Optimum Basin Management Program

Draft Phase I Report

Prepared for

Chino Basin Watermaster

August 19, 1999

WE Wildermuth Environmental, Inc.

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INTRODUCTION

An Optimum Basin Management Program (OBMP) for the Chino Basin (Figure 1-1) is being developed pursuant to a Judgment entered in the Superior Court of the State of California for the County of San Bernardino and a February 19, 1998 ruling as described below. Pursuant to the Judgment, the Chino Basin Watermaster (Watermaster) files an annual report of Watermaster activities with the Court each year. The information presented below regarding the Judgment, Watermaster, and the events leading up to the February 19, 1998 ruling was obtained from these annual reports.

THE CHINO BASIN JUDGMENT AND WATERMASTER

The Chino Basin Watermaster was established under a Judgment entered in the Superior Court of the State of California for the County of San Bernardino, entitled "Chino Basin Municipal Water District v. City of Chino *et al*," (originally Case No. SCV 164327, file transferred August 1989, by order of the Court and assigned new Case No. RCV 51010). The Honorable Judge Howard B. Wiener signed the Judgment on January 27, 1978. The effective date of this Judgment for accounting and operations was July 1, 1977.

The Judgment resulted from studies and discussions that began in the early 1970's and continued for several years. The initial action to formalize the producers' intentions was the passage in 1974 of a "Memorandum of Agreement on the Chino Basin Plan." In January 1975, Senator Ruben S. Ayala introduced Senate Bill 222 (S.B. 222) in the California Legislature. This bill authorized a production assessment levy of $2.00 per acre-foot per year for a period of three years. The funds were utilized to finance the essential studies and negotiations to implement a water management program for the Chino Groundwater Basin.

S.B. 222 was subsequently renumbered as a part of the Municipal Water District Law at Section 74120 of the Water Code. It was approved by Governor Ronald Reagan and filed with the Secretary of State on June 28, 1975. Three major groups that represented the majority of the producer's interests became active in the early negotiations under S.B. 222. The groups formalized into committees and eventually became known as the: Overlying (Agricultural) Pool, including the State of California and minimal producers; Overlying (Non-Agricultural) Pool representing industries; and Appropriative Pool, representing cities, water districts and water companies. Engineering, legal and other working sub-committees were formed to analyze and define specific problem areas. Representatives of the three pools, when acting together, were called the "Watermaster Advisory Committee." The Watermaster Advisory Committee forwarded recommendations for formal action to the Chino Basin Municipal Water District (CBMWD), which was assigned the responsibility of administering S.B. 222. Socio-economic, safe yield and other studies were conducted to provide the information necessary to reach an agreement regarding the allocation of rights between and within the pool committees.

The Watermaster Advisory Committee was established as the policy setting body and charged with oversight of Watermaster's discretionary activities. Members of each of the three pool committees met regularly to transact the business concerns of its respective producers. Decisions affecting more than one pool committee were forwarded to the Watermaster Advisory Committee. The Judgment provided a method to determine the voting power of the producers on the committees, through a formula based on assessments paid in the prior year and allocated safe yield.

The Judgment declares that the safe yield of the Chino Basin is 140,000 acre-ft/yr, which is allocated among the three pools as follows:

Overlying agricultural pool	82,800 acre-ft/yr
Overlying non-agricultural pool	7,366 acre-ft/yr
Appropriative pool	49,834 acre-ft/yr

A fundamental premise of the Judgment (aka the physical solution) is that all Chino Basin water users will be allowed to pump sufficient water from the Basin to meet their requirements. To the extent that pumping exceeds the share of the safe yield, assessments are levied by the Watermaster to replace the overproduction. The Judgment recognizes that there exists a substantial amount of available groundwater storage capacity in the Chino Basin that can be utilized for storage and conjunctive use of supplemental water and basin waters; makes utilization of this storage subject to Watermaster control and regulation; and provides that any person or public entity, whether or not a party to the Judgment, may make reasonable beneficial use of the available storage, provided that no such use shall be made except pursuant to a written storage agreement with the Watermaster.

EVENTS LEADING UP TO THE FEBRUARY 19, 1998 RULING

During fiscal year 1995-96, it was determined that the reappointment of the CBMWD board as Watermaster had not been submitted to the Court for approval in 1993. In January 1996, a motion was made and supported by a majority of the Advisory Committee to appoint the Advisory Committee to serve as Watermaster. Initially, this motion was supported by 71.64% of the Advisory Committee and as provided in Paragraph 16 of the Judgment, Watermaster Counsel was directed by the Advisory Committee to file the motion with the Court. A Watermaster Ad Hoc Transition Committee of pool members and interested parties was formed to work out the logistics involved with changing the Watermaster. Shortly after the motion was filed, the case was assigned to the Honorable Judge J. Michael Gunn. Fifteen committee members attended the first Ad Hoc Transition Committee meeting on January 31, 1996, and agreed unanimously to propose that an arbitrator or an arbitration process be put in place to address initial concerns raised by some parties to the Judgment regarding the Advisory Committee serving as Watermaster.

By early March, the Overlying (Agricultural) Pool and a few appropriators had reconsidered their positions and were opposed to the motion to appoint the Advisory Committee as Watermaster, even with an arbitration process. As a result, the motion was taken off calendar and additional Ad Hoc Transition Committee meetings were held. These meetings resulted in the development of a proposal for a nine-member board, which was approved by the Advisory Committee in April 1996. Watermaster Counsel was directed to file a motion to appoint the nine-member board, which was set for hearing on June 18, 1996.

On June 3, 1996, CBMWD filed an ex-parte motion to shorten the time on a motion to appoint itself as Interim Watermaster, to appoint itself "*nunc pro tunc*" Watermaster and to disqualify Watermaster Counsel based on the allegation that Counsel had a conflict of interest in serving both Watermaster and the Advisory Committee. The motion to shorten time was granted and the hearing was set for June 18, 1996. At the June 18, 1996 hearing, the Honorable Judge J. Michael Gunn granted the motions to appoint CBMWD nunc pro tunc and Interim Watermaster, and denied the motion to disqualify Watermaster Counsel. The Judge also ordered the parties to meet and confer regarding the nine-member board proposal, which continued the matter to a *meet and confer* among all the interested parties, held July 29, 1996.

July 29, 1996, was the first of two *meet and confers*, held at the City of Chino Council Chambers. Although there was much discussion on that date, the only substantive decision made was to hold an additional *meet and confer* on August 28, 1996.

As a result of the second *meet and confer*, a three-member Watermaster Board proposal was submitted to the Court for hearing on September 18, 1996. As of the Court hearing date, only two of the three municipal water districts invited to participate on the proposed three-member Watermaster Board had responded affirmatively. CBMWD was expected to agree to participate after consideration at their October board meeting and the Court continued the motion until November 20, 1996. CBMWD did not take action to participate on the three-member Watermaster Board as anticipated and the motion was taken off calendar in November of 1996. Four additional workshops were held during late 1996 and into the early months of 1997. As a result, the original nine-member Watermaster Board proposal was modified and approved by the Watermaster Advisory Committee on January 30, 1997, by a majority vote of 67.99 percent.

On March 11, 1997, a new motion to appoint a nine-member Watermaster Board was heard by the Honorable Judge J. Michael Gunn. On April 29, 1997, Judge Gunn issued a ruling which:

- Appointed Anne J. Schneider, Esq. as Special Referee to make a recommendation to the Court regarding the issues raised by the motions.
- Ordered CBMWD, the Advisory Committee, and the DWR (Department of Water Resources) to negotiate terms for the DWR to serve as Interim Watermaster.
- Granted a motion submitted on March 6, 1997, by the law firm of Cihigoyenetche, Grossberg & Clouse, general counsel for CBMWD, to disqualify Watermaster Counsel.

Negotiations began regarding the DWR serving as interim Watermaster through Special Counsel to the Watermaster Advisory Committee, James L. Markman, CBMWD Counsel, Jean Cihigoyenetche, and the attorneys for the DWR.

Anne Schneider accepted the Court's appointment to become a Special Referee and began the process necessary to make a recommendation to the Court. No substantial decisions were reached by fiscal year end and the matter continued into fiscal year 1997-98.

The Special Referee held a special hearing on October 21, 1997, at the Watermaster offices. By mid December 1997, the Special Referee filed her written *Report and Recommendation* with the Court. Based on the *Report and Recommendation*, the Honorable J. Michael Gunn entered a ruling on February 19, 1998 which:

- Appointed the Nine-Member Board as Interim Watermaster.
- Directed that an Optimum Basin Management Program be developed.
- Directed negotiation with DWR be resumed.
- Set hearing dates regarding:
  - The Optimum Basin Management Program (October 28, 1999).
  - Continuance of the Nine-Member Board (October 28, 1999).

- Status of negotiations with DWR to serve as Watermaster and to carry out Watermaster operations (September 30, 1999).

This report documents the development of the OBMP for the Chino Basin pursuant to the Honorable J. Michael Gunn's February 19,1998 ruling.

PROCESS TO DEVELOP THE OBMP

Since the ruling, the Watermaster, the producers, and other interested parties have met twice a month and held special workshops to develop the scope of work to prepare an OBMP and to cooperatively develop the OBMP. The Court officially accepted the scope of work to develop the OBMP on November 5, 1998.

Development of the OBMP required three parallel processes: institutional, engineering, and financial. The institutional process defined the management agenda, directed the engineering and financial processes, and built an institutional support for OBMP implementation. The engineering process developed planning data and management elements, and evaluated the technical and economic performance of the management elements. The financial process was supposed to develop alternative financing plans for the OBMP through its evolution. However because of institutional complexity involved in developing regional water supply facilities and their related financing, most of the financial process will occur in the latter half of 1999 and into the year 2000 – after this document is submitted to the Court in October 1999.

Institutional Process

The institutional process consisted of the following tasks:

Task 1 Identify needs and interests of interested parties.

Task 2 Establish a meeting schedule necessary to complete the OBMP within the time frame allocated.

Task 3 Develop and refine the scope of work based on identified needs.

Task 4 Identify early implementation actions and develop a list of potential program (management) elements of the OBMP to balance needs and interests.

Task 5 Evaluate program elements and develop recommended management and implementation plan.

The first three tasks were completed with the submission of the recommended scope of work to the Special Referee and the Court. Task 4 work was begun in June 1998 with several early implementation action items having already been approved and with initial management concepts submitted to begin the list of potential program elements of the OBMP. The management concepts that were submitted represented concepts or implementation plans that described the party's vision of the OBMP. Submission of management concepts continued into July and August of 1998 and reflected the needs and interests that were previously identified for the OBMP. All proposals submitted were discussed and listed.

As part of Task 5, those proposals that appeared the most promising were forwarded to the engineering and financial consultants for reconnaissance-level, technical, economic and financial analyses. The results of the engineering and financial analyses were submitted to the producers and Watermaster for review. Working together, the producers and the Watermaster Board have developed an Optimum Basin Management Program for the Chino Basin.

Engineering Process

The engineering process consisted of the following tasks:

Task 1 Develop Optimum Basin Management Program Criteria

Task 2 Assess Current State of the Basin

Task 3 Prepare Sections 1, 2, and 3 of the Optimum Basin Management Program document

Task 4 Develop the Components of the Optimum Basin Management Program

Task 5 Develop Implementation Plan

Task 6 Finalize Optimum Basin Management Program document

Tasks 1 and 2 define the basin problems, planning environment, and the needs and interests of the basin producers. Tasks 1, 2, and 3 were completed in December 1998 and draft Sections 1, 2, and 3 of the OBMP were provided to all interested parties for review. A matrix was developed that contains the goals, impediments to the goal, action items to achieve the goals and the implications of the action items. This matrix was used to define the program elements of the OBMP. Tasks 4 and 5 were engineering efforts to develop these elements and to describe the implementation process.

Over time, the institutional process Tasks 4 and 5, and engineering process Tasks 4 and 5 merged and became one seamless process. Completion of engineering process Task 6 will be completed when the financial process is completed sometime in the year 2000.

ORGANIZATION OF THE OPTIMUM BASIN MANAGEMENT PROGRAM REPORT

The OBMP report is being presented in two phases. This document is the Phase I report and contains a description of the OBMP and the following additional sections:

Section 2 – Current Physical State of the Basin – This section describes the state of the Basin in terms of historical groundwater levels, storage, production, water quality, and safe yield. Current and projected water demands and water supply plans are described. Problems in these areas are identified and potential solutions or solution processes are described.

Section 3 – Goals of the Optimum Basin Management Program – This section describes the major issues defined by stakeholders in the OBMP process, the mission statement for the OBMP process and the goals for the OBMP process.

Section 4 – Management Plan – This section describes program elements to achieve the goals of the OBMP, a management plan, and a process to periodically review and update the OBMP.

Appendix A – Public Comments. This appendix contains written correspondence and a transcript of public comments on the OBMP from a Watermaster hearing held on September 15, 1999 (bound separately).

The technical memoranda produced to support the program elements and implementation process described in Section 4 are on file at the Watermaster offices. Copies are available upon request.

The Phase II report consists of more detailed descriptions of capital-intensive and institutionally complex features of the OBMP. The Phase 2 report will be bound separately.

SECTION 2
STATE OF THE BASIN

This section has been prepared for the OBMP stakeholders so that they will have a common starting point or frame of reference from which to develop the OBMP. The stakeholders developed the outline of this section with input from the Special Referee.

This section of the OBMP report describes the Basin, its physical state, future water demands in the Chino Basin area, and concludes with a summary of problems within the Basin. The physical state of the Basin includes a description of groundwater levels, groundwater storage, production patterns, groundwater quality, and safe yield. These characteristics of the Basin are intimately related, as are the solutions to the problems associated with these characteristics. Water demands in the Chino Basin area include an estimate of current water usage and future water demand projections for groundwater and other sources, an assessment of water quality conditions, and future projections of wastewater generation – including the relationship of source water quality and wastewater quality.

DESCRIPTION OF THE BASIN

The Chino Basin consists of about 235 square miles of the upper Santa Ana River watershed. Figure 1-1 illustrates the boundary of the Chino Basin as it is legally defined in the stipulated Judgment in the case of Chino Basin Municipal Water District vs. the City of Chino *et al.* Figure 1-1 also shows the hydrologic boundary of the Basin, which is slightly different from the adjudicated boundary. Chino Basin is an alluvial valley that is relatively flat from east to west and slopes from the north to the south at a one to two percent grade. Valley elevation ranges from about 2,000 feet in the foothills to about 500 feet near Prado Dam. Chino Basin is bounded:

- on the north by the San Gabriel Mountains and the Cucamonga Basin;
- on the east by the Rialto-Colton Basin, Jurupa Hills, and the Pedley Hills;
- on the south by the La Sierra area and the Temescal basin; and
- on the west by the Chino Hills, Puente Hills, and the Pomona and Claremont Basins.

The Chino Basin is one of the largest groundwater basins in southern California with about 5,000,000 acre-ft of water in the Basin and an unused storage capacity of about 1,000,000 acre-ft. Cities and other water supply entities produce groundwater for all or part of their municipal and industrial supplies; and about 300 to 400 agricultural users produce groundwater from the Basin. The Chino Basin is an integral part of the regional and statewide water supply system. Prior to 1978, the Basin was in overdraft. After 1978, the Basin has been operated as described in the 1978 Judgment in Chino Basin Municipal Water District vs. City of Chino *et al*. (Chino Judgment or Judgment).

SURFACE WATER RESOURCES

The principal drainage course of the Chino Basin is the Santa Ana River. It flows 69 miles across the Santa Ana Watershed from its origin in the San Bernardino Mountains to the Pacific Ocean. The Santa Ana River enters the Basin at the Riverside Narrows and flows along the southern boundary to the Prado Flood Control Reservoir where it is eventually discharged through the outlet at Prado Dam. Chino Basin is traversed by a series of ephemeral and perennial streams that include: Chino Creek, San Antonio Creek, Cucamonga Creek, Deer Creek, Day Creek, Etiwanda Creek and San Sevaine Creek. Figure 2-1 illustrates the stream system in the Chino Basin. San Antonio Creek joins Chino Creek and along with Cucamonga Creek, discharges directly into the Prado Reservoir. Cucamonga Creek changes its name to Mill Creek just north of the Prado Reservoir. Deer Creek was realigned and now discharges into Cucamonga Creek. Currently, Etiwanda Creek discharges into Day Creek at Wineville Basin. In the near future, Etiwanda Creek will be joined with San Sevaine Creek. Day Creek and San Sevaine Creek flow south and enter the Santa Ana River upstream of the Prado Reservoir.

These creeks carry significant flows only during, and for a short time after, intermittent storms that typically occur from November through March. Year-round flow occurs along the entire reach of the Santa Ana River due to year round surface inflows at Riverside Narrows, discharges from municipal water recycling plants that discharge in the River between the narrows and Prado Dam, and rising groundwater. Rising groundwater occurs in Chino Creek, in the Santa Ana River at Prado Dam, and potentially other locations on the Santa Ana River depending on climate and season. The rising groundwater in Chino Creek and the Santa Ana River contains high concentrations of total dissolved solids (TDS). Year-round discharges are sustained:

- in Chino Creek from the Inland Empire Utilities Agency (IEUA) Regional Plant No. 2 (RP2) to the Prado Reservoir, the source of which is from recycled water discharges from RP2; and
- in Cucamonga Creek from IEUA Regional Plant No. 1 (RP1) to the Prado Reservoir, the source of which is from recycled water discharges from RP1.

Significant nuisance flows have developed in Cucamonga Creek above RP1, the source of which is excess landscape irrigation and other outside urban uses. Some of the storm water runoff from the San Gabriel Mountains and urban areas is diverted for recharge in flood retention and spreading basins. These basins are shown in Figure 2-1.

Geology

Chino Basin was formed when eroded sediments from the San Gabriel Mountains, the Chino Hills, Puente Hills, and the San Bernardino Mountains filled a structural depression. The formation of the Basin is described in detail in the *Final* Task 2.2 and 2.3 Report, Describe Watershed Hydrology and Identify Current TDS and TIN Inflows in the Watershed (Wildermuth, 1997). The bottom of the Basin – the effective base of the freshwater aquifer – consists of impermeable sedimentary and igneous rocks. The base of the aquifer is overlain by older alluvium of the Pleistocene period followed by younger alluvium of the Holocene period.

The younger alluvium varies in thickness from over 100 feet near the mountains to a just few feet, south of Interstate 10 and generally covers most of the north half of the Basin in undisturbed areas. The younger alluvium is not saturated and thus does not yield water directly to wells. Water percolates readily in the younger alluvium and most of the large spreading basins are located in the younger alluvium.

The older alluvium varies in thickness from about 200 feet thick near the southwestern end of the Basin to over 1,100 feet thick southwest of Fontana, and averages about 500 feet throughout the Basin. Well capacities range between 500 and 1,500 gallons per minute (gpm). Well capacities exceeding 1,000 gpm are common, with some modern production wells test-pumped at over 4,000 gpm (e.g., Ontario Wells 30 and 31 in southeastern Ontario). In the southern part of the Basin where sediments tend to be more clayey, wells generally yield 100 to 1,000 gpm. Three main water-bearing (hydrostratigraphic) units were identified by Montgomery Watson (1992) during the development of a three-dimensional groundwater model of the Basin. Figure 2-2 shows the locations of two (of seven) generalized cross-sections through the Chino Basin. These generalized cross-sections illustrate these main aquifer units and are shown in Figures 2-3 and 2-4.

Faults are one of the principal agents in the development of the landscape and restriction of groundwater flow in the Chino Basin. The basin is bounded by major fault systems along which the mountains and hills have been uplifted. The location of fault and groundwater barriers, and displacements in the effective base of the aquifer at faults are shown in Figure 2-2. The faults and groundwater barriers are significant in that they define the external boundaries of the Basin and influence the magnitude and direction of groundwater flow near the boundaries.

MAJOR FLOW SYSTEMS

While considered one basin from geologic and legal perspectives, the Chino Basin can be hydrologically subdivided into at least five flow systems that act as separate and distinct basins. Figure 2-5 is a groundwater elevation contour map for fall of 1997. Figure 2-5 also shows the location of five groundwater flow systems developed during the *TDS and Nitrogen Study* (Wildermuth, 1999) of which the Watermaster, the Chino Basin Water Conservation District (CBWCD), and the IEUA are study participants. Each flow system has a unique hydrology, and water resource management activities that occur in each flow system have little or no impact on the other systems. Each flow system can be considered a management zone. These management zones can be subdivided further if necessary to define and manage flow systems at a finer scale. These management zones are used to characterize the groundwater level, storage, production, and water quality conditions. Figure 2-6 shows these management zones relative to the subbasins used in the 1995 Regional Water Quality Control Plan (Basin Plan) for the Santa Ana Watershed. The Regional Water Quality Control Board, Santa Ana Region (Regional Board) has established water quality objectives for these subbasins and writes waste discharge requirements for waste dischargers based in part on these objectives. Presently, the Basin Plan subbasin boundaries and objectives are being rigorously reviewed. New boundaries similar to the management zone boundaries have been proposed. Revised boundaries and water quality objectives should be adopted sometime in the year 2000.

Management Zone 1. Management Zone 1 is bounded:

- on the southwest by the Chino and Puente Hills,
- on the northwest by the San Jose fault that separates Chino Basin from the Pomona and Claremont Heights Basins,
- on the north by an unnamed non-echelon fault system associated with the Cucamonga and Red Hill faults and separates the Chino Basin from the Cucamonga Basin,
- and on the east by a line that stretches from the southern most edge of the Red Hill fault to Prado Dam.

Groundwater in Management Zone 1 flows generally south with some localized flows to the west in response to groundwater production. Sources of water to Management Zone 1 include direct percolation of precipitation, returns from irrigation, recharge of storm flows and imported water in spreading basins, and subsurface inflow from the Pomona, Claremont Heights, and Cucamonga Basins. Discharge is through groundwater production and as rising groundwater in Chino Creek and the Santa Ana River.

Management Zone 2. Management Zone 2 is bounded:

- on the west by Management Zone 1,
- on the north by the Red Hill fault that separates the Chino Basin from the Cucamonga Basin,
- on the northeast by a segment of the Rialto-Colton fault,
- and on the east by a segment of Barrier J and a line extending from Barrier J in a southwesterly direction to a point of convergence with other management zone boundaries near Prado Dam.

Groundwater in Management Zone 2 flows generally in a southwesterly direction in the northern half of the management zone and then due south in the southern half of the zone. Sources of water to Management Zone 2 include direct percolation of precipitation, returns from irrigation, recharge of storm flows and imported water in spreading basins and subsurface inflow from the part of the Rialto Basin northwest of Barrier J and the Cucamonga Basin. Discharge is mainly through groundwater production and potentially small amounts of rising groundwater in the Prado Reservoir area.

Management Zone 3. Management Zone 3 is bounded:

- on the west by Management Zone 2,
- on the northeast by the Rialto-Colton fault that separates the Chino Basin from the Rialto Basin,
- on the southeast by the Bloomington divide, Jurupa Hills and line projecting from the most western extension of the Jurupa Hills to a point of convergence with other management zone boundaries near Prado Dam.

Groundwater in Management Zone 3 flows generally in a southwesterly direction. Sources of water to Management Zone 3 include direct percolation of precipitation, returns from irrigation, and subsurface inflow from the part of the Rialto Basin southeast of Barrier J. Discharge is mainly through groundwater production and potentially small amounts of rising groundwater in the Prado Reservoir area.

Management Zone 4. Management Zone 4 is bounded

- on the west by Management Zone 3,
- on the north by the Jurupa Hills,
- on the southeast by the Pedley Hills, and
- on the south by Management Zone 5.

Groundwater in Management Zone 4 flows west. Sources of water to Management Zone 4 include direct percolation of precipitation, and returns from irrigation. Discharge is through groundwater production.

Management Zone 5. Management Zone 5 is bounded:

- on the north and west by the Management Zones 3 and 4, Prado Dam,
- on the east by the Riverside Narrows, and
- on the south by the La Sierra area and Temescal Basin.

Sources of water to Management Zone 5 include streambed percolation in the Santa Ana River, direct percolation of precipitation, returns from irrigation and subsurface inflow from the Temescal Basin. Discharge is through groundwater production, consumptive use by phreatophytes, and rising groundwater in the Prado Reservoir area, and potentially other locations on the Santa Ana depending on climate and season.

GROUNDWATER LEVELS AND STORAGE

Historical Groundwater Level Monitoring

Various entities have collected groundwater-level data in the past. Municipal and agricultural water supply entities have historically collected groundwater-level data in programs that range from irregular, study-oriented measurements to long-term periodic measurements. Groundwater-level measurements were made for specific investigations such as various California Department of Water Resources (DWR) studies, the 1969 Judgment on the Santa Ana River (Orange County Water District *vs.* City of Chino *et al.*), and the Chino Basin Judgment (Chino Basin Municipal Water District vs. City of Chino *et al.*). The spatial extent and temporal history of groundwater-level measurements south of State Route 60 have always been less than north of State Route 60. The DWR and the San Bernardino County Flood Control District (SBCFCD) were very active in collecting groundwater-level measurements in the Chino Basin prior to the settlement of the Chino Basin adjudication. After the Judgment was entered in 1978, the water level monitoring south of State Route 60 stopped almost completely except for the cities of Chino, Chino Hills, and the Jurupa Community Services District (JCSD). Most of the pre-1978 measurements were digitized by the DWR.

Watermaster conducted its first mass groundwater-level monitoring program for the Chino Basin in the spring of 1986. In 1989, Watermaster initiated a more regular monitoring program for the Basin with groundwater-level measurements obtained in 1990, and periodically thereafter through 1997. Watermaster's program relies on municipal producers and other government agencies supplying their groundwater-level measurements on a cooperative basis. Watermaster staff supplements these data with groundwater-level measurements collected by staff, primarily south of State Route 60. In addition to Watermaster staff efforts, private contractors conducting well efficiency tests collect groundwater-level measurements and submit these measurements to Watermaster. Watermaster has digitized all of these recent measurements. Watermaster has combined digitized groundwater-level measurements from all known sources into a database structure that is maintained at Watermaster's office.

Watermaster began a process to develop a comprehensive groundwater-level monitoring program in the spring of 1998. The process consists of collecting groundwater-level data at all wells in the Basin from which groundwater-level measurements can be obtained for fall 1999, spring 2000, fall 2000, and spring 2001. These data will be mapped and reviewed. Based on this review and Watermaster management needs, a long-term water-level monitoring program will be developed and implemented in the fall of 2001.

Historical Groundwater Levels

This section describes the groundwater-level time histories in the Chino Basin by management zone and characterizes the differences between management zones. Figure 2-7 illustrates the location of wells whose groundwater-level time histories are discussed herein and the management zone boundaries described in Section 1. The wells were selected based on length of record, completeness of record, and geographical distribution. Wells discussed herein are identified by their state well number. The behavior of groundwater-levels at specific wells is compared to climate, to pre- and post-Judgment periods, and to other factors as appropriate.

Management Zone 1. Wells 01S07W08N01 (Figure 2-8) and 01S08W11R01 and 01S08W14A03 (Figure 2-9) illustrate typical groundwater-level time histories in the northern end of Management Zone 1. The accumulated departure from mean precipitation (ADFM) curve is plotted on Figures 2-8 and 2-9 to illustrate climatic conditions. Positive sloping lines on the ADFM curve imply wet years or wet periods. Negatively sloping lines imply dry years or dry periods. For example, the period between 1937 to 1944 and 1978 to 1983 are extremely wet periods, and are represented as positively sloping lines. The period 1945 through 1977 is a drought period and is represented as a negatively sloping line, punctuated with a few wet years (positively sloped in 1952, 1958 and 1969). Short-term groundwater-level fluctuations shown in these figures are caused by including static and dynamic observations in the groundwater-level time histories. These time histories follow the climatic trends very closely with the 01S08W11R01 and 0S08W14A03 (westernmost wells) being slightly more sensitive to high rainfall years than 01S7W08N01 (eastern well). The groundwater-level response in well 01S7W08N01 lags the 1937 to 1944 and the 1978 to 1983 wet periods by about three to four years. By comparison, wells 01S08W11R01 and 0S08W14A03 responded to the 1978 to 1983 wet period within a year. The difference in response time is due to proximity of recharge to the area near the wells. Wells 01S08W11R01 and 0S08W14A03 are relatively close the Upland and Montclair Basins. Well 01S7W08N01 is two miles east of wells 01S08W11R01 and 0S08W14A03 with no significant recharge facilities nearby. In addition, the Metropolitan Water District of Southern California (MWDSC) recharged large quantities of State Water Project (SWP) water in the Montclair Basins during the period 1978 to 1983. The depth to water in the vicinity of these wells ranged from about 460 feet in the late 1920s to about 600 feet in 1996.

Wells 01S08W28E01 (Figure 2-10) and 01S08W31J01 and 01S08W33D01 (Figure 2-11) are about three miles south of wells 01S08W11R01 and 01S08W14A03 (Figure 2-9). These wells follow the general climatic trend, but show essentially no response to intermittent wet years in 1952, 1958, and 1969. The post-1977 groundwater-level increase is due to the 1978 to 1983 wet period, the reduction in overdraft following the implementation of the Chino Basin Judgment, the initiation of groundwater replenishment with imported water, and the reduction in pumping due to increased use of imported surface water. The groundwater-level response in these wells responded to the 1978 to 1983 wet period within a year. The depth to water in the vicinity of these wells ranged from about 130 to 160 feet in the late 1920s to about 150 to 280 feet in 1996 with well 01S08W28E01 showing the greatest depth to water. Well 01S08W28E01 is a municipal production well owned by the City of Pomona and is located in an area of regionally depressed groundwater levels.

Wells 02S08W04P01 and 02S08W12F01 (Figure 2-12) are located about two to three miles south of well 01S08W28E01 (Figure 2-10) and wells 01S08W31J01 and 01S08W33D01 (Figure 2-11). These wells follow the general climatic trend, but show essentially no response to intermittent wet years in 1952, 1958 and 1969. The groundwater-level responses in these wells lag the 1937 to 1944 and the 1978 to 1983 wet periods by about two to three years. The response to the 1937 to 1944 wet period is surprisingly subtle compared to most other wells with contemporaneous time histories in Management Zone 1. This suggests that recharge in the area is low and that production is high. The post-1977 groundwater level increase for 02S08W04P01 is due to the 1978 to 1983 wet period, the reduction in overdraft following the implementation of the Chino Basin Judgment, the initiation of groundwater replenishment with imported water, and the reduction in pumping due to increased use of imported surface water. The depth to water in the vicinity of these wells ranged from about 20 to 40 feet in the late 1920s to about 200 feet in 1982.

From north to the south, the following observations can be made regarding time histories of groundwater levels in Management Zone 1:

- groundwater levels are down from observed period of record highs in the late 1920s;
- the lowest groundwater levels were observed around 1977;

- groundwater levels have recovered slightly since 1977 due in part to the wet period of 1978 to 1983, reduction in overdraft after 1977, the initiation of groundwater replenishment with imported water, and the reduction in pumping due to increased use of imported surface water;
- a condition of long-term overdraft has occurred in this management zone with groundwater levels dropping by about 100 to 140 feet between the late 1920s to the present with most of the decline prior to 1977 and the Chino Basin Judgment (1978).

Management Zone 2. Figure 2-13 contains groundwater-level time histories for 01S07W14G01, 01S07W27D01, and 02S07W09M01. These wells are aligned north to south, approximately along a flow line. The groundwater-level time histories in Figure 2-13 show a general decline since before the 1937 to 1944 wet period, with little or no response to wet years until 1978. The post-1977 increase is probably due to the combination of 1978 to 1983 wet period, reduction in overdraft following the implementation of the Chino Basin Judgment, the start of artificial replenishment with imported water in the San Sevaine and Etiwanda flood control basins, and the increased use of imported surface water. The depth to water for 01S07W27D01 ranged from about 200 feet in the late 1920s to about 380 feet in 1974, a decline in groundwater levels of about 180 feet.

Management Zone 3. Figure 2-14 contains time histories for wells 01S06W11B01 and 01S05W16C01 that are located in the most upgradient part of Management Zone 3. The groundwater-level observations in these wells follow the general climatic trend. The groundwater-level time history for well 01S06W16C01 shows a general decline since the 1920s and a general non-responsiveness to significant wet years or periods. For example, there is a slight response to the 1937 to 1944 and 1978 to 1983 wet periods and no response to wet years in 1952, 1958, and 1969. Well 01S06W11B01 behaves in a similar manner with slightly less responsiveness. The lack of responsiveness is due to the lack of significant sources of recharge. There are no major streams or recharge basins in the upper part of Management Zone 3. The peak groundwater levels for both of these wells are lagged about three years behind the peaks in the ADFM curve for the 1937 to 1944 and 1978 to 1983 wet periods. The depth to water ranges from about 360 to 430 feet in the late 1920s to about 430 to 540 in 1978 for wells 01S05W16C01 and 01S06W11B01, respectively. The groundwater decline from the 1920s to the early 1990s is about 20 feet and 60 feet for wells 01S05W16C01 and 01S06W11B01, respectively. Figure 2-15 is a similar plot for wells 01S05W30L01 and 01S06W23D01. These wells have similar response characteristics as 01S06W11B01 and 01S05W16C01 with about 60 to 70 feet of groundwater decline over the period from the late 1920s to the early 1990s.

The relative amount of decline from 1920s to 1977 is less in Management Zone 3 than in Management Zone 1. This is due to greater production in Management Zone 1 than in Management Zone 3 and because of the specific yield (fraction of usable groundwater per unit volume), which is greater in the eastern portion of Chino Basin than in the western portion. The alluvium in the eastern part of the Chino Basin is derived from granitic rocks of the San Gabriel Mountains. The alluvium on the west side of Chino Basin is derived in part from the San Gabriel Mountains and marine sedimentary rocks of the Chino and Puente Hills. The latter produce finer-grained alluvium with more clay and poorer storage properties.

Figure 2-16 contains time histories for wells 02S06W05B01 and 02S07W34H01. These wells are aligned northeast to southwest, approximately along a flow line. The groundwater-level time histories end in the late 1970s or early 1980s, as is typical for agricultural wells in the southern half of the Basin. These time histories follow the general climatic trend, however, there is trend among the wells of a decreasing climatic influence from northeast to southwest. The depth to water for 02S06W05B01 ranged from 130 feet in the late 1920s, to about 200 feet in 1978, a decline in groundwater levels of about 70 feet.

Management Zone 4. Management Zone 4 is bounded on the north by the Jurupa Hills, on the east by the Pedley Hills, on the south by Management Zone 5 and on the west by Management Zone 3. The only outflow from Management Zone 4 is by production. Figure 2-17 contains groundwater-level time histories for wells 02S06W16B02 and 02S06W14C02. These wells generally follow the climatic trend. The depth to water for 02S06W14C02 ranged from about 7 feet in 1945 to about 17 feet in 1993, corresponding to an overall decline in groundwater levels of about 10 feet for this period.

Management Zone 5. Management Zone 5 is bounded on the north and west by the Management Zones 3 and 4, on the east by the Riverside Narrows and on the south by various unnamed hills. Figure 2-18 contains time histories for wells 02S07W36H02, 02S06W26D02, and 03S07W03N01. Groundwater levels in these wells follow the general climatic trend. However, wells 2S07W36H02 and 03S07W03N01 are much less responsive than well 02S07W26D02 due to the stabilizing effects of being adjacent to the Santa Ana River. The depth to water for 02S07W26D02 ranged from about 24 feet in 1939 to about 28 feet in 1992, corresponding to an overall decline in groundwater levels of about 4 feet for this period.

For the most part, the response of groundwater levels in the Chino Basin to significant storms and wet climatic periods is small. There are two reasons for this. First, the mountain drainage areas tributary to the Chino Basin are relatively small compared to the size of Chino Basin (235 square miles) and the amount of water in storage (~5,000,000 acre-ft). The mountain drainage areas tributary to the Chino Basin areas are:

San Antonio Creek	17.7	sq mi
Cucamonga Creek	13.6	
Deer Creek	6.4	
Day Creek	7.7	
Etiwanda Creek	6.7	
San Sevaine Creek	9.7	
Total	61.7	sq mi

San Antonio Creek is mostly diverted for direct use and recharge in the Claremont Heights and Cucamonga Basins. Cucamonga, Deer, and Day Creeks are diverted for direct use and recharge in the Cucamonga Basin. Large storm flows from these creeks can make it into the Chino Basin, however these channels are concrete-lined and consequently large amounts of storm flow are not recharged. In contrast, San Bernardino area groundwater basins (Bunker Hill and Lytle Basins) – located just to the east of the Chino Basin – consist of about 120 square miles of aquifer and with about 466 square miles of tributary areas in the San Gabriel and San Bernardino mountains. The groundwater level response in the Chino Basin due to wet years is small, on the order of a few feet to tens of feet. In contrast, the San Bernardino area groundwater-level response to significant wet years and climatic periods could range from 100 to 300 feet.

Regional Groundwater Level Changes

Figures 2-19 and 2-20 are groundwater elevation contour maps for the Chino Basin for 1997 and 1933, respectively. The 1997 map is based on data collected in Watermaster's ongoing monitoring programs and is representative of current conditions. The 1933 map is based on groundwater-level data compiled and mapped by the DWR. Figure 2-21 shows the change in groundwater level from 1933 to 1997 based on the groundwater elevation maps for 1933 and 1997. The regional groundwater decline by management zone is:

Management Zone	Range
1	50 to 150 feet
2	50 to 100 feet
3	50 to 100 feet
4	less than 50 feet
5	less than 50 feet

Figure 2-22 is a map similar to Figure 2-21 with the water service area boundaries shown in place of management zone boundaries. The areas of greatest regional groundwater decline underlie the city of Pomona, the Monte Vista Water District, the City of Chino, and the western half of the City of Ontario.

Figure 2-23 shows the depth to water for fall 1997. Mendenhall surveyed the Basin in 1902 and found parts of the Chino Basin to be artesian as evidenced by springs and marshy areas (Mendenhall, 1904). This artesian area is also shown on Figure 2-23. In the artesian areas, the historical groundwater level or piezometric surface was at or exceeded the ground surface. Figure 2-23 suggests that the regional groundwater decline in the western Chino Basin is up to 200 feet since 1902. Groundwater levels appear to have stabilized since the Chino Basin Judgment was implemented and groundwater production has been managed within the Basin's safe yield. However, there may still be areas experiencing localized overdraft including the area overlain by the Cities of Chino, Chino Hills, Pomona, the western portion of the City of Ontario, and the Monte Vista Water District. Todd defines the *safe yield* of a groundwater basin as the amount of water that can be withdrawn annually without producing an undesirable result. Withdrawal or production is excess of safe yield is an *overdraft*. Domenico (1972) defines undesirable results to include not only the depletion of groundwater in storage but also intrusion of water of undesirable quality, contravention of existing water rights, and the deterioration of the economic advantages of pumping. Cherry (1979) includes subsidence in the list of undesirable results.

The significant issues related to large-scale regional groundwater declines in the Chino Basin include: decline in storage, higher pumping costs, loss of production capacity, water quality degradation, and subsidence.

In the mid-1970s, ground fissuring was identified in the southwestern portion of Chino Basin. Ground fissuring in this area has continued to the present, and subsidence has been documented and identified as the cause of ground fissuring (Kleinfelder, 1993; 1996). Kleinfelder documented regional subsidence through an analysis of topographic benchmarks from 1987 to 1993, 1993 to 1995, and from 1995 to 1999. The resulting contour maps of equal differences in elevation revealed a north-south trending, elongated area of subsidence underlying the City of Chino and California Institute of Men (CIM) (see Figures 2-23 and 2-24). Maximum subsidence over the period 1987-1995 was reported to be about 2 feet located along Central Avenue between Schaefer and Eucalyptus Avenues. However, about one foot (or 50 percent) of this subsidence occurred over the period from 1993-1995 – indicating that the rate of subsidence has increased. This was confirmed independently by scientists at the Jet Propulsion Laboratories using remote sensing (see www-radar.jpl.nasa.gov/sect323/InSar4crust/LosAngeles.html). Kleinfelder (1993; 1996) concluded that regional subsidence was caused by localized groundwater overdraft and declining groundwater levels. The reasoning to support this conclusion is four-fold:

- As shown in Figure 2-23, the area of regional subsidence and ground fissuring geographically coincides with the late 1800s artesian area mapped by Mendenhall (1904, 1908) – an area that has experienced extreme declines in groundwater levels.

- Subsidence is well documented in areas where underlying soils have experienced extensive fluid withdrawal. In saturated soils, buoyant conditions exist, where stresses between soil particles are low. But as the water level drops, the stresses between soil particles increase and overburden pressure causes soil consolidation.
- The initiation of ground fissuring temporally coincides with new groundwater production by the city of Chino Hills in the area of maximum subsidence. By 1975, groundwater levels had declined by a maximum of 200 feet in the former artesian area.
- Regional subsidence and ground fissuring is not attributable to other potential causes of subsidence. The area does not coincide with known faults or groundwater barriers and the area has not experienced significant petroleum extractions.

Methodology for Estimating Groundwater Storage

Estimating groundwater storage within the Chino Basin is a critical exercise because of the direct influence of storage upon the safe yield and reliability of the aquifer. The safe yield of a groundwater basin approximates the average annual recharge in a basin if the storage in the basin is large. The larger the storage, the more reliable the basin will be in dry period. The amount of water in storage in the Chino Basin is directly proportional to groundwater level.

The methodology for computing the volume of groundwater in storage consists of the following steps:

1. develop groundwater elevation maps for the basin;
2. obtain and map aquifer storage properties;
3. obtain and map the effective base of the freshwater aquifer;
4. divide the basin into a regular grid – with each grid cell assigned a:
   - groundwater elevation,
   - tops and bottom elevations of each aquifer
   - elevation of the effective base of the bottommost aquifer (*e.g.*, bedrock elevation), and
   - storage properties;
5. compute the volume of groundwater in storage for each grid cell, and sum the storage values of all grid cells.

In most parts of the Chino Basin, unconfined aquifers overlie confined aquifers. Thus, the storage in some grid cells consists of the sum of water in storage in confined and unconfined aquifers. The volume of groundwater in storage in each grid cell is estimated from the following equations:

volume in an unconfined aquifer in a grid cell is given by:

$$V_{i,l} = (GWE_{i,l} - B_{i,l}) * A_i * P_{i,l} \qquad \text{(Equation 1)}$$

volume in a confined aquifer in a grid cell is given by:

$$V_{i,l} = [(GWE_{i,l} - T_{i,l}) * SC_{i,l} + (T_{i,l} - B_{i,l}) * P_{i,l}] * A_I \qquad \text{(Equation 2)}$$

where:

$GWE_{i,l}$ is the groundwater/piezometric elevation for grid cell *i* and aquifer *l*
$T_{i,l}$ is the effective top elevation of a grid cell *i* and aquifer *l*
$B_{i,l}$ is the effective bottom elevation of grid cell *i* and aquifer *l*
A_i is the surface area of grid cell *i*
$P_{i,l}$ is the effective porosity of grid cell *i* and aquifer *l*
$SC_{i,l}$ is the storage coefficient of a grid cell *i* and aquifer *l*

Not all the water in storage is available for production. A minimum volume of groundwater must be maintained in storage to ensure that groundwater can flow to wells. This minimum storage is included in the volume computations described above.

A maximum storage could also be defined, although it is more difficult to do so. The difficulties associated with maximum storage relate to defining which high groundwater-level impacts are acceptable and to whom. An across-the-basin increase of 50 feet would probably impact only those lands near the Santa Ana River with unknown water quality impacts everywhere.

Time History of Groundwater Storage for the Basin

Groundwater-level maps were prepared using all available data for 1933, 1965, 1969, 1974, 1977, 1983, 1991, and 1997. Aquifer geometry and storage properties were developed from the Chino Basin Water Resources Management Study (CBWRMS) (Montgomery Watson, 1995). Equations 1 and 2 were used to estimate the groundwater in storage for these years. Figures 2-19 and 2-20 illustrate the spatial distribution of groundwater elevations within the Chino Basin for the fall 1997 and 1933, respectively. The estimated volume of groundwater in storage in the Chino Basin using this methodology and information was:

Year	Volume (acre-ft)
1933	6,300,000
1997	5,300,000

Groundwater storage decreased by about 1,000,000 acre-ft during the 64-year period of 1933 to 1997. Table 2-1 lists the estimated storage in each of the management zones shown in Figure 2-5 and aggregations of the management zones into the Lower Chino Basin (south of State Route 60), the Upper Chino Basin (north of State Route 60) and the Total Chino Basin. The storage estimates in Table 2-1 are shown graphically in Figures 2-25 and 2-26. The lowest level of groundwater storage during the period 1960 to the present occurred in 1977 at the end of a 33-year drought. Prior to 1977, groundwater storage was falling at a rate of about 25,500 acre-ft/yr. The decline in storage was due to drought and groundwater production in excess of sustainable yield. The period of 1978 though 1983 was an extremely wet period. The physical solution with the Chino Basin Judgment was implemented in 1978. The end of the drought and the elimination of basin-wide overdraft caused an increase in storage. Table 2-1 shows the change in storage relative to 1977 (the lowest level of storage) for the period 1965 to 1997. The losses in storage that occurred during the period 1965 to 1977 have been partially offset by gains in storage that occurred after 1977.

Figure 2-27 shows the time history of storage in the upper and lower parts of the Chino Basin. There was a decline in storage prior to 1977. After 1977, storage in the upper basin increases, however the rate of increase declines over time. This continued increase in storage after 1983 probably is due to:

- accumulation of unproduced safe yield rights in local storage accounts;
- lagged inflows from the deep unsaturated zone in the northern half of the Basin; and
- lagged subsurface inflows from the Lytle Basin north of Barrier J and the Riverside Basin through the Bloomington divide.

After 1977, storage in the lower part of the Basin appears to have stabilized and follows the general climatic pattern.

Table 2-2 and Figure 2-28 show a comparison of the time history of total Chino Basin storage to groundwater production, volume of water stored in cyclic and local storage accounts, and climate. As of fall 1997, the combined volume of water in cyclic and local storage accounts was about 274,000 acre-ft and is greater than the increase in total storage that occurred between 1977 (pre-Judgment) and the present. The increase in storage since 1977 is about 174,000 acre-ft. This is counter intuitive, that is, the change in total storage since 1977 should be greater than the volume of water in cyclic and local storage accounts – especially given that the Basin has experienced a wetter than average period since 1977. The discrepancy may be due in part to under reporting of production in the agricultural pool, storage losses to the Santa Ana River, and inaccuracies in the methods used to compute storage herein.

Losses From Storage

The surface water discharge in the Santa Ana River consists of storm flow and baseflow. Baseflow is divided into two components: wastewater discharged from publicly-owned treatment plants (POTWs) and rising groundwater. The rising groundwater component in the Santa Ana River can be divided into two components: short-term storage water from seasonal recharge along the river, and persistent rising water caused by the regional groundwater gradient towards the river. The short-term storage component of rising water will decrease when total groundwater storage is increased either naturally (wet years) or artificially. If total groundwater storage is maintained at higher levels, recharge of surface water from the Santa Ana River will decrease.

Because of the spatial distribution of storage, the rising groundwater response to increases in groundwater storage is often lagged and variable in time. For example, the baseflow at Riverside Narrows (the location where the Santa Ana River enters the Chino Basin) peaks about five to seven years after heavy recharge years in the upstream groundwater basins. Chino Basin groundwater discharge to the river also exhibits a slight lag time. The time history of baseflow at Prado consists of a complicated mix of rising water responses from the Bunker Hill, Riverside, Chino and Temescal Basins. Analysis of the increase in rising water in the Chino Basin caused by an increase in groundwater storage requires the filtering out of these other sources of surface discharge from historical records and modeling results.

The accumulation of groundwater in storage will cause an increase in groundwater discharge in the Santa Ana River and its tributaries Chino Creek and Mill Creek – losses from storage that are not recoverable. The physics of the groundwater storage-baseflow relationship can be represented by linear reservoir theory where outflow is directly proportional to storage:

$$O = K * S \qquad \text{(Equation 3)}$$

where:

O is the outflow from storage (L^3/T)

S is volume of water in storage (L^3)
K is the linear reservoir coefficient (T^{-1})
L denotes units of length and
T denotes unites of time.

This formula can be calibrated to a specific range of storage and groundwater management conditions. The flow in the Santa Ana River in the Chino Basin was decomposed into rising water from the Chino Basin and other components. The rising water component was subdivided into short-term storage water from seasonal recharge along the river in Management Zone 5, and persistent rising water caused by the regional groundwater gradient towards the River from all management zones. This decomposition was done using simulation model results from the **C**hino Basin **I**ntegrated **G**roundwater and **S**urface Water **M**odel (CIGSM) developed for the Chino Basin Water Resources Management Task Force (Montgomery Watson, 1995, and unpublished modeling results for calibration and planning simulations).

Historical Storage Losses to the Santa Ana River. Rising groundwater estimates were made for the period of model calibration 1960 to 1989, and the forecasting period of 1990 to 2040. Certain historical periods were studied to isolate the spatial effects of groundwater production patterns and hydrology on rising groundwater. For example, the period 1960 to 1977 represents the pre-Judgment period that has higher groundwater production than the period after 1978 that represents the period when the Basin was managed by Watermaster without basin-wide overdraft. Linear reservoir theory was used to develop a simple relationship of change in groundwater discharge to the Santa Ana River to incremental change in groundwater storage.

Hydrograph decomposition for the historical period was done using water balance tables from CIGSM for reaches of the Santa Ana River and its tributaries. Analysis of the hydrology of the period suggest that two periods could be used to develop a linear reservoir relationship:

- 1970 to 1977 representing a pre-Judgment period; and
- 1984 to 1989 representing a post-Judgment period.

The period 1970 to 1977 was a dry period following significant recharge along the river from the 1969 storms. The 1984 to 1989 period was also a dry period following the wet period from 1978 to 1983. Both of these periods exhibit recession flows typical of streams fed by groundwater systems. CIGSM model-estimated rising water was plotted against the model-estimated storage in the Chino Basin. The annual rising water estimates and respective storage estimates are shown graphically in Figures 2-34 and 2-35. Simple linear regressions were done for the 1974 to 1977 period and 1987 to 1989 period to estimate the linear reservoir coefficient (K) for the linear reservoir equation (Equation 3). The linear reservoir coefficient is the slope of the best-fit lines in Figures 2-34 and 2-35. The resulting linear reservoir coefficients are 0.0254 for the 1970 to 1977 period, and 0.0203 for the 1987 to 1989 period. Physically, the linear reservoir coefficient represents the fraction of the storage that annually becomes rising water. Thus, an increase in storage of 100,000 acre-ft in the 1987 will cause about 2,000 acre-ft of new rising water in the first year. Groundwater storage after the first year would be reduced to 98,000 acre-ft. In the second year, the storage would be reduced another 2.03 percent, or 1,970 acre-ft, and so on. The 0.0051 difference in linear reservoir coefficients for the pre- and post-Judgment periods is due in part to changes in groundwater production patterns, hydrology, and CIGSM modeling artifacts.

Future Storage Losses to the Santa Ana River. An estimate of the linear reservoir coefficient for the period 1990 through 2040 was estimated by comparing the total Santa Ana River flow at Prado Dam and groundwater storage for Alternatives 3 and 4 of the CBWRMS. Alternative 3 represents a specific groundwater management strategy that could be implemented. Alternative 4 is identical to Alternative 3 with the addition of a conjunctive use program and an increase in limits for local storage accounts. The conjunctive use program has three cycles of build up in storage to approximately 300,000 acre-ft and subsequent pump-out periods. The increase in storage in local storage accounts is gradual and incremental throughout the period. The rising water losses from the conjunctive use storage and the increase in local storage accounts are simply the difference in Santa Ana River flow between these alternatives. Table 2-3 lists the differences in groundwater storage and Santa Ana River flow. The linear reservoir coefficient for future conditions is estimated to be about 0.0408, or 4.1 percent of storage – about double that of the 1984 to 1989 period. The increase in the linear reservoir coefficient was caused by changes in groundwater production patterns, hydrology, and CIGSM modeling artifacts.

Computation of Storage Losses to Santa Ana River. The linear reservoir equation can be used to estimate losses from groundwater storage accounts to the Santa Ana River:

$$q_t = K * (S_t + 0.5 * T *(I_t - Q_t)) \qquad \text{(Equation 4)}$$

where:

q_t	is the annual loss from a storage account in period *t* to *t+1* (acre-ft/yr)
K	is the linear reservoir coefficient
S_t	is water in a storage account at the end of period *t* (acre-ft)
I_t	is the water put into a storage account in period *t* to *t+1* (acre-ft/yr)
Q_t	is the water taken from the storage account for use in period *t* to *t+1* (acre-ft/yr)
T	duration of time between *t* to *t+1*, assumed to be one year

The volume of water in storage accounts at the end of a period is equal to:

$$S_{t+1} = S_t + T * (I_t - Q_t - q_t) \qquad \text{(Equation 5)}$$

Using a linear reservoir coefficient of 0.0201 and Equation 4, the total water lost from local storage accounts and cyclic storage since the Judgment became active in 1978 is estimated to be about 50,000 acre-ft or about 18 percent of the volume that Watermaster currently assumed was in storage. The time history of accumulating storage accounts and estimated losses to baseflow are listed in Table 2-4. Watermaster does not currently compute losses from storage accounts. This means that when water in storage accounts is produced, additional overdraft of the Basin will occur. Losses from conjunctive use projects could be very large. In the example in Table 2-3, three filling and withdrawal cycles were done over a 40-year period with each reaching a fill capacity of 300,000 acre-ft. The model estimated losses of over 300,000 acre-ft over three fill and extraction cycles – a loss of over one-third of the water stored. If these losses were not accounted for, the Basin would be overdrafted by 300,000 acre-ft over the 40-year period.

The losses described above were developed from modeling studies. Monitoring to verify these losses has not been done in the past nor is it practical in the future. The measuring errors associated with such a program would be larger than the probable losses from storage. The only practical ways to estimate such losses are to:

- Use a linear reservoir model as described above, or
- Calibrate a groundwater flow model over the period that water is held in cyclic, local, and conjunctive use storage and compare it to a simulation run with the same hydrology that did not have water in these storage accounts. The difference in groundwater discharge to the river would be the losses due to cyclic, local, and conjunctive use storage. Adjustments to storage accounts could be made retroactively or a new loss factor established for the next period.

GROUNDWATER PRODUCTION

Historical Groundwater Production Monitoring

Prior to 1975, groundwater production monitoring was not formally done by a single entity for the benefit of the Basin. Municipal and some industrial producers kept production records with some submitting annual production reports to the State Water Resources Control Board (SWRCB). Very few agricultural wells had meters and fewer kept records of production. During the period 1975 to 1978, production monitoring at agricultural wells improved slightly. Most of the agricultural production volumes for the period preceding 1978 are comprised of estimates provided by producers and are not based on direct measurements from in-line flow meters.

Since 1978, Watermaster has collected information to develop production estimates. Production estimates in the appropriative pool and overlying non-agricultural pool are based on totalizing in-line flow meter data provided to Watermaster on a quarterly basis by these producers. Watermaster aggregates these quarterly values to obtain annual production for these pools. Production estimates for the agricultural pool are based in part on totalizing in-line flow meter data, water duty methods, and hour-meter data combined with well efficiency tests. As with the other pools, reporting is done by the producers. However, not all agricultural pool producers provide Watermaster with estimates of their production. About one third of agricultural pool producers either did not file production reports or filed incomplete reports in fiscal year 1997/98 (telephone discussion with Jim Theirl, 1998).

Historical Groundwater Production

Table 2-4 contains estimates of annual groundwater production in the Chino Basin from three different sources: summaries of SWRCB filings and interviews with some producers; Watermaster estimates, and production estimates developed for calibration of CIGSM developed for the CBWRMS. The second column in Table 2-5 contains annual production estimates that were used to develop the safe yield in the Judgment. The third column contains Watermaster estimates of annual production that are based on production reports submitted to Watermaster by the producers. The fourth column contains annual production estimates that are based on SWRCB filings, production reports from producers, and water duty methods. In the latter case, water duty methods were used as a check on reported production and supplemented reported production data when production data was missing or under-reported at wells.

The safe yield of the Chino Basin was based on the hydrology of the period 1965 to 1974. The average annual groundwater production for that period from SWRCB filings and interviews was estimated at 152,100 acre-ft/yr. The engineer working on the historical production data knew there was *unaccounted for* production and assumed that actual production was 20 percent more than the estimate from SWRCB filings and interviews, or about 180,000 acre-ft/yr (Carroll, 1977). This estimate is close to the 189,400 acre-ft/yr average for the same period from the CBWRMS.

In Table 2-5, the period of Watermaster groundwater production estimates overlaps the period of CBWRMS production estimates. For their common period of record (1975 through 1989), the CBWRMS estimates are consistently higher. This occurs in part because some of the agricultural producers fail to report production or fail to provide production information to Watermaster. For the CBWRMS, water demands based on land use were compared to reported production. If the water demand for the land uses in a given area was greater than reported production, then reported production was increased to meet the demands based on land use. This method was validated in the CIGSM model calibration process (Montgomery Watson, 1993). In the latter years, the CBWRMS production estimates increasingly diverge from Watermaster estimates. For their common period of record, the average annual groundwater production was estimated at 147,900 acre-ft/yr by Watermaster and 174,000 acre-ft/yr by the CBWRMS – a difference of about 26,000 acre-ft/yr. Actual production is probably somewhere in between Watermaster and CBWRMS estimates.

Spatial and Temporal Changes in Groundwater Production

Table 2-6 lists Watermaster's estimates of Chino Basin production by pool for the period of fiscal year 1974/75 to 1997/98, and the relative amount of production by pool. Over this period, groundwater production has ranged from a high of 181,000 acre-ft/yr (1975/76) to a low of about 122,600 acre-ft/yr (1982/83), and has averaged about 147,100 acre-ft/yr. The distribution of production by pool has shifted since 1975 with the agricultural pool production dropping from about 55 percent in 1974/75 to 28 percent in 1996/97. During the same period, appropriative pool production increased from about 40 percent in 1974/75 to 68 percent in 1996/97. The increases in appropriative pool production have kept pace with decline in agricultural production. Production in the overlying non-agricultural pool declined from about 5 percent in 1974/74 to about 2 percent in the mid-1980s, rose to about 4 percent by 1990/91 and has remained at about 4 percent of total production thereafter.

Figure 2-29 is a plot that compares the change in total groundwater production in the Chino Basin to the change in urban and agricultural/other non-urban land uses. Prior to 1980, the decline in groundwater production appears proportional to the decline in agricultural and other non-urban land uses. After 1980, groundwater production appears to be relatively stable even though the decline in agricultural and other non-urban land uses is accelerating.

Figures 2-30 and 2-31 are similar to Figure 2-29 except they represent the Basin north of State Route 60 and south of State Route 60, respectively. North of State Route 60, the pattern of land use change is similar to the entire basin, but the groundwater production that was declining from 1960 to 1980 rose sharply after 1980. South of State Route 60, groundwater production was generally declining throughout the period of 1960 to 1990. The rate of decline in production in the southern half of the Basin after 1980 matches the rate of increase in production north of State Route 60, such that the total annual production in the Basin after 1980 is relatively constant (see Figure 2-29).

Figures 2-32 through 2-36 illustrate the location and magnitude of groundwater production at wells in the Chino Basin for years 1960, 1970, 1980, 1989 and 1997. These maps are based on production estimates developed in the *Chino Basin Water Resources Management Study* (Montgomery Watson, 1995) and by Watermaster. Two trends are evident in the period 1960 through 1998:

- In the southern half of the Basin there is an increase in the number of active wells and a decrease in the per well production. This is due to the land use transition from predominately irrigated agriculture uses to predominately dairy uses and due to a recent well inspection program, resulting in more wells of record.

- In the northern half of the Basin there is an increase in the number of wells producing over 2,000 acre-ft/yr. This is consistent with the land use transition from agricultural uses to urban uses and with the trend for increasing imported water costs.

Groundwater Production and Safe Yield

Recent and past studies have provided some insight into the influence of groundwater production in the southern end of the Chino Basin on the safe yield of the Basin. Three studies were done that quantified the impacts of proposed desalters in the lower Chino Basin on groundwater discharge to the Santa Ana River. The proposed desalters were first described in *Nitrogen and TDS Studies, Upper Santa Ana Watershed* (James M. Montgomery, Consulting Engineers, Inc., 1991). This study matched desalter production to meet future potable demands in the lower Chino Basin through the year 2015. The well fields were sited to maximize the interception of rising water and to induce streambed percolation in the Santa Ana River. The decrease in rising water and the increase in streambed percolation were projected to range from 45 to 65 percent of total desalter production.

Well field design studies for the SAWPA desalter provided estimates of the volume of rising water intercepted by the currently proposed desalter – scheduled for completion in March 2000 (Wildermuth, 1993). These studies used a very detailed model of the lower Chino Basin (rectangular 400-foot by 400-foot grid covering the lower Chino Basin) to evaluate the hydraulic impacts on rising water and groundwater levels at nearby wells. These studies showed the relationship of interception of rising water to well field location and well field capacity. The fraction of the desalter production composed of decreased rising water and the increased stream bed percolation water was estimated to range from 40 to 50 percent.

No formal studies and estimates of desalter well field interception of rising water were made during the *Chino Basin Water Resources Management Study* (Montgomery Watson, 1995). An informal estimate of the interception of rising water was made by Wildermuth (letter to Neil Cline, dated August 9, 1993). Wildermuth used the groundwater model developed in *Chino Basin Water Resources Management Study* for a well field similar to the SAWPA desalter well field and used the model calibration period of 1960 to 1989. This study estimated the interception of rising groundwater at about 80 percent of desalter production capacity.

These three studies suggest that the yield of the Basin could be increased by simply increasing the production near the river, and that for every two acre-ft of new, near-river production the safe yield could be increased by one acre-ft, that is the marginal change in safe yield with increased near-river production is about 0.5 acre-ft/yr per acre-ft/yr of production. The opposite is also true. That is, if production were to decrease in the southern half of the Basin, the safe yield will also decrease. Agricultural production is projected to decrease about 40,000 acre-ft/yr when current agricultural land use transitions to urban use. If the magnitude and spatial distribution of current agricultural production is not replaced with new production then the yield of the Chino basin will decrease by a comparable amount.

HISTORICAL AND CURRENT GROUNDWATER QUALITY

Historical Groundwater Quality Monitoring

Various entities have collected groundwater quality data in the past. Municipal and agricultural water supply entities have collected groundwater quality data to comply with Department of Health Services requirements under Title 22 or for programs that range from irregular study-oriented measurements to long-term periodic measurements. Groundwater quality observations have been made by the DWR, by participants in the 1969 Judgment on the Santa Ana River (Orange County Water District *vs.* City of Chino *et al.*), by dischargers under order from the Regional Board, and by the County of San Bernardino. The DWR and the SBCFCD were very active in collecting groundwater quality data in the Chino Basin prior to the settlement of the Chino Basin adjudication. After the Judgment was entered in 1978, monitoring south of State Route 60 stopped almost completely except for the cities of Chino, Chino Hills, and Norco, and the Jurupa Community Services District (JCSD). Most of the pre-1978 measurements were digitized by the DWR. In 1986, Metropolitan Water District of Southern California (Metropolitan) conducted the first comprehensive survey of groundwater quality covering all constituents regulated in California Code of Regulations Title 22.

In 1989, Watermaster initiated a regular monitoring program for the Basin with groundwater quality data obtained in 1990 and periodically thereafter to the present. Watermaster's program relies on municipal producers and other government agencies supplying their groundwater quality data on a cooperative basis. Watermaster staff supplements this data with data obtained through a Watermaster sampling and analysis program in the area south of State Route 60. Water quality data are also obtained from special studies and monitoring that takes place under orders of the Regional Board. Watermaster has combined previously digitized groundwater quality data from all known sources into a database structure that is maintained at Watermaster's office.

Watermaster plans to begin the development of a new, more comprehensive water quality monitoring program to support the OBMP starting in July 1999. The program consists of two phases. The initial phase consists of collecting and analyzing groundwater quality samples at all producing wells in the over a three year period starting in July 1999. These data will be mapped and reviewed. Based on this review and Watermaster management goals in the OBMP, a long-term monitoring program will be developed The second phase consists of implementing the long term monitoring program and will start in July 2002.

Water Quality Conditions

Sources of water quality degradation can be classified into point and non-point sources. Point sources are confined to point discharges to the soil, groundwater, or stream systems. Examples include conventional wastewater and industrial discharges to streams or ponds, and leaky underground storage tanks. Non-point sources are areal discharges to soil, groundwater and surface waters, such as land application of waste and fertilizers and atmospheric deposition of contaminants to the soil and water bodies. The discussion below describes the water quality state of the Basin as it exists today for specific constituents of concern. The constituents described below are regulated for drinking water purposes in *California Code of Regulations, Title 22* or are regulated in the *1995 Water Quality Control Plan for the Santa Ana River Basin* (Basin Plan).

Figures 2-37a-h illustrate land uses in the Chino Basin in 1933, 1949, 1957, 1963, 1975, 1984, 1990 and 1993. These land use maps were developed from DWR land use surveys for 1933 through 1984, and from Southern California Association of Governments surveys for 1990 and 1993. The maps show a steady, dramatic change over time from agricultural to urban land uses. An exception to this occurs in the southern Chino Basin where dairies have moved in to replace irrigated and non-irrigated agriculture. These maps are useful in characterizing water quality degradation associated with non-point source loading from agriculture. The land uses shown in these maps are quantified in Table 2-7.

Total Dissolved Solids (TDS). TDS is regulated as a secondary contaminant in Title 22. The recommended drinking water maximum contaminant level (MCL) for TDS is 500 mg/L, however the upper limit is 1,000 mg/L. For irrigation uses, TDS should generally be less than 700 mg/L. The Regional Board has established TDS limitations for all municipal wastewater plants that discharge recycled water to the Santa Ana River. A problem arises in that TDS concentrations increase through municipal use -- typically by about 150 to 250 mg/L. The TDS limitations for water recycling plants that discharge to the Santa Ana River in the Chino Basin are listed below:

Plant	TDS Limit (mg/L)
IEUA RP1	540
IEUA RP2	610
IEUA Carbon Canyon	555
IEUA RP4	505
Western Riverside Regional	625
City of Riverside	650
Jurupa Indian Hills	650

The TDS in source (drinking) water generally must be kept well below 500 mg/L (preferably less than 300 mg/L) to ensure that recycled water discharged to the Santa Ana River and its tributaries meets Regional Board limitations. The treatment cost to remove TDS from water is very expensive – about $500 to $700 per ton.

Table 2-9 provides the average TDS concentrations by well for five-year periods from 1961 to 1995. These wells are grouped by management zones. Figures 2-38, 2-39, and 2-40 show average TDS concentrations in groundwater measured at wells for the periods 1961 to 1965, 1971 to 1975, and 1991 to 1995. Historically, TDS has not been measured at wells on an annual basis. The choice of one year, say 1963 for example, might have only one-third as many TDS measurements at wells compared to a five-year period. Thus, averaging TDS over a five-year period was necessary to get adequate spatial coverage of measurements.

TDS concentrations in the northeast part of the Basin range from about 170 to about 300 mg/L for the period 1960 through 1990, with typical concentrations in the mid- to low-200s. TDS concentrations in excess of 200 mg/L indicate degradation from overlying land use. With few exceptions, areas with significant irrigated land use or dairy waste disposal histories overlie groundwater with elevated TDS concentrations. The exceptions are areas where point sources have contributed to TDS degradation, such as the former Kaiser Steel site in Fontana and the former wastewater disposal ponds near IEUA Regional Plant No. 1 (RP1) in South Ontario. The TDS anomaly from Kaiser is not shown on Figures 2-38, 2-39 and 2-40. A TDS anomaly from former municipal wastewater ponds can be seen in the east central part of Management Zone 2.

The impacts of agriculture on TDS in groundwater primarily are caused by fertilizer use on crops, consumptive use, and dairy waste disposal. The TDS impacts from the dairies located in the southern half of the Basin is reflected at least partially in Figures 2-39 and 2-40. The intensity of the TDS loading from dairy waste to the Basin is illustrated in Table 2-8 (Table 2-1 from *Final Task 6 Memorandum, Development of a Three-Dimensional Groundwater Model*, Montgomery Watson, 1994). This table shows the steady buildup of the dairy cattle population in the southern Chino Basin between 1949 and 1989. The total amount of TDS from manure discharged to the southern half of the Basin that will reach groundwater is estimated to be about 1,200,000 tons through 1989 and averages about 29,000 tons per year. The dairy loading numbers in Table 2-8 assume that half of the manure was hauled out of the Basin after 1973, which was a requirement of the Santa Ana watershed Water Quality Control Plan enacted in

1973. The amount of manure exported out of the Basin was never verified until the late 1990's. The TDS loading to groundwater from dairy waste disposal activities could be far greater than estimated in Table 2-8.

As irrigation efficiency increases, the impact of consumptive use on TDS in groundwater also increases. For example, if source water has a TDS concentration of 250 mg/L, and the irrigation efficiency is about 50 percent (flood irrigation), the resulting TDS concentration in the returns to groundwater will be 500 mg/L, exclusive of the mineral increments from fertilizer. If the irrigation efficiency were increased to 75 percent, the resulting TDS concentration in the returns to groundwater will be 1,000 mg/L, exclusive of the mineral increments from fertilizer. For modern irrigated agriculture, the TDS impacts of consumptive use are more significant than mineral increments from fertilizers.

TDS concentrations in groundwater have increased slightly or remained relatively constant in the northern parts of Management Zones 1, 2, and 3. TDS concentrations are significantly higher in the southern parts of Management Zones 1, 2, and 3, and all of Management Zone 5 where they typically exceed the 500 mg/L recommended MCL and frequently exceed the upper limit of 1,000 mg/L.

Nitrate. Nitrate is regulated in drinking water in Title 22 with an MCL of 10 mg/L (as nitrogen). Table 2-10 provides the average nitrate concentrations by well for 5-year periods from 1961 to 1995. These wells are grouped by management zones. Figures 2-41, 2-42, and 2-43 show the average nitrate concentrations in groundwater measured at wells for the periods 1961 to 1965, 1971 to 1975, and 1991 to 1995. Nitrate measurements in the surface water flows in the San Gabriel Mountains and in groundwater near the foot of these mountains are generally less than 0.5 mg/L (Montgomery Watson, 1993). Nitrate concentrations in excess of 0.5 mg/L indicate degradation from overlying land use. Similar to TDS, areas with significant irrigated land use or dairy waste disposal histories overlie groundwater with elevated nitrate concentrations. The primary areas of nitrate degradation are the areas formerly or currently overlain by:

- Citrus in the northern parts of Management Zones 1, 2 and 3; and
- Dairy areas in the southern parts of Management Zones 1, 2 and 3 and all of Management Zone 5.

Nitrate concentrations in groundwater have increased slightly or remained relatively constant in northern parts of Management Zones 1, 2 and 3 over the period 1960 to the present. These are areas formerly occupied by citrus and vineyard land uses (see Figures 2-37a-d), and nitrate concentrations underlying these areas rarely exceed 20 mg/L (as nitrogen). Over the same period, nitrate concentrations have increased significantly in the southern parts of Management Zones 1, 2 and 3, and all of Management Zone 5. These are areas where land use has progressively converted from irrigated/non-irrigated agriculture to dairy uses (see Figures 2-37e-h), and nitrate concentrations typically exceed the 10 mg/L MCL and frequently exceed 20 mg/L by 1991-1995.

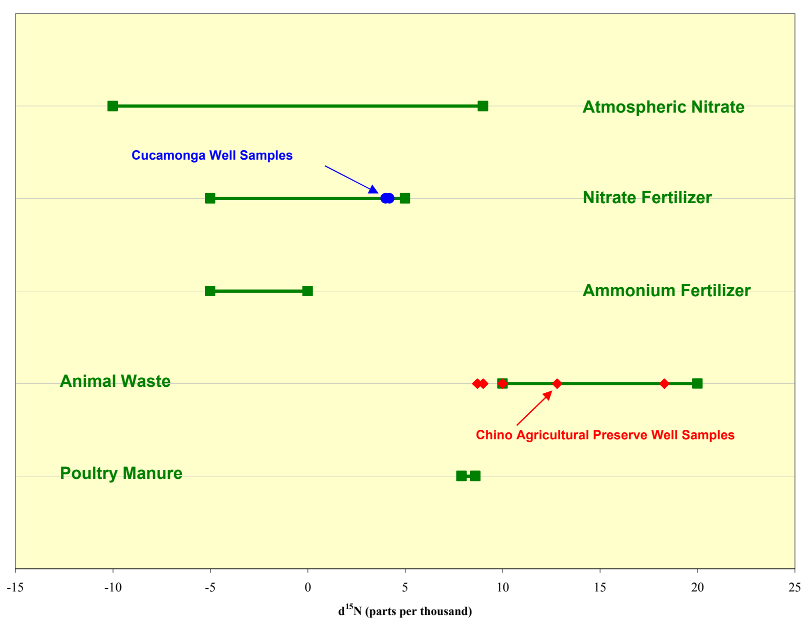
There are two stable isotopes of nitrogen: ^{14}N and ^{15}N. Within the nitrogen cycle, thermodynamic and kinetic processes occur which fractionate these isotopes in various nitrogen-bearing compounds. Most biologically-mediated reactions (*e.g.*, assimilation, nitrification, and denitrification) result in ^{15}N enrichment of the substrate and depletion of the product. Nitrogen isotope chemistry is a technique to help distinguish potential sources of nitrogen in the environment (Clark and Fritz, 1997). The enrichment of ^{15}N relative to atmospheric nitrogen is expressed as $\delta^{15}N$ and has units of parts per thousand (permil). The following table shows the ranges of nitrogen isotopes of potential sources of nitrate (Battaglin *et al.*, 1997):

Source of Nitrate	$d^{15}N$ of Nitrate (permil)
Atmospheric Nitrate	-10 to 9
Nitrate Fertilizer	-5 to 5
Ammonium Fertilizer	-5 to 0
Animal Waste	10 to 20
Poultry Manure	7.9 to 8.6

As part of the 1997 groundwater-monitoring program, samples were collected from six wells for nitrogen isotope analysis:

State Well Number	Region	Nitrate-N (mg/L)	$d^{15}N$ (permil)
01S07W14D01	Cucamonga – Former Citrus	3.2	4.0
01S07W14D02	Cucamonga – Former Citrus	4.0	4.2
02S07W34D	Chino Agricultural Preserve	106.0	12.8
03S07W05G	Chino Agricultural Preserve	77.3	18.3
02S07W20A	Chino Agricultural Preserve	64.5	10.0
02S07W16D	Chino Agricultural Preserve	63.6	8.7
02S07W16D - Duplicate		63.6	9.0

The samples from the wells in areas where the antecedent land use was predominantly citrus had nitrate values that were significantly below the maximum contaminant level (MCL) of 10 mg/L. Nitrate values in samples from the Chino Agricultural Preserve all exceeded the MCL by at least a factor of six. In addition, the $\delta^{15}N$ values for the Cucamonga wells were about 4 permil, while the $\delta^{15}N$ values for the Chino Agricultural Preserve wells ranged from 8.7 to 18.3 permil. The nitrogen isotope results are compared graphically with ranges from known sources in the figure below.



The high nitrate concentrations shown in Figure 2-43 probably depict the nitrate impacts from the agricultural waste disposal areas located in the southern half of the Basin.

Other Constituents of Potential Concern. Tables 2-11a through 2-11c summarize inorganic and organic constituents that have been analyzed for and detected in groundwater samples from wells in the Chino Basin through July 1998. Table 2-12 summarizes the information in Tables 2-11a through 2-11c for the constituents detected at or above their MCLs. This is a synoptic analysis and includes all available data, including data from several monitoring programs and studies. The water quality data reviewed in this synoptic analysis are derived from production wells and monitoring wells. Hence, the data do not represent a programmatic investigation of potential sources nor do they represent a randomized study designed to ascertain the water quality status of the Chino Basin. The data do represent the most comprehensive information available to date.

A large subset of this data was extracted from the California Department of Health Services (DHS) database (current through July 1998). For each constituent, the tables lists:

- the number of measurements at or above one-half the applicable MCL;
- the number of wells with measurements at or above one-half the applicable MCL;
- the number of measurements at or above the applicable MCL;
- the number of wells with measurements at or above the applicable MCL; and
- the applicable MCL.

The tables are organized as follows:

- Table 11a: Inorganic constituents, total trihalomethanes (THMs) and radioactivity with primary MCLs;
- Table 11b: Organic chemicals with primary MCLs;
- Table 11c: Inorganic constituents and organic chemicals with secondary MCLs, lead and copper rule, and California DHS Action Levels.

Table 12 summarizes the constituents that were detected at concentrations greater than one-half their MCL, and are grouped by chemical type. These values represent a mixture of data from monitoring and production well samples. Monitoring wells targeted at a potential source will likely have a greater concentration than a municipal or agricultural production well. Wells with constituent concentrations greater than one-half the MCL represent areas that warrant concern and inclusion in a long-term monitoring program. Groundwater in the vicinity of wells with samples greater than the MCL may be impaired from a beneficial use standpoint.

Inorganic Constituents. Five inorganic constituents were detected at or above their MCL in more than 20 wells:

- TDS;
- nitrate;
- fluoride;
- iron; and
- manganese.

TDS and nitrate have been discussed in previous subsections. Fluoride, iron, and manganese naturally exist in groundwater. Their concentrations depend on mineral solubility, ion exchange reactions, surface complexations, and soluble ligands. These speciation and mineralization reactions, in turn, depend on pH, oxidation-reduction potential, and temperature. Fluoride occurs naturally in groundwater in concentrations ranging from less than 0.1 mg/L to 10-20 mg/L (Freeze and Cherry, 1979). Based on the available data, none of these constituents shows a spatial pattern throughout Chino Basin (see Figures 2-44, 2-45 and 2-46). However, site-specific monitoring wells may reveal point sources (*e.g.*, wells near landfills have shown relatively high concentrations of manganese).

In addition, perchlorate has recently been detected in several wells in the Chino Basin (Figure 2-47), in other basins in California and other states in the West. The probable reason that perchlorate was not detected in groundwater until recently is that analytical methodologies did not previously exist that could attain a low enough detection limit. Prior to 1996, the method detection limit for perchlorate was 400 µg/L. By March 1997, an ion chromatographic method was developed with a detection limit of 1 µg/L and a reporting limit of 4 µg/L.

Perchlorate (ClO_4^-) originates as a contaminant in the environment from the solid salts of ammonium perchlorate (NH_4ClO_4), potassium perchlorate ($KClO_4$), or sodium perchlorate ($NaClO_4$). The perchlorate salts are quite soluble in water. The perchlorate anion (ClO_4^-) is exceedingly mobile in soil and groundwater environments. It can persist for many decades under typical groundwater and surface water conditions, because of its resistance to react with other available constituents. Perchlorate is a kinetically stable ion, which means that reduction of the chlorine atom from a +7 oxidation state in perchlorate to a -1 oxidation state as a chloride ion requires activation energy or the presence of a catalyst to facilitate the reaction. Since perchlorate is chemically stable in the environment, natural chemical reduction in the environment is not expected to be significant.

At very high levels, perchlorate interferes with the function of the thyroid gland and the production of hormones necessary for normal human development. In the extreme cases, it can cause brain damage in fetuses and a potentially fatal form of anemia in adults. However, effects of chronic exposures to lower levels currently detected in groundwater are not known.

Ammonium perchlorate is manufactured for use as an oxygenating component in solid propellant for rockets, missiles, and fireworks. Because of its limited shelf life, inventories of ammonium perchlorate must be periodically replaced with a fresh supply. Thus, large volumes of the compound have been disposed of since the 1950s in Nevada, California, Utah, and likely other states. While ammonium perchlorate is also used in certain munitions, fireworks, the manufacture of matches, and in analytical chemistry, perchlorate manufacturers estimate that about 90 percent of the substance is used for solid rocket fuel

Perchlorate is of concern because of the existing uncertainties in:

- the toxicological database documenting its health effects at low levels in drinking water;
- the actual extent of the occurrence of perchlorate in ground and surface waters, which is compounded by some uncertainty in the validation of the analytical detection method;
- the efficacy of different treatment technologies for various water uses such as drinking water or agricultural application; and
- the extent and nature of ecological impact or transport and transformation phenomena in various environmental media.

The requisite toxicology data available to evaluate the potential health effects of perchlorate are extremely limited. The US Environmental Protection Agency (EPA) Superfund Technical Support Center issued a provisional reference dose (RfD) in 1992 and a revised provisional RfD in 1995. Standard assumptions for ingestion rate and body weight were then applied to the RfD to calculate the reported range in the groundwater cleanup guidance levels of 4 to 18 (μg/L). In 1997, the DHS and California EPA's Office of Environmental Health Hazard Assessment reviewed the EPA risk assessment reports for perchlorate. Consequently, California established its provisional action level of 18 μg/L. On August 1, 1997, DHS informed drinking water utilities of its intention to develop a regulation to require monitoring for perchlorate as an unregulated chemical. Legislative action to establish a state drinking water standard for perchlorate has been introduced but has not been brought to a vote (CA Senate Bill 1033).

Volatile Organic Chemicals. Six volatile organic chemicals (VOCs) were detected at or above their MCL in more than 10 wells:

- 1,1-dichloroethene;
- 1,2-dichloroethane;
- benzene;
- tetrachloroethene (PCE);
- trichloroethene (TCE); and
- vinyl chloride.

TCE and PCE were/are widely used industrial solvents. TCE was commonly used for metal degreasing and was also used as a food extractant. PCE is commonly used in the dry-cleaning industry. About 80 percent of all dry cleaners used PCE as their primary cleaning agent (Oak Ridge National Laboratory, 1989). The areal distributions of PCE and TCE are shown in Figures 2-48 and 2-49. 1,1-Dichloroethane, 1,1-Dichloroethene, *cis*-1, 2-dichloroethene, 1,2-dichloroethane, and vinyl chloride are degradation by-products of PCE and TCE and their areal distributions are shown in Figures 2-50 though 2-54.

The spatial distributions of TCE and PCE appear to be correlatable to identified point sources in the Chino Basin (see the following subsection and Figure 2-58.) The areal distributions of 1,2-dichloroethane and vinyl chloride appear to be more extensive. 1,2-Dichloroethane is used as a lead-scavenging agent in gasoline (Oak Ridge National Laboratories, 1989) and the greater areal distribution of 1,2-dichloroethane and vinyl chloride may reflect numerous minor releases from gasoline stations, automobile service stations, *et cetera*. This hypothesis appears to be corroborated, in part, by the distribution of benzene, which is a minor contaminant in gasoline (see Figure 2-55). Gasoline used in the United States contains between 0.8 and 2 percent benzene (Oak Ridge National Laboratories, 1989).

Pesticides/herbicides. Two were detected at or above their MCL in more than 10 wells:

- dibromochloropropane (DBCP); and
- lindane.

DBCP was used as a fumigant for citrus, other orchards and some field crops prior to being banned in 1987. The areal distribution of DBCP appears to be related to historical citrus crop production in Chino Basin (see Figures 2-37a-d and 2-56). Lindane is used as an insecticide on foliar plants and fruit and vegetable crops; its areal distribution is shown in Figure 2-57.

Point Sources of Concern

The previous water quality discussion described water quality conditions broadly across the entire basin. The discussion presented below describes the water quality anomalies associated with known point source discharges to groundwater. Figure 2-58 shows the location of various point sources and areas of water quality degradation associated with these sources.

Chino Airport. The Chino Airport is located approximately four miles east of the City of Chino and six miles south of Ontario International Airport, and occupies an area of about 895 acres. From the early 1940s until 1948, the airport was owned by the federal government and used for flight training and aircraft storage. The County of San Bernardino acquired the airport in 1948 and has operated and/or leased portions of the facility ever since. Since 1948, past and present businesses and activities at the airport include modification of military aircraft, crop dusting, aircraft-engine repair, aircraft painting, stripping and washing, dispensing of fire-retardant chemicals to fight forest fires, and general aircraft maintenance. The use of organic solvents for various manufacturing and industrial purposes has been widespread throughout the airport's history (Regional Board, 1990). From 1986 to 1988, a number of groundwater quality investigations were performed in the vicinity of Chino Airport. Analytical results from groundwater sampling revealed the presence of VOCs above MCLs in six wells downgradient of Chino Airport. The most common VOC detected above its MCL is TCE. TCE concentrations in the contaminated wells ranged from 6.0 to 75.0 μg/L. Figure 2-58 shows the approximate areal extent of TCE in groundwater in the vicinity of Chino Airport at concentrations exceeding its MCL as of 1990. The plume is elongate in shape, about 2,200 feet wide and extends approximately 8,000 feet from the airport's northern boundary in a south to southwestern direction.

California Institute for Men. The California Institute for Men (CIM) located in Chino is bounded on the north by Edison Avenue, on the east by Euclid Avenue, on the south by Kimball Avenue and on the west by Central Avenue. CIM is a state correctional facility and has been in existence since 1939. It occupies approximately 2,600 acres – about 2,000 acres are used for dairy and agricultural uses and about 600 acres are used for housing inmates and related support activities (Geomatrix Consultants, 1996). In 1990, PCE was detected at a concentration of 26 μg/L in a sample of water collected from a CIM drinking water supply well. Analytical results from groundwater sampling indicate that the most common VOCs detected in groundwater underlying CIM are PCE and TCE. Other VOCs detected include carbon tetrachloride, chloroform, 1,2-dichloroethene, bromodichloromethane, 1,1,1-trichloroethane, and toluene. The maximum PCE concentration in groundwater detected at an individual monitoring well (GWS-12) was 290 μg/L. The maximum TCE concentration in groundwater detected at an individual monitoring well (MW-6) was 160 μg/L (Geomatrix Consultants, 1996). Figure 2-58 shows the approximate areal extent of VOCs in groundwater at concentrations exceeding MCLs as of May 1996. The plume is approximately 1,000 feet wide and extends about 3,600 feet southwest.

General Electric Flatiron Facility. The General Electric Flatiron Facility (Flatiron Facility) occupied the site at 234 East Main Street, Ontario, California from the early 1900s to 1982. Its operations consisted primarily of the manufacturing of clothes irons. Currently, the site is occupied by an industrial park. The Regional Board issued an investigative order to General Electric in 1987 after an inactive well in the City of Ontario was found to contain TCE and chromium above drinking water standards. Analytical results from groundwater sampling indicated that VOCs and total dissolved chromium were the major groundwater contaminants. The most common VOC detected at levels significantly above its MCL is TCE, which reached a measured maximum concentration of 3,700 μg/L. Other VOCs periodically detected, but commonly below MCLs, include PCE, toluene, and total xylenes, (Geomatrix Consultants, 1997). Figure 2-58 shows the approximate areal extent of TCE in groundwater at concentrations exceeding MCLs, as of November 1997. The plume is approximately 3,000 feet wide and extends about 8,400 feet south-southwest (hydraulically downgradient) from the southern border of the site.

General Electric Test Cell Facility. The General Electric Company's Engine Maintenance Center Test Cell Facility (Test Cell Facility) is located at 1923 East Avion, Ontario, California. Primary operations at the Test Cell Facility include the testing and maintenance of aircraft engines. A soil and groundwater investigation, followed by a subsequent quarterly groundwater-monitoring program, began in 1991 (Dames & Moore, 1996). The results of these investigations showed that VOCs exist in the soil and groundwater beneath the Test Cell Facility and that the released VOCs have migrated off site. Analytical results from subsequent investigations indicate that the most common and abundant VOC detected in groundwater is TCE. Other VOCs detected include PCE, *cis*-1,2-dichloroethene, 1,2-dicholoropropane, 1,1-dichloroethene, 1,1-dichloroethane, benzene, toluene and xylenes, among others. The historical maximum TCE concentration measured at an on-site monitoring well (directly beneath the Test Cell Facility) is 1,240 μg/L. The historical maximum TCE concentration measured at an off-site monitoring well (downgradient) is 190 μg/L (BDM International, 1997). Figure 2-58 shows the areal extent of VOC contamination exceeding federal MCLs as of March 1997. The plume is elongate in shape, about 1,000 to 1,200 feet wide and extends approximately 8,000 feet from the Test Cell Facility in a southwesterly direction.

Kaiser Steel Fontana Steel Site. Between 1943 and 1983, Kaiser Steel Corporation (Kaiser), operated an integrated steel manufacturing facility in Fontana. During the first 30 years of the facility's operation (1945-1974), a portion of the Kaiser brine wastewater was discharged to surface impoundments and allowed to percolate into the soil. In the early 1970s, the surface impoundments were lined to eliminate percolation to groundwater (Wildermuth, 1991). In July of 1983, Kaiser initiated a groundwater investigation that revealed the presence of a plume of degraded groundwater under the facility. In August of 1987, the Regional Board issued Cleanup and Abatement Order Number 87-121, which required additional groundwater investigation and remediation activities. The results of these investigations showed that the major constituents of the release to groundwater were inorganic dissolved solids and low molecular weight organic compounds. Wells sampled during the groundwater investigations measured concentrations of total dissolved solids (TDS) ranging from 500-1,200 mg/L and concentrations of total organic carbon (TOC) ranging from 1 to 70 mg/L. Figure 2-58 shows the approximate areal extent of the TDS/TOC groundwater plume as of November 1991. The plume is approximately 3,000 feet wide and extends about 17,000 feet southwest. As of November 1991, the plume had migrated almost entirely off the Kaiser site.

Milliken Sanitary Landfill. The Milliken Sanitary Landfill (MSL) is a Class III Municipal Solid Waste Management Unit located near the intersections of Milliken Avenue and Mission Boulevard in the City of Ontario. The facility is owned by the County of San Bernardino and managed by the County's Waste System Division. The facility was opened in 1958 and continues to accept waste within an approximate 140-acre portion of the 196-acre permitted area (GeoLogic Associates, 1998). Groundwater monitoring at the MSL began in 1987 with five monitoring wells as part of a Solid Waste Assessment Test investigation (IT, 1989). The results of this investigation indicated that the MSL has released organic and inorganic compounds to the underlying groundwater. At the completion of an Evaluation Monitoring Program (EMP) investigation (GeoLogic Associates, 1998), a total of 29 monitoring wells were drilled to evaluate the nature and extent of groundwater impacts identified in the vicinity of the MSL. Analytical results from groundwater sampling indicate that VOCs are the major constituents of the release. The most common VOCs detected are TCE, PCE, and dichlorodifluoromethane. Other VOCs detected above MCLs include vinyl chloride, benzene, 1,1-dichloroethane, and 1,2-dichloropropane. The historical maximum total VOC concentration in an individual monitoring well is 159.6 μg/L (GeoLogic Associates, 1998). Figure 2-58 shows the approximate areal extent of VOCs in groundwater at concentrations exceeding MCLs as of April 1998. The plume is approximately 1,900 feet wide and extends about 2,000 feet south of the MSL's southern border (GeoLogic Associates, 1998).

Municipal Wastewater Disposal Ponds. Treated municipal wastewater has been disposed into ponds located near the current IEUA Regional Plant 1 (RP1) located in south Ontario and the former Regional Plant 3 (RP3) located in south Fontana. The ponds located just east of RP1, commonly called the Cucamonga ponds, were used to dispose of untreated effluent collected by the Cucamonga County Water District (CCWD) and IEUA. RP3 and its disposal ponds are located on the southwest corner of Beech and Jurupa Avenues in the City of Fontana. Discharge to the Cucamonga ponds and the ponds of RP3 ceased between the early 1970s and the mid-1980s. The areas downgradient of these recharge ponds typically have elevated TDS and nitrate concentrations. The locations of these ponds are shown in Figure 2-58. Contaminant plumes emanating from these ponds have never been fully characterized.

Upland Sanitary Landfill. The closed and inactive Upland Sanitary Landfill (USL) is located on the site of a former gravel quarry at the southeastern corner of 15th Street and Campus Avenue in the City of Upland. The facility operated from 1950 to 1979 as an unlined Class II and Class III municipal solid waste disposal site. In 1982, USL was covered with a 10-inch thick, low permeability layer of sandy silt over the entire disposal site (GeoLogic Associates, 1997). Groundwater monitoring at the USL began in 1988 and now includes three on-site monitoring wells (an upgradient well, a cross-gradient well, and a downgradient well) (City of Upland, 1998). The results of groundwater monitoring indicate that USL has released organic and inorganic compounds to underlying groundwater (GeoLogic Associates, 1997). Groundwater samples from the downgradient monitoring well consistently contain higher concentrations of organic and inorganic compounds than samples from the upgradient and cross-gradient monitoring wells. Analytical results from groundwater sampling indicate that VOCs are the major constituents of the organic release. All three monitoring wells have shown detectable levels of VOCs. The most common VOCs detected above MCLs are dichlorodifluoromethane, PCE, TCE, and vinyl chloride. Other VOCs that have been periodically detected above MCLs include methylene chloride, *cis*-1,2 dichloroethene, 1,1-dichloroethane, and benzene. The 1990-95 average total VOC concentration in the downgradient monitoring well is 125 μg/L (GeoLogic Associates, 1997). Figure 2-58 shows the approximate areal extent of VOCs in groundwater at concentrations exceeding MCLs as of April 1998. However, the plume is defined only by the three on-site monitoring wells. The plume extent may be greater than is depicted on Figure 2-58.

National Priorities List Sites. Three facilities in, or directly tributary to, the Chino Basin are on the current National Priorities List (NPL) of Superfund sites:

- Stringfellow;
- Dodson Brothers; and
- Pacific Polishing (Figure 2-58).

Elevated levels of TCE and its degradation by-products have been detected in groundwater in the vicinity of the Dodson Brothers Superfund site (*cf.* Tables 2-44 and 2-53).

TCE/PCE Anomaly – South of the Ontario Airport. A plume containing TCE and PCE exists south of the Ontario Airport. The plume extends from approximately State Route 60 on the north, Turner Avenue on the east to Schaeffer Avenue on the south and Vineyard Avenue on the west. Figure 2-58 shows the approximate areal extent of the plume. The plume appears to be approximately 6,000 feet wide and 9,000 feet long. The maximum reported TCE and PCE concentrations are 142 μg/L and 2 μg/L, respectively.

Role of the Vadose Zone in Future Water Quality

The vadose zone is the unsaturated part of the aquifer that lies between the water table surface and the land surface. The vadose zone has become larger and thicker over time as the groundwater levels in the Basin have declined due to overdraft. Some of the contaminants discharged to the land surface or into ponds remain in the vadose zone. The mechanisms for retention of contaminants within the vadose zone are complex, but are generally caused by sorption and precipitation. Some contaminants move down towards the saturated zone at much lower rates (a few feet per year) than they can move once they get to the saturated zone (a few feet per day). MWDSC completed a study of the TDS and nitrate impacts in the Chino Basin from a proposed 700,000 acre-ft storage program California (MWDSC, 1988). The outcome of this study suggested that the raising of groundwater levels associated with the increase in storage would mobilize TDS and nitrates in the vadose zone and cause serious water quality problems throughout the Basin. The proposed storage program did not add contaminants – it flushed contaminants already in the vadose zone into the saturated zone. This potential effect could not be verified with more advanced modeling in the CBWRMS due to problems with the model. Real-world experiments to verify the TDS and nitrate contamination are not practical for a basin as large as the Chino Basin.

As the agricultural land uses in the Chino Basin convert, the loading of contaminants to the vadose zone will be significantly reduced, as will percolation at the land surface that drives the contaminants down towards the saturated zone. This will have the effect of reducing the rate of vadose zone loading to the saturated zone.

SAFE YIELD

The safe yield of the Chino Basin was established in the 1978 Judgment to be 140,000 acre-ft/yr. The basis for this estimate is described by William J. Carroll in his testimony on December 19 and 20, 1977, during the adjudication process. Table 2-13 lists the hydrologic components developed by Carroll to estimate the safe yield of the Chino Basin. These components were developed for the period 1965 to 1974, a period that Carroll referred to as the *base period*. The hydrologic components listed in Table 2-13 are described below.

Deep Percolation of Precipitation and Surface Inflow – consists of the deep percolation of precipitation and streamflow. Carroll developed the estimate of 47,500 acre-ft/yr based on an extrapolation of the early Chino Basin modeling results from the DWR.

Deep Percolation of Artificial Recharge – consists of the percolation of local runoff in spreading basins. Carroll estimated that the local runoff recharged in SBCFCD-controlled facilities to be about 2,800 acre-ft/yr during the base period. The Etiwanda Water Company also recharged about 1,000 acre-ft/yr of Deer and Day Creek water in the Chino Basin during the base period.

Deep Percolation of Chino Basin Groundwater Used for Irrigation (domestic and agricultural) – defined as the fraction of water applied for irrigation that percolates through the soil and recharges underlying groundwater. Carroll estimated that about 15 percent of the water used for domestic irrigation would percolate to groundwater; and that 45 percent of the water used for agricultural irrigation would percolate to groundwater. The volume of percolation of Chino Basin groundwater used for irrigation over the base period was estimated by Carroll to be about 61,700 acre-ft/yr.

Deep Percolation of Imported Water Used for Irrigation (domestic and agricultural) – same as deep percolation of Chino Basin groundwater except that the water used for irrigation is imported to and used over the Chino Basin. The volume of percolation of imported water used for irrigation over the base period was estimated by Carroll to be about 7,000 acre-ft/yr.

Recharge of Sewage – defined to be the percolation in ponds of wastewater discharged by municipal wastewater treatment plants. This component almost completely ceased during the base period and was known to be eliminated as a recharge source when the safe yield was estimated. The volume of sewage recharge over the base period was about 18,200 acre-ft/yr. The inclusion of recharge of sewage as a component of safe yield in the stipulated Judgment was therefore not hydrologically consistent with how the Basin was to be operated post-Judgment.

Subsurface Inflow – defined to be the groundwater inflow to the Chino Basin from adjacent groundwater basins and mountain fronts including:

Bloomington Divide (Riverside Basin)	3,500 acre-ft/yr
San Gabriel Mountain front	2,500 acre-ft/yr
Colton Rialto Basin	500 acre-ft/yr
Cucamonga Basin	100 acre-ft/yr
Claremont and Pomona Basins	100 acre-ft/yr
Jurupa Hills	500 acre-ft/yr
Total	**7,200 acre-ft/yr**
	say 7,000

Subsurface Outflow – defined as groundwater that rises to the ground surface in Prado Basin to become Santa Ana River flow. Estimates of subsurface outflow were based on studies by DWR, United States Geological Survey (USGS), and Carroll. Carroll estimated the subsurface outflow to average about 6,800 acre-ft/yr over the base period.

Extractions – consists of groundwater extractions from the Chino Basin. Carroll estimated the groundwater extractions to average about 180,000 acre-ft/yr during the base period.

In addition to these components, Carroll estimated the change in storage over the base period to be about 40,000 acre-ft/yr; that is, the groundwater in storage declined by about 400,000 acre-ft between 1965 and 1974. Carroll estimated the safe yield to be the equal to the average extraction over the base period minus the average annual overdraft during the base period:

safe yield = extraction - overdraft
= 180,000 - 40,000
= 140,000 acre-ft/yr

A more recent estimate the safe yield can be abstracted from the groundwater modeling work done for the *Chino Basin Water Resources Management Study -- Task 6 Memorandum Develop Three Dimensional Groundwater Model* (Montgomery Watson, 1994). The hydrologic components derived from the modeling results for a 30-year period -- October 1960 to September 1989 (water years 1961 to 1989) - are listed in Table 2-14. The safe yield based on the CBWRMS results (1961 to 1989) computed in a manner similar to Carroll is:

safe yield = extraction - overdraft
= 183,000 - 17,000

= 166,000 acre-ft/yr

The safe yield based on CBWRMS modeling results for the base period (1965 to 1974) used by Carroll would be:

safe yield = extraction - overdraft
= 189,000 - 20,000
= 169,000 acre-ft/yr

A more conceptually correct estimate of the safe yield would include a reduction for artificial recharge of imported water and other waters that are currently not part of the yield, such as recharge of reclaimed water. The adjusted estimates would then be:

Carroll's estimate 1965 to 1974	118,000 acre-ft/yr
CBWRMS estimate 1961 to 1989	151,000 acre-ft/yr
CBWRMS estimate 1965 to 1974	156,000 acre-ft/yr

Watermaster may decide to change the safe yield of the Basin based on new information such as that developed from the CBWRMS and subsequent studies. Safe yield is used to determine the need for replenishment obligation for individual parties to the judgment. New water from the capture and recharge of storm water, from induced recharge caused by increased southern basin production (or, conversely, the reduction of yield from reduced production in the southern Chino Basin), or from other sources will enhance the yield of the Basin and thereby reduce the cost of purchasing imported water for replenishment.

At the time the Chino Judgment was implemented (1978), about 41 percent of the safe yield was estimated to come from irrigation returns. Since that time, irrigated agriculture has declined and is projected to be almost completely gone by 2020. This will result in a decline in irrigation returns to groundwater and a potential decrease in the safe yield. In addition, San Bernardino County, Riverside County, and the US Army Corps of Engineers (USACE) have constructed flood control projects that capture and convey runoff to the Santa Ana River - effectively eliminating the groundwater recharge that formerly took place in the stream channels and flood plains in the Chino Basin. This also may have resulted in a decrease in the safe yield of the Chino Basin.

Water harvesting opportunities exist that can be used to offset the yield lost to urbanization and flood control improvements. Water harvesting consists of capturing and recharging runoff caused by urbanization. Most of the precipitation falling on undeveloped land or land in agricultural uses is lost to evapotranspiration. Runoff increases dramatically with urbanization due to drainage improvements, increased impervious land cover, and decreased evapotranspiration of rainfall. The potential yield from this additional runoff is numerically equal to the increase in runoff that occurs when the land is converted to urban uses. The actual yield is equal to the additional runoff that is captured and put to beneficial use. In the Chino Basin, the best and least expensive way to put this yield to beneficial use is groundwater recharge.

Urbanization also creates reclaimed water. Presently, most of this water is discharged to the Santa Ana River. IEUA currently plans to use some of their reclaimed water for direct uses, including non-potable industrial uses, irrigation, and groundwater recharge. Increasing the yield of the Chino Basin by increased capture of local runoff will improve the dilution of reclaimed water used for groundwater recharge and reduce the cost of mitigation requirements for such reclamation.

WATER DEMANDS AND WATER SUPPLY PLANS

Current and Future Water Demands

The purpose of this subsection is to describe the current and projected water demands and supplies for agencies that produce groundwater from the Chino Basin. This information will serve as the basis for identifying future water resources issues in the Chino Basin area. Updated forecasts of water demands and supplies were requested from each Chino Basin water agency and industrial producer. Requested data included demands, water supply plans by individual well or source, well construction and operating data, and water production and treatment costs. Many agencies provided updated information. Where responses were incomplete, previous information developed as part of the 1995 Chino Basin Water Resources Management Study (CBWRMS) was used. The planning period for this evaluation is 2000 to 2020.

Growth Projections. There are several indicators of potential growth within the Chino Basin study area. These include population, housing, employment, and land use. The Southern California Association of Governments (SCAG) periodically develops population, housing, and employment projections. SCAG prepares growth projections as part of its regional transportation planning for Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties. The most recent SCAG projection is SCAG-98, which was adopted in April 1998.

The SCAG-98 projection indicates the six-county region will grow from 15.6 million people in 1994 to 22.4 million in 2015. This represents an increase 6.7 million people between 1994 and 2015 and a growth rate of 43 percent. San Bernardino and Riverside counties are projected to grow at a rate that is more than double the regional average. San Bernardino County is projected to grow from 1,558,000 people in 1994 to 2,830,000 in 2020. Riverside County is projected to increase from 1,377,000 people in 1994 to 2,816,000 in 2020.

Population. Table 2-15 summarizes the population projections for the Chino Basin area by water purveyor. The SCAG projections were desegregated by city and census tract and combined by water purveyor service area. These projections indicate population will increase from 971,000 in 1994 to 1,631,000 in 2020. This is a growth rate of 68 percent or 2.6 percent per year. The population in some water service areas in the San Bernardino County portion of the Basin are projected to increase by as much as 125 percent.

Housing. Total housing is projected to increase from 284,000 units in 1994 to 496,000 in 2020, a growth rate of 75 percent. By comparing population and housing, the average occupancy is projected to decrease slightly from 3.4 to 3.3 persons per dwelling unit.

Employment. Employment is projected to increase from 316,000 jobs in 1994 to 702,000 jobs in 2020, a growth rate of 122 percent.

Water Demand Projections. Current water demands and supply projections form the basis for evaluating future water management programs in the Chino Basin area. Water demands are developed based on the water service areas shown in Table 2-16.

Water demand projections can be developed by several different methods. These include per capita, water duty and units of use approaches. The most frequently used methods are the per capita consumption method and the water duty method.

For this assessment, all water demands are based on information provided by the water agencies. In the absence of agency data, the assumptions in the CBWRMS have been used. These projections have been compared with the current SCAG projections. However, no adjustments to he demands have been made.

Projected water demands for the Chino Basin are presented in Table 2-16. This table indicates that Chino Basin area water demands will reach 348,000 acre-ft/yr in 2000 to 418,000 acre-ft/yr in 2020. Significant municipal water demand growth is expected to occur in the agricultural preserve area. This will result in increased demands for the Cities of Chino, Chino Hills and Ontario, and Jurupa Community Services District. Agricultural water demands are expected to decrease during the planning period as land is converted to urban uses.

Water Supply Plans

The principal water supplies in the Chino Basin area are groundwater pumped from the Chino Basin, other local groundwater and surface water, imported water purchased from Metropolitan and recycled water. The amounts of water utilized from each source are based on data provided by each water purveyor. If data was not provided, the supplies area based on projections developed for the Chino Basin Water Resources Management Study (1995). Each of these sources is discussed below. Table 2-17 presents projected water supply plans for appropriators in the Chino Basin area. Table 2-18 summarizes the water demands by major source categories. The growth in demand and general source plan is shown is shown graphically in Figure 2-60. Review of Table 2-18 and Figure 2-60 shows that there will be about 40,000 to 50,000 acre-ft/yr of Chino Basin production that will incur a replenishment obligation. The replenishment obligation can be met by the recharge of imported and reclaimed water, in-lieu replenishment involving imported water, and from water in local storage accounts. In the long run, the replenishment obligation of about 40,000 to 50,000 acre-ft/yr will need to be met with imported and recycled water. Thus the imported and recycled water components in Table 2-18 and Figure 2-60 should sum to a total of 40,000 to 50,000 acre-ft/yr higher.

Chino Basin Groundwater. The Chino Basin is the largest groundwater basin in the Upper Santa Ana Watershed. Water is reallocated from the Overlying Agricultural Pool to the Appropriative Pool when it is not put to use by the agricultural users. As agricultural production declines, the reallocations to the Appropriative Pool will increase. Total production from the Chino Basin is projected to range between 180,000 to 190,000 acre-ft/yr over the planning period. Production in excess of safe yield must be replaced through the purchase of replenishment water, which is imported into the Chino Basin, by the Watermaster.

Other Local Supplies. Other local water sources provide a portion of the water supplies for Chino Basin water agencies. These supplies include surface water and groundwater.

Surface Water. A number of water supply agencies, which produce groundwater from the Chino Basin, obtain a portion of their water supplies from local surface water sources. These agencies include the: City of Pomona, City of Upland, Cucamonga County Water District, Fontana Water Company, San Antonio Water Company, West End Consolidated Water Company, and West San Bernardino County Water District. The principal surface water sources include San Antonio Canyon, Cucamonga Canyon, Day Creek, Deer Creek, Lytle Creek and several smaller surface sources. For the most part, these surface water sources are fully developed and no significant additional supplies are anticipated to be developed in the future. Usage is expected to remain at 16,000-17,000 acre-ft/yr.

Other Groundwater. Other local groundwater supplies represent a significant supplemental source of water for Chino Basin water agencies. Other groundwater supplies in the study area include the Claremont Heights, Live Oak, Pomona and Spadra Basins in Los Angeles County, the Riverside South and Temescal Basins in Riverside County, and the Colton-Rialto, Cucamonga, Lytle Creek Bunker Hill, and Riverside North Basins in San Bernardino County. Agencies using other local groundwater include: City of Pomona, City of Upland, Cucamonga County Water District, Fontana Water Company, San Antonio Water Company, Southern California Water Company, West End Consolidated Water Company, and West San Bernardino County Water District. These supplies may increase slightly in the future as additional wells are constructed. However, most of these sources are essentially fully developed. Descriptions of these groundwater basins were presented in the CBWRMS Final Report (1995). The aggregate supply from these basins is currently 63,000 acre-ft/yr and is projected to be 76,000 acre-ft/yr in 2020.

Imported Water. Two regional agencies are responsible for imported water deliveries within the study area: Metropolitan Water District of Southern California (Metropolitan) and San Bernardino Valley Municipal Water District (SBVMWD). Metropolitan is a wholesale water agency serving supplemental imported water to 27 members (city and water agencies) in portions of Los Angeles, Orange, Riverside, San Bernardino, San Diego and Ventura counties. This service area has a current population of more than 16 million people. Approximately one-half of the total water used throughout the entire Metropolitan service area is imported water purchased from Metropolitan to supplement the local water supplies in its service area. Metropolitan obtains imported supplies from the Colorado River and the State Water Project (SWP). The demand for direct delivery of imported water for the Chino Basin purchased from Metropolitan is projected to increase from about 68,000 acre-ft/yr in 1997 to 129,000 acre-ft/yr by 2020, an increase of about 90% percent. The demand for replenishment water in the Chino Basin could reach 40,000 acre-ft/yr by 2020 if reclaimed water is not used for replenishment or direct uses and water in local storage accounts is not available for use as replenishment.

SBVMWD is a wholesale water purveyor in the easternmost portion of the study area and adjacent portions of San Bernardino County. SBVMWD is a SWP Contractor having an entitlement of 102,600 acre-ft/yr. In addition, SBVMWD is responsible for basin management in the Bunker Hill basin. The City of Rialto and West San Bernardino County Water District obtain water from SBVMWD through its Baseline Feeder that supplies Bunker Hill groundwater (included in *other groundwater* above).

Recycled Water. There are several existing sources of recycled water in use within the Chino Basin study area. These are the Pomona Water Reclamation Plant (operated by the Los Angeles County Sanitation Districts), Regional Plants 1, 2 and 4, and Carbon Canyon Water Reclamation Plant operated by IEUA, Upland Hills Water Reclamation Plant operated by the City of Upland, CIM Water Reclamation Plant operated by the California Institution for Men at Chino, and Indian Hills Water Reclamation Plant operated by Jurupa Community Services District. For this section, only existing and planned recycled water uses that will be implemented in the next two years are included in the water supply plans. This is about 11,500 acre-ft/yr.

Summary. The plans summarized in this section represent the current non-OBMP water supply plans of each individual water agency, as qualified previously. Future evaluation of these plans may indicate problems relative to their long-term feasibility. Availability of imported water supplies will have a significant effect on plan feasibility.

WASTEWATER FLOWS, TREATMENT AND DISPOSAL

This section summarizes existing and proposed municipal wastewater treatment and disposal plans for the Chino Basin study area for the planning period of 2000 through 2020. Existing municipal wastewater treatment facilities are described briefly along with a review of present and projected wastewater flows. Future treatment and disposal plans for the study area are also discussed.

Wastewater Flow Projections

Wastewater flow projections are made using a combination of methods similar to water demand projections. Depending on the planning data available, wastewater flow projections are made using per capita-based, EDU-based, area-based, and water consumption-based methods. The per capita method uses projected populations and average unit wastewater flows per person (90-110 gallons per day per person). EDU-based projections use unit flows per equivalent dwelling unit (EDU), where an EDU is the average amount of sewage generated by a single-family residential household (about 270 gallons per day). EDUs are estimated for commercial and industrial land uses using fixture unit counts or estimated wastewater flows. Flow projections are computed by projecting future EDUs and multiplying by the unit flow per EDU. Area-based methods typically use unit flow factors for each land use type. Flows are computed by multiplying the unit factor for each land use type by the corresponding acreage and totaling the individual flows for each land use type. Water consumption-based methods compute wastewater flows based on the difference between water demand and water consumption. Water consumption is the amount of water that does not return to the sewer system and is a function of the particular land use type and water use group. Currently, most wastewater flow projections in the study area are based on either per capita or EDU methods. Figure 2-61 illustrates the projected wastewater flows for each service area described below.

LACSD Service Area. The Los Angeles County Sanitation Districts (LACSD) furnishes wastewater services for Pomona and Claremont. Using the SCAG-98 growth projections and a wastewater generation factor of 110 gpcd, the wastewater flows for this area are estimated to increase from 22,000 acre-ft/yr to 30,000 acre-ft/yr in 2020.

IEUA Service Area. IEUA develops ten-year wastewater forecasts for its service area in conjunction with its annual capital improvement plan (CIP). As part of its current CIP, IEUA also prepared a fifty-year projection of wastewater flows. These projections indicate wastewater flows will increase from 57,000 acre-ft/yr in 1997 to 112,000 acre-ft/yr in 2020. This represents an increase of 96 percent.

Riverside County Service Area. Wastewater collection for the portion of the study area in Riverside County is provided by several agencies including Jurupa Community Services District and Norco. Other portions are unsewered. Wastewater flows for the Riverside County area are estimated to increase from 10,000 acre-ft/yr in 1997 to 15,000 acre-ft/yr by 2020 based on projected population increases. This includes wastewater generated by unsewered areas. Additional wastewater from outside the study area is expected to be treated at the Western Riverside Regional Water Reclamation Plant. However, no estimates of these additional flows were received.

Treatment and Disposal

Seven agencies are responsible for wastewater treatment and disposal for their respective areas. In Los Angeles County, LACSD is the treatment and disposal agency. In western San Bernardino County, IEUA and the City of Upland perform this role. In the easterly portion of the study area, the City of Rialto provides this service. In Riverside County, several agencies are responsible for wastewater treatment, including the Cities of Riverside and Corona, and JCSD.

There are three basic wastewater service areas within the study area. These areas include:

- LACSD System (Los Angeles County)
- IEUA System (Western San Bernardino County)
- Riverside County

LACSD System. The LACSD provides regional wastewater collection and treatment for most of Los Angeles County. LACSD is divided into districts that handle wastewater management within their service areas. LACSD No. 21 provides this service for the Claremont, La Verne, and Pomona service areas. Urban and industrial wastewater flows from the Los Angeles County portion of the study area are collected by the cities of Claremont, La Verne, and Pomona. This wastewater is routed to LACSD No. 21 for treatment at LACSD's Pomona WRP and San Jose Creek WRP. With the exception of recycled water used by the City of Pomona from the Pomona WRP, all wastewater reaching the sewer system is exported out of the study area. The Pomona WRP has capacity of 15 MGD and is expected to operate at that level during the planning period.

IEUA System. IEUA has constructed a Regional Sewerage System within its service area to collect, treat and dispose of wastewater delivered by contracting local agencies. The contracting cities and water districts are responsible for wastewater collection within their individual service areas. A system of regional trunk and interceptor sewers that convey sewage to regional wastewater treatment plants is owned and operated by IEUA. IEUA's wastewater collection system is divided into two major service areas: the Northern Service Area and the Southern Service Area.

IEUA currently operates four wastewater treatment plants: Regional Plant No. 1 (RP1), Regional Plant No. 2 (RP2) Regional Plant No. 4 (RP4), and Carbon Canyon Water Reclamation Plant (CCWRP). A fifth regional plant, known as Regional Plant No. 3 (RP3), is no longer in service. One new treatment plant, Regional Plant No. 5 (RP5), is in the planning stages. All of these plants are or will be capable of producing effluent that meets Title 22 requirements for water reclamation. Figure 2-62 illustrates the projected flows and capacity staging of these plants. Each of these plants are described below

Regional Plant No. 1. Although RP1 is designed to treat 44 mgd, the capacity was downrated to 32 mgd in 1992 due to more stringent permit requirements. The plant is being operated at an interim capacity of 41 mgd while plant upgrades are completed. A 1996 Regional Board cease and desist order requires the plant to be restored to its design capacity by 1999. RP1 is expected to operate at near its design capacity and treat wastewater flows from its service area and excess flows from RP4 until 2014. A plant expansion to about 56 mgd is planned to be on-line by 2014 to meet increased flows from its service area.

Regional Plant No. 2. RP2 serves the City of Chino and surrounding areas. A 1994 cease and desist order by the Regional Board requires the plant to be flood protected or relocated. Consequently, the plant will be potentially abandoned and its capacity replaced by a new RP5 by 2001. Solids handling facilities will continue to operate at this site.

Regional Plant No. 4. RP4 is a 7-mgd wastewater treatment facility that recently began operation. The plant will be expanded to 14 mgd by 2008 and 21 mgd by 2021. Population growth and corresponding wastewater production in the northeastern region of the District, including portions of City of Fontana and Cucamonga County Water District will determine the rate of expansion.

Carbon Canyon Water Reclamation Plant. Carbon Canyon Water Reclamation Plant (CCWRP) became operational in May 1992. CCWRP is designed to produce recycled water that can be used for non-potable purposes including industrial and irrigation uses in the western region of the Chino Basin. The initial design capacity of 10.2 mgd is planned for increase to 15.3 mgd in the year 2014. Sludge generated at the CCWRP is treated at the RP2 sludge processing facilities and will be for the foreseeable future.

Regional Plant No. 5. Growth in the southern portion of the IEUA service area will require additional treatment capacity. IEUA plans to construct a new RP5 by 2001. The initial phase of this plant will be 12 mgd of which 5 mgd will replace capacity at RP2. The new RP5 is expected to serve the San

Bernardino Agricultural Preserve area as well as treating 3.6 mgd from southern Ontario. A second phase expansion to 18 mgd is projected to be completed by 2008 with a third phase expansion by 2021.

Western Riverside County Regional Wastewater Treatment System. The Western Riverside County Regional Wastewater Authority, a Joint Powers Authority, has constructed a regional wastewater treatment facility to serve portions of Jurupa CSD, Norco, Home Gardens Sanitary District and Western MWD. This facility is located in Western Riverside County near the intersection of McCarty Road and Hellman Avenue. This facility has an initial treatment capacity of 8.5 mgd. The treatment plant will be expanded to an ultimate capacity of 13.3 mgd. The facility provides tertiary filtration and nitrogen removal to meet projected discharge requirements. Effluent from this plant will be discharged to the Santa Ana River. Projections of flows to this plant are not available as of the date of this report.

SUMMARY OF GROUNDWATER LEVEL, STORAGE, PRODUCTION AND WATER QUALITY PROBLEMS

Groundwater Level Problems

Overall, groundwater levels have declined between 50 to 200 feet in the Chino Basin since the turn of the century. The western side of the Basin, notably Management Zones 1a and 1b, has experienced the greatest decline in groundwater levels. The City of Chino and CIM have recently experienced ground-surface fissures that are thought to be related to increased groundwater production in the vicinity of the City of Chino. Groundwater producers that affect groundwater levels in this area include the cities of Chino, Chino Hills, Ontario, Pomona, the Monte Vista Water District, CIM, and agricultural producers. The City of Chino Hills has reported loss of production at one well due to recently declining groundwater levels. The management steps to eliminate groundwater-level problems in this area are described below.

Ground Level Survey. Conduct a ground-level survey of the area in Management Zone 1. This would include a review of past surveys and new surveys. The survey results would be compared to historical surveys to determine the location, rate, and magnitude of subsidence in the Basin. Periodic surveys should be conducted afterwards to monitor for further subsidence.

Monitoring. Develop and implement a groundwater-level and quality monitoring program that can be used to observed groundwater trends. This program should be developed and implemented before a groundwater recharge/production management plan is developed for Management Zone 1 in order to define local groundwater flow systems for better management of recharge and production.

Balance Groundwater Production and Recharge. Balance groundwater production with recharge in Management Zone 1, or, if necessary, balance production and recharge more locally within Management Zone 1. This may require temporarily reducing production below the level at which balance occurs to bring groundwater levels up to a safe level. A *safe* level needs to be determined. Recharge of local or native and imported water should be increased as much as practical. Given that recharge in the area is maximized, production may still have to be reduced in Management Zone 1 and replaced with either production from Management Zone 2 or some other source of water.

Groundwater Storage

The Chino Basin has immense storage capacity. Since the Judgment was implemented, total groundwater storage appears to have stabilized. However, as noted earlier, the storage in the Basin has declined by about 1,000,000 acre-ft since 1933. Therefore, there is at least 1,000,000 acre-ft of unused storage capacity available in the Basin. Increasing storage has some costs. There will be losses to the Santa Ana River due to rising groundwater. The analysis previously presented suggests that the losses from local and cyclic storage accounts due to rising groundwater during the period 1978 to 1997 could be as high as 50,000 acre-ft (or 18 percent of the volume that Watermaster assumes is in storage). Ignoring these losses will result in overdraft of the Chino Basin. A significant increase in groundwater storage, say on the order of 100,000s of acre-ft, may induce large groundwater losses to the Santa Ana River. In addition, a storage increase of this magnitude may have groundwater quality impacts due to flushing of contaminants within the vadose zone. The volume of safe storage from a water quality perspective is unknown. The management steps to mitigate the significant issues with groundwater storage are described below:

Develop Storage Accounting System that Includes Losses. Presently, Watermaster keeps track of transfers to and from local and cyclic storage accounts without accounting for groundwater losses. Watermaster should adopt a loss-estimating procedure and adjust the volume in storage accounts each year.

Water Quality Impacts from Conjunctive Use Programs. Mitigation measures need to be developed to protect producers in the event that large conjunctive-use programs cause unacceptable water quality impacts.

Groundwater Production

The primary issues for groundwater production are localized overdraft in Management Zone 1, and the potential changes in safe yield that can occur with changes in the location and magnitude of pumping. The location and amount of groundwater production generally appears to be balanced in the Basin except for Management Zone 1. Groundwater levels need to be increased in Management Zone 1 to minimize future subsidence and ground fissures, maintain production at a sustainable level, and improve groundwater quality. The management steps for this issue are identical to those for *Groundwater Levels.*

Groundwater production in the southern half of the Basin will need to be managed to ensure that safe yield is not reduced as agricultural areas convert to urban uses. Losses in safe yield due to decreases in agricultural production in the southern part of the Basin are distributed among the appropriators based on their initial share of safe yield. Thus, the loss in yield is translated throughout the Basin. Increasing production near the Santa Ana River could enhance exiting safe yield. The management steps for addressing this issue are listed below.

Optimization Studies. Conduct studies to optimize groundwater production patterns in southern Chino Basin. These studies will involve geologic investigations and modeling of southern Chino Basin.

Southern Basin Water Supply Plan. Develop a groundwater production and treatment plan that matches the emerging water demands of development in the southern Chino Basin with facilities necessary to provide water of appropriate quality.

Water Quality

The TDS and nitrate problems in the Basin are the most costly ones to deal with and are primarily non-point source related. By contrast, point-source dischargers of organic solvents and other contaminants are dealing with most of their related groundwater plumes. The cost of TDS and nitrate removal is estimated to be about $700 per acre-ft. The cost to remove solvents is generally under $100 per acre-ft. Figure 2-59 shows the locations of known point sources and areas with impaired water quality in the Chino Basin.

The source of the TDS and nitrate contamination in the northern part of the Basin has mostly disappeared. The primary sources of TDS and nitrate contamination in the southern part of the Basin are dairies and they will probably remain active for the next 20 years. TDS and nitrate degradation should continue in the southern basin for the foreseeable future and the cost to treat contaminated groundwater will escalate over current costs due to past and continued animal waste disposal practices. The steps to manage groundwater quality problems in the Basin are described below.

Point-Source Management. Watermaster should work with the Regional Board, Department of Toxic Substances Control and other regulatory agencies to identify point-source discharge related problems, facilitate their solution, and where necessary, use its institutional influence to obtain prompt and satisfactory mitigation. In some cases, the solution to a point-source problem and a non-point source problem can be addressed through one coordinated capture and treat project with reduced cost to all parties.

Non-point Source Management. The groundwater contaminated from non-point sources in the northern and southern parts of the Basin will need to be treated through dilution, demineralization or some other process, so that the water can be put to beneficial use. This is absolutely necessary in the southern Chino Basin to maintain safe yield. The *Optimization Studies* and *Southern Basin Water Supply Plan* steps listed under *Groundwater Production* apply here as well. The export of dairy waste from the Basin should be maximized.

Safe Yield

All the problems listed above need to be addressed to maintain safe yield. In addition to those steps, maximizing the capture and recharge of storm water and reclaimed water could increase safe yield. The SBCFCD, Riverside County Flood Control and Water Conservation District (RCFCWCD), and the USACE have developed and continue to develop new flood control projects that efficiently convey flood waters out of the Chino Basin and reduce recharge. This has a negative impact on safe yield. Watermaster needs to participate in these flood control projects to maximize recharge. Watermaster and the Chino Basin Water Conservation District initiated a multiphase recharge master plan study and completed Phase 1 in May 1998. Phases 2 and 3 need to be completed.

SECTION 3
GOALS OF THE OBMP

This section presents the mission statement for the OBMP, the issues, needs and interests that were articulated by the stakeholders, and the goals of the OBMP. Each of these items was developed as part of the institutional process. These items were discussed in numerous public meetings and their final form is based on the consensus of those stakeholders that participated in the process.

MISSION STATEMENT

The stakeholders have met twice per month since the February 19, 1998 ruling by Judge Gunn, to develop the OBMP. As part of this process, the stakeholders defined a new paradigm from which they view their stewardship responsibilities, current and anticipated problems in the Basin, and the solution approaches to those problems. This new paradigm is described in the following mission statement and core values developed by the stakeholders:

> *The purpose of the Optimum Basin Management Program is to develop a groundwater management program that enhances the safe yield and the water quality of the Basin, enabling all groundwater users to produce water from the Basin in a cost-effective manner.*

The stakeholders have adopted the following core values associated with the mission statement.

Water Quality. All producers desire to produce water of a quality that is safe and suitable for the intended beneficial use.

Long View. All producers desire a long term, stable planning environment to develop local water resources management projects. The producers, independently and through Watermaster, will strive to take the long view in their planning assumptions and decisions to ensure a stable and robust management program.

Increased Local Supplies. All producers will, for an undetermined time into the future, be dependent on high quality imported water for direct uses and for groundwater replenishment. Because high quality imported supplies may not be available, the producers will strive to minimize their dependency on imported water and to increase their dependency on local supplies when economically justified.

Groundwater Storage. Unused groundwater storage capacity in the Chino Basin is a precious natural resource. The producers will manage the unused storage capacity to maximize the water quality and reliability and minimize the cost of water supply for all producers. The program will encourage the development of regional conjunctive use programs.

Storm Water Recharge. The producers will strive to increase storm water recharge and thereby maintain and enhance the safe yield and water quality.

Reclaimed Water Recharge. The safe yield of the Chino Basin will be enhanced through the recharge of reclaimed water. The producers will strive to maximize the recharge of reclaimed water to enhance the safe yield and water quality.

Cost of Groundwater Supplies. The producers are committed to finding ways to subsidize the cost of using poor quality groundwater in a cost-effective and efficient manner.

MANAGEMENT ISSUES, NEEDS, AND INTERESTS

As part of the OBMP scoping process, issues, needs and interest were solicited from the stakeholders in the Basin. These issues, needs and interests have been summarized in a tabular form in Tables 3-1 through 3-7, where each table refers to a class of issues, needs and interests that include:

- safe yield
- native and imported water recharge
- quality and quantity
- reclaimed water
- conjunctive-use storage
- costs
- human resources and administration

Attribution for the source of each issue, need, and interest is listed in these tables. In some cases, a specific issue, need and interest may show up in more than one class. These needs and interests were discussed at several scoping meetings and were used to focus problem identification, OBMP goals, and the resulting OBMP scope of work.

MANAGEMENT GOALS OF THE OBMP

In June 1998, the stakeholders began the process of developing management goals for the OBMP that address the issues, needs, and interests of the producers. The process involved the proposal of an initial set of goals followed by discussion and group editing at the bi-monthly meetings. The initial set of goals of the OBMP is listed below.

Goal No. 1 – Enhance Basin Water Supplies. This goal applies not only to local groundwater, but also to all sources of water available for the enhancement of the Chino Groundwater Basin. The following activities enhance basin water supplies:

- *Enhance recharge of storm water runoff*. Increasing the recharge of storm water in the Basin will increase the water supplies in the Chino Basin. The relatively low TDS and nitrate concentrations of storm flow will improve groundwater quality.
- *Increase the recharge of recycled water*. The recharge of recycled water above that required for replenishment obligations can be used for safe yield augmentation and/or conjunctive use.
- *Develop new sources of supplemental water*. New sources of supplemental water, including surface and groundwater from other basins, can be used to meet Chino Basin area demands, reduce dependency on Metropolitan supplies, and improve drought reliability.
- *Promote the direct use of recycled water*. Promoting the direct use of recycled water for non-potable uses will make more native groundwater available for higher-priority beneficial uses.
- *Promote the treatment and use of contaminated groundwater*. Groundwater in some parts of the Basin is not produced because of groundwater contamination problems and thus the yield of the Basin may be reduced. The yield of the Basin can be maintained and enhanced by the production and treatment of these contaminated waters.

- *Reduce groundwater outflow*. Increasing groundwater production near the Santa Ana River will increase the streambed percolation of the Santa Ana River into the groundwater basin, and reduce groundwater outflow from the Basin and thereby increase the supply of groundwater in the Basin.
- *Re-determine safe yield.* Recent studies suggest that the safe yield may be greater than the 140,000 acre-ft as stated in the Judgment. The activities listed above will cause the yield to increase further. Continuing to operate the Basin at 140,000 acre-ft/yr will cause groundwater in the Basin to be lost to the Santa Ana River. The safe yield will be re-determined on an as needed basis to maximize the current yield and to cause future increases in yield

Goal No. 2 – Protect and Enhance Water Quality. This goal will be accomplished by implementing activities that capture and dispose of contaminated groundwater, treat contaminated groundwater for direct high-priority beneficial uses, and encourage better management of waste discharges that impact groundwater. The following activities will protect and enhance water quality:

- *Treat contaminated groundwater to meet beneficial uses*. Groundwater in some parts of the basins is not produced because of groundwater contamination problems. Groundwater quality can be protected by intercepting contaminants before they spread. Intercepted groundwater could be treated and used directly for high priority beneficial uses or injected back to the aquifer.
- *Monitor and manage the Basin to reduce contaminants and to improve water quality*. Actively assisting and coordinating with the Regional Board, the EPA, and other regulatory agencies in water quality management activities would help improve water quality in the Basin.
- *Manage salt accumulation through dilution or blending, and the export of salt*.
- *Address problems posed by specific contaminants.*

Goal No. 3 – Enhance Management of the Basin. This goal will be accomplished by implementing activities that will lead to optimal management of the Chino Basin. The following activities will protect and enhance management of the Basin:

- *Develop policies and procedures that will encourage stable, creative and fair water resources management in the Basin*.
- *Optimize the use of local groundwater storage.* Policies and procedures for local storage, cyclic storage and other types of storage accounts will be created to maximize drought protection and improve water quality, and to create an efficient system to transfer water from producers with surplus water to producers that need water.
- *Develop and/or encourage production patterns, well fields, treatment and water transmission facilities and alternative water supply sources to ensure maximum and equitable availability of groundwater and to minimize land subsidence*.
- *Develop conjunctive-use programs with others to optimize the use of the Chino Basin for in-basin producers and the people of California*.

Goal No. 4 – Equitably Finance the OBMP. This goal is based on the following principles:

- *The primary source of revenue to finance the implementation will be the consumers of the Chino Basin groundwater.*

- *The consumers in the Chino Basin must be treated equitably by passing the cost of the OBMP on a per acre-foot basis or by other methods, based on formulas to be determined.*
- *Financial incentives and disincentives will be established to assure that existing groundwater is pumped out of the Basin and a higher quality of water is used to replenish the Basin.*
- *Opportunities for creativity will be provided to the producers so that they are motivated to use their assets and abilities in the implementation of the OBMP.*
- *Recover value from utilization of storage of supplemental water and from rising water outflow.*

The Special Referee and her engineer reviewed these goals and provided direction to the stakeholders. In particular, the Special Referee suggested that the goals and action items were too vague. The goals and action items were refined and produced in a tabular format. The goals setting process concluded on November 26, 1998. The final set of goals is listed in Table 3-8. Table 3-8 lists each goal, the impediments to each goal, action items to surmount each impediment and achieve the goal, and the implication of the individual action items. The stakeholders were asked to review the final set of goals and action items listed in Table 3-8 to make sure that their individual issues, needs, and interests were addressed by the management goals. The stakeholders concluded that the set of goals listed in Table 3-8 addressed their needs and interests.

SECTION 4
MANAGEMENT PLAN

INTRODUCTION

The Optimum Basin Management Program (OBMP) goals, impediments to the goals, action items to remove the impediments, and implications of the action items are summarized in Table 3-8. This section of the OBMP report describes the actions that, when implemented, will achieve the goals of the OBMP. Table 3-8 includes a column that cross-references the action items listed for each goal with OBMP program elements. The program elements described herein include:

- Program Element 1 – Develop and Implement Comprehensive Monitoring Program
- Program Element 2 – Develop and Implement Comprehensive Recharge Program
- Program Element 3 – Develop and Implement Water Supply Plan for the Impaired Areas of the Basin
- Program Element 4 – Develop and Implement Comprehensive Groundwater Management Plan for Management Zone 1
- Program Element 5 – Develop and Implement Regional Supplemental Water Program
- Program Element 6 – Develop and Implement Cooperative Programs with the Regional Water Quality Control Board, Santa Ana Region (Regional Board) and Other Agencies to Improve Basin Management
- Program Element 7 – Develop and Implement Salt Management Program
- Program Element 8 – Develop and Implement Groundwater Storage Management Program
- Program Element 9 – Develop and Implement Conjunctive-Use Programs

The scope of the program elements was developed by the Chino Basin stakeholders. Each program element contains a series of comprehensive actions and plans to implement those actions. It is anticipated that a specific implementation program will be the result of Phase II of the OBMP development process. It will include the specific details of how the plan will be implemented and funded, and by whom. Implementation of all program elements is necessary to achieve the goals of the OBMP. Because of overlap and synergies, some of the program elements were combined as they were developed. The following program elements were combined: 3/5, 6/7, and 8/9. The program elements are summarized in this section. Task Memorandums were prepared for each program element during development of the OBMP Phase I Report and are available from the Watermaster offices. They describe each program element in detail and generally include:

- need and function
- description of program element actions
- cost
- implementation entities
- implementation schedule for the short-term (first three years), mid-term (4th through 10th years) and-long term (11th through 50th years)

The emphasis in this section is on a description of OBMP actions, schedule and cost. The program element descriptions provide Watermaster and the Court with a means of comparing actions taken in OBMP implementation with progress in achieving the goals of the OBMP.

PROGRAM ELEMENT 1 – DEVELOP AND IMPLEMENT COMPREHENSIVE MONITORING PROGRAM

Need and Function

Program Element 1 – Develop and Implement a Comprehensive Monitoring Program contains monitoring activities that are action items explicitly listed in Table 3-8 and provides information required by other program elements of the OBMP.

The first impediment to *Goal 1 – Enhance Basin Water Supplies* can be stated as: "Unless certain actions are taken, safe yield of the Basin will be reduced … due to groundwater outflow from the southern part of the Basin." This impediment speaks to the reduction in groundwater production in the southern part of the Basin as agricultural land is converted to urban uses, and to increase outflow as groundwater storage is increased due to other management activities. The amount of safe yield lost due to these activities needs to be computed and used in the administration of the Judgment – otherwise the Basin will be overdrafted. The re-determination of safe yield and estimation of losses from groundwater storage programs require comprehensive water level mapping across the Basin, analysis of water level time histories at wells, and accurate estimations of groundwater production. The current groundwater level monitoring is not adequate. The primary problems with the current groundwater level monitoring program include poor areal distribution of wells in the monitoring program, short time histories, questionable data quality, and insufficient resources to develop and conduct a comprehensive program. Groundwater production estimates from the agricultural pool rely on water duty methods for most of the producers and some producers do not provide the Chino Basin Watermaster (Watermaster) with information upon which production estimates can be made. Rigorous groundwater level and production monitoring programs are described below.

The first impediment to *Goal 2 – Protect and Enhance Water Quality* can be stated as: "Watermaster lacks comprehensive, long-term information on groundwater quality." The primary uses of water quality information include, but are not limited to:

- locate and characterize water quality challenges in the Basin and formulate corrective management plans;
- provide an understanding of how the Basin works;
- determine whether water quality produced by a well is suitable for the desired use (*e.g.*, potable quality for potable use); and
- design treatment systems to improve water quality to a level to meet a desired use.

Currently, Watermaster obtains water quality data from all the appropriators for their active wells and from the Regional Board for wells monitored under their supervision (*e.g.*, landfill monitoring and other special water quality investigations). Watermaster has a limited groundwater quality monitoring program in the southern part of the Basin measuring general minerals and physical properties at about 60 wells. There is little historical or current water quality information for most of the 600 agricultural wells in the southern half of the Basin, for wells in the overlying non-agricultural pool, and for inactive appropriative pool wells. The water quality being produced at a majority of the wells in the Basin is unknown.

A salt budget approach has been proposed as a management tool for the Basin. The salt management steps included in *Program Element 7 Develop and Implement Salt Management Program* will be used by the Watermaster and other stakeholders to reduce the rate of salt accumulation in the Basin. Groundwater quality monitoring will be used to help assess the state of salt in the Basin in the future after the salt management plans are implemented. The direction and cost of future water management activities in the Basin depends on the water quality. A comprehensive groundwater quality monitoring program is fundamental to management of the Basin. A rigorous groundwater quality monitoring program is described below.

The fifth impediment to *Goal 2 – Protect and Enhance Water Quality* can be stated as: "The Basin is not using as much high quality storm water as it could for recharge." The first step in determining how much storm water recharge is occurring is to monitor the volume of inflow and outflow that is occurring at existing facilities, the amount of storm water that is available for recharge in the absence of recharge facilities, and to estimate the associated water quality. Characterizing the water quality of local and imported waters used for recharge in the Basin is necessary to protect water quality for beneficial uses, assess salt balance, design treatment processes to produce water of a quality suitable for intended uses, and to minimize the cost of recycled water recharge. Engineering investigations can utilize these data to design new facilities, and modify/operate existing facilities.

Storage of water in the Basin for local or regional conjunctive use may cause outflow to the Santa Ana River and some of its tributaries in the Chino Basin to increase. The water quality of this outflow may cause water quality deterioration in the Santa Ana River and require mitigation. Watermaster needs to develop a long-term database to assess losses from storage, and surface water impacts in the Santa Ana River and its Chino Basin tributaries from groundwater management activities.

The second impediment to *Goal 3 – Enhance Management of the Basin* can be stated as: "Existing production patterns are not balanced, cause losses, can contribute to local subsidence, and water quality problems." The impediment speaks to a lack of local balance between groundwater recharge and production. The lack of information on how groundwater moves in the Basin can lead to production and replenishment patterns that cause loss of yield and other problems as stated in the impediment. Groundwater level, groundwater quality, and accurate production estimates are necessary to define the groundwater flow systems and to implement equitable and cost-effective management plans.

Monitoring Programs to Support Water Resources Management in the Chino Basin

Groundwater Level Monitoring Program. Watermaster began a process to develop a comprehensive groundwater level monitoring program in the spring of 1998. The process consists of two parts – an initial survey followed by long-term monitoring at a set of key wells. The initial survey was to consist of collecting groundwater level data at all wells in the Basin from which groundwater level measurements can be obtained for spring 1998, fall 1998, spring 1999, and fall 1999. Due to resource limitations at the Watermaster, the initial survey is partially complete and will not be completed until after fall 2001. The data from the initial survey will be mapped and reviewed. Based on this review and Watermaster management needs, a long-term monitoring program will be developed and implemented in the fall of 2001. Watermaster staff will conduct this program with minimal outside assistance. Watermaster staff expects that they will measure groundwater levels in the initial survey at about 400 wells in overlying agricultural pool and about 100 other wells from the other pools and unassigned monitoring wells. The long-term monitoring program will use about half of the wells used in the initial survey plus all wells in the other pools and unassigned wells monitored under the direction of the Regional Board and others. Keys well located in agricultural areas will be replaced as necessary if the original well must be destroyed when the agricultural land surrounding the well is converted to other use.

Groundwater Quality Monitoring Program. Watermaster will begin the development of a comprehensive water quality monitoring program in July 1999. As with the groundwater level monitoring program, the water quality monitoring program will consist of an initial survey and a long-term monitoring effort. The initial survey will consist of:

- collection of all water quality data from appropriators' wells that are tested by appropriators;
- collection of all water quality data from Regional Board for water quality monitoring efforts that are conducted under their supervision; and
- collection and analysis of at least one water quality sample at all (or a representative set of) other production wells in the Basin. Assumed maximum number of wells sampled by Watermaster staff in the initial survey is 600.

Re-sampling and analysis will be done at wells sampled by Watermaster if volatile organic compounds (VOCs) are detected. These data will be mapped and reviewed. Based on this review and Watermaster management goals in the OBMP, a long-term monitoring program will be developed and implemented in the fall of 2002. The long-term monitoring program will contain a minimum set of key wells that can be periodically monitored to assess water quality conditions in the Basin over time. Table 4-1 lists the analytes and the analytical costs for sampling 200 wells per year for three years (plus an estimated 10 more wells for verification re-sampling). The average annual analytical cost is about $185,000 per year and totals about $555,000 if all wells were sampled. Watermaster staff will be trained to obtain samples at these wells and will require a total of about 140 person-days per year. Outside services will cost about $60,000 per year. Water quality data for all operable wells in the other pools will be provided by the well owners in those pools.

Production Monitoring Program. All wells that produce more than 10 acre-ft/yr will have in-line totalizing flow meters. To accomplish this, about 600 agricultural wells will be equipped with in-line totalizing flow meters. Production records from wells owned by appropriators and overlying non-agricultural pool members will report quarterly as has been done in the past. Watermaster staff will read the meters of wells owned by agricultural pool members at least once a year during the period of mid-May through June. Watermaster staff will digitize all production records in Watermaster's database and use this information in the administration of the Judgment. The cost of the installing in-line flow meters in the overlying agricultural pool is summarized in Table 4-2 and totals about $810,000. It has been recommended by the overlying agricultural pool that Watermaster fund up to 50 percent of the cost, with the remaining funds coming from the individual producers.

In addition to the above, all producers will provide Watermaster on an annual basis a *water use and disposal survey* form that describes the sources of water used by each producer and how that water is disposed after use. The purpose of the form is to provide information to Watermaster that will enable accurate salt budget estimates as described in *Program Element 6 – Develop and Implement Cooperative Programs with the Regional Board and Other Agencies to Improve Basin Management*, and for other water resources management investigations that may be undertaken by Watermaster in the future as part of the OBMP.

Surface Water Discharge and Quality Monitoring. The current program of measuring water quality at recharge basins should be expanded to all recharge and retention basins that contribute significant recharge to the Basin. Water level sensors will be installed in all recharge and retention basins that contribute significant recharge to the Chino Basin. These facilities were listed in Table 3 of the *Program Element 2 – Develop and Implement a Comprehensive Recharge Program* draft memorandum and are reproduced here in Table 4-3. A total of 16 new water-level sensors will be required at a total cost of

$192,000. Water level data acquisition and water quality sampling will be done by Watermaster staff. The annual cost of laboratory analysis and interpretation of water level and water quality data is about $45,000.

Watermaster needs to assess the existing surface water discharge and associated water quality monitoring programs for the Santa Ana River and its Chino Basin tributaries to determine the adequacy of the existing monitoring programs for characterizing historical ambient conditions and their utility in detecting water quality impacts from future Chino Basin management activities. If necessary, Watermaster could contract with the agencies conducting these programs to modify their programs to accommodate Watermaster. Ideally, a cooperative program involving all the interested agencies could be developed at a reduced cost for all. The cost of the initial assessment of surface water data for the Santa Ana River is about $15,000.

Ground Level Monitoring Program. Ground level surveys are proposed herein as an offshoot of the subsidence issues in Management Zone 1. The stakeholders are interested in determining if and how much subsidence has occurred in the Basin. Watermaster will conduct an analysis of historical ground level survey and remote sensing data to make this determination. The analysis consists of the following tasks:

- Historical survey data collected and/or on file by federal, state, and local agencies will be compiled, mapped, and reviewed to estimate total subsidence for as long a period as possible. Estimated cost to complete this review is about $15,000.
- Synthetic aperture radar (SAR) imagery will be used to assess the time history of subsidence in the Basin for the period 1993 though 1999. Estimated cost to develop this time history is about $20,000. It should be noted that the City of Chino has already conducted a similar investigation for most of the Basin and that the effort described herein is to expand on the work already done by the City.
- Based on the above information, a network of ground elevation stations in subsidence-prone areas will be developed and periodic surveys of these stations will be done. The frequency of periodic surveys will be established for the Basin as a whole with more frequent surveys done for some areas of the Basin. The estimated cost of this effort is not certain. It should be noted that the City of Chino has already conducted a similar survey within the City of Chino and that the effort described herein is to expand on the surveys done by the City to the entire Basin.

These tasks can be accomplished in the first year.

Well Construction, Abandonment and Destruction Monitoring. Watermaster maintains a database on wells in the Basin and Watermaster staff makes frequent well inspections. Watermaster sometimes finds a new well during routine well inspections. The near-term frequency of inspection is expected to increase due to the groundwater level, quality and production monitoring programs. Watermaster needs to know when new wells are constructed as part of its administration of the Judgment. Valuable information for use in managing the Chino Basin is usually developed when wells are constructed including: well design, lithologic and geophysical logs, groundwater level and quality data, and aquifer stress test data. Producers generally notify Watermaster when they construct a new well but seldom, if ever, provide the information listed above. Watermaster has not generally asked for these data. Well owners must obtain permits from the appropriate county and state agencies to drill a well and to put the well in use. Watermaster will develop cooperative agreements with the counties of Los Angeles, Orange, Riverside, and San Bernardino, and the California Department of Health Services (DHS) to ensure that the appropriate entities know that a new well has been constructed. Watermaster staff will obtain well design, lithologic and geophysical logs, groundwater level and quality data, and aquifer stress test data.

The presence of abandoned wells is a threat to groundwater supply and a physical hazard. Watermaster staff will review its database, make appropriate inspections, consult with well owners, and compile a list of abandoned wells in the Chino Basin. The owners of the abandoned wells will be requested to properly destroy their wells following the ordinances developed by the county in which the abandoned well is located. Watermaster staff will update its list of abandoned wells annually and provide this list to the counties for follow-up and enforcement.

Cooperative Efforts with Appropriate Agencies to Implement Program

Groundwater Level Monitoring. Watermaster will develop a groundwater level measurement protocol for use by all cooperating entities. Groundwater levels will be obtained by the following entities:

- Overlying Agricultural Pool – Watermaster staff
- Overlying Non-agricultural Pool – pool member or Watermaster staff
- Appropriative Pool – pool member or Watermaster staff
- Other wells – Watermaster staff will obtain data from Regional Board or owners.

Groundwater Quality Monitoring. Watermaster will develop groundwater sampling and analysis protocols for use by all cooperating entities. Groundwater quality analyses will be obtained by the following entities:

- Overlying Agricultural Pool – Watermaster staff
- Overlying Non-agricultural Pool – pool member
- Appropriative Pool – pool member
- Other wells – Watermaster staff will obtain data from Regional Board or owners.

Proposed Production Monitoring Program. Watermaster will develop and implement an in-line meter installation program for the overlying agricultural pool. The installation program will take place over a three-year period starting in Watermaster fiscal year 1999/00. Groundwater production estimates and water use and disposal survey forms will be obtained by the following entities:

- Overlying Agricultural Pool – Watermaster will read meters and producers will prepare and submit water use and disposal survey forms
- Overlying Non-agricultural Pool – pool member will read the meters and prepare and submit the water use and disposal survey forms
- Appropriative Pool – pool member will read the meters and will prepare and submit the water use and disposal survey forms.

Surface Water Discharge and Water Quality Program. Watermaster will take the lead in completing the following activities:

- Chino Basin Water Conservation District (Conservation District) and Watermaster will jointly install water level sensors in all existing recharge and retention facilities that have potential for storm water recharge.
- Watermaster staff will obtain grab samples approximately every two weeks for all basins during the rainy season and have these samples analyzed.

- Watermaster will review the surface water discharge and associated water quality monitoring programs for the Santa Ana River and the lower Chino Basin tributaries, and compare what is available from these programs to what is needed for Watermaster investigations under the OBMP.

Ground Level Survey. Watermaster will conduct the analysis to estimate historical subsidence and to monitor future subsidence in the Chino Basin.

Monitoring of Well Construction, Abandonment and Destruction. Watermaster will take the lead in completing the following activities:

- Develop agreements with county and state agencies to notify each other regarding construction of new wells and to obtain construction related information.
- Watermaster staff will prepare a list of abandoned wells and request the owners of abandoned wells to properly destroy their wells.

The counties will follow-up to ensure that abandoned wells within their jurisdiction are properly destroyed.

Implementation Actions and Schedule

First Three Years (1999/00 to 2001/02). The following actions will be completed in the first three years commencing fiscal year 1999/00:

- Complete initial survey for the groundwater level program.
- Complete initial survey for groundwater quality program.
- Complete meter installation program for overlying agricultural pool.
- Complete ground level survey.
- Complete installation of water level sensors in recharge and retention facilities.
- Complete Santa Ana River surface water monitoring adequacy analysis.
- Start and continue surface water discharge and quality monitoring at recharge and retention facilities.
- Develop agreements with county and state agencies regarding notification of new well drilling.
- Well construction and related information will be requested as new wells are identified.
- A list of abandoned wells will be developed annually and the owners will be requested to properly destroy their abandoned wells.

Years Four to Ten (2002/03 to 2010/11). The following actions will be completed in years four through ten, commencing fiscal year 2002/03:

- Start and continue long-term groundwater level monitoring program, cause key wells to be relocated as necessary.
- Start and continue long-term groundwater quality monitoring program, cause key wells to be relocated as necessary.
- Continue production monitoring.

- Conduct remote sensing analysis using synthetic aperture radar or other techniques at least every ten years (2010/11) or sooner, if necessary.
- Participate, as necessary, in the Santa Ana River surface water monitoring.
- Continue surface water discharge and quality monitoring at recharge and retention facilities.
- Well construction and related information will be requested as new wells are identified.
- A list of abandoned wells will be developed annually and the owners will be requested to properly destroy their abandoned wells.

Years Eleven to Fifty (2011/12 to 2050/51). The following actions will be completed in years eleven to fifty, commencing fiscal year 2011/12:

- Continue long-term groundwater level monitoring program, cause key wells to be relocated as necessary.
- Continue long-term groundwater quality monitoring program, cause key wells to be relocated as necessary.
- Continue production monitoring.
- Conduct remote sensing analysis using synthetic aperture radar or other technique at least every ten years (2020/21, 2030/31, 2040/41, 2050/51) or sooner, if necessary.
- Participate as necessary in the Santa Ana River surface water monitoring.
- Continue surface water discharge and quality monitoring at recharge and retention facilities.
- Well construction related information will be requested as new wells are identified.
- A list of abandoned wells will be developed annually and the owners will be requested to properly destroy their abandoned wells.

PROGRAM ELEMENT 2 -- DEVELOP AND IMPLEMENT COMPREHENSIVE RECHARGE PROGRAM

Need and Function of the Program Element

The need for a comprehensive recharge program was described in the introduction to the Final Report for Phase 1 of the Chino Basin Recharge Master Plan (Wildermuth, 1998). Program Element 2 -- Develop and Implement Comprehensive Recharge Program contains action items explicitly listed in Table 3-8.

The first impediment to Goal 1 – Enhance Basin Water Supplies can be stated as: "Unless certain actions are taken, safe yield of the Basin will be reduced … due to groundwater outflow from the southern part of the Basin" speaks to poorly planned recharge where recharge of storm water and recycled water could be placed too low in the Basin to be recovered. Some recycled water projects that are currently being planned will increase recharge when groundwater production downgradient of these proposed recharge projects is decreasing. The result will be increased outflow to the Santa Ana River and no yield improvement. A comprehensive program must ensure that the locations of recharge and production are such that yield is maximized.

The second impediment to *Goal 1 – Enhance Basin Water Supplies* and the fifth impediment to *Goal 2 – Protect and Enhance Groundwater Quality* can be stated as: "The Basin is not using as much high quality storm water as it could for recharge." At the time the Chino Judgment was adopted (1978), about

41 percent of the safe yield was estimated to come from irrigation returns. Since that time, irrigated agriculture has declined and is projected to be almost completely converted to urban uses by 2020. This will result in a decline of irrigation returns to groundwater and a potential decrease in the safe yield. San Bernardino County, Riverside County, and the US Army Corps of Engineers (USACE) have constructed flood control projects that efficiently capture and convey storm flow to the Santa Ana River, effectively eliminating the groundwater recharge that formerly took place in the stream channels and flood plains in the Chino Basin. In most cases, no provisions were made to mitigate the loss of recharge from flood control projects. Also, there have been no mitigation efforts to preserve recharge when land use is converted from native and agricultural uses to urban uses. Thus, the safe yield may have decreased in the Chino Basin due to land use changes and flood control improvements. Water harvesting opportunities exist that can be used to offset the yield lost to urbanization and flood control improvements. Water harvesting consists of capturing and recharging new storm flow caused by urbanization. Most of the precipitation falling on undeveloped land or land in agricultural uses is lost to evapotranspiration. Storm flow increases dramatically with urbanization due to an increase in impervious land cover, decrease in evapotranspiration of rainfall, and construction of drainage improvements. The potential yield from this additional storm flow is numerically equal to the increase in storm flow that occurs when the land is converted to urban uses. The actual yield is equal to the additional rainfall-storm flow that is captured and put to beneficial use. In the Chino Basin, the best and least expensive way to put this new water to beneficial use is groundwater recharge.

Increasing the yield of the Chino Basin by increased capture of storm flow will improve ambient water quality and increase the assimilative capacity of the Chino Basin. Increasing the capture of storm flow will reduce the cost of mitigation requirements for recharge of recycled water. The Basin Plan assumes that a certain average annual quantity of storm flow will be recharged each year. The volume of recycled water that can be used in the Basin, without total dissolved solids (TDS) mitigation, is numerically-tied to the average annual quantity of storm flow that recharges the Basin. A decrease in the recharge of storm flow will result in a decrease in the volume of recycled water that will be permitted in the Basin without TDS mitigation. Likewise, an increase in the recharge of storm flow will result in an increase in the volume of recycled water that will be permitted in the Basin without TDS mitigation. Therefore, the volume of storm flow recharge from storm flow has a dramatic impact on the future and cost of recycled water recharge.

The annual replenishment obligation will grow from about 30,000 to 55,000 acre-feet per year (acre-ft/yr) over the next 20 to 30 years. Watermaster has access to spreading facilities with a current capacity of about 29,000 acre-ft/yr when imported water from Metropolitan is available. Assuming replenishment water is available seven out of ten years, the average annual recharge capacity of recharge facilities available to Watermaster is about 20,000 acre-ft year. The in-lieu recharge potential for the Chino Basin is about 57,000 acre-ft/yr and will remain constant over the next 20 to 30 years based on the water supply plan included in this OBMP. Assuming in-lieu replenishment water is available seven out of ten years, the average annual in-lieu recharge capacity available to Watermaster is about 40,000 acre-ft year. The replenishment obligation, available recharge capacity over the next 20 years is (acre-ft/yr):

Year	**Replenishment Obligation**	**--------------Recharge Capacity--------------**			**Surplus Recharge Capacity**
		Physical	**In-Lieu**	**Total**	
2000	31,000	20,000	40,000	60,000	29,000
2020	55,000	20,000	40,000	60,000	5,000

The surplus recharge capacity could be used up quickly by future replenishment needs and implementation of conjunctive-use programs. A modest conjunctive use program consisting of an annually occurring seasonal shift of imported demands and a dry year yield component that would use up 150,000 acre-ft of storage will require about 46,000 acre-ft of recharge capacity. New recharge capacity is needed immediately for even a modest conjunctive-use program. The availability of in-lieu recharge capacity listed above is not a certainty. In the present mode of basin management, in-lieu recharge capacity is available on an ad hoc basis and requires the cooperation of water supply agencies that have access to supplemental water. Watermaster needs to obtain enough recharge capacity to meet its replenishment obligations for ultimate demands on the Chino Basin. The safest and most conservative way to ensure that recharge capacity will be available is for Watermaster to develop new recharge capacity that will meet ultimate replenishment obligations. For an average annual recharge capacity of 55,000 acre-ft/yr, Watermaster will need an annual recharge capacity of about 80,000 acre-ft/yr (80,000~55,000/0.7). The new recharge capacity by management zone for the year 2020 is estimated to be about:

Management Zone 1	18,000 acre-ft/yr
Management Zone 2 and 3	34,000 acre-ft/yr
Total	52,000 acre-ft/yr

The allocation of recharge capacity to management zones is based on balancing recharge and production in each management zone with the year 2020 production pattern described in Program Elements 3 and 5. Figure 4-1 shows the existing spreading and storm water retention basins in the Chino Basin. Figure 4-1 also shows the preferred area, based on current knowledge, for new recharge basins in Management Zone 2 and 3. The preferred recharge area is rapidly developing. It is unlikely that Watermaster will be able to purchase lands already in urban use and construct new basins. Therefore, Watermaster needs to obtain new recharge sites in the preferred area immediately. Recharge capacity in Management Zone 1 can be obtained by expanding recharge capacity at the Montclair Basins, improving the Upland and Brooks Basins, and through groundwater injection. During Phase II of the OBMP, Watermaster will develop an implementation plan to secure a total physical recharge capacity of about 80,000 acre-ft/yr with recharge facilities sized and located that will balance the production and recharge.

Past Efforts by Watermaster and the Conservation District

The Conservation District and the Watermaster completed phase 1 of a three-phase work plan to improve recharge and establish a long-range recharge master plan for the Chino Basin. The three phases consist of:

> *Phase 1 - Initial Screening and Assessment.* Conduct an assessment of how much storm flow is currently recharged and how much additional recharge could occur at new and existing spreading basin sites. From this assessment a list of promising spreading basins will be developed. Research questions will be developed for the promising sites and a detailed scope of work will be developed for Phase 2. Phase 1 was completed in January 1998 and is summarized below.
>
> *Phase 2 - Engineering Assessments of Promising Sites.* Site-specific investigations, percolation rate monitoring and the preparation of cost estimates for developing and managing these basins will be developed in this phase. The institutional issues regarding ownership of facilities, management of non-Conservation District-owned facilities, disposition of water recharged, and Basin Plan modifications will be identified.

Principles of agreement will be developed that describe the institutional issues and means to resolve these issues through agreements. A list of recharge projects will be identified and prioritized based on need and cost effectiveness. A detailed scope of work will be developed for Phase 3.

Phase 3 - Develop an Implementation Plan. A plan to develop and manage spreading basins will be prepared. The plan will include existing and new basins and a schedule for spreading basin improvements based on developing recharge capacity to match need for increased groundwater yield at minimum cost.

The Phase 1 effort was completed in January 1998. The objective of the Phase 1 analysis of the Recharge Master Plan was to determine the potential for artificial recharge given the resources in the Chino Basin. This was accomplished through data collection, research, and a massive computational and engineering assessment. Existing storm water recharge in the Chino Basin was estimated to be about 12,000 acre-ft/yr. This 12,000 acre-ft is part of the existing safe yield. The potential storm water recharge was estimated to range from about 25,000 to 30,000 acre-ft/yr given proper routine maintenance at existing and then-current planned facilities. Subsequent investigations by the Conservation District suggest that the potential recharge is lower. Incorporating the Conservation District's recent work, the potential range is probably around 12,000 to 22,000 acre-ft/yr. Table 4-4 lists the existing flood control/spreading basins and annual average recharge estimates based on updated Phase 1 modeling results. Most basins are not maintained to optimize recharge and there is little quantitative information on basin conditions or current recharge performance. Recharge of storm flows at existing basins could reach about 28,000 acre-ft/yr under ultimate land use conditions. The investigation also showed that it was economical to construct recharge facilities in areas with low percolation rates (<0.25 ft/day) if the facilities were part of a flood retention project. The potential recharge capacity and cost for recharge of imported and recycled water were developed. Operational plans that specify the amount and scheduling of imported water and recycled water recharge were developed. About 17,000 acre-ft/yr of recycled water recharge capacity was developed. The potential for imported water recharge ranges from about 100,000 acre-ft/yr to 135,000 acre-ft/yr at existing basins and one new large facility. Based on the work done for Program Elements 3 and 5 of the OBMP, the imported water recharge capacity needs to be expanded from its current capacity of 29,000 acre-ft/yr to about 80,000 acre-ft/yr to accommodate Watermaster replenishment activities.

Phase 2 Scope of Work for Hydrogeologic and Engineering Investigations

The Phase 2 work, as recommended in the Phase 1 report, was not formally started. Phase 2 consists of eight tasks.

<u>Task 1 Conduct Reconnaissance Analysis to Identify Existing Recharge Basins and Potential New Recharge Sites.</u> The purpose of this task is to develop a list of existing basins that can be used to recharge storm water, recycled water and imported water; and to identify areas for new recharge facilities. Based on the results of this task, some existing basins and new sites with potential for recharge by spreading and injection will be studied in detail in subsequent tasks and others with little potential recharge will either be studied later or not considered as recharge sites. This task consists of the following subtasks:

1.1 Meeting(s) with San Bernardino County Flood Control District (SBCFCD), Riverside County Flood Control and Water Conservation District (RCFCWCD), Los Angeles County Public Works Department (LACPWD) (collectively, the flood control agencies), the USACE, the Conservation District and the Watermaster. The purpose of these meetings is to discuss the use of existing flood control/recharge basins, recharge potential of these basins, past investigations, future flood control plans that could in include recharge, and institutional impediments to storm water recharge.

1.2 Meetings with planning agencies and the flood control agencies to inform these agencies of the need to set aside open space for recharge and to locate suitable areas for future recharge sites; to seek their cooperation in obtaining such lands, and to develop incentive programs to set aside land for recharge. A permanent basin-wide water conservation planning committee chaired by the Watermaster will be formed to facilitate the process of building and maintaining recharge facilities.

1.3 Develop a financing concept to provide capital for the improvement of existing facilities, construction of new facilities, operations and maintenance, and to mitigate adverse impacts of new spreading basins.

1.4 Review new hydrogeologic and facilities information that became available after completion of the Phase 1 analysis.

1.5 Evaluate Phase 1 computer simulation results to determine the location and magnitude of storm flow that is not being captured at existing facilities and that could be captured and recharged in either new facilities or from improved operations at existing facilities.

1.6 Develop a list of existing and proposed recharge facilities that merit detailed investigation. The priority list should be based on management issues (*e.g.*, subsidence and water quality), cost effectiveness, and for existing facilities, the availability of the facilities for recharge.

1.7 Conduct reconnaissance level feasibility investigation of using injection wells for recharge in Management Zone 1. The purpose of this recharge will be to increase the piezometric levels, reduce future subsidence, and improve water quality.

Task 2 Preliminary Assessment of the Capture of New Recharge. The objective of this task is to estimate the fate of artificial recharge. That is, to estimate the recharge benefits, areas of potential high groundwater, and losses to the Santa Ana River. The scenarios to be tested include recharge scenarios developed in the Phase 1 analysis (modified based on the results of Conservation District investigations and the results of Task 1). The *Rapid Assessment Model (RAM) Tool,* currently under development by the Watermaster, or *Chino Integrated Groundwater Surface Water Model (CIGSM)* are two models that could be used to make this assessment. It is not likely that the CIGSM would be used due to the time and expense to make it ready for use (see Program Elements 6 and 7 later in this section).

Task 3 Conduct Field Program. The purpose of this task is to develop fundamental information that can be used to assess the recharge potential of some existing and proposed basins, and to develop design information for new basins. The field program recommended for Phase 2 includes:

- obtaining and interpreting continuous cores for the upper 50 feet of sediment in existing facilities and the upper 100 feet of sediments from areas adjacent to existing and proposed basins;
- trenching to observe and interpret the near surface soil profiles;
- gradation tests of materials obtained from the trenches; and

- the installation of water level sensors identical to what Conservation District has installed in some of their basins.

Water level data will be collected at basins that are equipped with water level sensors. These data will be interpreted to produce percolation rates at each basin. The percolation rates will be correlated to soil properties and subsurface conditions to determine what is controlling recharge at a specific facility and to develop general design guidelines for the Chino Basin area. The field program is summarized in Table 4-5 covers 16 existing basins and up to three new surface water recharge facilities. Table 4-5 includes a cost estimate for this field program. Field programs for injection tests in Management Zone 1 will be developed in the work done in Program Element 4 – Develop and Implement Comprehensive Groundwater Management Plan for Management Zone 1.

Task 4 Develop Principles of Agreement. This task involves developing principles of agreement between SBCFCD, RCFCWCD, USACE, the Conservation District, and the Watermaster regarding the operation of existing and proposed storm flow management facilities. The goals of the principles are to maintain flood protection and maximize recharge. This work will involve the preparation of draft principles and many meetings. New technical information will need to be developed on an *ad hoc* basis in response to technical issues that will be involved in the principles. A set of principles will be developed with the Regional Board regarding TDS and nitrogen offset credits for recharge of recycled water.

Task 5 Develop Preliminary Operating Plans and Designs. Preliminary operating plans and facility improvements will be developed for all (new and proposed) recharge basins in the Chino Basin based on the results of Tasks 1 through 4. Preliminary capital and operating cost estimates will be developed.

Task 6 Estimate the Average Annual Recharge for Each Basin. Given the results of Tasks 1 through 5, the input data for the computer simulation models used in Phase 1 will be updated. The simulation models will be used to estimate the average annual recharge in each recharge basin. Estimates of imported water and recycled water recharge capacity will be updated. The priority list developed in Task 1 will be updated based on the results of this task.

Task 7 Develop Early Action Plan and Scope of Work for Phase 3. Given the results of Tasks 1 through 6, an early action plan and scope of work for Phase 3 will be developed. The early action plan, will include a list of high priority recharge projects that can be implemented with minimal additional analyses, and a list of lower priority projects that will require longer lead times to implement. These projects may include operating existing facilities to increase recharge, other non-controversial modifications to existing facilities, and construction of new recharge facilities. The scope of work will contain engineering design, environmental assessment and processing, and financing tasks. The scope of work will contain parallel tracks for the early action plan and the lower priority projects.

Task 8 Prepare Report. Technical memoranda will be prepared for Tasks 1 through 7. A final summary report will be prepared incorporating the task memoranda and a scope of work for Phase 3.

Cooperative Efforts with Appropriate Agencies to Implement Program

There are two fundamental levels of implementation appropriate for the comprehensive recharge program: one to develop the program, and one to construct, manage and operate the program. For development of the program, the implementing agencies include:

- the Watermaster, representing the producers who will benefit from the recharge and who will pay the cost of the plan development and implementation;

- the Conservation District, the flood control agencies, and the USACE who own the existing facilities and who (for the flood control agencies) will benefit from reduced flood control costs and improved storm water quality in the Santa Ana River and its tributaries;
- the planning agencies whose cooperation will be necessary to site new recharge facilities within their service areas; Inland Empire Utilities Agency (IEUA), Three Valleys Municipal Water District (TVMWD), and Western Municipal Water District (WMWD) as the provider of imported and recycled water for recharge; and producers that will utilize their own facilities for groundwater injection.

Watermaster will develop the recharge program for the Basin in the first four years of OBMP implementation. Watermaster will enter in to agreements with cooperative entities to implement the recharge program. Potential cooperative entities include Conservation District, the flood control agencies, USACE, Metropolitan Water District of Southern California (MWDSC), IEUA, TVMWD, and WMWD. These contracts will include specific performance goals and schedule. Watermaster will monitor these contracts very closely. If the cooperative entities fail to perform according to the terms of their contract, then Watermaster will terminate the agreements and either enter into an agreement with another cooperative entity or implement the program itself.

Implementation Actions and Schedule

First Three Years (1999/00 to 2001/02). The following actions will be completed in the first three years commencing fiscal year 1999/00:

- The Phase 2 scope of work should be completed within the first three years.
- Based on the results of the Phase 2 work, a list of high priority and low priority recharge projects will be identified. An action plan will be developed to implement the high priority projects as soon as possible and to implement the low priority projects as resources will allow.
- Task 1.1 and 1.2 should begin immediately, prior to the OBMP being submitted to the Court for approval.
- Watermaster advisory committee should form an *ad hoc* committee to start the coordination process and formalize the permanent basin-wide water conservation planning committee. Task 1.5 should also begin immediately.
- In year three, all high priority projects that involve re-operation of existing recharge/flood control facilities should be implemented, and Phase 3 should be started.
- Watermaster should begin the process of acquiring new recharge sites and easements identified in the Phase 2 and 3.

Years Four to Ten (2002/03 to 2010/11). The following actions will be completed in years four through ten, commencing fiscal year 2002/03:

Years four and five

- Complete Phase 3.
- Implement all high priority projects that involve construction and re-operation at existing facilities.

- Watermaster should continue the process of acquiring new recharge sites and easements identified in the Phase 2 and 3. By year five, recharge sites should have acquired to recharge at least 55,000 acre-ft/yr.
- Update the comprehensive recharge program in year 5.

Years five to ten

- Implement all high priority projects that involve the construction of new recharge facilities.
- Update the comprehensive recharge program in year 10.

Years Eleven to Fifty (2011/12 to 2050/51). The following actions will be completed in years eleven to fifty, commencing fiscal year 2011/12:

- Implement all other recharge projects based on need and available resources.
- Update the comprehensive recharge program every five years.

PROGRAM ELEMENT 3 – DEVELOP AND IMPLEMENT WATER SUPPLY PLAN FOR THE IMPAIRED AREAS OF THE BASIN

PROGRAM ELEMENT 5 – DEVELOP AND IMPLEMENT REGIONAL SUPPLEMENTAL WATER PROGRAM

Need and Function of the Program Elements

These program elements serve the OBMP goals listed in Table 3-8. The specific goals, impediments and action items are described below.

The first impediment in *Goal 1 – Enhance Basin Water Supplies* can be stated as: "Unless certain actions are taken, safe yield of the Basin will be reduced due to outflow from the southern part of the Basin." The fourth impediment in *Goal 2 – Protect and Enhance Water Quality* can be stated as: "Poor ambient groundwater quality limits direct use of groundwater and can lead to loss of Basin yield." Most of the agricultural land use in the southern part of the Basin will convert to urban uses over the next 20 to 30 years. Groundwater from the southern part of the Basin will have to be treated prior to use for these new land uses. Groundwater outflow to the Santa Ana River will occur if the decrease in agricultural groundwater production in the southern part of the Basin is not matched by an increase in municipal groundwater production in the same area. The increase in outflow will result in a decrease in safe yield that will reduce the initial rights of the producers in appropriative pool by about 74 percent. The increase in groundwater outflow to the Santa Ana River will cause an increase in river discharge and a degradation of water quality in the river. Currently, agricultural production in the southern part of the Basin is estimated using primarily water duty methods to be about 40,000 acre-ft/yr. Annual estimates of agricultural production are expected to be larger after in-line meters are in place. If the current level of groundwater production in the southern part of the Basin were to cease, the rising water discharge to the Santa Ana River could increase by approximately the numerical equivalent of the current production – about 40,000 acre-ft/yr. This new discharge would have an associated TDS concentration of about 1,300 milligrams per liter (mg/L) (almost twice the basin plan objective of 740 mg/L and 2.5 times the secondary drinking water MCL of 500 mg/L) and a nitrogen concentration of 30 mg/L-N (three times the basin plan objective of 10 mg/L-N and primary drinking water MCL of 10 mg/L-N). The Santa Ana River downstream of the Chino Basin is the primary drinking water supply for most of Orange County. Therefore, Santa Ana River water quality impacts caused by not producing Chino Basin groundwater will adversely affect the municipal water supplies in Orange County. The Regional Board has indicated that any adverse impacts to the Santa Ana River water quality associated with increased outflows from Chino Basin groundwater will have to be completely mitigated – presumably by desalting recycled water discharges to the Santa Ana River.

The third impediment in Goal 1 – Enhance Basin Water Supplies can be stated as: "Because there is a lack of assimilative capacity for total dissolved solids and nitrogen in the Chino Basin, there are economic limitations on the recharge of recycled water." Most of the recycled water produced in the Basin is exported out of the Basin because of either lack of demand for direct use or economic limitations caused by the lack of assimilative capacity in the Chino Basin. The TDS and nitrogen objectives in the Santa Ana Watershed are under rigorous review and new water quality objectives and water recycling guidelines should be implemented in the next few years. Recharge of recycled water could be used to replenish over-production, supplement the yield of the Basin, and lower the demand for imported water from the Sacramento Delta. There are three treatment options that that can be used to enable the recharge of recycled water: desalting recycled water prior to recharge, desalting groundwater to offset the salt load in the recycled water, and blending recycled water with low TDS imported and/or storm waters.

The fourth impediment in *Goal 1 – Enhance Basin Water Supplies* can be stated as: "Because future demands are increasing and there are limitations on basin and traditional supplies, new sources of supplemental water need to be developed." Alternatives to the use of imported water from MWDSC need to be developed to meet future demands, improve reliability and minimize cost of supplies. The new supplies include recycled water, groundwater from adjacent basins, Santa Ana River water and other waters as can be identified and conveyed to the Chino Basin.

The third impediment in *Goal 2 – Protect and Enhance Water Quality* can be stated as: "There is ongoing legacy contamination in the vadose zone with TDS and nitrogen from agriculture." The vadose zone that underlies areas that were or are currently in agricultural use is likely to be degraded with TDS and nitrogen. The vadose zone will contribute to future TDS and nitrogen degradation of the saturated zone. The primary areas of concern are the areas that were formerly in citrus in the northern part of the Basin and the entire southern half of the Basin. There are two significant implications of legacy contamination in vadose zone: groundwater degradation from TDS and nitrogen will continue into the future long after the agriculture has left – even if extraordinary efforts are used to clean up degraded groundwater; and, groundwater treatment ranging from blending to desalting will be necessary far into the future to put the degraded groundwater to beneficial use.

There are other goals and impediments to goals that are listed for these program elements, but they are somewhat redundant with those listed above and are not described herein. Fundamentally, the goal of Program Elements 3 and 5 is to develop a regional, long range, cost-effective, equitable, water supply plan for producers in the Chino Basin that incorporates sound basin management. The water supply plan developed during Phase II of the OBMP process will include:

- a cost-effective plan to maximize the beneficial use of Chino Basin groundwater and the safe yield.
- a program to reliably meet the long-term water supply needs of area purveyors.
- an implementation program.

Water Demand Planning Assumptions

The planning assumptions and basic data used to develop and evaluate water supply plans are described below.

Available Water Supply from the Impaired Area. As urbanization of the agricultural areas of San Bernardino and Riverside counties in the southern half of the Basin occurs, the agricultural water demands will decrease and urban water demands will increase significantly. Future development in these areas is expected to be a combination of urban uses (residential, commercial, and industrial). The cities of Chino, Chino Hills, and Ontario, and the Jurupa Community Services District (JCSD) are expected to experience significant new demand as these purveyors begin serving urban customers in the former agricultural area. For planning purposes, the agricultural area is assumed to be fully developed by the year 2020.

Based on current estimates of overlying agricultural pool production, it is expected that at least 40,000 acre-ft/yr of groundwater will need to produced in the southern part of the Basin to maintain the safe yield. Actual replacement groundwater production required could be far greater than 40,000 acre-ft/yr if current agricultural production is greater than reported to Watermaster. Recall in the Section 2 discussion on Chino Basin production, that there was a difference in the agricultural production reported to Watermaster (based on water duty methods) and the production estimates developed in the CBWRMS based on water duty methods and water budget modeling, with Watermaster's estimates being about 26,000 acre-ft/yr lower for the period 1978 to 1989. Watermaster will install in-line meters on all wells over the next three years after which accurate estimates of agricultural production will be available. If these estimates show that agricultural production is higher than previously reported, then the groundwater production rates from the southern part of the Basin will have be increased to maintain yield.

Water Supply Plans. Water demands, supply projections for agencies that produce groundwater from the Chino Basin, and estimates of the safe operating yield of the Basin are the basis for evaluating the water supply plans presented in this analysis. Initial water supply plans were developed by Montgomery Watson in 1998 and modified by WE, Inc., based on information supplied by the municipal and industrial producers. The initial plans are shown in Table 2-17.

Based on the data presented in Section 2, the municipal and industrial demands are projected to increase 30 percent between 2000 and 2020. Several agencies will experience increases in demand exceeding 30 percent over the next 20 years, including the cities of Chino, Chino Hills, Norco, Ontario, Cucamonga County Water District (CCWD), Fontana Water Company (FWC), JCSD, and the West San Bernardino County Water District (WSBCWD). Forecasts from municipal and industrial entities indicate that water supply sources for the Chino Basin in 2020 will consist predominantly of Chino Basin wells through direct use or treatment and use, groundwater and treated surface water from other basins, and MWDSC supplies.

The demand data in Section 2 and individual water supply plans were used to quantify the future demand for each purveyor that will need to be satisfied from new water supply sources. Future sources for each purveyor were evaluated and classified into two categories: secure sources and non-secure sources. Secure sources are those with a high probability of being available throughout the planning period. These include existing and available supplies from Chino Basin wells, existing water and desalter plants (*i.e.*, WFA/JPA, CCWD, and TVMWD water treatment plants and Santa Ana Watershed Project Authority [SAWPA] Desalter), imported treated MWDSC water from the Weymouth treatment plant, and imported surface water from other basins. Non-secure sources are not currently available and must be developed to serve the Basin purveyors. These depend on a future event, such as the construction of a treatment plant or acquisition of a new water source.

Table 4-7 lists the 2020 demand projections, projected secure water supply sources including Chino Basin groundwater, production rights, over/under production, the water needed in the future, and the replenishment obligations. The quantity of water that will be required by each water purveyor was found by subtracting the secure water supply for each purveyor from the purveyor's 2020 demand.

As shown in Table 4-6 of the 404,000 acre-ft/yr of total demand predicted in 2020, approximately 364,000 acre-ft/yr will be met from secure water sources with the remaining 40,000 acre-feet of demand being met from projects described in this program element. The breakdown of the 40,000 acre-ft/yr by purveyor from largest to smallest user is as follows:

Jurupa CSD	10,720 acre-ft/yr
City of Chino	9,540 acre-ft/yr
City of Ontario	8,400 acre-ft/yr
City of Chino Hills	5,600 acre-ft/yr
City of Norco	3,260 acre-ft/yr
Santa Ana River WC	2,170 acre-ft/yr
Swan Lake	350 acre-ft/yr
Total in 2020	40,040 acre-ft/yr

The demand in years 2005, 2010, and 2015 was predicted assuming a uniform increase in annual demand for each of the above purveyors. Table 4-7 lists the demands for these intermediate planning years.

For the purpose of this analysis, it was assumed that there is approximately 48,000 acre-ft/yr of agricultural production in the southern part of the Chino Basin in the year 2000, and that this production will reduce to about 8,000 acre-ft/yr in the year 2020. This decline in agricultural production must be matched by new production in the southern part of the Basin or the safe yield in the Basin will be reduced. The remaining 8,000 acre-ft/yr of production in the southern part of the Basin will be used by the State of California.

Potential Supplemental Water Supply Sources. An evaluation of potential future supplemental water supply sources is given in Table 4-8. Of these sources, the most viable is supplied through existing basin conventional water treatment plants that treat imported State Water Project (SWP) water from MWDSC. For the purposes of this analysis, it is assumed that future supplemental water supplies will come from expansion of the CCWD Lloyd Michael water treatment plant (WTP) and the WFA/JPA Agua de Lejos WTP.

Alternative Water Supply Plan Descriptions

Four initial water supply plan alternatives and ten subalternatives were developed. The initial alternatives consisted of various combinations of wells, desalters, water treatment plants, water and brine pipelines, and pumping stations. Purveyors that will require new water supplies include the cities of Chino, Chino Hills, Ontario, Norco, JCSD, Santa Ana River Water Company (SARWC), and Swan Lake. A fifth alternative was also developed that included three subalternatives for various levels of recycled water use. The water supply plans are described in detail in the Task Memorandum on file with the Watermaster for this Program Element. The initial alternatives that were evaluated included:

Alternative 1: Supplemental Water Deliveries Only

- Subalternative 1A: Supplemental Water Delivery – Agricultural Converts to Urban Uses
- Subalternative 1B: Supplemental Water Delivery – Agricultural Use Stays

Alternative 2: Groundwater Pump, Treat, and Serve Only

- Subalternative 2A-1: Regional Groundwater Pump, Treat, and Serve – Agricultural Converts to Urban Uses
- Subalternative 2A-2: Ad Hoc Groundwater Pump, Treat, and Serve – Agricultural Converts to Urban Uses
- Subalternative 2B-1: Regional Groundwater Pump, Treat, and Serve – Agricultural Use Stays
- Subalternative 2B-2: Ad Hoc Groundwater Pump, Treat, and Serve – Agricultural Use Stays

Alternative 3 – Conjunctive Use

- Subalternative 3A: Conjunctive – Agricultural Converts to Urban Uses
- Subalternative 3B: Conjunctive – Agricultural Use Stays

Alternative 4: Supplemental Water Delivery and Regional Groundwater Pump, Treat, and Serve

- Subalternative 4A: Supplemental Water Delivery and Regional Pump, Treat, and Serve – Agricultural Converts to Urban Uses
- Subalternative 4B: Supplemental Water Delivery and Regional Pump, Treat, and Serve – Agricultural Use Stays

Alternative 5: Reclaimed Water Delivery

- Subalternative 5A: Direct Non-Potable Reuse Only
- Subalternative 5B: Reclaimed Water Delivery for Spreading Only
- Subalternative 5C: Direct Non-Potable Reuse and Recharge of Reclaimed Water

Recommended Water Supply Plan for the OBMP

Considerable discussion of the alternative water supply plans occurred at the OBMP workshops in February through May of 1999. The discussions focused, in part, on the assumption and details of each alternative and cost. Based on technical, environmental, and cost considerations, the stakeholders selected Alternative 4A for detailed review and refinement. Alternative 6A was developed based on Alternative 4A and 5C, includes an accelerated desalting schedule and has no future supplemental water deliveries to the southern part of the Basin. The Alternative 6A water supply plan consists of the following key elements.

Groundwater Production Pattern. Groundwater production for municipal use will be increased in the southern part of the Basin to: meet the emerging demand for municipal supplies in the Chino Basin, maintain safe yield, and to protect water quality in the Santa Ana River. All new southern Basin production will require desalting prior to use. The cities of Chino, Chino Hills, Ontario and Norco, and the JCSD will maximize their use of groundwater from the southern part of the Basin prior to using other supplies. The SAWPA desalter, currently under construction will have to be expanded from 8 million gallons per day (mgd) to 10 mgd by 2003. Two new desalters will be constructed – the *east* and *west* desalters. The east desalter will need to be on-line by late 2003 at a capacity of 14 mgd. The west desalter will need to be on-line by 2010 with a capacity of 7.5 mgd. Both these new desalters will be expanded in the future. The cost of the southern Basin desalting system will be shared by all Basin producers such that the agencies making direct use of this water above are not unfairly burdened with the cost of treating this water. It was demonstrated during discussions on this program element that equitable cost sharing could be achieved. It was also demonstrated that the groundwater production pattern in the Alternative 6A water supply plan was the least cost plan when lost safe yield and Santa Ana River water quality mitigation costs are avoided. The stakeholders came to an agreement on May 27, 1999 that the Alternative 6A water supply plan should be included in the OBMP.

The total replenishment obligation associated with this groundwater production pattern is 31,000 acre-ft/yr in the year 2000 and will increase to about 55,000 acre-ft/yr by the year 2020. The replenishment obligation can be satisfied using water in local storage, direct recharge of imported and recycled water, and by in-lieu exchange.

Imported Water. Imported water use will increase to meet emerging demands for municipal and industrial supplies in the Chino Basin area, Watermaster replenishment, and conjunctive use. Expanded use of imported water in the northern part of the Basin will have a lower priority than maintaining groundwater production in the southern part of the Basin.

Recycled Water. Recycled water use (direct use and recharge) will increase to meet emerging demands for non-potable water and artificial recharge. Under the current Basin Plan, all new recycled water use will require mitigation for TDS and nitrogen impacts. Recycled water use will be expanded as soon as practical. The two new desalters described above and the increase in storm water recharge will provide mitigation for the expanded use of recycled water.

Under Alternative 6A , two new desalters will be constructed and the SAWPA desalter currently under construction will be expanded immediately. The general location of these desalters, their respective well fields, product water pipelines, and delivery points are shown in Figure 4-2. Table 4-9 shows the timetable for the new desalters along with the salt removal capacity of these desalters. Table 4-10 contains the capital and annual costs for these facilities. An initial financing and cost sharing plan for this part of the OBMP will be developed during the Phase II OBMP process.

Implementation Requirements and Issues

Technical evaluation requirements and issues relating to facilities siting, facilities description and operations, and technical feasibility include:

- Basin exploration to assess ambient water quality and potential well field locations.
- Geotechnical and hydrogeological investigations.
- Siting investigations for desalters, wells, pipelines, and other facilities.
- Pump tests to determine viability of aquifer production.
- Modeling for safe yield impacts for alternatives identified in the OBMP.
- Preliminary engineering (reverse osmosis [RO] process design, facility layouts, pipeline alignments).
- Aquifer and groundwater quality monitoring.
- Santa Ana Regional Interceptor (SARI) capacity/availability.

- Analyses of the availability/capacity of existing infrastructure.
- Project phasing schedule.
- Construction delivery method (design-bid-build versus design-build).

Financial evaluation requirements and issues include:

- Economic feasibility analysis.
- Project financing plan.
- Interagency agreements/approvals/contracts.
- Potential impact on replenishment obligations.
- Cost/benefit analyses to evaluate incentives.
- Method of operation (agency operation versus contract operation).
- Future availability of MWDSC incentives.
- Sale of rising groundwater to Orange County.

California Environmental Quality Act (CEQA) and permitting requirements and issues include:

- Selection of implementing/lead agency.
- Preparation of necessary documents for CEQA/ National Environmental Policy Act (NEPA) compliance.
- Compliance with Basin Plan.
- Regulatory requirements/approvals from DHS and Regional Board Requirements.
- Interagency agreements/approvals/contracts.

Implementing Agencies

There are a number of specific responsibilities that must be defined when implementing any of the previously discussed alternatives. These responsibilities are listed in Table 4-11. One agency could assume all the responsibilities listed in Table 4-11; however, reality dictates that no single agency can typically meet all of these responsibilities. The following section provides a description of the agencies that could become the lead implementing agency for the construction, operation, and technical and financial support of the chosen water supply alternative.

Chino Basin Watermaster. Watermaster was created on January 27, 1978 by the San Bernardino County Superior Court after extensive negotiations between the municipal, industrial, and agricultural producers. The Chino Basin Watermaster is the entity charged with administering adjudicated water rights and managing groundwater resources within the Chino Basin. The Watermaster's primary responsibilities include: manage and control the replenishment of water supplies in the Basin, acquire and spread replenishment water as needed, approve and facilitate the storage of supplemental water in the Basin, and develop and implement an optimum basin management program to manage the Basin.

Inland Empire Utilities Agency. IEUA, formerly the Chino Basin Municipal Water District, serves 570,000 people and covers 242-square miles in the areas of Chino, Chino Hills, Fontana, Montclair, Ontario, Rancho Cucamonga, Upland and the Chino Agricultural Preserve. The Agency's major responsibilities are: wastewater treatment and disposal; supplemental water supply; industrial waste or non-reclaimable waste disposal; and water recycling. Under the *Regional Sewage Service Program*, the Agency operates three domestic wastewater treatment plants. The program enables local communities to take advantage of shared facilities and to further reduce costs by combining staffs and operations. Two additional water recycling facilities will be on-line in the next 10 years to accommodate the growth of the area's industrial and residential communities, as well as to meet increasingly stringent environmental regulations.

Three Valleys Municipal Water District. In recognition of the need for additional sources of water for the growing region, the Pomona Area Water Committee was organized in 1945 for securing annexation to the MWDSC. Through the efforts of the committee, the District was formed on January 26, 1950 by public election. The District is a local government agency with a board of directors elected by the registered voters residing within the District's boundaries. The District's boundary includes approximately 133 square miles with a current population of 475,000. Approximately 126,600 retail customers are served by the local agencies to whom the District provides supplemental water.

Western Municipal Water District. Western Municipal Water District of Riverside County was formed in 1954 to bring supplemental water to growing western Riverside County. Western's district consists of a 510-square mile area of western Riverside County, with a population of nearly one-half million people. Western is in the heart of the Santa Ana Basin and within its district lies the communities of Jurupa, Mira Loma, Rubidoux, Riverside, Norco, Corona, Elsinore Valley, and Rancho California. A member agency of the Metropolitan Water District of Southern California, Western serves imported water directly to more than 10,000 retail customers who are located in the unincorporated and non-water bearing areas around Lake Mathews and portions of the city of Riverside. The District also serves ten wholesale customers with Colorado River and SWP water. In addition to its retail water service, the District has committed to retail sewer service to 2600 customers in the Lake Hill/Home Gardens area.

Santa Ana Watershed Project Authority. SAWPA is a joint powers agency that was originally formed to develop water and wastewater management plans for the Santa Ana River watershed. The agency is now responsible for regional water quality planning and implements projects at the request of its member agencies. Members of SAWPA include: IEUA, Eastern Municipal Water District (Riverside County), San Bernardino Valley Municipal Water District (SBVMWD), WMWD (Riverside County), and the Orange County Water District (OCWD). SAWPA owns and operates the Santa Ana Regional Interceptor (SARI) sewer brine disposal system that offers a means of exporting non-reclaimable wastewater from the southern portion of the Chino Basin (CBMWD Reclaimed Water Master Plan, 1993). In addition to the SARI, SAWPA, in cooperation with a number of other agencies who provided support and financial resources, constructed the Arlington Desalter to begin reversing the Arlington Basin's salinity. The Arlington Desalter produces approximately 6 mgd of drinking quality water. SAWPA also owns and operates the SAWPA Chino Desalter that, upon construction by the year 2000, will supply approximately 8 mgd of potable drinking water to JCSD, Chino, Chino Hills, and Norco.

Cooperative Efforts with Appropriate Agencies to Implement Program

Watermaster will assume the leadership role for developing and implementing the OBMP regional water supply plan (Alternative 6 described above) including the development of new desalting plants and the expansion of the new SAWPA desalter. Watermaster will enter into agreements with cooperative entities to implement the OBMP regional water supply plan. Potential cooperative entities include CCWD, IEUA, TVMWD, WMWD, SAWPA, WFA/JPA, and private entities. These contracts will include specific performance goals and schedule. If a cooperative entity fails to perform according to the terms of their agreement, then Watermaster will terminate the agreements and either enter into an agreement with another cooperative entity or implement the program itself.

The new desalting projects could be designed, built, operated and owned by IEUA, WMWD, SAWPA, or by private entity under long-term contract to supply water from the desalters. A private entity may be the preferred way to construct the east desalter because of rapid implementation requirements of that desalter.

CCWD, IEUA, TVMWD, and WFA/JPA will be responsible for providing imported supplies.

IEUA and WMWD will be responsible for expanding the recycled water use in the Basin.

Implementation Actions and Schedule

First Three Years (1999/00 to 2001/02). The following actions will be completed in the first three years commencing fiscal year 1999/00:

<u>Preliminary Engineering – Year 1</u>

- Basin exploration to assess current water quality and identify well field locations.
- Geotechnical and hydrogeological investigations.
- Siting investigations for desalters, wells, pipelines, and other facilities.
- Re-evaluation of potential purveyor water supplies/demands.
- Analysis of availability & capacity of existing infrastructure.
- Analysis of SARI capacity & availability.
- Concept design for new treatment facilities.
- Preparation of necessary documents for CEQA/NEPA compliance.
- Regulatory requirements/approvals from DHS and Regional Board Requirements.
- Conditional use and other permits from local agencies.
- Economic feasibility analysis.
- Project financing plan.
- Selection of implementing/lead agency.
- Interagency agreements/approvals/contracts.
- Method of operation (agency operation versus contract operation).

<u>Design and Construction of East Desalter and</u>
<u>Design and Construction of Expansion of SAWPA Desalter – Years 2 and 3</u>

- Purchase land for ultimate facilities.
- Pre-design investigations.
- Pump tests to determine groundwater production.
- Re-evaluation of purveyor water supplies/demands.
- Preliminary engineering.
- RO process design.
- Facility site layouts.
- Pump station design.
- Final design.
- Bidding and contract award.
- Construction.

- Start-up by 2003.

Years Four to Ten (2002/03 to 2010/11). The following actions will be completed in years four through ten, commencing fiscal year 2002/03

Design and Construction of Western Desalter

- Purchase land for ultimate facilities.
- Pre-design investigations.
- Pump tests to determine groundwater production.
- Re-evaluation of potential purveyor water supplies/demands.
- Geotechnical and hydrogeological investigations.
- Preliminary engineering.
- RO process design.
- Facility site layouts.
- Pump station design.
- Final design.
- Bidding and contract award.
- Construction
- Start-up by 2010

East, West, and SAWPA desalters:

- Operate facilities through period.
- Upgrade facilities as necessary to maintain state-of-the-art and to meet regulatory requirements.

Years Eleven to Twenty (2010/11 to 2019/20). The following actions will be completed in years eleven to twenty, commencing fiscal year 2010/11

Expansion of Eastern Desalter, and
Expansion of Western Desalter

- Pre-design investigations.
- Pump tests to determine groundwater production.
- Re-evaluation of potential water supplies/demands.
- Geotechnical and hydrogeological investigations.
- Preliminary Engineering.
- RO process design.
- Facility site layouts.
- Pump station design.
- Final design.
- Bidding and contract award.
- Construction.
- Start-up by 2015.

East, West, and SAWPA desalters:

- Operate facilities through period.

- Upgrade facilities as necessary to maintain state-of-the-art and to meet regulatory requirements.

PROGRAM ELEMENT 4 – DEVELOP AND IMPLEMENT COMPREHENSIVE GROUNDWATER MANAGEMENT PLAN FOR MANAGEMENT ZONE 1 (MZ1)

Need and Function

Program Element 4 – Develop and Implement Comprehensive Groundwater Management Plan for Management Zone 1 contains action items explicitly listed in Table 3-8.

The second impediment to *Goal 1 – Enhance Basin Water Supplies* can be stated as: "Unless certain actions are taken, piezometric levels in the deep aquifers of Management Zone 1 will continue to decline adding to the potential for additional subsidence and fissures, lost production capability and water quality problems. This impediment speaks to a localized subsidence and fissuring problem within the City of Chino and to a potentially larger and similar problem in the southern end of Management Zone 1 in the former artesian area. This part of the Basin contains a higher fraction of fine-grained materials that originated from sedimentary deposits in the Chino and Puente Hills. This area also consists of a multiple aquifer system. The upper aquifer(s) are moderately high in TDS and are often very high in nitrate. The City of Chino Hills has drilled a series of wells into the deeper aquifer(s) to obtain better quality water. The storage and hydraulic properties of the deeper aquifers are quite limited relative to the upper aquifer. The correlation of the recent groundwater production in the deep aquifers and the timing of the subsidence and fissuring, and a review of the hydrogeologic data from the area very strongly suggest that deep aquifer production is the likely cause of the subsidence. Figure 4-2 illustrates the location and magnitude of subsidence and fissuring in the City of Chino and Figure 4-3 shows the location of the this subsidence anomaly relative to Management Zone 1 and the former artesian area. The *Program Element 4 – Develop and Implement Comprehensive Groundwater Management Plan for Management Zone 1* task memorandum is on file and available from the Watermaster offices. It describes the subsidence problem in the Management Zone 1 area as it is currently understood in more detail.

MZ 1 Management Plan

The continued occurrence of subsidence and fissuring in Management Zone 1 is not acceptable and must be reduced to tolerable levels or completely abated. However, there is some uncertainty as to the causes of subsidence and fissuring and more information is necessary to distinguish among potential causes. An interim management plan must be developed and implemented to:

- minimize subsidence and fissuring in the short-term;
- collect the information necessary to understand the extent and causes of subsidence and fissuring; and
- formulate an effective long-term management plan.

MZ 1 Interim Management Plan. The interim management plan would consist of the following activities:

- Voluntarily modify groundwater production patterns in Management Zone 1 for a five-year period. For example, there is some indication that deep aquifer production beneath the City of Chino contributed to recent subsidence and fissuring in the area. Reduction or elimination of deep aquifer production beneath the area of subsidence and fissuring is a logical short-term mitigation strategy.

- Balance recharge and production in Management Zone 1. Based on preliminary engineering investigations with RAM tool, it appears that current levels of pumping and recharge are balanced. However, increases in pumping should be balanced with increases in recharge.
- Determine gaps in existing knowledge. Primarily, there is a lack of understanding of Management Zone 1 hydrogeology, of the nature and extent of subsidence and fissuring, and of the exact causes of subsidence and fissuring.
- Implement a process to fill the gaps in existing knowledge. This would include hydrogeologic, geophysical, and remote sensing investigations of Management Zone 1, as well as certain monitoring programs, such as piezometric, production, water quality, ground level, and subsidence monitoring.
- Formulate a long-term management plan. The long-term management plan will include goals, activities to achieve those goals, and a means to evaluate the success of the plan.

MZ 1 Long-Term Management Plan. The long-term management plan will be formulated during the interim management plan based on investigations, monitoring programs and data assessment. It will likely include modifications to groundwater pumping rates and the locations of pumping, recharge, and monitoring. The long-term management plan will be adaptive in nature – meaning monitoring and periodic data assessment will be used to evaluate the success of the management plan and to modify the plan, if necessary.

Cooperative Efforts with Appropriate Agencies to Implement Plan

The subsidence and fissuring problem appears to be currently focused in the City of Chino and the California Institution for Men (CIM). However, it is reasonable given the current knowledge, to expand the minimum area of concern to the entire former artesian area shown in Figure 4-3 and slightly beyond that area. Changes in pumping and recharge patterns in Management Zone 1, and more generally the area of concern, will most likely be part of the management plan. The producers in the area include the cities of Chino, Chino Hills, Ontario, Pomona and Upland, the Monte Vista Water District (MVWD), San Antonio Water Company (SAWC), Southern California Water Company (SCWC), the State of California (CIM, California Institution for Women [CIW]), and SAWPA. Watermaster may need to have entities that increase their production to provide for the recharge of an equivalent amount of water to maintain the balance of pumping and recharge. Watermaster will take the leadership role in the development and implementation of the Management Zone 1 management plan.

Implementation Actions and Schedule for the First Five Years

Year 1

- Establish a Management Zone 1 committee and develop interim management plan.

Years 2 to 5

- Implement the interim management plan, including appropriate monitoring.

Years 3 to 5

- Annual assessment of data from monitoring programs, and modification of monitoring programs if necessary.

Year 5

- Develop long-term management plan.

Implementation Actions and Schedule for Years Six to Ten.

Year 6

- Implement the long-term management plan.

Years 6 to 10

- Annual assessment of data from monitoring programs, and modification of management plan if necessary.

Implementation Actions and Schedule for Years Eleven to Fifty.

Assessment of data from monitoring programs every three years and modification of management plan if necessary.

PROGRAM ELEMENT 6 – DEVELOP AND IMPLEMENT COOPERATIVE PROGRAMS WITH THE REGIONAL BOARD AND OTHER AGENCIES TO IMPROVE BASIN MANAGEMENT

PROGRAM ELEMENT 7 – DEVELOP AND IMPLEMENT SALT MANAGEMENT PROGRAM

Need and Function

These program elements are needed to address some of the water quality management problems that have occurred in the Basin. These water quality problems are described in Section 2 *Current Physical State of the Basin* and Table 3-8 in Section 3 *Goals of the OBMP*. The specific water quality issues addressed by these program elements are listed below:

- The Special Referee has indicated that Watermaster needs to routinely demonstrate that implementation of the OBMP will lead to groundwater quality improvements. Watermaster should develop and use a method to determine water quality trends and to verify whether the OBMP is improving water quality.
- There is legacy contamination in the vadose zone from past agricultural activities (TDS and nitrogen) that will continue to degrade groundwater long into the future.
- Watermaster does not have sufficient information to determine whether point and non-point sources of groundwater contamination are being adequately addressed.
- There is ongoing salt and nitrogen loading from agriculture.

Demonstration of Water Quality Improvement

The TDS and nitrogen challenges in the Chino Basin are caused by agriculture and safe yield management. The TDS and nitrogen impacts from agriculture were described in Section 2. Table 4-12 shows in summary format how the TDS concentration in source supplies and fertilizer affect the TDS concentration in irrigation return flows to groundwater. The TDS concentration in the irrigation return flow is about four times higher than the TDS concentration in the irrigation supply. The majority of the increase in TDS concentration is caused by consumptive use and a negligible contribution from the fertilizer. The table also shows the affect of the use of dairy manure for fertilizer and soil improvement. The TDS contribution from manure is much larger than from commercial fertilizer, however the concentration increase from consumptive use is more significant particularly for source water TDS concentrations typical in the southern part of the Basin (>500 mg/L). Similar TDS concentration increases in irrigation return flows occur for other crop types such as citrus and grapes, both of which were significant in the past. Table 4-12 shows TDS concentrations for urban irrigation return flows for a representative range in municipal source water TDS concentration. The range of TDS concentrations in urban irrigation returns is from about 1,200 to 1,800 mg/L with less than ten percent coming from fertilizers and the overwhelming majority of the TDS increase coming from consumptive use.

Figure 4-4 is a map that shows the general groundwater flow directions in the Chino Basin. The map contains velocity vectors that show direction and relative velocity of groundwater flow. One of the more interesting interpretations of this map is that groundwater generally flows away from the Santa Ana River. Small amounts of rising groundwater occur seasonally in Chino and Mill Creeks and are typically less than 11,000 acre-ft/yr. The only way significant amounts of groundwater can leave the Basin are through consumptive use, the discharge of recycled water to the Santa Ana River near Prado, and the discharge of brine to either the Santa Ana Regional Interceptor (SARI) or the Non-Reclaimable Waste Line (NRWL). The groundwater flow pattern shown in Figure 4-5 is largely influenced by production. If there were a significant reduction in groundwater production in the southern part of the Basin, then groundwater outflow to the Santa Ana River would increase and the safe yield would be reduced. The safe yield of the Basin depends on recharge of Santa Ana River water and minimal outflow of groundwater to the river. Without the recycled water discharges to the Santa Ana River near Prado dam and brine discharges to the SARI and the NRWL, the Chino Basin would almost be a completely closed system.

The vadose zone is the part of the aquifer that lies between the soil and the water table. The vadose zone is partially saturated and buffers the mineral salt loads entering from the soil. The buffering effect reduces the magnitude of the peak loads to the saturated zone and spreads out the loading of the saturated zone over a period of time that is longer than the soil loading. Salts in the vadose zone are being released to the saturated zone now and will continue to be released to the saturated zone for some time after the agricultural lands are converted to urban uses. The quantity of salt reaching groundwater should reduce in the future for two reasons:

- salt loading to the soil from agricultural will reduce over time
- less water will percolate through the vadose zone as the agricultural area becomes paved through urbanization (60 to 80 percent impervious).

If current rates of agricultural loading were to continue indefinitely, TDS and nitrate concentrations in groundwater could continue to rise. TDS projections for the Chino Basin that were made during the *Chino Basin Water Resources Management Study* (CBWRMS) suggested that the TDS concentrations would continue to rise in groundwater throughout most of the 50-year planning horizon of 1990 through 2040. These graphs are included in the Program Element 6 Task Memorandum on file and available from the Watermaster offices. In the CBWRMS, agricultural activities were assumed to decline to minimum levels by the year 2020. If and when the land use in the area is converted to urban uses, the source water TDS served to the new urban areas will be always less than 400 mg/L and the mineral salts from the source water will be mostly discharged in recycled water discharges to the Santa Ana River, brine line discharges (from new desalters) and increased rising groundwater flows to the Santa Ana River. The TDS concentration in groundwater will, after some period of time, decline slowly but should still remain significantly higher than be served as a municipal supply.

The Court will require Watermaster t develop and use a method to demonstrate that actions taken in the OBMP will improve groundwater quality. The question arises: how *do we assess progress towards improving groundwater quality if groundwater monitoring alone will continue to show degradation even after significant steps are taken to improve water quality?*

The alternatives available to the Watermaster range from groundwater quality monitoring alone to the application of numerical models in conjunction with monitoring. As mentioned above, if groundwater monitoring were the only metric for measuring improvement, then it will appear for many years that construction of desalters and the export of dairy waste will have no benefit. The use of numerical models to assess progress in improving water quality is extremely expensive if their only use were to assess such progress.

A method that combines monitoring and a salt budget is more practical and cost-effective than large-scale modeling. The salt budget approach consists of a salt mass accounting in each management zone and the Basin as a whole. The magnitude of each inflow and outflow component would be estimated. The TDS and nitrogen concentration of each inflow and outflow component would be estimated. Water quality will improve if the flow-weighted concentration in the inflow is less than the flow-weighted concentration in the outflow.

$$[S\ I_k{*}C_k] \ / \ [S\ I_k] \ - \ [S\ O_j{*}C_j] \ / \ [S\ O_j] < 0 \quad \text{water quality is improving}$$
$$[S\ I_k{*}C_k] \ / \ [S\ I_k] \ - \ [S\ O_j{*}C_j] \ / \ [S\ O_j] > 0 \quad \text{water quality is degrading}$$
$$[S\ I_k{*}C_k] \ / \ [S\ I_k] \ - \ [S\ O_j{*}C_j] \ / \ [S\ O_j] = 0 \quad \text{water quality is not changing}$$

where: I_k is volumetric recharge component *k*
C_k is the TDS or nitrogen concentration associated with recharge component *k*
O_j is volumetric discharge component *j*
C_j is the TDS or nitrogen concentration associated with discharge component *j*

The inflow components include: precipitation, artificial recharge of storm flows, artificial recharge of recycled water, and applied water. The outflow components include: evapotranspiration, surface water outflow, recycled water export, groundwater export and brine export. The TDS and nitrogen mass increments added to water as it is applied to irrigated lands or to disposal land needs to be estimated. The inflow and outflow components used in this approach will produce average recharge and discharge from the Basin, that is, there will be no change in groundwater storage.

The salt budget will be computed for existing conditions to assess the current balance, hereafter referred to as the baseline case. An assessment of future water quality improvements that will occur from the OBMP will be made by changing the water and waste management assumptions in the baseline case to reflect OBMP implementation. The changes in the inflow and outflow components and their associated TDS and nitrogen concentration will be made and the salt budget equations would be re-solved. The relative improvement of water quality will be assessed by comparing the salt budget of the OBMP to the baseline plan. Later, during periodic OBMP updates, the salt budget will be computed based on the then current water quality (from monitoring programs) and the then current water and waste management plans. These periodic assessments will allow Watermaster to determine if the OBMP is improving water quality.

There are some limitations to the salt budget method and the use of such a method should be considered in light of all anticipated water quality assessment needs in the Basin. Table 4-13 presents a tabular comparison of future water quality information requirements with alternative methods and approximate costs to use those methods over the next 20 years. The CBWRMS developed a comprehensive set of models for the Chino Basin that is capable of assessing the impact of past and future water resources management activities on groundwater level, streamflow, and water quality. The *Chino Integrated Groundwater and Surface Water Model* (CIGSM) is extremely complex and expensive to maintain and use.

The salt budget method will cost about $80,000 to $100,000 to develop and use the first time. Subsequent uses, in either OBMP updates or *ad hoc* investigations, will involve developing new water quality input data based on new monitoring data and revised water and waste management scenarios. Total cost over the next 20 years should range between $300,000 to $400,000. CIGSM is composed of series of models. In contrast to the salt budget method, CIGSM is very complex and difficult to use. The cost to re-calibrate CIGSM, to update the planning data, and to use the model to evaluate the initial OBMP is about $700,000 based on recent detailed estimates developed for the TIN/TDS Study (Wildermuth Environmental, 1999). The cost to use CIGSM over the next 20 years will run between $3,000,000 to $4,000,000.

Cooperative Efforts with the Regional Water Quality Control Board

Watermaster does not have sufficient information to determine whether point and non-point sources of groundwater contamination are being adequately addressed. Watermaster's past monitoring efforts have been largely confined to mineral constituents in the southern half of the Basin and to available monitoring data supplied by municipal and industrial producers. The Regional Water Quality Control Board (Regional Board) has limited resources to detect, monitor and cause the clean up of point and non-point water quality problems in the Chino Basin. The Regional Board commits its resources to enforce remedial actions when it has identified a potential responsible party. The Regional Board does not take action when the sources are not easily identified or when the sources are diffuse, such as non-point sources. Notable examples include the mercury problem in the east Ontario area and some solvent plumes in the lower Chino Basin. It is not a question of Regional Board willingness to in this area; it is the allocation of limited RWQCB resources. Watermaster can improve water quality management in the Basin by committing resources to:

- identify water quality anomalies through monitoring;
- assist the Regional Board in determining sources of the water quality anomalies;
- establish priorities for clean-up jointly with RWQCB; and
- remove organic contaminants through its regional groundwater treatment projects in the southern half of the Basin.

The last bulleted item requires some explanation. The well field for SAWPA desalter will eventually intercept a solvent plume of unknown origin that is emanating from the Chino airport area. There is a second solvent plume northeast of the Chino airport area that could be intercepted by the current desalter or another future desalter. This will require additional treatment for the water produced by the desalter. The desalter project can be used to clean up these plumes at some additional cost. The cost of cleaning up the solvent plumes at the desalters will be less than the cost of a dedicated solvent removal system. The additional cost should be paid for by the entity responsible for the solvent discharge. A similar process was used by the Regional Board and Kaiser Steel Corporation to mitigate a TDS plume in the north half of the Chino Basin.

TDS and Nitrogen (Salt) Management in the Chino Basin

TDS and nitrogen management will require minimizing TDS and nitrogen additions by fertilizers and dairy wastes, desalting of groundwater in the southern part of the Basin (for water supply purposes), and maximizing the artificial recharge of storm water. The latter two management components are included in Program Elements 3 and 2, respectively

The agricultural area in the southern part of the Chino Basin will gradually convert to urban uses over the next 20 to 30 years and, thus, in the long term, the TDS and nitrogen challenges from irrigated agriculture and dairy waste management will go away. The Regional Board will adopt new dairy waste discharge requirements in the summer of 1999. The requirements will include the following:

- Each dairy will develop and implement an engineered waste management plan that will contain dairy process water and on-dairy precipitation runoff for up to a 25-year, 24-hour storm
- Manure scraped from corrals must be exported from the dairy within 180 days
- All manure stockpiled in the Chino Basin as of December 1, 1999, will be exported from the Basin by December 1, 2001.
- No manure may be disposed of in the Chino Basin
- Some manure can be applied to land at agronomic rates if and only if in the opinion of the Executive Officer there is reasonable progress toward the construction of a new desalter in the Chino Basin.

The Santa Ana River Watershed Group (SARWG) is a stakeholder group made up of municipal, county, regional and federal agencies, and private individuals that are working through complex land use and environmental issues in the Santa Ana Watershed. One of their work products is a draft manure management strategy (MMS) for the Chino Basin. The primary component of MMS is the export of manure either as a raw or an improved material. The MMS describes the economics of manure management and the means to finance manure export.

The new dairy waste discharge requirements may have the unintended result of actually causing Santa Ana River quality to degrade. Some or all of the dairy farmers could move out of the Basin if they cannot afford to continue dairy operations as a result of the new waste discharge requirements. A rapid departure of the dairies will result in a rapid decline in groundwater production in the southern part of the Basin and a subsequent increase in poor quality rising water. The rising groundwater will degrade the river. As part of the OBMP, Watermaster will annually review the economics of dairy waste management in the Chino Basin and may contribute funds to subsidize the removal of manure from the Basin. In the first year of the OBMP implementation, Watermaster will contribute $150,000. Watermaster will closely monitor the activities of the Regional Board, SARWG and others whose actions will influence the amount of TDS and nitrogen entering the Basin.

The urban land use that will replace agriculture will require low TDS municipal supplies that in turn will produce lower TDS irrigation returns to groundwater than those generated by agriculture. The construction of desalters in the southern part of the Basin (as described in Program Elements 3 and 5) will extract and export huge quantities of salt from the Basin. Table 4-9 lists the salt removal capacity of desalters described in Program Elements 3 and 5. By 2020, the salt removal capacity of the desalters will reach over 80,000 tons per year. The dairy salt contribution is currently about 30,000 tons per year. It is premature to set salt reduction goals until the salt budget method described above is developed and the salt budget is assessed for the Basin. However, it seems reasonable to expect that the salt budget will be impacted favorably by the desalters and future land use conversions, and that Watermaster should expect a reduction in salt loading of about 80,000 to 100,000 tons of salt per year in the next 20 to 30 years.

Implementation Actions and Schedule

First Three Years (1999/00 to 2001/02). The following actions will be completed in the first three years commencing fiscal year 1999/00:

- Watermaster will form an ad hoc committee, hereafter *water quality committee*. The purposes of the *water quality committee* are to review water quality conditions in the Basin and to develop (with the Regional Board) cooperative strategies and plans to improve water quality in the Basin. The committee would meet regularly with

Regional Board staff to share information and to recommend cooperative efforts for monitoring groundwater quality and detecting water quality anomalies. The schedule and frequency of meetings will be developed with the Regional Board during the first year of the OBMP implementation.

- Watermaster will refine its monitoring efforts to support the detection and quantification of water quality anomalies. This may require additional budgeting for analytical work and staff/support.
- If necessary, Watermaster will conduct investigations to assist the Regional Board in accomplishing mutually beneficial objectives.
- Watermaster will seek funding from outside sources to accelerate detection and clean up efforts.
- Develop salt budget goals, develop the salt budget method described above and review all the OBMP actions.
- Watermaster will annually review the economics of dairy waste management in the Chino Basin and may contribute funds to subsidize the removal of manure from the Basin. In the first year of the OBMP implementation, Watermaster will contribute $150,000.

At the conclusion of the third year, the *water quality committee* will have met several times, developed and implemented a cooperative monitoring plan with the Regional Board, and developed a priority list and schedule for cleaning up all known water quality anomalies.

Years Four through Fifty (2002/03 to 2050/51). The following actions will be completed in years four through fifty, commencing fiscal year 2002/03:

- Continue monitoring and coordination efforts with the Regional Board.
- Annually update priority list and schedule for cleaning up all known water quality anomalies.
- Continue to seek funding from outside sources to accelerate clean up efforts.
- Implement projects of mutual interest.
- As part of periodic updates of the OBMP, re-compute the salt budget using the salt budget method. The salt budget method would be used to reassess future OBMP actions to ensure that salt management goals are attained.
- Annually review the economics of dairy waste management in the Chino Basin and consider contributing funds to subsidize the removal of manure from the Basin.

PROGRAM ELEMENT 8 – DEVELOP AND IMPLEMENT GROUNDWATER STORAGE MANAGEMENT PROGRAM

PROGRAM ELEMENT 9 – DEVELOP AND IMPLEMENT CONJUNCTIVE USE PROGRAMS

Need and Function

The first impediment to *Goal 1 – Enhance Basin Water Supplies* can be stated as: "Unless certain actions are taken, safe yield of the Basin will be reduced … (because) the current manner in which Watermaster manages cyclic and local storage accounts will cause overdraft." Watermaster is concerned about the magnitude of water lost from the Chino Basin from rising groundwater when groundwater is stored in the local storage, cyclic, conjunctive use and other storage accounts. Watermaster is interested in determining how much water can be stored without significant loss from local accounts and in developing a procedure to equitably distribute these losses among entities that have storage accounts. Watermaster may consider setting limits for individual storage accounts for members of the overlying non-agricultural and appropriative pools that ensure reasonable and beneficial use of Chino Basin water.

The third impediment to *Goal 3 – Enhance Management of the Basin* can be stated as: "About 500,000 acre-ft of storage in the Chino Basin cannot be used due to water quality and institutional issues." The impediment speaks to two issues. The first issue is a concern by the producers of adverse water quality impacts if groundwater storage is significantly (see Section 2) increased. The second issue is the past inability of Watermaster, producers, and MWDSC to be able to agree on a conjunctive use program for the Chino Basin.

Parties to the Judgment can store un-pumped groundwater rights for various reasons that include:

> **Future use during shortage of other less expensive water supplies.** Some parties to the Judgment have access to other sources of water that are less expensive than producing Chino Basin groundwater. The alternative water supplies available to these parties include imported water, local streamflow, and other groundwater basins. By not pumping their Chino Basin rights, they can then store water in the Chino Basin for later use when their other less expensive sources are scarce. This is conjunctive use.
>
> **Exchange or sell to other producers.** Some parties to the Judgment produce less than their rights resulting from decreased demand, groundwater quality problems, or because they have access to other less expensive supplies. The un-pumped water pursuant to the Judgment can be exchanged or sold to other parties to the Judgment.
>
> **Temporary shortfall in production capacity.** Some parties may not be able to use all their rights due to temporary shortfalls in production capacity caused by water quality or mechanical problems. The un-pumped water goes into local storage accounts until production capacity is recovered or increased.

As a means of efficiently managing their available water supply, each appropriative and overlying non-agricultural producer tries to minimize the cost of water from the sources of supply available to that producer. Some producers have multiple sources of supply and some have limited supplies. Some agencies are in a position, because of the sources of supply available to them, to accumulate water in local storage accounts in most years. Conversely, some agencies produce groundwater from the Chino Basin in excess of their rights and cannot make use of local storage accounts except through the purchase or lease of other water. There are two fundamental reasons why storage limits should be considered.

> **Ensure reasonable beneficial use.** The accumulation of water in local storage accounts in quantities that cannot be put to a reasonable beneficial use is in conflict with Section 2 of Article X of the California Constitution. Therefore, if a local storage account maximum storage limit needs to be set, the limit should be based on the producer's ability to put the stored water to reasonable beneficial use.
>
> **Reduce groundwater losses to the Santa Ana River.** The cumulative losses of water from local storage accounts can grow to be large and, thus, the ability to use the stored water to Chino Basin producers is lost. These losses could be minimized by storing water for shorter periods of time prior to use and by limiting the water put into storage accounts to an amount that can be put to reasonable beneficial use.

Estimate of the Water Lost from Storage

The accumulation of groundwater in storage without an increase in groundwater production will cause the baseflow to increase in the Santa Ana River and some of its tributaries (Chino Creek and Mill Creek). Investigations conducted by Watermaster in 1995 concluded that losses from water in local storage accounts and cyclic storage are about two percent per year of the water in storage. These losses could reach over four percent in the future if groundwater production patterns are not managed in the southern part of the Basin. Exhibit A in the Program Element 8 Task Memorandum (on file and available from the Watermaster offices) shows the estimated losses from each local storage account, the cyclic storage account, and the Basin as a whole for the 20-year post-Judgment period of 1978 to 1997. The total water lost from local storage accounts and cyclic storage for the 20-year period of 1978 through 1997 is about 50,500 acre-ft. If the water in these storage accounts is produced without accounting for the losses then the Basin will be overdrafted by an amount equal to the water lost from storage.

Storage Limit Concepts

Currently there is no existing aggregate limit for local storage accounts. Watermaster's Uniform Groundwater Rules and Regulations (UGRR) contains an aggregate threshold storage value of 100,000 acre-ft above which losses to rising water are to be computed and allocated to the storage parties on a pro rata basis. The UGRR does not specify whether the loss is to be computed for the increment of storage above 100,000 acre-ft or total storage. The 100,000 acre-ft threshold value is an arbitrary number. Some loss will occur when water is placed into local storage. Using 100,000 acre-ft as a threshold value ensures that up to 2,000 acre-ft/yr of unaccounted-for-losses from storage will occur every year. This water will not be in the Basin when the storage parties attempt to recover the stored water. If losses are not accounted for, then the Basin is not being operated in the safe yield mode as required by the Judgment. Therefore, regardless of how storage limits are set, Watermaster should deduct the rising water losses from planned storage for all local storage accounts and for the storage accounts of non-Judgment parties. There are several different ways to develop upper limits on the individual local storage accounts. Some of these are described below.

Limit based on the ability to use. In this concept, an upper limit is based on the storage party's ability to store and recover all the water in its account over a fixed period, say five years. The storage party would have to demonstrate that it has enough production capacity to recover all the water in storage over a five-year period. The fixed period would be the same for all storage parties. In this concept, each storage party would have to demonstrate to Watermaster that they have the ability to put a specific volume of water into storage and be able to recover that water, adjusted for losses, over a fixed period of time. Thus, the storage party will have the facilities in place for groundwater production. This type of limit ensures that the water is put to a reasonable beneficial use. For example, suppose an agency has Chino Basin production capacity of 25,000 acre-ft/year, an operating yield of 15,000 acre-ft/yr and the fixed period has been set at five years. Then they would be allowed to put 50,000 acre-ft into its local storage account. If an agency were to increase its Chino Basin production capacity then its local storage account limit could be increased by an amount equal to five times the increase in production capacity. The five-year period used above is arbitrary – Watermaster would need to determine the length of the fixed period.

Arbitrary limits. In discussions regarding storage limits in prior years, Watermaster considered setting storage limits based on a multiple of safe yield for overlying non-agricultural pool and a multiple of operating safe yield for the appropriative pool. Parties that have historically over-produced and that will continue to over-produce may not ever be able to use such a local storage account. Parties that under-produce will fill their accounts and may hold water in these accounts for long periods of time and incur large storage losses. This has been the trend with the past operation of the local storage accounts. Upper limits based on this concept are arbitrary and may not provide for reasonable beneficial use of Chino Basin water. Storage limits based on a multiple of prior years production, an arbitrary volume equal for all parties, or any other arbitrary volume suffer from the same limitations.

Limit based on time water is in storage. In this concept, no volume limit would be set. Water could not be kept in storage for more than some fixed period of time, say ten years, regardless of the amount of water in storage. Water transferred from the local storage account for use by the storage party would be taken from the earliest water put into the local storage account. The storage party would be required to recover a volume of groundwater from its local storage account, sell or transfer a similar volume to another party, or sell a similar volume to Watermaster in order to reduce the quantity in its storage account by an amount equal to the water stored prior to the fixed period less losses to rising water. Simply stated, unused water from the first year would either be used or sold to Watermaster or other producer in the eleventh year, unused water from the second year would either be used or sold in the twelfth year, and so on if a ten year time limit is used.

Upper limit based on total storage and time water is in storage. This is a composite of the *ability to use* and *time in storage* concepts. In this case a volumetric upper limit would be set for each storage party based on the storage party's ability to store and recover water over a fixed period of time. A time constraint would be added such that water would not be kept in storage more than some fixed period of time.

In all the above storage limit concepts, the storage parties would sell their current year under-production to Watermaster or other parties to the Judgment each year that their local storage accounts are full. Watermaster, or parties to the Judgment, would then use this water to meet current replenishment obligations.

Implementation of Local Storage Account Limits

Watermaster's UGRR presently require an *initial determination of local storage requirements to be made*. Watermaster then allocates this storage to members of the appropriative and overlying non-agricultural pools when specific parties make an application for a local storage agreement. Watermaster must periodically review the status of the local storage accounts and adjust the local storage requirement as described in the UGRR. While not explicitly described in the Judgment or UGRR, local storage account limits based on the *ability to use*, *time in storage,* or a composite of the two, are consistent with the Judgment and could be implemented with some changes in the UGRR.

Local storage account limits based on the *ability to use* require that each agency make a determination of their Chino Basin groundwater production capacity and submit that finding to Watermaster. Watermaster would determine the duration over which the volume in local storage accounts would be used. Storage account limits for each storage party would be computed as:

Storage Limit = duration of storage period * (Chino Basin production capacity
– average operating yield)

The average operating yield would equal the average of previous years operating yield entitlements (*e.g.*, five year average). Watermaster could periodically, or upon petition by a storage party, review and adjust the storage limits.

Local storage account limits based on the *time in storage* require that Watermaster determine the time-in-storage limit. Watermaster could then go through production and local storage account records to determine if water must be either used or sold to Watermaster. Local storage account limits based on the composite of the *ability to use* and *time in storage* require the implementation steps described for both concepts.

Some storage parties may currently have more water in their local storage accounts than would be allowed in the storage limit concepts listed above. In this case, the storage party would not be allowed to put water into their local storage accounts and under-production would be purchased by Watermaster.

If, as a result of these storage limits, Watermaster is required to purchase more water than is required for replenishment, then either the storage party will be allowed to temporarily store additional water in its local storage account or Watermaster payments for that water may have to be temporarily deferred.

Water in local storage accounts is used for replenishment of overdraft either by the producer's that hold a local storage account, or is sold to other producers with replenishment obligations. It is possible that Watermaster could fulfill all replenishment obligations exclusively from local storage accounts for several years. Watermaster should fulfill the need for replenishment from increased production with imported water for those areas that have a critical need for imported water and use the water stored in local storage accounts for the rest of the replenishment obligation.

Storage Management Program

Since 1995, the producers have developed numerous storage management proposals. This storage management program described here was developed in April and May of 1999 and differs from the previous proposals that sought to assign all the readily-useful storage in the Basin up among producers. If successfully implemented, storage limits on individual storage accounts may not need to be considered by Watermaster. The proposal described herein will allow:

- Watermaster to develop conjunctive use programs that will benefit all the producers in the Basin;
- ensure that Basin water and storage are put to maximum beneficial use; and
- maintain the integrity of the Judgment.

Definitions. *Operational Storage Requirement* – The operational storage requirement is the storage or volume in the Chino Basin that is necessary to maintain safe yield. In the context of this storage management program, the operational storage is estimated to be about 5,300,000 acre-ft. An engineering analysis will be done to assess the operational storage requirement of the Basin as part of the implementation of this program.

Safe Storage – Safe storage is an estimate of the maximum storage in the Basin that will not cause significant water quality and high groundwater-related problems. In the context of this storage management program, the safe storage is estimated to be about 5,800,000 acre-ft. An engineering analysis will be done to assess the safe storage requirement of the Basin as part of the implementation this plan.

Safe Storage Capacity – The safe storage capacity is the difference between safe storage and operational storage requirement and is the storage that could be safely used by producers and Watermaster for storage programs. Based on the above, the safe storage capacity is about 500,000 acre-ft. The allocation and use of storage in excess of safe storage will preemptively require mitigation, that is, mitigation must be defined and resources committed to mitigation prior to allocation and use.

Key Elements

- No maximum storage limit will be placed on local storage accounts for a period of five years ending on June 30, 2004, and water that becomes eligible for storage can be stored.
- The need for storage limits will be re-evaluated in five years based on the ability of the storing party to use the water in storage (ability to use concept) and on Watermaster's need for storage programs that provide regional benefits.
- Storage is not assignable.
- All water in local storage and other storage accounts will incur losses at a rate of 2 percent of water in storage each year starting in fiscal year 2002/03.
- The storage loss rate and safe yield will be estimated in the year 2012/13 and every ten years thereafter.
- Watermaster will develop regional conjunctive-use programs to store supplemental water for MWDSC and other entities that can cause supplemental water to be stored in the Basin.
- The regional conjunctive-use programs will provide benefits to all producers in the Basin, the people of California and the nation. Watermaster's conjunctive-use programs will take priority over conjunctive-use programs developed by others.
- Storage committed to conjunctive-use programs may consist of two parts, storage within the safe storage capacity and storage in excess of safe storage. Storage in excess of safe storage capacity will preemptively require mitigation.
- The initial target storage for Watermaster's conjunctive-use program will be 150,000 to 300,000 acre-ft within the safe storage capacity.
- Cyclic storage will be folded into conjunctive-use storage.
- Watermaster's conjunctive-use program tentatively consists of the following elements:
  - complete the existing short term conjunctive-use project;
  - seasonal peaking program for in Basin use and dry year program to reduce the demand on Metropolitan to 10 percent of normal summer demand (requiring 150,000 acre-ft of storage);
  - dry-year export program; and
  - seasonal peaking export program.

Re-determination of Safe Yield and Storage Loss Rates. The safe yield and storage loss rate will be assessed every ten years starting in the year 2012/13. The ten-year period of 2002/03 to 2011/12 will be used to compute the safe yield and to estimate the storage loss rate.

Safe yield and storage loss rate determinations require accurate groundwater level and production data. Watermaster does not have accurate production data from agricultural producers. Watermaster estimates most of the production in the agricultural pool using a water duty method that does not meet the requirements of the Judgment. Program Element 1 of the OBMP includes a program to install meters and obtain production measurements from all wells in the Basin. It will take three years to fully meter all agricultural wells. Watermaster will have accurate production monitoring at all wells starting in year

2002/03. Watermaster is in the process of developing a groundwater level monitoring program for the Basin. This plan should be implemented in the year 1999/00.

The safe yield in the Judgment was developed over the period 1965 to 1974 using the procedure described in Section 2 of the OBMP report. The safe yield will be re-determined in year 2012/13 using the ten-year period 2002/03 to 2011/12 because it will contain accurate production data and groundwater level data. A ten-year period is proposed to be consistent with the method used in the engineering work for the Judgment and is the minimum necessary to estimate a safe yield.

Re-determination of the storage loss rate will require the use of a numerical flow model. The *RAM Tool* developed by Watermaster will be modified and used for this purpose. The model would be used as follows:

- Calibrate the RAM tool for the safe yield period. In the calibration process, the hydrology for the period 2002/03 to 2011/12 will be developed including deep percolation of applied water and precipitation, unmeasured storm water recharge, subsurface inflow from adjacent basins, and uncontrolled discharges from the Basin (rising water).
- Once calibrated, the water supply plans of the producers and other storage entities will be modified to assume that no water would be put into storage accounts. The model will be rerun with this assumption and the results would be compared to the calibration run to determine losses from storage and the storage loss rate.
- The storage loss rate would be set based on the relationship of water in storage and associated losses.

Watermaster's new groundwater level and production monitoring are crucial to this effort.

Implementation Actions and Schedule

First Three Years (1999/00 to 2001/02). The following actions will be completed in the first three years commencing fiscal year 1999/00:

- Receive Court approval of OBMP.
- Evaluate need to modify Watermaster UGRR to reflect the storage management plan.
- Determine the operational storage requirement and safe storage.
- Begin formal implementation of comprehensive monitoring programs described in Program Element 1 (including groundwater level, groundwater quality, production, and surface water monitoring in the Santa Ana River).
- Complete the existing short-term conjunctive-use pilot project with MWDSC.
- Conduct engineering and environmental analyses, other feasibility efforts, and negotiate agreements to:
- implement a conjunctive-use program that includes seasonal peaking for in Basin use and dry year program to reduce the demand on MWDSC to 10 percent of normal summer in-Basin demand (requiring 150,000 acre-ft of storage);
- implement a conjunctive-use program for dry-year export; and
- implement a seasonal peaking program for export.

Years Four through Ten (2002/03 to 2008/09). The following actions will be completed in years four through ten, commencing fiscal year 2002/03:

- Continue monitoring as described in Program Element 1.
- Begin construction of facilities to implement the conjunctive-use projects listed in *years one through three*, in year 2003/04.
- Commence conjunctive-use operations.
- Start assessing losses in year 2002/03.

Years Eleven through Fifty (2009/10 to 2048/49). The following actions will be completed in years eleven through fifty, commencing fiscal year 2009/10:

- Continue monitoring as described in Program Element 1.
- Continue conjunctive-use operations.
- In year 2012/13, compute safe yield and storage loss rate for period 2002/03 through 2011/12, and reset safe yield and storage loss rates for the next the next ten-year period 2012/13 to 2021/22. Reassess storage management plan and modify Watermaster UGRR, if needed.
- In year 2022/23, compute safe yield and storage loss rate for period 2012/13 through 2021/22, and reset safe yield and storage loss rates for the next the next ten-year period 2022/23 to 2031/32. Reassess storage management plan and modify Watermaster UGRR, if needed.
- In year 2032/33, compute safe yield and storage loss rate for period 2022/23 through 2031/32, and reset safe yield and storage loss rates for the next the next ten-year period 2042/43 to 2041/42. Reassess storage management plan and modify Watermaster UGRR, if needed.
- In year 2042/43, compute safe yield and storage loss rate for period 2032/33 through 2041/42, and reset safe yield and storage loss rates for the next the next ten-year period 2052/53 to 2051/52. Reassess storage management plan and modify Watermaster UGRR, if needed.

PROGRAM COST AND EARLY IMPLEMENTATION PLAN

Table 4-14 contains a 20-year cost projection for implementation of the OBMP. The 20-year cost of OBMP implementation is about $400,000,000. The following program elements will be implemented entirely by Watermaster:

- Program Element 1 – Develop and Implement Comprehensive Monitoring Program
- Program Element 4 – Develop and Implement Comprehensive Groundwater Management Plan for Management Zone 1
- Program Element 6 – Develop and Implement Cooperative Programs with the Regional Water Quality Control Board, Santa Ana Region (Regional Board) and Other Agencies to Improve Basin Management
- Program Element 7 – Develop and Implement Salt Management Program
- Program Element 8 – Develop and Implement Groundwater Storage Management Program

Watermaster has committed to fund these program elements in their entirety through Watermaster assessments and through grants obtained directly by Watermaster. The Watermaster budget for fiscal 1999-2000 provides funding necessary to begin the efforts described in these program elements. The cost of the first three years is about $2,900,000 and average annual cost for the next 20 years is about $480,000.

The following program elements will be started by Watermaster in fiscal 1999-2000 and will be completed by others by agreement with Watermaster:

- Program Element 2 – Develop and Implement Comprehensive Recharge Program
- Program Element 3 – Develop and Implement Water Supply Plan for the Impaired Areas of the Basin
- Program Element 5 – Develop and Implement Regional Supplemental Water Program

The Watermaster budget for fiscal 1999-2000 provides funding necessary to begin the planning processes for these program elements. For Program Element 2, Watermaster's projected budget includes funds for completion of Phases 2 and 3 of the recharge master plan of $430,000 to be spent in the first three years of OBMP implementation. For Program Elements 3 and 5, the Watermaster budget contains funds to start the planning process and to define the scope of the facilities at enough detail so that agreements can be done for others to build and operate the facilities required in these program elements. Watermaster has budgeted about $650,000 for this process over the first three years of OBMP implementation. These agreements will be described in Part 2 of the OBMP report documents.

The Watermaster budget includes funds to begin the planning process for Program Element 9 – Develop and Implement Conjunctive-Use Programs. Watermaster has budgeted about $430,000 for this process over the first three years of OBMP implementation. The stakeholders envision that the cost of conjunctive use will be borne by outside interests that will store water in the Chino Basin.

OBMP PROGRESS REPORTS AND PROGRAM UPDATES

Watermaster will report progress on the OBMP in its annual report to the Court. Watermaster will formally review and update the OBMP at a frequency of five years or less.

LEGAL QUESTIONS AND ISSUES

The Judgment prescribes the process by which the Watermaster Board receives recommendations from the producers and is empowered to make decisions. To address the unresolved legal questions and issues identified below, the items will be brought to the individual pool committees for discussion and consideration. The pools in turn will develop their positions and recommendations for discussion and consideration by the Advisory Committee. The Advisory Committee will meet to discuss and consider the questions. The Advisory Committee's recommendations will be forwarded to the Watermaster Board for its consideration and implementation. Should the Watermaster Board disagree with the Advisory Committee recommendation, it has several options based on the Judgment and past practice. These options are:

If the Advisory Committee vote is equal to or greater than 80 percent:

1. Ask the Advisory Committee to reconsider the question based on a Board recommendation.

2. If the Advisory Committee does not wish to reconsider the matter, the Watermaster Board may ask the Court to consider the matter.

If the Advisory Committee vote is less than 80 percent:

1. Hold a hearing on the matter and develop written findings and conclusions.

During implementation of the OBMP, all unresolved legal questions and issues listed below will be addressed through the process described above. A schedule to address these items will be developed, and Watermaster will prepare written findings and conclusions to be submitted to the Court as part of the implementation process. This will be done regardless of the Advisory Committee vote or Watermaster findings and conclusions in an effort to more effectively keep the Court apprised of the OBMP implementation progress.

Watermaster recommends this manner of addressing legal questions and issues pursuant to the Judgment and in keeping with the Plaintiff's Post Trial Memorandum filed with the Court on July 12, 1978. At 4:13-20 in Paragraph B. 2. Watermaster Organization and Powers, of the Post Trial Memorandum it states:

> "At the same time, the Watermaster Advisory Committee was created and given broad powers to review, advise and consent to the actions of the Watermaster, subject to more detailed actions by the pool committees formed to advise, consent and administer the affairs of the several pools established under the Physical Solution. In these many provisions, there is a balance created to assure the protection of the private rights of the parties and the general public interest in the preservation of the resource. (emphasis added)."

The process described above will be used to address the legal questions and issues listed below.

- Transfers of water within and from the overlying non-agricultural pool
- Clarification and/or expansion of definitions of types of water in Judgment
- Evaluation of Judgment provisions and rules and regulations affected by the OBMP

These questions and issues will be resolved in the first three years of the OBMP implementation.

REFERENCES

BDM International. Inc. 1997. Phase II Off-Site Groundwater Investigation Progress Report. General Electric Aircraft Engines. West Coast Operations. Volume I.

Battaglin, W. A., C. Kendall, D. A. Goolsby, and L. Boyer. 1997. Plan of study to determine if the isotopic rations of $d^{15}N$ and $d^{18}O$ can reveal the sources of nitrate discharged by the Mississippi River into the Gulf of Mexico. US Geological Survey Open-File Report 97-230.

California Regional Water Quality Control Board, Santa Ana Region. 1990. Cleanup and Abatement Order No. 90-134 for County of San Bernardino, Department of Airports. Chino Airport.

California Regional Water Quality Control Board, Santa Ana Region. 1992. Waste Discharge Requirements and Producer/User Water Reclamation Requirements for Chino Basin Municipal Water District Regional Plant No. 3, Fontana, San Bernardino County. Order No. 92-61, NPDES No. CA8000205.

Carroll, W. J. 1977. Superior Court of California for the County of San Bernardino, "Chino Basin Municipal Water District *vs*. City of Chino, *et al*.," Case No. 164327, Reporter's Transcripts of Proceedings, December, 1977.

City of Upland, Public Works Department, Environmental Division. 1998. Waste Discharge Orders and Monitoring and Reporting Programs, Order 88-77, 93-57, 94-17.

Clark, I. and P. Fritz. 1997. Environmental Isotopes in Hydrogeology. Lewis Publishers/CRC Press. New York.

Dames & Moore. 1996. Data Transmittal Report, 18th Round, Quarterly Groundwater Monitoring Program, Remedial Investigation, General Electric Test Cell Facility. Ontario, California. Job No. 28171-204-112.

Freeze R. A. and J. A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. New Jersey.

GeoLogic Associates. 1997. Engineering Feasibility Study, Upland Landfill, City of Upland. Job No. 9767.

GeoLogic Associates. 1998. Phase II Evaluation Monitoring Program Report, Technical Report and Appendices, Milliken Sanitary Landfill. County of San Bernardino.

Geomatrix Consultants, Inc. 1996. Addendum to Work Plan for Phase III Groundwater Assessment, CIM, Chino. Geomatrix Project No.: S2064.04.

Geomatrix Consultants, Inc. 1997. Quarterly Groundwater Monitoring Report, Calendar Quarter October-December 1997. Project No. 1796.09 AH.

IT Corporation. 1989. Final Report, Solid Waste Assessment Test, Milliken Sanitary Landfill. San Bernardino County.

James M. Montgomery, Consulting Engineers, Inc. 1991. Nitrogen and TDS Studies, Santa Ana Watershed.

Mark J. Wildermuth Water Resources Engineer. 1991. Phase IV Groundwater Remediation Feasibility Study.

Mendenhall, W. C. 1905. The Hydrology of San Bernardino Valley, California: USGS Water Supply Paper 142, 124p.

Mendenhall, W. C. 1908. Ground waters and irrigation enterprises in the foothill belt, southern California: USGS Water Supply 219.

Metropolitan Water District of Southern California. 1988. Chino Basin Groundwater Storage Program – Draft Environmental Impact Report. Report Number 975. June 1988.

Montgomery Watson. 1993. Task 6 Memorandum, Development of a Three-Dimensional Groundwater Model. Prepared for Santa Ana Watershed Project Authority.

Montgomery Watson. 1994. Final Task 6 Memorandum, Development of a Three-Dimensional Groundwater Model. Prepared for Santa Ana Watershed Project Authority.

Montgomery Watson. 1995. Chino Basin Water Resources Management Study.

Oak Ridge National Laboratory. 1989. The Installation Restoration Program Toxicology Guide. Prepared for Harry G. Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base. Under DOE Interagency Agreement No. 1891-A076-A1.

Wildermuth, M. J. 1993. Letter report to Montgomery Watson regarding the Combined Well Field for the Chino Basin Desalter. September 21, 1993.

Wildermuth, M. J. 1993. Letter to Neil Cline, dated August 9, 1993.