINANTS IF THE EXTENT OF CONTAMINATION IS NOT WELL DEFINED
D	**PARTIAL RESTORATION** C + EXTRACTION & TREATMENT WITHIN HIGH-LEVEL CONTAMINATION AREAS	√	√	√	√	√		• WOULD REDUCE SPREAD OF HIGH-LEVEL CONTAMMINATION
	WITH UPGRADIENT INJECTION WELLS	√	√	√	√	√		• POTENTIAL FOR SPREADING CONTAMINANTS IF THE EXTENT OF CONTAMINATION IS NOT WELL DEFINED
E	**MORE COMPLETE RESTORATION** D + EXTRACTION & TREATMENT WITHIN LOW-LEVEL CONTAMINATION AREAS, WITH INJECTION WELLS UPGRADIENT OF EXTRACTION WELLS	√	√	√	√	√	√	• MOST COMPLETE REMEDIAL APPROACH • REQUIRES MOST COMPLETE DEFINITION OF AREAS OF CONTAMINATION

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TABLE 3-2

SUMMARY OF ESTIMATED COSTS AND SCHEDULES FOR DIFFERENT REMEDIAL ACTION APPROACHES

REMEDIAL ACTION APPROACH		RI/FS		REMEDIAL ACTION			
		RI/FS COST RANGE ($ MILLION)	RI/FS DURATION (YEARS)	CAPITAL COST RANGE ($ MILLION)	O & M COST RANGE ($ MILLION)	TOTAL COST RANGE ($ MILLION)	RI/FS DURATION (YEARS)
A	WELLHEAD TREATMENT USE OF EXISTING SYSTEMS ONLY	2.9 - 4.7	3 - 5	109 - 131	75 - 138	184 - 269	14 - 21
A	CENTRALIZED APPROACH	5.7 - 10	3 - 5	70 - 113	75 - 138	145 - 251	7 - 11
B	CONTAINMENT AT WHITTIER NARROWS A + EXTRACTION, TREATMENT, + INJECTION AT WHITTIER NARROWS	5.2 - 18	3 - 6	86 - 181	75 - 159	162 - 340	8 - 22
C	CONTAINMENT WITHIN THE BASIN B + EXTRACTION & TREATMENT AT DOWNGRADIENT END OF PLUME AREAS	14 - 32	4 - 7	143 - 471	72 - 207	215 - 678	6 - 22
C	WITH UPGRADIENT INJECTION WELLS	15 - 35	4 - 7	170 - 491	80 - 242	249 - 733	10 - 27
D	PARTIAL RESTORATION C + EXTRACTION & TREATMENT WITHIN HIGH-LEVEL CONTAMINATION AREAS	15 - 33	4 - 7	181 - 489	98 - 221	279 - 710	7 - 22
D	WITH UPGRADIENT INJECTION WELLS	20 - 39	5 - 7	186 - 506	98 - 242	284 - 747	8 - 27
E	MORE COMPLETE RESTORATION D + EXTRACTION & TREATMENT WITHIN LOW-LEVEL CONTAMINATION AREAS, WITH INJECTION WELLS UPGRADIENT OF EXTRACTION WELLS	25 - 51	7 - 10	126 - 510	91 - 293	217 - 800	8 - 28

3.3 CONCLUSIONS ABOUT THE EPA GENERAL APPROACH

Clearly, the assessments EPA has conducted thus far indicate that implementing Superfund program mandates in the San Gabriel Basin will be an expensive, time-consuming, and complex endeavor. Complete restoration (the virtual removal of contamination from the aquifer) of the basin is, in all probability, not feasible from a technical perspective. The preliminary estimates indicate progress toward a technically-achievable level of restoration would take decades and approximately $1 billion dollars. Parallel efforts to identify and take enforcement action against the parties responsible for contamination and, also, to facilitate participation in the remediation by state and local agencies will also be resource-intensive and complex.

As described in Sections 1.0 and 2.0, EPA has gathered a great deal of information over the last 5 years and has conducted complex and detailed analyses of how the contamination in the San Gabriel Basin could be remediated. Since the four sites were listed on the NPL, EPA has taken action according to the following general strategy implemented at all federal Superfund sites:

- First, deal with immediate public health threats
- Second, contain contamination on the site
- Third, develop a long-term plan for achieving remediation goals

To address of immediate public health threats, EPA evaluated a number of water purveyor systems in the San Gabriel Valley to determine if exposure above MCLs was occurring, or was likely to occur without EPA action. (This evaluation included the mutual water companies in El Monte and the eight purveyors described in Section 1.1.1.) Based on those assessments and state mandates, EPA decided to construct a carbon adsorption treatment plant to treat water from existing Richwood Mutual Water Company wells. EPA's subsequent decision to construct an air stripping treatment facility at Suburban Water Systems' Bartolo Well Field will also prevent exposure to VOC contamination and contribute to contamination containment.

Remediation in the Whittier Narrows area including at the Bartolo Well Field contributes to the second part of the strategy--to contain the contamination within the San Gabriel Basin and prevent migration into the Central Basin. This emphasis is consistent with the EPA mandates to protect human health and the environment and to prevent degradation of valuable groundwater resources.

Step three of the general strategy was begun with the preliminary assessment of remedial alternatives described above. The alternatives evaluated consider basinwide, generally single-objective, approaches. The estimated costs and schedules in Table 3-2 illustrate the overall level of effort required to follow various approaches. The remainder of this document represents the next phase of the planning process. In the following section, the options available for remedial strategy development in the San Gabriel Basin will be revisited. The preliminary basinwide cost estimates presented in Table 3-2 will be refined and updated based on new data. To identify specific actions in the short and long term, the general overall objectives and cost estimates outlined in this section will be reevaluated to reflect the present and future needs and concerns of the residents and water suppliers of the San Gabriel Valley, the Greater Los Angeles Area, and of the State of California.

4.0 BASINWIDE STRATEGY

Preliminary estimates of the level of effort required to achieve various basinwide remedial objectives were presented in Section 3.0. This early assessment represented the first major step in the development of this plan and helped focus continued efforts to define and compare the various options available. These estimates consider a basically single-objective, basinwide approach that allows first-cut estimates to be made of the effort associated with various remedial techniques. However, considerable time and expense would be required before any of the alternatives listed in Section 3.0 could actually be implemented. Therefore, subsequent planning efforts have included (1) revising the single-objective, basinwide estimates, and (2) evaluating a more manageable multiple-objective approach that allows immediate attention to be focused on the most pressing problems.

A summary of this evolution of EPA's long-term strategy to remediation of contaminated groundwater in the San Gabriel Basin, the basis of this Basinwide Plan, is presented in this section.

The framework in which the components of this strategy are described is outlined in Figure 4-1. The two basic approaches to organizing remedial actions and investigations into an effective plan--a single-objective, basinwide approach and an incremental, multiple-objective approach--are introduced in Section 4.1. The relatively straightforward single-objective approach is used to reevaluate the cost and level-of-effort estimates presented in Section 3.0, within an operable-unit framework. The multiple-objective approach forms the basis for assembling the ingredients of the strategy presented in this document.

In Section 4.2, a series of distinct groups of concerns and issues are described and prioritized in terms of their relative need for attention. These include (1) specific remedial objectives for which individual operable units can be designed, (2) gaps in the information available on the physical characteristics of the basin that pertain to the relative need to initiate remedial actions expeditiously and the investigations needed to fill these gaps, (3) a variety of concerns associated with water supply and the degree of contamination in different parts of the basin, and (4) activities required to recover the cost of previous (Stage I) actions and to procure funds for future actions. The prioritized lists defined for each of these elements are brought together into a composite strategy in Section 4.3. They are then translated into a staged plan in Section 4.4. Finally, the timing of stages and enforcement-lead actions is discussed in Section 4.5.

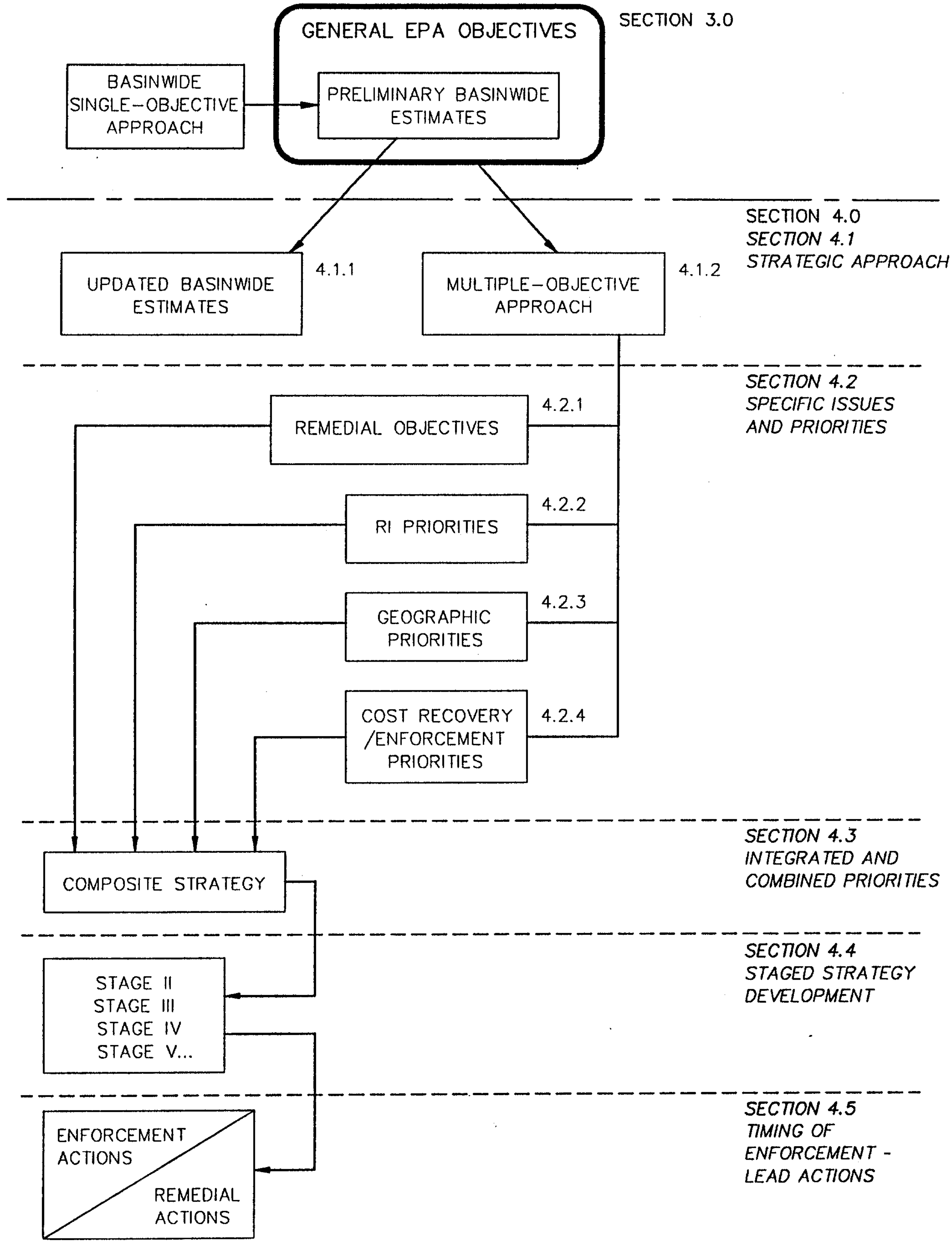

FIGURE 4-1
DEVELOPMENT OF BASINWIDE STRATEGY
DRAFT BASINWIDE TECHNICAL PLAN
SAN GABRIEL BASIN

F:\FIGURES\LA062440.TP\FIG4-1.DWG 12/18/89

A list of 38 potential operable units is compiled and described in Appendix A. The potential cost and remedial effectiveness of this range of potential operable units is evaluated in a general, comparative manner. In Section 5.0, a subset of this list is selected to represent the range of actions described by the entire list of operable units. The potential effects of implementation of this subset on contaminant migration is examined in greater detail, along with potential costs and other factors affecting difficulty of implementation.

4.1 STRATEGIC APPROACH

The two approaches described below are similar in that both consider the use of the operable units listed in Appendix A as a method of addressing various remedial objectives. Their differences generally lie in the manner in which these operable units are assembled into a complete strategy: the single-objective, basinwide approach groups together operable units that address a single type of objective throughout the basin for the primary purpose of evaluating the feasibility of pursuing such an objective; the multiple-objective approach uses many of the same operable units to build an overall strategy that initially pursues the less aggressive objectives and uses information gathered in the course of their implementation to subsequently address more ambitious objectives.

4.1.1 SINGLE-OBJECTIVE BASINWIDE APPROACH

Given the required information, the feasibility of attaining a single specific objective throughout the San Gabriel Basin can be evaluated. Such evaluations provide an understanding of the relative attainability, in terms of cost and design effectiveness, of different objectives. They are not intended to represent the actual process by which these actions will be implemented; the multiple-objective approach described later is more suitable for that purpose in the case of the San Gabriel Basin.

The preliminary evaluations of the potential cost of pursuing various basinwide objectives presented in Tables 3-1 and 3-2 are taken a step further by evaluating groups of operable units that address a particular type of objective. Objectives evaluated in such a manner include the following:

1. Maintain an adequate water supply--Essentially, provide treatment at existing wells where contaminant concentrations exceed drinking water standards. The requirement of such measures would be foreseen with the ability to accurately predict the lateral migration of contaminants. This approach would prevent the acceleration of contaminant migration caused by moving production ahead of contamination (described in Section 2.0), and is similar to Remedial Action Approach A (described in Section 3.2).

2. Control contaminant migration--In addition to providing treatment to wells producing water contaminated above standards, actively control contaminant migration by focusing high rates of production along the downgradient boundaries of areas of contamination in a fashion similar to that described for Remedial Action Approach C in Section 3.2. This objective would ultimately require less treatment than the previous one because contamination migration into "clean" areas would be reduced.

3. Remove contamination--Aggressively install wells and modify existing ones to maximize contaminant removal from the most highly contaminated horizons in the most contaminated areas. This is the most comprehensive objective (similar to Remedial Action Approaches D and E in Section 3.2), involving the removal of groundwater contamination to the extent that production wells in the basin would be generally limited to contaminated areas and produce water treated to meet drinking water standards. By focusing large-scale extraction within areas of high-level contamination, it is assumed that regional hydraulic gradients will be modified so as to limit further migration of contamination, thereby protecting downgradient "uncontaminated" areas. Ideally, it would include measures to remove residual contamination from the vadose zone and any pools of Dense Nonaqueous Phase Liquids (DNAPLs) to minimize the effects of continuing sources.

These objectives are listed in order of increasing difficulty, and a correspondingly greater amount of data are required for their implementation. Conceptually, removing contamination is considered EPA's overall objective, as discussed in Section 3.0. Practically, for reasons mentioned in Section 3.0 and others outlined below, the more immediate goal of EPA's efforts is to maintain an adequate water supply with a long-term objective involving more substantial remediation. This incremental approach is discussed in the following section. The following paragraphs address the single, basinwide objectives listed above.

Unfortunately, the predictive ability required to actually implement the direct courses of action implied by the two latter basinwide objectives requires a higher level of understanding than is presently available. In particular, the vertical and horizontal extent of contamination and the hydrogeologic characteristics of the aquifer must be better defined to allow predictions of the potential effects of specific actions to be made within acceptable levels of confidence. Without this knowledge, there is considerable risk of incurring adverse effects by implementing actions that result in changes in groundwater flow patterns. Without a complete picture of the extent of contamination or the properties of the aquifer, attempts to slow or contain the spread of contamination could actually increase the rate of migration into other areas. Attempts to remove contamination from the center of contaminated zones might alter flow patterns to the extent that contamination from other zones is drawn towards the wells, contaminating the region between them.

Although single-objective approaches do not represent a course of action that can be realistically implemented in the near term, they illustrate what such courses of action would entail, particularly in terms of potential cost. Clearly, for the reasons described above, such cost estimates can be made in only approximate terms and require a number of broad assumptions, including (1) that actual conditions in the basin are similar to the present conception, (2) that with a greater level of understanding, the operable units evaluated will continue to be considered reasonable methods of accomplishing the objective, and (3) that current costs of implementation are reasonable estimates of future costs. Accordingly, cost estimates of pursuing the three general objectives described above are contained in Appendix B and summarized in Table 4-1.

In addition to the costs listed in Table 4-1, actual implementation of the more ambitious single-objective, basinwide approaches would require additional funding for the investigative and managerial efforts needed to attain the appropriate level of understanding. As described in Section 3.0, these efforts could take an additional 10 years. Although individual actions to maintain a potable water supply can be immediately implemented (and have been implemented), a complete strategy for the long-term maintenance of a water supply requires reasonable prediction of future contaminant migration. These costs and delays can be avoided with a plan that allows for an incremental acquisition of data through implementation of initial, less ambitious actions, and subsequent expansion as data become available that suggest additional action is required.

The least expensive (in terms of capital costs) of the costs listed in Table 4-1 is that for providing treatment at every well contaminated above MCLs. The primary difference between the ultimate results of implementing the incremental, basinwide approach described in later sections and a simpler program of treatment at all contaminated wells, is the ability of the former to manage the continued migration of contamination and, potentially, reduce the overall extent of contamination. The value of an (at least partially) uncontaminated aquifer in Southern California is almost impossible to estimate. If portions of the aquifer from which good-quality water can be produced without treatment are preserved, the benefits to both water consumers and purveyors are apparent. However, as explained in Section 2.0, the value of the aquifer is related not only to local water-supply issues, but also to a much larger regional problem that could potentially affect all of Southern California.

The estimated costs of the second and third single-objective approaches are similar, and roughly comparable to those of implementing the actions described in Sections 6.0 through 9.0. It appears that within an operable unit-based framework, it would cost roughly the same to build barriers to continued migration as it would to pump contamination from the middle of contaminated areas. Thus, it seems reasonable that an approach that incorporates both of these types of remedial actions, depending on area-specific conditions, is appropriate.

Table 4-1
SUMMARY OF SINGLE-OBJECTIVE COST ESTIMATES

Objective	Item	Estimated Cost ($ X 1,000)
Maintain an Adequate Water Supply	VOC Treatment (186 wells) =	63,480
	Nitrate Treatment (140 wells) =	44,226
	Cumulative Operation and Maintenance Costs*	
	(for 30 years; net present value at 10%) =	116,337
	(for 30 years; net present value at 5%) =	213,221
	(for 30 years; net present value at 3%) =	285,149
	TOTAL (using O&M present value at 10%) =	224,043
	TOTAL (using O&M present value at 5%) =	320,927
	TOTAL (using O&M present value at 3%) =	392,855
Control Contaminant Migration	Wellhead Treatment	
	VOC Treatment (55 wells) =	22,760
	Nitrate Treatment (41 wells) =	13,470
	Migration Control Operable Units	
	Capital Costs (11 OUs) =	201,170
	(including both VOC and nitrate treatment)	
	Annual O&M costs =	14,387
	Cumulative Operation and Maintenance Costs	
	(for 30 years; net present value at 10%) =	135,669
	(for 30 years; net present value at 5%) =	221,128
	(for 30 years; net present value at 3%) =	281,985
	TOTAL (using O&M present value at 10%) =	373,069
	TOTAL (using O&M present value at 5%) =	458,528
	TOTAL (using O&M present value at 3%) =	519,385
Remove Contamination	Capital Costs (12 OUs) =	304,730
	Annual O&M cost =	10,526
	Cumulative Operation and Maintenance Costs	
	(for 30 years; net present value at 10%) =	92,260
	(for 30 years; net present value at 5%) =	161,785
	(for 30 years; net present value at 3%) =	206,310
	TOTAL (using O&M present value at 10%) =	396,990
	TOTAL (using O&M present value at 5%) =	466,515
	TOTAL (using O&M present value at 3%) =	511,040

* First objective annual O&M costs are assumed to increase from $8,371,000 to $21,086,000 over 20 years.

One of the less certain aspects of these estimates is the cumulative cost of operating and maintaining installed facilities (O&M), for which present value has been calculated at three different discount rates. The manner in which the need for O&M funds would potentially change over time is particularly important in the case of the first objective. Although the approaches to all three objectives are conceptual, it appears certain that the O&M costs required to operate and maintain treatment units that are installed at wells as they become contaminated are likely to grow considerably as the number of treatment units grows. The length of time over which treatment would be installed on a well-by-well basis to meet the first objective (assumed to be a minimum of 20 years) required the extensive 30-year period to be applied to the O&M cost estimates of all three objectives. Although present-value O&M costs are roughly similar for the three objectives (given the range of discount rates and the time period considered), it is apparent that over more lengthy periods of time, the cumulative O&M for the first objective would be highest. In fact, based on current cost estimates, the ultimate annual cost of operating treatment units at all wells contaminated above MCLs may be as high as twice the annual O&M cost of the 12 operable units implemented to remove contamination. Thus, the overall cost of following the first objective would likely be considerably higher than the cost of pursuing the other objectives over the long term.

In addition to long-term O&M considerations, other factors that support the cost-effectiveness of remedial actions to contain and/or remove contamination within the basin include the cost of utilizing the basin's tstorage capacity in the future, the potential for VOC contamination to degrade to more toxic breakdown products, the effect of unidentified and uncontrolled sources, and migration of VOCs through other pathways. These considerations are discussed in Section 2.3.4.

4.1.2 MULTIPLE-OBJECTIVE APPROACH

As described above, an incremental and sequential approach that involves multiple objectives would provide a method by which remediation of groundwater contamination in the San Gabriel Basin may proceed given current levels of knowledge. Initial implementation of relatively simple operable units that involve existing wells and remedial investigations will allow subsequent evaluation and possible implementation of more aggressive actions. In this manner, actions that individually address a variety of objectives can be undertaken, avoiding implementation delay until the ability to safely implement a single-objective approach is achieved.

To assure the proper timing of events, numerous concerns must be evaluated in the development of an effective multiple-objective approach. An incremental remediation strategy must consider the timing of investigative and remedial actions to (1) allow early attention to the most pressing problems, and (2) assure actions are timed to allow the most aggressive actions (which rely on earlier activities) to occur as quickly as possible. Therefore, in the following sections, priorities are defined that consider the relative urgency of a variety of issues. By defining priorities and critical paths, it is possible to evaluate the cumulative benefits of actions. Actions that address a number of broad issues are generally preferable to those that address only one.

In addition to concerns related to the selection of the technical approaches to remediation (e.g., remedial objectives and RI requirements), topics covered in the following sections include purveyor-related issues and other area-specific needs, present and projected extent of contamination, and actions associated with cost recovery of past actions and enforcement of future actions. These discussions will be followed by a summary in which all issues will be integrated to formulate a composite strategy. Finally, the strategy will be used to outline the principal components of an incremental, basinwide plan.

4.2 SPECIFIC ISSUES AND PRIORITIES

4.2.1 REMEDIAL OBJECTIVES

A wide variety of remedial actions may be considered within a multiple-objective approach to remediation of contaminated groundwater in the San Gabriel Basin. Other factors being equal, these actions may best be considered in terms of the objectives they address. The objectives listed below are generally consistent with those described previously (Sections 3.0 and 4.1). A few additional distinctions are made to better distinguish among the variety of operable units described in Appendix A.

1. Prevent Exposure of the Public to Contaminated Groundwater
2. Maintain an Adequate Water Supply
3. Protect Natural Resources
4. Control Migration of Contaminated Groundwater
5. Remove Contaminated Groundwater

An additional objective implicit in all of those listed above is the prevention of further groundwater contamination from surface sources. Essential to any remediation scheme is the identification and control of the sources of contamination. As described previously, source identification and investigation efforts at specific facilities have already been initiated and recently expanded under the auspices of the cooperative agreement between EPA and Los Angeles RWQCB. However, the extent of near-surface contamination is only beginning to become known, and it is considered premature to include source-related remedial actions in the plan at this time. This plan, therefore, focuses on remedial action and investigative activities that address the problem of groundwater contamination in deep production wells, rather than high-level contamination in shallow groundwater in the vicinity of identified sources. Source-related actions should be identified and incorporated into the plan as additional data from RWQCB-sponsored investigations become available. Additionally, it is hoped that the heightened environmental awareness of the general public, punctuated by the passage of legislation assigning the financial responsibility of remediation to polluters, will likely limit the further intentional introduction of contaminants. Clearly, vigorous enforcement of pertinent legislation is a requirement.

As mandated by Congress, the costs of future remedial actions implemented by EPA will be borne by PRPs. The process of identifying, investigating, and negotiating with PRPs is considered the primary mechanism of controlling potential primary sources of contamination. As described in Section 2.0, secondary sources of contamination include residual contamination in the soil and aquifer and pockets of pure contaminants below the water table (DNAPLs). Because of the great difficulty associated with locating and identifying such secondary sources, they are not specifically considered in this technical plan. However, should such a secondary source be encountered during the course of remediation, its removal or control should be investigated and undertaken wherever feasible.

Actions related to source identification, cost recovery, and enforcement are described further in Section 4.2.4, Cost Recovery and Enforcement Priorities. The remedial objectives described above are summarized in the following paragraphs.

Prevent Exposure of the Public to Contamination. This is a fundamental objective common to all basinwide remedial actions. Potential exposure pathways include consumption and/or contact with contaminated domestic, industrial, or agricultural water supplies, air emissions from highly contaminated areas, and contact with bodies of contaminated surface water.

Maintain an Adequate Water Supply. The general goals of this objective include maintaining the currently available groundwater supply and alleviating potential water supply problems as they occur in existing systems.

Protect Natural Resources. Natural resources that are potentially impacted by subsurface contamination in the San Gabriel Basin include both the groundwater and the alluvial aquifer of the basin. Groundwater in the basin represents an approximately 240,000 acre-foot-per-year renewable resource, and the alluvial aquifer is currently used on a regional scale for the infiltration and storage of supplemental water. Accordingly, actions that protect important pumping centers or allow the continued storage and retrieval of supplemental water would address this objective. Actions that allow increased storage and retrieval will help alleviate regional water supply problems that continue to become more acute with time. The San Gabriel Basin could provide storage for substantial quantities of imported water for later retrieval.

Control Migration of Contaminated Groundwater. The contaminant migration control objective requires mitigating the spread of contamination within the San Gabriel Basin and minimizing the spread of contamination into other groundwater basins. The purpose of actions that focus on managing contaminant migration will be to isolate contamination within presently contaminated areas, including the containment of areas of high-level contamination surrounded by lower-level contamination. On the other hand, actions intended to protect natural resources (discussed above) will be designed primarily to prevent migration of contaminants into water supply pumping centers. Management of interbasin migration from the San Gabriel Basin to the Central Basin is being addressed by the Whittier Narrows Operable Unit and is not considered in this report.

Remove Contaminated Groundwater. The contaminant removal objective considers remediation of contaminated groundwater within the basin by removing contaminants and decreasing the extent of contamination.

Remedial Objective Priorities. Although all of these objectives are important, some are clearly more urgent than others. Some imply aggressive remedial actions that require considerable investigation prior to design and implementation, others address less aggressive objectives that may require little additional investigation. As shown in Figure 4-2, the order implied by the previously listed objectives generally assumes the following:

- Increasing difficulty of implementation
- Increasing amount of required remedial investigations
- Increasing cost
- Increasing effectiveness in attaining basinwide remediation of groundwater contamination
- Decreasing urgency

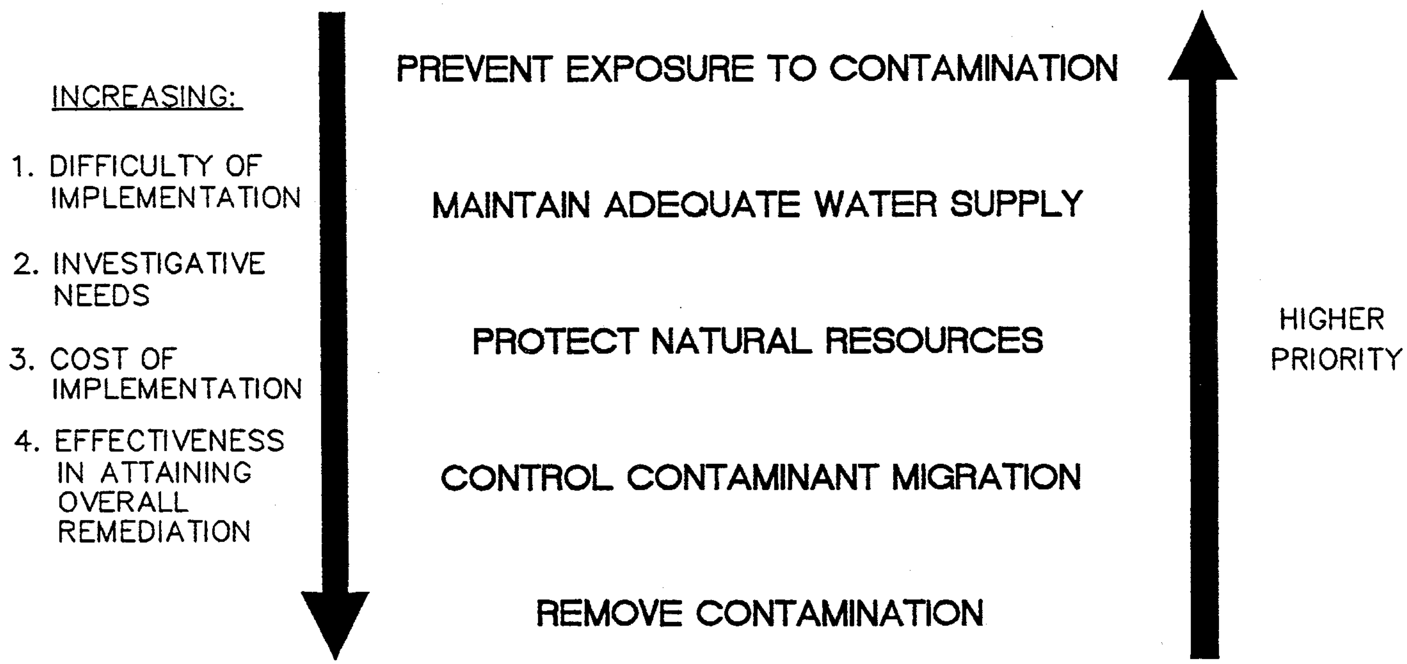

FIGURE 4-2
REMEDIAL OBJECTIVES

The list of objectives thus echoes the overall EPA approach to remediation described in Section 3.0:

1. Protect public health
2. Contain contamination
3. Design long-term remediation

The priority of actions that addresses these objectives is clear; as with EPA's overall approach, immediate problems must be dealt with in a manner consistent with the eventual achievement of a long-term solution. The priority of objectives is also consistent with the structure of the incremental, multiple-objective approach, in which initial implementation of relatively simple actions allows subsequent implementation of the more aggressive and difficult actions that will provide the long-term solution. Although less aggressive actions will generally be an immediate priority, the eventual, more ambitious objectives are the ultimate goal of remediation. This is shown in Figure 4-2.

Actions that address the individual remedial objectives are not mutually exclusive, and an action that focuses on one objective will probably address other objectives to a certain degree. For example, an action primarily intended to maintain an adequate water supply will remove some contaminated groundwater, thereby possibly protecting a nearby pumping center to some degree, while also preventing exposure of the public to contaminated groundwater.

Based on the current level of understanding of basinwide hydrogeologic and contamination conditions, the more aggressive objectives cannot be addressed immediately in most cases. This is because data are insufficient to adequately design a specific action and evaluate the potential for incurring potentially harmful effects. For example, contaminant removal and migration control actions typically require substantial knowledge of aquifer properties and the vertical and lateral extent of contamination in order to be effective. Given these uncertainties, inadequate design of a remedial action could result in the failure to accomplish the intended objective, as well as allow the spread of contaminants into previously uncontaminated areas. In addition, the feasibility of ever completely meeting the more aggressive actions is presently indeterminable. For example, if the extent and magnitude of VOC contamination is considerably greater than expected, a remedial action designed to substantially reduce contaminant concentrations in groundwater over a specific area may instead have virtually no effect on water quality. Had the true extent of contamination been ascertained beforehand in such cases, it would probably have been decided that another form of remediation would have been more cost-effective.

However, it may be possible to initially implement less aggressive actions that may be modified at a later date. These actions would address more comprehensive objectives, allow data relevant to other actions to be collected, or alter conditions to increase the potential for the success of other actions.

Therefore, more aggressive or "difficult" actions may sequentially become feasible as a result of the prior implementation of less aggressive or less ambitious actions.

In addition to level-of-understanding considerations, the selection of appropriate operable unit actions is tempered by circumstances requiring immediate attention. As an example, acute local water supply problems have prompted the short-term implementation of operable units in the past. Alternatively, as monitoring programs continue, contamination of large pumping centers may be foreseen and require actions to prevent further contaminant migration in local areas and assure an adequate water supply.

While it may be possible, and indeed necessary, to alter basinwide strategies with time, actions implemented at operable units are typically constrained in scope. Once an ROD has been finalized, it is difficult to alter the action as initially intended and designed, unless the action is designed to be implemented incrementally. Therefore, because of the need to build upon remedial actions, it is essential that initial operable units consider potential actions and incorporate specific activities to collect the data necessary for these actions from the outset.

4.2.2 REMEDIAL INVESTIGATION PRIORITIES

As mentioned in Section 4.1, the ability to predict the response of the groundwater regime to remedial action is an essential aspect of the development of a remedial strategy. A numerical model of groundwater flow and contaminant transport provides such an ability, the reliability of which varies with the quality and completeness of the data base on which it is based. Again, as mentioned previously, data available for the San Gabriel Basin are considered insufficient to predict this response with an adequate degree of confidence for remedial design purposes on a basinwide scale. A numerical model of the basin is described, along with the conceptual model upon which it relies, in the Draft Report of Remedial Investigations (EPA, 1989b).

Various investigations were undertaken in the San Gabriel Basin that have been used to develop a conceptual hydrogeologic model. The three general components of the model include geology, groundwater flow conditions, and the nature and extent of contamination. Because of the limited investigations performed to date, several data deficiencies and uncertainties are associated with the model. The spatial resolution of the data is particularly limited given the average spacing (approximately 0.5 miles) between data points (predominantly existing production wells). Clearly, additional remedial investigations are necessary to refine these models of the basin and allow their use in the selection, design, and implementation of future remedial actions.

Additional specific data needed to refine the conceptual model should primarily provide the following information:

- o Vertical distribution of contaminants
- o Lateral extent of contamination
- o Hydrogeologic properties

The vertical distribution of contaminants can be determined to some extent through depth-specific sampling of existing wells. Data from existing wells are limited to the specific intervals over which they are screened. Data from throughout the aquifer, particularly at deep intervals from which water production is rare, are typically only obtainable through installation of new wells or well clusters. Determination of the lateral extent of contamination can only be further refined through the installation and sampling of monitoring wells. Aquifer testing and lithologic logging at all new wells will help decrease the uncertainty associated with current estimates of hydrogeologic properties.

A number of wells and associated remedial investigations have been identified for collecting the data necessary to address selected contamination and hydrogeologic uncertainties in different areas of the basin. These wells and recommended investigations are listed in Table 4-2 and shown in Figure 4-3. It should be noted that the ability to understand the regional response of the groundwater system to stresses imposed locally at operable units depends upon the adequacy of the regional data base. Adequate understanding of regional conditions decreases the risk of incurring potentially adverse effects. Therefore, although substantial investigation will be concentrated in the vicinity of operable units and scheduled to directly precede their implementation, additional remedial investigations, possibly removed from specific operable units by several miles, are required to achieve adequate regional knowledge.

Generally, remedial investigations at wells with high contaminant concentrations are considered a higher priority than investigations at wells with relatively low levels. Remedial investigations at wells located in areas lacking relevant hydrogeologic data are considered a higher priority than in areas that are relatively well understood. Wells located in unlayered, high permeability recharge areas of the basin (Areas 2, 3, and 5) are considered a higher priority than those located in layered discharge areas. Contamination in unlayered recharge areas is more likely to influence large portions of the aquifer than contamination in layered discharge areas where groundwater flow is concentrated by low-conductivity zones and towards discharge zones. Finally, investigations in regions with larger zones of contaminated groundwater are considered a higher priority than those in areas with more limited contamination.

Table 4-2
MINIMUM REMEDIAL INVESTIGATIONS REQUIRED FOR
REFINEMENT OF CONCEPTUAL MODELS

Well Logging and Depth-Specific Sampling				New Monitoring Well Clusters	
	Depth (feet)				
	Screened	Interval	Aquifer		
Well	Top	Bottom	Bottom	No.	Rationale
AREA 1					
01901681	222	693	860	0	VOC concentrations are low; existing production wells are deep enough
01902786	325	821	1,300		
AREA 2					
01901055	120	648	1,920	3	Reduce uncertainty in vertical and downgradient extent
01902019	199	626	1,190		
01902027	156	798	1,950		
AREA 3					
Well logging not recommended because the most contaminated wells are too shallow.				3	Reduce uncertainty in vertical and downgradient extent
AREA 4					
Suitable wells were logged as part of Whittier Narrows OUFS				2	Investigate potential link to contamination in other areas
AREA 5					
01900029	275	585	1,039	3	Reduce uncertainty in vertical and downgradient extent
01900031*	300	585	1,512		
01900035	250	582	1,680		
01900882	198	484	1,470		
08000060*	300	600	1,200		
08000093	420	1,190	1,630		
71903093	275	506	1,790		
91901439*	330	833	1,255		
AREA 6					
Well logging not recommended because of limited screening intervals				2	Reduce uncertainty in downgradient extent
AREA 7					
Well logging not required because contaminant concentrations are low				0	VOC concentrations are low

* Depth-specific sampling performed in 1989.

Specifically, the following criteria have been combined to create the prioritized list of remedial investigation wells listed in Table 4-3:

- o Contaminant concentrations
- o Hydrogeologic data gaps

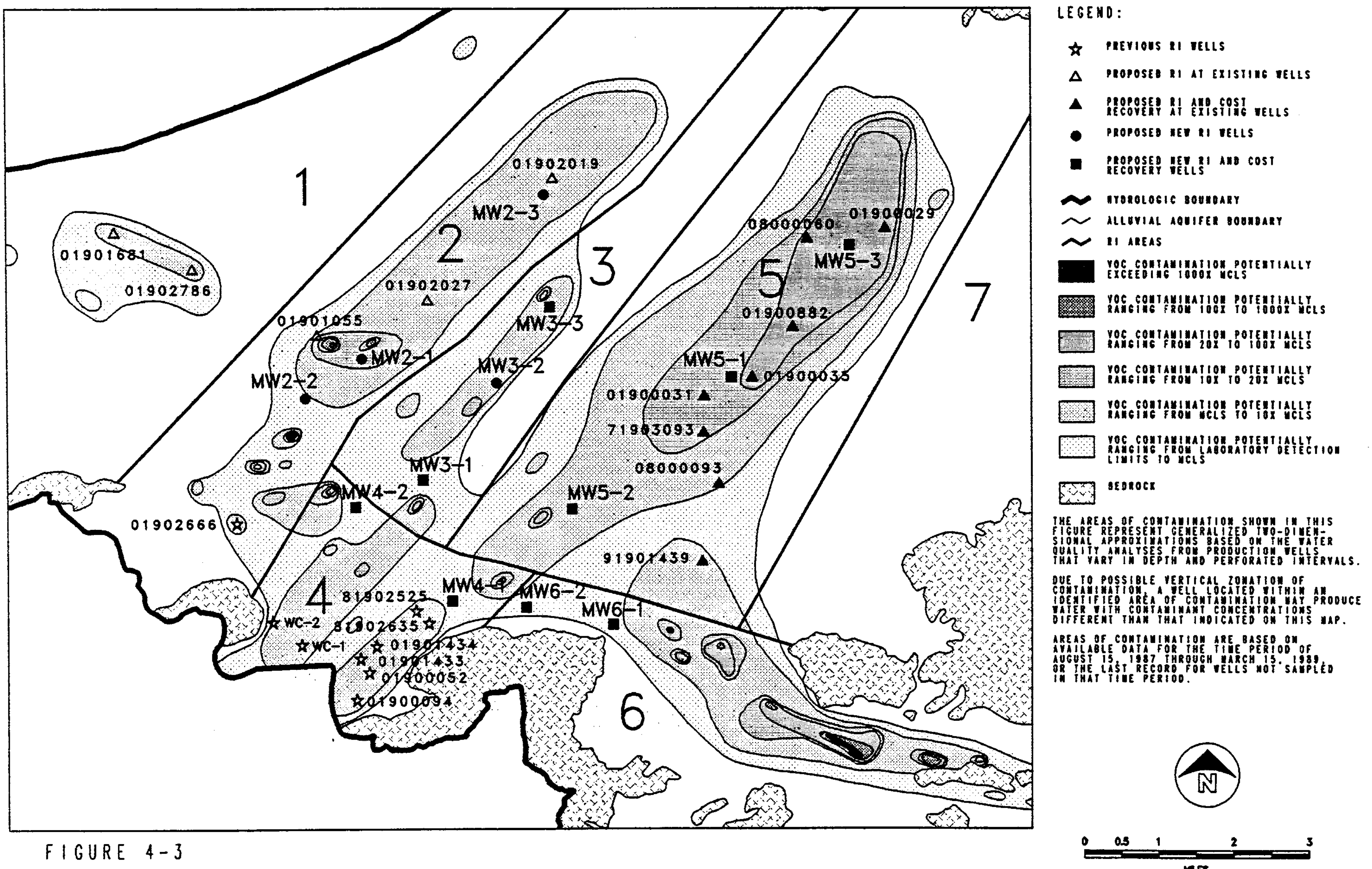

FIGURE 4-3

PREVIOUS AND RECOMMENDED INVESTIGATIONS

Draft Basinwide Technical Plan

San Gabriel Basin

- o Recharge versus discharge areas
- o Extent of contamination

The manner in which these criteria were considered is explained to some extent in the previous paragraph. The combination of criteria to produce the single prioritized list of wells in Table 4-3 was undertaken with some degree of professional judgment based on the experience of individuals involved in basinwide remedial investigations over the last few years (EPA, 1989b). Overall, the relative importance of the individual criteria is reflected in the order in which they are listed above. This table also identifies well location, approximate vertical extent of the aquifer monitored, and the maximum measured VOC concentration in the well (or area, in the case of a new well).

4.2.3 GENERAL GEOGRAPHIC PRIORITIES FOR REMEDIAL ACTION

It is important to consider regional factors in addition to the technical requirements for remediation in prioritizing areas for implementation of operable units. For example, several issues should be incorporated into a basinwide strategy to minimize the effects of contamination on the purveyors responsible for supplying water to the inhabitants of the basin. To aid in the comparison and prioritization of different geographic regions for remedial action, a variety of predominantly water purveyor-related issues is considered within the seven RI areas, which have been further subdivided for this purpose as shown in Figure 4-4. These geographic criteria are the primary consideration in prioritizing remedial actions and associated remedial investigations. Four major issues of this type are described in the following paragraphs. These criteria are considered for each area in Figure 4-4; the results are summarized as "high," "moderate" ("mod"), and "low" in Table 4-4.

<u>Confidence in the Extent of VOC Contamination</u>. Well defined zones of contamination enhance the ability of purveyors to manage potable water production. From a basinwide perspective, the importance of better defining the extent of contamination is paramount for defining and evaluating remedial alternatives. Without an adequate understanding, the potential for incurring adverse effects through the implementation of inappropriate remedial actions is increased. Confidence in the definition of lateral and vertical extent of contamination was assessed based on the availability of water quality data and construction details of the existing production and monitoring wells in the basin.

Degree of Water Supply Problem. The potential for water supply problems is assessed based on current and assumed future conditions. It should be remembered that, because of the limited data base, priorities based on the current understanding are preliminary and subject to modification as more information

Table 4-3
WELLS SELECTED FOR RI ACTIVITIES RANKED BY PRIORITY

Ranking	Well No.	RI Area	Maximum VOC Level Detected (ug/l)	Approx. Percent of Aquifer Monitored	Well Location*
1	01900029	5	770	40	Towards upgradient end of large >50 zone
1	01900031	5	85	15	Towards downgradient end of large >50 zone
1	01900035	5	130	20	Central portion of large >50 zone
1	08000060	5	1100	30	Towards upgradient end of large >50 zone
1	71903093	5	88	15	Downgradient end of large >50 zone
1	91901439	5	12	45	Downgradient end of >MCL zone in southeast Area 5
2	New MW 6-1	6	>Detect zone	100	Western Area 6 near downgradient end of >MCL zone
3	New MW 5-1	5	>50 zone	55	Southcentral portion of large >50 zone
3	New MW 5-2	5	>MCL zone	50	Southern Area 5 in >MCL zone
4	01901055	2	142	25	Downgradient end of large >MCL zone
4	01902019	2	121	40	Upgradient end of large >MCL zone
4	01902027	2	26	35	Central portion of large >MCL zone
4	New MW 2-1	2	>50 zone	30	Downgradient end of >50 zone in central Area 2
5	New MW 4-1	4	>Detect zone	100	Between two >MCL zones
5	New MW 2-2	2	>MCL zone	45	Downgradient of large >MCL zone
5	New MW 3-1	3	>Detect zone	35	In southeast Area 3 between 2 >MCL zones
6	New MW 3-2	3	>MCL zone	40	Central portion of large >MCL zone
6	New MW 3-3	3	>MCL zone	50	Towards upgradient end of large >MCL zone
7	01901681	1	23	75	Downgradient end of largest >MCL zone
7	01902786	1	7.6	45	Upgradient end of largest >MCL zone
8	0190882	5	230	20	Central portion of large >50 zone
8	08000093	5	10	50	Eastern edge of large >MCL zone
8	New MW 5-3	5	>50 zone	80	Northern portion of large >50 zone
9	New MW 6-2	6	>Detect zone	100	Western portion near Area 4
10	New MW 2-3	2	>MCL zone	80	Towards upgradient end of large >MCL zone
11	New MW 4-2	4	>Detect zone	100	Northwestern portion

*Contaminated zones and wells referred to are displayed in Figure 4-3

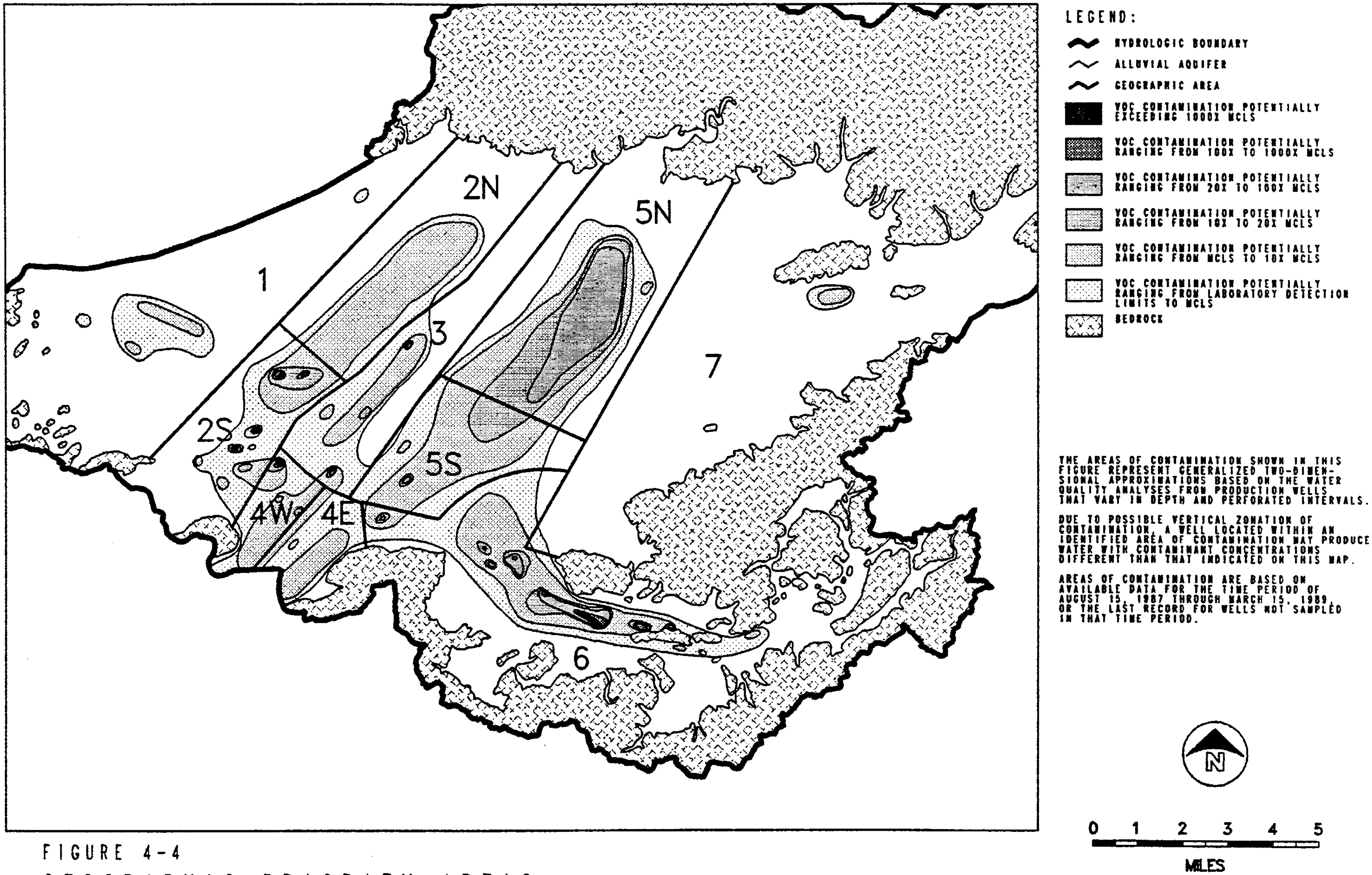

FIGURE 4-4

GEOGRAPHIC PRIORITY AREAS

Table 4-4
GEOGRAPHIC COMPARISON OF RI AREAS

RI Area*	Confidence In Estimated Extent of VOC Contamination		Degree of Water Supply Problem		Relative Levels Of VOC Contamination	Potential For Contaminant Migration		Priority Ranking
	Lateral	Vertical	Current	Future		Into Area	Out of Area	
5 N	High	Low	High	High	High	High	High	1
5 S	Mod	Low	Mod	High	Mod	High	Mod	2
2 N	Mod	Mod	High	High	Mod	Mod	High	3
6	Mod	Low	Mod	Mod	High	High	High	4
2 S	Low	Low	Low	High	Mod	High	Low	5
4 E	High	High	Low	Mod	Low	High	Mod	6
3	Mod	High	Mod	Mod	Mod	Low	Mod	7
1	Mod	Low	Low	Low	Low	Low	Low	8
4 W	Mod	Mod	Low	Mod	Low	Mod	Mod	9
7	Low	Low	Low	Low	Low	Low	Low	10

*For RI Areas or subareas, see Figure 4-4.

becomes available. In particular, EPA does not have specific information on the water supply situation of all purveyors, except for the eight purveyors for which system evaluations were prepared (as described in Section 1.1.1). This assessment does not consider potential water supply problems, either current or future, resulting from nitrate contamination.

For current conditions, the descriptive modifier "high" indicates a probable near-term problem in meeting water supply demands as a result of VOC contamination. The modifier "low" indicates that VOC contamination has had or will have little effect on the local water purveyor's ability to meet demand.

The percentages of wells that have produced water with contaminant concentrations in excess of MCLs for VOCs are shown below. They highlight the degree of water supply problems purveyors have faced in the past 3 years and still must contend with.

o Area 1 - Approximately 20 percent.

o Area 2N - Over 90; one purveyor has lost the use of more than 50 percent of his wells because of VOC contamination.

- o Area 2S - Approximately 20 percent.
- o Area 3 - Over 50 percent.
- o Area 4E - Approximately 50 percent.
- o Area 4W - No water supply wells.
- o Area 5N - Approximately 70 percent of the wells in the Azusa-Baldwin Park area; a purveyor in this area has lost the use of 75 percent of his wells because of VOC contamination.
- o Area 5S - More than 40 percent.
- o Area 6 - Over 90 percent; approximately 75 percent of one purveyor's wells have been removed from service because of VOC contamination.
- o Area 7 - Less than 10 percent; however, nitrate contamination exceeding MCLs is pervasive throughout most of Area 7.

The areas identified in Figure 4-4 have been evaluated further based on the potential impact of VOC contamination on meeting future water supply demands. This evaluation assumes continued migration of contaminants with no remediation of currently contaminated zones. Again, this and other evaluations of this kind are limited by interpretations that are based exclusively on currently available information. To supplement the available data base, EPA has requested that Watermaster compile additional data from individual water purveyors.

<u>Relative Levels of VOC Contamination</u>. Levels of VOC contamination in production wells are assessed based on groundwater sampling data. The use of groundwater for drinking purposes is especially hampered in areas where contaminant concentrations are greatest because of the decreased ability to use highly contaminated water to blend with other water. Generally, "high" refers to areas where production wells indicate relatively high concentrations of VOC contamination. In portions of Areas 2 and 3, very high concentrations of VOCs have been detected in shallow source investigation monitoring wells. Because the production wells in there are pump from deeper intervals, the relative levels of contamination there are considered moderate.

<u>Potential for Contaminant Migration</u>. This criterion relates to contaminants migrating into a particular area from adjacent upgradient areas or from sources within the area. The criterion also considers the potential impact of contamination migrating downgradient of the area into uncontaminated areas. The potential for contaminant migration is evaluated in Table 4-4 based on the

current extent of contamination and upon current and historical pumping patterns.

Table 4-4 also identifies the relative geographic priorities of RI areas and subareas for future basinwide remedial actions. Based on geographic considerations, Areas 5 and 6 should be prioritized for initial remedial actions because of water supply problems, the potential for contaminant migration affecting adjacent areas, and the currently high levels of VOC contamination detected in production wells. On the other hand, VOC contamination has had relatively minor impact in Areas 1, 4W, and 7. Therefore, from a purveyor-related perspective, these areas should receive a lower priority in the planning of basinwide remedial activities.

4.2.4 COST RECOVERY AND ENFORCEMENT PRIORITIES

EPA's approach to funding remedial actions in the San Gabriel Basin is to pursue operable units already in the feasibility study, design, or implementation phase as fund-lead actions and to recover costs accrued for development and implementation of the actions from PRPs. Future operable units are intended to be funded by PRPs identified during source identification activities.

EPA's cost recovery and enforcement strategy has direct impacts on San Gabriel Basin RI/FS and Remedial Design and Action (RD/RA) activities. RWQCB will conduct source identification activities under a cooperative agreement with EPA. Data generated by site owners under the lead of RWQCB will be used to identify PRPs. The State of California is expected to fund oversight of source investigation and cleanup at individual sites after potential sources are identified. Data generated by site investigations will be used by EPA to link PRPs to contamination at the operable units. The statute of limitations established by CERCLA (Section 113), coupled with the time required to conduct the PRP search (source identification and investigation), to evaluate the data and develop technical cases, and to enter into negotiations with PRPs, is critical to the timing of future investigations. Likewise, initiation of future operable units will also be affected by the time required to identify and investigate PRPs, because PRP funding will be needed for their implementation.

RWQCB began source identification activities in 1985 to locate sources of contaminants detected in drinking water wells. Identification efforts were initiated first in the vicinity of La Puente, City of Industry, and El Monte (Figure 4-5). In 1989, EPA provided funding to the State Water Resources Control Board (SWRCB) and RWQCB to expand the source investigation program (known as the Well Investigation Program). Source identification areas have been expanded to address potential source areas for the Richwood,

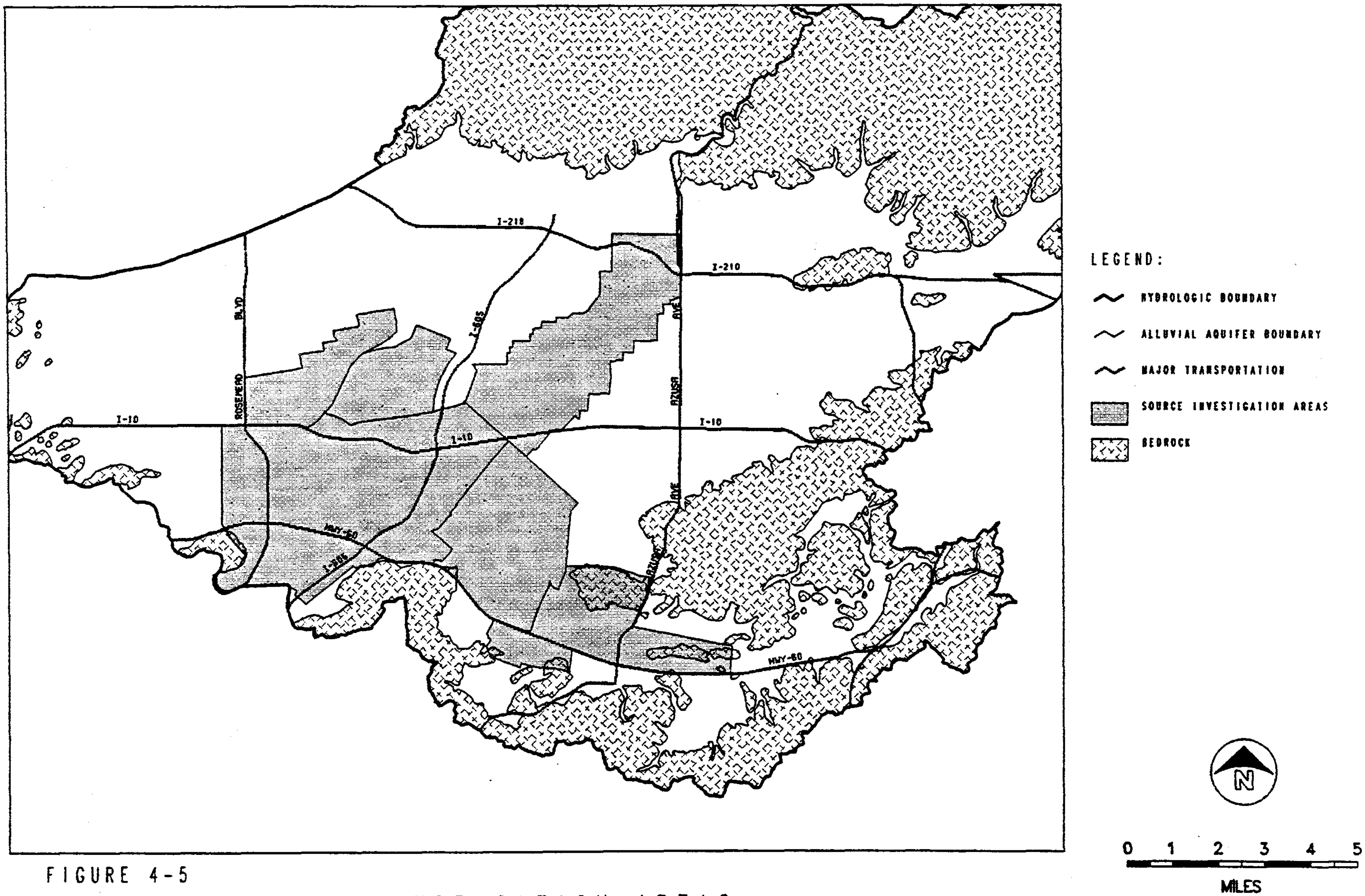

FIGURE 4-5
LARWQCB SOURCE INVESTIGATION AREAS

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Whittier Narrows, and Suburban operable units to support EPA's cost recovery efforts. In addition, source identification efforts were recently initiated in the Azusa/Baldwin Park area to support future EPA enforcement actions. As of March 16, 1990, all of the 231 potential source sites identified in the El Monte area have been inspected. Soil assessments have been or are being performed at 42 sites and groundwater assessments at 16 sites. There are 279 potential source sites in the La Puente area, of which 88 have been inspected, 52 have had or are having soil assessments conducted, and 38 have had or are having groundwater assessments conducted. In the vicinity of the City of Industry, 308 potential source sites have been identified. Inspections have occurred at 116 sites, soil assessments have been or are being performed at 45 sites, and groundwater assessments at 22 sites. In the area surrounding the Richwood Operable Unit, 106 potential sources have been identified. All of these have been inspected, with soil assessments completed or being performed at 10 sites and groundwater assessments at 3 sites. Potential source sites number 1,788 in the Whittier Narrows area. Inspections have taken place at 962 of these sites. Soil assessments have been completed or are being performed at 131 sites, and groundwater assessments at 59 sites. In the Azusa/Baldwin Park area, the newest source investigation area, 1,659 potential source sites have been identified to date. Of these, 52 have been inspected, soil assessments have been completed or are being performed at 21 sites, and groundwater assessments at 4 sites.

The cost recovery and enforcement issues discussed in the following paragraphs include (1) timing and scheduling of activities, and (2) RI efforts needed to develop technical cases linking PRPs to contamination at operable units. Cost recovery priorities are discussed for operable units already initiated prior to this plan (Stage I), and enforcement priorities are discussed on a generic basis for future operable units. The Whittier Narrows and Suburban Bartolo Well Field Operable Units are discussed together because potential contaminant source areas are the same.

Richwood Mutual Water Company. A revised ROD was signed in September 1987 for the Richwood Operable Unit. Construction of the remedial action began in mid-1988. Because this is the first remedial action in the basin, cost recovery actions for the Richwood Operable Unit are a priority.

PRP search efforts in this area were begun by RWQCB in 1989. The installation and sampling of at least one monitoring well in the northern portion of Area 3 may be necessary to better understand subsurface conditions, to aid in the identification of PRPs.

Whittier Narrows and Suburban Water Systems' Bartolo Well Field. The ROD for the Suburban Operable Unit was signed in September 1988, and construction is scheduled to begin in early 1991. EPA is currently conducting RI/FS activities for the Whittier Narrows Operable Unit, and it is expected that a proposal for a remedial action will be presented to the public for review and comment later this year. The ROD is scheduled for completion within the next year. It is expected that construction of the remedial action will begin approximately 1 to 2 years after signing the ROD, depending on the complexity of the remedial action selected.

Potential source areas include portions of Areas 2, 3, 4, 5, and 6. Potential source areas where PRPs can be linked to contamination in Whittier Narrows should be identified early in the process to focus PRP search efforts. This will require a sizeable RI effort to better understand subsurface conditions and assess the potential link between various areas of the basin and contamination observed at Whittier Narrows. This additional RI effort may be conducted as part of RWQCB-led site assessments being conducted in the vicinity. If they are not, however, EPA may conduct the investigations as part of overall basinwide RI efforts. It is essential that on- and offsite investigations conducted by PRPs continue under the lead of RWQCB. Potential source areas and sites need to be prioritized so that PRPs can be identified, technical cases developed, notice letters issued, and cases filed within the statute of limitations. These activities all require close coordination between EPA and RWQCB for data transfer, coordination of efforts, and prioritization of source areas and sites.

As previously described, source identification has begun in six areas of the basin. To better define the hydrogeology of those areas, and groundwater flow conditions between them and the Richwood, Whittier Narrows, and Suburban operable units, a variety of investigations have been identified and are tabulated in Table 4-5.

Future Operable Units. EPA's strategy for future operable units is to follow an enforcement-lead approach to compel PRPs to implement specific actions. For future operable units, PRP search efforts will be concentrated in specific areas. These areas will be defined based on interpretations of contaminant transport velocities and groundwater flow directions. In cases where these areas overlap with previous investigation areas, PRP search efforts will not be duplicated. Thus, the Whittier Narrows cost recovery investigations, which cover most of the basin, may include areas affecting future operable units.

For the average operable unit in the basin, the PRP search is estimated to take 1.5 years. A PRP search of this length is assumed to include inspection of about 2,000 facilities and identification of about 60 potential source sites. Technical case development may require up to an additional year after the PRP search is completed. Issuance of general and special notice letters and negotiations are assumed to require an additional 0.5 year after technical case development. Therefore, negotiations to settle on PRP funding of an operable unit might be completed approximately 3 years after the PRP search begins. The

Table 4-5
SUMMARY OF COST RECOVERY PRIORITIES

RI Area	Type of Investigation
3	o Installation and depth-specific sampling of one new monitoring well in northern area (near Richwood Operable Unit) o Installation and depth-specific sampling of one deep monitoring well in southern area near Whittier Narrows
4	o Installation and depth-specific sampling of two new monitoring wells in northern portion
5	o Installation and depth-specific sampling of three new monitoring wells o Depth-specific sampling of eight existing deep wells
6	o Sampling and tracer testing of San Jose Creek and gravel subdrain system o Installation and depth-specific sampling of two new monitoring wells between Whittier Narrows and the Puente Valley

overall impact of EPA strategy on future operable units will depend on the actual size of the source area and progress of the PRP search conducted for each operable unit. If a settlement is not reached, and litigation is necessary, it will take even longer to implement an operable unit.

4.3 INTEGRATED AND COMBINED PRIORITIES

Development of a single, staged, basinwide remedial strategy is predicated on the ability to combine, integrate, and prioritize the individual objectives, remedial investigation needs, geographic needs, and cost recovery and enforcement aspects of remediation. Review of the information summarized above indicates that many of the remedial, geographic, and cost recovery and enforcement priorities are interrelated by RI area. This allows development of a staged basinwide remedial strategy consistent with the relative needs of different portions of the basin. Table 4-6 summarizes some of the more salient issues outlined in the previous sections.

Prioritized, issue-specific groupings of geographic, remedial investigation, cost recovery, and enforcement needs with associated RI areas are presented in the

Table 4-6
Generalized Components of San Gabriel Strategy

Focus of Generalized Action	Rationale	Scope of Actions
Mitigate an Imminent Threat to Public Health	Prevent exposure of public to contamination	Operable Unit defined by the nature of the threat.
Cost Recovery	EPA responsibility to recover costs for the Richwood, Whittier Narrows, and Suburban operable units.	Investigations designed to identify source areas of contamination at Stage I operable units and PRPs.
Remedial Investigation Needs	Further definition of basinwide hydrogeology and contamination conditions necessary to increase the potential for successful remedial, cost recovery, and enforcement actions.	Investigations conducted independently or in support of operable units to obtain data that will allow reasonable levels of confidence in the ability to predict the response of the natural system to remedial actions. These data will allow future operable units to be built upon previous actions to satisfy more ambitious objectives.
Remediation of Basinwide Groundwater Contamination	Maintain supply of potable water, contain and remove contaminants from groundwater.	Operable units may be selected based on remedial objectives and current level of knowledge.
Enforcement Actions	Data developed through implementation of the above actions is assumed to support enforcement (and cost recovery) actions throughout. Specific additional enforcement actions may be implemented as identified or needed.	Investigations designed to identify source areas of contamination at future operable units and PRPs.

first column of Table 4-7. The three levels shown generally correspond to actions previously defined as being of relatively high, medium, or low priority. Based on these groupings, this plan will identify and select operable units and investigation activities within a given area that address cost recovery, remedial investigation, and geographic data needs while concurrently satisfying one or more remedial objectives.

The column labeled Basinwide Recommended Areas in Table 4-7 considers the following three factors in translating the general issue-specific priorities into a time-dependent schedule:

- Critical paths
- Cumulative benefits
- Remedial objective priorities

Critical paths that interrelate different types of actions help constrain the scheduling of actions. For example, although RI needs for Area 2 are considered a lower priority by themselves, early RI efforts will expedite subsequent implementation of remedial actions in Area 2 at an intermediate stage. Recognition of cumulative benefits is reflected in Area 3, for example, where RI needs, considered a secondary priority by themselves, may be satisfied to a large degree by cost recovery actions and, thus, become part of an early stage. Likewise, RI efforts in Areas 5 and 6, considered high priorities, may also satisfy cost recovery needs.

Remedial objective hierarchies are considered in Areas 5, 6, and 2, which have the largest zones of contamination in the basin and require the greatest amount of remediation, respectively. The current level of knowledge of hydrogeologic conditions is considered inadequate to institute ambitious remedial actions at an early stage, particularly in Areas 5 and 6, as reflected in the list of RI priorities. Therefore, remedial investigations and actions in these areas have been subdivided into components (a, b) for sequential implementation.

It should be noted that the groupings in Table 4-7 are not intended to represent an unyielding methodology or strategy towards remediation of groundwater contamination within the basin. Rather, the need for modifications to the strategy is expected to become apparent based on the additional data developed during ongoing remedial investigations and operable unit remedial actions. Modifications will also be required in response to circumstances presenting an imminent threat to public health or otherwise requiring immediate attention. Enforcement actions are not considered separately in Table 4-7. Factors affecting the incorporation of enforcement actions into a basinwide plan of remediation, along with the priorities summarized in Table 4-7, are described more fully in the following section.

Table 4-7
PRIORITIZED GROUPINGS

Relative Priority	Issue	Recommended Areas: Issue-Specific	Recommended Areas: Basinwide
High	Geographical/Remedial	5N, 5S	5a, 6a
	Cost Recovery	3, 4, 5, 6	3, 4, 5, 6
	RI Needs	5, 6 (central)	2, 3, 5a, 5b, 6
	Enforcement		Support 5, 6
Medium	Geographical/Remedial	2, 3, 4E, 6	2a, 5b, 6b
	RI Needs	2, 3, 4, 5	2b, 3, 5b
	Enforcement		Support 2, 5, 6
Low	Geographical/Remedial	1, 4W, 7	1, 2b, 3, 4, 6c, 7
	RI Needs	1, 5, 6	1
	Enforcement		Support 1, 2, 4, 5, 7

Note: Priorities are designated by RI Area (Figure 1-2) or subarea (Figure 4-4). Issue-specific priorities refer to those identified in Tables 4-3, 4-4, and 4-5. Basinwide priorities are identified based on the integration of Issue-Specific priorities. Where there is a potential for multiple stages of remedial actions and corresponding investigations in one area, RI Area numbers are differentiated by letters representing consecutive actions in the same area (designated a and b in Areas 2 and 5, and a, b, and c in Area 6).

4.4 STAGED STRATEGY DEVELOPMENT

From the column of basinwide priorities in Table 4-7, the sequencing of events can easily be further defined into a specific, incremental remedial strategy by considering two additional factors to those listed above:

- o The nature and scope of actions required to address different issues (as summarized in Table 4-6)
- o Balanced level of effort between stages

Five different general types of actions have been described in the previous sections. Briefly, actions required to mitigate imminent threats to the public must be implemented as their need is recognized. Conditions requiring short-term actions of this type might include loss of a potable water supply to a segment of the population or the presence of substantially contaminated surface water within the accessible environment. Cost recovery actions include investigative efforts to identify PRPs responsible for contamination at existing operable units and recover previous expenditures by EPA. Remedial investigations will be undertaken to obtain data on hydrogeologic conditions in support of designing specific operable units, as well as to refine the ability to understand and predict the hydraulic response of the entire basin to changing pumping patterns (e.g., operable units). Remedial actions will be implemented typically as operable units designed to address a variety of objectives. Types of actions that have been considered to address the remedial objectives outlined in Section 4.2.1 are described in Appendix A. EPA will implement future operable units as enforcement-lead projects. Therefore, source investigation activities and enforcement actions will be necessary before their implementation. Enforcement actions will likely control the timing of implementation of future EPA activities in the basin. The incorporation of these actions into the remedial plan and their influence on timing is discussed further in the following section.

The efficiency of an incremental remedial plan is enhanced if care is taken to avoid any duplication of efforts. Recognition of a potential overlap in benefits between activities intended for different purposes, and potentially of different priority, can be used to reduce the overall number of actions by redistributing priorities. For example, as mentioned previously, cost recovery and remedial investigations are typically required in the same area. However, because they are needed for different purposes that may be of different priority, they might not necessarily be considered as a single action. Remedial investigations required to refine the conceptual basinwide model and those required to design and implement specific operable units are another example of a potential overlap of benefits. The timing of remedial investigations should be redistributed to hasten acquisition of basinwide data while allowing design and implementation of high-priority remediation to continue.

Finally, the scope of separate stages of remediation should be balanced to some degree. The staged implementation of actions provides a manageable framework for undertaking remedial design and investigation, and cost recovery and enforcement efforts. Stages that are previously defined and planned, even preliminarily, can be implemented relatively efficiently because efforts of all types can be foreseen, planned, and performed in an overlapping, episodic fashion that mirrors the beginning and ending of separate stages. Thus, it is important that stages be of similar scope to assure that staffing and funding are sufficient and allow for smooth and continuous transitions between stages. The timing and overlap between stages are described further below.

Table 4-8 presents the same actions represented by the second column of Table 4-7 within a staged framework that includes consideration of the planning factors described. Again, timing concerns and their relationship to this outline of proposed actions are discussed in the following section. The plan itself will be described by stages in Sections 6.0 through 9.0.

4.5 TIMING OF ENFORCEMENT-LEAD ACTIONS

As explained previously, future remedial actions conducted by EPA are intended to be implemented in an "enforcement-lead" fashion. In other words, it is EPA's intention to obtain funding from PRPs for implementation. This issue affects the timing and staging of the specific actions (and components of actions) summarized in Table 4-8.

The implementation of remedial actions is typically preceded by an RI/FS and design. Actions that support enforcement include source identification, source investigation, and negotiation. These components can be interrelated in time; PRP identification and source investigations can begin at the same time feasibility studies are developed. This idea is shown schematically in Table 4-9 for two stages involving seven hypothetical remedial actions.

The columns in Table 4-9 represent units of time that are difficult to define at this time. Depending on the level of resources available and the type of activity to be undertaken, each column may represent anywhere between one and four years. It is clear that source identification efforts should begin at the outset of each stage to accelerate eventual implementation. Source investigation areas will be defined for the operable units that make up the stage, and identification efforts can begin on all operable units with an emphasis on those designated for initial implementation. Investigation of specific facilities can commence immediately upon their identification. Again, priority will be given to PRPs associated with the highest priority remedial actions. It should be noted that efforts are currently underway to investigate sources in much of the basin to recover costs for the Whittier Narrows and Bartolo Well Field Operable Units (Figure 4-5). Thus, identification and investigation efforts for subsequent actions may be substantially abbreviated.

The status of actions of a previous stage at the outset of a subsequent stage is particularly noteworthy in an enforcement-lead environment. In Table 4-9, actions associated with Stage III are separated from Stage II actions by the bold line. At the time Stage III begins, only one Stage II action would have been implemented, although feasibility studies would have been completed for all

Table 4-8
PROPOSED SCHEDULE OF IMPLEMENTATION

Stage	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
I			OU[1] A[2]	RI[3] 2 OUs			
II		RI	CR[4] RI	CR	CR RI A,B[2] OU A	CR RI	
III		RI B OU A	RI	RI	RI C[2] OU B	OU A	
IV	RI	OU B	OU	OU	OU C	OU B	RI
V	OU						OU

[1] OU = Operable unit (remedial action)
[2] A,B,C = Staged actions. New or modified OUs implemented in the same area to address more ambitious actions, or staged RIs undertaken to provide additional data in the same area, particularly in support of staged OUs.
[3] RI = Remedial investigations
[4] CR = Cost recovery investigations

Note: Stage I includes all previous or ongoing actions.
Area numbers refer to those defined in Figure 1-1.

Stage II actions. This overlap between stages provides a smooth, continuous level of effort with no gaps between the implementation of individual actions. The gap in time before initial implementation of Stage II operable units (the empty boxes in the lower left-hand corner of Table 4-9) will be filled by ongoing actions, particularly cost recovery actions and design and implementation of the Whittier Narrows Operable Units.

TABLE 4-9
CONCEPTUAL TIMING OF ENFORCEMENT-LEAD ACTIONS

TODAY ——————————— *TIME* ———————————→

RI/FS	STAGE II A	B	C	D	STAGE III E	F	G			
SOURCE INDENTIFICATION	ABCD	ABCD	BCD	CD	D | EFG	EFG	FG	G		
SOURCE INVESTIGATION	ABC	ABCD	ABCD	ABCD	BCD | EF	CDEFG	DEFG	EFG	FG	G
NEGOTIATION		A	B	C	D	E	F	G		
DESIGN			A	B	C	D	E	F	G	
IMPLEMENTATION				A	B	C	D	E	F	G

<u>EXPLANATION</u> COLUMNS REPRESENT UNDEFINED UNITS OF TIME THAT ARE PROBABLY VARIABLE IN LENGTH.

LETTERS REFER TO CONCEPTUAL OPERABLE UNITS (A, B, C, AND D ARE STAGE II ACTIONS; E, F, AND G ARE STAGE III ACTIONS.).

RI/FS = REMEDIAL INVESTIGATION AND FEASIBILITY STUDY.

F:\FIGURES\LA062440.TP\TAB4-9.DWG 12/18/89

5.0 EVALUATION OF REPRESENTATIVE OPERABLE UNITS

The prioritized issues and strategies developed in Section 4.0 provide a framework with which specific actions, including remedial actions associated with operable units, may be screened and selected for immediate and future implementation. The 38 potential operable units presented in Appendix A represent a wide variety of actions designed to address the remedial objectives described in Section 4.2.1 in specific portions of the basin.

Also contained in Appendix A are tables in which the potential operable units are compared in terms of their relative ability to satisfy their intended major objective as well as a comparative evaluation of factors affecting costs of implementation. Although these tables serve as a rough measure of relative cost-effectiveness, additional evaluation of these actions is required to provide a basis with which to select actions for inclusion in the basinwide plan.

To provide a basis for selection of actions for immediate and future implementation, three types of evaluations of potential operable units are described in this section:

1. Numerical modeling of groundwater flow and contaminant migration
2. Requirements regarding water supply and distribution
3. Estimated costs

One of the most influential factors on the present flow system in the San Gabriel Basin is the pumping of groundwater, which accounts for approximately 80 percent of the groundwater withdrawn from the alluvial aquifer (the other 20 percent represents groundwater discharge to rivers and subsurface flow out of the basin). Almost every operable unit considered involves an alteration of the current pumping pattern. It is essential that the effect of these changes on groundwater flow directions and contaminant migration be assessed. Implementation of operable units that require considerable changes to the location and magnitude of pumping centers without an adequate understanding of the hydrogeologic consequences could have harmful effects. Numerical modeling is a useful tool with which to assess these effects and can also be used to better define the optimal location and depth of extraction wells required to assure the ability of an operable unit to achieve its desired objective.

Installation and operation of extraction/production wells anywhere in the San Gabriel Basin will pose a variety of complex problems related to disposal of the treated water, if pumping rates exceed demand. Additionally, in most cases it will be necessary to shut down existing wells to assure the continued migration of contaminants towards the selected extraction wells. The water distribution and supply systems currently in use throughout the basin are complexly interwoven networks that are managed by a large number of institutions ranging from local, small-scale purveyors to statewide agencies. At this stage, the complexities of distributing water from a new source using the existing distribution system are too difficult to evaluate from a basinwide perspective. Instead, it is assumed in the assessments described below that the total amount of water pumped from the basin for remedial purposes will be the same as current production rates. Additional water extracted at new operable units will be balanced by a reduction of pumping or shutdown of existing wells elsewhere, typically located downgradient of the operable unit. Before implementing operable units, a detailed feasibility study will be conducted to determine the best combination of pumping and shut-down wells to provide the greatest benefits for contaminant migration control in a cost-effective manner.

Because it is unknown how much of the existing distribution system will be available and able to redistribute the water produced by operable units, two alternate scenarios have been assessed regarding the requirements of new pipelines. In the first scenario, the water produced and treated at the operable units is delivered directly to the nearest pipeline that is at least 12 inches in diameter. The assumption that the existing distribution system in the vicinity of the operable unit will be capable of distributing water from the newly producing wells probably represents the lowest cost method of handling redistribution. Detailed evaluation of the local distribution system would be required, however, to determine if this assumption is true for a particular operable unit. The second scenario assumes that none of the existing distribution network will be available to redistribute water. Instead, the water produced and treated at the operable unit will be distributed to the wells that were shut down or had pumping reduced at a rate similar to previous production through pipelines constructed as part of the operable unit. This scenario, under which the existing distribution system is not used at all, probably represents an upper-bound cost alternative for distributing treated water. The potential for distributing water produced in excess of demand to spreading centers or rivers will be discussed in a qualitative fashion. This and other considerations regarding water supply and distribution will be evaluated in much more detail as part of feasibility studies and design-level investigations conducted prior to implementing any operable unit.

Consideration of the probable actual costs of the recommended alternatives is required to construct a long-range plan consistent with funds available for this purpose. Cost and schedule estimates will be little more than rough approximations given the level of data available to evaluate a large number of remedial alternatives. As above, these estimates are presented principally for comparative purposes and will require substantial revision prior to implementing any of the recommended actions.

These three types of evaluations have been conducted on a representative subset of the 38 operable units listed in Appendix A. Analysis of a small number of operable units allows for more detailed evaluations than would be possible if all 38 operable units were evaluated in a more general fashion. Selection of a subset of the entire suite of alternatives is described below. The eight operable units selected for more detailed evaluation reflect nothing more than a representative range of potential remedial actions. They are not intended to include only those actions considered as the most important or of greatest priority. Rather, they are considered representative of the more complete range of alternatives listed in Appendix A. The results of evaluations of this small number of operable units will be extrapolated to other similar actions in later sections.

The following description of the selection of a representative subset of operable units is followed by three sections summarizing the results of the types of evaluations described above. These sections are summaries of more detailed descriptions of the evaluations contained in Appendixes C, D, and E.

5.1 IDENTIFICATION OF REPRESENTATIVE OPERABLE UNITS

Of the 38 operable units listed in Appendix A, 8 have been chosen as representative of the range of actions reflected in the entire list. These have been selected according to the following three criteria:

- Operable units located in different portions of the basin. It is evident that some portions of the basin should be given preference in the formulation of a long-range plan. However, if a long-range plan is to consider remediation of groundwater contamination throughout the basin, the different characteristics (particularly the hydrogeologic characteristics) of different parts of the basin should be considered in the course of future investigation. Furthermore, if detailed evaluations are performed on operable units from a limited area, extrapolation of those results to operable units in other areas may not be straightforward.

- Operable units that represent a variety of types of remedial actions. To best understand the economic, hydrogeologic, and institutional complexities of the different types of remedial actions possible, a list of representative alternatives should include most (if not all) of the types of remedial actions considered feasible, including those designed to simply maintain an adequate water supply, as well as those intended to reduce the extent of contamination or control its migration.

- Operable units that are likely to be implemented. Specific alternatives selected for additional analysis should include only those considered to be reasonable candidates for future implementation.

Accordingly, the eight operable units described below have been selected for the analyses described in the following sections and in Appendixes C, D, and E. Operable units are named according to the RI area they are in (by number), and by well groups they contain (by letter). Their locations within the San Gabriel Basin are shown in Figures A-1 through A-7 of Appendix A.

1E The primary objective of operable unit (OU) 1E is to control the migration of zones of VOC contamination in Area 1, in the westernmost portion of the basin. This OU consists of two wells located at the downgradient margin of two zones contaminated above MCLs. One of these has been removed from service and would resume pumping upon implementation of the OU. The average capacity of the wells is 1,466 gpm, with a total capacity of 2,931 gpm. When balanced with the historical production of the wells at which production is decreased, the OU wells extract an average of about 3,320 ac-ft/yr.

2J OU 2J is designed to control migration of the large zone of contamination in Area 2 with three new extraction wells along the downgradient boundary of the contaminated zone. Each well is designed to extract 3,000 gpm. Upon balancing OU extraction with the demand at other, surrounding production wells, the OU wells pump an average of about 13,866 ac-ft/yr.

2BCFK This operable unit is designed to remove contaminants from the large zone of VOC contamination in Area 2. It consists of 14 existing wells and an additional new well installed just downgradient of a small zone with high (greater than 50 ug/l) concentrations of contaminants. The average capacity of the OU wells is 1,905 gpm, with a total capacity of 28,570 gpm. The average OU extraction when adjusted to correspond to the historical pumping at nearby production wells is about 34,430 ac-ft/yr.

4K OU 4K consists of three new wells located downgradient of the large zone of contamination originating in Area 5. It is proposed as a means of controlling further migration of contaminants towards Whittier Narrows from Area 5, and, potentially, Area 6. The proposed new wells would also help control the migration of contamination from Area 6 towards the Whittier Narrows area. Wells that may be shut down or at which production may be substantially reduced downgradient of this operable unit are assumed in these evaluations to include several that make up the Whittier Narrows Operable Unit. Careful reevaluation of this assumption will be required prior to the design or implementation of such an action. The total capacity of these wells is expected to be about 6,250 gpm; the average annual extraction is 10,100 ac-ft.

5TUV OU 5TUV is designed to remove contamination from the largest contaminated zone in the basin (Area 5) with three new wells located within a large zone contaminated above 50 ug/l. Total capacity of these wells is 10,500 gpm, and the annual extraction is about 17,000 ac-ft.

5CDGFIJ OU 5CDGFIJ is comprised of three Area 5 operable units (5CDI, 5CDG, and 5IJ) and well cluster 5F. Cluster 5F is included because high levels of CTC have been detected. The objective of OU 5CDGFIJ is the same as that of OU 5TUV. However, OU 5CDGFIJ would remove contamination through 13 existing wells located throughout the contaminated zone of Area 5. The average capacity of these wells is 2,500 gpm (total capacity is 32,524 gpm. When this capacity is adjusted to the historical demand at surrounding production wells, the average extraction rate for the entire OU is about 45,000 ac-ft/yr.

5W OU 5W consists of four new wells located between Area 6 and the pumping center in the southeastern portion of Area 5. The new wells are intended to protect the pumping center from future migration of contamination from Area 6. Although contamination has already been detected at the pumping center, much higher levels of contaminants upgradient of these wells are expected to migrate towards it and further contaminate the production wells. The total capacity of the four wells is 10,000 gpm. Adjusted to the total historical demand of available production wells in the vicinity, the OU extraction rate is about 15,412 ac-ft/yr.

6AB Five existing wells in Area 6, all currently shut down because of contamination, are included in this OU. Implementation of OU 6AB would provide an additional source of water to the Puente Valley, as well as provide a degree of migration control from the upper reaches of the Puente Valley where some of the highest contaminant levels identified to date are currently found. The average capacity of these wells is about 788 gpm. The average annual extraction rate, when balanced with the historical demand of available production wells, is about 4,314 ac-ft/yr.

5.2 POTENTIAL EFFECTS OF REMEDIAL ACTIONS ON GROUNDWATER FLOW AND CONTAMINANT MIGRATION

The potential effects of remedial actions on groundwater flow and contaminant migration are evaluated through the use of numerical modeling of the eight OUs described above. Each operable unit is evaluated based on a comparison with a reference simulation. The reference simulation is described in some detail in the Draft Report of Remedial Investigations (EPA, 1989b). In this reference simulation, referred to as the base case model in the following paragraphs, the rates of groundwater pumping of the last 10 years are assumed to represent production in the San Gabriel Basin for the next 10 years.

A discussion of the general procedures used to modify the base case model to simulate the effects of the different OUs, followed by a detailed description of each OU simulation, and a discussion of results after 10 years (39 quarters-years) is presented in Appendix C. Generally, the base case model was modified for each OU simulation by increasing production at the OU wells and by reducing production downgradient. As mentioned previously, this produces no net change in the total basinwide production, minimizing disruption of the existing distribution system and avoiding the need to dispose of excess water. The results are evaluated based upon the relative effect of each OU on groundwater flow and contaminant migration. It should be noted that neither the base case nor the OU simulation consider continuing sources of contamination; the OU simulations are primarily designed to be comparative and should not be considered in absolute terms. Thus, the descriptions of reductions in the extent of contamination should be considered primarily in comparative terms. Likewise, descriptions of declining rates of contaminant removal should also be considered in this light. The effects of assuming no continuing sources on these evaluations are discussed in greater detail in Appendix C. The following section provides a brief evaluation of the results of each OU numerical simulation after approximately 10 years, and a brief discussion of their relative effectiveness.

1E The extent of the primary zone of contamination in the northwestern region of Area 1 after almost 10 years is about 0.25 square mile smaller in the OU simulation than in the base case. Differences in the extent of contamination as a result of base case pumping and extraction at OU 1E include a reduction of the contaminated zone by approximately 25 percent more than would otherwise occur in the northwestern portion of Area 1. Contaminant concentrations are reduced to approximately 5 ug/l near the northernmost OU well (see discussion above of the meaningfulness of this result). Contamination near the other OU well is below maximum contaminant levels (MCLs).

Regionally, the groundwater flow pattern does not reflect the production modifications made in OU 1E, as it flows in a southwesterly direction over much of Area 1. Towards the southwestern portion of Area 1, groundwater flows toward the northwest. Although regional patterns remain roughly the same, local flow directions are directed more toward the two OU wells than in the base case because of their relatively high production rates. This is particularly true in the area immediately west of the OU wells where groundwater flow is dominated by the effects of wells shut down in the OU simulations. These flow conditions suggest that a little less than half of the nitrate contamination in the area will be deflected toward the OU wells. The rest will continue to migrate predominantly westerly, with some deflection toward the south. Thus, it does not appear that nitrates will represent a significant portion of the contaminants extracted at the OU wells.

In comparison to present conditions, OU 1E effectively reduces the overall areal extent of contamination by approximately 90 percent (about 0.25 square mile). Thus, OU 1E appears to go beyond its intended objective of migration control. Levels of contamination decrease from 25 ug/l to below 5 ug/l near the northernmost OU well. The base case shows a similar pattern in the reduction of the extent and magnitude of contamination, albeit to a lesser extent.

2J A comparison of the results of the OU 2J and base case simulations suggests two significant changes: (1) the areal extent and localized zones of higher contamination (i.e., 25 ug/l and greater) in the central portion of Area 2 are reduced by about 0.25 square mile, and (2) the areal extent of contamination in the southern portion of Area 2, downgradient of the OU 2J wells, increases about 1.1 square miles. This increase is partially offset by an overall decrease in the extent of contamination above MCLs in the central part of Area 2. The increase in areal extent of contamination in the southern portion of Area 2 is certainly affected by the shutdown of wells in this area. The influence of the three OU wells on downgradient contamination is limited because of the combined effects of water being preferentially drawn from the north of Area 2, and the regional gradient being toward the southwest. However, in the central region of Area 2, the zone of contamination is more effectively reduced than in the base case because of the local increase in production around OU wells.

The effects of the OU are slightly wider spread than was the case with OU 1E. Slight shifts in the extent of VOC contamination occur in Area 5, which appear to result from slight increases in groundwater flow velocities along the western margin of Area 5. Most of the changes to the groundwater system, however, occur within a few miles of the OU extraction wells. Nitrate contamination above MCLs does not occur within any of the areas affected by this operable unit.

VOC contamination of 25 ug/l or greater appears to be completely removed from Area 2, except for the 25 ug/l zone in the center (again, here and below, see discussion of the effects of not considering continuing sources of contamination above and in Appendix C). The combined effect of changes to groundwater flow patterns, and the decreased pumping in the southern portion of

Area 2, will probably not alleviate the lower contaminant concentrations (i.e., less than 25 ug/l) in the southern portion of the area. The objective of migration control of this operable unit is thus generally met in terms of controlling migration of high-level contamination (greater than 25 ug/l). However, contamination of lower levels is less affected.

2BCFK A comparison of the results of the OU 2BCFK and the base case simulations, as with OU 2J, indicates two significant differences. First, in the central portion of Area 2, the areal extent of localized zones with concentrations in excess of MCLs are reduced by approximately 1.4 square miles. Second, the areal extent of contamination greater than 5 ug/l in the southern portion of Area 2, downgradient of the OU 2BCFK wells, increases by about 1.5 square miles. In the central portion of Area 2, the area prescribed by the 5 ug/l contour around OU 2BCFK is about 15 percent smaller than that of the base case. However, the area surrounded by the 25 ug/l contour contained within this 5 ug/l contour increases, and is approximately 40 percent larger in extent in the OU simulation than in the base case.

Regionally, water levels drop over much of the basin as a result of pumping OU 2BCFK wells. The effect of the OU is regional and is observed in all areas except 7 because OU 2BCFK is located within a zone of relatively high hydraulic conductivity and because of the large production rates of the OU wells. However, relatively minor effects are observed in the northern region of Area 5 because hydraulic gradients in that area are large enough to overcome the effects of the OU. Nonetheless, the effects on water levels do not appear to substantially affect groundwater flow directions; and none of the areas affected in terms of flow directions contain significant nitrate contamination. However, one of the wells turned off, in southwestern Area 3, contains nitrate contamination above 45 mg/l. If the zone is as small as is currently thought, nitrates will represent a very small fraction of the contaminants extracted at the OU wells.

The combined effects of changes in the regional gradient, and the decreased pumping in the southern portion of Area 2,will probably not remove contamination of lesser concentrations (i.e., 5 ug/l to 25 ug/l) in the southern portion of the area. Compared to OU 2J, however, OU 2BCFK's objective of removing contaminants can apparently be achieved in a relatively cost-effective manner as with only three times more production; OU 2BCFK removes seven times more contamination than OU 2J.

4K After 10 years of pumping OU 4K wells, the major zone of contamination above 5 ug/l in Area 5 migrates approximately 1 to 2 miles toward the south, at both its northern and southern extent. Compared to the base case simulation, the southern extent of this zone appears to have migrated southeast and increased the size of the contaminated zone by approximately 5 percent (or about 0.26 square mile) in Area 6. On the other hand, in the vicinity of Whittier Narrows, the extent of contamination is reduced by 5 to 10 percent (or about 0.2 square mile). Currently, these parts of Areas 4 and 6 do not appear to be contaminated. Toward the south of Area 4, the OU simulation results suggest that contamination after 10 years has been entirely removed from Area 4 except for 2 small isolated zones of 5 ug/l contamination. In the base case simulation, substantially more contamination remains in this southern area of Area 4 after the same amount of time.

The migration of contaminants from Area 5 appears not to have been effectively stopped by the OU wells in Area 4, suggesting that production rates at the OU wells are insufficient. Actions intended to control migration require a particularly high level of remedial investigation to adequately design screening intervals and pumping rates on the basis of the vertical extent of contamination. In the numerical model, the vertical location of contaminants is highly generalized. With the appropriate data, an actual OU, designed to selectively extract from discrete vertical intervals, may be far more effective at controlling migration than is implied by this analysis.

No areas of significant nitrate contamination above MCLs appear affected by OU 4K. Nevertheless, the presence of nitrate contamination above MCLs a little over a mile upgradient of the OU wells suggests that it may be expected to reach their zone of influence well within 10 years. Overall, the general direction of groundwater flow does not vary significantly, either regionally or locally.

Contamination in the southern region of Area 4 decreases primarily as a result of the decrease in downgradient production rates. Hydraulic conductivities are relatively high (100 ft/day) through Whittier Narrows, which enhances the already rapid transport of contaminants through the area. The objective of migration control, as stated above, would most likely be far better achieved by a carefully designed extraction system than is suggested by the results of this simulation.

5TUV Because of extraction at the three OU 5TUV wells, zones contaminated above 5 ug/l and 25 ug/l are reduced by approximately 5 to 10 percent within the north end of the main zone of contamination in Area 5, after approximately 10 years. The area above 25 ug/l in the southeastern corner of Area 5, the result of migration of contaminants from Area 6, is reduced by approximately 10 to 15 percent in comparison to the base case. Areally, these percentages correspond to a total reduction in the extent of all zones of contamination by about 1.8 square miles after 10 years (assuming no continuing sources). Toward the south, however, the area above 5 ug/l in the OU 5TUV simulation, also associated with contamination in Area 6, is 5 percent greater (increases by less than 0.4 square mile) than in the base case.

Contamination after 10 years in the OU simulation is substantially reduced because of the change in groundwater flow directions toward the OU wells in the center of Area 5. These wells also represent a significant increase in production relative to most wells in the base case. The increase in areal extent of the contaminated zone in the southern part of the area is probably the result of decreased production in that region. The decreased production allows local groundwater flows to be influenced more by regional groundwater flows than by nearby production.

Although very slight shifts from base case flow directions are evident over a relatively large portion of the basin, overall the regional effects of this OU are small. The greatest changes in flow directions occur in the immediate vicinity of the OU extraction wells, and in southeastern Area 5, near the mouth of the Puente Valley where a large number of wells are turned off. Because two of the OU wells border nitrate contamination above MCLs, it is clear that nitrates can be expected to be extracted from these wells throughout the lifetime of this OU. Pumping at these wells will shift the regional southwesterly flow direction somewhat more to the west, which may hasten the spread of contaminants toward them. However, nitrate contamination may be expected to reach the northern two OU wells whether or not they are returned to production. Furthermore, it appears likely that extraction and treatment at these wells may delay nitrate contamination from migrating past them to the west and southwest in this northern area of Area 5.

The goal of OU 5TUV of removing contamination from Area 5 appears to be effectively addressed, given the assumptions of actual extent of contamination and continuing sources represented in the numerical model.

5CDGFIJ This OU is similar to OU 5TUV, except that OU 5CDGFIJ uses existing wells and pumps approximately twice as much water. Effects on the location and extent of the major zone of contamination in Area 5 does not appear significantly different as a result of OU 5CDGFIJ pumping as for 5TUV pumping. After 10 years, contamination migrates approximately 1 to 2 miles to the south. The area contaminated above 5 ug/l in the OU simulation appears to migrate in an easterly direction in Areas 6 and 7, and southern Area 5, increasing the extent of contamination by approximately 5 percent as compared to the base case. Contamination also appears to migrate to the west, toward Whittier Narrows. In the central part of Area 5, the results of the OU simulation indicate that the zone of VOC contamination above 5 ug/l is reduced by approximately 10 to 15 percent overall compared to the base case. The zone contaminated above 25 ug/l is reduced by approximately 20 percent at the north end of the main zone of contamination in Area 5. In less than 10 years, these percentages correspond to a total decrease in the areal extent of zones contaminated above 5, 25, and 75 ug/l in the central portion of Area 5 of about 6.5 square miles. A small increase of about 0.6 square mile near the Puente Valley also occurs.

In general, groundwater flow directions and magnitudes throughout the San Gabriel Basin are similar in the base case and OU 5CDGFIJ simulations. The OU 5CDGFIJ wells are close enough to the westernmost boundary of nitrate contamination above MCLs to assume that substantial nitrate contamination will be extracted along with VOCs. In fact, the predominant southwestern flow may be expected to carry nitrates into the vicinity of some of these wells whether or not production is resumed. As with OU 5TUV, OU 5CDGFIJ wells will probably form a fairly effective barrier to continued migration of nitrate contamination in the northern parts of the basin. Some additional spread of nitrate contamination, however, may result from pumping of the southernmost OU wells.

OU 5CDGFIJ appears capable of a high degree of contaminant removal. Compared to OU 5TUV, OU 5CDGFIJ removes contamination approximately 2.5 times more effectively, with only twice the rate of extraction. Again, remedial investigations performed prior to implementation of this OU will allow considerable refinement in well design. However, the large mass of contamination removed in the numerical simulation indicates a huge potential for substantially reducing contamination in Area 5 with an action of this type. Furthermore, although contaminants removed by OU 5CDGFIJ wells will be limited to the intervals penetrated by the existing wells, supplemental extraction by new wells (i.e., OU 5TUV) would prove even more effective in removing contaminants from throughout the aquifer, particularly from great depths not influenced by existing wells.

5W The objective of Operable Unit 5W is the protection of a large regional pumping center, located just above Area 6 in the southeastern corner of Area 5, from contamination upgradient in Area 6. Simulation results suggest that migration of the large zone of contamination in Area 6 is prevented by the OU wells, thereby successfully protecting the pumping center. After 10 years, contamination of 25 ug/l or greater is centered around the OU wells on the border of Areas 5 and 6. The primary zone of contamination in Area 5 migrates approximately 1 to 2 miles more to the south than in the base case. At its southern extent, this zone appears to migrate to the southwest, toward Whittier Narrows in Area 4.

Relative to the base case, the results of the OU simulation indicate that the zone contaminated above 5 ug/l is reduced by approximately 15 percent after 10 years. This reduction occurs primarily in the southern portion of Area 5, with some reduction taking place in the northwestern portion of Area 6. The greater than 25 ug/l zone is reduced by approximately 10 percent in the same locations. The overall areal extent of potential contamination greater than 25 ug/l that is prevented by this OU in 10 years is 3.14 square miles in the numerical simulation. In the northern parts of Area 5, the main zone of contamination does not appear to undergo significant change from the base case.

Flow throughout the southeastern Area 5, northern Area 6, and the southwestern corner of Area 7 is substantially affected by pumping the OU 5W wells. Most of the changes in direction occur toward the OU wells. The shifts in the extent of contamination in central Area 5 shown in Figure C-30 can be seen in Figure C-31 to be the result of shifts in flow directions in that area. Nitrates occur above MCLs throughout the area and are expected to be a significant component of the contaminants extracted at the OU wells. Overall, the effects of the OU wells on the current extent of nitrate contamination may well be beneficial: much of the southwesterly flow that has been responsible for spreading nitrate contamination in the area will be diverted in southerly and southeasterly directions toward the OU wells. This may not only control the migration of nitrates, but may eventually reduce their extent substantially in this area.

In the simulation, OU 5W accomplishes its objective of preventing further contamination of groundwater at the pumping center in the southeastern region of Area 5. In the base case, groundwater flows from Area 6 through the pumping center in the southeastern region of Area 5. It continues southwest towards Whittier Narrows, allowing contamination to pass through the pumping center as it is transported through Area 4. In the OU simulation, contamination from the Puente Valley, however, is captured earlier and more effectively than in the base case because of the greater localized production upgradient of the pumping center in Area 5, relative to the base case production in the same area.

6AB Comparison of the base case and OU 6AB simulation results suggests that migration of the western margin of contamination exceeding 5 ug/l in Area 6 is slowed because of the effect of OU production upgradient in the Puente Valley. However, because of the decrease in migration northward out of the valley, the zone contaminated above 5 ug/l increases in areal extent by approximately 5 percent (about 0.6 square mile) in Area 6, and decreases by approximately 5 percent (about 0.6 square mile) in Area 5 after 10 years. Simulation results suggest that contamination of 25 ug/l or greater is completely removed from Area 6 in the absence of continuing sources. Alternatively, contamination exceeding 25 ug/l in the southeastern region of Area 5 increases by approximately 25 percent in areal extent in response to the decrease in production in this area. The direction of this increase in areal extent is toward Area 6. OU production in Area 6 affects the extent of contamination in Area 7, as indicated by the 5 ug/l contour, which appears to be drawn more toward Area 6. Other zones of contamination within the basin do not appear affected by the OU pumping in the simulation.

Within the Puente Valley, flow directions are shifted in a more northerly direction downgradient of the OU wells in the OU simulation than in the base case simulation. The resultant deterrence of westward migration out of the Puente Valley may be one of the more important effects of this action. The spread of VOCs occurring west of the mouth of the valley is reduced, while the extent of contamination at the valley mouth itself is increased. This degree of migration control is remarkable in an operable unit as small as this one that relies on existing wells. Used in conjunction with other actions that address contamination at the valley mouth itself, it may prove effective as a means of managing migration out of the valley toward Whittier Narrows.

The migration of nitrate contamination above MCLs, which occurs throughout the area, may not be significantly altered by OU 6AB. However, the extent of nitrate contamination in the area is highly interpretative in the western corner of Area 6 where there are almost no data available. If nitrates are present in that area, their migration toward Whittier Narrows will be slowed in the same way VOC contamination is affected.

OU 6AB achieves its objective of providing additional treated groundwater to Area 6 without significantly increasing the contaminant levels or areal zones of contamination simulated in the base case. However, a degree of migration control west of the mouth of the Puente Valley appears to be an important by-product of pumping these wells.

In general, most of the operable units successfully reduce the spread of contaminated areas after less than 10 years of operation with the assumption of no continuing sources. Although these simulations, based on a regional numerical model with regionally averaged properties, can only approximate the actual effects of changing pumping patterns, the results emphasize the need to carefully assess the potential for spreading contamination into uncontaminated areas. Much of this spreading can probably be avoided by choosing other wells at which to reduce pumping. In addition, with a finer understanding of local conditions, new extraction wells can be designed, and existing wells modified, to more effectively remove contamination than was possible to be shown with the numerical model.

Table 5-1 summarizes the pumping rate, amount of contaminants removed, and the effect on contaminant transport of each OU. The mass of contaminants removed is a function of the pumping rate and of the concentration of the groundwater pumped in each OU. OUs 5CDGFIJ and 5TUV remove the most contamination from the basin because these wells have the highest rate of production and are located in the most extensively contaminated portions of the basin. On the other hand, OUs 6AB and 1E remove the smallest amount of contamination.

5.3 POTENTIAL EFFECTS OF REMEDIAL ACTIONS ON WATER SUPPLY AND DISTRIBUTION SYSTEMS

Remedial actions at the eight representative operable units described above typically involve extraction of contaminated water at OU wells, eliminating or reducing production at downgradient and upgradient wells, treatment to reduce contaminants in the extracted groundwater to concentrations below drinking water standards, and redistribution of the treated water. As discussed in Section 5.2, defined in this manner, the proposed remedial alternatives result in no net change in basinwide groundwater extraction. However, by modifying

Table 5-1
SUMMARY OF RESULTS OF 10-YEAR SIMULATIONS OF REPRESENTATIVE OPERABLE UNITS

OU	Total Capacity (gpm)	Average Production Rate (ac-ft/yr)	Mass of Contaminants Removed (lb/10yrs)	Areas Where Concentration Changed
1E	2,931	3,320	1,022	Area 1 (-)
2J	9,000	13,840	1,053	Central Area 2 (-) South Area 2 (+)
2BCFK	28,570	34,400	7,340	North Area 2 (-) South Area 2 (+)
4K	6,250	10,000	1,092	West Area 6 (+) North Area 4 (-)
5TUV	10,500	16,800	8,457	Central Area 5 (-) Southeastern Area 5 (+)
5CDGFIJ	32,524	39,600	52,813	Central Area 5 (-) Southeastern Area 5 (+)
5W	3,400	15,400	3,799	Area 6 (-) Southeast Area 5 (-) Central Area 5 (+)
6AB	1,366	4,000	567	Area 6 (-) Southeast Area 5 (+/-)

Note: (-) Indicates concentrations decreased in OU simulation compared to the basecase; (+) indicates an increase.

current extraction patterns, transfer and exchange of treated water across purveyor service boundaries are required in most cases. Treatment of extracted water and redistribution of treated water to areas served by wells at which production is reduced or eliminated (collectively termed "shut-down" wells in this section) are discussed below; additional details are included in Appendix D.

Redistribution of the treated water is, in most cases, the single most important component of the cost of implementing remedial measures. Currently, detailed information on existing water distribution pipeline systems, the physical conditions of the pipelines, network operation details, pipeline ownership, and other related factors for the 45 water purveyors has not been compiled. Therefore, at this stage, evaluations of the use of existing pipelines to distribute treated water are difficult. To develop preliminary cost estimates for implementation of the OUs, two alternative pipeline alignments are evaluated. The first alternative assumes that existing pipelines greater than 12 inches in diameter are available for the redistribution of water. In this alternative, pipelines are assumed to be required to deliver the water from the treatment plants to the nearest existing 12-inch pipeline. However, it is recognized that the existing pipelines are currently being used to deliver water from currently producing wells to their service areas. These pipelines may not, therefore, be available to distribute water from operable unit wells, unless the currently producing wells are shut down. To take this limitation into account, a second alternative is proposed in which the treated water is delivered directly to the shut-down wells through new pipelines. Costs associated with constructing new pipelines are generally higher than those incurred by using the existing pipeline network to the extent possible.

Actual pipeline costs are expected to generally fall between those estimated in the following section for both of these alternatives. In some cases, however, substantial redesign at the feasibility-study stage may result in a cost that is outside (probably below) this range. It is likely that, in some cases, significantly fewer wells may be required to be shut down and tied into a redistribution network. For example, as shown in Table D-1 in Appendix D, 40 percent of the wells assumed shut down for OU 1E represent about 10 percent of the total OU production. It is not likely that shutting down these wells will be considered worth the cost based on their minimal contribution; and the overall cost of the OU would, in that case, be considerably reduced.

A feasibility study of alternate methods of redistributing the treated water will be performed prior to implementing any OU. Depending on conditions at the time of implementation, it may be determined that disposal of excess water to spreading centers or river channels is preferable to redistributing pumped water. However, as discussed in Section 5.2, the efficacy of the OUs is typically enhanced by limiting or eliminating production from existing production wells. One way of reducing redistribution requirements with a potentially minimal effect on the efficacy of the OU is to incorporate a conjunctive-use scenario into the remedial action. With conjunctive use, it may be possible to expand extraction at OU wells and export the treated water, and minimize the effect on currently producing wells. Selection of the appropriate strategy will be determined on a site-specific basis.

The following discussion summarizes target treatment levels, treatment technologies for VOC removal, treatment facility siting criteria, pipeline design assumptions, and distribution of treated water to shut-down wells. This discussion is presented in greater detail in Appendix D.

SARA guidance proposes that a range of treatment criteria be considered in remedial action alternatives. Applicable and Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) provide the treatment criteria. To qualify as ARARs, both federal and state MCLs must be promulgated. For compounds that have no MCLs, other standards such as California Action Levels (ALs) and Federal Health Advisories are generally used. General ranges of target treatment levels for various contaminants are listed in Appendix D.

Based on a review of available physical and chemical treatment technologies (EPA 1988), the most viable technologies for removal of VOCs observed in groundwater from the San Gabriel Basin include: stripping (e.g., pack tower air, rotary air, steam); granular activated carbon (GAC); and advanced oxidation. The relative applicability of each technology to treat VOCs found in San Gabriel Basin groundwater is also tabulated in Appendix D. Evaluation and selection of a specific treatment process for each OU will be addressed in a feasibility study completed prior to its implementation.

Treatment facility siting has a direct impact on the water supply and distribution system. Few undeveloped properties are currently available in the San Gabriel Basin for siting such a facility. Existing development, right-of-way, land use restrictions, community acceptance, centralized or decentralized plants new pipelines required to convey water from extraction wells to treatment plant, and distribution of treated water to shut-down wells are some of the factors that affect the siting of a treatment facility. For the purposes of this assessment, the number of required treatment facilities proposed is estimated to minimize both the length of pipeline required to transport extracted water to treatment facilities and treatment costs. However, because this assessment is based on limited data, it should be considered preliminary and subject to substantial revision prior to the actual design and implementation of these operable units.

Estimates of the size and locations of pipelines are based on estimated period peak flows used as withdrawal rates from extraction wells and reduced production rates for wells that are shut down. The maximum quarterly demand is used to estimate maximum daily peak flow, assuming that peak hourly demand will be met by the existing system's storage. Pipelines are sized to minimize head loss, without installing excessively large pipe. Approximate pipeline layouts follow existing pipelines, where possible, to reduce easement conflicts. Table 5-2 lists the number of treatment facilities, their size requirements, and pipeline lengths to redistribute treated water into the existing distribution network (Alternative 1). Table 5-3 lists the same information for Alternative 2, in which treated water is redistributed to the shut-down wells.

The following paragraphs provide a brief evaluation of the assumed distribution of treated water at each OU. These descriptions are summaries of more detailed discussions presented in Appendix D, including Figures D-1 through

D-16, which show the proposed pipeline alignments and treatment plant locations for the two alternatives.

1E Operable Unit 1E consists of two existing wells pumped at capacity with a combined total of 1,184 acre-feet per quarter (ac-ft/qtr). These wells are within an area contaminated above 25 ug/l. Wells that are shut down are both downgradient and upgradient of the OU extraction wells. One of the OU wells is owned by the same purveyor who also owns nine of the shut-down wells, five of which are downgradient and in the vicinity of the OU well. Locating a treatment plant close to this well should allow for the

Table 5-2
SUMMARY OF ESTIMATED PIPELINE LENGTHS AND TREATMENT PLANT CAPACITY REQUIREMENTS - ALTERNATIVE No. 1
(Distribution of treated water to nearest existing 12-inch or greater pipeline)

Operable Units	Pipe Line Diameter (inches)	Length (feet)	River Crossings	Highway Crossings	Treatment Plant Number	Size (gpm)	VOC Concentration (ppb)	Nitrate Concentration (ppm)
1E	12	13,950	2	0	1	1,500	25	<45
	18	8,200	1	0	2	1,500	25	<45
2J	12	3,900	0	0	1	10,000	25	<45
	18	12,400	1	0				
	24	2,900	0	0				
	30	14,300	2	2				
2BCFK	12	28,600	1	1	1	23,750	25	<45
	18	23,300	4	0	2	4,850	25	<45
	24	21,850	2	0				
4K	12	10,100	1	1	1	3,125	25	>45
	18	21,600	0	0	2	3,125	25	>45
5TUV	12	4,900	1	0	1	10,000	25	>45
	18	31,700	0	0				
	24	26,100	0	1				
5CDGFIJ	12	13,800	0	1	1	12,000	100	>45
	18	25,600	4	0	2	12,000	100	>45
	24	27,400	0	0	3	15,000	100	>45
5W	12	2,400	0	0	1	10,000	50	>45
	18	13,900	0	0				
	24	6,500	0	0				
6AB	12	2,250	0	0	1	3,250	25	>45
	18	13,400	0	1				
	24	7,000	0	0				

Note: VOC Volatile organic compound(s)
gpm Gallons per minute
ppb Parts per billion
ppm Parts per million

redistribution of treated water to these five wells using existing pipeline with relatively minor amounts of additional pipeline to accommodate the increased production at the OU well. A second treatment plant is required for the other OU well.

Thus, the first distribution alternative for OU 1E is predominantly made up of pipeline from the wells to treatment plants, with some additional 12- and 18-inch-diameter pipelines supplementing the existing network (Table 5-2). Detailed analyses of the current pipeline network may reveal that it is inadequate for redistributing the total capacity of treated water from these facilities to service areas. The second distribution alternative

Table 5-3
SUMMARY OF ESTIMATED PIPELINE LENGTHS AND TREATMENT PLANT CAPACITY REQUIREMENTS - ALTERNATIVE No. 2
(Distribution of treated water to shut-down wells)

Operable Units	Pipe Line Diameter (inches)	Length (feet)	River Crossings	Highway Crossings	Treatment Plant Number	Size (gpm)	VOC Concentration (ppb)	Nitrate Concentration (ppm)
1E	12	21,000	3	0	1	1,500	25	<45
	18	15,000	1	0	2	1,500	25	<45
2J	12	29,000	2	0	1	10,000	25	<45
	18	13,000	0	0				
	24	11,000	2	1				
2BCFK	12	34,000	4	0	1	23,750	25	<45
	18	13,000	4	1	2	4,850	25	<45
	24	27,000	4	0				
4K	12	21,000	2	1	1	3,125	25	>45
	18	32,000	1	4	2	3,125	25	>45
5TUV	12	7,400	0	1	1	10,000	25	>45
	18	19,800	0	1				
	24	48,800	2	2				
5CDGFIJ	12	68,600	2	2	1	12,000	100	>45
	18	63,400	2	2	2	12,000	100	>45
	24	47,500	2	2	3	15,000	100	>45
5W	12	10,500	0	0	1	10,000	50	>45
	18	11,100	1	2				
	24	13,200	0	0				
6AB	12	15,300	0	0	1	3,250	25	>45
	18	3,400	0	0				
	24	16,400	2	0				

Note: VOC Volatile organic compound(s)
gpm Gallons per minute
ppb Parts per billion
ppm Parts per million

includes much more pipeline interconnecting the treatment facilities with the shut-down wells (Table 5-3). The second alternative includes new pipelines to distribute treated water to the currently producing wells, from which the water can be routed to service areas as at present.

2J This OU consists of three new wells with a combined capacity of 3,600 ac-ft/qtr. The total OU production rate has been set at 3,460 ac-ft/qtr to balance existing production at downgradient wells. The three OU wells are within one-half mile of one another. Considering the relative closeness of these wells, one treatment facility is proposed for treatment of extracted water from all three OU wells. The shut-down wells are both upgradient and downgradient of the OU wells. The proposed distribution pipelines parallel the existing pipeline, where possible. In areas where existing pipelines have not been identified, proposed pipelines generally follow existing roads.

Pipelines proposed for the first alternative (Table 5-2) include 12- and 18-inch-diameter pipes to distribute water from the wells to the treatment facility, and pipes up to 30 inches in diameter to distribute treated water to the existing distribution system within purveyor boundaries. In the second alternative (Table 5-3), considerably greater lengths of pipeline are required to distribute the water from the treatment facility to each of the shut-down wells.

2BCFK The objective of OU 2BCFK is to utilize one new well and 14 existing wells to remove contamination within Area 2 at a recommended overall rate of 11,542 ac-ft/qtr (Appendix A). Considering the large area covered by the shut-down wells, redistribution of treated water requires crossing several purveyor boundaries, and interconnecting extraction wells with shut-down wells may require substantial construction of new pipelines. Because the OU wells are clustered in two general areas within Area 2, two treatment facilities are proposed.

Estimated pipeline lengths and treatment facility sizes for both alternatives are summarized in Tables 5-2 and 5-3. Because of the large number of wells involved, considerable pipeline is required just to deliver the water to centralized treatment facilities, and, from there, to purveyor service areas. In the second alternative, new pipeline connects wells south and west of the operable unit with the southernmost treatment facility. In addition, delivery of treated water to shut-down wells east and west of clusters 2B and 2C requires extensive new pipeline.

4K The objective of OU 4K is to manage the migration of contaminants from Areas 5 and 6 into Area 4. The production capacity of the three OU wells is approximately 2,525 ac-ft/qtr. These wells are within the area of groundwater contamination exceeding 25 ug/l. To balance OU production with historical production rates at other wells, production at wells both upgradient and downgradient of the OU is reduced or eliminated.

Two treatment facility locations are proposed at either end of the three aligned OU extraction wells. In the first pipeline alternative, a total of 31,700 feet of 12- and 18-inch-diameter pipeline is used to convey water from the extraction wells to the treatment facilities, and to deliver the treated water from these two facilities to the existing distribution system (Table 5-2). In the second alternative, 21,300 additional feet of pipeline are required to deliver the treated water to each of the shut-down wells (Table 5-3).

<u>5TUV</u> Operable Unit 5TUV consists of three new wells, each producing 1400 ac-ft/qtr (production capacity totalling approximately 4,242 ac-ft/qtr). The objective of this OU is to remove contamination at depth within Area 5. The OU wells are within the area contaminated above 25 ug/l. Because all the shut-down wells are downgradient (south) of the OU extraction wells, one potential treatment facility, located at the southernmost OU well, is considered suitable, particularly as a central location for the redistribution of treated water. Interconnection of the OU extraction wells with the identified treatment facility requires approximately 4.5 miles of new pipeline. The first alternate pipeline layout (Table 5-2) requires a total of almost 12 miles of pipeline, between 12 and 24 inches in diameter, to deliver water to the treatment facility, and deliver treated water to purveyors' service areas. Pipeline lengths may be reduced somewhat through a more thorough evaluation of the existing distribution system, in the course of conducting a feasibility study, to identify more convenient connection points into the existing system.

The second alternative (Table 5-3), in which existing pipelines are assumed to be unavailable, requires a total of about 14 miles of pipeline. To distribute treated water to the shut-down wells, two mains along the existing pipelines (where possible) are proposed.

<u>5CDGFIJ</u> The objective of Operable Unit 5CDGFIJ, as with OU 5TUV, is to remove contamination from Area 5. This operable unit is made up of 13 existing wells within the area contaminated above 25 ug/l in Area 5. A combined production rate of 13,139 acre-ft/qtr

is recommended in Appendix A. Individual production rates of wells vary from 400 gpm to 4,200 gpm. Because wells shut down downgradient and upgradient of the OU wells do not meet the 13,139 ac-ft/qtr of production at OU wells, OU production is reduced to 9,900 ac-ft/qtr. OU extraction wells are distributed such that treatment of extracted water at three central locations is considered suitable and cost-effective.

The first distribution alternative for OU 5CDGFIJ (Table 5-2) includes over 12 miles of new pipeline up to 24 inches in diameter to transport water to the three treatment facilities, and to distribute treated water into existing pipelines. Almost 34 miles of pipeline, on the other hand, are required to deliver treated water to each of the shut-down wells (Table 5-3).

5W

The objective of Operable Unit 5W is to protect a large regional pumping center from contamination downgradient of Area 6, in the southeastern corner of Area 5. The OU uses four new wells, located in Area 5, just upgradient of the pumping center. With a combined production of 10,000 gpm or 4,040 ac-ft/qtr, each well is assigned a recommended production of 2,500 gpm. These wells are within the greater than 25 ug/l contamination zone. To balance the extraction rates with the historical pumping volumes at available shut-down wells, OU production is reduced to approximately 3,850 ac-ft/qtr. Considering the proximity of the four OU extraction wells, one centrally located treatment facility is considered adequate. Delivery of extracted water to the facility, and of treated water to the purveyor's service area, is estimated to require about 4.3 miles of pipeline between 12 and 24 inches in diameter (Table 5-2).

For the second distribution alternative (Table 5-3), shut-down wells in this OU can be grouped into two sets for distribution of treated water. Nine of the shut-down wells are in the vicinity of the OU wells. These are served by a few, relatively short 12- and 18-inch-diameter pipelines. The remainder of the downgradient wells are approximately 2.5 to 3 miles from the OU wells. These may be served by a 24-inch pipeline. Approximately 6.6 miles of pipeline are required for the second alternative.

6AB

Although the original primary objective of Operable Unit 6AB, as described in Appendix A was to provide drinking water, the numerical evaluations described in the previous section and in Appendix C illustrate its ability to slow the migration of contamination in the Puente Valley westward toward Whittier Narrows. This OU utilizes five existing wells currently shut down. The OU wells will produce a total of 1,312 ac-ft/qtr if pumped at capacity, with individual production rates ranging from less than 200 gpm to 1,500 gpm. To balance these extraction rates with historical rates of shut-down wells, this evaluation considers a total production rate of approximately 1,000 ac-ft/qtr. Because of the proximity of the OU wells to one another, one treatment facility is considered adequate.

The OU wells are located within an area in which groundwater contamination exceeds 25 ug/l. The first distribution alternative includes over 4 miles of pipeline linking the extraction wells with the treatment facility, and delivering treated water to the purveyor's service area (Table 5-2). The location of the treatment facility adjacent to the service areas of existing wells minimizes the need for extensive new pipeline. The second alternative includes about 6.6 miles of pipeline to treat the extracted water and deliver it to the shut-down wells (Table 5-3). Most of the pipeline in the second alternative is 24 inches in diameter.

5.4 ESTIMATED COSTS

Cost estimates developed for the representative subset of operable units described above are detailed in Appendix E and summarized in this section. These are primarily based on information developed in Appendixes A, C, and D. In most cases, very little design detail is available as an estimate basis. Accordingly, these estimates have been developed using aggregate quantities for the two alternate water distribution systems and conceptual-level information for treatment facilities. The general assumptions regarding the configuration of water distribution systems discussed in the previous section clearly influence these cost estimates considerably. Because of the level of detail of the information available and the assumptions used regarding water distribution requirements, these estimates may be considered conservative.

The estimates summarized in this section and described in more detail in Appendix E are Rough Order of Magnitude (ROM) estimates. This type of estimate, typically prepared with preliminary or conceptual information, has a range of confidence of -30 percent to +50 percent. Estimates for operable unit feasibility studies (OUFSs) are generally also ROM type estimates, although more information regarding the configuration of the various alternatives is available than for the present set of estimates. In the case of either set of estimates, these evaluations of probable cost should be utilized for comparative purposes only.

The pricing of these estimates is for the greater Los Angeles area for mid-1989. No attempt has been made to escalate these costs to a future time period as the specific periods of performance are not readily determinable at this time.

The following paragraphs summarize the costs estimated for each of the representative operable units. Estimates for each of the components of the total operable unit cost are based on a variety of assumptions documented in Appendix E. Tables itemizing these components are also included in Appendix E; a summary of the information in Appendix E is provided in Table 5-4. Two separate tables representing the two distribution alternatives are presented for each operable unit in Appendix E. The two sets of costs are also summarized separately in Table 5-4. In the remaining sections of Volume One of this report, many of the summary costs will be described in terms of the median (or arithmetic mean) of costs estimated for the two distribution alternatives. The use of a single number to describe the potential cost of an operable unit greatly simplifies many of the discussions and cost summaries presented in later sections. There is no basis for the use of a median other than the assumption that actual costs are likely to fall between those estimated for each of the distribution alternatives (if the OU includes the specific extraction and shut-down wells assumed in Appendix C).

<u>1E</u> Neither of the two treatment facilities proposed for OU 1E require off-gas carbon absorption treatment because of the relatively small flows and concentrations anticipated. The total Remedial Action (RA) Capital Cost for the first OU 1E alternative is estimated at $7,501,000, with a total OU Cost of $8,133,000 (Table 5-4). The total RA Capital Cost for the second OU 1E alternative is estimated at $9,332,000, with a total OU Cost of $9,964,000. The estimated annual O&M costs of the two alternatives are $188,000 and $211,000, respectively.

<u>2BCFK</u> This operable unit is characterized by relatively large piping quantities, particularly for the second distribution alternative. Capital and O&M cost estimates for the two distribution scenarios are summarized in Table 5-4. Estimated treatment costs incorporate vapor-phase carbon treatment on the air stripper off-gas system. The estimated Capital Cost for the first distribution alternative is $40,456,000 while the Total OU Cost is estimated at $41,420,600.

The estimated total Capital Cost for the second distribution alternative is $64,444,000. Estimated remedial investigation and feasibility study costs bring the total to $65,408,600. The estimated annual O&M costs for the two alternatives are $1,560,000, and $1,926,000, respectively.

Table 5-4
SUMMARY OF COST ESTIMATES
SUBSET OF REPRESENTATIVE OPERABLE UNITS

Operable Unit	Extraction Wells	Piping and Pumping	Treatment Facilities	Other Construction	Total Construction[1]	Total Cap. Cost[2]	Monit. Well Install.	Other RI	FS	Total Cost	Annual O&M
FIRST DISTRIBUTION ALTERNATIVE											
1E	-	$2,683,500	$344,000	$575,100	$5,043,700	$7,501,000	-	$89,600	$542,400	$8,133,000	$188,000
2BCFK	$272,000	17,108,300	2,195,000	1,568,000	29,600,600	40,456,000	$200,600	40,000	724,000	41,420,600	1,560,000
2J	815,900	8,320,000	1,064,000	1,005,500	15,687,600	21,419,000	259,800	44,800	542,400	22,266,000	589,000
4K	815,900	4,787,600	1,472,400	818,000	11,051,500	15,563,000	-	-	542,400	16,105,400	495,000
5CDGFIJ	-	17,325,500	7,578,700	1,887,700	37,508,700	51,435,000	778,400	-	724,000	52,937,400	3,591,000
5TUV	815,900	11,123,000	2,105,100	1,236,100	21,392,100	29,074,000	-	-	724,000	29,798,000	881,000
5W	1,087,800	5,749,400	2,105,100	930,000	13,821,200	18,914,000	-	-	542,400	19,456,400	765,000
6AB	-	3,649,200	755,100	657,700	7,086,800	9,877,000	-	60,000	542,400	10,479,400	296,000
SECOND DISTRIBUTION ALTERNATIVE											
1E	-	3,603,200	344,000	630,300	6,408,500	9,332,000	-	89,600	542,400	9,964,000	211,000
2BCFK	272,000	29,153,400	2,195,000	2,290,700	47,475,600	64,444,000	200,600	40,000	724,000	65,408,600	1,926,000
2J	815,900	9,804,600	1,064,000	1,094,500	17,890,700	24,375,000	259,800	44,800	542,400	25,222,000	644,000
4K	815,900	7,655,300	1,472,400	990,100	15,307,200	21,274,000	-	-	542,400	21,816,400	558,000
5CDGFIJ	-	36,526,500	7,578,700	3,039,800	66,003,100	89,674,000	778,400	-	724,000	91,176,400	4,283,000
5TUV	815,900	14,238,900	2,105,100	1,423,100	26,016,300	35,280,000	-	-	724,000	36,004,000	985,000
5W	1,087,800	7,179,800	2,105,100	1,015,800	15,943,900	21,763,000	-	-	542,400	22,305,400	813,000
6AB	-	4,604,300	755,100	715,000	8,504,200	11,779,000	-	60,000	542,400	12,381,400	319,000

Notes: 1. Construction Total includes bid and scope contingencies, in addition to items included in the table.
2. Total Capital Cost includes construction services, land acquisition, and engineering, legal, and administrative costs, in addition to those items included in the table.

2J The Capital Cost for the first distribution alternative for OU 2J, which includes three extraction wells, a single treatment facility utilizing air stripping with vapor-phase carbon off-gas treatment, and distribution piping and required pumps, is estimated at $21,419,000 with a Total OU Cost of $22,266,000. The annual O&M cost is estimated at $589,000 for the first alternative.

The increased pipeline requirements of the second distribution alternative bring the total Capital Cost to $24,375,000, with a total cost of implementation estimated at $25,222,200 (Table 5-4). The associated annual O&M estimate is $644,000.

4K The estimated costs for OU 4K include three extraction wells, two treatment facilities utilizing air stripping with vapor-phase carbon off-gas treatment for VOC removal with ion-exchange units for nitrate removal, and piping and associated pumps. Total Capital Cost of implementation is estimated at $15,563,000 with a total OU Cost of $16,105,400.

In contrast, as shown in Table 5-4, distributing treated water directly to the affected wells increases the total Capital Cost to $21,274,000, and the total OU Cost to $21,816,400. Annual O&M costs for the two distribution alternatives are estimated at $495,000 and $558,000, respectively.

5CDGFIJ Operable Unit 5CDGFIJ includes three treatment facilities for removal of both VOCs and nitrates, and substantial distribution piping and associated pumping for both distribution alternatives. The total Capital Cost for the first alternative (Table 5-4) is estimated at $51,435,000 with a Total OU Cost of $52,937,400. The annual O&M costs estimated for this alternative are $3,591,000.

For the second distribution alternative, pumping treated water to the wells at which pumping is reduced or eliminated results in a total estimated Capital Cost of $89,674,000. The total cost of implementing the second alternative is estimated at $91,176,400, with an annual estimated O&M cost of $4,283,000.

5TUV The total Capital Cost for OU 5TUV, which includes three new, deep, extraction wells, a single treatment facility utilizing air stripping with vapor-phase carbon off-gas treatment for VOC removal and with ion-exchange units for nitrate removal, and piping and associated pumping, is estimated at $29,074,000 with a Total OU Cost of $29,798,000, assuming the first distribution alternative will be sufficient. The annual O&M cost of OU 5TUV is estimated at $881,000 using the first distribution alternative.

Using the second distribution alternative, the total Capital Cost is estimated at $35,280,000. Including remedial investigation and feasibility study costs, estimated implementation costs total $36,004,000. O&M costs for this operable unit with the second distribution scenario are estimated to total $985,000.

5W The total Capital Cost for this operable unit, assuming the first distribution alternative, is estimated at $18,914,000 (Table 5-4). Although OU 5W includes four new extraction wells, a treatment facility utilizing air stripping with vapor-phase carbon off-gas treatment for VOC removal, with ion-exchange units for nitrate removal, the relatively small number of wells at which production is curtailed limits its estimated cost. With remedial investigation and feasibility costs, the estimated cost of implementation is $19,456,400. The costs associated with the second piping scenario are estimated at $21,763,000 Capital, and a total implementation cost of $22,305,400. O&M costs are estimated at $765,000 and $813,000, for the two alternatives respectively.

6AB The costs for OU 6AB, which considers one treatment facility utilizing air stripping with vapor-phase carbon off-gas treatment for VOC removal and with ion-exchange units for nitrate removal and distribution piping and associated pumps, are even more limited than those estimated for OU 5W because of the use of existing wells. Assuming the first piping alternative, the total Capital Cost is estimated at $9,877,000, and the total cost of implementation is estimated at $10,479,400. Using the second distribution scenario increases the estimated Capital Cost to $11,779,000, and the total cost of implementation to $12,381,400. O&M estimates range from an annual $296,000 for the first alternative, and $319,000 annually for the second distribution alternative.

6.0 STAGE II ACTIVITIES

The evaluations of the subset of potential remedial actions summarized in Section 5.0 provide a basis for the selection of specific actions to address the priorities identified in Section 4.0. The highest of these priorities requires the most immediate attention, as reflected in the actions identified below for implementation in Stage II. Stage II is intended to occur immediately following Stage I, which includes all actions and investigations undertaken to date throughout the basin, and is summarized in Section 1.0. The timing of the actions described below will be addressed to some degree in the description of baseline conditions for Stage III (Section 7.1).

6.1 BASELINE CONDITIONS

To properly evaluate actions scheduled for implementation during a particular stage, it is useful to assess the physical condition of the basin at the outset of the stage. For Stage II, which is intended to begin immediately, baseline conditions are essentially those that exist today. The current understanding of (1) extent of contamination, (2) groundwater flow, and (3) hydrogeologic characteristics of the basin is documented in the Draft Report of Remedial Investigations (EPA, 1989b).

The present extent of VOC contamination is summarized in Figure 1-2. The areas of contamination that have been identified are based primarily on data from existing production wells supplemented with data from shallow monitoring wells. The monitoring wells were, for the most part, installed as part of source investigation studies. The present interpretation of the extent of contamination in the basin is thus limited to data from areas where contamination has previously been identified or suspected; there are few data from areas where there is only minor groundwater extraction or where potential sources are not currently under investigation. As remediation efforts proceed, uncertainty in the extent of contamination will decrease; and baseline conditions will be known in more detail at the outset of future stages than is currently possible. Conversely, present conditions are obviously better understood today than baseline conditions for future stages, which will be described in progressively more uncertain terms.

Groundwater flow patterns in the San Gabriel Basin are dominantly a function of pumping patterns. The natural gradient of the basin is away from all the surrounding hills and mountains towards the only significant outlet of groundwater and surface water through Whittier Narrows (Figure 1-1). However, because approximately 80 percent of the groundwater in the basin is extracted from production wells, this natural flow pattern has been substantially altered. For example, much of the water in the western portion of the basin (RI Areas 1 and 2) flows towards production wells near the western margin of the basin, away from Whittier Narrows. Therefore, the direction and velocity of contaminant migration is very much dependent on pumping patterns; and alteration of pumping patterns is the most straightforward way of managing contaminant migration.

As described in Section 2.0, water purveyors in the basin have been forced to shut down wells in contaminated areas and construct new ones in clean or less contaminated areas. These actions only delay the problem, and may accelerate the spread of contamination into uncontaminated areas. Vertical migration of contamination has also been affected by purveyors who have avoided contaminated horizons by extracting from deeper zones, which, because of the absence of intervening confining layers throughout most of the basin, may have the effect of drawing the contamination down into other horizons. Clearly, remediation efforts should consider not only halting these practices, but also reversing them by pumping and treating water within highly contaminated areas, and stopping or reducing pumping in less contaminated areas.

6.2 SUMMARY OF ACTIONS

Remediation efforts to be undertaken in Stage II will address the two most contaminated areas in the Basin, RI Area 5 (Azusa-Baldwin Park), and the boundary between Areas 5 and 6 (near the mouth of Puente Valley). In addition, investigative efforts will be undertaken in Areas 2, 3, and 4, as well as in the vicinity of the operable units in Areas 5 and 6. The investigative and remedial actions of Stage II are summarized in Table 6-1 and Figure 6-1.

Investigative efforts are a major part of Stage II because of the need to recover costs of previous actions and to obtain data required to proceed with future actions with a reasonable degree of confidence. Investigations to support cost recovery efforts in Stage II address potential source areas for the contamination at the Richwood Operable Unit and the Whittier Narrows and Suburban Operable Units. Source investigations for the Richwood Operable Unit cover a relatively small portion of the basin in Area 3. Potential source areas for the Whittier Narrows Operable Unit, on the other hand, cover a large portion of the entire basin in Areas 3, 4, 5, and 6. Cost recovery investigations in these areas can be combined with remedial investigations required to implement high priority remedial actions in Areas 5 and 6.

In general, the focus on investigative efforts in this stage is intended to accomplish the following:

1. Set the stage for a successful enforcement strategy for obtaining funds for future actions by emphasizing source investigation activities throughout most of the basin

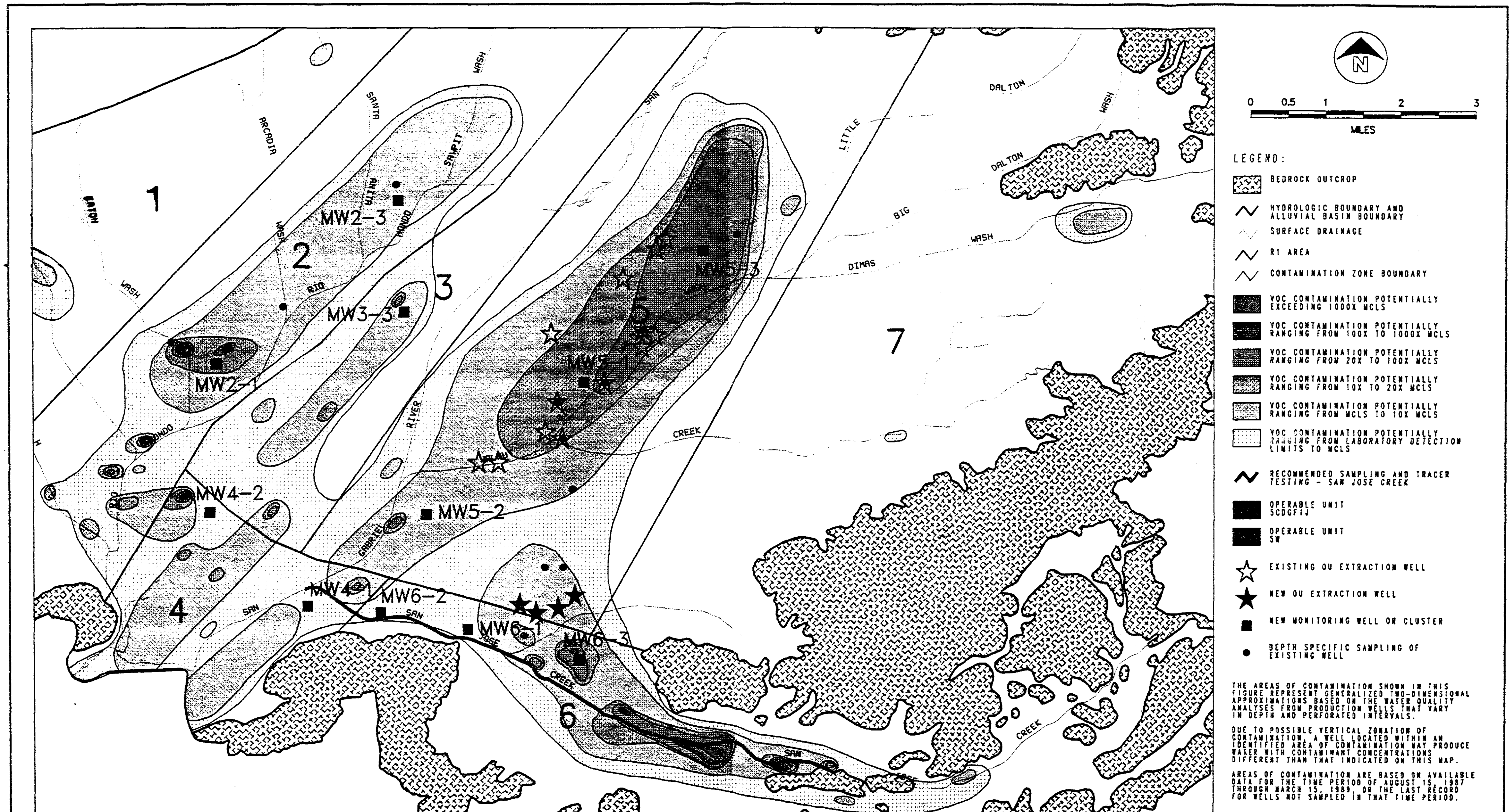

FIGURE 6-1

SUMMARY OF STAGE II ACTIONS

Draft Basinwide Technical Plan
San Gabriel Basin

Table 6-1
SUMMARY OF STAGE II ACTIONS

RI Area	Type of Action	Rationale	Activities
<u>Area 2</u>	Remedial Investigation	Better define extent of contamination. Required for planning of Area 2 remedial activities in Stage III.	Well logging and depth-specific sampling of three wells: 01901055 01902019 01902027. Installation and depth-specific sampling of two new monitoring wells (MW 2-1, MW 2-3).
<u>Area 3</u>	Remedial Investigation	Increase understanding of subsurface conditions in the vicinity of the Richwood Operable Unit and in the identification of PRPs. Better define the vertical extent of contamination to aid planning of remedial activities in Stage IV.	Installation and depth-specific sampling of a new monitoring well (MW 3-3).
<u>Area 4</u>	Remedial Investigation	Investigate the continuation of contaminated zones across the northern part of Area 4.	Installation and depth-specific sampling of two new monitoring wells in northern portions of Area 4 (MW 4-1, MW 4-2).
<u>Area 5</u>	Remedial Investigation	Reduce uncertainty in the vertical and downgradient extent of contamination to support remedial actions in Stages II, III, and, potentially IV. Monitoring wells will be constructed as part of Feasibility Study for Operable Unit 5CDGFIJ.	Well logging and depth-specific sampling of eight wells: 01900029 01900031 01900035 01900882 08000060 08000093 71903093 91901439 Installation and depth-specific sampling of one new monitoring well in center of contaminated zone (MW 5-1).
	Remedial Action	Provide a local supply of potable water, extract contaminants, and reduce migration velocities. Monitoring wells will monitor long-term performance and help determine Stage III actions.	Operable Unit 5CDGFIJ, including the installation and depth-specific sampling of two new monitoring wells in northern and southern portions of contaminated zone (MW 5-2, MW 5-3).
(Southeastern Area 5)	Remedial Investigation	Support remedial action at the mouth of the valley.	Depth-specific sampling of well 98000108.
	Remedial Action	Prevent further migration of high-level contamination out of the Puente Valley northward toward the pumping center in southeastern Area 5.	Operable Unit 5W

Table 6-1
(Continued)

RI Area	Type of Action	Rationale	Activities
Area 6	Remedial Investigation	Investigate potential pathways for contaminant transport in the Puente Valley. Better define the hydrogeology of the Puente Valley to support remedial action at the mouth of the valley.	Sampling and tracer testing of San Jose Creek and gravel sub-drain. Installation and depth-specific sampling of two new monitoring wells between the Puente Valley and Whittier Narrows (MW 6-1, MW 6-2). Numerical simulation of groundwater (and surface water) flow system through the Puente Valley. Installation of one new monitoring well to support operable unit 5W.

2. Address large areas of uncertainty in the current level of knowledge concerning the hydrogeology of the basin and the extent of contamination, which will greatly improve predictive abilities and allow aggressive remediation to occur as soon as possible

The specific actions recommended for implementation in Stage II are described more fully in the following sections.

6.3 OPERABLE UNIT 5CDGFIJ

Potential operable units (OUs) consisting of existing wells within the large area of high-level contamination in Area 5 (described in Appendix A) have been combined into OU 5CDGFIJ[1]. The objectives of this operable unit include extracting and treating highly contaminated groundwater to remove contaminants from the aquifer, reduce the rate of contaminant migration, and help with local water supply problems that have occurred as a result of the contamination. A large number of the wells in the area, presently out of service or pumped only intermittently because of contamination, are considered to allow a degree of flexibility in selecting the most appropriate wells during the feasibility-study phase. As mentioned in Section 5.3, and described in Appendix C, pumping from all of the wells will potentially remove a substantial mass of contaminants. Remedial investigations required prior to implementation of this operable unit will better define the distribution of contaminants in the subsurface. It is likely that contamination in the area consists of numerous plumes located within different vertical intervals. The wells that will eventually make up this operable unit will be selected for pumping and treating contaminated groundwater in terms of their spatial relation to contaminated zones, and their effectiveness in extracting contamination.

Depth-specific sampling of the wells listed in Table 6-1 will allow the vertical zonation of contamination to be better defined. Current interpretations rely on water quality data from samples that represent the entire screened intervals of the wells. As described in the Draft Report of Remedial Investigations (EPA, 1989b), these vertically averaged data yield little information regarding the location of zones where contaminants may be concentrated. By locating these zones, the efficiency of the operable unit can be increased by modifying the existing wells to selectively extract from the most contaminated vertical intervals.

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[1]Operable unit nomenclature is described in Appendix A. Briefly, numbers refer to RI Area, and letters refer to clusters of existing or new wells. The characteristics of well clusters are listed in Appendix A.

The existing wells, however, sample only a portion of the aquifer. No data are available regarding the presence of contaminants at depths greater than those represented by existing wells. The potential for contamination at greater depths is considerable in light of the apparent lack of confining layers in the area, and the potential presence of vertically downward gradients (EPA, 1989b). As discussed in Section 4.2.2, it is envisioned that at least three deep monitoring wells or well clusters will be required to properly evaluate the presence of contamination in the deeper portions of the aquifer in this area. A single multiport well or well cluster near the middle of OU 5CDGFIJ will be required at the Feasibility Study stage to investigate conditions at depth and to assist in the evaluation and design of the OU. Two additional monitoring wells near the upgradient and downgradient margins of OU 5CDGFIJ will be constructed as part of the remedial action to monitor its performance, and determine the need for and help support the design of Stage III actions in this area.

The effects of this operable unit on groundwater flow and contaminant transport were estimated through numerical simulations described in Appendix C and summarized in Section 5.2. The effects described were calculated assuming that all the wells in clusters C, D, G, F, I, and J would be pumped to the extent possible without producing water in excess of existing pumping rates in the area. To accommodate the water produced by these wells, it is assumed that a relatively large number of wells located predominantly downgradient of the operable unit will be taken out of service. This will avoid the problem of disposing of excess water and enhance the ability of the operable unit to reduce the rate of contaminant migration by substantially lessening the hydraulic gradient in the area. Additional assumptions made in evaluating this operable unit include supplying treated water to either (1) the existing distribution system or (2) the wells taken out of service to avoid disrupting the present distribution system (Appendix D).

A feasibility study of this operable unit will determine the adequacy of these assumptions. It is likely that the operable unit will include only some of the wells presently considered and some degree of redistribution of treated water. The feasibility study will evaluate wells available for extraction as well as those at which production will be curtailed in sufficient detail to determine how best to maximize the degree of contaminant migration control, as well as the overall cost-effectiveness of the OU. It should be possible to develop an incremental implementation plan that gradually replaces water produced at current production wells with water from the OU wells. On the other hand, it may be possible to pump OU wells at or near capacity and dispose of much of the treated water through recharge in river channels or at existing spreading centers. When demand exceeds that of the operable unit wells, the wells taken out of service may be reactivated intermittently. Additional details regarding potential water distribution scenarios for OU 5CDGFIJ are contained in Section 5.3 and in Appendix D.

Another alternative would be to implement this operable unit as part of a plan for conjunctive use of groundwater and surface water. Under this option, the treated groundwater would be exported to other areas of Southern California instead of being distributed for local water supply needs. The overall balance of water supply throughout the basin would be maintained by additional recharge of imported surface water during periods when supplemental water is available. The Metropolitan Water District of Southern California and the Upper San Gabriel Valley Municipal Water District are currently planning to study the feasibility of this option.

The result of the feasibility study and associated public decisionmaking process will be to establish a preliminary groundwater management plan for the area. This management plan would prescribe the order of preference for operating wells and necessary groundwater treatment facilities in the area to meet local water supply needs, or for export out of the basin as part of a conjunctive-use program. Extensive performance monitoring of the operable unit would be conducted after implementation to determine the degree of contaminant migration control achieved by the OU, as well as the feasibility of eventually achieving more effective control of contaminant migration through implementation of supplemental actions in later stages.

A breakdown of potential costs associated with this operable unit is contained in Appendix E, and summarized in Section 5.4. Estimated costs include the assumptions regarding remedial investigations, feasibility studies (including monitoring wells), and redistribution of treated water, as described above. Performance monitoring costs are included for all Stage II actions in a summary table at the end of Section 6. Also included are Operation and Maintenance (O and M) costs for treatment and pumping of extracted water, and periodic sampling and maintenance of monitoring wells. Table 6-2 summarizes these costs.

6.4 OPERABLE UNIT 5W

Operable Unit 5W is expected to consist of four new wells located just north of the mouth of the Puente Valley, as shown in Figure 6-1. The wells are proposed to depths of about 850 feet with individual capacities of about 2,500 gpm. As described in Sections 2.0, 5.3, and Appendix C, the extensive high-level contamination throughout the Puente Valley is migrating towards the large pumping center in the southeastern corner of Area 5. The wells in this pumping center currently produce water that exceeds drinking water standards, but is brought into compliance by blending it with water from other parts of the basin. If contamination is allowed to spread unchecked throughout the basin, less clean water for blending will be available; and the concentration of contamination at the wells in this pumping center may increase to the point that blending is no longer feasible.

Table 6-2
SUMMARY OF ESTIMATED COSTS FOR OPERABLE UNIT 5CDGFIJ
($ X 1,000)

Item	Alternative 1	Alternative 2
Remedial Investigation	778	778
Feasibility Study	724	724
Design, Legal, and Administrative	9,275	16,171
Construction	37,509	66,003
Services During Construction and Land Acquisition	4,651	6,900
Total	52,937	91,176
Median Operable Unit Cost	72,056	
Annual Operation and Maintenance (O&M) Costs	3,591	4,283
Median Annual O&M Costs	3,937	

It may be argued that the easiest way to deal with this problem is by treating the water in this pumping center and allowing pumping in the area to continue as before. However, treatment at existing wells in the southeastern portion of Area 5 will not provide the following long-term benefits of the more aggressive 5W OU:

- Contain high-level contamination within its present extent
- Allow the continued use of existing wells without treatment to meet peak demand

These benefits are important considerations not only from the perspective of maintaining a supply of clean water that will continue to meet an ever-growing demand, but they also allow use of the basin for the future storage and retrieval of imported water. As discussed in Sections 2.0 and 3.0, as the problem of potable water supply becomes more acute in Southern California, the ability to store and subsequently retrieve large volumes of water in basins that are, like the San Gabriel Basin, ideally located and otherwise suited for this purpose, will become essential. Operable Unit 5W will prevent the high-level contamination in the Puente Valley from ever reaching this important pumping center, and prevent contaminant concentrations in this portion of the basin from becoming so high as to disallow production of potable water through blending. Although it is foreseen that, initially, currently producing wells will be taken out of service in favor of production from the new 5W wells, they will continue to be available for meeting peak demand and for future use as part of a basinwide plan of storage and retrieval of imported water.

Design of this operable unit will probably require depth-specific sampling of a well at the pumping center (98000108). It also requires installation of at least one monitoring well or well cluster upgradient of the proposed new wells to provide detailed subsurface data in the area and to monitor the migration of contaminants towards them after their construction. In addition, studies of the local-scale hydrogeology, including numerical simulation of flow and transport, conducted as part of the overall remedial investigation, will aid the design of an effective well extraction system.

The ability of this operable unit to contain the high-level contamination within the Puente Valley has been simulated with the numerical model described in Appendix C and summarized in Section 5.2. The configuration of the four wells described appears to represent an effective barrier to the northward migration of Puente Valley contamination. As before, the potential cost of OU 5W has been estimated on the basis of a number of simplifying assumptions that may need to be refined as additional data become available. Table 6-3 summarizes these estimates.

6.5 REMEDIAL INVESTIGATION

As mentioned above and shown in Table 6-1, investigative efforts throughout the basin will be a substantial part of Stage II. Remedial investigations are required to support (1) remedial actions to be implemented as part of Stage II, (2) remedial actions to be implemented in future stages, (3) efforts to recover the costs of Stage I actions from PRPs, and (4) to refine understanding of hydrogeologic conditions basinwide.

A good portion of the remedial investigation will support the two operable units described above and will not be considered further as independent actions. As shown in Figure 6-1, additional investigative efforts include sampling of existing wells in Areas 2 and 5; installation, logging, and sampling of monitoring wells in Areas 2, 3, 4, 5 and 6; sampling, tracer testing, and detailed analysis of surface water and groundwater flow in the vicinity of San Jose Creek; and analyses to incorporate these data into conceptual and numerical models of the entire San Gabriel Basin.

Depth-specific sampling of three wells in Area 2 will improve understanding of subsurface conditions primarily for planning of future remedial actions. In addition to the existing wells, two new deep monitoring wells will be installed

Table 6-3
SUMMARY OF ESTIMATED COSTS FOR OPERABLE UNIT 5W
($ X 1,000)

Item	Alternative 1	Alternative 2
Feasibility Study	542	524
Construction	13,821	15,944
Services During Construction and Land Acquisition	1,682	1,894
Design, Legal, and Administrative	3,411	3,924
Total	19,456	22,305
Median Operable Unit Cost	20,881	
Annual O&M Cost	765	813
Median O&M Cost	789	

and sampled in the northern and southern portions of the large contaminated zone in Area 2. Although additional investigations will be performed in Stage III, the results of these preliminary actions will allow refinement of Stage III actions as required towards the end of Stage II.

A monitoring well will be installed, logged, and sampled in the northern portion of Area 3 to provide better understanding of subsurface conditions in the vicinity of the Richwood Operable Unit and aid in the identification of PRPs. Depth-specific sampling of existing wells is not recommended because the most contaminated wells are confined to the upper 10 to 15 percent of the aquifer. Depth-specific data from deeper monitoring wells in Stages II and III will determine whether contamination is indeed confined to shallow depths and will help interpret contaminant pathways.

The installation of wells in Areas 4 and 6 will also greatly improve current interpretations of groundwater conditions and subsurface flow. Specifically, the two wells in each of these areas will help fill some of the largest data gaps in the basin regarding the continuity of individual zones of contamination.

The San Jose Creek may provide a pathway for high-velocity transport of contamination out of the Puente Valley. Contamination has been detected in both the creek and the gravel subdrain. Sampling and analysis of the creek and subdrain systems, along with analyses of deeper groundwater flow in the valley, will help to describe long-term contaminant transport in the basin.

These analyses may also provide data supporting a surface water OU in Stage III.

Additional analysis is required throughout Stage II (as well as throughout all stages) to incorporate data as they are acquired into the conceptual model of hydrogeologic conditions basinwide, and subsequently into the numerical model of basinwide flow and contaminant transport (EPA, 1989b). These efforts will be closely coordinated with efforts that encompass the more local problems to allow feedback of the results of each. Towards the end of Stage II, the results of all these investigations will be thoroughly documented and used to monitor the success of remediation efforts to date and to refine recommendations for future actions. As mentioned previously, the results of these investigations must be assumed at present to generally concur with the current interpretation of basinwide conditions. As an illustration of the importance and potential impact of continuing efforts to maintain a basinwide data base for analysis of conditions throughout the region, two alternate Stage III conditions will be presented: Section 7.0 will describe actions considered most likely to make up the next stage of remediation; and Appendix F describes an alternate set of actions that would be required if the results of the Stage II investigations conclude that conditions differ substantially from current interpretations.

Table 6-4 summarizes the costs associated with Stage II cost recovery and remedial investigations other than those needed to support OUs 5CDGFIJ and 5W.

6.6 SUMMARY OF ESTIMATED STAGE II COSTS

Estimated costs of Stage II actions are summarized in Table 6-5. The estimated cost of monitoring the performance of the two Stage II operable units has also been included. Although the cost of monitoring the performance of an operable unit will be considered part of the cost of the remedial action, it is unrealistic to accurately design and develop cost estimates for monitoring systems on an operable-unit-specific basis before developing a feasibility study. In addition, a contingency fund of $5,000,000 has been added to allow imminent water supply problems related to VOC contamination at production wells to be addressed in a timely manner.

Table 6-4
SUMMARY OF ESTIMATED COSTS FOR REMEDIAL INVESTIGATION
($ X 1,000)

Item	Cost
Area 2 Well Installation and Sampling	536
Area 3 Well Installation and Sampling	260
Area 4 Well Installation and Sampling	520
Area 5 Well Installation and Sampling	792
Area 6 Well Installation and Sampling	602
San Jose Creek Investigation	196
Basinwide RI	5,080
Total	7,986

Table 6-5
SUMMARY OF ESTIMATED COSTS FOR STAGE II REMEDIAL AND INVESTIGATIVE ACTIONS
($ X 1,000)

Item	Cost
Operable Unit 5CDGFIJ	72,060
Operable Unit 5W	20,880
Additional Remedial Investigation	7,990
Operable Unit Performance Monitoring	635
Contingency for Imminent Threats	5,000
Total Cost of Implementation	106,565

7.0 STAGE III ACTIVITIES

This section summarizes one of two sets of recommended actions for Stage III. Because the selection of Stage III actions relies somewhat on the results of investigations undertaken in Stage II, alternative actions to those described below should be considered. The Alternate Stage III actions, described in Appendix F, are presented to illustrate the uncertainty of recommending future actions. The scenario assumed in the activities described in this section will continue to be assumed in the selection of Stages IV and V actions, for which no alternatives are presented.

In addition to greater knowledge of conditions at depth, at the time Stage III is initiated, there will also be a much improved understanding of contamination near the surface, and, in particular, in the vicinity of potential sources. As mentioned previously, this plan does not currently include actions that specifically target shallow, source-related contamination issues because of the present lack of data. However, it is foreseen that Stage III will also include a variety of source control and remediation activities that are not described below.

7.1 BASELINE CONDITIONS

Conditions of groundwater flow and extent of contamination at the outset of Stage III are best estimated in a qualitative fashion as a function of (1) time, (2) the effects of remedial actions already implemented in Stages I and II, and (3) assumptions regarding the results of remedial investigations. Because of the difficulty in assessing any of these factors, an estimation of baseline conditions for Stage III is, at best, educated conjecture. The time factor will be estimated based on the assumptions regarding the timing of enforcement-lead actions discussed in Section 4.5. The process of obtaining funding prior to implementation of Stage II actions will probably be the rate-determining factor in executing recommended activities. Although the effects of remedial actions could be assumed to be similar to those simulated numerically (as described in Section 5.2 and Appendix C), Stage II actions will most likely not have been implemented for very long, if at all; and their effects will not have affected the existing conditions by the time Stage III actions begin. The results of remedial investigations will be assumed to generally confirm present interpretations of hydrogeologic conditions and the extent of contamination in this section. However, as mentioned above, as an illustration of the potential severity of this assumption, an alternate scenario is presented in Appendix F. The Appendix F scenario assumes that Stage II remedial investigations yield information that substantially alters the conceptual model of the extent of contamination described below.

Time of Initiation of Stage III. Table 7-1 illustrates Stage II remedial actions inserted into the conceptual enforcement-lead timing scheme introduced in Section 4.5. Much of Stage II involves investigative efforts to reduce technical uncertainty regarding hydrogeologic and water quality conditions throughout the basin. Remedial investigations associated with specific Stage II remedial actions will be performed at the Feasibility Study phase. Thus, it may be possible to reach a point in time, represented by the third time column in Table 7-1, at which feasibility studies of Stage III actions can commence within a relatively short period.

As explained before, it is difficult to ascertain the exact amount of time represented by the columns in Table 7-1. It was assumed in Section 4.5 that each of the columns could represent anywhere between 1 and 4 years. Thus, it is assumed in the estimation of baseline conditions of this and other future stages that the efforts represented in each column will be accomplished in approximately 2 years. This estimation is entirely dependent on EPA and LARWQCB staffing levels and on the availability of funding to commence enforcement-lead actions. Again, it should be noted that because source identification efforts currently underway for the Whittier Narrows Operable Unit already cover a large portion of the basin, the assumed progress of enforcement-lead actions may be reasonable.

Effects of Stage II Remedial Actions. As shown in Table 7-1, at the time Stage III actions enter the Feasibility Study phase, no Stage II actions may have been fully implemented. Thus, at the outset of Stage III, approximately 4 years after the initiation of Stage II, previous actions that have impacted groundwater flow and contaminant transport need not be considered. In addition, contamination in the basin will not have migrated very far from its present location; priorities associated with the location of areas of extensive contamination are not expected to have changed. In essence, it is assumed that conditions will be similar at the outset of Stage III to the conditions described for the outset of Stage II.

Assumed Results of Remedial Investigations. A number of assumptions are described below regarding the general nature of the results of remedial investigations conducted prior to Stage III. An alternate set of assumptions is presented in Appendix F.

In Area 2, it is assumed that depth-specific data from three existing wells and two deep monitoring wells installed in Stage II reveal contamination to be somewhat limited vertically to shallow portions of the aquifer. However, the presence of low concentrations of contamination in the deeper screened intervals may suggest that continued pumping at deep levels is drawing contamination deeper. In particular, it is assumed that samples from one of the deepest intervals exhibit high contaminant concentrations, suggesting a potential for substantial contamination of the aquifer beneath the existing Area 2 wells,

TABLE 7-1
STATUS OF STAGE II ACTIONS AT INITIATION OF STAGE III

TODAY ——— *TIME* ———→

	STAGE II		*STAGE III*		
RI/FS	5CDGFIJ	5W			
SOURCE INDENTIFICATION	AREAS 5 & 6	AREAS 5 & 6	AREAS 5 & 6		
SOURCE INVESTIGATION	AREAS 5 & 6	AREAS 5 & 6	AREAS 5 & 6		
NEGOTIATION		5CDGFIJ	5W		
DESIGN			5CDGFIJ	5W	
IMPLEMENTATION				5CDGFIJ	5W

<u>EXPLANATION</u> LETTERS REFER TO OPERABLE UNIT DESIGNATIONS DESCRIBED IN SECTION 5.0 AND APPENDIX A.

RI-AREA NUMBERS ARE DEFINED IN FIGURE 1-2. COLUMNS REPRESENT UNDEFINED UNITS OF TIME THAT ARE PROBABLY VARIABLE IN LENGTH.

RI/FS = REMEDIAL INVESTIGATION AND FEASIBILITY STUDY.

which only penetrate through approximately half of the aquifer thickness. Overall, the additional data in Area 2 are assumed to support initiation of remedial actions using existing wells. The deep monitoring wells installed in Stage II will continue to be sampled regularly to monitor conditions throughout the thickness of the aquifer. An additional monitoring well will be installed at the downgradient boundary of the large zone of contamination to monitor the ability of Stage III remedial actions to manage the migration of contaminants southward.

It is assumed that Area 3 investigations generally corroborate the existing interpretation of the vertical extent of VOC contamination. Depth-specific sampling of the monitoring well is assumed to reveal that a number of highly contaminated horizons appear to persist to several thousand feet. Therefore, two new monitoring wells (MW 3-1 and MW 3-2) will be installed in Stage III in the central portion of the contaminated area, as well as at its downgradient boundary. The latter well (MW 3-1) will also better establish the potential continuity between contamination in Areas 3 and 4.

It is also assumed that the results of logging and sampling of two new monitoring wells in the northern portion of Area 4 indicate that contamination between Whittier Narrows and Areas 3, 5, and 6 is continuous. An additional monitoring well (MW 4-3) will be installed at an as yet unknown location in northern Area 4 to better define the boundaries of contamination in this area.

Depth-specific sampling of eight existing wells in Area 5 is assumed to allow better definition of contamination in the upper portion of the aquifer. This information is used to modify wells in Operable Unit 5CDGFIJ (at the design stage in Table 7-1). Data from the deep monitoring wells installed in Stage II are assumed to reveal moderate to high levels of contamination within specific intervals throughout most of the aquifer thickness, supporting the need to install additional monitoring wells and proceed with an operable unit (or expansion of the existing operable unit) to extract contaminants from depth.

Tracer tests in the San Jose Creek and underlying gravel subdrain system are assumed to substantiate the potential for rapid migration of high concentrations of contaminants from the Puente Valley and Area 4. However, the assumed absence of significant contamination in surface water similar to that found in groundwater nearby suggests a present lack of connectivity between the surface-water and groundwater systems. Additional data from two new monitoring wells in the far western portion of Area 6 are assumed to indicate a continuity of contamination between the two areas.

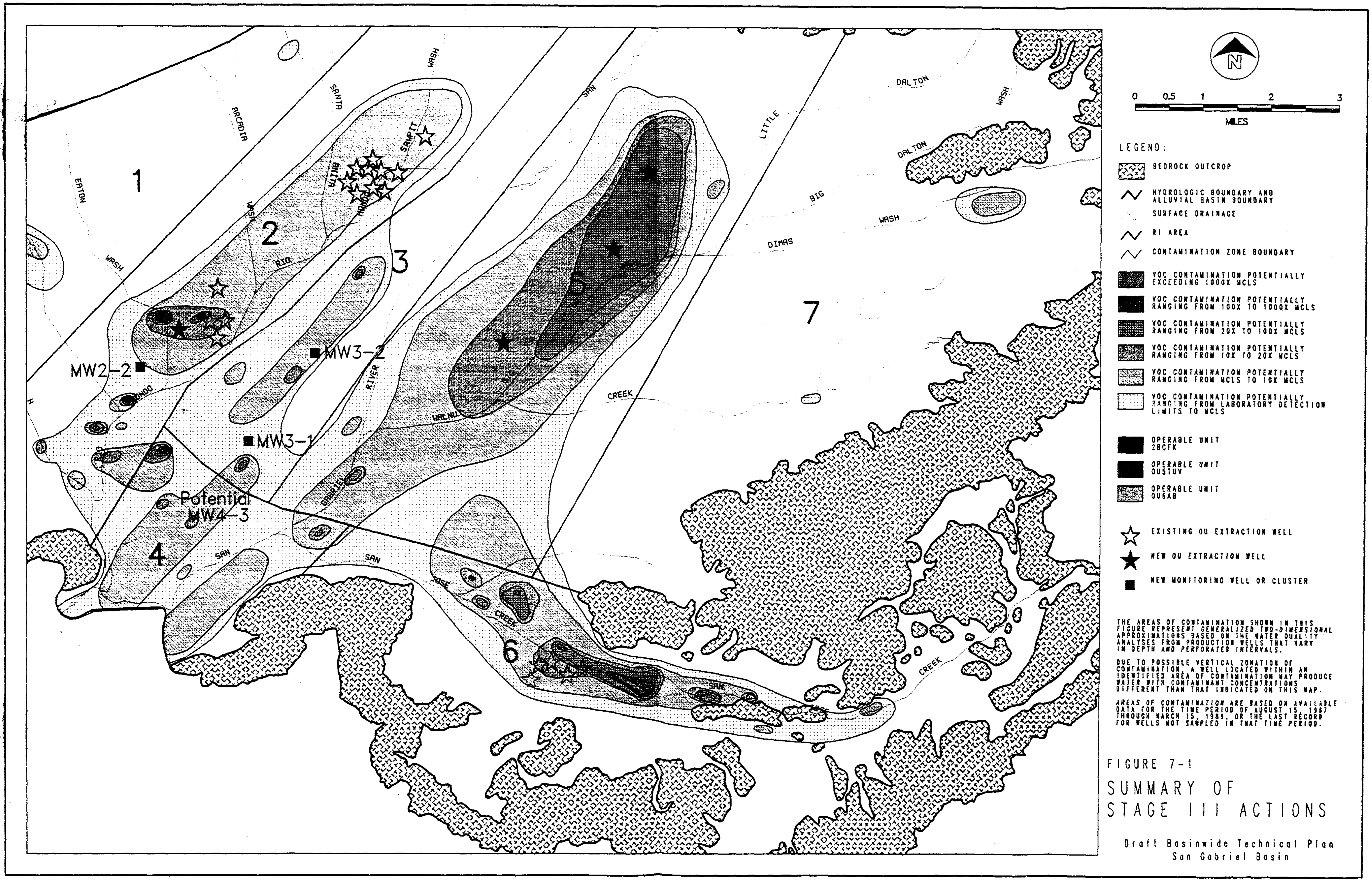

FIGURE 7-1

SUMMARY OF STAGE III ACTIONS

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San Gabriel Basin

7.2 SUMMARY OF ACTIONS

Remediation efforts to be undertaken in Stage III focus on continued actions in Areas 5 and 6, along with new actions in Area 2, and are based on data acquired in Stage II. Remedial investigations will be performed to support the three Stage III remedial actions, and to support potential Stage IV actions by continuing to explore conditions in the deepest portion of the aquifer in Area 3. Stage III actions are summarized in Table 7-2, and Figure 7-1.

The emphasis of Stage III actions is on the continuation of remedial efforts in Areas 5 and 6, and the initiation of remedial efforts in Area 2. The nature of these actions is somewhat dependent on the results of investigations performed in Stage II. With remedial actions underway in the three most contaminated portions of the basin, investigations are required to assess conditions in Area 3, and potentially in Area 4.

7.3 OPERABLE UNIT 2BCFHK

Operable Unit 2BCFHK is a combination of Operable Units 2BCFH and 2BCFK in Appendix A. As with OU 5CDGFIJ in Stage II, this combination increases the flexibility allowed to evaluate the feasibility of alternate remedial configurations prior to implementation. Specifically, a feasibility study will determine whether the operable unit should include an existing well (2H) or a new well (2K). (However, OU 2BCFK is used to represent this remedial action in Figure 7-1 and Table 7-3 as it is anticipated that either OU 2K or OU 2H will be selected, and the actual OU will not contain both.) The depth-specific sampling of both existing production wells and new monitoring wells performed in Area 2 during Stage II will provide the basis for selection and modification of the wells in OU 2BCFHK to enhance contaminant removal from the most contaminated zones. In addition, because much of the field data for this operable unit will already have been collected, its rapid implementation in Stage III will be facilitated. Moreover, the early attention to acquiring data in Area 2 will allow source identification and investigation actions for OU 2BCFHK to proceed as quickly as staff resources allow.

An additional new monitoring well (MW 2-2) will be installed at the downgradient margin of the large contaminated zone in Area 2 to provide long-term monitoring of contaminant migration southward. The numerical simulations of the effects of OU 2BCFK described in Appendix C show an increase in contaminant migration southward. This increase is for the most part probably the result of shutting down wells south of the OU that would otherwise extract the contaminated water. It is anticipated that careful review of data from production and monitoring wells throughout the area will allow the OU wells to be modified to maximize withdrawal from the most highly contaminated horizons. Adequate well design should prevent most of the contamination from moving

Table 7-2
SUMMARY OF STAGE III ACTIONS

RI Area	Type of Action	Rationale	Activities
Area 2	Remedial Action	Provide a local supply of potable water, extract contaminants, and reduce migration velocities. Monitoring conditions throughout the saturated thickness at the downgradient margin of contamination will, along with Stage II monitoring wells, provide long-term performance monitoring and help support potential remedial actions in Stage IV, and basinwide investigations.	Operable Unit 2BCFHK, including installation and depth-specific sampling of one new monitoring well (MW 2-2).
Area 3	Remedial Investigation	Better define the extent of contamination to evaluate the need for remedial actions in Stage IV, and support basinwide investigations.	Installation and depth-specific sampling of two new monitoring wells (MW 3-1, MW 3-2).
Area 4	Remedial Investigation	Investigate further the continuity of areas of contamination in Area 4 with upgradient areas, and evaluate the need for additional remedial action in Area 4.	Based on results of Stage II investigations, potentially includes installation and depth-specific sampling of one additional monitoring well (MW 4-3) in northern portion of Area 4.
Area 5	Remedial Action	Remove contaminated water at depth. Feasibility and design for this action are supported in part by data from Stage II monitoring wells.	Operable Unit 5TUV.
Area 6	Remedial Action	Extract contaminants and reduce migration of Puente Valley contamination toward Whittier Narrows.	Operable Unit 6AB.

Table 7-3
SUMMARY OF ESTIMATED COSTS FOR OPERABLE UNIT 2BCFK
($ X 1,000)

Item	Alternative 1	Alternative 2
Remedial Investigation	241	241
Feasibility Study	724	724
Construction	29,601	47,476
Services During Construction and Land Acquisition	3,560	5,348
Design, Legal, and Administrative	7,295	11,621
Total	41,421	65,409
Median Operable Unit Cost	53,415	
Annual Operation and Maintenance (O&M) Cost	1,560	1,926
Median O&M Cost	1,743	

southward. MW 2-2 will permit the southern migration of Area 2 contamination to be carefully monitored.

The estimated costs of OU 2BCFK (representing a potential scenario for OU 2BCFHK), including only those portions of the remedial investigation required that are performed in Stage III, are summarized in Table 7-3.

7.4 OPERABLE UNIT 5TUV

Operable Unit 5TUV will be designed to remove contaminants from the largest zone of contamination in the basin (Area 5) located in horizons that are inaccessible to the wells in OU 5CDGFIJ. By supplementing OU 5CDGFIJ with the more aggressive OU 5TUV, removal of contamination from Area 5 will proceed more quickly; and a larger mass of contaminants will be prevented from migrating southward into presently uncontaminated areas. In addition, the results of numerical simulations (Section 5.3 and Appendix C) indicate that the effect of these two actions on the regional potentiometric surface will be largely limited to Area 5. Thus, although local depression of the surface will decrease the hydraulic gradient and slow migration, groundwater effects on other portions of the basin may not be pronounced.

Design and installation of the three deep extraction wells that make up Operable Unit 5TUV will rely on data obtained from three deep monitoring wells (MW 5-1, MW 5-2, and MW 5-3 in Stage II). Implementation of OU 5TUV will thus probably follow implementation of OU 2BCFHK and OU 6AB (described below), which consist entirely of existing production wells, except for one potential new extraction well in OU 2BCFHK. The three monitoring wells will provide data for both the construction of the extraction wells, as well as for monitoring the continued progress of the operable unit after installation of the extraction wells.

The combination of OU 5TUV and OU 5CDGFIJ may produce a volume of treated water that exceeds demand within the area in which redistribution is feasible. A feasibility study of this operable unit will require careful consideration of the options for alternate disposal, including distribution to spreading grounds and river channels, as a means of returning water to the aquifer, or export out of the basin to other areas of Southern California as part of a conjunctive-use program. Water distribution and treatment options for both of these operable units are considered independently in Section 5.4 and Appendix D.

A summary of the estimated costs of OU 5TUV is listed in Table 7-4.

Table 7-4
SUMMARY OF ESTIMATED COSTS FOR OPERABLE UNIT 5TUV
($ X 1,000)

Item	Alternative 1	Alternative 2
Feasibility Study	724	724
Construction	21,392	26,016
Services During Construction and Land Acquisition	2,439	2,902
Design, Legal, and Administrative	5,243	6,362
Total	29,798	36,004
Median Operable Unit Cost	32,901	
Annual O&M Cost	881	985
Median Annual O&M Cost	933	

If contamination is found to extend to the bottom of the aquifer, it may be determined that attempting to remove deep contamination in Area 5 is not a cost-effective alternative. It may be determined that a more cost-effective solution is to extract at downgradient wells, and intercept the contamination as it migrates toward Whittier Narrows. These considerations would have been evaluated at the end of Stage II--see Appendix F for an alternate outcome of Stage II investigations--or they may need to be more fully evaluated in the feasibility study for this OU.

7.5 OPERABLE UNIT 6AB

Implementation of Operable Unit 5W in Stage II will prevent the northward migration of high-level contamination towards the pumping center in the southeastern corner of Area 5. The water produced by OU 5W (as well as that produced by OU 5CDGFIJ and, eventually, OU 5TUV) will more than replace that currently produced at the pumping center. Thus, the additional supply of water produced by the five wells in OU 6AB will probably not be required unless demand increases dramatically. However, the contamination contained by OU 5W will still remain at high levels within the Puente Valley, and will probably continue to migrate westward toward Whittier Narrows. Operable unit OU 6AB provides a relatively low-cost measure of contaminant removal in a highly contaminated area using existing wells. The results of the contaminant transport simulations described in Section 5.2 and Appendix C demonstrate the ability of 6AB to retard migration westward out of the Puente Valley. Therefore, although the original objective of OU 6AB, as described in Appendix A, was as an additional supply of drinking water, it is described herein as a means of managing the migration of contaminants out of the Puente Valley.

All five existing wells in the Puente Valley, presently shut down or pumped at reduced rates because of poor water quality in the area, make up this operable unit. Sampling of these wells will be required in the design of this operable unit. In addition, the analyses of the effects on groundwater flow and contaminant transport are required at all operable units that alter pumping patterns. In the case of OU 6AB, particular emphasis on the potential effects on the efficiency of OU 5W will be needed as pumping of the OU 6AB wells may deflect groundwater flow somewhat from the OU 5W wells.

A summary of the estimated costs of operable unit 6AB is presented in Table 7-5.

7.6 REMEDIAL INVESTIGATION

The third largest contaminated zone in the San Gabriel Basin is in Area 2. Remedial action (OU 2BCFHK) using existing wells (and potentially one new extraction well) will be undertaken in Stage III to begin the removal of contaminants from the upper half of the aquifer. This initial action will not resolve the additional potential problem of continued migration of contamination southward. However, the installation of a deep monitoring well at the downgradient margin of the contaminated zone as part of OU 2BCFHK will provide data with which to evaluate the effect of the operable unit on southward migration.

Table 7-5
SUMMARY OF ESTIMATED COSTS FOR OPERABLE UNIT 6AB
($ X 1,000)

Item	Alternative 1	Alternative 2
Remedial Investigation	60	60
Feasibility Study	542	542
Construction	7,087	8,504
Services During Construction and Land Acquisition	1,009	1,150
Design, Legal, and Administrative	1,781	2,124
Total	10,479	12,381
Median Operable Unit Cost	11,430	
Annual O&M Cost	296	319
Median Annual O&M Cost	308	

High concentrations of contamination are known to occur at very shallow levels in the southern portion of Area 2. This contamination has been detected by source investigations in the area; source control actions initiated on the basis of these source investigations may provide the remediation required to address shallow contamination. On the other hand, if monitoring at MW 2-2 indicates that contamination continues to migrate southward at relatively high velocities, and has potentially contaminated deep groundwater to the south, additional remedial actions will be required in the southern portion of Area 2 in Stage IV.

Although remediation of Area 3 is considered of lower priority than remediation of the larger contaminated zones in Areas 5, 6, and 2, the discovery of substantial contamination at depth in this, the deepest portion of the aquifer, could alter the relative significance of contamination in Area 3. Installation of monitoring wells MW 3-1 and MW 3-2 in Stage III will supplement the information gathered from MW 3-3 in Stage II to support remedial action in

Stage IV and to provide a better understanding of subsurface flow conditions in the southern portion of the basin.

Additional investigations to determine the continuity of contamination in Area 4 with contamination in upgradient areas may be necessary. These investigations could foreseeablely include installation of an additional monitoring well (MW 4-3) in the northern portion of Area 4 (Figure 7-1) to better define the previously undetected contamination at depth in the area.

As in Stage II, remedial investigation in Stage III will include continuous updating of the basinwide data with the additional field data acquired. These data will continue to be used to update conceptual and numerical models of hydrogeologic conditions and the extent of contamination. These models are required to monitor the continued migration of contaminants and the effects of remedial actions as they are implemented. This will also allow continuous reevaluation of the recommendations of this plan.

Table 7-6 presents a summary of the estimated costs of these actions.

Table 7-6
SUMMARY OF ESTIMATED COSTS FOR REMEDIAL INVESTIGATION
($ X 1,000)

Item	Cost
Area 3 Well Installation and Sampling	778
Area 4 Well Installation and Sampling	201
Basinwide RI	5,080
Total	6,059

7.7 SUMMARY OF ESTIMATED STAGE III COSTS

A summary of the estimated costs of the actions described in the preceding sections for implementation during Stage III is presented in Table 7-7. As was done for Stage II, the approximate cost of monitoring the performance of Stage III operable units has been added to the summary table. It is assumed that the contingency fund of $5,000,000 from Stage II will still be available; if not, an additional $5,000,000 should be obtained at the beginning of Stage III to maintain the ability to respond to imminent threats to the water supply.

Table 7-7
SUMMARY OF ESTIMATED COSTS FOR STAGE III REMEDIAL AND INVESTIGATIVE ACTIONS
($ X 1,000)

Item	Cost
Operable Unit 2BCFHK	53,420
Operable Unit 5TUV	32,900
Operable Unit 6AB	11,430
Additional Remedial and Cost Recovery Investigations	6,060
Operable Unit Performance Monitoring	782
Total Cost of Implementation	104,592

8.0 STAGE IV ACTIVITIES

The activities recommended in this section for implementation during Stage IV are generally based on the same assumptions regarding the results of Stage II investigations outlined in the previous section. As with Stage III, a variety of alternatives for Stage IV could be considered. However, single sets of actions, considered most likely to be required in terms of the present state of knowledge regarding conditions in the basin, will be presented for Stages IV and V. As before, baseline conditions will be described in which a series of assumptions regarding the results of investigations performed in Stage III are presented.

One of the characteristics of Stage IV (and subsequent) actions is the ability, based on the wealth of information collected in the interim, to undertake aggressive actions considered unacceptable for implementation today because of potentially harmful consequences. Migration control actions, for example, can now be designed with an acceptable level of confidence in their performance and success. Although it was possible to design and install OU 5W in Stage II, considerable effort was focused on acquiring information in the area prior to its implementation. Additionally, the location of OU 5W at the mouth of the Puente Valley limits the extent of possible damage that could result from spreading of existing contamination into uncontaminated areas. In Stage IV, it may be possible to design and install actions of this type throughout the basin.

8.1 BASELINE CONDITIONS

Conditions at the time of implementation of Stage IV will be described qualitatively as a function of (1) time, (2) the effects of remedial actions implemented in previous stages, and (3) the results of previous investigations, as was done for Stage III.

Time of Initiation of Stage IV. As before, it is assumed that the process of conducting enforcement-lead actions will control the timing of implementation of Stage III actions. Table 8-1 is a continuation of Table 7-1 in which Stage III actions have been inserted to estimate the status of previous actions at the beginning of Stage IV.

As shown in Table 8-1, OUs 5CDGFIJ and 5W (Stage II) will probably have been implemented and in operation at the outset of Stage IV; OU 2BCFHK is expected to be in the construction phase of its development; and OUs 6AB and 5TUV will be in the design and negotiation phases respectively. This rather compressed schedule assumes that enforcement actions for OU 2BCFHK began at the outset of Stage III, while actions in support of Stage II activities

TABLE 8-1
STATUS OF STAGE III ACTIVITIES AT INITIATION OF STAGE IV

TODAY ———— *TIME* ————→

RI/FS	*STAGE II* 5CDGFIJ	5W	*STAGE III* 2BCFHK	6AB	5TUV	*STAGE IV*		
SOURCE INDENTIFICATION	AREAS 5 & 6	AREAS 5 & 6	AREAS 5,6 | &2	AREAS 5,6 & 2	AREAS 5 & 6	AREA 5		
SOURCE INVESTIGATION	AREAS 5 & 6	AREAS 5 & 6	AREAS 5,6 | &2	AREAS 5,6 & 2	AREAS 5 & 6	AREA 5		
NEGOTIATION		5CDGFIJ	5W	2BCFHK	6AB	5TUV		
DESIGN			5CDGFIJ	5W	2BCFHK	6AB	5TUV	
IMPLEMENTATION				5CDGFIJ	5W	2BCFHK	6AB	5TUV

<u>EXPLANATION</u> LETTERS REFER TO OPERABLE UNIT DESIGNATIONS DESCRIBED IN SECTION 5.0 AND APPENDIX A.

RI-AREA NUMBERS ARE DEFINED IN FIGURE 1-2. COLUMNS REPRESENT UNDEFINED UNITS OF TIME THAT ARE PROBABLY VARIABLE IN LENGTH.

RI/FS = REMEDIAL INVESTIGATION AND FEASIBILITY STUDY.

were still underway. As with assumptions regarding the degree of development of interpretations of the extent of contamination and hydrogeologic conditions in the basin, assumptions regarding the absolute length of time elapsed prior to the implementation of future stages become less and less accurate with time. Therefore, although the columns in Table 8-1 will continue to be assumed to represent a period of roughly 2 years, it is emphasized that the actual time at which Stage IV will commence is currently very difficult to predict.

<u>Effects of Stage III Actions</u>. Given the assumptions of absolute time discussed above (and in light of the uncertainty of these assumptions), it can be seen in Table 8-1 that OUs 5CDGFIJ and 5W will be the only ones implemented and, presumably, operating, at the outset of Stage IV. Furthermore, if it is assumed that construction and implementation of the OU is finalized at the end of the time period in which it is listed, then OU 5CDGFIJ will have been in operation for a short time (one column), and operation of OU 5W will have just begun. Therefore, as at the start of Stage III, the effects of previous actions on conditions in the basin are assumed to be negligible at the outset of Stage IV.

<u>Assumed Results of Remedial Investigations</u>. As before, several assumptions regarding the general nature of the results of Stage III investigations are described below.

It is assumed that the extent of contamination at depth in Area 2 is now even better understood as a result of data collected from the OU 2BCFHK wells and the additional deep monitoring well constructed in Stage III. Most of the contamination in the northern and central portions of Area 2 is assumed to be well within the vertical zone of capture of the OU 2BCFHK wells. Accordingly, further remediation of the contamination in this area is not considered necessary as it is assumed that refined numerical simulations predict that the modified OU 2BCFHK wells should be able to eventually extract the existing contamination in the area. However, as shown by the preliminary simulations of the effectiveness of OU 2BCFHK described in Section 5.3 and Appendix C, migration of contaminants southward is expected to continue.

Depth-specific logging of monitoring well MW 3-1 in Area 3, south of the contaminated zone, is assumed to encounter no VOC contamination significantly above MCLs at any depth. It is also assumed that Stage II investigations in the northern portion of Area 4 suggested a continuity of contamination with Area 3. New data from MW 3-1 are assumed to indicate that present contamination in the central portion of Area 3 is not continuous with the contamination encountered in monitoring wells in northern Area 4. As discussed below, this is not necessarily inconsistent with the historical migration of contamination from Area 3 into Area 4.

These assumed data illustrate the type of complexities that will certainly be encountered as efforts in the basin progress. The nature and extent of contamination is very dependent, not only on physical processes that control the migration of contaminants, but on the nature of their sources as well. The Stage III data are assumed to basically support the existence of a "pulsed" source of broad frequency somewhere in Area 3. This source(s) introduced contamination historically that has since migrated into Area 4. Subsequent introduction of contaminants has affected Area 3, but migration has not yet reached Area 4. Therefore, in Stage IV, it is assumed to be possible to initiate actions at the downgradient boundary of contamination in Area 3 to prevent these contaminants from reaching Area 4. (It should be noted that there is currently no direct evidence of such a "pulsed" source of contamination. This assumption has been incorporated into Stage IV merely as an illustration of some of the potential difficulties in interpreting the historical migration of contamination.)

Data from monitoring wells in Area 4, along with data from the numerous source investigations and source control actions that have been underway under the lead of the LARWQCB, are expected to have better established the limits of contaminated zones in the north and northwestern portions of Area 4. Specifically, a number of fairly limited areas of highly contaminated groundwater are assumed to have been defined surrounding various clusters of facilities (generally corresponding to the zones presently interpreted in northwestern Area 4). Further action is required to supplement ongoing efforts at the various facilities to address the migration of contamination from each facility.

As described in Stage III, the contamination in Area 5, although most concentrated in the central portion of Area 5, is assumed to be continuous all the way to Whittier Narrows. Thus, aggressive migration control actions to control all contamination in the area are not possible given the lack of a downgradient boundary to control. Instead, continuous monitoring in Area 5 confirms the progress of OUs 5CDGFIJ and 5TUV in removing the high-level contamination in the central portion of Area 5 before it is allowed to migrate. Contamination in southern Area 5 and Area 4 would be allowed to continue to migrate southward where it will be removed by the Suburban and Whittier Narrows wells before it can enter the Central Basin.

In Area 6, a slightly different condition is assumed: the recently-constructed OU 5W appears to be successfully containing the Puente Valley contamination from entering the pumping center in Area 5. Operable Unit 6AB, in the design phase at the outset of Stage IV, would retard the migration of some of the high-level contamination in the upper reaches of the Puente Valley from migrating westward toward Whittier Narrows. However, given the greatly improved ability to predict the response of groundwater flow patterns to stresses induced by additional pumping, it is assumed that additional effort will be required to prevent the eventual migration of contamination from the Puente Valley toward Whittier Narrows. As in Area 3, it is assumed to have been determined in Stage II that Puente Valley contaminants have already reached portions of Area 4. More recent contamination currently in the valley must now be prevented from migrating further.

8.2 SUMMARY OF ACTIONS

In Stage IV, the remediation of some of the smaller zones of contamination is expected to be initiated. It may be possible at this stage to more aggressively control migration in limited contaminated areas. Additional actions could be initiated to further support previous remediation efforts in Areas 2 and 6. Efforts already underway in Area 5 would continue to be carefully monitored. Investigations in Areas 1 and 7 would be undertaken to better define the magnitude of the contamination in these areas that in previous stages have been considered a relatively low priority. Stage IV actions are summarized in Table 8-2 and Figure 8-1.

In Area 1, remedial investigations, consisting primarily of depth-specific sampling of existing wells, would be initiated to better define the extent of contamination in that area. Analysis of these data is expected to support (and establish the need for) future remedial action in this area.

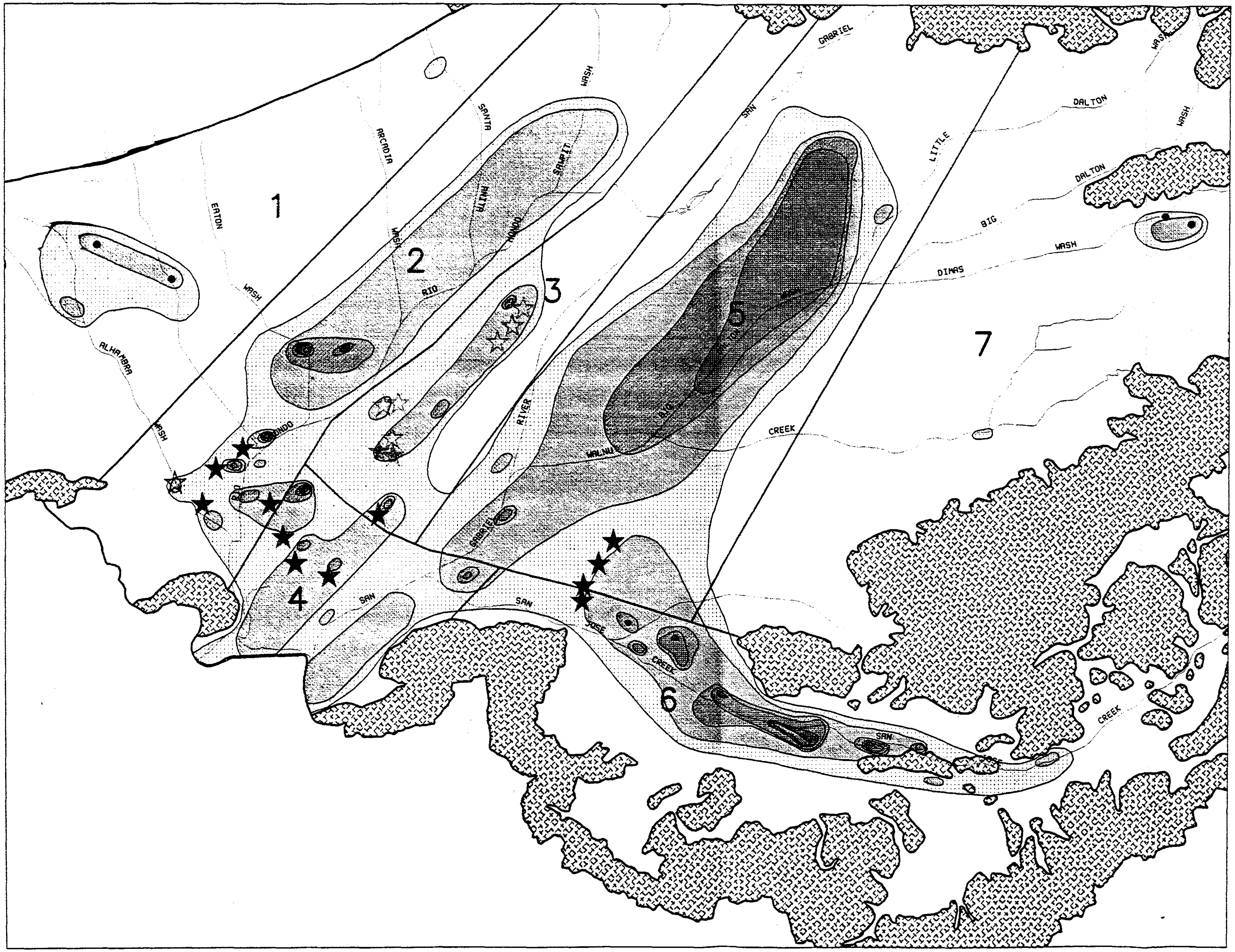
As described above, it is assumed that OU 2BCFHK will provide effective control of the contamination in the northern and central portions of Area 2. However, to control contamination in the southern portion of Area 2, actions would be implemented in Stage IV to supplement efforts already underway as part of source-control actions related to the shallow contamination in the area. The actions undertaken by PRPs in southern Area 2 to remediate the contamination considered related to their own facilities will require supplementary efforts to address contamination migrating into the area from the north. Operable Unit 2LM is expected to supply this support with four new extraction wells and one existing well.

Operable Unit 3BDEGF will be implemented in Area 3 to begin the removal of contaminants in the fourth most contaminated portion of the basin. Data from the monitoring wells installed in Stage III (described above) are expected to better define the downgradient boundary of contamination. Operable Unit 3BDEGF consists of existing wells to extract contaminants from the upper portion of the aquifer, as well as two new extraction wells at the downgradient boundary to control contamination migrating southward at a variety of levels within the aquifer.

Data from numerous source-control investigations and actions that will have been underway for some time under the lead of the LARWQCB in the northwestern part of Area 4, supplemented with information from monitoring wells installed in Stages II and III, may indicate the need for additional efforts to remove contaminants from the area. It is assumed that these will be

Table 8-2
SUMMARY OF STAGE IV ACTIONS

RI Area	Type of Action	Rationale	Activities
Area 1	Remedial Investigation	Better define extent of contamination. Required for planning of potential remedial activities in Stage V.	Well logging and depth-specific sampling of two wells: 01901681 01902786
Area 2	Remedial Action	Supplement source control efforts in southern Area 2 to address contamination migrating from the central and northern portions of Area 2.	Operable Unit 2LM
Area 3	Remedial Action	Remove contamination from the central portion of Area 3 and prevent migration southward into Area 4.	Operable Unit 3BDEGF
Area 4	Remedial Action	Supplement source control efforts in northwestern Area 4 to address contamination from numerous facilities in various reletively small areas.	Operable Unit 4IJ
Area 6	Remedial Action	Control the migration of high-level contamination from Area 6 (Puente Valley) towards Area 4 (Whittier Narrows).	Operable Unit 6E
Area 7	Remedial Investigation	Better define extent of contamination. Required for planning of potential remedial activities in Stage V.	Well logging and depth-specific sampling of two wells: 01902270 01902271



0 0.5 1 2 3
MILES

LEGEND:

- BEDROCK OUTCROP
- HYDROLOGIC BOUNDARY AND ALLUVIAL BASIN BOUNDARY
- SURFACE DRAINAGE
- RI AREA
- CONTAMINATION ZONE BOUNDARY
- VOC CONTAMINATION POTENTIALLY EXCEEDING 1000X MCLS
- VOC CONTAMINATION POTENTIALLY RANGING FROM 100X TO 1000X MCLS
- VOC CONTAMINATION POTENTIALLY RANGING FROM 20X TO 100X MCLS
- VOC CONTAMINATION POTENTIALLY RANGING FROM 10X TO 20X MCLS
- VOC CONTAMINATION POTENTIALLY RANGING FROM MCLS TO 10X MCLS
- VOC CONTAMINATION POTENTIALLY RANGING FROM LABORATORY DETECTION LIMITS TO MCLS
- OPERABLE UNIT 6E
- OPERABLE UNIT 2LM
- OPERABLE UNIT 3BDEGF
- OPERABLE UNIT 41J
- EXISTING OU EXTRACTION WELL
- NEW OU EXTRACTION WELL
- DEPTH SPECIFIC SAMPLING OF EXISTING WELL (01901681, 01902786, 01902270, 01902271)

THE AREAS OF CONTAMINATION SHOWN IN THIS FIGURE REPRESENT GENERALIZED TWO-DIMENSIONAL APPROXIMATIONS BASED ON THE WATER QUALITY ANALYSES FROM PRODUCTION WELLS THAT VARY IN DEPTH AND PERFORATED INTERVALS.

DUE TO POSSIBLE VERTICAL ZONATION OF CONTAMINATION, A WELL LOCATED WITHIN AN IDENTIFIED AREA OF CONTAMINATION MAY PRODUCE WATER WITH CONTAMINANT CONCENTRATIONS DIFFERENT THAN THAT INDICATED ON THIS MAP.

AREAS OF CONTAMINATION ARE BASED ON AVAILABLE DATA FOR THE TIME PERIOD OF AUGUST 15, 1987 THROUGH MARCH 15, 1989, OR THE LAST RECORD FOR WELLS NOT SAMPLED IN THAT TIME PERIOD.

FIGURE 8-1
SUMMARY OF STAGE IV ACTIONS

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enforcement-lead actions that supplement source-control actions at specific facilities. Operable Unit 4IJ consists of (approximately) four new extraction wells at the downgradient margins of relatively small areas of highly contaminated groundwater. This operable unit is expected to address contamination that has migrated from various facilities and coalesced into these small, composite plumes. By removing this contamination while it is still relatively close to its sources, the identification of PRPs is facilitated; and the need to upgrade the Whittier Narrows Operable Unit to prevent the future migration of these contaminants into the Central Basin is eliminated. Where a small area of contamination is clearly attributable to one or two sources, LARWQCB may require responsible parties to clean up that contamination. In those cases, other agency involvement may not be required.

Operable Unit 6E, in the western part of Area 6, may be required to complete the level of migration control initiated with OUs 5W and 6AB. Although OU 6AB, consisting of treatment at existing wells in the valley is expected to provide a level of interim control by slowing this process, additional data may show that more aggressive action will be required.

As in Area 1, investigation of the currently relatively small zone of contamination in Area 7 would begin in Stage IV. Data collected from existing wells should support potential remedial action in Stage V. As shown in Section 2.0, the contamination in Area 7 has the potential of spreading and contaminating a substantial portion of the easternmost part of the basin with time, particularly if residual contamination is great enough to provide a continuous source. Once the most extensively contaminated areas in the rest of the basin have been addressed, it will be possible to consider action at the currently small areas of contamination in Areas 1 and 7 before they become large problems.

8.3 OPERABLE UNIT 2LM

As discussed above, OU 2LM, consisting of four new extraction wells and one existing well, may be required at this stage to supplement the effect of OU 2BCFHK in the northern and central portions of Area 2, as well as the effects of source-control actions in the area. Although implementation of OU 2BCFHK may require eliminating much of the present production in southern Area 2, further action would help protect the pumping center in the southwest corner of Area 2. As with the wells in the southeastern part of Area 5 to be protected by OU 5W, preventing high-level contamination at important production wells enhances the value of the basin for future storage and retrieval, even if current production from them is not required to satisfy demand.

Remedial investigation required to undertake a feasibility study and design of this operable unit will, at a minimum, require depth-specific sampling of the existing local wells. However, in Stage IV, it is anticipated that extensive additional information acquired from the source investigations performed underthe lead of the LARWQCB, along with the data acquired from the Stages II and III investigations, will have provided the basis for a fairly detailed conceptual model of conditions throughout Area 2. Additional investigations to support OU 2LM will probably be limited to local areas with data gaps in the conceptual model.

Estimated costs for the various activities associated with OU 2LM are listed in Table 8-3.

Table 8-3
SUMMARY OF ESTIMATED COSTS FOR OPERABLE UNIT 2LM
($ X 1,000)

Item	Cost (Median)
Feasibility Study	542
Construction	8,457
Services During Construction and Land Acquisition	965
Design, Legal, and Administrative	2,068
Total	12,032

8.4 OPERABLE UNIT 3BDEGF

Operable Unit 3BDEGF (a combination of OUs 3BDEG and 3F in Appendix A) will serve a dual purpose: removal of contamination in Area 3 and control of migration southward into Area 4. Although the assumption regarding the lack of continuity of contamination into Area 4 may appear somewhat arbitrary, an action of this type at this stage is considered likely to be necessary, regardless of the location of the downgradient extent of contamination in Area 3. The six existing wells (3BDEG) in this operable unit could be modified to remove contaminants from the zones of highest contamination within the portion of aquifer accessible to them. Additional contamination, particularly at depth, could be removed at the downgradient boundary of the contaminated zone by two new extraction wells. The various investigations performed in Area 3 during Stages II and III should have provided the majority of the data required to design this operable unit. As with OU 2LM, it is difficult to predict what data gaps will still persist in the area at the time at which this OU enters the feasibility-study phase.

However, given the rather ambitious objective of preventing further migration of a fairly large and complex area of contaminated groundwater, considerable care will be required to assure all levels of contamination are captured by the existing and installed wells. Consequently, a moderate level of effort will be assumed to conduct the remedial investigation of this operable unit, despite the substantial efforts already undertaken in the area.

Table 8-4 lists the estimated costs of OU 3BDEGF.

Table 8-4
SUMMARY OF ESTIMATED COSTS FOR OPERABLE UNIT 3BDEGF
($ X 1,000)

Item	Cost (Median)
Remedial Investigation	134
Feasibility Study	724
Construction	16,583
Services During Construction and Land Acquisition	1,968
Design, Legal, and Administrative	4,072
Total	23,481

8.5 OPERABLE UNIT 4IJ

The location of four new extraction wells at Operable Unit 4IJ is particularly dependent on the nature of data acquired during investigations in the area. In the estimated costs listed in Table 8-5, it is assumed that the extent of contamination in the northwestern part of Area 4 is generally coincident with current interpretations. It is also assumed that four wells, located as shown in Figure 8-1 and in Appendix A, will be sufficient to control a small number of fairly isolated zones of high-level contamination. Much of the information regarding conditions in this area is expected to have already been collected, particularly from source investigations and source-control efforts overseen by the LARWQCB. However, as with OU 3BDEGF, migration control actions require a high degree of confidence to assure adequate capture of contamination. Therefore, although it is difficult to predict the nature of future interpretations of conditions in this area, it is assumed that considerable remedial investigation will be required for adequate design of this operable unit.

Table 8-5
SUMMARY OF ESTIMATED COSTS FOR OPERABLE UNIT 4IJ
($ X 1,000)

Item	Cost (Median)
Feasibility Study	542
Construction	8,676
Services During Construction and Land Acquisition	1,414
Design, Legal, and Administrative	2,220
Total	12,852

8.6 OPERABLE UNIT 6E

Operable Unit 6E is the most ambitious remedial action to be undertaken in Stage IV. As described in Appendix A, this operable unit consists of four new extraction wells located at the western margin of the mouth of Puente Valley. These wells will provide a barrier to the migration of contamination westward toward Whittier Narrows. Earlier implementation of this action was not considered feasible; it may not be possible to verify the need for this type of action until data from OUs 5W and 6AB become available. These earlier actions addressed the pressing problem of protecting wells (5W), and of slowing the movement of high-level contamination in the central and upper reaches of the valley (6AB).

With data from the various monitoring wells, coupled with information from LARWQCB-led investigations throughout the area, it should be possible to design an operable unit of this type with a high degree of confidence in its success in Stage IV. Remedial investigations for this operable unit will be substantial. However, as was the case for the other actions described in this stage, most of the effort will probably involve using data already collected to design the OU 6E extraction wells. Additional data collection will be primarily limited to filling data gaps. Accordingly, the estimated costs listed in Table 8-6 reflect the complexity of designing a successful remedial action of this type.

Table 8-6
SUMMARY OF ESTIMATED COSTS FOR OPERABLE UNIT 6E
($ X 1,000)

Item	Cost (Median)
Feasibility Study	542
Construction	18,060
Services During Construction and Land Acquisition	2,375
Design, Legal, and Administrative	4,495
Total	25,472

8.7 ADDITIONAL REMEDIAL INVESTIGATIONS

As outlined previously, remedial investigations to be undertaken in Stage IV that will not be directly associated with Stage IV remedial actions include depth-specific sampling of wells in Areas 1 and 7. This information will be used to assess the need to undertake remedial actions in those areas. If that need is established, these investigations should provide most of the data required to implement the actions in Stage V.

As in previous stages, updating of the conceptual and numerical models of the basin will continue throughout Stage IV. However, at this stage, the emphasis in these efforts will shift from establishing the type of remedial actions to be implemented in the future to the monitoring of actions already in operation or in the process of implementation. Because of the early focus on acquiring data in Stages I, II, and III, Stage IV investigations will be fairly sophisticated. The ability to understand the dynamics of the hydrologic system within an acceptable degree of uncertainty will be much superior to current capabilities. These efforts will continue throughout the remediation process in the San Gabriel Basin. The estimated costs of these additional remedial investigations are listed in Table 8-7.

8.8 SUMMARY OF ESTIMATED STAGE IV COSTS

Table 8-8 presents a summary of the estimated costs of the actions and investigations described in this section and considered for implementation in Stage IV. The cost of monitoring the performance of Stage IV operable units, which was not included in the previous operable unit cost estimates, is included in the summary table. It is anticipated that additional contingencies for imminent loss of water supply in portions of the basin will no longer be necessary once Stages II and III actions become operational.

Table 8-7
SUMMARY OF ESTIMATED COSTS FOR ADDITIONAL REMEDIAL INVESTIGATIONS

Item	Cost
Area 1 Investigation	90
Area 7 Investigation	90
Basinwide RI	5,080
Total	5,260

Table 8-8
SUMMARY OF ESTIMATED COSTS FOR STAGE IV REMEDIAL AND INVESTIGATIVE ACTIONS

Item	Cost
Operable Unit 2LM	12,030
Operable Unit 3BDEGF	23,480
Operable Unit 4IJ	12,850
Operable Unit 6E	25,470
Additional Remedial Investigations	5,260
Operable Unit Performance Monitoring	1,167
Total Cost of Implementation	80,257

9.0 STAGE V ACTIVITIES

The Stage V activities described in this section represent the final actions, and those with the lowest priorities. These Stage V actions address the currently small zones of contamination in Areas 1 and 7. On the basis of investigations performed in Stage IV, it may be determined that these actions are not required, particularly in the case of Area 1. Groundwater flow directions in the vicinity of the VOC contamination in Area 1 are toward local pumping wells, and contamination is not likely to spread beyond them. In addition, by the time Stage IV nears completion, PRPs may have already addressed the small areas of contamination associated with their facilities. In this case, other than LARWQCB oversight, no additional agency involvement would be required.

In Area 7, there is a potential for the currently limited contamination to spread into a much larger area, as shown in Section 2.0. However, baseline conditions described below for the initiation of Stage V assume that the need for actions in Areas 1 and 7 has been established.

The actual activities that will make up Stage V will probably include a number of supplemental actions to more fully control contaminant migration in one or more of Areas 5, 6, 2, and 3. Continuous monitoring of previously implemented actions will determine the need for additional effort. At present, it will be assumed that actions initiated in Stages I through IV will be sufficient.

9.1 BASELINE CONDITIONS

The following paragraphs summarize assumptions regarding (1) time, (2) the effects of remedial actions implemented in previous stages, and (3) the results of previous investigations, at the outset of Stage V.

Time of Initiation of Stage V. Stage IV included the most ambitious range of actions implemented in any stage. Thus, the period of time elapsed between the initiation of Stages IV and V will likely be correspondingly long. If, as was done previously, it is assumed that enforcement activities will dominate the timing of implementation, Table 9-1 may be considered to represent the status of previous actions at the outset of Stage V.

Unlike the status of previous remediation efforts in Stages III and IV, a large number of actions would have been implemented and in operation for some years at the initiation of Stage V. No fewer than six previously described operable units (all of Stages II and III, and one Stage IV action) are expected to have been implemented prior to Stage V (Table 9-1). However, because Stage V actions would take place in the eastern and westernmost portions of the basin,

TABLE 9-1
STATUS OF STAGE IV ACTIVITIES AT INITIATION OF STAGE V

TODAY ——— *TIME* ———→

RI/FS	*STAGE II* 5CDGFIJ	5W	*STAGE III* 2BCFHK	6AB	5TUV	*STAGE IV* 2LM	3BDEGH	4IJ	6E	*STAGE V*		
SOURCE INDENTIFICATION	AREAS 5 & 6	AREAS 5 & 6	AREAS 5,6 &2	AREAS 5,6 & 2	AREAS 5 & 6	5 AREAS 2,3,4,&6	AREAS 2,3,4,&6	AREAS 3,4, & 6	AREAS 4 & 6	AREA 6		
SOURCE INVESTIGATION	AREAS 5 & 6	AREAS 5 & 6	AREAS 5,6 &2	AREAS 5,6 & 2	AREAS 5 & 6	5 AREAS 2,3,4,&6	AREAS 2,3,4,&6	AREAS 3,4, & 6	AREAS 4 & 6	AREA 6		
NEGOTIATION		5CDGFIJ	5W	2BCFHK	6AB	5TUV	2LM	3BDEGF	4IJ	6E		
DESIGN			5CDGFIJ	5W	2BCFHK	6AB	5TUV	2LM	3BDEGF	4IJ	6E	
IMPLEMENTATION				5CDGFIJ	5W	2BCFHK	6AB	5TUV	2LM	3BDEGF	4IJ	6E

EXPLANATION LETTERS REFER TO OPERABLE UNIT DESIGNATIONS DESCRIBED IN SECTION 5.0 AND APPENDIX A.

RI-AREA NUMBERS ARE DEFINED IN FIGURE 1-2. COLUMNS REPRESENT UNDEFINED UNITS OF TIME THAT ARE PROBABLY VARIABLE IN LENGTH.

RI/FS = REMEDIAL INVESTIGATION AND FEASIBILITY STUDY.

F:\FIGURES\LA062440.TP\TAB9-1.DWG 01/04/90

the effects of previous actions on groundwater flow patterns in these areas will be considered to be minimal.

Effects of Stage IV Actions. Stage V actions will focus on portions of the basin that are not likely to be substantially affected by previous actions in the more central parts of the basin. Furthermore, it is assumed that the remedial actions implemented in large areas of contamination continue to progress. Additional efforts to supplement those of previous stages will not be considered.

Results of Remedial Investigations. Depth-specific sampling in Areas 1 and 7 during Stage IV will be performed to better characterize the hydrogeology and extent of VOC contamination. At the time of implementation of Stage V (an expected minimum of 15 to 20 years from the present as shown in Table 9-1), contamination in Area 7 may be considerably more extensive than it is today, according to the numerical simulations described in Section 2.0. On the other hand, contamination in Area 1 is not expected to migrate away from local pumping centers and, thus, is likely to be removed from the aquifer before it can spread into other areas. Therefore, it is possible that Area 1 actions may be required prior to Stage V to address water supply problems imposed by contamination at the Area 1 wells. Alternatively, Area 1 wells may be taken out of service to accommodate water supplied by two Area 2 operable units, allowing the contamination in that area to spread into a larger area.

It is assumed that the extent of contamination in Area 7 is as shown in Figures 2-7 and 2-8, which present the results of a 20-year simulations of contaminant transport in the basin assuming a number of continuing sources of contamination and present pumping patterns. In Area 1, because of the inability to accurately predict the status of pumping in that area 10 years hence, it is assumed that regional sampling and Stage IV depth-specific sampling define an area of contamination roughly corresponding to the present interpretation (as shown in Figure 1-2).

9.2 SUMMARY OF ACTIONS

Two actions are described below for implementation in Stage V. These are shown in Figure 9-1. Operable Units 1ED and 7AB are combinations of potential operable units in Appendix A.

9.3 OPERABLE UNIT 1ED

The configuration of wells required to remediate contamination in Area 1 in Stage V will be better defined on the basis of the status of production wells and the extent of contamination in that area at the time such action becomes necessary. For the purposes of preliminary planning of Stage V actions, the cost and magnitude of an Area 1 action is assumed similar to OU 1ED, a combination of OUs 1E and 1D in Appendix A. By combining existing wells (1E) with new wells (1D), a wider range of potential conditions is addressed; and options for consideration in the feasibility study for this operable unit are increased.

Remedial investigation required to support this operable unit is expected to begin in Stage IV with the depth-specific sampling of OU 1E wells. It may be necessary, depending on the apparent vertical and lateral extent of contamination, to supplement that information with data from additional monitoring wells, particularly if it is considered likely that contamination extends to depths other than those sampled by the existing wells. The estimated costs of OU 1ED are listed in Table 9-2.

Table 9-2
SUMMARY OF ESTIMATED COSTS FOR OPERABLE UNIT 1ED
($ X 1,000)

Item	Cost (Median)
Remedial Investigation	90
Feasibility Study	542
Construction	11,464
Services During Construction and Land Acquisition	2,019
Design, Legal, and Administrative	2,986
Total	17,101
Annual O&M Costs	263

9.4 OPERABLE UNIT 7AB

Operable Unit 7AB represents two of the potential operable units described in Appendix A, which, like OU 1ED, include both existing and new extraction wells. The existing wells may well be closer to the upgradient boundary of contamination at the time of initiation of Stage V actions because of the continued migration of contaminants to the southwest. Supplementing extraction at existing wells with extraction at at least one additional new well is thus likely to be required to adequately capture a substantial percentage of the contamination.

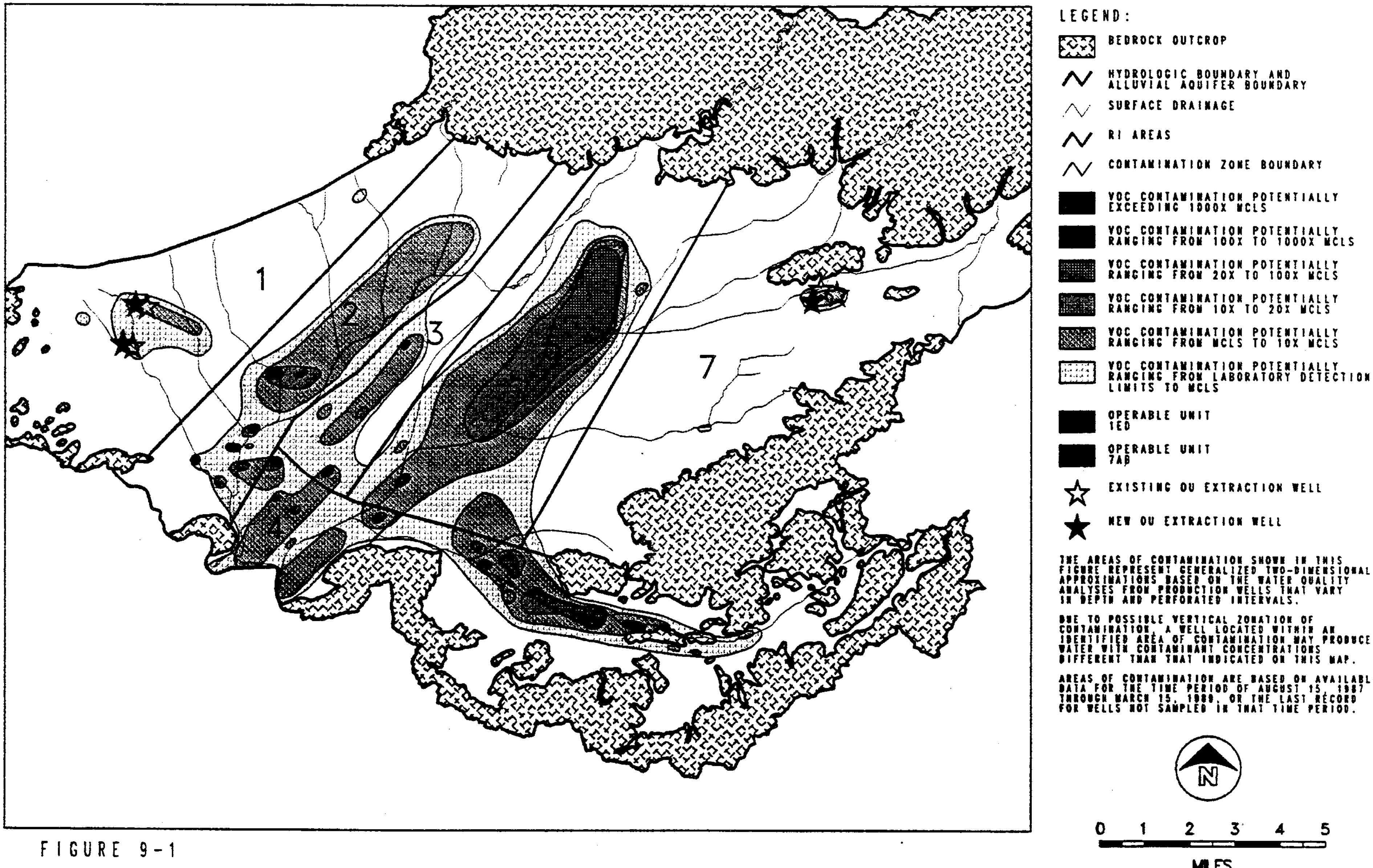

FIGURE 9-1
SUMMARY OF STAGE V ACTIONS

Draft Basinwide Technical Plan
San Gabriel Basin

The predictive simulations of future contaminant migration described in Section 2.0 suggest that detectable contamination in Area 7 will be continuous with that in Area 5 in about 20 years. With the additional pumping associated with OUs 5CDGFIJ and 5TUV, migration toward that area may have been accelerated. Groundwater contaminated above MCLs, however, is not likely to spread as quickly and, even with a steeper gradient toward Area 5, will likely be contained within a relatively limited area at the time Stage V is implemented. Thus, pumping and treating water at the existing wells, supplemented with an additional extraction well at the downgradient boundary of groundwater contaminated above drinking water standards, are expected to provide the remediation required to control the migration of contaminants in the area. Eventually, depending on the nature of residual contaminants, this should remove the bulk of the contamination.

As with OU 1ED, remedial investigation in support of OU 7AB is scheduled to have begun in Stage IV. Again, it may be required to supplement that information with data from an additional monitoring well, particularly if downgradient migration has been significant. Costs of OU 7AB have been estimated as shown in Table 9-3. Because the OU 7AB wells are located in the extreme eastern corner of the basin, in an area where no detailed cost estimates have been performed (i.e., none of the OUs in the representative subset described in Section 2.0 were in Area 7), the extrapolation of costs estimated for other OUs is particularly uncertain in this case. Pipeline and pumping costs are particularly difficult to estimate. Thus, in contrast to previous operable unit cost estimates, no O&M costs, which are closely tied to the amount of redistribution required, have been estimated for OU 7AB.

Table 9-3
SUMMARY OF ESTIMATED COSTS FOR OPERABLE UNIT 7AB
($ X 1,000)

Item	Cost (Median)
Feasibility Study	542
Construction	5,016
Services During Construction and Land Acquisition	731
Design, Legal, and Administrative	1,267
Total	7,556

9.5 ADDITIONAL REMEDIAL INVESTIGATIONS

In Stage V, remedial investigations other than those required to support OUs 1ED and 7AB will primarily include the continued monitoring of conditions basinwide, with particular emphasis on the progress of operable units in Areas 2, 3, 4, 5, and 6. These investigations will likely consist of periodic updates of the conceptual and numerical models of the entire basin and local areas surrounding previous operable units. These investigations must continue until it becomes apparent that contaminant concentrations are declining throughout the area, and that the migration of individual contaminated areas has been controlled and, hopefully, eliminated.

9.6 SUMMARY OF ESTIMATED STAGE V COSTS

The estimated cumulative costs of Operable Units 1ED and 7AB, along with the cost of maintaining updated conceptual and numerical models of the basin and monitoring operable unit performance, are listed in Table 9-4.

Table 9-4
SUMMARY OF ESTIMATED COSTS FOR STAGE V REMEDIAL AND INVESTIGATIVE ACTIONS
($ X 1,000)

Item	Cost
Operable Unit 1ED	17,100
Operable Unit 7AB	7,556
Additional Remedial Investigations	5,080
Operable Unit Performance Monitoring	514
Total Cost of Implementation	30,250

10.0 SUMMARY AND CONCLUSIONS

To date, the first two steps in the general strategy followed by EPA in the San Gabriel Basin, addressing immediate public health threats and containing contamination to the site, are being met by the Stage I activities carried out in the basin. This Basinwide Technical Plan represents the third step of this strategy: development of a long-term plan for achieving the eventual remediation of contaminated groundwater throughout the basin.

10.1 SUMMARY OF STAGES

Enforcement-lead remedial actions recommended for implementation in stages, as described in Sections 6.0 through 9.0, are summarized in Table 10-1, and shown in Figure 10-1. If assumptions regarding the time required to institute enforcement actions requiring PRPs to implement remedial actions are reasonable, and the overlap and scheduling implicit to the organization of actions in Table 10-1 is achievable, a long-term program over the course of decades will be required just to implement the actions recommended. The time required for essentially complete contaminant removal in the vicinity of each operable unit, on the other hand, is impossible to determine given the almost total lack of data regarding the presence, magnitude, and location of residual, undissolved sources of VOCs in the basin that may continue to introduce contaminants into the groundwater. In all likelihood, it is doubtful that the objective of complete contaminant removal can be achieved in any identifiable timeframe. Uncertainty in the time it will take to complete remediation, however, should precipitate action rather than delay until some of the intangible factors are better understood. In the case of continuing sources of contamination in the subsurface, questions will likely never be resolved.

The Stage II activities outlined in Section 6.0 represent actions considered of the highest priority that require immediate attention. These actions include substantial remedial investigation to fill gaps in the current conceptual interpretation of conditions within the aquifer. Because this information is needed to support efforts to recover the costs of previous actions in the basin, it is possible to combine priorities and accomplish several objectives with single actions. In addition to investigative efforts, however, Stage II also includes two remedial actions that will for the first time actively reduce the levels of contamination (and, potentially, the extent of contamination) and attempt to control migration into currently uncontaminated areas.

TABLE 10-1
SUMMARY OF REMEDIAL ACTIONS BY STAGE

TODAY ——— *TIME* ———→

RI/FS	*STAGE II* 5CDGFIJ	5W	*STAGE III* 2BCFHK	6AB	5TUV	*STAGE IV* 2LM	3BDEGF	4IJ	6E	*STAGE V* 7AB	1ED			
SOURCE INDENTIFICATION	AREAS 5 & 6	AREAS 5 & 6	AREAS 5,6 &2	AREAS 5,6 & 2	AREAS 5 & 6	5 AREAS 2,3,4,&6	AREAS 2,3,4,&6	AREAS 3,4,&6	AREAS 4 & 6	AREAS 6 7,&1	AREAS 7 & 1	AREA 1		
SOURCE INVESTIGATION	AREAS 5 & 6	AREAS 5 & 6	AREAS 5,6 &2	AREAS 5,6 & 2	AREAS 5 & 6	5 AREAS 2,3,4,&6	AREAS 2,3,4,&6	AREAS 3,4,&6	AREAS 4 & 6	AREAS 6 7,&1	AREAS 7 & 1	AREA 1		
NEGOTIATION		5CDGFIJ	5W	2BCFHK	6AB	5TUV	2LM	3BDEGF	4IJ	6E	7AB	1ED		
DESIGN			5CDGFIJ	5W	2BCFHK	6AB	5TUV	2LM	3BDEGF	4IJ	6E	7AB	1ED	
IMPLEMENTATION				5CDGFIJ	5W	2BCFHK	6AB	5TUV	2LM	3BDEGF	4IJ	6E	7AB	1ED

<u>EXPLANATION</u> LETTERS REFER TO OPERABLE UNIT DESIGNATIONS DESCRIBED IN SECTION 5.0 AND APPENDIX A.

RI-AREA NUMBERS ARE DEFINED IN FIGURE 1-2. COLUMNS REPRESENT UNDEFINED UNITS OF TIME THAT ARE PROBABLY VARIABLE IN LENGTH.

RI/FS = REMEDIAL INVESTIGATION AND FEASIBILITY STUDY.

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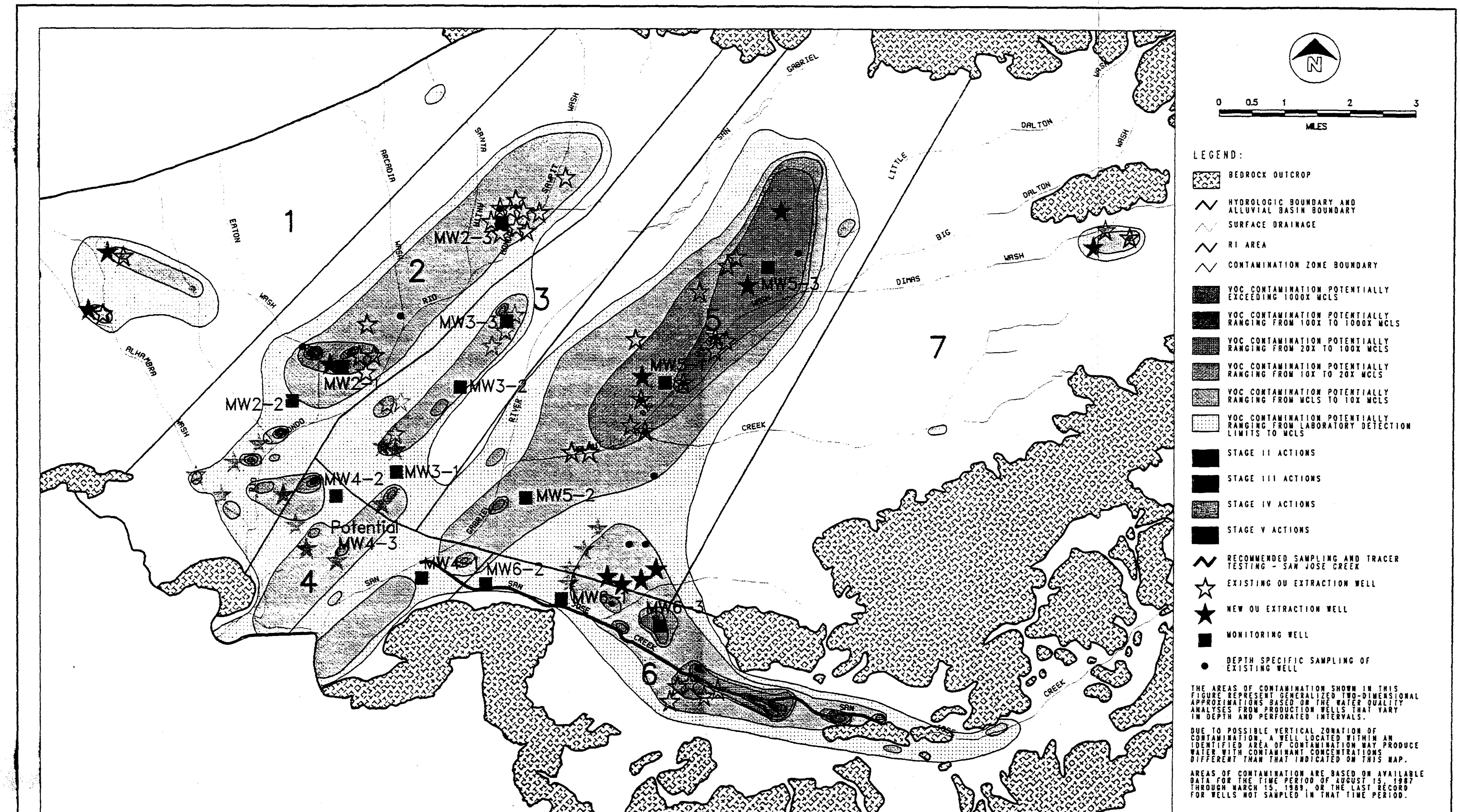

THE AREAS OF CONTAMINATION SHOWN IN THIS FIGURE REPRESENT GENERALIZED TWO-DIMENSIONAL APPROXIMATIONS BASED ON THE WATER QUALITY ANALYSES FROM PRODUCTION WELLS THAT VARY IN DEPTH AND PERFORATED INTERVALS.

DUE TO POSSIBLE VERTICAL ZONATION OF CONTAMINATION, A WELL LOCATED WITHIN AN IDENTIFIED AREA OF CONTAMINATION MAY PRODUCE WATER WITH CONTAMINANT CONCENTRATIONS DIFFERENT THAN THAT INDICATED ON THIS MAP.

AREAS OF CONTAMINATION ARE BASED ON AVAILABLE DATA FOR THE TIME PERIOD OF AUGUST 15, 1987 THROUGH MARCH 15, 1989, OR THE LAST RECORD FOR WELLS NOT SAMPLED IN THAT TIME PERIOD.

FIGURE 10-1

SUMMARY OF STAGES

Draft Basinwide Technical Plan
San Gabriel Basin

In Stage III, Stage II efforts in the two most contaminated areas of the basin would be supplemented with additional actions designed to accelerate eventual remediation and further isolate these presently contaminated areas. Stage III also addresses the contamination in Area 2, the third most contaminated portion of the basin.

By the time Stage IV efforts are initiated, uncertainty in the ability to simulate the response of groundwater in the basin to stresses imposed by changes in pumping patterns will have been reduced sufficiently to allow the implementation of aggressive actions, without the potential for inducing harmful effects. It will be possible to "fine-tune" previous remediation with actions that focus on contamination not adequately or completely controlled by previous actions. In addition, Stage IV includes aggressive remediation of the contaminated portion of Area 3.

Stage V actions are essentially those currently considered to be of lowest priority that were not addressed in previous stages. In addition to operable units in Areas 1 and 7, it is likely that Stage V will also include various actions required to supplement actions initiated in earlier stages, or address contamination not yet identified. The need for such actions would be determined by continuously acquiring and reviewing new data, incorporating it into the conceptual and numerical models of the basin, and reevaluating activities to be undertaken at each stage. A centralized, ongoing effort to manage the technical implementation of this plan is required to provide the ability to perform these functions.

10.2 SUMMARY OF COSTS

The estimated costs of implementing each stage of this plan are summarized in Table 10-2. These costs are essentially derived from the operable unit-specific estimates described in Appendix E, and summarized in the descriptions of each of the stages. It should be noted that these costs are not related to the single-objective estimates presented in Appendix B and summarized in Section 4.0. The single-objective cost estimates are supplied only to illustrate the potential differences in overall cost in pursuing various, alternate, general approaches to remediation. The cost estimates summarized in Table 10-2, on the other hand, represent a more realistic, multiple-objective approach.

10.3 BASINWIDE TECHNICAL MANAGEMENT

It has been emphasized throughout this report that the limited current level of understanding of conditions throughout the basin precludes the immediate remediation of every part of the basin. Staging of actions into discrete steps allows the information required to reduce this uncertainty to be obtained without delaying the initiation of partial remediation efforts. However, reduction of this uncertainty will be accelerated if incorporation of data into the current conceptual and numerical models of the basin is performed by a single, central group responsible for the continuous updating of these models. The type of role such a group might perform during the implementation of a single stage is illustrated in Figure 10-2.

Table 10-2
SUMMARY OF ESTIMATED COSTS FOR STAGE V REMEDIAL AND INVESTIGATIVE ACTIONS
($ X 1,000)

Item	Cost
Stage II	106,565
Stage III	104,592
Stage IV	80,257
Stage V	30,250
Total	321,674

Generally, implementation of remediation actions in stages allows concurrent activities, including technical oversight and model updating activities, to occur in an organized, episodic manner. As illustrated in Figure 10-2, the state of knowledge at the outset of a stage, embodied in documented conceptual and numerical models, will form the basis for designing and implementing remedial actions and investigations during the course of that stage. As data are accumulated from investigations undertaken during a particular stage, as well as from the monitoring of previous actions, they must be continuously reviewed and incorporated into the data base to assure that the conceptual and numerical models remain current. Towards the end of a stage, the revised models should be documented and used to reevaluate the activities recommended to address the next level of priorities.

In all, a central basinwide technical management team that will continuously oversee the entire remediation process would provide the following:

- o A consistent approach to implementing actions and interpreting conditions throughout the execution of this plan

- o A continuously updated and consistent data base

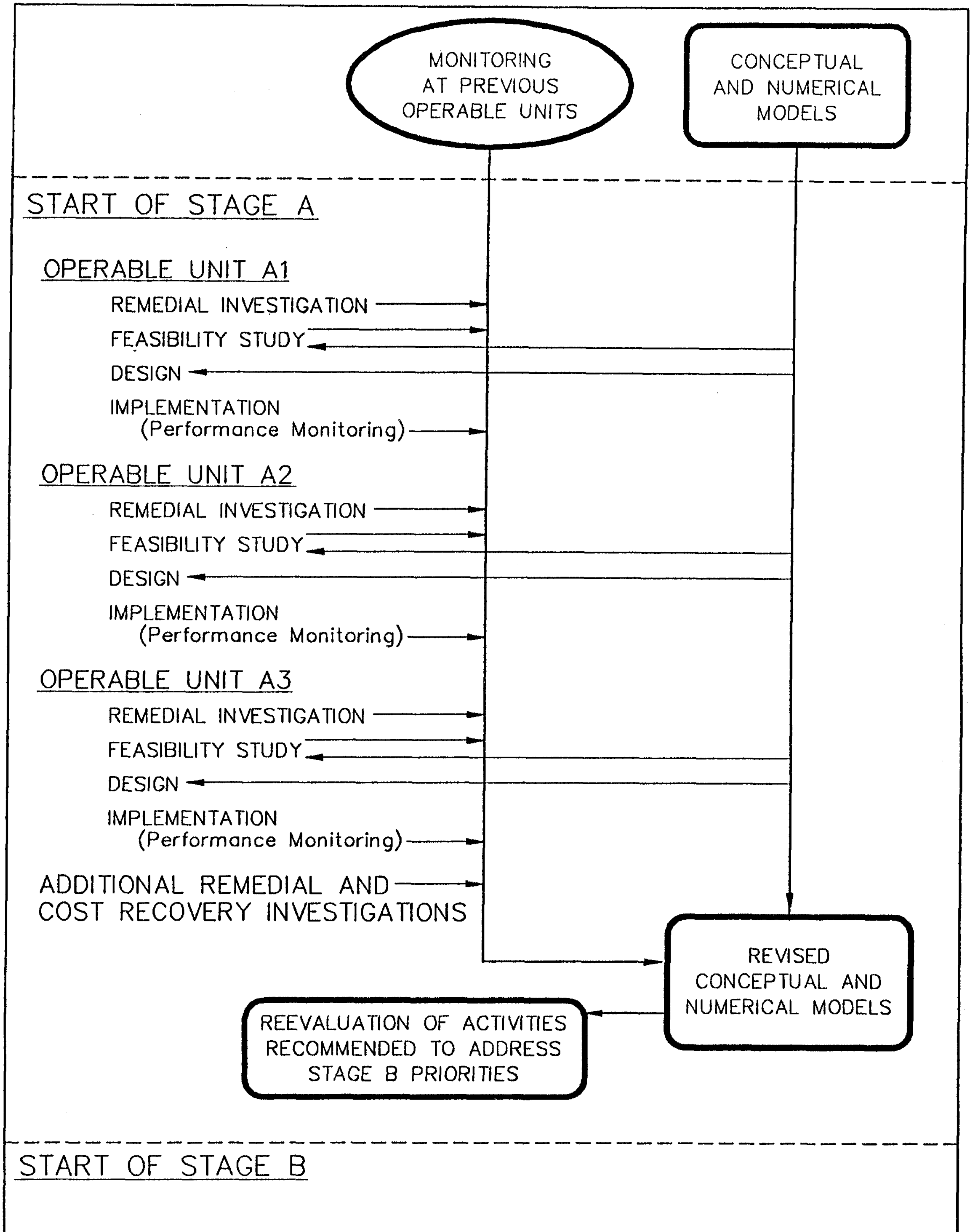

FIGURE 10–2
CONTINUING TECHNICAL MANAGEMENT OF BASINWIDE PLAN
DRAFT BASINWIDE TECHNICAL PLAN
SAN GABRIEL BASIN

F:\FIGURES\LA062440.TP\FIG10-2.DWG 3-30-90

- o The ability to administer the plan in a dynamic fashion by constantly reevaluating the best course of action

- o Regular monitoring of conditions basinwide to be able to implement actions to address immediate threats to the public health

- o Regular monitoring of the progress of remedial action

The cost of this centralized technical management has been incorporated into the estimated total cost of the individual stages.

In closing, a number of additional issues that relate to the potential success of remediation in the San Gabriel Basin should be restated; namely, the need for strong leadership and a concerted, cooperative effort on the part of all parties involved to coordinate the execution of the technical and administrative components of a long-term strategy. Within this context, it is the intent of this plan, in addition to providing a framework for long-term remediation that considers the relative importance of numerous technical and institutional factors, to underscore the following:

- o The complexity of the problem, both from the standpoint of multiple plumes of contamination caused by multiple sources, as well as the difficulty of accurately predicting the response of a highly heterogeneous aquifer 170 square miles in area and over 4,000 feet thick to remediation efforts

- o The absolute necessity of redistributing the present pumping pattern, requiring the short- and long-term cooperation of all organizations responsible for water production and quality in the basin

- o The immense value of the San Gabriel Basin as the prime, and possibly only, available source of water to about one million people; and, perhaps even more importantly, as a key component in the long-term management of the very limited water resources of Southern California.

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VOLUME II

REM IV

Remedial Planning Activities
at Selected Uncontrolled
Hazardous Waste Sites–Zone II

Environmental Protection Agency
Hazardous Site Control Division
Contract No. 68-01-7251

PUBLIC REVIEW DRAFT
BASINWIDE TECHNICAL PLAN
REPORT

VOLUME TWO
SAN GABRIEL BASIN
LOS ANGELES, CALIFORNIA

April 17, 1990

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April 17, 1990

Appendix A
IDENTIFICATION OF POTENTIAL OPERABLE UNITS

APPENDIX A

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APPENDIX A

TABLES

FIGURES

Appendix A
IDENTIFICATION OF POTENTIAL OPERABLE UNITS

A.1.0 INTRODUCTION

Potential operable units (OUs) have been identified throughout the basin to address the remedial objectives described in Section 4.2.1. In general, each OU consists of one or more groups of wells (clusters) made up of existing production wells, proposed new extraction/production wells, or a combination of existing and proposed wells.

It is not intended that the identification of an OU specify a particular remedial action such as wellhead treatment. However, specific actions are implied in many instances by the choice of objectives and the definition of the OU. A varying number of OUs have been identified in each of the seven Remedial Investigation (RI) Areas based on the extent of contamination and the number and location of wells within the area.

The following sections discuss remedial objectives (as summarized in Section 4.2.1) and potential remedial actions; well identification procedures; OU identification; area-specific OU descriptions, including brief discussions of some of the RIs that may be required prior to implementation of each particular alternative; and a comparative evaluation of OUs.

A.2.0 REMEDIAL OBJECTIVES AND POTENTIAL REMEDIAL ACTIONS

A number of remedial objectives for mitigation of groundwater contamination in the San Gabriel Basin form the basis for both identification of OUs and evaluation of potential remedial action responses. A detailed discussion of general basinwide strategy and specific remedial objectives considered at the OU level is presented in Section 4.0. Potential remedial actions may be used alone or grouped into a variety of combinations to define a suite of remedial actions. These remedial actions may be applied to mitigate a specific problem at a specific location OU to address the remedial objectives. A brief recapitulation of the remedial objectives (prevent exposure, maintain adequate water supply, protect natural resources, manage contaminant migration, and remove contaminants) is presented below, followed by a discussion of the remedial actions and associated objective(s).

A.2.1 SUMMARY OF REMEDIAL OBJECTIVES

A.2.1.1 Prevent Exposure of the Public to Contaminated Groundwater

Preventing exposure of the public to contaminated groundwater is a fundamental objective common to all basinwide remedial actions. Potential exposure pathways include consumption and/or contact with contaminated domestic and industrial water supplies, air emissions from highly contaminated areas, and contact with contaminated surface water bodies.

A.2.1.2 Maintain an Adequate Water Supply

The goals of this objective are to maintain the currently available groundwater supply and alleviate potential water supply problems as they occur in existing distribution systems.

A.2.1.3 Protect Natural Resources

The goal of this objective is to allow the continued development of the groundwater in the San Gabriel Basin as an approximately 200,000 acre-foot per year renewable resource and to allow continued storage and retrieval of supplemental water within the basin.

A.2.1.4 Control Migration of Contaminated Groundwater

Controlling the spread of contaminants within the San Gabriel Basin and minimizing the spread of contamination into other groundwater basins are the goals of the contaminant migration objective.

A.2.1.5 Remove Contaminated Groundwater

The contaminant removal objective goal is to provide remediation of contaminated groundwater within the basin by removing contaminants and decreasing the extent of groundwater contamination.

A.2.2 REMEDIAL ACTIONS AND RELATED REMEDIAL OBJECTIVES

A.2.2.1 Treatment at Existing Wells

Remedial alternatives include installing systems to treat contaminated groundwater from existing wells or groups of wells. Treatment alternatives would likely include air stripping, carbon adsorption, or advanced oxidation (i.e., ozone-peroxide), with discharge of the treated groundwater directly to the existing distribution systems.

Remedial alternatives that focus solely on treatment at existing wells could effectively address water supply and contaminant removal objectives. Additionally, depending on the location of the existing well(s) selected for treatment, a degree of contaminant migration control could be affected and groundwater resources could be preserved locally. Wellhead treatment differs from the aggressive pump/treat options described below in that it is intended exclusively for existing wells that will probably continue to pump according to demand, which severely limits migration control benefits. Treatment at existing wells can be used in conjunction with other actions to achieve objectives more ambitious than maintaining an adequate water supply. Available data are probably sufficient in most cases to implement a treatment action with little additional RI, thereby minimizing associated RI costs and lead time prior to initiation of the action.

A.2.2.2 Aggressive Extraction from Center of Contaminated Zones

Aggressive pumping and treatment of contaminated groundwater from the central, more highly concentrated areas of contamination is considered one of the most efficient techniques available for removing contamination from the aquifer. In addition to contaminant removal, such an action would provide a supply of potable water and help prevent exposure of the public to contaminants, as well as limit the risk of spreading high concentrations of contamination to uncontaminated areas.

The term "aggressive," in this context, is meant to imply pumping from both existing and new wells, probably at rates exceeding those ordinarily required to meet demand. Existing wells in highly contaminated areas are presently inactive in most cases; and local demand is being satisfied from elsewhere in the basin. A large amount of aggressive pumping may lead to an excess of discharged groundwater, some of which may be returned to the groundwater system or passed to the next basin. Treated groundwater could be provided to replace production at other wells. Through careful selection of other production wells to be shut down, regional hydraulic gradients may be altered, and therefore, provide additional benefits of limiting the spread of contamination to other areas. Implementing aggressive pumping actions in the center of contaminated zones without reducing current pumping rates in other areas by a proportional amount would require careful consideration of treated water disposal options and the management of the groundwater basin as mandated in the adjudication judgement (discussed in Section 3.0). Significant RI effort may be associated with this type of action to better define the vertical extent of contamination.

A.2.2.3 Aggressive Downgradient Extraction from Contaminated Zones

The primary purpose of downgradient extraction alternatives is to prevent migration of contaminated groundwater beyond the OU. An OU of this type, if properly designed, would also preserve groundwater resources downgradient, provide potable water for local consumption, and prevent exposure of the public to contamination. Such an OU would typically consist of groundwater extraction, treatment, and disposal of the treated water.

The term "aggressive" is defined above. Groundwater extraction would be accomplished by a line of new, existing, or new and existing wells located along the downgradient margin of a contaminated area. This margin could represent the downgradient boundary of contamination above maximum contaminant levels (MCLs) or greater to allow continued use of less contaminated water for blending. Wells could be spaced and screened in a manner appropriate to intercept migrating contaminants to the extent possible. Based on the available data, probable treatment options for the extracted groundwater include carbon adsorption, air stripping, and advanced oxidation. The success of a downgradient extraction OU in effectively preventing further migration of a "plug" of contamination depends on maintaining the direction of contaminant migration into the capture zone of the OU wells. As with the central extraction alternative described above, a downgradient extraction alternative would likely produce water in excess of local demand. Problems related to disposal of the excess treated water may be avoided by reducing or eliminating production at other wells. Additionally, the efficiency of the OU could be enhanced by the effects of altered pumping patterns on the regional hydraulic gradient, or by limiting extraction to vertical intervals containing the highest concentrations of contaminants. Substantial RI efforts are required for the design and implementation of actions of this type to better define the vertical extent of contamination and predict the dynamic response of the hydraulic system. Disposal of the treated groundwater may be to existing water distribution systems, surface water bodies, injection wells, aquifer recharge facilities, or a combination of these options.

A.2.2.4 Surface Water Remedial Actions

Surface water remedial actions could be implemented to protect the public from exposure by minimizing the potential for contact with contaminated water at the surface. Additionally, these actions could retard or block a relatively rapid migration pathway and remove contaminants from the system. Data regarding the nature of the contamination, surface water-groundwater interactions, or physical characteristics of the improved portions of the San Jose Creek channel must be reviewed in detail to assess the potential risk of exposure and accelerated migration and evaluate the need for short-term action. For the purposes of this assessment, it is assumed that remedial actions would likely consist of any of a variety of contaminant migration control techniques including surface water diversion, collection, or blockage of the channel or subdrain of the lined channel prior to eventual discharge to Whittier Narrows.

A.3.0 IDENTIFICATION OF WELLS

To simplify the assembly of existing and proposed wells into OUs, wells were grouped into "clusters" of similar characteristics (i.e., depth and perforation interval) and proximal location. Consideration of well clusters provides a convenient framework for presenting information and describing OUs made up of one or more clusters. The term "cluster" will be retained throughout the remainder of this appendix, even though several clusters consist of only one well. Well clusters are referred to by letters preceded by the RI Area number. For example, there are two clusters in Area 7: 7A and 7B.

Existing candidate wells identified for inclusion in clusters include only those wells with maximum detected levels of trichloroethene (TCE), tetrachloroethene (PCE), carbon tetrachloride (CTC), 1,2-dichloroethene (1,2-DCE), 1,2-dichloroethane (1,2-DCA) (cis and trans), or 1,1,1-trichloroethane (1,1,1-TCA) exceeding MCLs at any time. Wells with contaminant concentrations less than these regulatory criteria are not considered. In some instances, proposed new well locations have been identified to supplement existing wells to address a specific OU objective. These well locations and estimated screened intervals are based on area-specific estimates of contaminant conditions, hydrogeologic properties, and the desired objective of the OU.

Pertinent data on the individual wells identified in well clusters are presented in Table A-1. Maximum and mean contaminant concentrations listed for existing wells were calculated from water quality data from samples taken through August 1988. Mean contaminant concentrations listed for the proposed new wells are estimates based on the mean concentrations of existing wells in the vicinity multiplied by a factor of 1.5. The 1.5 factor reflects two assumptions: (1) new extraction wells will likely be selectively screened over limited contaminated intervals, and (2) contaminant concentrations in migration-control wells are expected to be greater than those of wells screened over larger intervals, and will probably increase with time. Total volatile organic compounds (VOCs) removed per million gallons is the sum of the mean concentrations of all six contaminants, converted from micrograms per liter (ug/l) to pounds per million gallons (lb/MG). The total amount of VOCs removed per year represents the pounds of VOCs removed per million gallons multiplied by total gallons pumped per year (assuming the well is pumped at capacity for the entire year). The overall trend for each well has been estimated visually as summarized in Table A-1. Numbers ranging between -3 to +3 correspond to the interpreted combined slope of individual VOCs. (Positive numbers indicate an increasing trend.) Data used to estimate contaminant concentrations in proposed wells and to determine well clusters in Table A-1 are presented in Tables A-2 and A-3, respectively.

Table A-1
Well Cluster Data

CLUSTER*	WELL NUMBER	SCREEN INTERVAL	TOTAL DEPTH (FT)	CAP. (GPM)	WELL STATUS (a)	YEAR INST.	TCE MAX (ug/l)	TCE MEAN (ug/l)	PCE MAX (ug/l)	PCE MEAN (ug/l)	CTC MAX (ug/l)	CTC MEAN (ug/l)	DCE MAX (ug/l)	DCE MEAN (ug/l)	DCA MAX (ug/l)	DCA MEAN (ug/l)	TCA MAX (ug/l)	TCA MEAN (ug/l)	VOCs REMOVED (lbs/mgal)	VOCs REMOVED (lbs/yr)	VOC TREND	NO3 MAX (mg/l)	NO3 MEAN (mg/l)	WELL OWNER
1A	01902786	325-821	827	1730	P	1974	0.1	0.0	7.6	5.0	0.0	0.0	4.0	1.3	0.0	0.0	0.0	0.0	0.05	48.0	0			San Gabriel Co. Water Dist.
1B	01900018	237-496	548	493	N	1923	16.0	6.0	0.5	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05	13.2	0	648.0	209.3	Alhambra, City of
1C	01900013	247-743	831	568	S	1949	12.3	6.3	1.8	0.2	0.1	0.0	1.2	0.2	0.0	0.0	0.0	0.0	0.06	16.8	-1			Alhambra, City of
	01900012	260-735	755	839	P	1949	13.1	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	27.6	-1			Alhambra, City of
1D	1D000001	200-400	400	750	NEW			0.1		20.0								0.0	0.17	66.4				
	1D000002	200-400	400	750	NEW			5.1				0.2							0.04	17.3				
1E	01903097	320-652	800	1681	P	1973	8.2	3.4	0.0	0.0	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.03	25.9	+1			Alhambra, City of
	01901681	222-693	720	1250	T	1924	1.2	0.1	23.0	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.11	73.7	0	50.5	50.5	South Pasadena, City of
2A	01902030	116-456	540	668	S	1926	29.0	11.8	1.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	35.9	+1	76.9	32.0	So. Cal. Water Co.- San Gab.
	01902461	400-475	540	779	P	1957	16.0	5.4	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05	18.9	+1	50.0	45.0	So. Cal. Water Co.- San Gab.
2B	01902018	UNK.	318	360	T	1925	260.0	158.3	15.0	7.4	0.0	0.0	20.0	20.0	0.0	0.0	54.0	54.0	2.00	378.9	0			So. Cal. Water Co.- San Gab.
	01902017	182-275	285	553	T	1922	340.0	159.7	23.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	31.0	31.0	1.67	484.9	-1	52.0	52.0	So. Cal. Water Co.- San Gab.
	01900418	73-420	440	2200	P	1924	167.0	34.2	11.0	3.3	0.2	0.0	5.2	1.3	1.5	0.5	49.0	4.8	0.37	426.0	-2	54.0	49.7	Monrovia, City of
	01900419	80-480	500	3800	P	1946	45.4	4.8	3.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	5.3	1.3	0.06	111.4	0	50.0	33.9	Monrovia, City of
	01900356	221-306	356	1684	T	1918	17.0	6.9	1.0	0.8	0.0	0.0	1.2	0.4	0.0	0.0	7.2	2.0	0.08	74.1	0			Cal Amer Water-Duarte System
2C	01902019	199-626	656	3200	T	1950	121.0	27.1	12.0	3.0	0.0	0.0	1.8	0.5	2.6	0.7	29.0	12.6	0.37	614.8	-1	52.0	52.0	So. Cal. Water Co.- San Gab.
	01900420	233-502	530	3843	P	1950	48.0	0.7	3.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.7	0.01	26.3	+2			Monrovia, City of
	01900417	74-470	476	2297	P	1918	42.0	8.1	3.9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.3	0.08	94.0	-2	48.3	25.9	Monrovia, City of
	01901013(b)	275-528	550	2800	P	1927	48.0	19.3	6.8	2.3	0.3	0.0	6.5	1.7	8.4	1.0	52.0	5.5	0.25	366.0	-2			Arcadia, City of
	01901014(b)	256-634	656	3000	P	1931	83.0	11.4	19.0	1.8	2.6	0.1	5.3	1.1	0.0	0.0	12.0	1.2	0.13	204.8	-2			Arcadia, City of
2D	01902948	229-600	600	1100	P	1966	16.0	7.2	3.6	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.08	43.8	0			So. Cal. Water Co.- San Gab.
	01902034	274-455	540	804	P	1951	11.9	4.5	3.1	1.6	0.0	0.0	0.9	0.2	0.0	0.0	1.1	0.4	0.06	23.6	-2			So. Cal. Water Co.- San Gab.
2E	21900749	175-505	530	1290	P	1954	19.2	7.7	3.0	1.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08	51.2	0			San Gabriel Valley Water Co.
	28000065	185-600	620	2700	P	1974	17.5	6.9	0.9	0.2	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.06	84.7	-1			San Gabriel Valley Water Co.
	21902857	184-600	600	2300	P	1963	25.0	8.7	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.07	89.6	-1			San Gabriel Valley Water Co.
	01902027	156-798	800	1010	S	1955	25.8	12.1	6.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.12	66.4	-2			So. Cal. Water Co.- San Gab.
2F	01902031	81-186	206	340	T	1942	86.0	52.3	20.0	13.5	3.0	3.0	1.0	0.5	0.0	0.0	0.0	0.0	0.58	103.4	0			So. Cal. Water Co.- San Gab.
	01902032	110-184	196	260	T	1937	83.0	35.5	22.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.36	49.8	0			So. Cal. Water Co.- San Gab.
	01901695	126-342	358	494	T	1947	80.0	20.8	5.6	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.19	49.1	0			El Monte, City of
	01902020	62-187	446	739	P	1944	14.6	2.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	9.1	0	48.0	48.0	So. Cal. Water Co.- San Gab.
2G	01902787	304-363	392	274	Q	1961	9.6	3.9	0.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	5.3	0			Cal. Water Co.- San Marino
2H	01901055	120-648	648	650	P		142.0	52.8	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	150.7	-1			Clayton Manufacturing Co.
2I	01902666	226-475	504	230	T		8.0	5.0	0.7	0.4	0.0	0.0	0.2	0.1	0.1	0.0	0.2	0.1	0.05	5.6	0			Los Angeles, County of
2J	2J000001	100-800	800	3000	NEW			42.0		0.6									0.36	561.0				
	2J000002	100-800	800	3000	NEW			42.0		0.6									0.36	561.0				
	2J000003	100-800	800	3000	NEW			42.0		0.6									0.36	561.0				

NOTE: * Well locations are shown in Figures A-1 through A-7

Table A-1 (continued)

CLUSTER*	WELL NUMBER	SCREEN INTERVAL	TOTAL DEPTH (FT)	CAP. (GPM)	WELL STATUS (a)	YEAR INST.	TCE MAX (ug/l)	TCE MEAN (ug/l)	PCE MAX (ug/l)	PCE MEAN (ug/l)	CTC MAX (ug/l)	CTC MEAN (ug/l)	DCE MAX (ug/l)	DCE MEAN (ug/l)	DCA MAX (ug/l)	DCA MEAN (ug/l)	TCA MAX (ug/l)	TCA MEAN (ug/l)	VOCs REMOVED (lbs/mgal)	VOCs REMOVED (lbs/yr)	VOC TREND	NO3 MAX (mg/l)	NO3 MEAN (mg/l)	WELL OWNER
2K	2K000001	100-600	600	3000	NEW			66.0		19.2		2.3		0.5					0.73	1157.5				
2L	2L000001	100-200	200	500	NEW			62.3		102.1				0.4				17.1	1.52	399.2				
	2L000002	100-200	200	500	NEW					57.0									0.48	125.1				
	2L000003	100-200	200	500	NEW			21.2		27.0				0.5		0.4		0.0	0.41	107.7				
	2L000004	100-200	200	500	NEW					1005.0									8.39	2205.8				
2M	01900458	150-586	600	644	P	1954	6.0	2.2	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	6.3	0			Monterey Park, City of
2N	01902018	UNK.	318	360	T	1925	260.0	158.3	15.0	7.4	0.0	0.0	20.0	20.0	0.0	0.0	54.0	54.0	2.00	378.8	0			So. Cal. Water Co.- San Gab.
	01902017	182-275	285	553	T	1922	340.0	159.7	23.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	31.0	31.0	1.67	484.9	-1	52.0	52.0	So. Cal. Water Co.- San Gab.
	01902019	199-626	656	3200	T	1950	121.0	27.1	12.0	2.7	0.0	0.0	1.8	0.5	2.6	0.7	29.0	12.6	0.36	610.6	-1	52.0	52.0	So. Cal. Water Co.- San Gab.
3A	01901178(c)	250-300	300	300	P	1945	5.0	0.3	78.5	20.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.18	27.9	-1			Hemlock Mutual Water Co.
	01902806(c)	124-240	248	550	P	1962	3.0	0.2	210.0	73.4	0.1	0.0	0.0	0.0	0.0	0.0	1.5	0.1	0.61	177.9	-1			Hemlock Mutual Water Co.
3B	11900729	128-193	198	1800	P	1946	1.8	0.1	46.0	12.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	97.1	+1			San Gabriel Valley Water Co.
3C	01901522(c)	114-195	195	200	P	1935	3.0	1.2	92.0	36.6	0.2	0.0	0.0	0.0	0.0	0.0	0.6	0.2	0.32	33.4	0			Richwood Mutual Water Co.
	01901521(c)	121-142	148	650	P	1954	1.7	0.4	96.0	31.2	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.1	0.26	90.4	0			Richwood Mutual Water Co.
3D	01901694	100-190	226	1329	T	1932	7.8	2.4	22.1	9.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	69.5	0			El Monte, City of
3E	01900120	140-190	202	498	P	1934	0.0	0.0	16.0	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	8.6	0			Rurban Homes Mutual Water Co
	01900121	125-165	175	488	P	1934	1.4	0.1	54.1	13.2	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.1	0.11	28.6	0			Rurban Homes Mutual Water Co
3F	3F000001	100-600	600	2500	NEW			3.6		14.3		0.0							0.15	196.2				
	3F000002	100-600	600	2500	NEW			3.6		14.3		0.0							0.15	196.2				
3G	01901692	198-544	544	2000	P	1967	3.7	2.1	5.4	1.9	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.03	35.6	0			El Monte, City of
	01901699	235-498	516	2149	P	1956	7.2	2.7	5.0	1.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	43.7	0			El Monte, City of
4A	01902529	UNK.	UNK.	100	P		8.0	4.0	189.0	123.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.06	56.0	0			California Country Club
4B	08000049	UNK.	80	200	P		7.1	2.4	33.0	12.7	0.0	0.0	1.0	0.3	0.0	0.0	7.5	2.5	0.15	15.7	-2			Tyler Nursery
4C	01900001	UNK.	50	350	P		5.0	1.3	19.0	8.4	0.0	0.0	0.4	0.1	0.0	0.0	2.0	0.8	0.09	16.1	0			Texaco inc.
4D	11900095	106-275	326	1200	P		11.0	6.2	8.6	4.7	0.0	0.0	1.9	0.7	0.0	0.0	4.2	1.7	0.11	69.4	-1			Rincon Irrigation Co.
	01902790	128-360	392	1800	P		11.0	6.5	4.4	3.6	0.0	0.0	1.9	1.1	0.0	0.0	3.3	1.6	0.11	100.3	0			Rincon Ditch
4E	81902525	155-370	402	2500	T,R	1955	17.0	9.2	18.5	9.1	3.4	0.9	4.0	2.1	0.2	0.1	7.6	5.3	0.22	293.2	0			San Gabriel Valley Water Co.
	81902635	145-350	401	1157	T	1959	12.0	2.8	7.3	2.4	0.6	0.0	1.5	0.7	0.5	0.1	2.5	0.3	0.05	32.1	+1			San Gabriel Valley Water Co.
4F	01901433	120-614	622	2791	P	1949	12.0	2.8	5.5	1.7	1.8	0.1	1.8	0.6	0.2	0.0	0.6	0.1	0.04	65.3	-2			Southwest Suburban Water
	01900052	UNK.	464	1000	P		21.0	6.4	7.4	3.1	0.0	0.0	1.7	0.7	0.0	0.0	7.5	3.8	0.12	61.3	-1			Rose Hills Memorial Park
4G	41900745	178-400	664	878	P	1953	1.0	0.3	6.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	8.1	+2			San Gabriel Valley Water Co.
4H	4H000001	50-400	400	1250	NEW			6.0		186.0									1.60	1053.5				

NOTE: * Well locations are shown in Figures A-1 through A-7

Table A-1 (continued)

CLUSTER*	WELL NUMBER	SCREEN INTERVAL	TOTAL DEPTH (FT)	CAP. (GPM)	WELL STATUS (a)	YEAR INST.	TCE MAX (ug/l)	TCE MEAN (ug/l)	PCE MAX (ug/l)	PCE MEAN (ug/l)	CTC MAX (ug/l)	CTC MEAN (ug/l)	DCE MAX (ug/l)	DCE MEAN (ug/l)	DCA MAX (ug/l)	DCA MEAN (ug/l)	TCA MAX (ug/l)	TCA MEAN (ug/l)	VOCs REMOVED (lbs/mgal)	VOCs REMOVED (lbs/yr)	VOC TREND	NO3 MAX (mg/l)	NO3 MEAN (mg/l)	WELL OWNER
4I	41000001	50-250	250	750	NEW			46.5		22.2				7.7		2.7		82.2	1.35	531.3				
	41000002	50-250	250	750	NEW			12.8										0.3	0.11	43.0				
4J	4J000001	50-250	250	750	NEW														0.00	0.0				
	4J000002	50-250	250	750	NEW			5.1		220.5								5.1	1.93	759.5				
4K	4K000001	50-700	700	2500	NEW			9.0		8.7		0.7		2.1		0.1		3.0	0.20	258.9				
	4K000002	50-600	600	2500	NEW			9.0		8.7		0.7		2.1		0.1		3.0	0.20	258.9				
	4K000003	50-300	300	1250	NEW			9.0		8.7		0.7		2.1		0.1		3.0	0.20	129.4				
5A	01902537	350-638	655	3636	S	1951	250.0	20.3	95.0	6.6	0.0	0.0	2.0	0.1	0.0	0.0	8.0	0.3	0.23	433.8	-2	60.1	38.2	Azusa, City of
	01900831	252-474	500	1821	T	1930	302.0	81.1	25.0	9.7	0.0	0.0	435.0	146.6	21.0	8.5	3200.0	973.4	10.18	9746.7	-2	68.0	65.0	Glendora, City of
	11900038	350-614	630	1600	P		940.0	477.5	700.0	330.3	16.0	5.4	350.0	77.2	2.0	0.2	430.0	195.9	9.07	7630.9	-3			AZ-Two, Inc.
5B	01900029	272-585	600	1370	T	1961	770.0	414.8	100.0	29.5	20.0	10.2	11.0	3.0	5.3	1.7	7.6	1.5	3.84	2769.7	0			Valley County Water Co.
	01900117	200-304	310	UNK.	Q		520.0	310.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.59	0.0	0			Manning Bros.
5C	01900034	300-524	540	3200	T	1952	700.0	104.7	305.0	63.0	1.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	1.40	2361.7	0			Valley County Water Co.
	08000060(b)	300-600	600	4200	P	1971	1100.0	260.5	500.0	126.0	5.3	1.2	100.0	41.7	20.0	1.5	345.0	53.5	4.04	8931.4	-2			Valley County Water Co.
	01902169	UNK.	UNK.	400	R		87.0	44.0	30.7	18.4	1.1	0.6	8.3	4.2	0.0	0.0	8.2	4.1	0.59	124.9	0			Polopolus et al
5D	01900882	198-484	500	2861	T	1951	230.0	130.0	10.0	8.8	3.0	2.2	2.1	1.4	3.7	1.6	5.2	2.1	1.22	1835.3	0			Covina Irrigating Co.
	01900883	102-194	335	2450	T	1911	195.0	125.5	7.9	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.11	1434.7	0			Covina Irrigating Co.
	01900885	110-330	398	2275	T	1911	200.0	104.7	7.6	4.8	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.92	1102.7	0			Covina Irrigating Co.
5E	01902971	203-475	500	400	P		0.0	0.0	0.0	0.0	0.9	0.6	1.0	0.3	0.0	0.0	2.0	1.3	0.02	3.9	0			Sonoco Products Co.
	61900718	110-481	510	2918	P	1951	3.3	0.8	6.0	1.7	1.2	0.4	3.0	1.2	2.0	0.3	1.9	0.9	0.04	67.2	-1			San Gabriel Valley Water Co.
	61900719	172-478	516	3250	P	1955	1.1	0.2	0.8	0.3	2.3	1.0	0.4	0.1	3.2	0.3	2.5	0.3	0.02	31.4	0			San Gabriel Valley Water Co.
5F	08000039	540-602	622	754	T	1972	0.3	0.2	0.0	0.0	48.0	27.2	0.0	0.0	0.0	0.0	0.0	0.0	0.23	90.7	0			Valley County Water Co.
5G	01900035	250-582	600	3700	T	1955	130.0	41.1	4.8	0.7	8.5	6.1	1.3	1.3	8.0	8.0	0.0	0.0	0.48	928.9	0			Valley County Water Co.
5H	01901598	120-349	400	3765	P	1917	28.0	8.8	5.0	1.9	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.09	179.2	0	74.0	62.6	Southwest Suburban Water
	01901599	105-361	361	3396	P	1911	18.0	5.9	13.2	2.7	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.07	129.2	-2	65.4	58.3	Southwest Suburban Water
5I	01900031(d)	300-585	600	2900	P	1965	85.0	22.8	10.0	3.5	16.0	7.5	4.9	1.6	2.3	1.6	1.4	0.4	0.31	475.2	+2			Valley County Water Co.
	71903093	275-506	526	1246	P	1971	88.4	16.8	12.0	3.3	13.0	4.8	1.3	0.3	9.0	3.1	0.0	0.0	0.24	154.4	+1			San Gabriel Valley Water Co.
	71900721	276-462	478	1881	T,R	1954	111.0	13.8	6.4	1.3	17.0	6.0	6.6	1.0	4.4	2.4	0.0	0.0	0.20	202.0	+2			San Gabriel Valley Water Co.
5J	51902858	174-474	500	3457	P	1963	15.0	3.0	6.3	1.6	17.1	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08	147.2	+2			San Gabriel Valley Water Co.
	51902947	175-475	500	3200	P	1965	19.0	5.5	8.1	2.4	23.0	6.5	0.0	0.0	0.9	0.2	0.0	0.0	0.12	206.6	0			San Gabriel Valley Water Co.
5K	08000093	420-1190	1210	2800	P		10.2	6.4	0.0	0.0	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.06	82.0	-1			Southwest Suburban Water
	01903067	205-380	562	860	P	1964	16.0	5.5	0.8	0.3	2.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.05	22.9	-1	59.8	52.3	Southwest Suburban Water
5L	01902951	UNK.	106	250	S		11.0	10.1	140.0	128.1	2.2	1.0	4.0	1.6	0.8	0.2	5.6	3.0	1.20	158.0	0			Ward Duck Company
5M	91901439	330-833	854	1600	P	1949	12.0	4.7	0.6	0.1	1.0	0.2	1.5	0.2	5.0	0.7	0.0	0.0	0.05	41.6	-1			San Gabriel Valley Water Co.
	91901440	282-762	810	aband.	A	1952	10.0	2.3	9.4	1.7	0.2	0.0	0.4	0.1	0.2	0.1	0.0	0.0	0.03	0.0	0			San Gabriel Valley Water Co.
	98000068	280-780	800	2500	S	1976	10.0	4.0	22.0	6.3	0.3	0.0	2.6	0.9	1.0	0.1	1.0	0.2	0.10	126.1	-1			San Gabriel Valley Water Co.

NOTE: * Well locations are shown in Figures A-1 through A-7

Table A-1 (continued)

CLUSTER*	WELL NUMBER	SCREEN INTERVAL	TOTAL DEPTH (FT)	CAP. (GPM)	WELL STATUS (a)	YEAR INST.	TCE MAX (ug/l)	TCE MEAN (ug/l)	PCE MAX (ug/l)	PCE MEAN (ug/l)	CTC MAX (ug/l)	CTC MEAN (ug/l)	DCE MAX (ug/l)	DCE MEAN (ug/l)	DCA MAX (ug/l)	DCA MEAN (ug/l)	TCA MAX (ug/l)	TCA MEAN (ug/l)	VOCs REMOVED (lbs/mgal)	VOCs REMOVED (lbs/yr)	VOC TREND	NO3 MAX (mg/l)	NO3 MEAN (mg/l)	WELL OWNER
5N	01900337	UNK.	200	437	S	1933	15.4	5.7	9.2	0.7	0.0	0.0	0.7	0.1	0.0	0.0	0.0	0.0	0.05	12.4	-2			Southwest Suburban Water
5P	01901627	UNK.	351	1895	P	1920	4.3	0.3	14.0	4.2	0.0	0.0	0.2	0.0	0.0	0.0	1.1	0.3	0.04	40.0	0			Southwest Suburban Water
5Q	01902117	280-660	660	4779	P	1926	0.0	0.0	7.4	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	85.6	0	108.0	98.0	Azusa Valley Water Co.
5R	5R000001	100-300	300	1000	NEW			15.5		188.6		2.0		1.2		0.5		4.5	1.77	931.0				
5S	5S000001	100-1000	1000	3500	NEW			6.5		3.2		8.9				0.2			0.16	285.8				
	5S000002	100-1000	1000	3500	NEW			6.5		3.2		8.9				0.2			0.16	285.8				
	5S000003	100-1000	1000	3500	NEW			6.5		3.2		8.9				0.2			0.16	285.8				
5T	5T000001	100-1000	1200	3500	NEW			31.1		0.6		25.1		1.1		6.0			0.53	979.4				
5U	5U000001	150-1000	1200	3500	NEW			204.6		105.3		2.0		36.2		1.2		30.0	3.16	5825.9				
5V	5V000001	200-1000	1000	3500	NEW			289.5		173.3		2.7		111.9		4.4		159.8	6.19	11391.4				
5W	5W000001	50-850	850	2500	NEW			9.2		3.2		0.8		1.5		0.3		0.2	0.13	164.6				
	5W000002	50-850	850	2500	NEW			9.2		3.2		0.8		1.5		0.3		0.2	0.13	164.6				
	5W000003	50-850	850	2500	NEW			9.2		3.2		0.8		1.5		0.3		0.2	0.13	164.6				
	5W000004	50-850	850	2500	NEW			9.2		3.2		0.8		1.5		0.3		0.2	0.13	164.6				
5X	01902581	UNK.	291	950	S	1912	40.0	11.6	9.0	3.5	2.9	1.0	4.9	2.5	0.0	0.0	3.6	2.3	0.17	87.2	-1	47.8	47.8	City of Industry
	01902582	UNK.	281	1050	S	1912	19.0	7.2	15.0	5.4	3.5	1.9	7.6	6.2	0.0	0.0	5.1	4.5	0.21	115.9	-2	55.6	55.6	City of Industry
	01903072	UNK.	120	200	P		0.7	0.6	1.2	0.9	0.8	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.02	1.8	0			Ward Duck Company
5Y	01903081	200-580	610	1855	P		0.1	0.0	0.2	0.0	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.9	0			California Domestic Water Co
	01902967	200-800	812	3700	P	1966	0.2	0.0	0.0	0.0	1.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.00	3.6	0			California Domestic Water Co
	01903057	197-785	805	4330	P		0.1	0.0	2.3	0.2	1.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.00	8.6	0			California Domestic Water Co
6A	31902820	155-282	282	1500	T	1953	39.0	17.9	105.0	56.6	0.0	0.0	15.0	8.3	0.0	0.0	14.0	9.3	0.77	607.0	0			Southwest Suburban Water
	31902819	102-184	200	1035	T	1917	50.0	27.4	190.0	100.0	19.0	2.4	16.0	13.6	0.0	0.0	39.0	16.0	1.33	723.9	-2			Southwest Suburban Water
	01901617	56-85	250	UNK.	T,E		26.8	24.7	33.0	30.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.46	0.0	0			Southwest Suburban Water
6B	01901621	316-430	436	146	T,E	1925	47.0	31.3	227.0	134.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.38	106.1	0			Southwest Suburban Water
	01901625	39-166	198	469	T,R	1949	53.0	23.5	335.0	112.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.13	278.9	-2			Southwest Suburban Water
6C	6C000001	30-400	400	1000	NEW			336.6		182.3				5.7				46.8	4.77	2508.0				
6D	6D000001	50-800	800	2000	NEW			175.8		113.6				61.4				113.4	3.87	4074.5				
	6D000002	50-800	800	2000	NEW			175.8		113.6				61.4				113.4	3.87	4074.5				
6E	6E000001	50-400	400	1500	NEW			9.2		3.2		0.8		1.5		0.3		0.2	0.13	98.8				
	6E000002	50-800	800	2500	NEW			9.2		3.2		0.8		1.5		0.3		0.2	0.13	164.6				
	6E000003	50-900	900	2500	NEW			9.2		3.2		0.8		1.5		0.3		0.2	0.13	164.6				
	6E000004	50-900	900	2500	NEW			9.2		3.2		0.8		1.5		0.3		0.2	0.13	164.6				
6F	6F000001	20-100	100	400	NEW			26.7		340.8				5.0				20.0	3.27	689.0				
6G	6G000001	50-800	800	2000	NEW			20.3		40.7		3.0		1.0				4.2	0.58	606.4				

NOTE: * Well locations are shown in Figures A-1 through A-7

Table A-1 (continued)

CLUSTER*	WELL NUMBER	SCREEN INTERVAL	TOTAL DEPTH (FT)	CAP. (GPM)	WELL STATUS (a)	YEAR INST.	TCE MAX (ug/l)	TCE MEAN (ug/l)	PCE MAX (ug/l)	PCE MEAN (ug/l)	CTC MAX (ug/l)	CTC MEAN (ug/l)	DCE MAX (ug/l)	DCE MEAN (ug/l)	DCA MAX (ug/l)	DCA MEAN (ug/l)	TCA MAX (ug/l)	TCA MEAN (ug/l)	VOCs REMOVED (lbs/mgal)	VOCs REMOVED (lbs/yr)	VOC TREND	NO3 MAX (mg/l)	NO3 MEAN (mg/l)	WELL OWNER
7A	01902270	103-190	414	331	P	1926	1.1	0.3	10.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.3	0.04	6.2	-1			So. Cal. Water Co.-San Dimas
	01902271	138-282	316	588	P	1930	9.9	2.8	22.0	8.8	0.0	0.0	1.1	0.5	0.0	0.0	1.7	0.6	0.11	32.8	0	90.0	79.8	So. Cal. Water Co.-San Dimas
7B	7B000001	75-300	300	750	NEW			2.4		9.1				0.3				0.9	0.11	41.6				
																		Totals	108.1	90532				

Notes:

(a) E- no electricity to well
N- well shutdown, nitrate contamination
P- production well
Q- well shutdown, reason unknown
R- pump removed from well
S- standby well
T- well shutdown, VOC contamination (some wells pumped intermittently during periods of high demand)

(b) air stripper installed

(c) carbon treatment installed

(d) aeration system installed

* Well locations are shown in Figures A-1 through A-7

Continue

Table A-2

Existing Well Data Used To Estimate Contaminant Concentrations In Proposed New Wells

New Well	Existing Well(s) Data Utilized
1D000001	Well 01901681
1D000002	Well 01903097
2J000001	Average of clusters 2G and 2H
2J000002	"
2J000003	"
2K000001	Average of wells 01902031 and 01902032
2L000001	Average of the six W11BBC monitoring wells
2L000002	Average of the five W11RTMW monitoring wells
2L000003	Avg. of well 01902666 and the four W11JCI MWs
2L000004	Monitoring Well W11APPE1
3F000001	Well 01901694
3F000002	"
4H000001	Well 01902529
4I000001	Average of the six W11CIMW monitoring wells
4I000002	Well Z1000122
4J000001	Monitoring well W11LPB01
4J000002	Monitoring well W11NCMW1
4K000001	Average of cluster 4E
4K000002	"
4K000003	"
5R000001	Well 01902951
5S000001	Average of cluster 5J
5S000001	"
5S000001	"
5T000001	Average of clusters 5G and 5f
5U000001	Average of cluster 5C
5V000001	Average of cluster 5A
5W000001	Average of clusters 5M and 5N
5W000002	"
5W000003	"
5W000004	"
6C000001	Average of monitoring wells X10BMW16 and 17
6D000001	Avg. of the four X10MDBH MWs and X10BTW01-04 MWs
6D000002	"
6E000001	Average of clusters 5M and 5N
6E000002	"
6E000003	"
6E000004	"
6F000001	Average of monitoring wells X10AJB25,26,27
6G000001	Average of monitoring wells X10WGB15,18,20,21
7B000001	Average of cluster 7A