MOJAVE WATER AGENCY

2004 REGIONAL WATER MANAGEMENT PLAN

INTEGRATED REGIONAL WATER MANAGEMENT PLAN
GROUNDWATER MANAGEMENT PLAN
URBAN WATER MANAGEMENT PLAN

Mojave Water Agency

VOLUME 1:
REPORT

Schlumberger Water Services

September 2004
Adopted February 24, 2005

TABLE OF CONTENTS

VOLUME 1: REPORT

FIGURES

FIGURES

VOLUME 2: APPENDICIES

Appendicies:

Appendix A	Judgment After Trial January 10, 1996, Mojave Basin Area Adjudication
Appendix B	Technical Memo 3
Appendix C	Water Demand Estimation
Appendix D	Issues Questionnaire, Summary of Responses to the Issues Questionnaire
Appendix E	Technical Advisory Committee to the Mojave Water Agency Minutes
Appendix F	*The Panorama* –A newsletter published by the Mojave Water Agency
Appendix G	Resolution approving the Mojave Water Agency 2004 Regional Water Management Plan
Appendix H	Existing Monitoring Protocols
Appendix I	Well Construction Data from MWA Well Database
Appendix J	AB 3030 – Groundwater Management Planning SB 1938 – Groundwater Management and State Funding California Urban Water Management Planning Act Proposition 50 - Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002

1

INTRODUCTION

The Mojave Water Agency (MWA) was formed in 1959 by an act of the California Legislature and was activated by a vote of the residents in 1960 to manage declining groundwater levels in the Mojave Basin Area, Lucerne Valley and El Mirage Basin. The Morongo Basin and Johnson Valley areas were annexed in 1965. MWA covers over 4,900 square miles, a hydrologically diverse region that has a unique set of water management issues. Over the last decade, much has been accomplished toward the development and implementation of a comprehensive water resources plan to address these issues. Key accomplishments and events of recent years include:

1. The 1993 Stipulated Judgment, 1996 Judgment After Trial and several court decisions that have followed
2. Adoption of the 1994 Regional Water Management Plan
3. Construction of a number of key facilities including the Morongo Basin Pipeline, Rock Springs Outlet, Hi-Desert Water District recharge facilities, Mojave River Pipeline and the Hodge, Lenwood and Dagget recharge facilities
4. Purchase of an additional 25,000 acre-feet of supply from the State Water Project
5. Completion of several studies by USGS including the report entitled "Simulation of Ground-Water Flow in the Mojave River Basin"

Essentially all water supplies within MWA are pumped from the local groundwater basins and groundwater levels generally have been declining for the past 50 years or more. Adjudication proceedings were initiated due to concerns that rapid population growth would lead to further overdraft. The resulting Warren Valley Basin Judgment and the Mojave Basin Area Judgment both require that additional surface water be imported to help balance the basins.

MWA has an annual contract for up to 75,800 acre-feet of water from the State Water Project (SWP) although due to variability in deliveries of SWP water, the average annual supply available to MWA is currently estimated to be 58,400 acre-feet. In order to balance the basin by the year 2020, it will be necessary for MWA to utilize its full SWP supply. Construction of projects by MWA within its service area is necessary to build, operate, maintain and replace the State Water Project facilities to which MWA is contractually obligated. These projects are necessary to fulfill MWA's contractual obligations with the State of California and to insure water availability to all of its residents.

Purpose

MWA first prepared a Regional Water Management Plan in 1994 (Bookman-Edmonston Engineering, Inc. 1994). Since that time, several developments have prompted MWA to prepare a plan update. These developments include advancements in the basin adjudication process, a more refined understanding of the hydrology and hydrogeology of the service area, population increases, shifts in agricultural and urban water demands, and the growing realization that the Mojave region can be a strategic element in the long-term management of California's water supplies. The Mojave Groundwater Basin is located along the California Aqueduct and has nearly two million acre-feet of available storage, which could make the region a strategic player in solving state-wide water storage and conjunctive use problems while addressing its internal water resources needs. Recent additions to California law promote development of integrated water resource management plans and groundwater management plans by providing preference to agencies with such plans for funding through state grant programs. **This Plan serves as an Integrated Regional Water Management Plan, Groundwater Management Plan and Urban Water Management Plan and meets the requirements of SB 221, SB 610, SB 1938 and AB 901.**

The RWMP was supported through a March 22, 2001 Memorandum of Understanding (MOU) with the DWR Integrated Storage Investigation which requires a "Basin Advisory Panel" of local civic and technical leaders and other stakeholders. This update was prepared in three phases with input from a Technical Advisory Committee (TAC) convened as the advisory panel. Objectives were: 1) to review and revise, as necessary, previous estimates of water supply and demand, 2) identify and solicit input from stakeholders with interest in long-term reliable water supplies for the region, and 3) identify a suite of preliminary alternatives that will help MWA achieve its goals in water supply management for the next two decades. Proposed projects and management actions are tailored to address at least one key water management issue in the basin.

The following six key water management issues emerged as a result of this process:

- Current demand exceeds supply; future demand will also exceed supply unless corrective actions are taken
- Naturally occurring water quality problems affect drinking water supplies
- Many of the groundwater basins are in overdraft
- All but two of the subareas have riparian ecosystem maintenance issues

- Wastewater infrastructure issues affect the two subareas with the largest water demands
- Many subareas within MWA are impacted by activities in other subareas

Fundamental objectives established with the input of the TAC are to: 1) balance future water demands with available supplies and, 2) maximize the overall beneficial use of water throughout MWA. To compare expected performance of alternative combinations of projects and management alternatives, a screening model was developed. The screening model simulates the changes to groundwater hydrology, Mojave River flows, and pumping and return flows that would result from implementation of the identified projects and management actions. Each alternative was evaluated and ranked according to its effectiveness in meeting the long-term needs of the basin.

This draft Regional Water Management Plan incorporates the highest-ranking alternatives. The draft will undergo an environmental review and the MWA Board of Directors will adopt a final Plan. This Plan provides MWA with long-term direction for management and development of resources and describes MWA's resource management and development strategy through the year 2020. The Plan concludes with 60 Management Actions. Chapters of the Plan are summarized below.

Chapter 2, Agency and Stakeholder Background, describes the MWA and the adjudications of the Mojave Basin Area and Morongo Basin/Johnson Valley Area. The previous 1994 Regional Water Management Plan is summarized and the major stakeholders are identified.

Chapter 3, Physical Setting, describes geography, geology, groundwater conditions, aquifers, groundwater basins, water districts, surface water resources, climate, and wastewater systems.

Chapter 4, Water Supply, provides a detailed description of natural and imported water supplies and their variability within the MWA.

Chapter 5, Water Demand, describes current and projected future water demand in the Mojave Basin Area and Morongo Basin/Johnson Valley Area. Water balances for the year 2020 are presented for two different agricultural demand scenarios, including single dry year and multiple dry year scenarios.

Chapter 6, Water Shortage Contingency Planning, summarizes water shortage contingency plans of MWA and service area water purveyors.

Chapter 7, Water Conservation and Demand Management Measures, provides an overview of water conservation plans and practices of the MWA, cities, water agencies and other groups in the MWA service area.

Chapter 8, Stakeholder Assessment and Public Outreach, describes the public outreach efforts taken by the MWA during the development of this Plan and summaries water management issues of stakeholders in the MWA service area.

Chapter 9, Basin Management Objectives and Alternatives, describes the development of Basin Management Objectives and performance measures developed with the Technical Advisory Committee, a description of supply enhancement projects, and the development and evaluation of alternatives.

Chapter 10, Management Actions, contains 60 actions for implementation of the Plan.

Integrated Water Management Plan

California Water Code Section 79562.5 (b) states that DWR shall establish standards that address, at a minimum "the major water related objectives and conflicts of the watersheds in the region covered by the plan, including water supply, groundwater management, ecosystem restoration, and water quality elements." While specific standards for Integrated Regional Water Management Plans have not yet been developed, this Plan was developed to address all four Integrated Regional Water Management Plan elements identified in the Water Code.

MWA has developed this Regional Water Management Plan through a comprehensive systems approach. The Plan integrates components related to groundwater management, urban water management, agricultural water use, environmental habitat protection and restoration, water quality, and stakeholder and public outreach. The Plan meets requirements of the Urban Water Management Planning Act and requirements for Groundwater Management Plans pursuant to the Water Code and components recommended by DWR as elaborated below.

Urban Water Management Plan

This Regional Water Management Plan was prepared for the MWA in order to comply with 2003 California Urban Water Management Act requirements including amendments made by Senate Bill 610 and Assembly Bill 901. The California Urban Water Management Planning Act (Division 6 Part 2.6 of the Water Code) requires water suppliers with over 3,000 customers or that supply over 3,000 acre-feet of water annually to prepare Urban Water Management Plans (UWMP). MWA does not supply water directly, but holds the State Water Project contract and imports water to replenish groundwater basins and to meet obligations of the Mojave Basin Area and Warren Valley judgments. Seven water supply agencies within the MWA have developed UWMPs. The checklist at the end of this chapter indicates where in this Plan specific UWMP components are located.

Groundwater Management Plan

This Plan contains components included in California Water Code Sections 10750-10753.10 related to Groundwater Management Plans. The California State Legislature passed Assembly Bill 3030 (AB 3030) during the 1992 legislative session allowing local agencies to develop Groundwater Management Plans. The legislation declares that groundwater is a valuable resource that should be carefully managed to ensure its safe production and quality. The legislation also encourages local agencies to work cooperatively to manage groundwater resources within their jurisdiction. Senate Bill 1938 was passed by the Legislature September 16, 2002 and made changes and additions to sections of the Water Code created by AB 3030. This Plan addresses all the relevant components related to Groundwater Management Plans in the Water Code, as well as the components recommended by DWR in *California's Groundwater*, Bulletin 118 (DWR, 2003).

The Water Code sections related to Groundwater Management Plans apply to all groundwater basins identified in the California Department of Water Resources (DWR) Bulletin 118 (DWR, 1980), except those basins already subject to groundwater management by a local agency or a watermaster unless approved by the watermaster. The MWA overlies several groundwater basins (see Chapter 3), as defined by DWR in Bulletin 118. Nothing in this Plan supercedes the Mojave Basin or Warren Valley Basin adjudications. The checklist at the end of this chapter indicates where in this Plan specific Groundwater Management Plan components are located.

Public Outreach

Significant public outreach efforts were made during development of this Plan. These efforts involved evaluation of questionnaires and holding meetings with individuals, groups and a Technical Advisory Committee. Outreach efforts were directed at stakeholders from local water agencies, state and federal agencies, municipalities, San Bernardino County, and 13 local community groups. Lists of stakeholders are included in Chapter 2 of this Plan. Stakeholder assessment and public outreach efforts are discussed in Chapter 8.

Interrelation of Plan Elements

There is overlap in the requirements of Integrated Regional Water Management Plans, Urban Water Management Plans and Groundwater Management Plans. New laws now require UWMPs of water suppliers that utilize groundwater (all urban suppliers in MWA use groundwater) to include a description of the groundwater basin and location and amounts of groundwater pumped. Plan elements specific to Integrated Regional Water Management Plans, Urban Water Management Plans and Groundwater Management Plans are located throughout this Plan, placed in chapters according to general subject.

Checklists

Three checklists are contained on the following pages. The first relates to Integrated Regional Water Management Plans, the second relates to Urban Water Management Plans and the third relates to Groundwater Management Plans. The checklists contain a summary of Water Code elements to be addressed, section numbers of the Water Code where the requirement can be found, and the location in this Plan where the subject is addessed. Copies of the relevant Water Code sections are included in Appendix J.

Integrated Regional Water Management

Plan Checklist

Items to Address	Section of Law	Location in Plan
Water related objectives and conflicts	79562.5(b)	Chapter 9
Water supply	79562.5(b)	Chapter 4
Groundwater management	79562.5(b)	Chapter 10
Ecosystem Restoration	79562.5(b)	Chapter 10
Water quality	79562.5(b)	Chapter 10

Urban Water Management Plan Checklist

Checklist Organized According to Subject

Items to Address	Section of Law	Location in Plan
Public and Stakeholder Outreach		
Make plan available for public inspection before its adoption.	10642	Chapter 8 Appendix F
Adopt plan as prepared or as modified after the public hearing.		Appendix G
Coordinate the preparation of its plan with other appropriate agencies, including direct and indirect suppliers, wastewater, groundwater, and planning agencies (refer to Section 10633).	10620 (d) (2)	Pg. 2 - 8
Demand, Supply, Reliability and Contingency Planning		
Provide current and projected population in 5-year increments to 20 years.	10631 (a)	Table 5 - 20
Describe the climate and demographic factors.		Pg. 3 - 25
Identify and quantify the existing and planned sources of water available in 5-year increments to 20 years	10631 (b)	Table 4 - 9
Describe opportunities for exchanges or transfers of water on short-term or long-term basis.	10631 (d)	Pg. 4 - 36
Quantify current and past water use in 5-year increments to 20 years.	10631 (e) (1)	Pg. 5 - 21
Identify projected water uses among water use sectors in 5-year increments to 20 years.	10631 (e) (2)	Pg. 5 - 21
Describe average, single dry and multiple dry water year data.	10631 (c)	Tables 4 - 3, Pg. 4 - 4
Describe any plans to replace inconsistent water sources.		Pg. 4 - 30
Provide minimum water supply estimates based on driest three-year historic sequence.	10632 (b)	Table 4 - 4
Describe the reliability of water supply.	10631 (c)	Pg. 4 - 30
Describe the vulnerability of water supply to seasonal or climatic shortage.		Pg. 4 - 30
Provide an assessment of the reliability of the water supplier's water service to its customers during normal, single dry, and multiple dry water years.	10635 (a)	Pg. 4 - 17
Compare the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in 5-year increments (refer to 10631 (c)).		Table 5 - 15

Items to Address	Section of Law	Location in Plan
Compare normal, single dry, and multiple dry water year projected water supply sources available to the water supplier with the normal, single dry, multiple dry water year projected water uses (refer to 10631 (c)).		Table 5 - 14
Provide actions a water supplier will take to prepare for a catastrophe.	10632 (c)	Chapter 6
Provide a copy of a draft water shortage contingency resolution or ordinance	10632 (h)	
Provide water shortage stages of action, including up to a 50 percent reduction outlining specific water supply conditions at each stage.	10632 (a)	Chapter 6
Provide mandatory prohibitions.	10632 (d)	Chapter 6
Provide penalties or charges.	10632 (f)	Chapter 6
Provide consumption reduction methods	10632 (e)	Chapter 6
Provide an analysis of the impacts on the water supplier revenues and expenditures	10632 (g)	Chapter 6
Provide measures to overcome revenue and expenditure impacts.		Chapter 6
Provide a mechanism for determining actual reductions in water use.	10632 (i)	Chapter 6

Wastewater and Reclamation

Describe the wastewater collection and treatment systems in the supplier's service area.	10633 (a)	Pg. 3 - 25
Quantify the amount of wastewater collected and treated in the supplier's service area.		Pg. 3 - 27
Describe the methods of wastewater disposal in the supplier's service area.		Pg. 3 - 25
Describe the type, place, and quantity of recycled water currently used in the supplier's service area.	10633 (b)	Pg. 3 - 25
Describe and quantify potential uses of recycled water in 5-year increments to 20 years.	10633 (c) (d)	Table 3 - 4
Describe the technical and economic feasibility of serving the potential users of recycled water.		Pg. 3 - 27
Describe the actions that may be taken to encourage recycled water use.	10633 (e)	Pg. 3 - 25
Provide the projected acre-feet results of recycled water used per year.	10633 (e)	Table 3 - 4
Provide a plan for optimizing the use of recycled water in the supplier's service area.	10633 (f)	Pg. 3 - 25
Provide actions to facilitate the installation of dual distribution systems and to promote recirculating uses.		Pg. 3 - 25

Items to Address	Section of Law	Location in Plan
Groundwater		
Identification of groundwater as a water supply source.	10631 (b)(1)	Pg. 4 - 12
Groundwater management plan preparation.		Pg. 1 - 2
Groundwater management plan adoption.		Appendix G
Copy of the groundwater management plan.		This Plan
Describe groundwater basin(s).	10631 (b)(2)	Pg. 3 - 5
Identify the groundwater basin(s).		Pg. 3 - 6
Identify adjudicated basins.		Pg. 2 - 3
Copy of order or decree of adjudication.		Appendix A
Describe the amount of groundwater the supplier has the legal right to pump.		Appendix A
Describe and analyze location of groundwater pumped for past 5 years based on information that is reasonably available.	10631 (b) (3)	Appendix H
Describe and analyze amount of groundwater pumped for past 5 years based on information that is reasonably available.		
Describe and analyze sufficiency of groundwater pumped for past 5 years based on information that is reasonably available.		Pg. 4 - 13
Describe and analyze location of groundwater that is projected to be pumped based on information that is reasonably available.	10631 (b)(4)	Appendix H
Describe and analyze amount of groundwater that is projected to be pumped based on information that is reasonably available.		Chapter 5
Water Supply Projects and Water Supply Programs		
The description explains how all the water supply projects and water supply programs increase the water supplies to meet the total projected water use as established pursuant to subdivision (a) of Section 10635.	10631 (h)	Chapter 9
Identify specific future water supply projects and water supply programs that may be implemented to increase the amount of water available during average, single-dry and multiple-dry water years.		Chapter 9
Describe the increase in water supply that is expected to be available from each of the specific future water supply projects and water supply programs.		Chapter 9
Describe the estimated implementation timeline for each future water supply project and water supply program.		Chapter 9

Items to Address	Section of Law	Location in Plan
Water Quality		
Includes information, to the extent practicable, relating to the quality of existing water supply sources over the next 20 years in five year increments.	10634	Pg. 4 - 29
Describes the manner in which water quality affects water management strategies.		Chapter 10
Describes the manner in which water quality affects supply reliability.		Chapter 10

Groundwater Management Plan

Checklist Organized According to Required and Recommended Components

Items to Address	Section of Law	Location in Plan
Required Components		
Provide documentation that a written statement was provided to the public describing the manner in which interested parties may participate in developing the groundwater management plan.	10753.4(b)	Appendix F
Provide basin management objectives for the groundwater basin that is subject to the plan.	10753.7 (a)(1)	Chapter 9
Describe components relating to the monitoring and management of groundwater levels, groundwater quality, inelastic land surface subsidence and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by pumping.	10753.7 (a)(1)	Chapter 10 Appendix H
Describe plan to involve other agencies that enables the local agency to work cooperatively with other public entities whose service area or boundary overlies the groundwater basin.	10753.7 (a)(2)	Ch 8
Adoption of monitoring protocols for the components in Water Code Section 10753.7 (a)(1)	10753.7 (a)(4)	Appendix H
Provide a map showing the area of the groundwater basin as defined by DWR Bulletin 118 with the area of the local agency subject to the plan as well as the boundaries of other local agencies that overlie the basin in which the agency is developing a groundwater management plan.	10753.7 (a)(3)	Fig 3 - 2
Recommended Components		
Manage with the guidance of an Advisory Committee.		Chapter 8 Appendix E
Describe the area to be managed under the plan including historical data related to groundwater levels, quality, subsidence, groundwater/surface water interactions, issues of concern and a discussion of supplies and demands.		Chapter 3
Describe how each of the management objectives helps meet goals.		Chapter 9
Provide a map showing locations of monitoring sites for groundwater levels and quality and stream gauges.		Appendix H
Summarize types of monitoring, types and frequency of measurements.		Appendix H
List monitoring well characteristics including well depth, screened intervals and well type.		Appendix I

2

AGENCY AND STAKEHOLDER BACKGROUND

Mojave Water Agency

The California State Legislature authorized the formation of the Mojave Water Agency (MWA) in 1959 for the purpose of managing declining groundwater levels in the Mojave Basin Area, El Mirage Basin, and Lucerne Basin. The Legislature's act required the vote of the residents within the boundaries of the proposed agency, which would finalize the creation of the agency. With the vote of the people, MWA was formed on July 21, 1960. MWA was expanded by annexation in 1965 to include the Johnson Valley and Morongo Basin areas. Today, MWA covers an area of over 4,900 square miles, as seen in Figure 2-1.

MWA was formed to manage groundwater levels that have been in decline since the early 1950s. Today, overdraft has reduced groundwater stored in the region by nearly two million acre-feet. The enabling act authorizes MWA to do "any and every act necessary, so that sufficient water may be available for any present or future beneficial use of the lands and inhabitants within MWA's jurisdiction." Clearly, MWA needed to find ways to assure a long-term, reliable water supply and where possible, reverse the overdraft of the groundwater basin.

MWA was formed to manage groundwater levels that have been in decline since the early 1950s.

The first step MWA took to reduce the water shortage within its jurisdiction was to become a SWP contractor, which entitled it to 50,800 acre-feet per year of water delivered via the California Aqueduct. Later, MWA purchased an additional 25,000 acre-feet of entitlement from Berrenda Mesa Water District to bring its total annual entitlement to 75,800 acre-feet.

Schlumberger Water Services

MWA Location

Mojave Water Agency
2004 Regional Water Management Plan

Figure 2-1

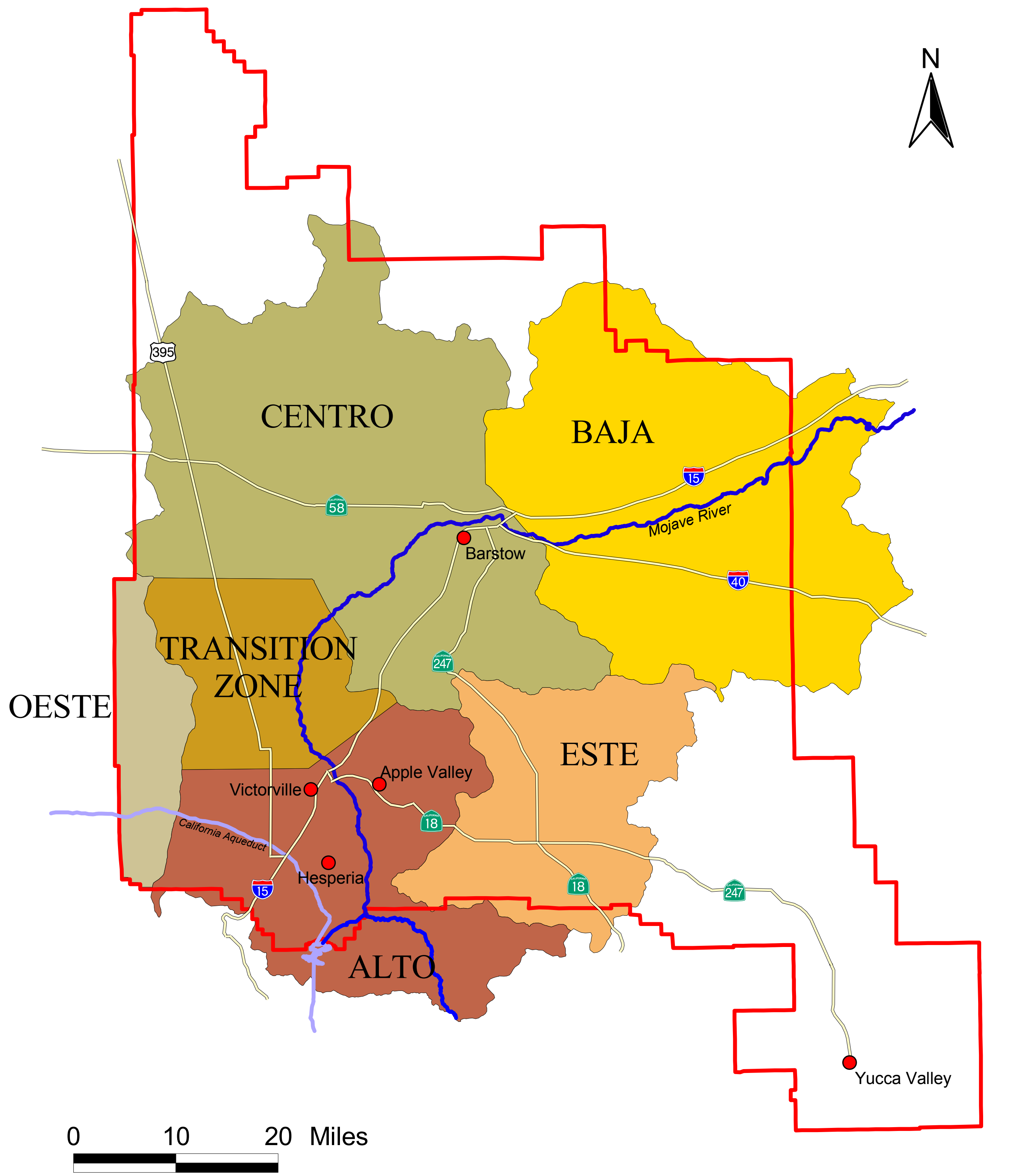
Date: January 2004

Prepared By: KTW

For management purposes under the Mojave Basin Area Judgment, MWA split the Mojave River watershed and associated groundwater basins into five separate "subareas." The locations of the five subareas (Oeste, Este, Alto, Centro, and Baja) are shown in Figure 2-2. The subarea boundaries are based on hydrologic divisions defined in previous studies (DWR 1967), evolving over time based on a combination of hydrologic, geologic, engineering and political considerations. Also for the purposes of implementing the Judgment, the northern part of the Alto Subarea was defined as a sub-management unit – the Alto Transition Zone; this zone was created to acknowledge local geology and to better address the water flow from Alto to Centro.

To distribute the water to the points of need, MWA has taken a central role in designing and constructing the Morongo Basin and Mojave River pipelines, which extend from the California Aqueduct. The Morongo Basin Pipeline was completed in 1994 and deliveries began in 1995 to the Hi-Desert Water District. Water flowing through the pipeline is diverted to recharge ponds in an effort to reduce overdraft in the Warren Valley Basin. The MWA also financed and constructed the oversize of reach 1 of the Morongo Basin Pipeline to facilitate artificial recharge of the Alto Subarea along the Mojave River in the vicinity of Hesperia and Apple Valley. The Mojave River pipeline is being built in phases. Facilities have been constructed from the California Aqueduct to the vicinity of Barstow. The Hodge and Lenwood Recharge Sites, located west of Barstow, have also been constructed and received a total of 3,842 acre-feet of water during 1999-2000. The Daggett Recharge Site, east of Barstow, was completed in 2001. Investigations are underway to site additional recharge basins in the Baja Subarea. Figure 2-3 shows the locations of MWA's current and future conveyance and recharge features.

MWA roles and responsibilities have expanded since 1960. Today, MWA is involved with educational programs, water rights administration, and data collection. Adjudication of water rights within the Mojave Basin Area is a major role of the agency today and will be discussed in greater detail later in this chapter. MWA also has gradually assembled the data necessary to better understand the dynamic interaction between surface water and groundwater flows in the basins, and in particular, the significant role that the geology in the area plays in the migration of groundwater from south to north. Teaming with the U.S. Geological Survey (USGS), MWA has



Schlumberger Water Services

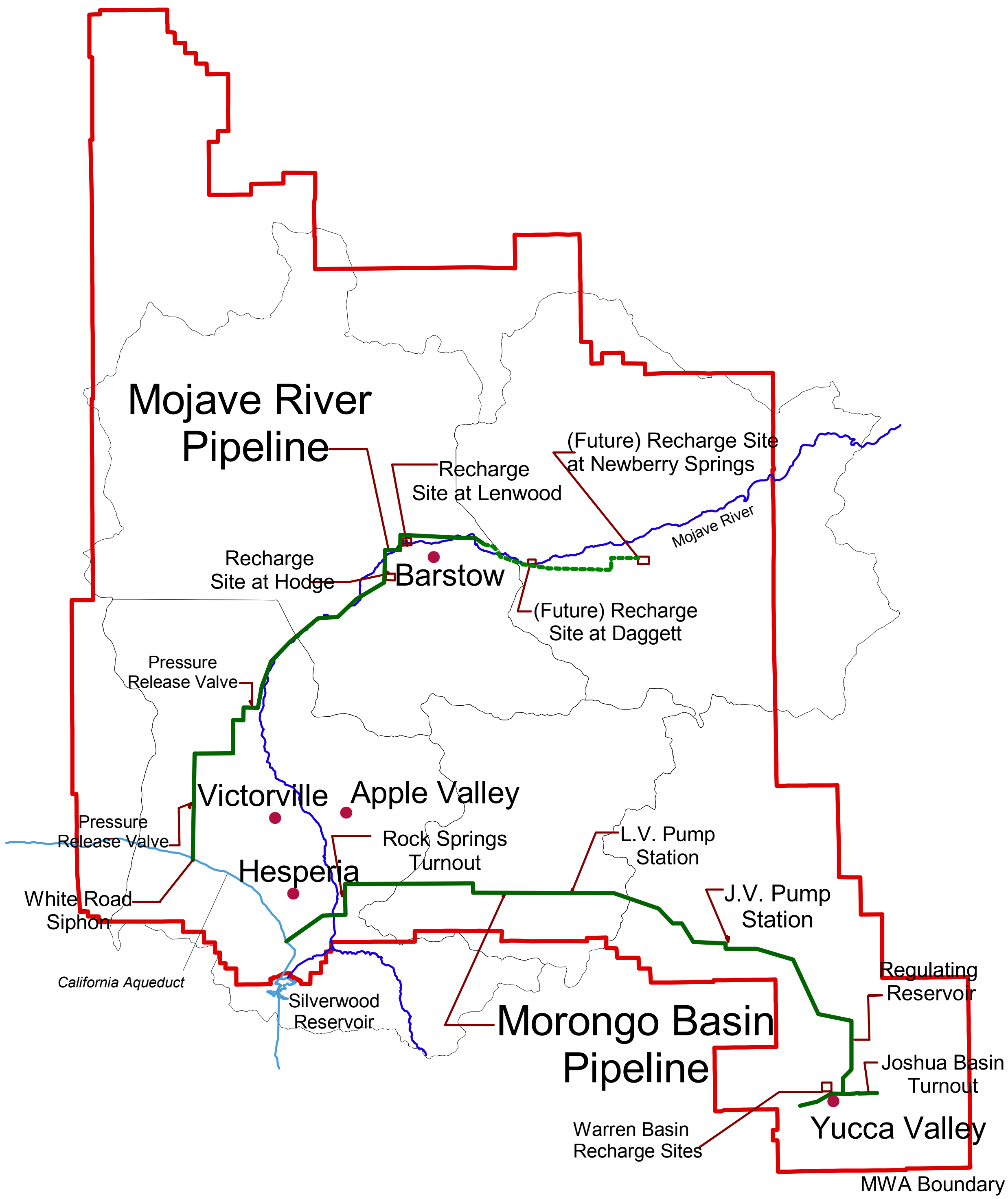
Base Map

Mojave Water Agency
2004 Regional Water Management

Figure 2-2

Date: January 2004

Prepared By: KTW



Schlumberger Water Services

Current and Future Facilities

Mojave Water Agency
2004 Regional Water Management Plan

Figure 2-3

Date: January 2004

Prepared By: KTW

constructed monitoring wells to measure groundwater quality and water levels, run geophysical surveys to understand variations in subsurface geology, installed an auxiliary Lower Narrows low flow gage on the bank opposite the main gage, took over as USGS cooperator for some gages that the California Department of Water Resources (DWR) had funded until the early 1990's, and established weather stations to monitor rainfall and evaporation. MWA also assumed responsibility for assignment of local well numbers in cooperation with DWR.

Adjudication

Mojave Basin Area

Fearing uncontrolled overdraft of the Mojave Basin, adjudication proceedings were initiated in the mid-1960s, but were never finalized. Triggered by the rapid growth within the Mojave Water Agency service area, particularly in the Victor Valley area, the City of Barstow and the Southern California Water Company filed a complaint in 1990 against upstream water users claiming that the increased withdrawals and lowering of groundwater levels reduced the amount of natural water available to downstream users. The complaint requested that 30,000 acre-feet of water be made available to the Barstow area annually and that MWA obtain supplemental water for use in other areas of MWA's service area.

About a year later, the Mojave Water Agency filed a cross-complaint which declared that the native waters of the Mojave River and underlying groundwater were insufficient to meet the current and future demands made upon them. The cross-complaint asked the court to determine the water rights of all surface water and groundwater users within the Mojave Basin Area and the Lucerne and El Mirage Basins. During the following two years, negotiations resulted in a proposed Stipulated Judgment that: 1) formed a minimal class of producers using 10 acre-feet or less per year who were dismissed from the litigation, and 2) offered a physical solution for water production by the remaining producers. The Superior Court bound the stipulating parties to the Stipulated Judgment in September 1993. The Court further bound the non-stipulating parties to the terms of the Stipulated Judgment in January 1996 following trial. The text of the Stipulated Judgment can be found in Appendix A.

Some of the non-stipulating parties appealed the Judgment of the Superior Court and the Appellate Court issued a final decision in June 1998. The final decision of the Appellate Court held the stipulating parties to the terms of the Stipulated Judgment, but excluded the appealing parties, with the exception of one appellant who sought a revised water production right under the Judgment. MWA requested the California Supreme Court to review the Appellate Court's decision in July 1998. The Supreme Court affirmed the Appellate Court's decision in August

2000 regarding the Stipulated Judgment and the exclusion of the appealing parties from the Judgment, but over-turned the decision of the Appeals Court as to the one party seeking additional production rights.

The Mojave Basin Judgment assigned Base Annual Production (BAP) quotas to each producer using 10 acre-feet per year or more, based on historical production. Users are assigned a variable Free Production Allowance (FPA), which is a uniform percentage of BAP set for each subarea. This percentage is reduced, or "ramped-down" over time until total FPA comes into balance with available supplies. This percentage was set at 70% for most subareas as of June 2003. Any water user that pumps more than their FPA is compelled to purchase replenishment water from MWA equal to the amount of production in excess of the FPA.

Warren Valley Basin

Groundwater from the Warren Valley Basin is used to supply Yucca Valley and its environs. Extractions from the Basin began exceeding extractions in the 1950s. The progressively increasing overdraft led to adjudication of the Basin in 1977.[1] In its Judgment, the court appointed the Hi-Desert Water District as Watermaster and ordered it to develop a physical solution for halting overdraft. Objectives identified by the Watermaster Board included managing extraction, importing water supplies, conserving stormwater, encouragement of conservation and reclamation, and protecting groundwater quality. A Basin Management Plan[2] was adopted that called for importing SWP water from MWA through the then-proposed Morongo Basin Pipeline to balance demand and replenish past overdraft. The text of the Warren Valley Judgment can be found in Appendix A.

Summary of 1994 Regional Water Management Plan

The first Regional Water Management Plan (RWMP) was completed in June 1994 by Bookman-Edmonston Engineering, Inc. The plan developed recommendations that followed the following broad objectives:

---

[1] Hi-Desert Water District v. Yucca Water Company Ltd., Case Number 172103, San Bernardino, California, September 16, 1977.
[2] Warren Valley Basin Management Plan, Kennedy/Jenks/Chilton, January 31, 1991. Adopted by Watermaster May 10, 1991.

1. Eliminate overdraft and meet future demands on the groundwater basins by obtaining additional imported water supplies and/or reducing consumptive use demands.
2. Protect the groundwater basins from degradations in water quality.
3. Participate in implementation of any judgment resulting from ongoing Mojave River adjudication.
4. Be responsive to changing conditions by modifying the present plan as necessary.
5. Work closely with local agencies and water purveyors on key issues, particularly water conservation.
6. Accomplish the above in a cost-effective and environmentally sound manner.

The plan provided the details for structural and non-structural projects that could be completed in part or in full over three phases. Phase 1 projects were proposed for development over the ensuing 5 years. Phase 2 projects were anticipated during the following 5 to 10 years, as financing would allow. Phase 3 projects were considered long-term goals scheduled for completion by the year 2015. The recommended projects for Phases 1, 2, and 3 are listed below, along with the current status of each.

Phase 1 (Structural)

- Drilling wells for monitoring program
  Status: incomplete; more wells are needed away from Mojave River and deeper beneath the river
- Rock Springs recharge facility & turnout
  Status: completed
- Increase recharge of natural supplies
  Status: no action
- Groundwater recharge in the Centro and Baja subareas from Mojave River Pipeline
  Status: Centro has two recharge basins (Hodge & Lenwood) and Baja has (Daggett). One additional basin is planned for Baja and siting studies are ongoing.
- Groundwater recharge in Este (Lucerne) from Morongo Basin Pipeline
  Status: incomplete; no recharge, purchased land in Lucerne Valley, prepared preliminary design and performed environmental review
- Groundwater recharge in Oeste (El Mirage)
  Status: no action, except for USGS feasibility of recharge in Sheep Creek
- Recharge in Morongo Basin with Morongo Basin Pipeline Extension
  Status: recharge taking place in Warren Valley Basin

Phase 1 (Non-structural)

- Release to Mojave River from Lake Silverwood
  Status: releases discontinued since the completion of the Rock Springs Turnout
- Water monitoring programs
  Status: completed, but expanding
- Purchase of State Water Project (SWP) Water
  Status: ongoing; however not all available water has been purchased due to financial constraints
- Legislative changes to MWA Act
  Status: Act amended to allow MWA to implement well programs in furtherance of the Judgment
- Water Quality Protection Programs
  Status: water quality monitoring for recharge programs at Rock Springs Outlet, Hodge, Lenwood and Warren Basin; MWA wells used to support water quality monitoring for Mojave Watershed program with State Board.
- Water conservation program to reduce consumptive use
  Status: ongoing through education programs and demonstration gardens
- Investigation of additional water importation projects
  Status: ongoing; purchased 25,000 acre-feet/yr of SWP entitlement from Berrenda-Mesa Water District; executed water exchange agreement with Solano County Water Agency
- Zones of Benefit to collect benefit assessments
  Status: no action
- Improvement districts to finance facilities
  Status: no action

Phase 2 (Structural)

- Groundwater extraction & delivery to Mojave River Aqueduct
  Status: no action

Phase 2 (Non-Structural)

- Zones of Benefit to collect benefit assessments
  Status: no action
- Improvement districts to finance facilities
  Status: no action
- Contracts with purveyors
  Status: ongoing

Phase 3 (Structural)

- Delivery of imported water and groundwater to water users

  Status: Ordinance 9 water sale approved for City of Victorville from Mojave River Pipeline, ongoing deliveries to Hi-Desert Water District, Makeup and Replacement Water deliveries under the Judgment
- Meeting peaking requirements and constructing water treatment facilities

  Status: no action

Phase 3 (Non-Structural)

- Contracts with purveyors

  Status: ongoing
- Water allocation policies

  Status: hierarchy of water delivery priorities during shortages identified through Ordinance 9; ongoing

Major Stakeholders

Success of any water management plan depends on the degree of involvement with the stakeholder community. In developing the water management alternatives for evaluation, MWA has been careful to involve stakeholders from the beginning of the process. This involvement has included one-on-one interviews, group meetings, and evaluation questionnaires. Water users form the core of the stakeholder group in the basin, including water districts, cities, private water agencies, and agribusiness. Additional essential stakeholder involvement includes environmental organizations, regulatory agencies, development interests, and community associations.

*Success of any water management plan depends on the degree of involvement with the stakeholder **community.***

The stakeholders noted in the following list have been notified regarding the outreach process organized by MWA during the RWMP update. Some of the common interests of the stakeholders in each group are also noted in the list. Chapter 8 provides a more detailed list of the stakeholder issues developed from the individual/group meetings and questionnaire process.

Water Agencies

Local water agencies share many issues related to local and regional water supplies. They are all interested in the ability of their individual systems to meet the needs of their customers. Each agency has its own set of quantity and quality needs and each agency has individual goals for the regional water system.

- Apple Valley Foothill County Water District
- Apple Valley Heights County Water District
- Apple Valley Ranchos Water Company
- Apple Valley View Water District
- Baldy Mesa Water District
- Bar H Mutual Water Company
- Bighorn-Desert View Water Agency
- Chamisal Mutual Water Company
- Daggett Community Services District
- Hesperia Water District
- Hi-Desert Water District
- Joshua Basin Water District
- Jubilee Mutual Water Company
- Juniper Riviera County Water District
- Lucerne Valley County Service Area 29
- Lucerne Valley Mutual Water Company
- Lucerne Vista Municipal Water Company
- Mariana Ranchos County Water District
- Newberry Community Services District
- Rancheritos Mutual Water Company
- San Bernardino County Special Districts
- Sheep Creek Water Company
- Silver Lakes Association
- Southern California Water Company
- Spring Valley Lake Association
- Thunderbird County Water District
- Victor Valley Water District
- Victor Valley Water Reclamation Authority
- Willow Wells Mutual Water
- Yermo Community Services District

State and Federal Agencies

The state regulatory agencies are charged with enforcing the State's laws associated with water rights, environmental protection, and the protection of water quality. The California Department of Water Resources has provided financial assistance for preparation of this plan. The U.S. Geological Survey has provided a variety of services for over 100 years, including stream gaging, hydrogeologic assessment and modeling. It is imperative that MWA works cooperatively with these agencies.

- California Department of Water Resources
- California Department of Fish and Game
- State Water Resources Control Board
- Lahontan Regional Water Quality Control Board
- U.S. Geological Survey

Municipalities (cities, county, other)

Municipalities may or may not be water purveyors. Regardless, all municipalities share a keen interest in their local and regional water supplies. The economic health of a region is tied to its ability to demonstrate that affordable high quality water is going to be available as the region develops.

- City of Adelanto
- City of Barstow
- City of Hesperia
- City of Victorville
- San Bernardino County Department of Public Works and Flood Control
- San Bernardino County Planning Department
- Town of Apple Valley
- Town of Yucca Valley

Miscellaneous Community Interests

Local community groups have an opportunity to provide input on issues and needs associated with their particular location. This type of specific input is very beneficial to the regional planning process.

- El Mirage Property Owners Association
- Public Works Advisory Committee, City of Hesperia
- Silver Valley Realty
- Mojave Basin Area Judgment Subarea Advisory Committees
- MWA Technical Advisory Committee (TAC)
- The Bradco Companies (real estate)
- Citizens for a Better Community
- Jess Ranch
- Newberry Springs – Harvard Property Owners Association
- Palisades Ranch
- Rancho Los Flores
- Silver Lakes Association
- Spring Valley Lakes Association

3

PHYSICAL SETTING

Much has been written about the geology and hydrology of the Mojave area, with some information dating back to the early 1900s. The U.S. Geological Survey (USGS), in cooperation with the Mojave Water Agency (MWA), conducted the most recent work in the area.[3] Their report culminated several years of intense field work that included installation of groundwater monitoring wells along the Mojave River, geophysical surveys, surface water hydrology measurements, groundwater level measurements, groundwater quality sampling, meteorological measurements, and well production tests. The final component of this effort was the development of a comprehensive groundwater flow simulation model, used as an analysis tool to evaluate past and present groundwater conditions, as well as a predictive tool to evaluate the effects of future water usage and management scenarios.

Developing viable alternatives requires a clear understanding of the region's physical setting.

This chapter summarizes the pertinent findings regarding the physical setting for the Mojave Basin Area and the Morongo Basin/Johnson Valley Area. The principal objective of this chapter is to highlight conclusions regarding the physical setting that have been developed since the publication of the 1994 Regional Water Management Plan (RWMP). The latest USGS study contains a more thorough presentation of these subjects.[4]

Physiographic Setting

The MWA service area lies in the California High Desert, which is part of the Mojave Desert (Figure 3-1). The High Desert Area is located on the northeastern flanks of the San Bernardino and San Gabriel Mountains, which separate the High Desert from the coastal basins and inland valleys of the greater Los Angeles area. These mountains, which reach elevations of over 10,000 feet above sea level, were uplifted along the San Andreas Fault. The High Desert Area is

[3] Stamos et al. 2001
[4] ibid

characterized overall as an alluvial plain. This plain consists of valleys and closed basins composed of water-bearing unconsolidated sediments. Hills and low mountains consisting of non-water-bearing consolidated bedrock separate these valleys and basins. The plain is criss-crossed by a series of northwest-trending geologic faults, resulting in offsets of geologic layering and barriers to groundwater flow. Overall, land surface elevations within the MWA service area range from 5,500 feet above sea level in the San Bernardino Mountains on the southern boundary to 1,500 feet near Afton Canyon on the eastern boundry.

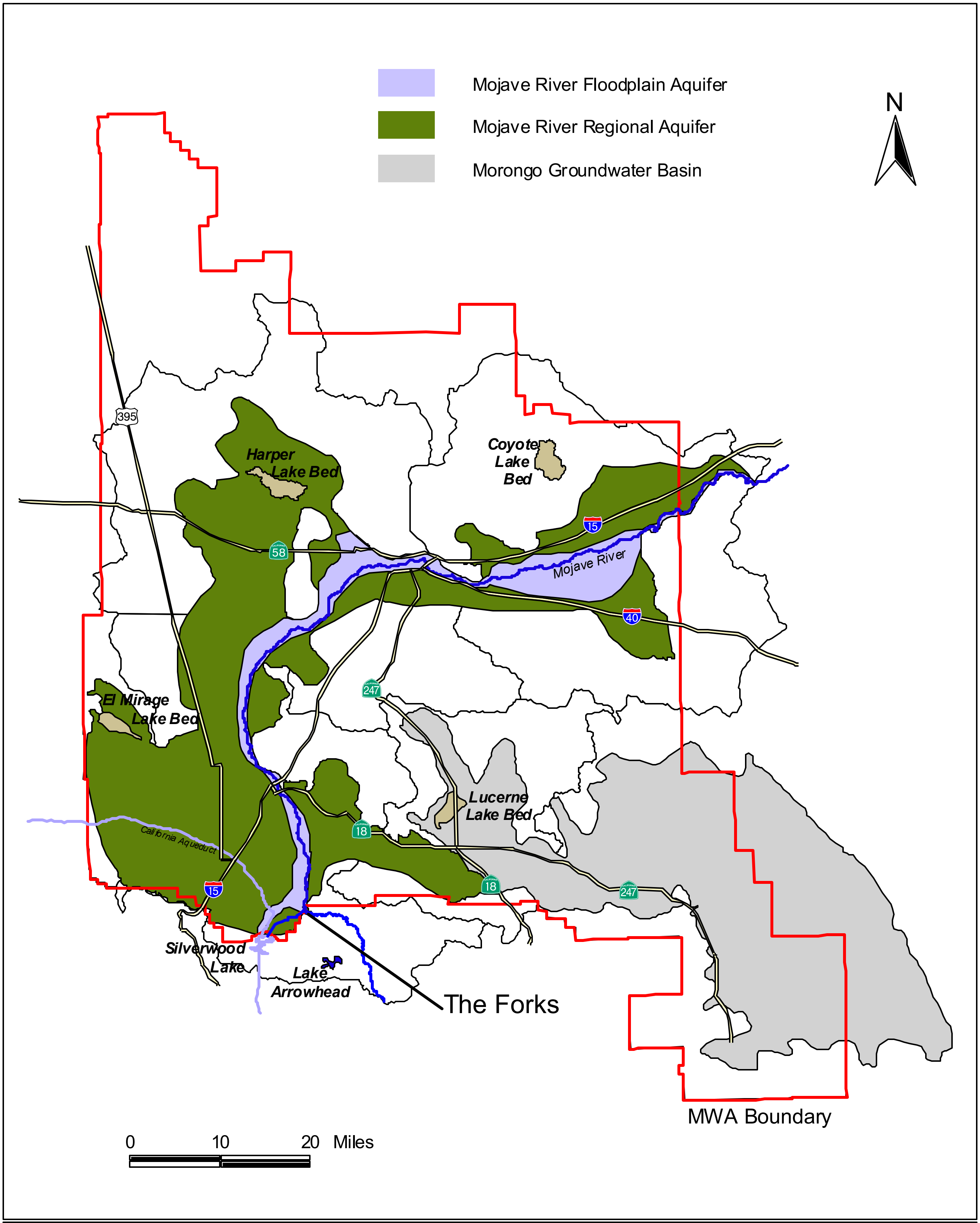
The MWA service area is divided into two major surface water drainage areas:

- the Mojave River Area that drains into the Mojave River or local terminal dry lakes. The Mojave River Area is the larger and more developed of the two.
- the Morongo Basin/Johnson Valley Area that drains into the Colorado River drainage or local terminal dry lakes.

Terminal dry lakes (often referred to as playas) are lake beds that collect water only during periods when there is sufficient runoff, have no outlet, and lose all their water to evaporation.

The Mojave River is the main surface water drainage feature within the MWA service area. The surface water drainage of the Mojave River covers an area of 3,800 square miles.[5] It is fed by rainfall and snow pack from the San Bernardino Mountains. The river is formed by the confluence of two smaller streams descending from the mountains at a place called The Forks (Figure 3-1).

[5] ibid



Schlumberger Water Services	**Hydrologic Setting** Mojave Water Agency 2004 Regional Water Management Plan	Figure 3-1 Date: June 2002 Prepared By: BCW

The river then runs north and then east for about 100 miles, where it flows through Afton Canyon and terminates at Soda and East Cronese Lakes; these lakes pond water only after major storm events. At present the Mojave River is perennial (continuously flowing) only along a short section downstream of The Forks, in the vicinity of Upper and Lower Narrows and Afton Canyon, and in the section immediately downstream of the Victor Valley Wastewater Reclamation Authority's treatment plant, about 4 miles downstream of the Lower Narrows. However, during and immediately after storms (principally during the winter), the Mojave River flows along several (sometimes all) of its reaches. Most of the river flow occurs immediately after storms.

The Morongo Basin/Johnson Valley area has no sizeable rivers, only small ephemeral streams that collect runoff from surrounding mountains during storms. The mountain stream runoff either percolates into the stream bed or, during large storm events, flows to dry lake beds where it evaporates. The area encompasses parts of five separate surface water drainages – Warren, Copper Mountain, Emerson, Means, and Johnson.

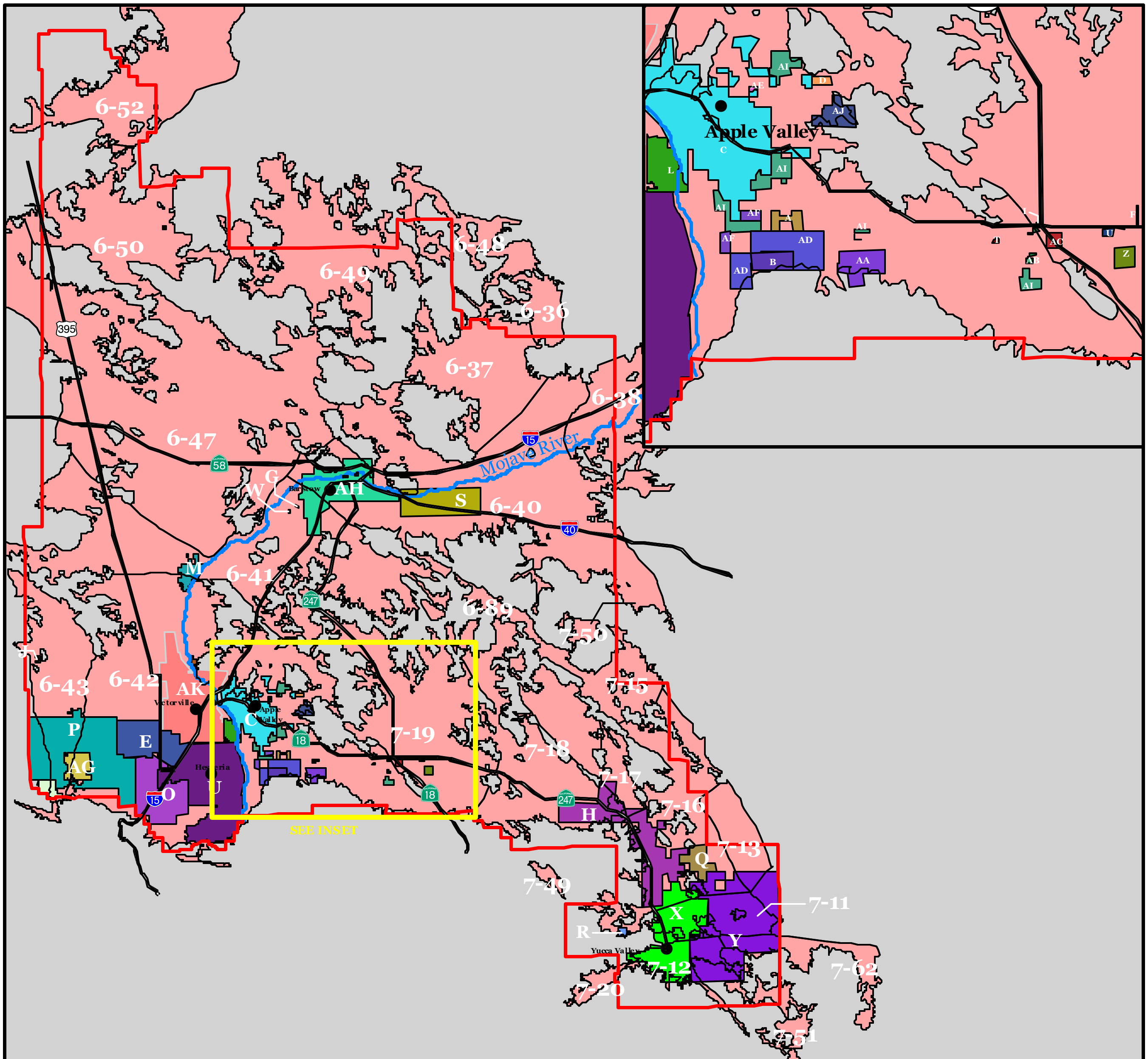
The groundwater basins have been designated in a number of ways. The Department of Water Resources Bulletin 118-03 defines 22 groundwater basins within the two broad hydrologic regions overlying the Mojave Water Agency area. The Mojave River Basin lies within the South Lahontan hydrologic region. The Warren Valley/Johnson Valley area and the portion of the Lucerne Valley east of the Helendale Fault lie in the Colorado River hydrologic region. The DWR basins are listed in Table 3-1. The DWR basins and the overlying water suppliers are displayed in Figure 3-2.

The DWR Coyote Lake Valley, Caves Canyon Valley, Kane Wash Area and Lower Mojave River Valley groundwater basins lie primarily in the Baja subarea. The Middle Mojave River Valley includes parts of the Transition Zone and Centro subarea. The Harper Valley groundwater basin is within the Centro subarea. The Upper Mojave River Valley basin includes parts of the Transition Zone, Alto, and Este subareas. The El Mirage Valley groundwater basin is primarily within the Oeste subarea. The Mojave River Valley basins cover an area of 1,400 square miles (Figure 3-1).

Table 3-1: DWR Groundwater Basins

Basin Number	Basin Name	Area[6] (acres)	Groundwater Budget Type[7]
South Lahontan Hydrologic Region			
6-37	Coyote Lake Valley	88,200	A
6-38	Caves Canyon Valley	73,100	A
6-40	Lower Mojave River Valley	286,000	A
6-41	Middle Mojave River Valley	211,000	A
6-42	Upper Mojave River Valley	413,000	A
6-43	El Mirage Valley	75,900	A
6-47	Harper Valley	410,000	A
6-49	Superior Valley	120,000	C
6-50	Cuddeback Valley	94,900	C
6-52	Searles Valley	197,000	C
6-89	Kane Wash Area	5,960	C
Colorado River Hydrologic Region			
7-11	Copper Mountain Valley	30,300	A
7-12	Warren Valley	17,200	A
7-13	Deadman Valley	118,500	C
7-15	Bessemer Valley	39,100	C
7-16	Ames Valley	110,000	C
7-17	Means Valley	15,000	C
7-18	Johnson Valley Area	111,600	C
7-19	Lucerne Valley	148,000	A
7-20	Morongo Valley	7,240	C
7-50	Iron Ridge Area	5,250	C
7-62	Joshua Tree	33,800	A

[6] Total area of basin both in and outside of MWA boundary
[7] Type A – either a groundwater budget or model exists, or actual extraction data is available
Type C – not enough available data to provide an estimate of the groundwater budget or basin extraction



	DWR groundwater basin (#-#)
	MWA boundary
A	Apple Valley Foothill Company WD
B	Apple Valley Heights (South)
C	Apple Valley Ranchos Water Co
D	Apple Valley View Mutual Water Co
E	Baldy Mesa WD
F	Bar 'H' Mutual Water Co
G	Bar Len Mutual Water Co
H	Bighorn Desert View WA
I	Center Water Co
J	Chamisal Mutual Water Co
K	County Svc Area-42
L	County Svc Area-64
M	County Svc Area-70c
N	County Svc Area-70g
O	County Svc Area-70j
P	County Svc Area-70l
Q	County Svc Area-w1
R	County Svc Area-w4
S	Daggett Community Svcs District
T	Desert Dawn Mutual Water Co
U	Desert Springs Mutual Water Co
V	Hesperia WD
W	Hi Desert Mutual Water Co
X	Hi Desert WD
Y	Joshua Basin WD
Z	Jubilee Mutual Water Co
AA	Juniper Riviera Co WD
AB	Lucerne Valley Mutual Water Co
AC	Lucerne Vista Mutual Water Co
AD	Mariana Ranchos Co
AE	Navajo Mutual Water Co
AF	Rancheritos Mutual Water Co
AG	Sheep Creek Water Co
AH	So Cal Water Co- North
AI	So Cal Water Co- South
AJ	Thunderbird Co WD
AK	Victor Valley Water District

Schlumberger Water Services

Groundwater Basins and Water Districts

Mojave Water Agency
2004 Regional Water Management Plan

Figure 3-2

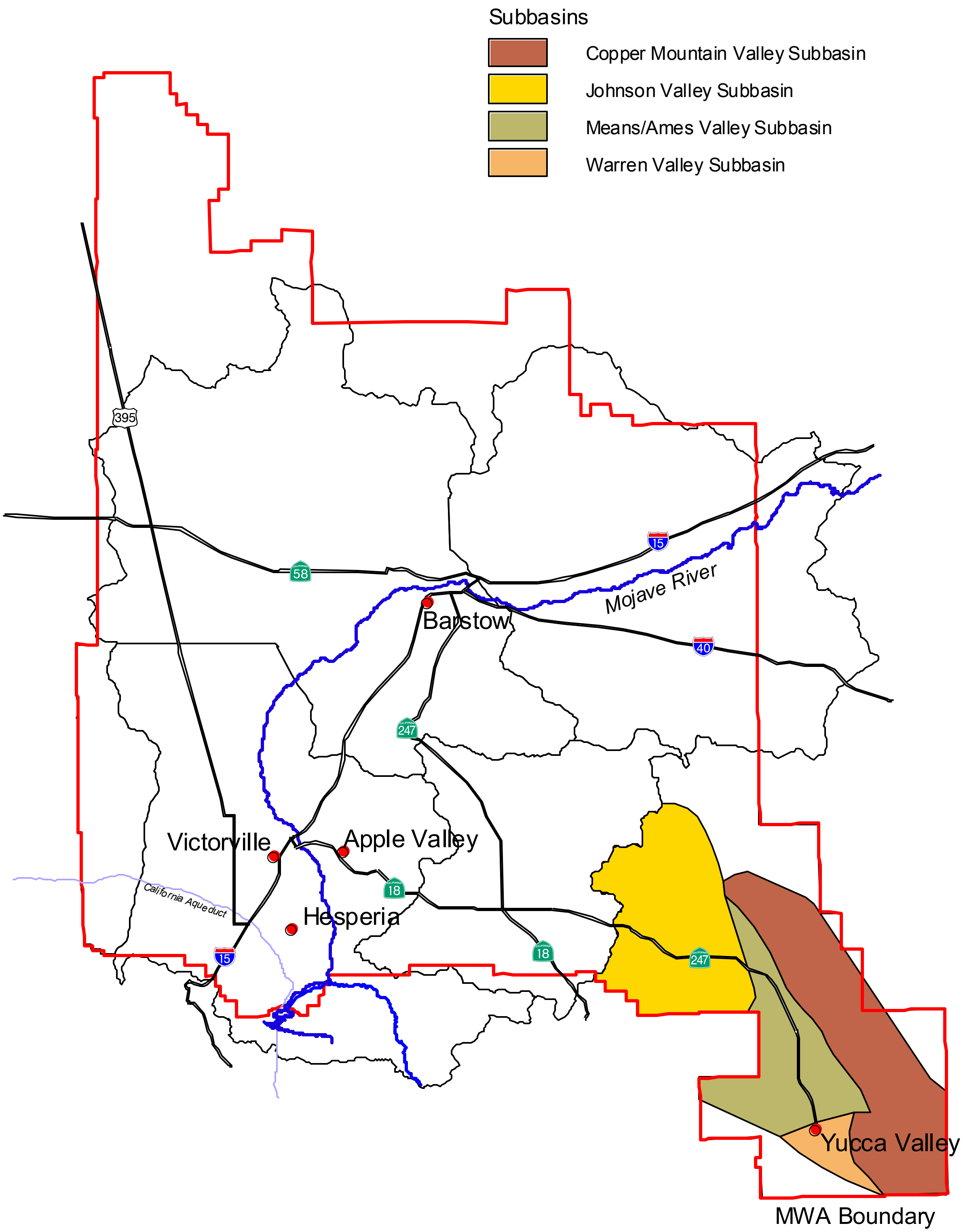
Date: October 2003

Prepared By: KTW

The northern potion of MWA also overlies portions of the Searles Valley, Cuddeback Valley, and Superior Valley groundwater basins. These areas are mostly unpopulated Federal lands administered by the Bureau of Land Management (BLM).

During recent investigations, USGS has grouped the other basins within the MWA service area into the Morongo Groundwater Basin. Including the portion of the Lucerne Valley east of the Helendale Fault in the Este subarea, this grouping encompasses nearly 1,000 square miles (Figure 3-1). The Morongo Groundwater Basin has been divided into as many as 17 subbasins by investigators in the past. All or part of 11 of these groundwater basins are within the MWA boundary. Three of these, Deadman Valley, Bessemer Valley, and Iron Ridge groundwater basins are mostly unpopulated Federal lands administered by BLM and lie near MWA's eastern boundary. Bulletin 118-03 states that there is not enough available data to provide either an estimate of groundwater budgets nor extractions from these basins. These basins are not further considered in this Plan.

There have been many different and conflicting references to the basins and subbasins within the MWA service area. For the purposes of this report, major "basins" are referred to as the Mojave Basin Area and the Morongo Basin/Johnson Valley Area. The Mojave Basin Area subbasin classifications used in this report are the: Este, Alto, Oeste, Centro, and Baja subareas defined in the Mojave Basin Judgment. The Morongo Basin/Johnson Valley Area subbasin classifications are shown in Figure 3-3. The subbasin classifications are Johnson Valley, Means/Ames Valley, Warren Valley, and Copper Mountain Valley. These are the same classifications used in the 1994 RWMP. ***Groundwater*** basins defined in DWR Bulletin 118 are different from the major basins and are shown in Figure 3-2. This figure also shows the boundaries of the overlying water supply agencies.



Schlumberger Water Services

Morongo Basin/Johnson Valley Area Subbasins

Mojave Water Agency
2004 Regional Water Management Plan

Figure 3-3

Date: January 2004

Prepared By: KTW

Geology

The geology of the Mojave Basin Area is characterized by sedimentary alluvial basins bordered by igneous and metamorphic mountain ranges and uplands; the uplands dominated by the San Gabriel and San Bernardino Ranges along the Mojave Basin's southern border. A typical geologic cross-section depicting the geologic sequence is shown in Figure 3-4. The recently updated geologic map for the basin is shown in Figure 3-5.[8] The ranges and uplands are composed of pre-Tertiary (greater than 65 million years ago) igneous and metamorphic rocks (labeled as pTb in accompanying figures), and Tertiary (1.64 to 65 million years ago) volcanic and sedimentary rocks (Tv and Ts, respectively). Numerous extensive strike-slip faults trend northwest to southeast across the basin, causing predominantly horizontal displacement (but also vertical displacement for some faults) in the geologic section.

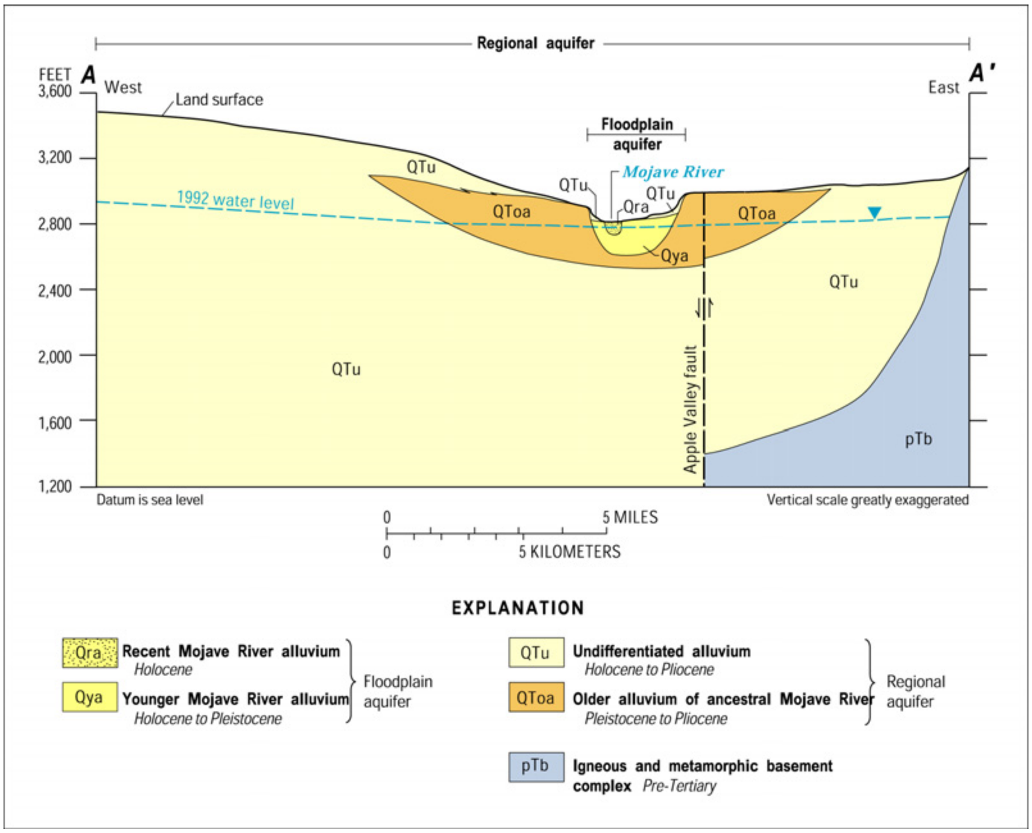
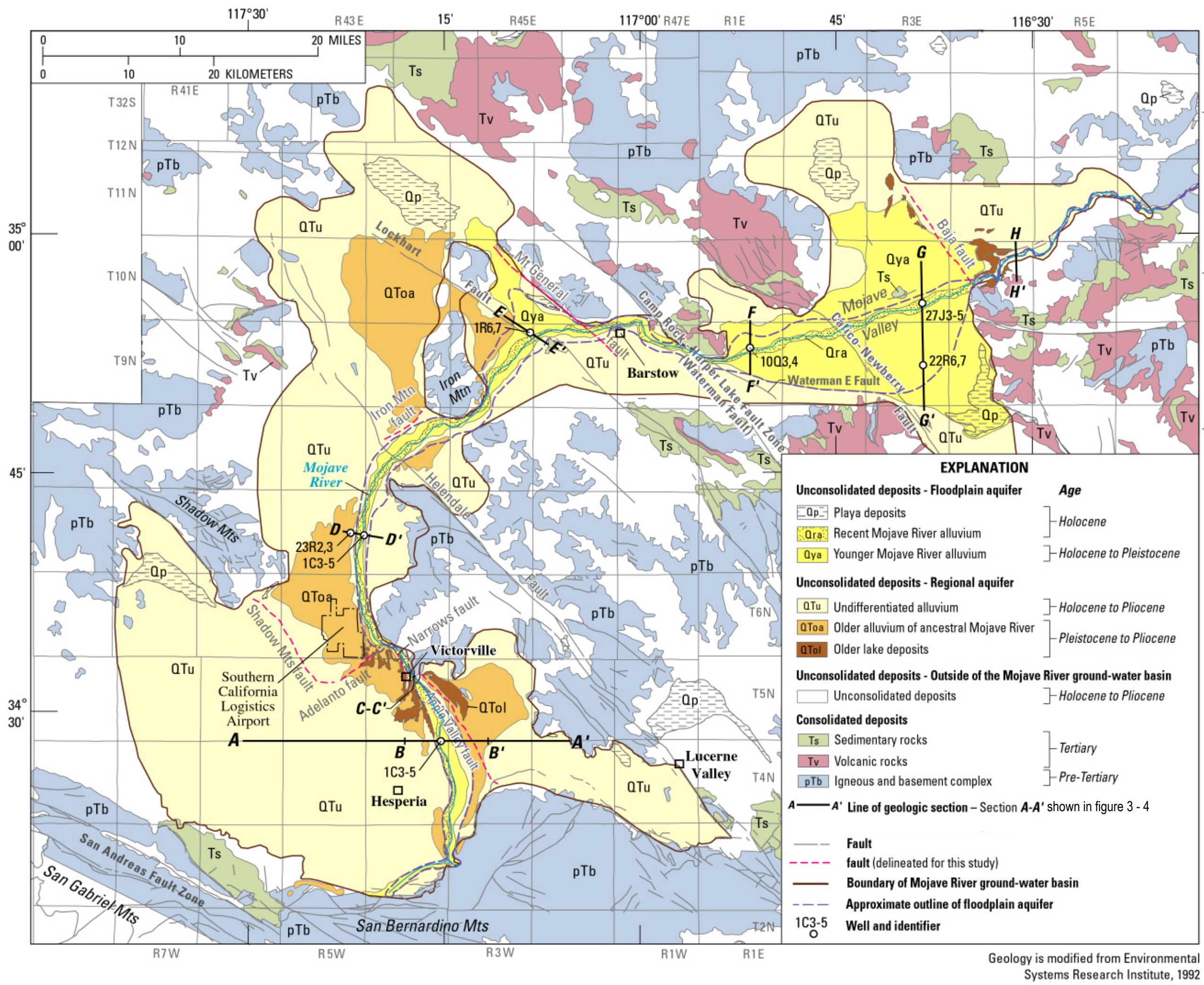


Figure 3-4: Typical Geologic Cross-Section of Mojave River Groundwater Basin[9]

[8]Stamos, et al., 2001
[9]ibid



Source: Stamos et al., 2001

Geology of Mojave River Groundwater Basin

Mojave Water Agency
2004 Regional Water Management Plan

Figure 3-5

Date: January 2004

Prepared By: KTW

Schlumberger Water Services

The alluvial basins are composed of Quaternary (0 to1.64 million years ago) unconsolidated river, lake, and playa deposits. The river deposits comprise different ages of granitic sand, silt, and gravel laid down by the Mojave River and its predecessors – the youngest deposits directly surrounding the current river bed, with progressively older deposits further from the river or deeper below it. Surrounding and underlying the current and ancestral Mojave River alluvium are poorly sorted alluvial deposits from ancestral alluvial fans, braided-streams, lakes or playas.

The geology of the Morongo Basin/Johnson Valley Area has not been investigated to the same degree as the Mojave Basin Area. In general, the area is similar to the Mojave Basin Area – sedimentary basins surrounded by igneous/metamorphic mountain ranges/uplands. The sedimentary basins are composed of Quaternary and Tertiary continental deposits (Smith and Pimentel 2000).[10] The mountain ranges include the Ord and Granite Mountains in the north, Bullion Mountains in the east, San Bernardino Mountains in the southwest, and Pinto and Little San Bernardino Mountains in the south. As in the Mojave Basin Area, numerous northwest to southeast trending strike-slip faults traverse the Morongo Basin/Johnson Valley Area.

Groundwater

The predominant groundwater basin within the MWA service area is the Mojave River Groundwater Basin, encompassing 1,400 square miles as outlined in Figure 3-1, and having an estimated total water storage capacity of nearly 5 million acre-feet.[11] This basin is essentially a closed basin – very little groundwater enters or exits the basin. However, within the basin groundwater movement occurs between the different subareas, as well as groundwater-surface water and groundwater-atmosphere interchanges. Groundwater is recharged into the basin predominantly by (1) infiltration of water from the Mojave River, accounting for 80% of the total basin natural recharge[12] (2) infiltration of storm runoff from the mountains, and (3) manmade recharge (from irrigation, wastewater, fish hatcheries, and imported water).

The Mojave River Groundwater Basin has nearly 5 million acre-feet of storage capacity.

Over 90% of the basin groundwater recharge originates in the San Gabriel and San Bernardino Mountains.[13] Groundwater is discharged from the basin primarily by well pumping, evaporation through the soil, transpiration by plants, seepage into dry lakes where accumulated water evaporates, and seepage into the Mojave River.

[10] Smith and Pimentel 2000
[11] Bookman-Edmonston Engineering, Inc. 1994
[12] Stamos et al. 2001b
[13] Hardt 1971

The Morongo Groundwater Basin (including a portion of the Lucerne Basin which is in the Este Subarea) encompasses 1,000 square miles, of which about 60% lies within the MWA service area (Figure 3-1). This basin is composed of a large number of both closed and connected subbasins. Groundwater is recharged into the basin primarily by (1) infiltration of water from ephemeral streams and (2) manmade recharge. In 1995, artificial recharge ponds were installed by MWA near Yucca Valley in the Warren Valley subbasin with funding provided by a DWR loan which is currently being repaid by Hi-Desert Water District customers.

Groundwater is discharged from the Morongo Groundwater Basin primarily by well pumping, evaporation through the soil, transpiration by plants, and seepage into dry lakes where accumulated water evaporates.

Figure 3-6 shows a water table contour map of the Mojave River and Morongo Groundwater basins determined from well water level measurements in 1998. The direction of groundwater flow is perpendicular to the contours. Within the Mojave Basin Area, the groundwater flow direction is generally to the north from the base of the San Gabriel and San Bernardino mountains to near Iron Mountain; the flow then changes to the east from Iron Mountain to Afton Canyon. On a subbasin scale, the groundwater flow direction is as follows:

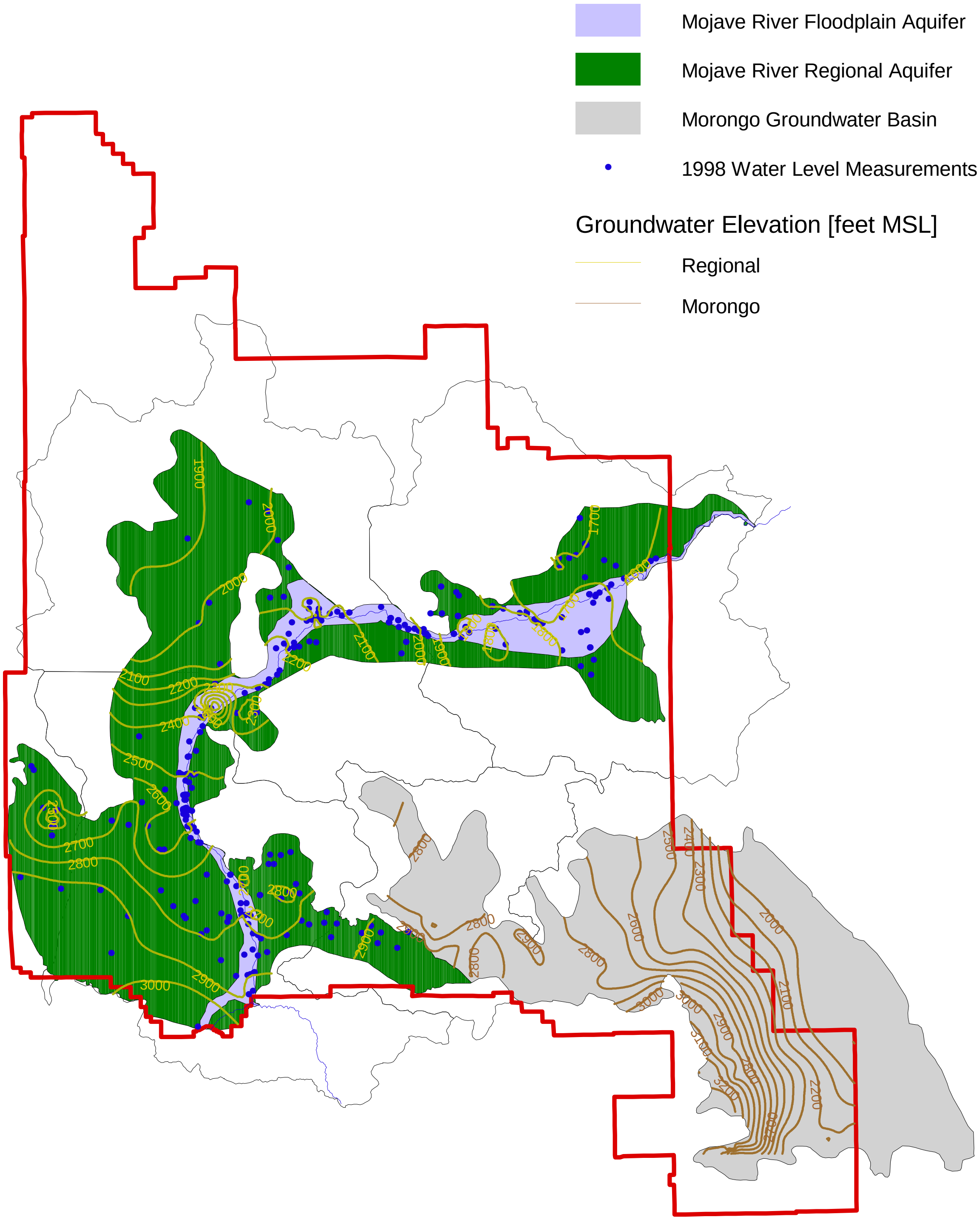
- Este Subarea – east to west on the southwest side of the Helendale Fault, changing to more northward at the Alto Subarea boundary. The Helendale Fault acts as a groundwater flow barrier, resulting in higher groundwater levels on the southwest side of the fault. On the northeast side of the fault, flow is radially inwards towards the northeast part of Lucerne (dry) Lake – an evaporation discharge site

- Oeste Subarea – south to north/northeast, with a dry lake in the northern part of the subarea (El Mirage Lake) that acts as an evaporation discharge site

- Alto Subarea – south to north/northeast

- Centro Subarea – south to north on the west side of Iron Mountain, leading to Harper Lake that acts as an evaporation discharge site. East of Iron Mountain there is flow south to north and northwest around the mountain, ending at Harper Lake, as well as flow to the east/northeast

- Baja Subarea – west to east/northeast towards Afton Canyon, with some flow heading northward to Coyote Lake – another evaporative discharge site



Schlumberger Water Services

1998 Water Level Contours

Mojave Water Agency
2004 Regional Water Management Plan

Figure 3-6

Date: January 2004

Prepared By: KTW

Groundwater flow in the Morongo Groundwater Basin east of the Este Subarea is generally from west to east-northeast (Figure 3-6). Natural recharge influx originates from the mountains on the southern and western boundaries of the basin – resulting in groundwater flow gradients to the north, east, and south adjacent to these boundaries, before turning to the east-northeast. Groundwater is almost universally flowing in an east-northeast direction to the eastern boundary of MWA. There is no water level data to verify whether the flow continues in this direction beyond MWA boundary. Localized groundwater flow conditions exist in the vicinity of the developed area of Yucca Valley, where there is an artificial recharge site.

The Regional Aquifer in the Morongo Groundwater Basin is composed of Quaternary and Tertiary sediments of continental origin, bounded and traversed by faults in many of the subbasins.[14] The sediments are unconsolidated near the surface, becoming partly consolidated and less permeable at depth; most well production comes from the unconsolidated section. Aquifer thickness is not well known throughout the basin, but is known to be greater than 750 feet near Yucca Valley and Joshua Tree based on well depths and is believed to be as much as 10,000 feet thick.[15] The aquifer system in the Morongo Groundwater Basin has not been characterized in detail. Water quality is not known at depth.

The major development in understanding the geology and hydrogeology of the Mojave Basin Area in the past few years has been a better differentiation of the alluvial aquifers that lie beneath and near the Mojave River, and in particular, the nature of groundwater flow through these units. In the past, the conceptual model for the alluvium that lies beneath the Mojave River has been more or less a homogeneous unit of interbedded sands, gravels, silts and clays. Recently studies have led researchers to conclude that the permeability of the alluvium changes significantly with horizontal and vertical distance from the river course, resulting in two interconnected aquifers: the Floodplain Aquifer and the Regional Aquifer.[16]

The new conceptual model is illustrated by the USGS cross-section[17] presented herein as Figure 3-4. Directly beneath the river, unconsolidated alluvium up to 250 feet thick called Recent Mojave River Alluvium (Qra) and Younger Mojave River Alluvium (Qya) has relatively high permeability with mostly clean sands and gravels, which results in rapid percolation of surface flow. In some places Qra and Qya are separated by a low permeability, clay-rich layer; this layer is most pervasive in the Alto Transition Zone. This alluvium (Qra and Qya) has been designated

[14] Smith and Pimentel 2000
[15] Moyle 1984
[16] Stamos, et al., 2001
[17] ibid

the Floodplain Aquifer. The aquifer extends in width from 120 feet at the Upper Narrows to more than five miles in parts of the Baja Subarea, as shown in Figure 3-1.[18]

One of the formations comprising the Regional Aquifer is an older unconsolidated alluvial unit called the Older Alluvium of the Ancestral Mojave River (QToa). This unit lies directly beneath and alongside the Qya alluvium, extending up to five miles on each side of the present river course – not always outcropping at the surface (Figure 3-4). The thickness of the unit is about 400 to 500 feet south of the Southern California Logistics Airport and about 25 to 80 feet north of that point.[19] The Older Alluvium has lower permeability than the Floodplain Aquifer units and is made up of fluvial sands, gravels, and silts deposited by the ancestral Mojave River during the middle Pleistocene (about 800,000 years ago).

The unique characteristics of the Floodplain and Regional Aquifers are important considerations for developing alternatives.

The other unit comprising the Regional Aquifer is the Undifferentiated Alluvium (QTu), which is generally less influenced by the recent and ancestral Mojave River. This is by far the largest alluvial unit in the basin, consisting of poorly sorted sands, gravels, silts, and clays. The Undifferentiated Alluvium has lower permeability than the alluvium deposited by the recent and ancestral Mojave River due to the accumulation of secondary cementing agents and poor grain sorting. Also, the permeability in this unit decreases with increasing depth, resulting in reduced flow between the upper 300 to 800 feet and lower zones (as deep as 2,000 feet). The surface boundaries of the two aquifers approximated by USGS are shown in Figure 3-1.

The difference in groundwater flow characteristics between the Floodplain and Regional aquifers is well illustrated by the difference in representative hydrologic properties. The two most important characteristics describing the occurrence and movement of groundwater are the rate at which water can move through a cross-section of the aquifer and the amount of water that can be drained from a volume of the aquifer; these characteristics are quantified by the properties of transmissivity and specific yield, respectively.

Transmissivity is directly proportional to a particular aquifer's thickness. Comparison of transmissivity estimates in the two aquifers, determined from well pumping analysis[20] and calibration of the USGS simulation model,[21] indicate that as much as a 10 to over 1,000 times greater amount of water can be moved across an identical width of the Floodplain Aquifer within

[18] ibid
[19] ibid
[20] Hardt 1971
[21] Stamos, et al., 2001

the same time period as compared to the Regional Aquifer. Comparison of specific yield estimates determined from calibration of the USGS simulation model[22] indicate that the Floodplain Aquifer can store about two to four times as much removable water per unit volume than the Regional Aquifer.

While the Floodplain and Regional aquifers have different hydrologic properties, they are connected hydraulically; that is, water and fluid pressure responses are transmitted between the aquifers.[23] Unlike many of the faults in the area that are barriers to flow, there is not a continuous impermeable barrier between the two aquifers; the geologic conceptual model is that the younger, higher permeability, unconsolidated alluvium of the Floodplain Aquifer lays directly on top of the older, lower permeability, unconsolidated alluvium of the Regional Aquifer.[24] The hydraulic connection between aquifers is supported by chemical and isotopic data which indicate that in areas near the river the Regional Aquifer contains water that was recharged by the Mojave River less than 50 years ago.[25] However, the same study concludes that the earliest the water at some distance from the Mojave River (located within the Regional Aquifer) has been recharged is on the order of thousands of years.

Recent groundwater simulation model runs by the USGS have shown that in the Alto, Transition Zone and Baja subareas the groundwater flowed from the Regional Aquifer to the Floodplain Aquifer during predevelopment conditions and from the Floodplain Aquifer to the Regional Aquifer (a reversal of flow) during the adjudication period from 1931-90.[26] In the Centro Subarea groundwater flowed from the Floodplain Aquifer to the Regional Aquifer during both periods, but the rate of flow increased significantly during the adjudication period. These results indicate that pumpage can cause changes in fluid pressure that can dramatically reverse and increase the amount of groundwater flowing from the Floodplain to the Regional Aquifer – further supporting the contention that the aquifer systems are connected. However, the results do not necessarily show that the reverse scenario is plausible – that changes in the pumpage or recharge can cause a large inflow of groundwater from the Regional to the Floodplain Aquifer.

---

[22] ibid
[23] Stamos et al. 2001b
[24] ibid
[25] Izbicki et al. 1995
[26] Stamos et al. 2001b

Nor do the results indicate how far into the Regional Aquifer, and at what rate, the inflow from the Floodplain Aquifer reaches.

The USGS has applied their model to simulate the effect of artificial recharge on groundwater levels in the Mojave River Groundwater Basin.[27] These modeled results show that 20 years of artificial recharge at eight sites along the Mojave River and a few locations in the Regional Aquifer markedly mitigate the decline in groundwater levels within a ten mile radius of the recharge sites, particularly compared to drought conditions. The simulation does not explicitly account for the movement of the artificial recharge water through the unsaturated zone to the water table, a process that could take a long time and result in considerable water losses. A chemical tracer study performed by the USGS at a potential artificial recharge site near Victorville (Alto Subarea)[28] in a wash off the main Mojave River channel concludes that it takes about 200 years for natural recharge water from an intermittent stream bed to infiltrate to the water table 130 meters below the surface. However, it should be noted that constant wetting from artificial recharge should considerably decrease the time required for water to reach the water table.

The significance of the recent geologic and hydrogeologic findings from a regional water management standpoint is that water moves through the Floodplain Aquifer at much higher rates than through the Regional Aquifer, although the two aquifers appear to be hydraulically linked. As a consequence, stresses originating from either of the aquifers can significantly affect groundwater flow direction and rates in the Floodplain Aquifer, as well as recharge rates from the Mojave River into the Floodplain Aquifer – which accounts for 80% of the total recharge to the Mojave River Groundwater Basin.[29]

The slow groundwater flow rates in the Regional Aquifer and the preferential groundwater flow path along the much more permeable Mojave River may make it difficult to recharge the pumping depressions in the Regional Aquifer by way of percolation ponds along the river. Therefore, overcoming low groundwater levels in pumping depressions that are away from the river will require recharge facilities overlying the Regional Aquifer. Further, because of the very low permeability zones layered within the undifferentiated alluvium that might restrict vertical migration of recharge water, injection wells should be investigated as a mechanism to recharge these areas.

---

[27] ibid
[28] Izbicki et al. 2000
[29] Stamos et al. 2001b

Another key finding is how significantly the numerous geologic faults impede groundwater flow in the basin. At least 12 of the faults that cross the basin (faults are shown in Figure 3-4), mostly in a northwest-southeast direction, are horizontal barriers, or partial barriers, to flow in the Regional Aquifer and, in some cases, the Floodplain Aquifer.[30] These faults are characterized by large, "stair step" drops in the water table across the faults and, in some cases, significant changes in the groundwater flow direction – indicating limited groundwater movement across the faults.

DWR Documentation of Overdraft Conditions

The Department of Water Resources' Bulletin 118 series documents conditions in California's groundwater basins. The 1980 edition of Bulletin 118 states that there is evidence of overdraft in the following basins: Lower Mojave River Valley, Middle Mojave River Valley, Upper Mojave River Valley, Harper Valley, Warren Valley and Lucerne Valley.

The 2003 edition of Bulletin 118 did not include an evaluation of individual groundwater basins to determine if they were in overdraft.

Efforts to Eliminate Overdraft

Each of the groundwater basins that are identified as being in overdraft in Bulletin 118 has been subjected to adjudication. The Lucerne Valley and Upper, Middle, and Lower Mojave River Valley basins are included in the Mojave Basin Area Judgment. The Warren Valley Basin is adjudicated by the Warren Valley Basin Judgment. The Mojave Basin Area and Warren Valley adjudications mandate that the groundwater extractions from each basin do not exceed the estimated annual supplies, and empower the Watermasters of each basin to enforce pumping limits to ensure that the groundwater basins are not overdrafted.

One of the fundamental objectives of this Plan is to "balance future water demands with available supplies recognizing the need to stabilize the groundwater basin storage balance over long-term hydrologic cycles." As part of preparation of this Plan update, projects and management actions were identified that would allow MWA to meet this objective by 2020 while also meeting a second objective to "maximize the overall beneficial use of water throughout MWA by supplying water in quantity and of quality suitable to the various beneficial uses." These objectives are described in greater detail in Chapter 9.

[30] ibid

Surface Water

Riparian Habitat/Wetlands

Within the Mojave Water Agency boundaries are various habitat types that are mostly characterized by desert plants and animals. However, there are some important wetland and riparian areas that exist along the Mojave River, Harper Dry Lake, portions of Sheep Creek, and various other drainages. How the agency addresses these areas is mostly dependent on whether they lie within, or outside, the Mojave Basin adjudicated area and Exhibit H to the Judgment. Exhibit H outlines a Biological Resource Mitigation Trust Fund that provides funding to support water table elevations that DFG proposes as necessary to maintain the riparian habitat of these areas, including specific species. Specific wells and monitoring locations are established in Exhibit H. A biological mitigation fund is described which will be expended for mitigation if certain criteria aren't met. For a detailed list of species, monitoring requirements, and biological trust fund conditions please refer to Exhibit H of the Mojave River Area Judgment located in Appendix A of this Plan.

Exhibit H

Exhibit H of the Mojave River Area Judgment defines riparian areas to be maintained in the Mojave River Floodplain from approximately the Upper Narrows to the Lower Narrows, the Lower Narrows to the Helendale Fault, Transition Zone, and the Baja Subarea reach of the Mojave River also referred to as the Camp Cady area (refer to habitat figures in Exhibit H). Mitigations defined for these riparian areas consist of hydrologic flow requirements and groundwater or surface water elevations.

Exhibit H specifies the flow desired by Fish and Game to maintain riparian habitat in the Transition Zone to be 21,000 acre-feet per year. Much of the flow in the Transition Zone comes from the wastewater treatment facility owned and operated by the Victor Valley Wastewater Reclamation Authority (VVWRA) who is not a party to the adjudication. In order to assure maintenance of the riparian area in the Transition Zone, DFG entered into a Memorandum of Understanding with VVWRA in July 2003 to maintain flows from the wastewater treatment facility that will, in conjunction with base flow, provide 15,000 acre-feet per year to the Transition Zone. VVWRA discharge obligations will be limited to 9,000 acre-feet per year from the treatment facility. This MOU was entered into to ensure that any construction and operation of sub-regional treatment facilities would not adversely affect the riparian areas of the Transition Zone.

Riparian areas between the Upper and Lower Narrows consist mostly of Cottonwood Willow habitat that is in fairly good condition. The San Bernardino County Flood Control District does regular mechanical maintenance of the channel, and the area is highly urbanized. DFG is not currently concentrating efforts to restore habitat in this area.[31]

As recent as the mid-1970s, the Camp Cady area had thriving Mesquite groves with three ponds in the central and eastern sections. Since then, groundwater elevations have dropped about 40 feet and most of the Mesquite trees on the western end are dead or dying. Flood flows in the 1990s damaged earthen dikes impounding water in the channel and the ponds have since emptied leaving little water in the river channel. DFG has purchased property at the western edge of this area and is focusing efforts on maintaining channel flows, and perhaps reestablishing surface water ponding, to provide habitat for terrestrial animals.

Groundwater levels were established in Exhibit H for key wells in the Mojave River floodplain. These wells, and their associated groundwater levels as measured from the ground surface to standing water are included below in Table 3-2.

Table 3-2: Groundwater Elevations Established in Exhibit H

Well	Location	Groundwater Level (feet)
H1-1	Victorville/Alto zone (upper Narrows area)	7.0 below surface
H1-2	Victorville/Alto zone (upper Narrows area)	7.0 below surface
H2-1	Lower Narrows/Transition Zone zone	10.0 below surface
H3-1	Harvard/Eastern Baja Riparian Forest Habitat (Camp Cady Area)	7.0 below surface
H3-2	Harvard/Eastern Baja Riparian Forest Habitat (Camp Cady Area)	1.0 above surface

Note: Of these wells, only H3-1 has been installed; other monitoring is accomplished using surrogate wells or gauging stations (L. Eckhart, personal communication, November 26, 2003).

Areas outside Exhibit H

There are also riparian areas outside of the adjudicated area boundary both within and outside the MWA service area. Most notably are riparian areas from Big Bear to the adjudicated area along the Deep Creek, the Western Fork of the Mojave River from Silverwood Lake, the Afton Canyon area on the eastern end of the adjudicated area, and areas in Harper Dry Lake and Lucerne Valley.[32]

Most of the land along Deep Creek is owned and managed by the U.S. Forest Service. The riparian habitat from the Fish Hatchery to the adjudicated area is in good condition. An area known as Rancho Los Flores has riparian habitat in good condition that is currently under

[31] T. Billhorn, personal communication, Nov. 17, 2003
[32] B. Jones, personal communication, Nov. 24, 2003

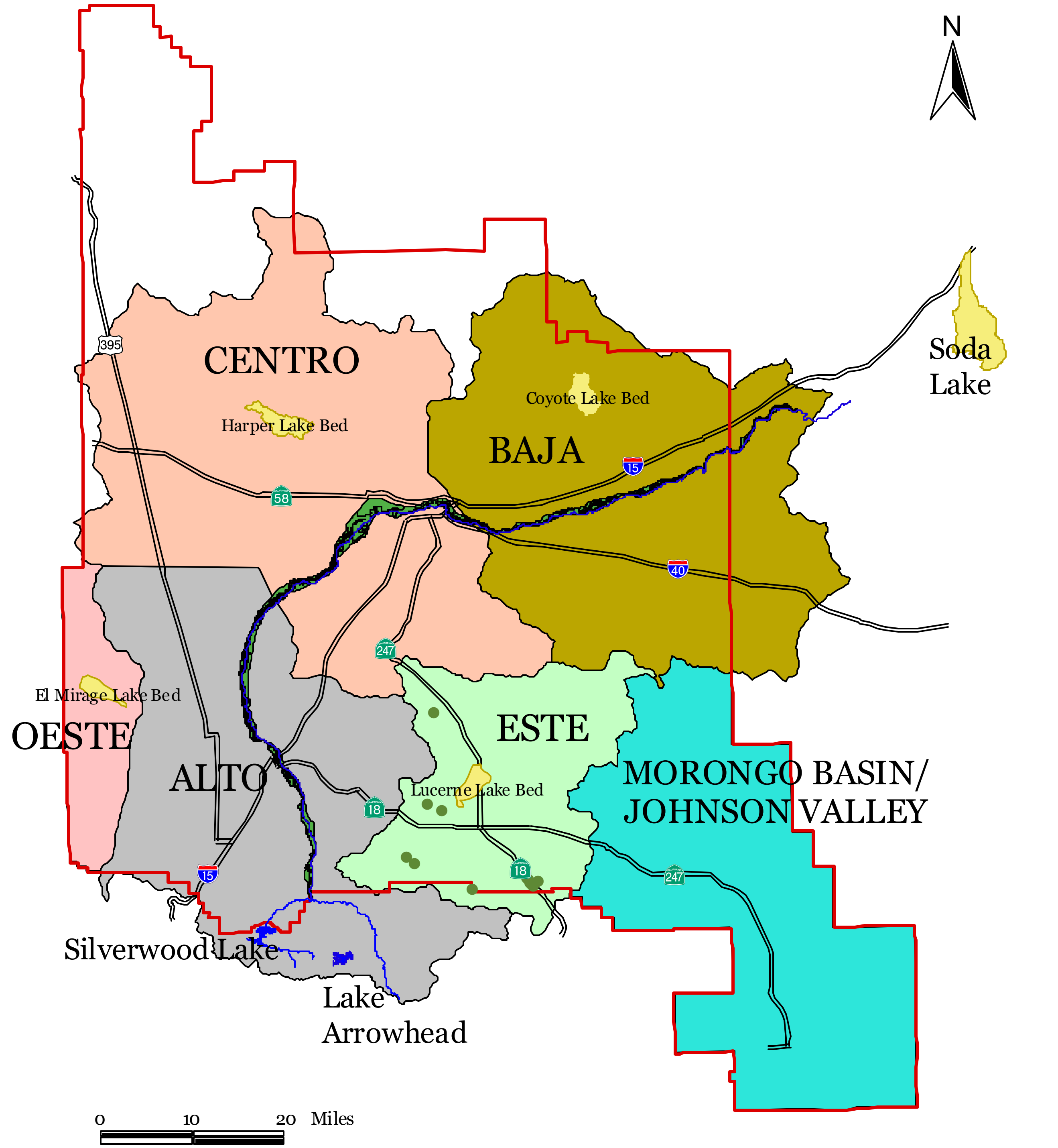
pressure from development. The DFG is working with the developers to address these issues. The Fish Hatchery diverts about 9,000 acre-feet per year of water, but most of this is returned to the river after flowing through the hatchery.

Harper Dry Lake has federally-designated wetlands (marked by emergent vegetation) that historically were maintained mostly by agricultural irrigation runoff from the Most agricultural property that went out of business in the early 1990s. Since then, the Bureau of Land Management (BLM) has been working with FPL Energy Operating Services, a company that manages a nearby solar power plant, to reestablish flows to specific marsh areas, mostly the southeastern portion of Harper Dry Lake. The California Energy Commission made enhancement of the marsh areas a condition of the power plant permit and incorporated this into the mitigation measures. BLM designated this area a Watchable Wildlife Area, which has abundant wildlife species including migrant waterfowl. BLM is currently looking to acquire more property in the area to further enhance the wetland areas.

Lucerne Valley has some riparian areas scattered mainly around washes and springs along the mountain ranges to the south. These areas include Rabbit Springs, Old Woman Springs, and various washes. Most of these properties, such as Rabbit Springs, are in private ownership. The habitat is marked by Cottonwood/Willow habitat with many sensitive species. The source of water for these areas is naturally occurring springs that continue to produce good quality water. Most of the habitat is located at spots along the Helendale fault. There are groups of individuals working with the property owners to preserve portions of the riparian areas on the property.[33]

Afton Canyon Natural Area is located 37 miles northeast of Barstow along Interstate 15 between the Afton Road and Basin Road exits. Afton Canyon is designated as an Area of Critical Environmental Concern to protect plant and wildlife habitat, and to preserve scenic values of the riparian area within the canyon. Afton Canyon is one of two stretches of the Mojave River that maintains continuous flow throughout the year. The BLM is currently in the fourth year of a multi-year effort to restore the riparian and wetland values in the area. Riparian areas determined by MWA are shown in Figure 3-7.

[33] C. Bell, personal communication, Nov. 25, 2003



MWA boundary | Riparian locations | Riparian vegetation

Schlumberger Water Services	**Riparian Habitat and Dry Lake Beds** Mojave Water Agency 2004 Regional Water Management Plan	Figure 3-7 November 2003 Prepared by: KTW

Climate

The Mojave Water Agency maintains a Climatology Network that consists of 14 weather stations collecting various weather data on temperature, precipitation, and evaporation. Rain gages are mostly located within the Mojave Basin Area and the surrounding mountains. Runoff in the upper watershed contributes substantially more to the recharge of the basin than precipitation falling in the basin. Average rainfall within the lower lying areas of the Mojave Basin Area and Morongo Basin/Johnson Valley area is roughly five inches per year. Data for precipitation at the Lake Arrowhead gage, located in the San Bernardino Mountains, was analyzed to evaluate the extreme annual variations in stream flow. The average yearly precipitation at this gage is 43.2 inches per year. The standard deviation about the mean is 19.7 inches per year. This high standard deviation correlates to large fluctuations in the annual amount of rainfall received in the San Bernardino and San Gabriel Mountains – the former being the primary source of recharge for the groundwater basin. The large variation in annual rainfall within the surrounding mountains directly affects the annual water supply of the basin, and is further discussed in Chapter 4 of this Plan.

Wastewater

Wastewater is imported to the Mojave Basin Area from the Lake Arrowhead Community Services District, Big Bear Area Regional Wastewater Agency, and Crestline Sanitation District.[34] In 2000, the Alto Subarea received 1,941 acre-feet from the Lake Arrowhead CSD, discharged into the Mojave River about two miles downstream of the Forks. The Crestline Sanitation District discharged 863 acre-feet into the Alto subarea upstream of the West Fork gage at the Los Flores Ranch. In 2000, the Este Subarea received 2,600 acre-feet from Big Bear ARWWA, discharged near Camp Rock Road and Highway 247 in the Lucerne Valley.

The City of Adelanto, the City of Barstow, and the Victor Valley Wastewater Reclamation Authority (VVWRA) provide wastewater collection and treatment services within the Mojave Water Agencies boundaries. The VVWRA serves Victorville, Hesperia, Apple Valley, and San Bernardino County Service Areas 42 and 64. VVWRA is by far the largest of the wastewater agencies with a current treatment capacity of 11.0 million gallons per day (MGD) with plans to expand by another 7.0 to 8.5 MGD by 2020. The City of Adelanto treats 1.2 MGD while the City of Barstow treats 0.066 MGD. County Service Area 70-C serves Silver Lakes. The USMC camp at Nebo also provides wastewater treatment services. There are currently no users of reclaimed wastewater in the MWA service area, although there are a number of entities identified to receive reclaimed wastewater in the future.

[34] Mojave Basin Area Watermaster 2001

The City of Adelanto

The City of Adelanto currently treats 1.2 MGD of wastewater and discharges this quantity to percolation ponds.

The City of Barstow

The City of Barstow collects wastewater through a system constructed starting in 1939. Barstow currently contracts the operation of its wastewater collection and treatment system. The system has the capacity to treat 7.5 MGD through aeration basins, secondary clarifiers, a chlorine contact chamber, and a chlorine contact lagoon. After treatment, the effluent is discharged to the Mojave River adjacent to the treatment facilities. Currently the City collects and treats 66 thousand gallons per day (0.066 MGD) of wastewater. With anticipated growth, the treatment plant is anticipated to treat 1.75 MGD by 2020. There is currently no wastewater recycling activity nor are there plans to recycle wastewater in the future.[35]

Victor Valley Wastewater Reclamation Authority

VVWRA conveys wastewater using 40.5 miles of interceptor sewer and two pump stations to its Regional Wastewater Reclamation Plant. Approximately 9.8 MGD is currently treated at the VVWRA facility which has a capacity of 11.0 MGD. Processes employed include screening, grit removal, primary clarification, biological oxidation of wastes with complete nitrification and partial denitrification, secondary clarification, coagulation, flocculation, filtration, and disinfection. Dissolved air flotation thickening and anaerobic digestion stabilizes biosolids that are then dewatered and dried prior to disposal via direct agricultural land application or by mixing with finished compost for agricultural markets. The reclaimed water is then discharged directly into the Mojave River channel or percolated into ponds in the Floodplain Aquifer. VVWRA and the Department of Fish and Game entered into an MOU to provide minimum discharge of approximately 9,000 acre-feet per year (24.7 acre-feet per day) to the Mojave River Channel to support riparian vegetation and habitat.

VVWRA estimates that its capacity to collect and treat wastewater with the existing facilities will be surpassed around 2006.[36] VVWRA estimates that the wastewater flow by 2020 will be approximately 18.62 MGD. The current plan for dealing with the additional growth and increase in wastewater treatment requirements is to construct two sub-regional recycled water facilities by the year 2005. Another two sub-regional facilities are projected to be built by 2010. These facilities will provide additional wastewater treatment and at the same time, produce recycled

[35] City of Barstow General Plan – Part C, Chapter VI.2 Utilities and Public Services, Technical Report 4/20/1997

[36] Sewerage Facilities Plan Update, Year 2000 Amendment, Adopted by the VVWRA Board of Commissioners October 26, 2000.

water for the surrounding communities. There are currently no off-site consumers of reclaimed wastewater in the VVWRA service area although in June 2003 the Lahontan Regional Water Quality Control Board granted VVWRA a permit to use recycled water to irrigate the golf course and landscaped areas at the Southern California Logistics Airport. The project represents VVWRA's first off-site recycled water use project (landscaping at the treatment facility on Shay Road is already irrigated with recycled water, and recycled water is used for processing, dust control, and fire protection at the on-site regional compost facility). 131 potential recycled water customers have been identified with a combined need for about 37,400 acre-feet per year (afy). Twenty-two large customers were identified with a total need for 8,677 afy including several golf courses, parks, municipalities, and schools. The quantity of expected wastewater flows is described in Table 3-3 in 5-year increments to 2020.

Table 3-3: Total Wastewater Flow Projections (MGD)

Member Agency	2000	2005	2010	2015	2020
Victorville including SCLA	5.38	6.33	7.58	8.96	10.29
CSA 42	0.05	0.05	0.05	0.05	0.05
CSA 64	0.74	0.89	1.04	1.21	1.28
Apple Valley	1.46	1.87	2.26	2.80	3.42
Hesperia	1.06	1.52	2.07	2.75	3.58
Total	**8.69**	**10.66**	**13.00**	**15.77**	**18.62**

Based on the assumption that all of the additional flows would be recycled, and the identified possible users, the projected recycled wastewater that will be produced and used is shown in Table 3-4.

Table 3-4: Recycled Water Projections (MGD)

Member Agency	2000	2005	2010	2015	2020
Victorville including SCLA	0.00	0.95	2.20	3.58	4.91
CSA 42	0.00	0.00	0.00	0.00	0.00
CSA 64	0.00	0.15	0.30	0.47	0.54
Apple Valley	0.00	0.41	0.80	1.34	1.96
Hesperia	0.00	0.46	1.01	1.69	2.52
Total	**0.00**	**1.97**	**4.31**	**7.08**	**9.93**

The estimated cost to provide facilities to reclaim the projected amount of wastewater is $75 million to $125 million. Annual operation and maintenance costs for each subregional facility ranges from $0.55 to $1.13 million. The project is to be funded from a number of federal or state grants and low-interest loans obtained through the State Revolving Fund. Consultants have been retained to provide engineering and environmental documentation services for the four subregional treatment facilities. The cost of providing reclaimed water, transmission infrastructure, and ownership of distribution facilities has yet to be determined.

The Wastewater Reclamation and Recycling Program address a number of issues in the VVWRA service area. The need for additional collection and transmission facilities, the desire of the member agencies to use water as wisely as possible, and the need for additional treatment capacity have all contributed to the aggressive pursuit of this program.

4

Water Supply

This chapter reviews the current understanding of the water supply within the Mojave Water Agency (MWA). The variability of water supply and delivery capability of the State Water Project (SWP) are summarized. Actual water deliveries from the SWP to the MWA from 1978-2001 are also presented.

Mojave Basin Area

A summary of the water supply for the Mojave Basin Area is included in this section based on the average and median surface water inflows. The average and median water supplies are compared to illustrate the extreme variations in annual water supply for the Basin. Elements of water supply examined in this section include: gaged surface flow, ungaged surface flow, subsurface flow, deep percolation of precipitation, wastewater imports, and phreatophyte consumption.

Water supplies in the Mojave Water Agency service area are highly variable – an important factor in developing project alternatives.

Gaged Surface Inflow and Outflow

The average water supply to the basin during the period 1931-2001 was determined in part from U.S. Geological Survey (USGS) stream gage records. A review of these records indicates the flow of the river and thus the Basin water supply is highly variable.

A number of sites on the Mojave River have historically been monitored for surface flow. Records for some sites extend as far back as 1900. Consistent records are available from 1931 when USGS established gaging stations on the Mojave River. Consequently, data from 1931 and forward are utilized for water supply planning purposes.

Five stream gage locations with records to at least 1931 are currently monitored on the Mojave River. Table 4-1 summarizes these gages, indicating the period of record, average, median, peak and minimum flow at each gage. The stream gages are maintained and operated by the USGS under a cooperative program with MWA. All gages currently in operation record river stage data in fifteen-minute increments. USGS personnel take a direct stream measurement at least once a month and more frequently during storm events. The Lower Narrows Gage has direct measurements taken at least once a week.

Table 4-1: Mojave River Stream Gages

Gage Name and Station Number	Period of Record[1]	Average Flow[2]	Median Flow[2]	Peak Flow[2] (Year)	Minimum Flow[2] (Year)
West Fork Near Hesperia (10261000)[3]	1930	23,500	6,200	134,400 (1978)	0 (1951)
Deep Creek Near Hesperia (10260500)	1905	47,800	21,000	304,400 (1993)	2,200 (1951)
Lower Narrows Near Victorville (10261500)[4]	1900	52,400	23,200	298,500 (1969)	5,300 (2001)
Barstow (10262500)	1931	16,700	0	151,800 (1969)	0 (Many)
Afton (10263000)	1930-32, 1952-78, 1981-02[5]	8,100	900	75,600 (1969)	200 (1975)

[1]All gages listed are currently operational.
[2.]For period of record 1931-2001. Flow refers to acre-feet per year.
[3.]The USGS has operated two gages at West Fork since 1930, 10261000 and 10260950.
[4]The Lower Narrows Gage was located about 3 miles upstream from its current location and operated there from 1900-1906 and 1931-36.
[5]USGS has estimated the record for the missing periods.

Three additional sites on the Mojave River were previously gaged to monitor stream flow. These sites were eventually determined to be unsuitable primarily due to unstable controls and changing stage-discharge relationships, and were abandoned. The sites and their periods of record include Below Forks Near Hesperia (1972– 96), Wild's Crossing Near Helendale (1967-70) and Hodge (1931, 1971-92).

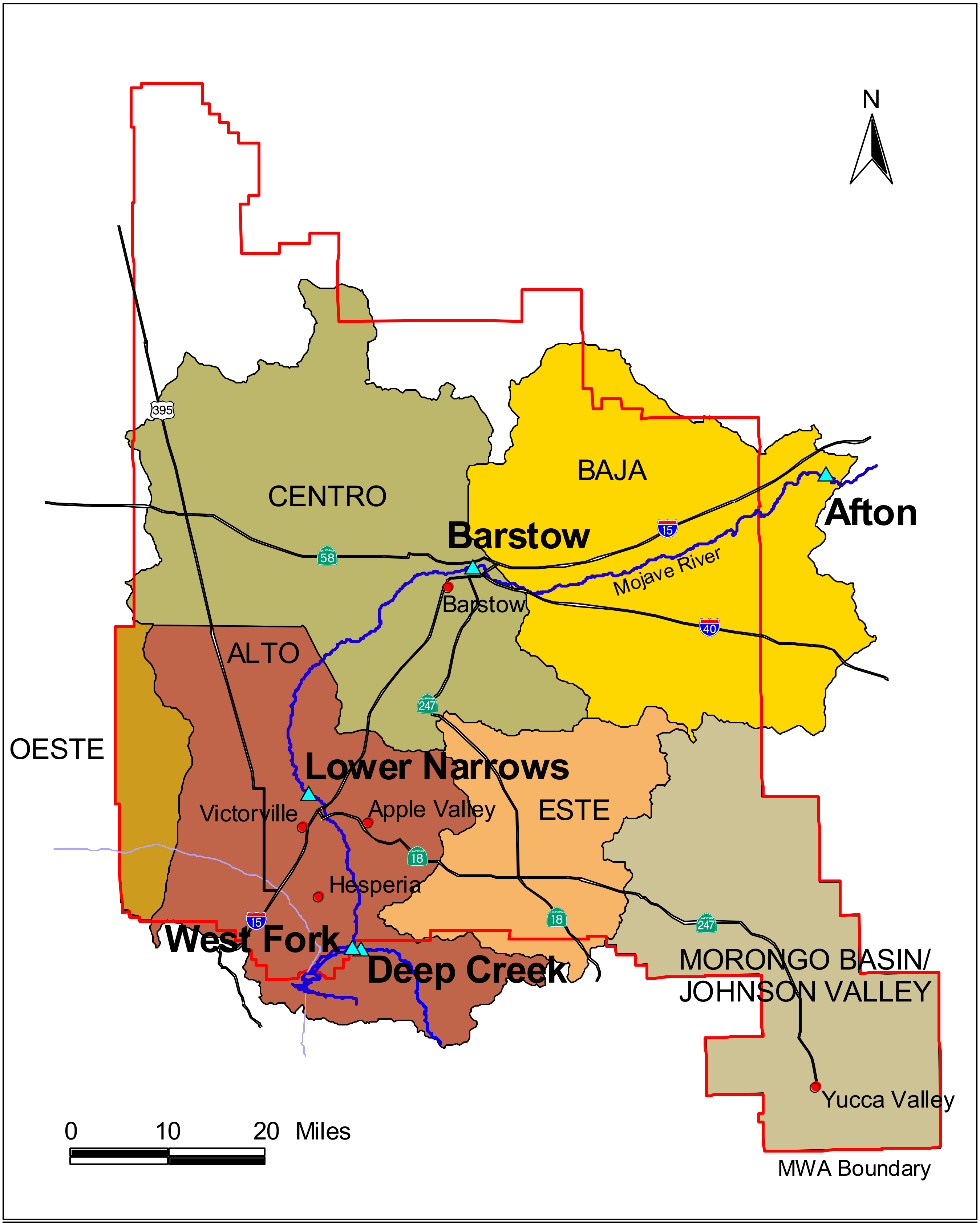
Figure 4-1 shows the location of the operating stream gages summarized in Table 4-1. The Deep Creek station is located about 1 mile upstream of the confluence with the West Fork of the Mojave River (known as the "Forks"). The drainage area tributary to the Deep Creek Gage is 134 square miles.

Two gaging stations have been operated on the West Fork of the Mojave River. The first station (10261000) was located approximately 0.5 mile upstream of the Forks and operated from 1930-71, before the construction of the Cedar Springs Dam at Silverwood Lake and the Mojave River Dam at the Forks. The second station (10260950) is located approximately 0.6 mile upstream of the Forks and has been operated since 1974. The drainage area tributary to the West Fork Gage is 70.3 square miles.

The dam at the Forks is ungated and serves to attenuate peak flows during large storm events and prevent downstream flooding. The flow at this location constitutes the primary water supply to the main stem of the Mojave River; consequently, the combined data from the Deep Creek and West Fork gages represent the total flow at the headwaters of the Mojave River. The average annual discharge at the Forks is 71,300 acre-feet for the period 1931 through 2001.

The source of water at the Forks is runoff from snowmelt and rainfall originating in the San Bernardino Mountains. Lower velocity flows from snowmelt and smaller storm events usually percolate into the riverbed a short distance downstream of the Forks. The surface water tends to flow in a northerly direction within the river channel towards the Narrows, which is approximately five miles in length and is subdivided into the Upper and Lower Narrows. The groundwater gradient is in the same general direction and groundwater is discharged into the River upstream of the Upper Narrows about 12 miles below the Forks. This occurs due to shallow bedrock that forces groundwater back into the River channel.

The Lower Narrows gage is located approximately 18 miles downstream of the Forks near the City of Victorville. The drainage area tributary to the gage is 513 square miles. A second gage was installed at this site in 1996 to refine recordings of low flows. The low flow gage was washed out in the winter of 1998 and replaced the following summer.



Schlumberger Water Services

Stream Guage Locations

Mojave Water Agency
Regional Water Management Plan Update

Figure 4-1

Date: January 2004

Prepared By: KTW

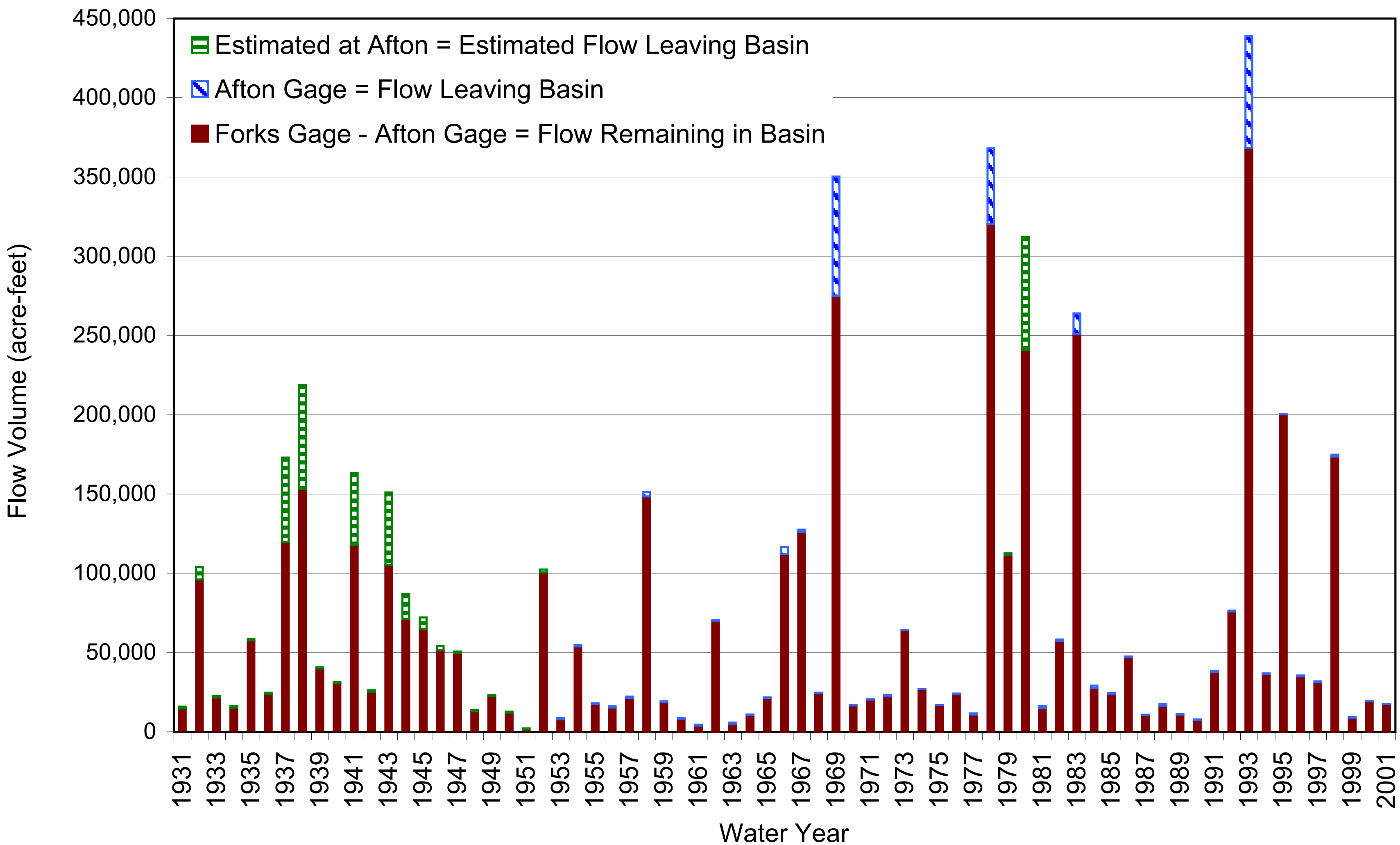
Data from this site is used to determine compliance with obligations for the maintenance of a certain minimum base flow from the Alto to the Centro Subarea as mandated by the Mojave Basin Area Judgment (1996). Base flow is defined by the Judgment as "that portion of the total surface flow measured annually at Lower Narrows which remains after subtracting storm flow." The average annual discharge of total flows at Lower Narrows is 52,400 acre-feet for the period from 1931 to 2001. Base flow there has historically been as high as 26,700 acre-feet in Water Year 1940-41 and averaged approximately 21,000 acre per year for the period 1931-90. The base flow at the Lower Narrows in Water Year 2001 is at a historic low of 5,345 acre-feet.

Base flow leaving the Lower Narrows region quickly infiltrates back into the river channel. Surface flows are augmented about 22 miles downstream of the Forks (4 miles downstream of the Lower Narrows) by discharges from the Victor Valley Wastewater Reclamation Authority (VVWRA). The discharges from the treatment plant continue as surface flows for about 4 miles nearly to the community of Silver Lakes. Discharges from the VVWRA totaled 9,006 acre-feet in Water Year 2000.

The Barstow gage is approximately 53 miles downstream from the Forks. This gage site is typically dry because the River flows at Barstow only in response to large storm events in the watershed. The average annual discharge at this location is 16,700 acre-feet for the period from 1931 to 2001. The Barstow gage has recorded surface flow in 35 of the 71 years of operation. The tributary drainage area is 1,291 square miles.

The Afton gage is located about 100 miles downstream of the Forks and is about 6 miles downstream (east) of the eastern boundary of the Baja Subarea, providing a measure of surface water exiting the Mojave Basin Area. The Afton gage generally has a small component of baseflow, caused by thinning of the aquifer and associated low groundwater discharge. In some years the base flow has ceased, but averages about 400 acre-feet per year. The combined baseflow and stormflow results in an average annual discharge of 8,100 acre-feet at the Afton gage between 1931 and 2001. The drainage area for the Afton site is 2,121 square miles.

The stream gage data demonstrate that the majority of flow in the Mojave River is retained (recharged) in the Basin. During approximately 80% of the recorded years, discharge at the Afton gage averaged less than 1,000 acre-feet. The average difference between flow entering the Basin at the Forks and flow leaving the Basin at Afton is roughly 63,200 acre-feet per year during 1931 through 2001. Figure 4-2 compares the total flow entering the Basin to the total flow exiting the Basin annually. In most years, almost all of the surface water entering the Basin infiltrates within the Basin. Records show that a few large flows pass the Afton gage every nine



Schlumberger Water Services

Annual Volume of Gaged Surface Water Entering and Exiting the Basin (1931-2001)

Mojave Water Agency
Regional Water Management Plan Update

Figure 4-2

Date: January 2004

Prepared By: KTW

years on average. However, the recharge from these large storm event years (inflows minus outflows) contributes substantial amounts of water to the regional groundwater supply, and almost all of the water supply to the Centro and Baja subareas.

Annual Variability of Water Supply

Average water supplies derived from a specific period of record are typically selected to be representative of long-term water supply conditions. Precipitation and runoff are highly variable and reliance upon an inappropriate period of record will misrepresent the quantity of water that may be available over the longer term. A representative hydrologic base period should contain a distribution of wet, dry and normal years. Determining average water supplies in this manner provides some certainty to the process of planning for the quantity of water that should be available and can accrue to groundwater storage.

The 1994 RWMP and the Mojave Basin Area Judgment utilize the hydrologic base period encompassing Water Years 1931 through 1990. This period was selected because the data available for the gages was continuous. The average flow at the Forks from 1931-90 was 65,000 acre-feet, with annual flows ranging from less than 6,500 acre-feet to more than 360,000 acre-feet. The median flow at the Forks for this same period was 24,700 acre-feet. Given the range of measured annual flows during this 60-year period, the median flow is the best representation of the amount of supply that can be expected in any given year over a long-term period.

A plot of the accumulated annual departure from the base period (1931-1990) average of 65,000 acre-feet for surface flows measured at the Forks is shown in Figure 4-3. This plot illustrates water supply trends on an annual basis for inflow recorded at the Forks. A negative sloping line from one water year to the next indicates a below average inflow and a positive sloping line indicates an above average inflow. The purpose of Figure 4-3 is to illustrate that since the base period (1931-1990) average of 65,000 acre-feet was established, the basin has experienced a wetter hydrologic period relative to that established average. This report recognizes the recent wet period (1991-2001) and utilizes this hydrologic data to calculate an updated basin water supply.

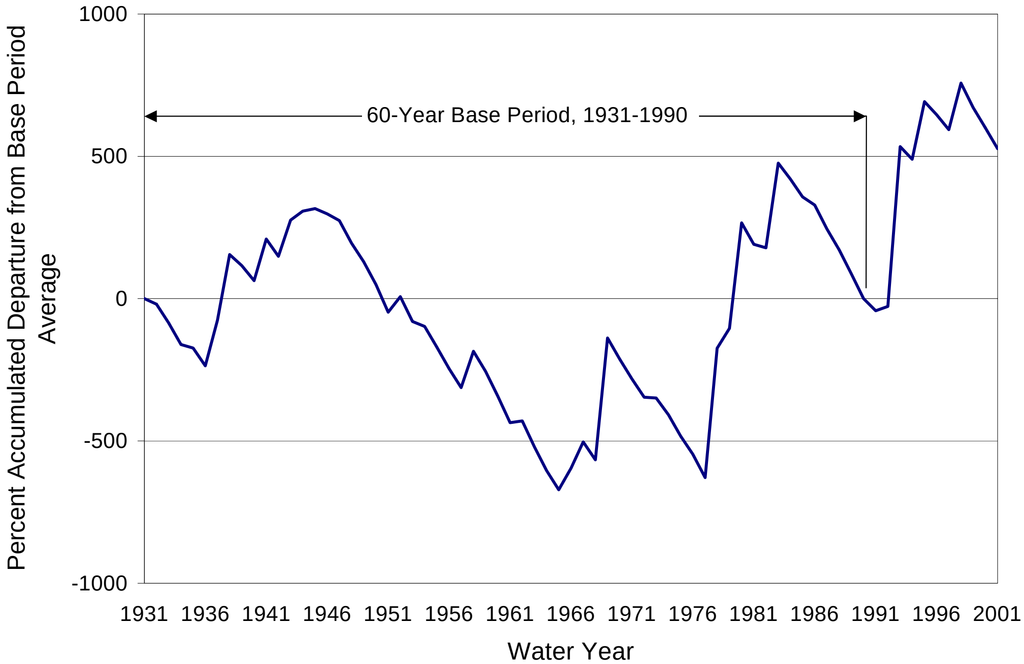


Figure 4-3: Accumulated Departure from Base Period (1931-1990) Average for Seasonal Discharge at the Forks

Extreme variations in streamflow have occurred at the Forks during the period of record. Annual values have ranged from 6,380 acre-feet to 428,700 acre-feet between 1931 and 2001. The extreme variations in streamflow at the Forks result in large annual fluctuations in available groundwater recharge.

Figure 4-4 displays a plot of exceedence probabilities for discharge at the Forks. The exceedence probability plot illustrates how often an annual flow of a certain magnitude isexpected to occur. As an example, the average annual flow at the Forks is 71,300 acre-feet for 1931-2001. As shown on Figure 4-4, this average is weighted by the larger events that occur sporadically. Approximately 68% of the annual recorded flows have been below this average and 32% have been above this average. This should be considered for planning periods of five years or less because annual inflows less than the average volume are likely to occur in two out of three years. Statistically, three to five-year periods will occur where inflows to the basin will be well below the average total inflow. The basin is more likely to receive annual inflows closer to the median inflow of 27,200 acre-feet per year based on the period of record from 1931-2001. This means that half of the time the basin will receive more than 27,200 acre-feet per year and less than 27,200 acre-feet per year the rest of the time. Water supply planning alternatives should consider the effect that variations from the average supply might have on any proposed alternatives.

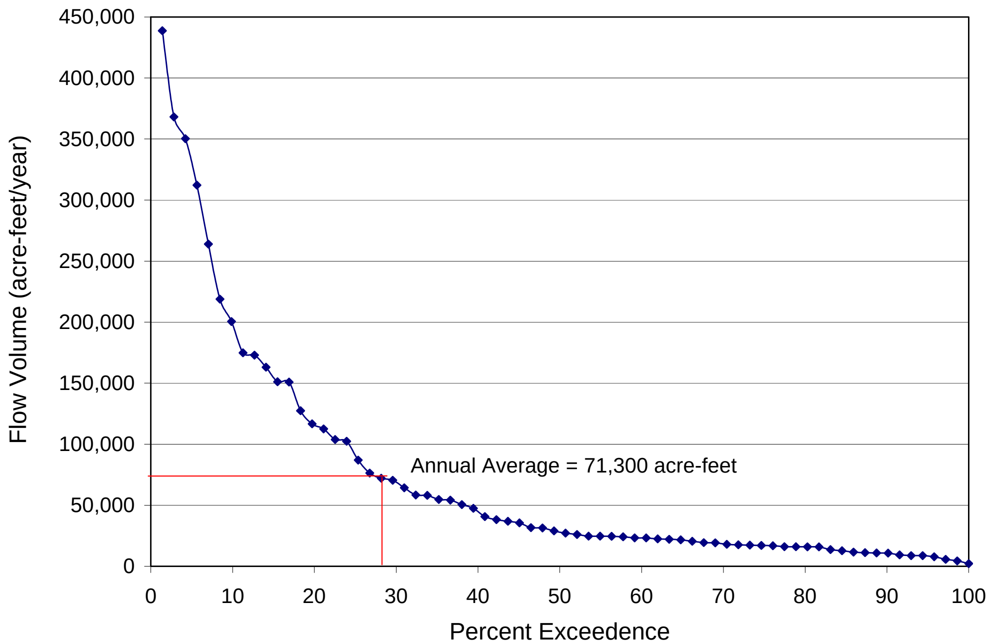


Figure 4-4: Percent Exceedence at the Forks (1931-2001)

Ungaged Surface Inflow and Outflow

Table 4-2 shows that an estimated 7,200 acre-feet of ungaged water flows annually into the Este, Oeste, Alto, and Baja subareas of the Mojave Basin Area (Webb 2000). The only surface water outflow in the Mojave Basin Area is gaged through Afton Canyon.

Table 4-2: Mojave Basin Area - Net Average Annual Water Supply

	Este	Oeste	Alto	Centro	Baja	Entire Basin
WATER SUPPLY						
Surface Water Inflow						
Gaged	0	0	71,300 [a]	0	0	71,300
Ungaged	1,700	1,500	3,600	34,700 [1]	14,400 [2]	7,200[3]
Subsurface Inflow	0	0	1,200	2,000	1,200	0[4]
Deep Percolation of Precipitation	0	0	3,500	0	100	3,600[5]
Import Wastewater						
Lake Arrowhead CSD	0	0	1,900	0	0	1,900[6]
Big Bear ARWWA	2,600	0	0	0	0	2,600[6]
Crestline Sanitation District	0	0	900	0	0	900[6]
Total:	**4,300**	**1,500**	**82,400**	**36,700**	**15,700**	**87,500**
OUTFLOW AND LOSSES						
Surface Water Outflow						
Gaged	0	0	0	0	8,100 [b]	8,100
Ungaged	0	0	34,700 [1]	14,000 [7]	0	0[4]
Subsurface Outflow	800	400	2,000	1,200	0	0[4]
Phreatophyte Consumption	0	0	11,000 [8]	3,000 [8]	2,000 [8]	16,000
Total:	**800**	**400**	**47,700**	**18,200**	**10,100**	**24,100**
					NET AVERAGE ANNUAL WATER SUPPLY:	**63,400**

[1]Estimates taken from Webb 2000

[2]Includes 14,000 ac.ft. of Mojave River flow from Centro and 400 ac.ft. of inflow from Kane Wash and Boom Creek; estimates taken from Webb 2000

[3]Sum of ungaged surface water inflows less ungaged surface water outflows; estimates taken from Webb 2000

[4]All subsurface flow is assumed to exchange within subareas (no external inflows or outflows). No external ungaged surface water outflow

[5]Estimates taken from Webb 2000

[6]Mojave Basin Area Watermaster 2001

[7]From reported flows at USGS gaging station, Mojave River at Barstow

[8]Phreatophyte consumption taken from Lines and Bilhorn (1996)

a Period of record from 1931-2001

b Period of record from 1931-2001; 1931-1952 are estimated values

Subsurface Flow

Table 4-2 summarizes the subsurface inflow for the subareas within the Mojave Basin Area. No significant amount of groundwater is exchanged with areas outside the Mojave Basin Area. However, subsurface exchange does occur between subareas within the Basin (Webb 2000).

Approximately 1,200 acre-feet of groundwater combined annually flows from Este and Oeste to Alto; 2,000 acre-feet flows from Alto to Centro; and 1,200 acre-feet per year flows from Centro to Baja.

Deep Percolation of Precipitation

An estimated 3,600 acre-feet of deep percolation of precipitation occurs annually in the Mojave Basin Area as shown on Table 4-2 (Webb 2000). The majority of the deep percolation of precipitation takes place in the Alto Subarea (3,500 acre-feet per year) and a minor component takes place in the Baja Subarea (100 acre-feet per year).

Wastewater Imports

Wastewater is imported to the Mojave Basin Area from the Lake Arrowhead Community Services District, Big Bear Area Regional Wastewater Agency, and Crestline Sanitation District (Mojave Basin Area Watermaster 2001). In 2000, the Alto Subarea received 1,941 acre-feet from the Lake Arrowhead CSD, discharged into the Mojave River about 2 miles downstream of the Forks near the City of Hesperia. The Crestline Sanitation District discharged 863 acre-feet into Alto upstream of the West Fork gage at the Los Flores Ranch. In 2000, the Este Subarea received 2,600 acre-feet from Big Bear ARWWA, discharged near Camp Rock Road and Highway 247 in the Lucerne Valley.

Phreatophyte Consumption

The most recent estimate of annual phreatophyte consumption is 16,000 acre-feet for 10,000 acres of riparian vegetation. The data is derived from analysis prepared in 1995 in a cooperative effort between the USGS, California Department of Fish and Game and the MWA (Lines and Bilhorn 1996). The analysis determined that 1995 was considered an average year of water consumption for the existing riparian vegetation, and noted that annual water use by riparian vegetation will vary by up to 50% from the average. Variation would depend on available water supply, with up to 50% more water than the average consumed during wet years and up to 50% less consumed during dry years. As shown in Table 4-2, the average consumption by riparian vegetation within Alto is 11,000 acre-feet per year, 3,000 acre-feet per year in Centro, and 2,000 acre-feet per year in Baja. The analysis found that of the 11,000 acre-feet average in Alto, 5,000 acre-feet is consumed above the Lower Narrows and 6,000 acre-feet is consumed between the Lower Narrows and the boundary with Centro (an area referred to as the “Transition Zone”). Another 600 acre-feet of average annual water consumption by riparian vegetation were also identified in the Afton Canyon area, outside of the MWA.

Groundwater

Essentially all of the water used within the MWA is supplied by pumping groundwater. The Physical Solution to the Mojave Basin Area Judgment set limits on the amount of groundwater production that can occur in each subarea without incurring an obligation to buy imported water. Subareas upstream have an annual obligation to subareas downstream based on long-term averages between 1931 and 1990. Each major producer has an established Free Production Allowance (FPA) that is currently 80% of its Base Annual Production (BAP), which is defined as the producer's highest annual use verified for the 5-year base period from 1986-90, for all uses other than municipal and industrial use in Alto. FPA for Alto municipal and industrial use has been reduced to 70% of BAP for the 2003-04 water year, with an additional reduction to 65% of BAP scheduled for the 2004-05 water year. The allocated FPA represents each producer's share of the water supply available for that subarea. The Judgment requires that reductions in FPA occur in increments of 5% per year until the available FPA in each subarea is in balance with the available water supply. Producers are required to replace any water pumped above their FPA determined for that year. Replacement can occur either by paying the Mojave Basin Area Watermaster to purchase supplemental water from MWA or by transferring unused production rights within that subarea from another party to the Judgment.

Essentially all of the water used within the MWA is supplied by pumping groundwater.

As described in the previous chapter, the Alto, Centro and Baja subareas contain two interconnected aquifers referred to as the Floodplain Aquifer and the Regional Aquifer; Oeste and Este subareas only contain the Regional Aquifer. The Floodplain Aquifer is located along the path of the Mojave River and is directly recharged by the river. The Regional Aquifer underlies and surrounds the Floodplain Aquifer, encompassing the remainder of the Mojave River Groundwater Basin. Prior to development in the area, groundwater flowed primarily from the Regional Aquifer to the Floodplain Aquifer. However, the groundwater flows have reversed in recent years, and the groundwater flow from the Floodplain Aquifer is currently the primary recharge component for the Regional Aquifer (Stamos et al. 2001b). The Regional Aquifer is also recharged to a lesser degree by deep percolation of precipitation and storm runoff from ungaged tributaries.

Groundwater production was initially developed along the Mojave River in the early 1900s. By the mid-1950's, when long-term overdraft is recognized to have commenced, groundwater production was about 190,000 acre-feet, with the majority occurring along the Mojave River. By 1994, about half of the pumping came from wells located away from the River in the Regional Aquifer (Stamos et al. 2001b). As noted in Chapter 3, the increase in water production in the basin has significantly influenced the interaction between the Floodplain and Regional Aquifers. The changes in location of production indicate that Plan alternatives will need to recharge heavily pumped areas within the Regional Aquifer.

Figures 4-5 through 4-7 show historical water level data for wells within the Regional Aquifer. The decline in groundwater levels range from 50 feet to 100 feet for the three wells displayed. These figures illustrate the steady decline in water levels over the past 50 years, and that the Regional Aquifer is generally in a state of overdraft.

Figures 4-8 and 4-9 display historical water level data for wells within the Floodplain Aquifer. These figures illustrate the direct affect the Mojave River has on groundwater levels within the Floodplain Aquifer. During the 1980s, annual flows in the Mojave River were below average and groundwater levels within the Floodplain Aquifer declined. Conversely, the 1990s were a much wetter period and groundwater levels within the Floodplain Aquifer increased. It is important to note that while groundwater levels in the Floodplain Aquifer respond relatively rapidly to hydrologic conditions as compared to the Regional Aquifer, the long-term average water level in the Floodplain Aquifer is also declining.

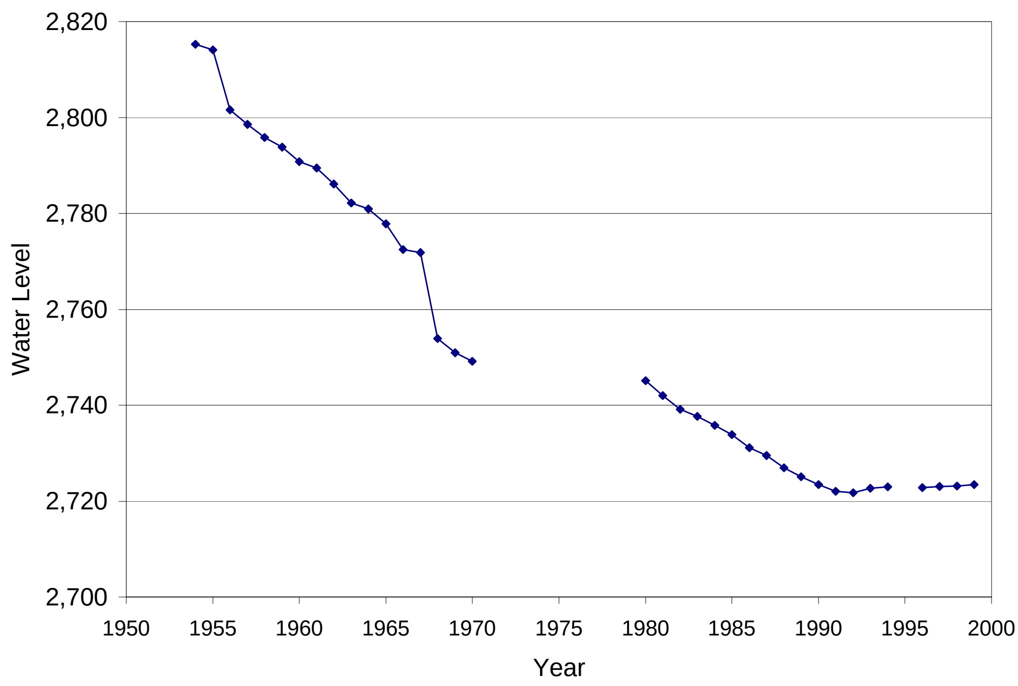


Figure 4-5: Historical Groundwater Levels for State Well Number 05N01E17D01, located in the Regional Aquifer in the Este Subarea

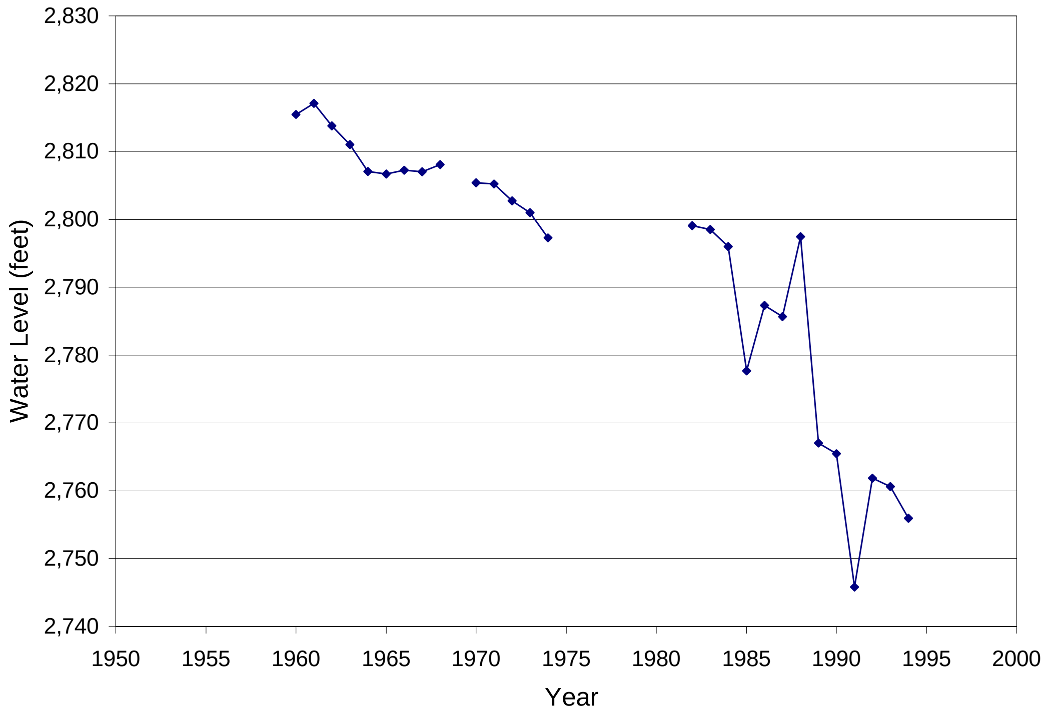


Figure 4-6: Historical Groundwater Levels for State Well Number 05N05W22E02, located in the Regional Aquifer in the Alto Subarea

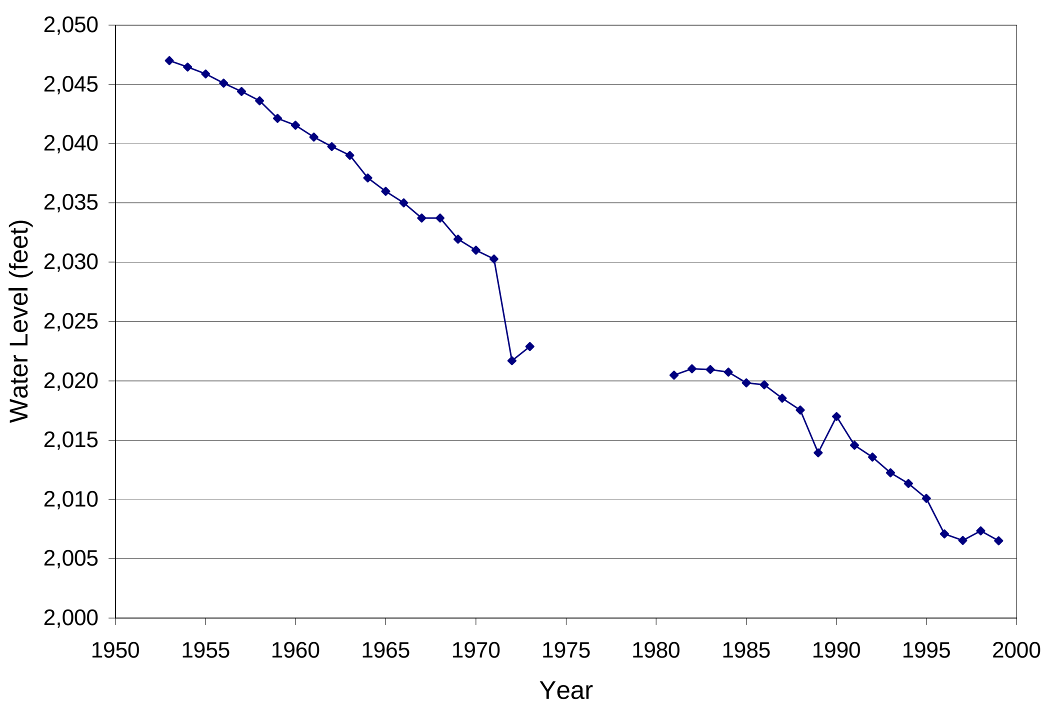


Figure 4-7: Historical Groundwater Levels for State Well Number 11N03W28R02, located in the Regional Aquifer in the Centro Subarea

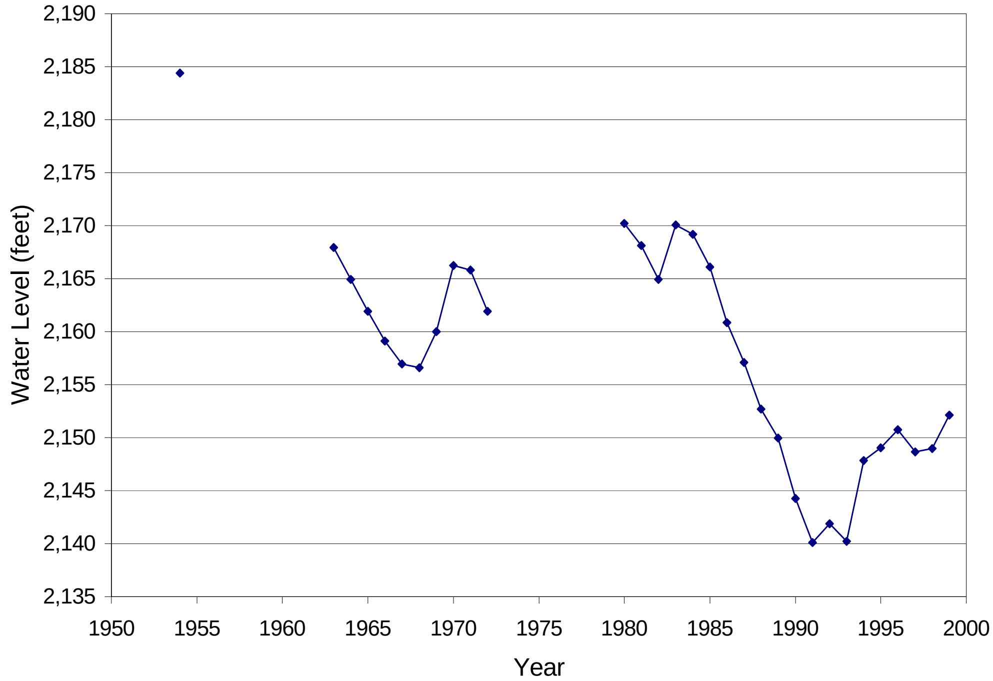


Figure 4-8: Historical Groundwater Levels for State Well Number 5N04W11P03, located in the Floodplain Aquifer in the Alto Subarea

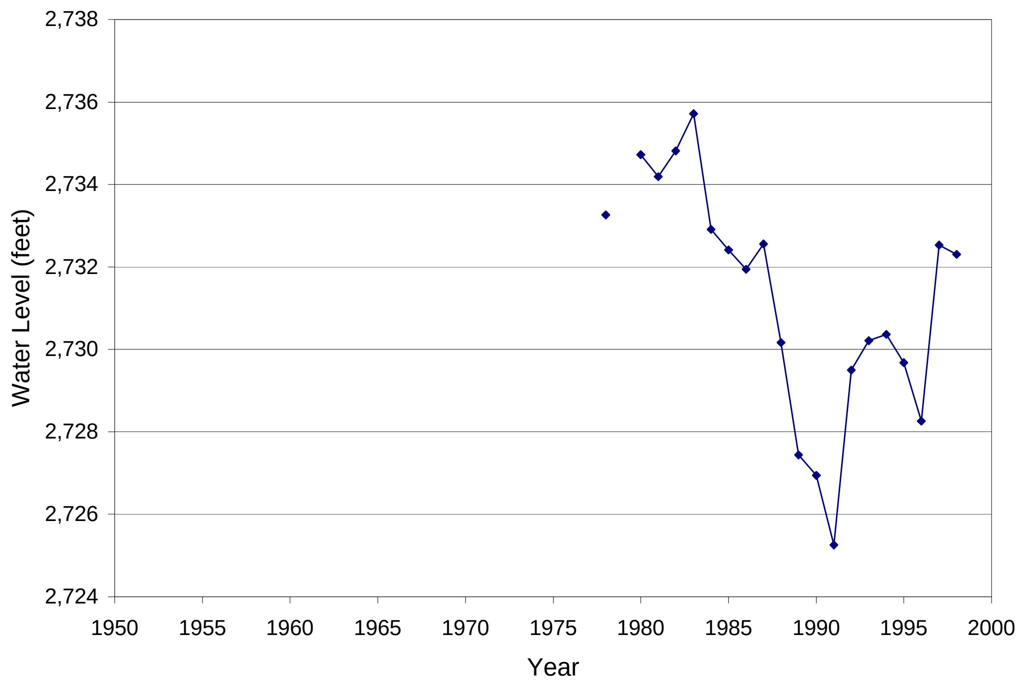


Figure 4-9: Historical Groundwater Levels for State Well Number 09N03W13R01, located in the Floodplain Aquifer in the Centro Subarea

The average annual net water supply for the Mojave Basin Area is estimated in Table 4-2. The volume of water available to meet water supply needs averages 63,400 acre-feet annually for the period 1931-2001. The Alto Subarea has the largest water supply, primarily due to proximity to the headwaters of the Mojave River. The Centro and Baja subareas are dependent upon infrequent, very large storm events for groundwater recharge. The Este and Oeste subareas have the least amount of supply, most of which originates from ungaged surface water. The Este Subarea receives the majority of its current water supply from wastewater imports. Table 4-2 reflects averaged values and does not take into account the annual variation in water supply.

The average annual water supply estimates in Table 4-2 are higher than estimates from the 1994 RWMP for the period 1931-90. This analysis averages USGS stream gage data from 1931 to 2001. The increase is attributed to above average streamflow and increased wastewater imports since 1990. 1993 was the highest year of record for inflow at the Forks. The inflow of about 428,700 acre-feet was 660% of the 1931-90 average of 65,000 acre-feet. 1995 and 1998 were also substantially wetter than average. The period 1931-2001 was about 10% wetter than the period 1931-1990. Generally, the previous 35 years have been considerably wetter than average when compared to the 1931-1990 period; conversely, the period 1945-1965 was considerably drier than average. This illustrates the extreme variation in annual water supply.

Dry Year and Multiple Dry Year Water Supply

An estimate of the average annual dry year water supply for each subarea within the Mojave Basin Area is shown on Table 4-3. Dry year water supplies are assumed to be equal to the median water supply values on the Mojave River. By this definition, half of all years would be considered dry, or less than 22,100 acre-feet per year. Median values for gaged surface flow cover the period of record, 1931-2001. Median values for ungaged surface flows are adjusted from the average values found in Table 4-2, to median values based on the percent difference (62%) between average and median flow at the Forks. This assumption was made based on the correlation that over 90% of ungaged surface flow entering the Basin originates in the same mountains as the gaged surface flow measured at the Forks. Thus, it is assumed that the difference between the average and median flow at the Forks provides a reasonable correlation to the difference between the average and median flow of ungaged surface water entering the Mojave Basin.

An estimate of the average annual multiple dry year water supply for each subarea within the Mojave Basin Area is shown on Table 4-4. Multiple dry year estimates represent the average Mojave River flow during the period 1988-1990. Values for ungaged surface flows are reduced from the average values found in Table 4-2 by the same method described above.

While the annual average net water supply is 63,400 acre-feet per year, average annual dry year water supply is only 22,100 acre-feet and average annual multiple dry year water supply is only 3,900 acre-feet. This demonstrates the area's dependence on large, infrequent storm events to provide the majority of groundwater recharge. Dry year water supply probabilities should be taken into consideration when evaluating the near-term implications of water supply alternatives. Decreases in groundwater levels caused by temporary declines in annual water supply may not harm the long-term water supply of a basin but can have adverse impacts. Evaluating the dry year water supply for near-term implications may be important for a number of reasons. Temporary declines in groundwater can increase pumping costs, diminish groundwater quality, and harm riparian habitat by decreasing the amount of water available in the root zone. Management issues concerned with near-term implications should consider the dry year water supply of the Mojave River Basin since it is a better representation of the expected annual water supply for any three- to five-year period. When evaluating long-term water supply management issues, the average values summarized in Table 4-2 are appropriate.

Morongo Basin/Johnson Valley Area

The groundwater basins within the Morongo Basin/Johnson Valley Area are bounded by the Ord and Granite Mountains to the north; the Bullion Mountains to the east; the San Bernardino Mountains to the Southwest; and the Pinto and Little San Bernardino Mountains to the south. Different investigations have divided the region's groundwater basins into 17 subbasins, but not all of them are contained within MWA (Smith and Pimentel 2000). The water supply estimates prepared for the 1994 Regional Water Management Plan compiled water supply data for the region into 4 subbasins. Table 4-5 summarizes the net average annual water supply estimates for each of the groundwater basins that comprise the Morongo Basin/Johnson Valley Area.

Table 4-3: Mojave Basin Area - Average Annual Dry Year Water Supply

	Este	Oeste	Alto	Centro	Baja	Entire Basin
WATER SUPPLY						
Surface Water Inflow						
Gaged	0	0	27,200 [a]	0	0	27,200
Ungaged	650 [1]	550 [1]	1,400 [1]	13,200 [1]	200 [1]	2,800 [2]
Subsurface Inflow	0	0	1,200	2,000	1,200	0 [3]
Deep Percolation of Precipitation	0	0	1,750	0	50	1,800 [4]
Import Wastewater						
Lake Arrowhead CSD	0	0	1,900	0	0	1,900
Big Bear ARWWA	2,600	0	0	0	0	2,600
Crestline Sanitation District	0	0	900	0	0	900
Total:	**3,250**	**550**	**34,350**	**15,200**	**1,450**	**37,200**
OUTFLOW AND LOSSES						
Surface Water Outflow						
Gaged	0	0	0	0	900 [b]	900
Ungaged	0	0	13,200 [1]	0	0	0
Subsurface Outflow	800	400	2,000	1,200	0	0
Phreatophyte Consumption	0	0	5,500 [5]	1,500 [5]	1,000 [5]	8,000
Total:	**800**	**400**	**20,700**	**2,700**	**1,900**	**8,900**
				NET MEDIAN ANNUAL WATER SUPPLY:		**28,300**

[1]Estimates based on ratio of dry year inflow to average inflow
[2]Sum of Este (700 ac.ft.), Oeste (600 ac.ft.), Alto (1,400 ac.ft.) and Baja (200 ac.ft from Kane Wash and Boom Creek).
[3]All subsurface flow is assumed to exchange within subareas (no external inflows or outflows)
[4]Because historical precipitation during dry years has been approximately 50% of the long-term average, deep percolation of precipitation during dry years is assumed to be equal to 50% of the long-term average deep percolation
[5]Phreatophyte consumption taken from Lines and Bilhorn (1996)
a Period of record from 1931-2001
b Period of record from 1931-2001; 1931-1952 are estimated values

Table 4-4: Mojave Basin Area
Average Annual Multiple Dry Year Water Supply

	Este	Oeste	Alto	Centro	Baja	Entire Basin
WATER SUPPLY						
Surface Water Inflow						
Gaged	0	0	10,800 [a]	0	0	10,800
Ungaged	100 [1]	100 [1]	200 [1]	2,000 [1]	0 [1]	400 [2]
Subsurface Inflow	0	0	1,200	2,000	1,200	0 [3]
Deep Percolation of Precipitation	0	0	1,750	0	50	1,800 [4]
Import Wastewater						
Lake Arrowhead CSD	0	0	1,900	0	0	1,900
Big Bear ARWWA	2,600	0	0	0	0	2,600
Crestline Sanitation District	0	0	900	0	0	900
Total:	**2,700**	**100**	**16,750**	**4,000**	**1,250**	**18,400**
OUTFLOW AND LOSSES						
Surface Water Outflow						
Gaged	0	0	0	0	300 [a]	300
Ungaged	0	0	2,000 [1]	0 [1]	0	0
Subsurface Outflow	800	400	2,000	1,200	0	0
Phreatophyte Consumption	0	0	5,500 [5]	1,500 [5]	1,000 [5]	8,000
Total:	**800**	**400**	**9,500**	**2,700**	**1,300**	**8,300**
MULTIPLE DRY YEAR NET ANNUAL WATER SUPPLY:						**10,100**

[1] Estimates based on ratio of multiple dry year inflow to average inflow

[2] Sum of Este (100 ac.ft.), Oeste (100 ac.ft.), and Alto (200 ac.ft.)

[3] All subsurface flow is assumed to exchange within subareas (no external inflows or outflows)

[4] Because historical precipitation during dry years has been approximately 50% of the long-term average, deep percolation of precipitation during dry years is assumed to be equal to 50% of the long-term average deep percolation

[5] Phreatophyte consumption taken from Lines and Bilhorn (1996)

a Period of record from 1988-1990

Table 4-5: Morongo Basin/Johnson Valley Area Net Average Annual Water Supply

Basin	Net Average Annual Supply (Acre-feet per Year)
Means/Ames Valley	600
Copper Mountain Valley	600
Johnson Valley	2,300
Warren Valley	900*

Source: Boyle Engineering Corporation 1993 (for Copper Mountain 550 was rounded to 600)

* Hi–Desert Water District reports unpublished USGS estimates of 200 acre-feet per year net average annual supply in Warren Valley.

The net average water yield of the entire Morongo Basin/Johnson Valley Area is about 4,400 acre-feet per year. However, the net average water supply for the relatively uninhabited Johnson Valley is relatively undeveloped and has water quality constraints in some areas. The 1994 RWMP estimated that the Johnson Valley Basin net average annual water supply is about 2,300 acre-feet per year. The Johnson Valley supply was not considered in the net water supply balance, resulting in a net average water supply of 2,100 acre-feet per year for the developed groundwater basins.

The water supply is derived primarily from precipitation in the tributary areas within the Little San Bernardino and San Bernardino Mountains. Major ephemeral streams in the area include the Pipes Wash and Yucca Creek.

A great portion of water water supply needs relies on MWA's ability to provide State Water Project water through the Morongo Basin Pipeline. Without that water or a different source of supplemental water, overdraft of the Warren Valley Basin is likely to occur once again. In 1995 the Morongo Basin Pipeline was completed from the California Aqueduct near the City of Hesperia to the Town of Yucca Valley. Two recharge sites have been developed to take water from this facility and are receiving imported State Water Project water. The quantities of water imported to date for the Hi-Desert Water District are presented in Table 4-5. The imported water supplies recharge the previously overdrafted Warren Valley Basin. The Pipeline has capacity to also deliver water to the benefit of the Big Horn-Desert View Water Agency, the Joshua Basin Water District and the County of San Bernardino.

Dry Year and Multiple Dry Year Water Supply

The dry year and multiple dry year water supplies in the Morongo Basin/Johnson Valley area are assumed to be reduced proportionally to the reduction in surface water flows at the Forks. These values are shown for each subbasin in Table 4-6. Excluding the Johnson Valley subbasin, the net annual dry year water supply is 800 acre-feet/year during an average dry year and 110 acre-feet/year during a multiple dry year period.

Table 4-6: Morongo Basin/Johnson Valley Area Average Annual Dry Year Water Supply

Basin	Dry Year Average Annual Supply (Acre-feet per Year)	Multiple Dry Year Average Annual Supply (Acre-feet per Year)
Means/Ames Valley	230	30
Copper Mountain Valley	230	30
Johnson Valley	880	130
Warren Valley	340	50

Well Data

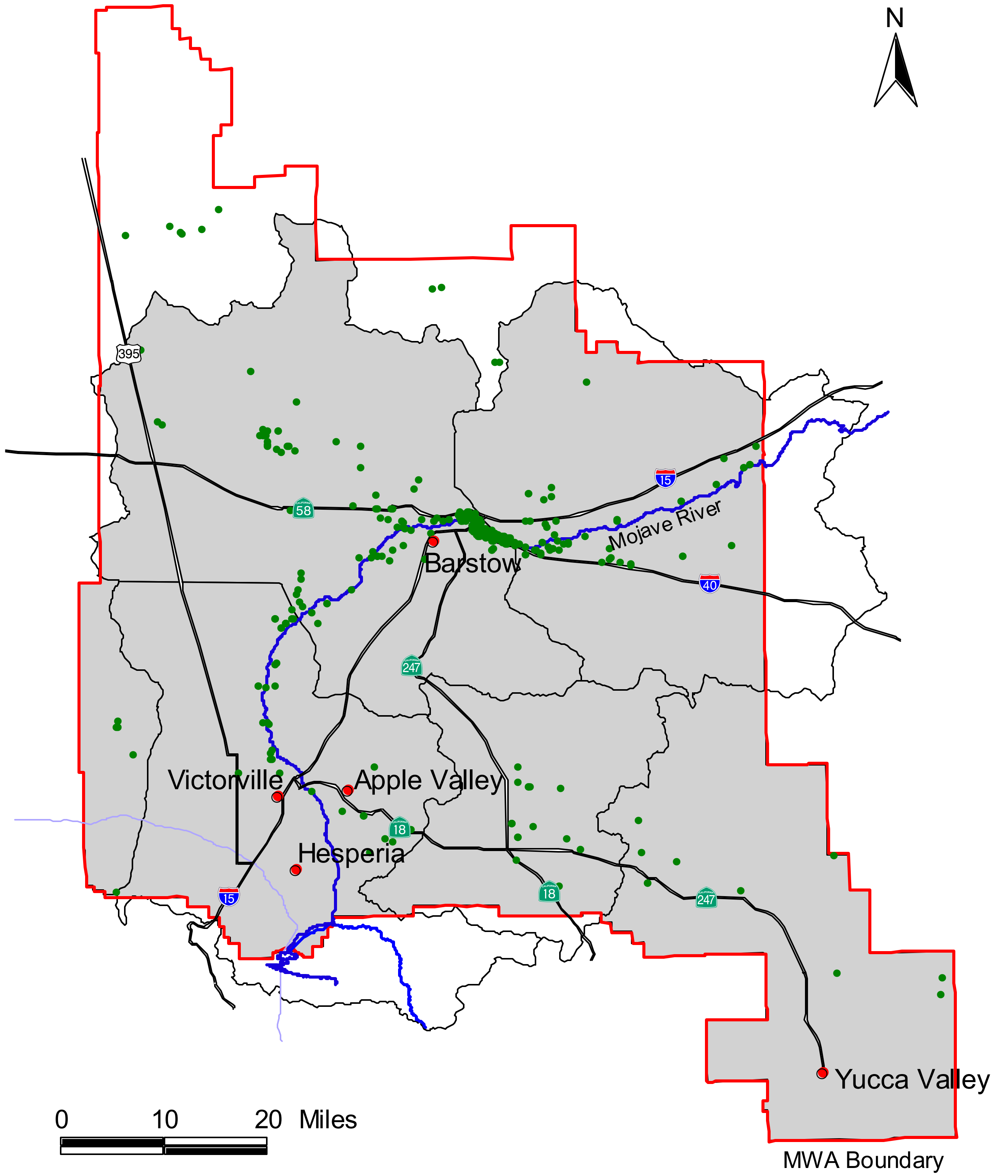
Digital well data provided by MWA was compiled in a database for data query and analysis. Data attributes in the database include water quality, water levels, well production, and GPS locations. The GPS well locations supplied by MWA were compared to the water quality, water level, and water production data to assess data spatial distribution within the MWA. A database query that contains well number, well depth, perforated interval, well type and status is included as Appendix I.

Samples of spatial and temporal analyses utilizing the database and a geographic information system (GIS) are provided on Figures 4-10 and 4-11. A complete analysis of water quality within the Basin is extremely labor intensive and beyond the scope of this Plan, but the Agency anticipates undertaking this effort in the near future.

Figure 4-10 displays the wells within the current database that have at least one historical measurement for total dissolved solids (TDS) above 500 mg/L. Using GIS to analyze water quality is beneficial for locating areas with particular water quality concerns. As seen on the plot the densest concentration of wells with TDS measurements above 500 mg/L is in the Barstow area. It is important to note that the majority of monitoring wells are concentrated in the Floodplain Aquifer and thus the majority of water quality measurements are taken from the Floodplain Aquifer.

Additional monitoring wells in the Regional Aquifer would help evaluate differences in water quality between the two aquifers. Besides spatial analysis, a temporal analysis can be done to evaluate how water level fluctuations affect water quality. Figure 4-11 displays the water level and TDS measurements for State Well 08N03W05J01.

As part of future efforts, the entire database could be linked to a GIS to provide spatial analyses of water level data and all water quality parameters within the Basin. Additional work could also focus on collecting, filtering, and adding supplementary water quality data available from the Department of Health Services and local agencies within the MWA service area.



Schlumberger Water Services

Groundwater Wells Measuring Above 500 mg/L Total Dissolved Solids

Mojave Water Agency
Regional Water Management Plan Update

Figure 4-10

Date: January 2004

Prepared By: KTW

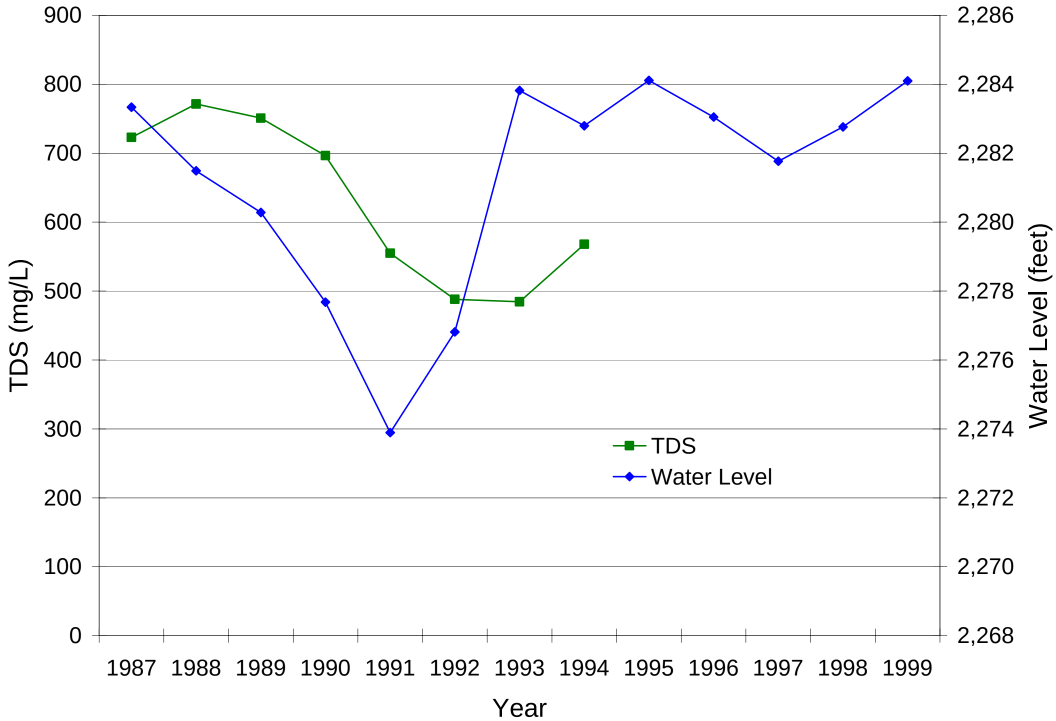


Figure 4-11: Total Dissolved Solids (TDS) with Water Level (feet above mean sea level) for State Well 08N03WO5JO1

State Water Project

MWA is entitled to 75,800 acre-feet of State Water Project (SWP) water per year. This includes the addition of 25,000 acre-feet of entitlement that was purchased from the Berrenda-Mesa Water District in 1998. Imported SWP water has historically been supplied to the MWA through the Mojave Basin and Morongo Basin pipelines and releases from Silverwood Lake. The State Water Project has delivered approximately 150,000 acre-feet of water to MWA from 1972 through 2001 (DWR 2001, and MWA). Table 4-7 summarizes the imported State Water Project water delivered to MWA.

Table 4-7: Deliveries of State Water Project Water to the MWA, 1978-2001

Year	Lake Silverwood[1]	Rock Springs[2]	Kramer Junction (AVEK)[3]	Hodge[4]	Lenwood[5]	Hi-Desert Pipeline[6]	Total
1978	22,500	0	0	0	0	0	22,500
1979	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983	24,489	0	0	0	0	0	24,489
1984	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0
1991	2,032	0	1,391	0	0	0	3,423
1992	9,334	30	1,310	0	0	0	10,674
1993	9,973	0	1,514	0	0	0	11,487
1994	819	15,434	1,399	0	0	0	17,652
1995	0	4,503	1,227	0	0	3,010	8,740
1996	0	2,134	1,316	0	0	3,977	7,427
1997	0	7,134	1,405	0	0	5,501	14,040
1998	0	2,190	1,345	0	0	2,357	5,892
1999	0	283	1,439	994	2,673	2,682	8,071
2000	0	2,451	1,361	2,144	1,476	3,930	11,362
2001	0	57	1,385	0	0	2,878	4,320
TOTAL	**69,147**	**34,216**	**15,092**	**3,138**	**4,149**	**24,335**	**150,077**

[1]Lake Silverwood releases do not include releases made by DWR for purposes other than delivery to MWA. Prior to construction of the Morongo Basin Pipeline, the only means to deliver SWP water to MWA was through releases at Cedar Springs Dam at Silverwood Lake, upstream of the West Fork Gage in the Alto Subarea. The 1978 releases were part of a conjunctive use demonstration project with the DWR. The 1983 releases were non-entitlement water purchased from the Central Valley and delivered by SWP facilities.

[2]The Rock Springs Outlet was constructed on the Morongo Basin Pipeline in 1994 to release SWP water into the Mojave River in the Alto Subarea near the City of Hesperia at Rock Springs Road approximately 5 miles downstream of the Forks. All subsequent deliveries to Alto have been made here.

[3]The MWA has an agreement with the Antelope Valley-East Kern Water Agency (AVEK) to transfer MWA entitlement to AVEK each year sufficient to allow AVEK to transport the MWA entitlement to a power plant in the Kramer Junction area within the MWA boundary (Centro Subarea).

[4]The Hodge recharge facility, located about 40 miles downstream of the Forks, was constructed in 1999 to deliver SWP water to the Centro Subarea from the Mojave River Pipeline.

[5]The Lenwood recharge facility, located about 48 miles downstream of the Forks, was constructed in 1999 to deliver SWP water to the Centro Subarea from the Mojave River Pipeline.

[6]The Morongo Basin Pipeline was completed to Landers in the Morongo Basin/Johnson Valley Area in 1994, and the Hi-Desert Pipeline extension was completed to the Town of Yucca Valley in 1995.

The only internal allocations of SWP water within MWA is for a maximum of 7,257 acre-feet to Improvement District M (IDM) located in the Morongo Basin/Johnson Valley Area. These allocation deliveries may be limited to the same percentage of total entitlement that MWA is approved to receive from the State Water Project by the State Department of Water Resources. Limitations have not occurred to date because neither MWA nor the IDM member entities have approached maximum delivery capability. MWA also has an existing agreement to transfer up to 2,250 acre-feet per year to the Antelope Valley-East Kern Water Agency (AVEK). The water is transported by AVEK to a power plant located near Kramer Junction within the MWA. One of the major issues raised by stakeholders in the basin is how the remaining SWP entitlement will be distributed in the basin.

Figure 4-12 displays historical deliveries of SWP water for the years 1978 to 2001 to all State Water Project Contractors (DWR 2001b). The figure shows the percent of water requested by the Contractors that was delivered. The SWP Contractors have received the entire amount of water requested 75% of the time. On average, Contractors received 88% of the water requested. There were six years during the early 90's, 2000 and 2001 when deliveries were less than 100 percent of request. The allocation of entitlement for 2001 was 39%. At this level of allocation, MWA would have been able to receive 29,600 acre-feet of water.

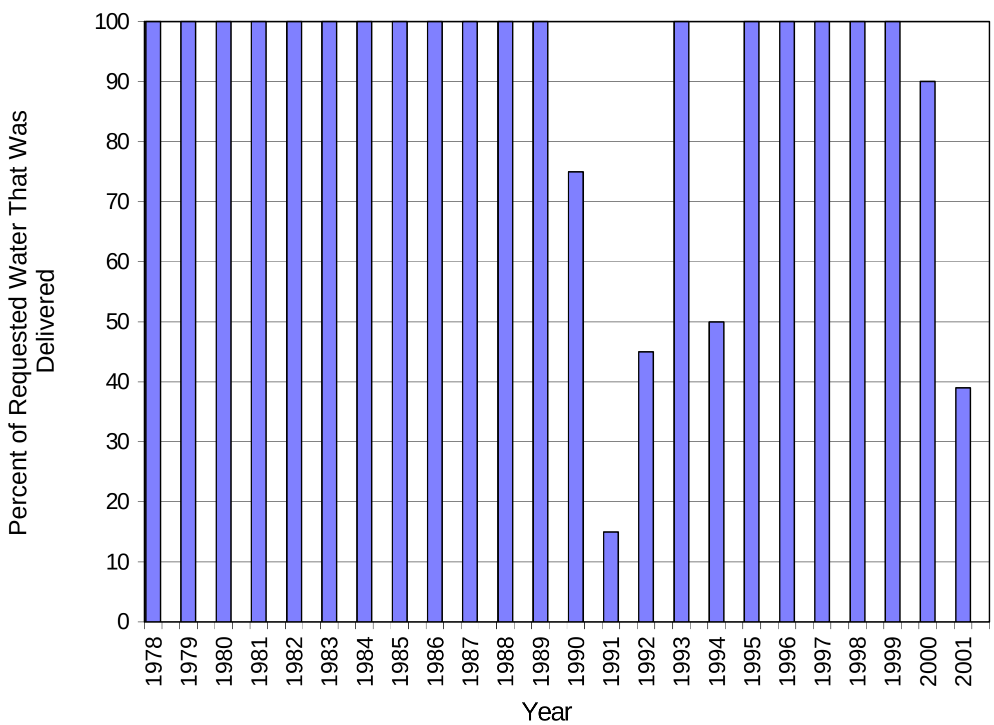


Figure 4-12: Historical SWP Percent of Deliveries Requested by Contractors

The variability of SWP deliveries is expected to increase in the future as Contractors request larger amounts of their maximum entitlement. System constraints such as Delta export restrictions and competition for the available water supply will increase management challenges. Even if MWA chooses to purchase its full entitlement of 75,800 acre-feet annually, its full entitlement will not be available every year. According to the State Water Project Reliability Report (DWR 2002), MWA can expect to receive an average of 58,400 acre-feet of its SWP supply under 2020 conditions. This estimate is based on 2020 demand projections with the current facilities in place. During a dry or critical year as defined by the Sacramento River Index, the SWP will be able to supply an average of 43,200 acre-feet. During a multiple dry year period (1988-1990), MWA's SWP supply will be about 22,900 acre-feet/year. Table 4-8 shows the average annual SWP supply available during all years, dry years, and in a multiple dry-year period. Figure 4-13 shows the projected probability of exceedance of SWP deliveries to MWA in 2020.

Table 4-8: Average Annual State Water Project Supplies

Year Type	State Water Project Supply (Acre-feet per Year)
Average	58,400
Dry Year	43,200
Multiple Dry Year	22,900

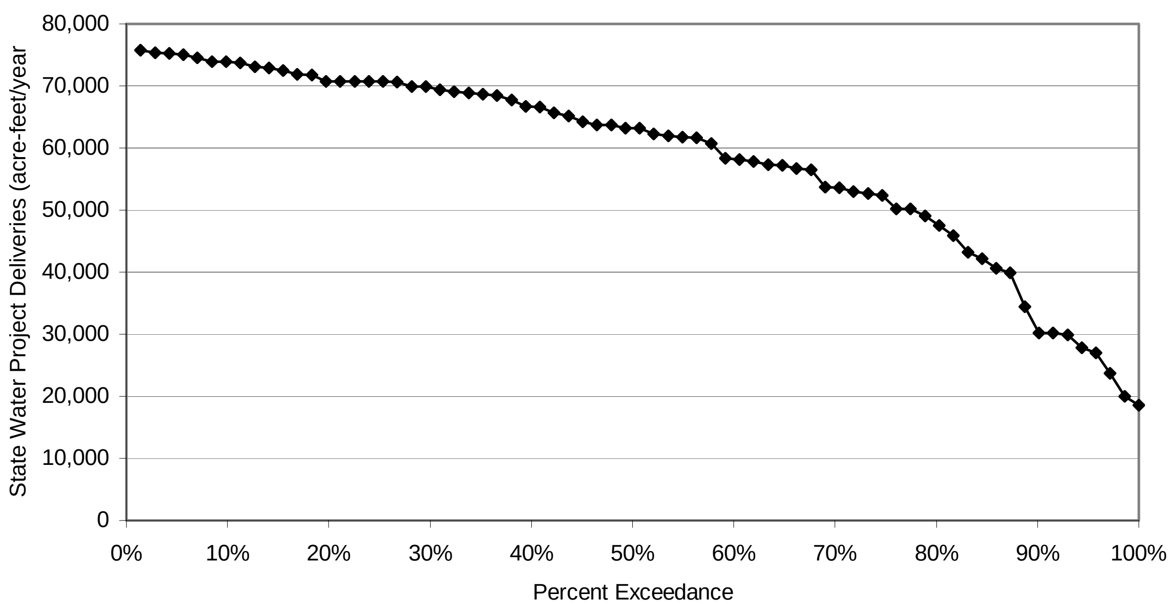


Figure 4-13: Percent Exceedence of SWP Deliveries in 2020

The recent history of deliveries and current efforts to improve system flexibility and reliability indicate that deliveries from the SWP will continue to be variable for the next ten to fifteen years. Efforts to meet water supply delivery objectives continue to be developed by the Department of Water Resources and the State Water Contractors. For example, contract provisions allow for the delivery of "interruptible" water supplies to Contractors during periods of abundant water supply after other SWP water supply and storage objectives have been met. The Contractors and the Department also continue to develop programs allowing transfers of entitlement between Contractors to maximize storage of Project water supplies when available.

MWA currently has an entitlement exchange program in place with the Solano County Water Agency (SCWA). This Agreement allows MWA to receive entitlement deliveries from the SCWA during hydrologic periods when the SCWA has approved entitlement in excess of their needs. MWA will subsequently allow the SCWA to utilize some of their approved entitlement during periods of drought, but not more than half of the quantity of SCWA entitlement that has previously been delivered to MWA. It is possible that in some years MWA could receive more than its full entitlement due to these programs. Therefore basin recharge alternatives designed to use SWP water should consider the effects of a variable water supply.

Water Quality

MWA's groundwater basins contain numerous areas with water quality issues. These issues are described in Chapter 8. Key contaminants include arsenic, nitrates, iron, manganese, Chromium VI, total dissolved solids (TDS), total petroleum hydrocarbons (TPH), and volatile organic compounds (VOC's). Measurements in excess of drinking water standards have been found for many of these constituents within each subarea in the Mojave Basin Area and each subbasin within the Morongo Basin/Johnson Valley area. Groundwater in these areas will have to be treated or replaced.

Another potential water quality issue facing MWA is the accumulation of salt in the groundwater basins. Because the Mojave River Basin and Morongo Basin/Johnson Valley areas are closed basins, salt contained in imported reclaimed wastewater and State Water Project (SWP) supplies are mostly not removed from the basin. An average of about 5,400 acre-feet of reclaimed wastewater is discharged into the MWA from outside its boundary and about 8,400 acre-feet of State Water Project water are currently imported each year. MWA is planning to increase its SWP utilization to 58,000 acre-feet per year, which will further increase the introduction of salts into the system.

MWA has initiated efforts to develop a groundwater quality analysis system for the entire MWA service area. The project will include an evaluation of existing groundwater data and identification of data needs, the development of an information management system that will allow MWA to collect, reconcile, analyze, and access water quality information, and the development of a water quality and analysis system to meet MWA's long-term water quality objectives.

Digital well data provided by MWA was compiled in a Microsoft® Access 2000 Database for data query and analysis. Data attributes in the database include water quality, water levels, well production, and GPS locations. The GPS well locations supplied by MWA were compared to the water quality, water level, and water production data to assess data spatial distribution within the MWA. Groundwater quality for a number of constituents and for each subarea are presented in Figures 4–3 through 4–9.

Inconsistent Water Sources

Because water use within the MWA service area is supplied entirely by groundwater, MWA does not have any inconsistent water sources that cause reduced deliveries to users within the service area. A potential exception is areas where water quality could limit use as a potable supply. Wellhead treatment or provision of an alternative supply is planned for these areas. While many of the sources that recharge the groundwater basin have high annual variability, including flows on the Mojave River and supplies from the State Water Project, the groundwater basins used within the MWA service area are sufficiently large to allow for continued water use during dry periods with only a temporary decline in groundwater levels.

Planned Water Supply Sources Through 2020 in Five-year Increments

The amount of available water supply to the Mojave Water Agency is not expected to change between now and 2020. In addition to its net average annual supply of 63,400 acre-feet per year, MWA has an average annual SWP supply of 58,400 acre-feet per year, for a total supply of 121,800 acre-feet per year. Table 4-9 shows the availability of each of these types of water in five-year increments through 2020.

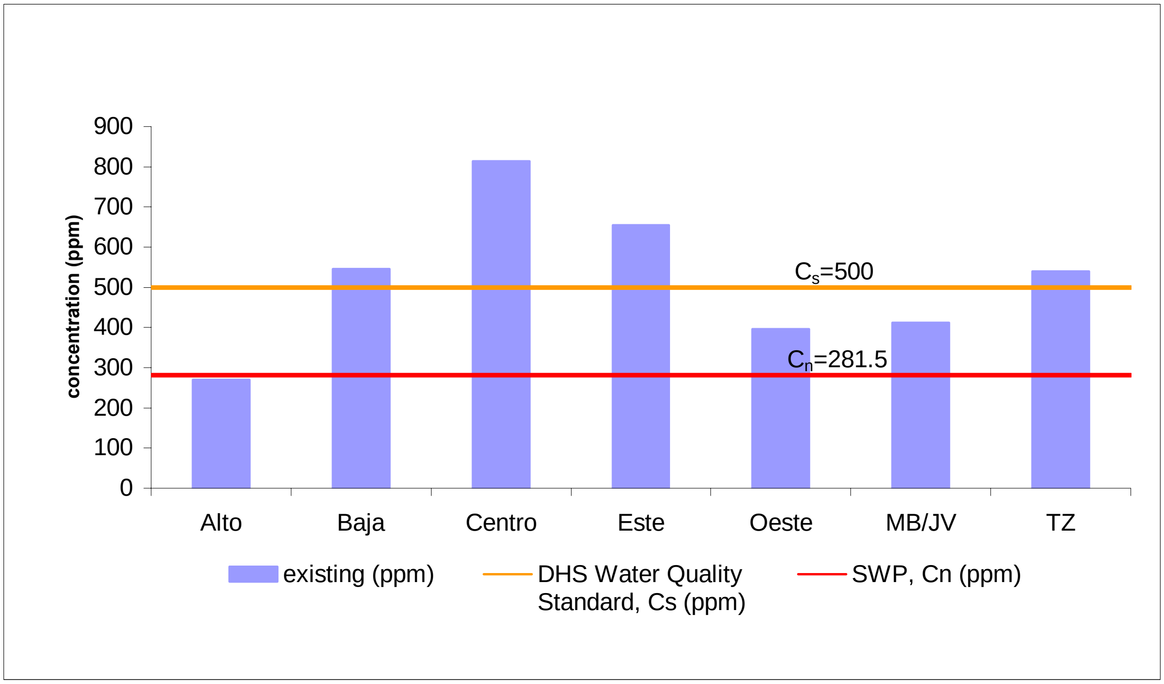


Figure 4-14: Total Dissolved Solids

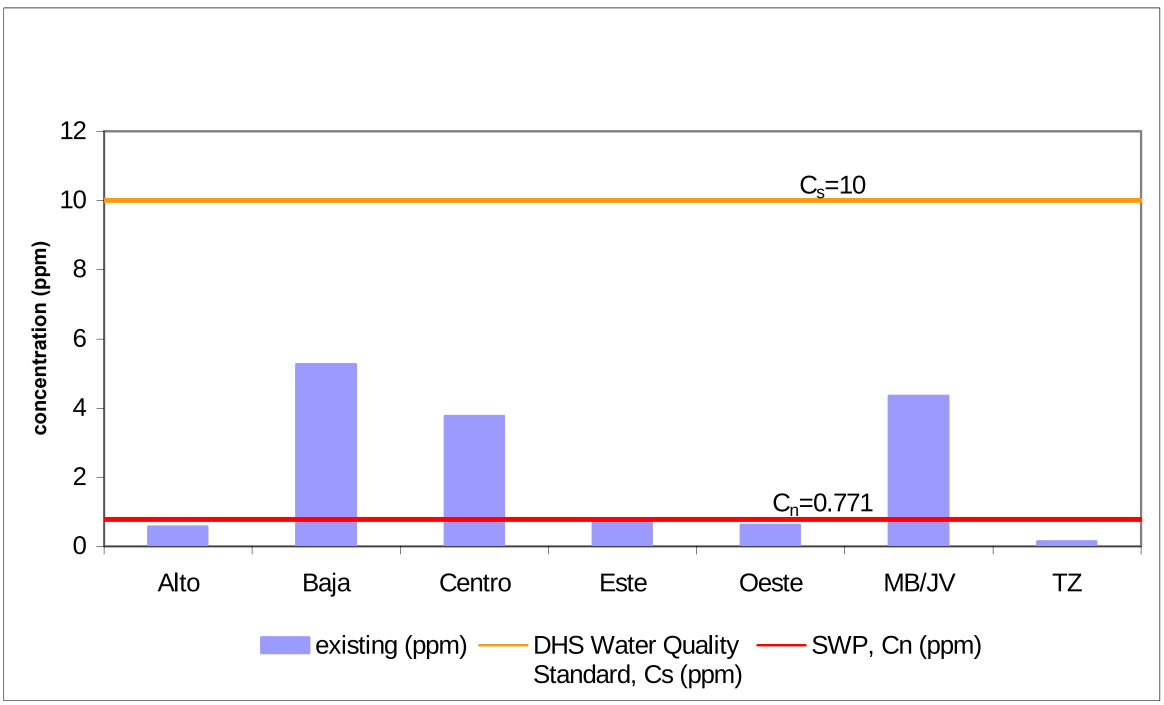


Figure 4-15: Nitrates

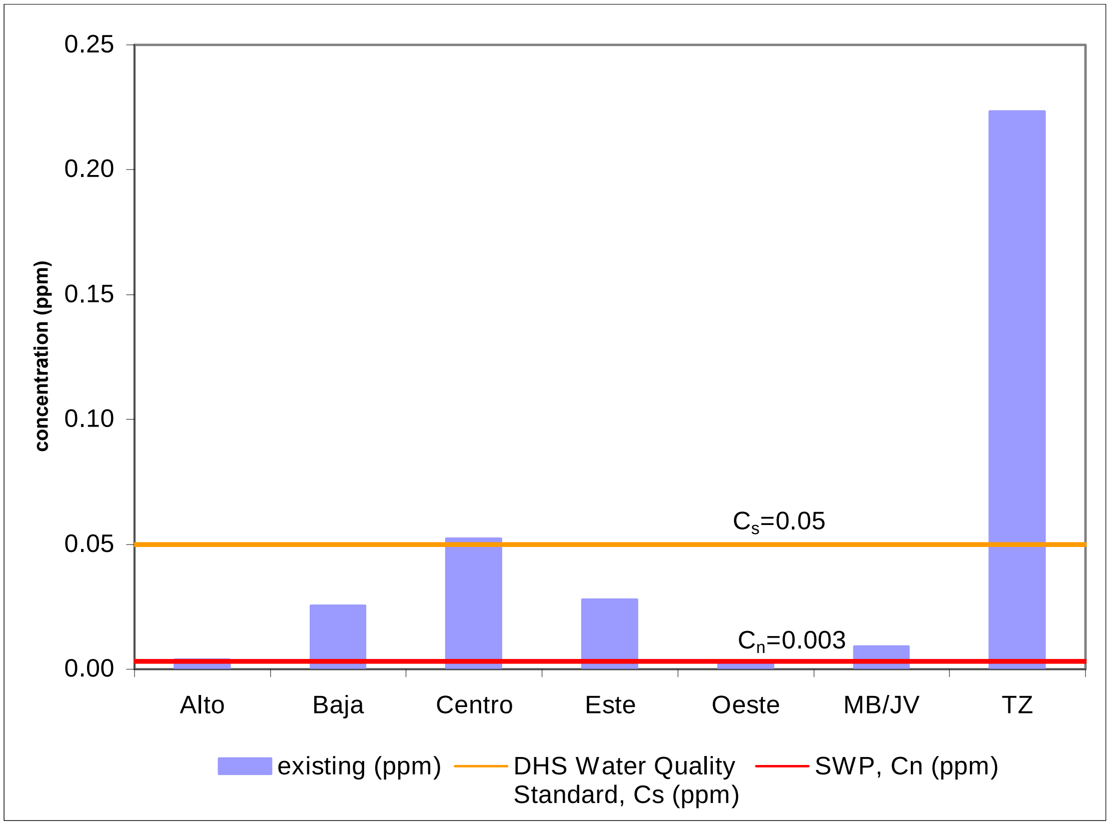


Figure 4-16: Manganese

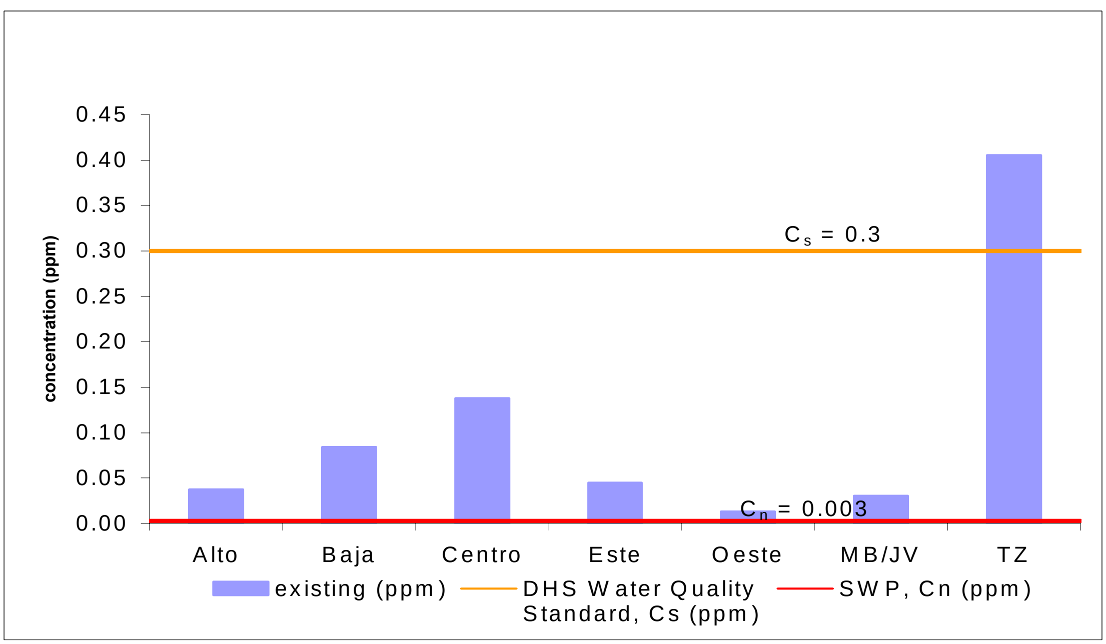


Figure 4-17: Iron

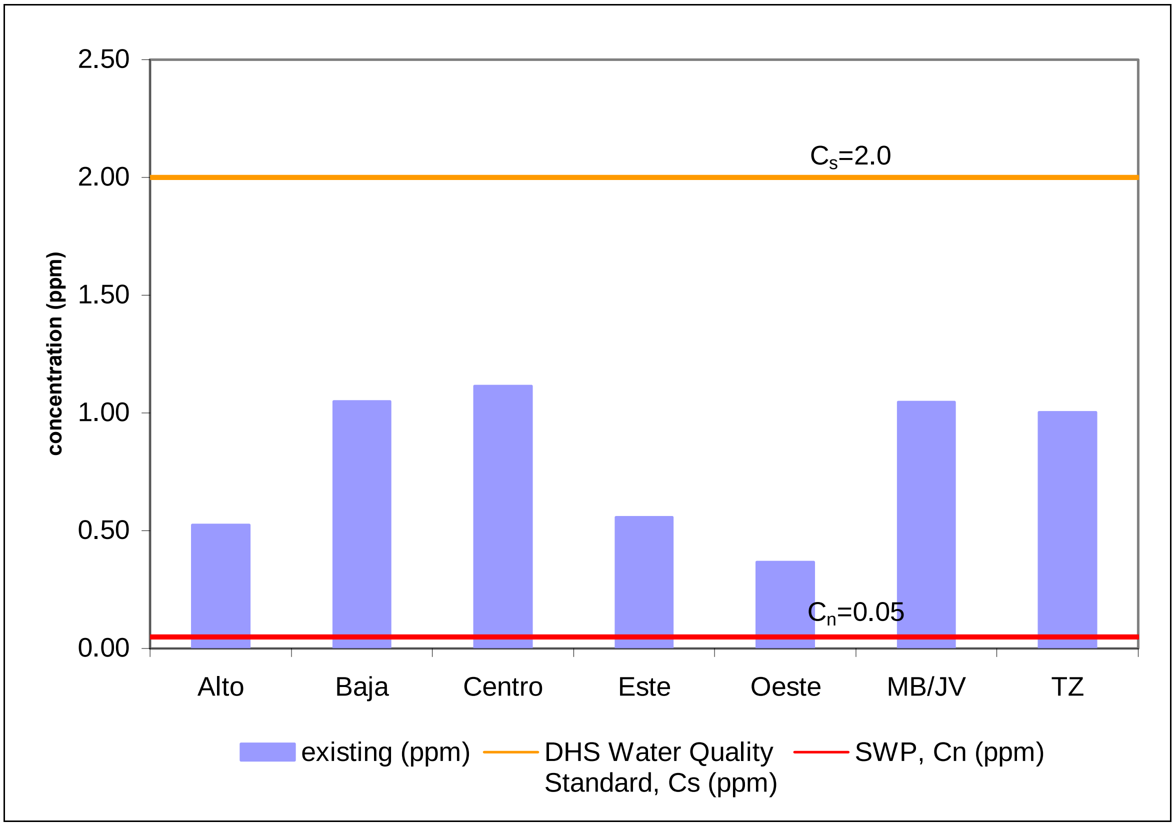


Figure 4-18: Fluoride

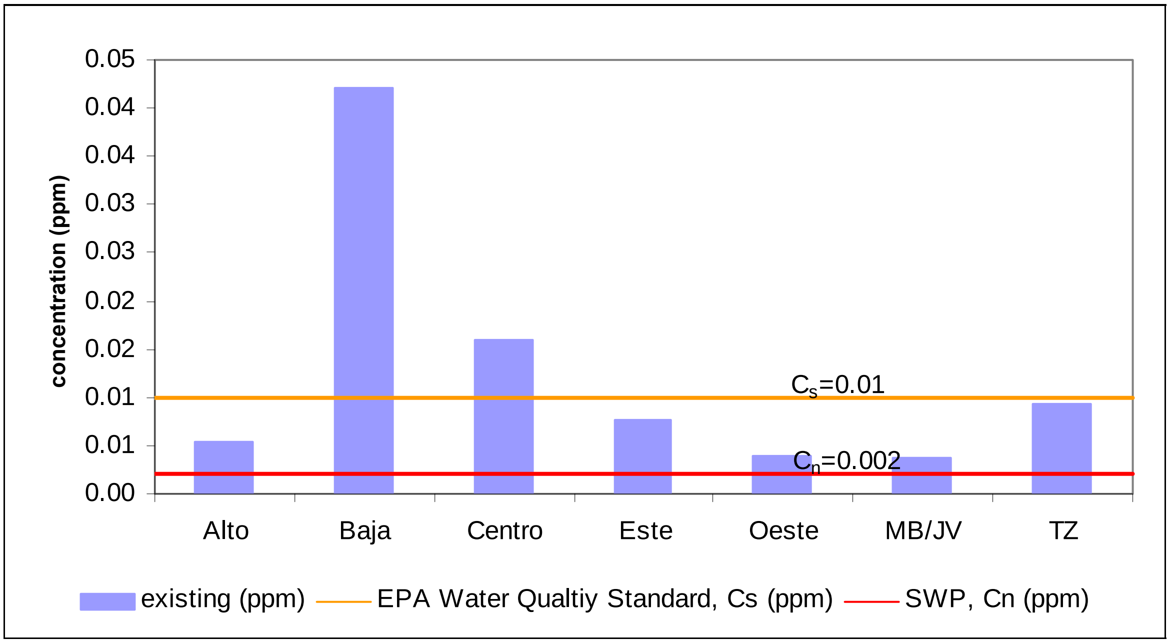


Figure 4-9: Arsenic

Water Quality and Management Strategies

The quality of water dictates numerous management strategies a water purveyor will implement, including, but not limited to, the selection of raw water sources, treatment alternatives, blending options, and modifications to existing treatment facilities. Maintaining and utilizing high quality sources of water simplifies management strategies by increasing water supply alternatives, water supply reliability, and decreasing the cost of treatment. The source water supplies are of good quality. Maintaining high quality source water allows for efficiently management of water resources by minimizing costs while distributing high quality water.

Water Quality and Supply Reliability

Maintaining the quality of water supplies increases the reliability of each source by ensuring that deliveries are not interrupted due to water quality concerns. A direct result from the degradation of a water supply source is increased treatment cost before consumption. The poorer the quality of the source water, the greater the treatment cost. Groundwater may degrade in quality to the point that is not economically feasible for treatment. In this scenario the degraded source water is taken off-line. This in turn decreases water supply reliability by decreasing the total supply and increasing demands on alternative water supplies.

Currently, water quality does not affect water supply reliability. Maintaining the current level of quality is vital to maintaining a reliable water supply.

Table 4-9: Available Water Supply Sources Through 2020

Supply Type	2000	2005	2010	2015	2020
Natural*	63,400	63,400	63,400	63,400	63,400
SWP	58,400	58,400	58,400	58,400	58,400
Total	121,800	121,800	121,800	121,800	121,800

*Average annual natural water supply data as shown in Table 4-2

Opportunities for Short and Long-Term Transfers

MWA is expected to have an estimated 400,000 acre-feet of unused State Water Project supply between now and 2020. One option for utilizing this supply would be to transfer a portion of it to another party as part of a storage agreement or exchange program. MWA and the Metropolitan Water District of Southern California (Metropolitan) recently agreed on a Water Exchange Pilot Program with the goals of facilitating a water exchange in the short term and helping to determine the feasibility of a similar long-term exchange program between the two parties. Under the terms of the Pilot Program, Metropolitan will deliver to Mojave up to 75,000 acre-feet of its SWP deliveries or other water. In exchange, in years when Metropolitan requests water, MWA will provide Metropolitan water through exchange of MWA's SWP deliveries for that year.

In addition, the rules of the Mojave Basin Area Adjudication allow for the possibility of in-basin transfers. Under the rules of the Judgment producers are allowed to sell unused Base Annual Production (BAP) and Free Production Allowance (FPA) to other parties within the same subarea. This mechanism allows industrial and municipal users to purchase BAP from agricultural or other users to augment their ability to pump water. Table 4-10 summarizes the amount of transfers that have occurred in each subarea through 2002.

Table 4-10: Permanent Transfers of Base Annual Production by Subarea WY94-02

Year Type	BAP Transfers (Acre-feet)
Alto	22,941
Baja	24,928
Centro	28,566
Este	5,248
Oeste	1,247
Total	82,930

Timeline for Implementation of Proposed Projects

As part of the RWMP Update, 19 projects and management actions were identified to address the water supply and water quality issues that MWA must address to provide a sustainable water supply through 2020. These projects and management actions can be found in Appendix B. This list includes both MWA and non-MWA projects, as well as projects and actions that might be developed in partnership with MWA. The following projects have been identified as having the highest priority:

- implementing 10% municipal conservation in the Mojave Basin and 5% in Morango Basin/Johnson Valley
- wastewater reclamation in Alto
- wellhead treatment in Alto
- recharge in the Alto Floodplain and Regional and Warren Valley aquifers
- providing a new water supply for Pioneertown

Each of these projects will begin implementation within the next 3-5 years.

The following projects have lower priority, but are being evaluated for possible implementation by 2020:

- a regional treatment plant in Alto
- recharge in the Alto Transition Zone, Baja, Centro, Este, Oeste, Copper Mountain Valley, and Means/Ames Valley
- providing a new water supply for Hinkley

5

WATER DEMAND

Introduction

As discussed in Chapter 3, the Mojave Water Agency (MWA) consists of two distinct hydrologic planning areas referred to as the Mojave Basin Area and the Morongo Basin/Johnson Valley Area. The Mojave Basin Area is further sub-divided into five subareas (hydrologic subbasins) known as Alto, Baja, Centro, Este, and Oeste. The Morongo Basin/Johnson Valley Area also contains four hydrologic subbasins referred to as Johnson Valley, Means/Ames Valley, Copper Mountain Valley and Warren Valley Basins. These subareas are used for planning purposes to determine safe yield and to report groundwater well production.

Since 1994, MWA has tabulated production in these planning subareas organized by demand sector. The demand sectors include agriculture, municipal, industrial, golf courses and parks, and recreational lakes. These data are used to characterize the current water demand within each subarea and also to project possible future water production within each sector in each subarea.

Production and consumptive use are two important concepts. Consumptive use values are presented in this chapter.

Groundwater production is an accurate measure of the water demand within each subarea, but it cannot be compared directly with the water supply estimates presented in Chapter 4. A portion of the water pumped is returned to the groundwater aquifer and becomes part of the available water supply. For example, much of the water applied to agriculture, golf courses, and parks percolates back to the groundwater aquifer. The portion of the groundwater pumped that does not return to the aquifer is referred to as consumptive use. In this chapter, consumptive use totals are presented rather than groundwater production to allow for a direct comparison with the estimated water supply in each subarea. The consumptive use rates used in this report are derived from Webb (2000), which performed a detailed analysis of the production and consumptive use for each subarea within the Mojave Basin Area.

This chapter presents the current and projected future consumptive use for each subarea. All of the data contained in this chapter is presented by water year. For a detailed discussion of the data available and of the methods used to generate the numbers presented in this chapter, please refer to Appendix C.

Current Water Demand

Demographics

Table 5-1 shows the 1990 and 2000 estimated populations for each subarea in the Mojave Basin Area and for each subbasin in the Morongo Basin/Johnson Valley Area in 1990 and 2000. The population increased in every subarea in the Mojave.

Table 5-1: Comparison of Actual and Projected 2000 Population

	1990 Actual[1]	2000 Actual	Annual Pct Change	2000 Projected[1]	Percent Difference
Mojave Basin Area					
Alto	180,700	236,600	+2.7%	259,200	-8.7%
Baja	8,800	5,100	-5.3%	12,600	-59.5%
Centro	33,000	33,700	+0.2%	47,300	-28.8%
Este	5,300	6,000	+1.2%	7,600	-21.1%
Oeste	5,800	7,400	+2.5%	8,300	-10.8%
Subtotal Mojave	233,600	288,800	+2.1%	335,000	-13.8%
MB/JV Area[2]					
Copper Mtn. Valley	10,200	9,600	-0.6%	11,500	-27.5%
Johnson Valley	N/A	400	N/A	N/A	N/A
Means/Ames Valley	4,700	7,500	+4.8%	5,900	+27.0%
Warren Valley	24,300	14,700	-4.9%	32,700	-55.0%
Subtotal MB/JV	39,200	32,200	-1.9%	51,900	-37.9%
Total	**272,800**	**321,000**	**+1.6%**	**386,900**	**-17.0%**

[1]1990 actual and 2000 projected population estimates from 1994 RWMP.
[2]Morongo Basin/Johnson Valley subbasin populations represent the population served by each subbasin, not the population that overlies the subbasin. This assumption is consistent with the 1994 RWMP.

Basin Area except for Baja. The largest increase was in Alto, which experienced an annual percent growth rate of 2.7% per year between 1990 and 2000. Baja showed a population reduction of 5.3% per year between 1990 and 2000. The overall population of the Mojave Basin Area increased from about 234,000 to about 289,000 between 1990 and 2000.

The 2000 population of the Morongo Basin/Johnson Valley area is estimated to be about 32,000 in 2000, which is about 7,000 less that the estimate for 1990 in the 1994 RWMP. However, many people in the area suspect that the 1990 population was overestimated. The population estimates shown in Table 5-1 represent the population served by the production in each groundwater basin. These estimates do not therefore necessarily represent the population living in any particular geographic area. This assumption is consistent with the 1994 RWMP. For example, the Hi-Desert Water District (HDWD) operates production wells that draw from both the Means/Ames Valley and Warren Valley subbasins. Between 1990 and 2000, the quantity of water that was extracted by HDWD in the Means/Ames Valley subbasin was greatly increased due to the operation of the newly drilled Well #24, and the extractions from the Warren Valley subbasin were correspondingly reduced. This shift in production is the reason why the Means/Ames subbasin shows a 4.8% average annual increase in population and the Warren Valley subbasin shows a 4.9% decrease in population between 1990 and 2000. If HDWD had continued to pump primarily from the Warren Valley subbasin in 2000 as it had in 1990, the population served by both the Means/Ames and Warren Valley subbasins would have been less in 2000 than it was in 1990.

Table 5-1 also shows the projected 2000 populations from the 1994 Regional Water Management Plan (RWMP). Every subarea and subbasin in the Mojave Water Agency except for the Means/Ames subbasin experienced less growth than was projected in the 1994 RWMP. The increase in population shown for the Means/Ames Valley subbasin does not represent an increase in actual population, but a shift in service for a portion of HDWD from the Warren Valley subbasin.

The overall population of the Mojave Water Agency increased from about 273,000 in 1990 to about 321,000 in 2000, which represents an average annual growth rate of 1.6% per year. The year 2000 population was 17% less than what was projected in the 1994 RWMP.

Table 5-2 shows year 2000 estimates of population, housing units, average household size, land area and population per acre for individual cities within the Mojave Water Agency.

Table 5-2: Year 2000 Demographic Data for Selected Cities

City	Subarea	Population*	Housing Units*	Average Household Size*	Land Area (sq. miles)	Population per acre
Adelanto	Alto	18,130	5,547	3.53	63	0.45
Apple Valley	Alto	54,239	20,163	2.90	73	1.16
Barstow	Centro	21,119	9,153	2.71	33	1.00
Hesperia	Alto	62,582	21,348	3.12	67	1.45
Victorville	Alto	64,029	22,498	3.03	74	1.35
Yucca Valley	MB/JV Area	16,865	7,952	2.38	40	0.66

*Population, Housing Unit and Household Size data from 2000 U.S. Census

Consumptive Use

Table 5-3 summarizes the difference between the projected consumptive use estimates for 1995 and 2000 by the 1994 RWMP and actual consumptive use estimates for those two years. Figures 5-1, 5-2 and 5-3 graphically present the Mojave Basin Area data from Table 5-3. The actual urban consumptive use in the Mojave Basin Area was 7% higher than the projected amount for 1995 while agricultural consumptive use was 23% less than the projected amount. The Mojave Basin Area urban consumptive use for year 2000 was 14% greater than projected and the agricultural consumptive use was about 44% less than projected. In the Morongo Basin/Johnson Valley area, the actual consumptive use was 17% less than the projected consumptive use in 1995 and 32% less in 2000.

Table 5-3: 1995 and 2000 Projected and Actual Consumptive Use (Acre-feet/year)

	1995 Projected	1995 Actual	Difference	Percent Difference
Mojave Basin Area				
Urban Uses*	53,800	57,500	3,700	7%
Agricultural Uses	70,500	54,400	-16,100	-23%
Subtotal Mojave	124,300	111,900	-12,400	-10%
MB/JV Area				
Urban Uses*	3,270	2,700	-570	-17%
Total	**127,600**	**114,600**	**-13,000**	**-10%**

	2000 Projected	2000 Actual	Difference	Percent Difference
Mojave Basin Area				
Urban Uses*	61,700	70,300	8,600	14%
Agricultural Uses	62,600	34,900	-27,700	-44%
Subtotal Mojave	124,300	105,200	-19,100	-15%
MB/JV Area				
Urban Uses*	3,810	2,600	-1,210	-32%
Total	**128,100**	**107,800**	**-20,300**	**-16%**

*Urban uses include municipal, industrial, golf course, and recreational water uses

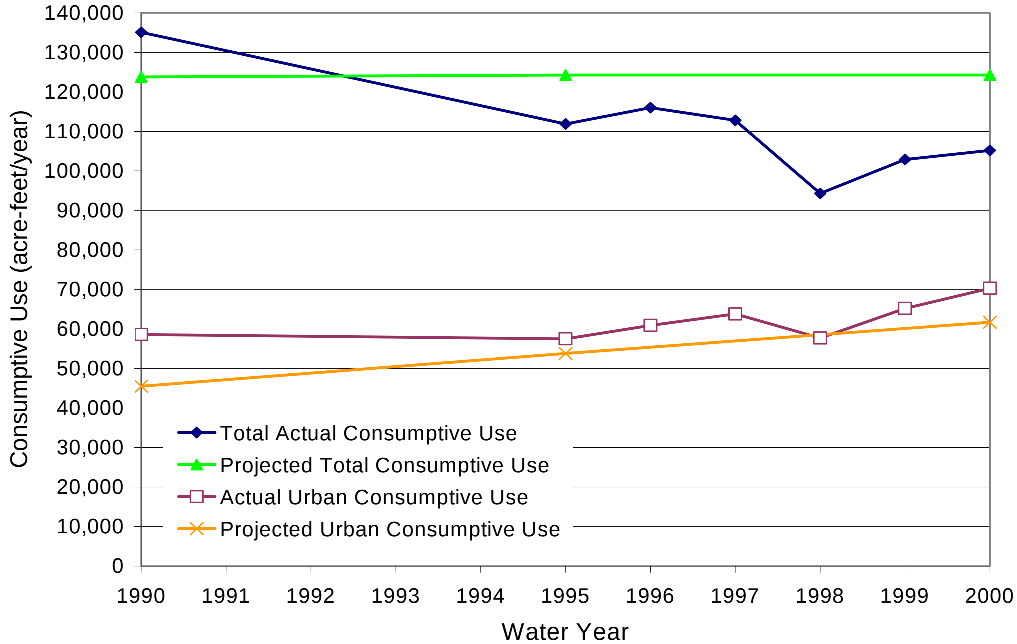


Figure 5-1: Mojave Basin Area Actual Total and Urban Consumptive Use for1990 - 2000 and 1994 RWMP Projected Use

The 1994 RWMP projected a 1.1% total increase in total Mojave Water Agency consumptive use between 1990 and 2000. The actual consumptive use during this period decreased by 14.9%, which represents a decline of about 18,700 acre-feet.

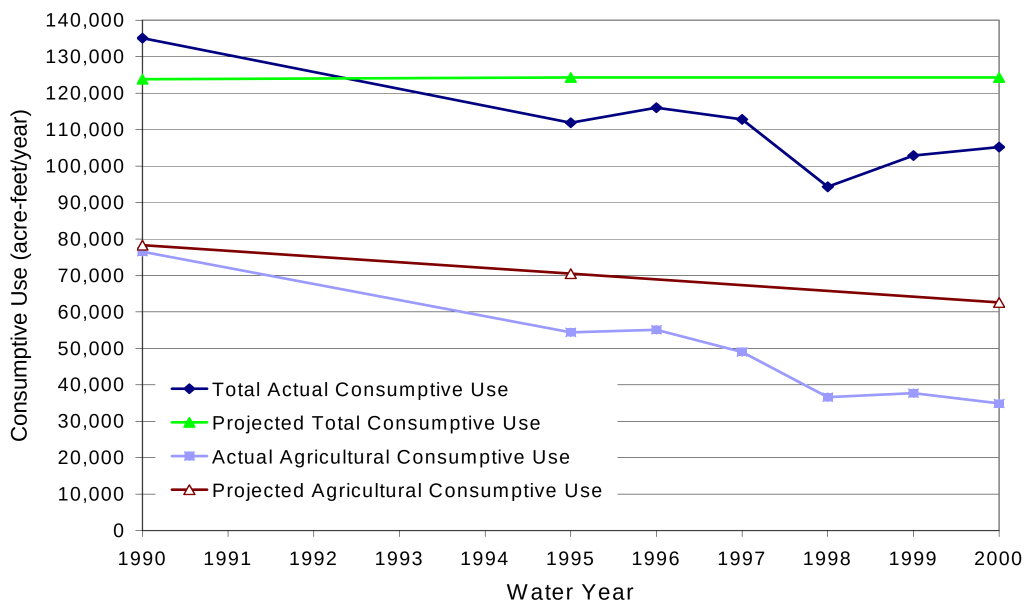


Figure 5-2: Mojave Basin Area Actual Total and Agricultural Consumptive Use for 1990-2000 and 1994 RWMP Projected Use

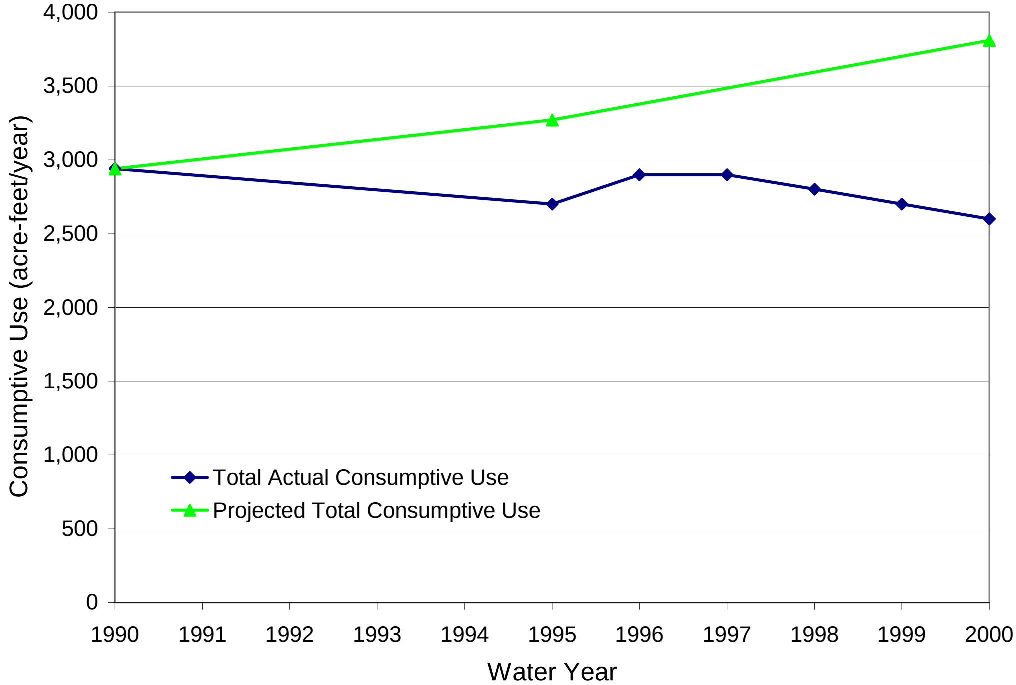


Figure 5-3: Morongo Basin/Johnson Valley Area Actual Total Consumptive Use for 1990-2000 and 1994 RWMP Projected Use

Mojave Basin Area

The urban consumptive use amounts cited above include all of the non-agricultural uses such as industrial, municipal, golf courses and parks, and recreational lakes. MWA has more recently estimated production for each of these uses separately. Table 5-4 shows estimates of historical consumptive use from 1995 to 2001 for each subarea in the Mojave Basin Area for the various water uses identified above. Figure 5-4 shows the total Mojave Basin Area consumptive use estimates during this time period. The municipal consumptive use estimates in Alto and Oeste have been adjusted to account for the operation of County Service Area (CSA) 70L. While the population of CSA 70L is almost evenly split between Alto and Oeste, about 80% of the production is in Oeste. As a result, the municipal consumptive use estimates in Oeste are greater than 50% of production while the estimates for Alto are less than 50% of production.

Agricultural consumptive use has been declining in all subareas in the Mojave Basin Area since about 1990 while other consumptive uses have remained fairly constant since 1995. The additional decrease in consumptive use of applied water during 1998 as shown on Figure 5-4 was possibly the result of an unusually large amount of local precipitation during that year.

Figures 5-5 through 5-9 show the consumptive use in Alto, Baja, Centro, Este, and Oeste for the various types of use from 1995 through 2001. The recent trends within each subarea are discussed briefly below.

Alto (Figure 5-5)

Since 1995, municipal consumptive use has increased 16.5% from 28,400 acre-feet to 33,100 acre-feet. During the same time period, however, agricultural consumptive use in Alto has decreased by 72.2%, from 9,000 acre-feet to 2,500 acre-feet. As a result, total consumptive use in Alto has remained fairly steady in recent years.

Baja (Figure 5-6)

Agriculture is the primary use of water in the Baja Subarea. Between 1995 and 2001, agricultural consumptive use in Baja declined by 31.4%, from 22,300 acre-feet to 15,300 acre-feet. Industrial consumptive use has increased by 350% since 1995, from 1,400 acre-feet to 6,300 acre-feet in 2001, due mostly to an increase in water use by power generating facilities in the area. Between 1995 and 2001 total consumptive use in the Baja Subarea declined by 1,900 acre-feet.

Centro (Figure 5-7)

In Centro, both agricultural and urban consumptive use has been declining in recent years. Between 1995 and 2001, municipal and industrial use declined by about 11.6% from 8,600 acre-feet to 7,600 acre-feet. Agricultural consumptive use declined by 59.2%, from 16,900 acre-feet to 6,900 acre-feet. Total consumptive use in Centro has declined from 25,700 acre-feet to 14,700 acre-feet between 1995 and 2001.

Este (Figure 5-8)

Agricultural water use has been decreasing in recent years in Este. Between 1995 and 2001 agricultural consumptive use decreased by 29.3%, from 4,100 acre-feet to 2,900 acre-feet. Urban consumptive use remained fairly constant during these years. Total consumptive use in Este was about 4,600 acre-feet in 2001, compared to 6,300 acre-feet in 1995.

Oeste (Figure 5-9)

Oeste agricultural consumptive use in 2001 was 1,000 acre-feet, compared to 2,100 acre-feet in 1995. Municipal consumptive use has increased between 1995 and 2001 from 1,500 acre-feet to 1,900 acre-feet. Because the decrease in agricultural consumptive use has been greater than the increase in urban use, total consumptive use in Oeste decreased by 700 acre-feet between 1995 and 2001.

Table 5-4: Mojave Basin Area Historical Consumptive Use (Acre-feet/year)

Alto	1995	1996	1997	1998	1999	2000	2001
Agricultural	9,000	8,200	9,100	4,800	4,500	3,800	2,500
Industrial	5,300	4,000	3,700	3,100	4,000	4,200	3,900
Municipal	28,400	32,000	31,900	28,800	31,300	34,400	33,100
Golf Courses	2,500	2,300	2,200	2,300	2,800	2,200	2,400
Recreational	2,800	3,800	4,100	4,900	6,100	6,900	5,800
Total	**48,000**	**50,300**	**51,000**	**43,900**	**48,700**	**51,500**	**47,700**

Baja	1995	1996	1997	1998	1999	2000	2001
Agricultural	22,300	24,900	21,000	18,300	18,800	17,700	15,300
Industrial	1,400	1,100	3,300	2,500	4,300	5,500	6,300
Municipal	2,000	2,800	2,200	1,700	2,400	2,500	2,400
Golf Courses	0	0	0	0	0	0	0
Recreational	2,600	2,300	3,200	3,900	2,600	2,500	2,400
Total	**28,300**	**31,100**	**29,700**	**26,400**	**28,100**	**28,200**	**26,400**

Centro	1995	1996	1997	1998	1999	2000	2001
Agricultural	16,900	14,900	12,600	8,400	9,800	8,900	6,900
Industrial	2,500	2,500	2,700	1,600	1,800	1,900	1,900
Municipal	6,100	6,600	6,500	5,700	5,900	6,300	5,700
Golf Courses	200	200	200	100	200	200	200
Recreational	0	0	0	0	0	0	0
Total	**25,700**	**24,200**	**22,000**	**15,800**	**17,700**	**17,300**	**14,700**

Este	1995	1996	1997	1998	1999	2000	2001
Agricultural	4,100	4,800	4,000	3,300	3,200	3,200	2,900
Industrial	1,500	800	1,300	800	1,000	900	700
Municipal	700	900	900	900	900	900	1,000
Golf Courses	0	0	0	0	0	0	0
Recreational	0	0	0	0	0	0	0
Total	**6,300**	**6,500**	**6,200**	**5,000**	**5,100**	**5,000**	**4,600**

Oeste	1995	1996	1997	1998	1999	2000	2001
Agricultural	2,100	2,300	2,300	1,800	1,400	1,300	1,000
Industrial	0	0	0	0	0	0	0
Municipal	1,500	1,600	1,600	1,400	1,900	1,900	1,900
Golf Courses	0	0	0	0	0	0	0
Recreational	0	0	0	0	0	0	0
Total	**3,600**	**3,900**	**3,900**	**3,200**	**3,300**	**3,200**	**2,900**

Total Mojave Basin Area	1995	1996	1997	1998	1999	2000	2001
Agricultural	54,400	55,100	49,000	36,600	37,700	34,900	28,600
Industrial	10,700	8,400	11,000	8,000	11,100	12,500	12,800
Municipal	38,700	43,900	43,100	38,500	42,400	46,000	44,100
Golf Courses	2,700	2,500	2,400	2,400	3,000	2,400	2,600
Recreational	5,400	6,100	7,300	8,800	8,700	9,400	8,200
Total	**111,900**	**116,000**	**112,800**	**94,300**	**102,900**	**105,200**	**96,300**

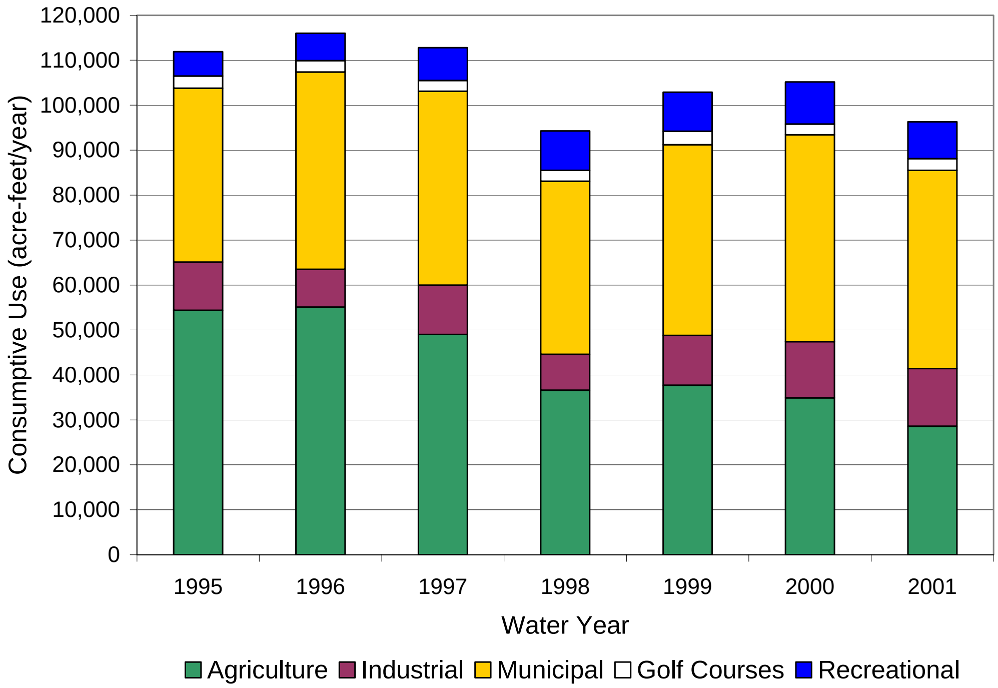


Figure 5-4: Mojave Basin Area Total Consumptive Use by Sector for 1995-2001

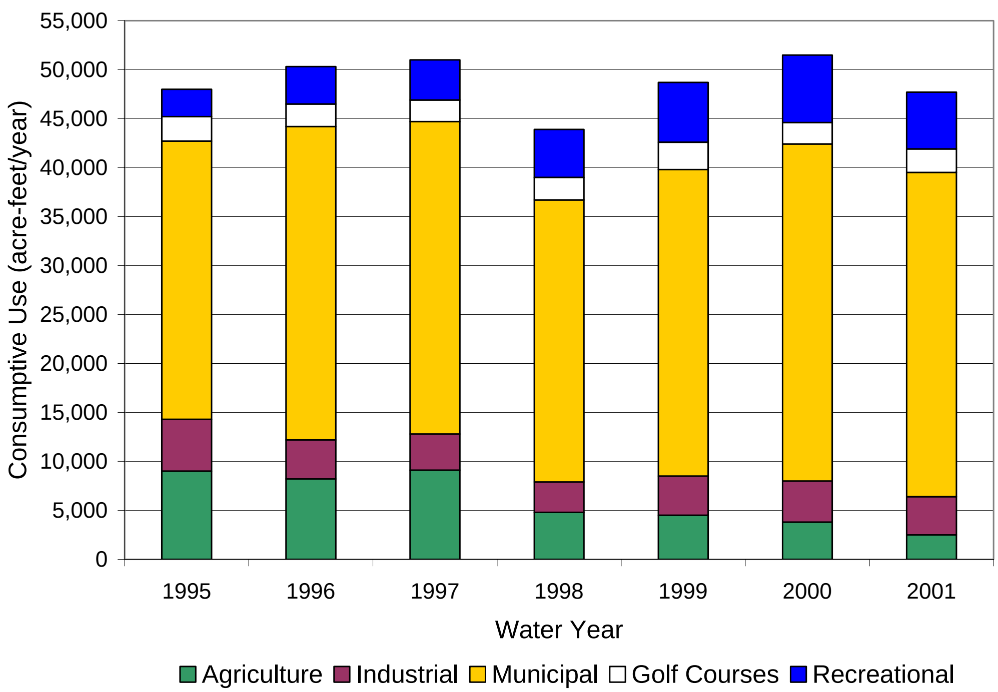


Figure 5-5: Alto Subarea Consumptive Use by Sector for 1995-2001

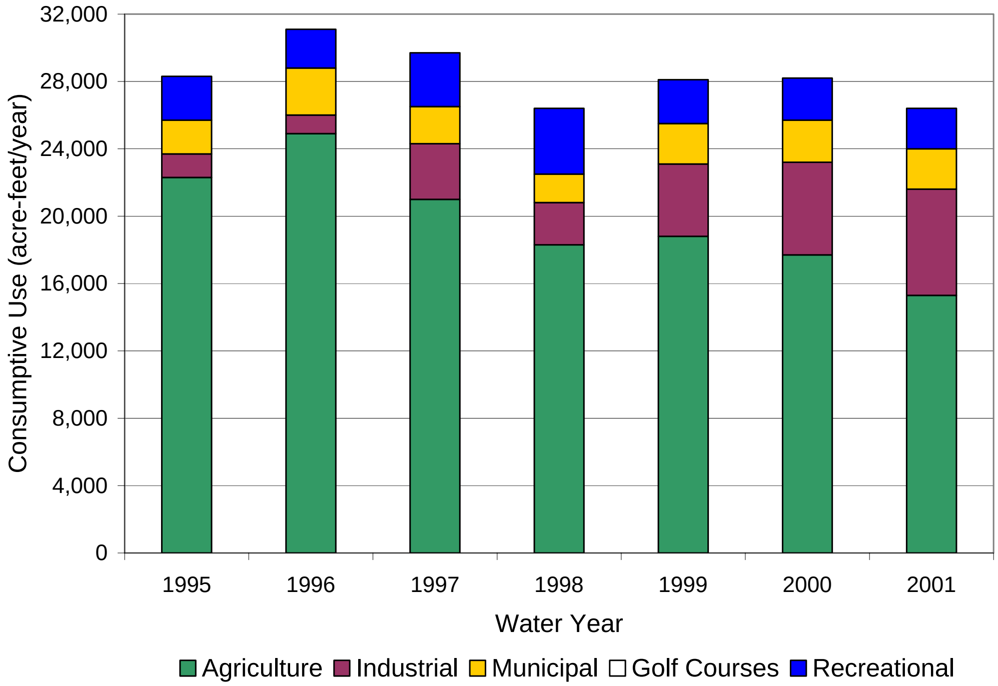


Figure 5-6: Baja Subarea Consumptive Use by Sector for 1995-2001

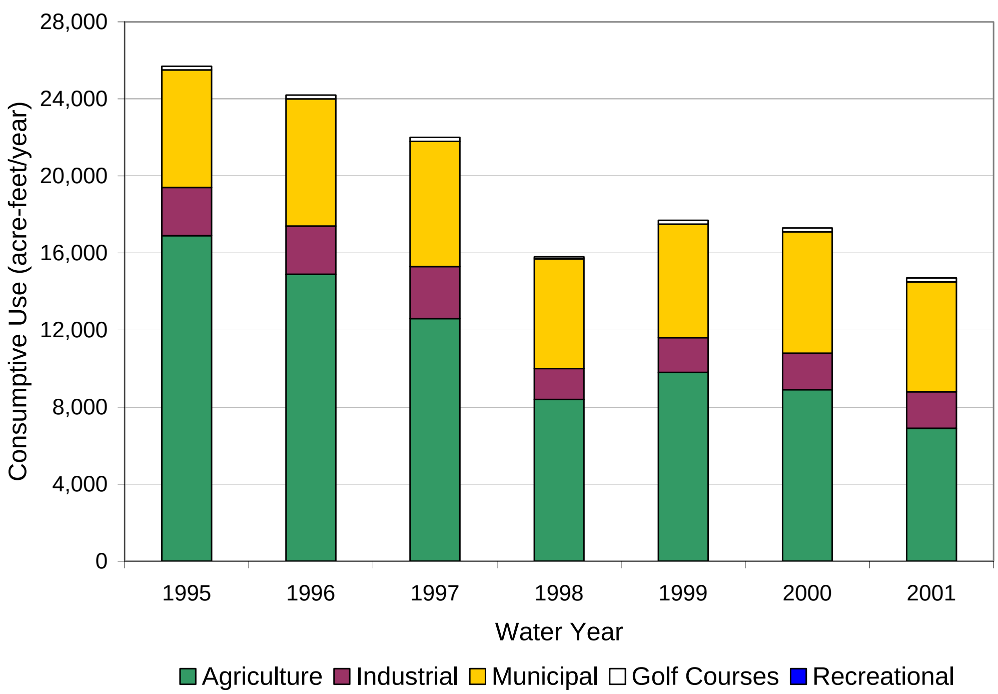


Figure 5-7: Centro Subarea Consumptive Use by Sector for 1995-2001

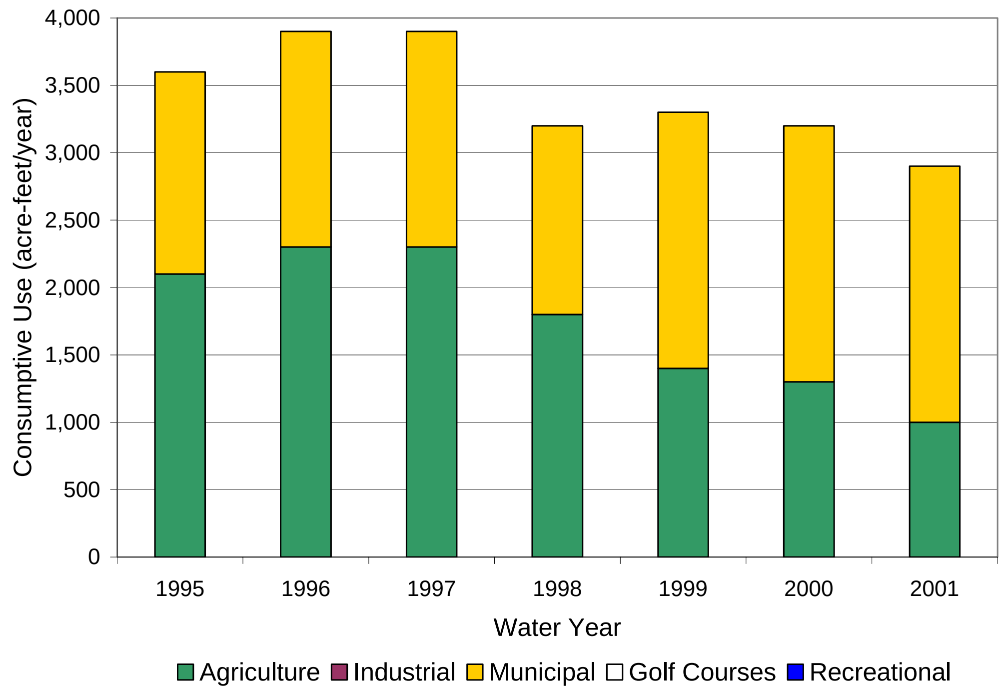


Figure 5-8: Este Subarea Consumptive Use by Sector for 1995-2001

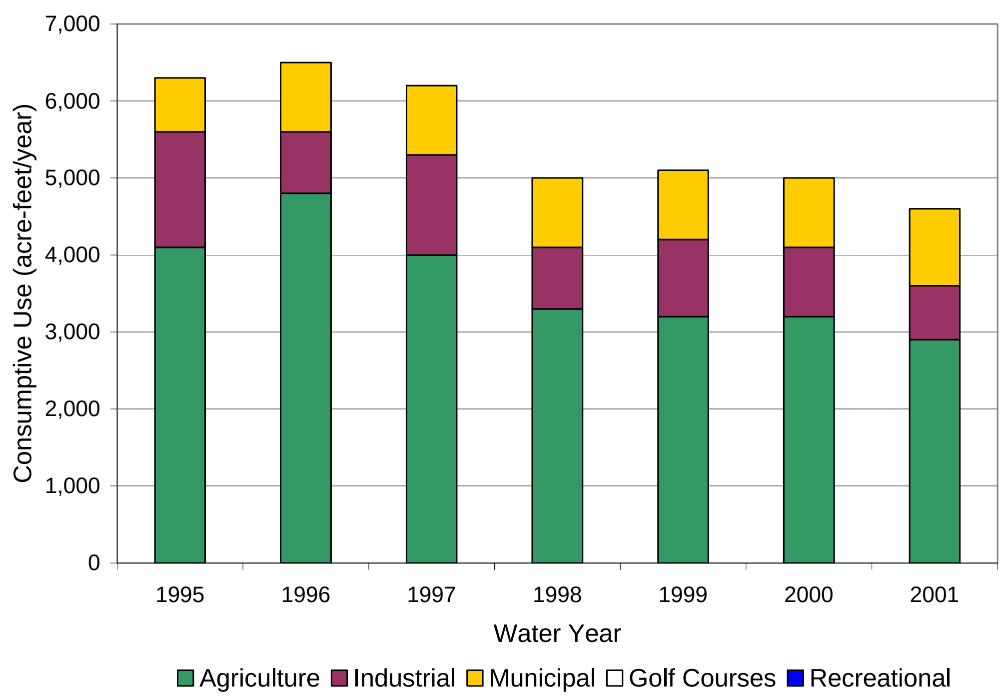


Figure 5-9: Oeste Subarea Consumptive Use by Sector for 1995-2001

Morongo Basin/Johnson Valley Area

Table 5-5 shows consumptive use estimates for each demand sector within each subbasin in the Morongo Basin/Johnson Valley Area. Because production estimates were not available in the Morongo Basin/Johnson Valley Area for 2001, Table 5-5 shows consumptive use estimates from 1995-2000. Production data is not available for the Johnson Valley subbasin. The consumptive use estimate for the Johnson Valley Area for 2000 was determined using the 2000 population estimate shown in Table 5-1 and assuming that the per capita use was the same as the remainder of the Morongo Basin/Johnson Valley Area.

The municipal consumptive use in the Means/Ames Valley and Warren Valley subbasins has not necessarily been proportional to the production in each of those subbasins. This is due to: (1) the pumping operation of the HDWD, which overlies both subbasins and has production wells in each subbasin, and (2) the operation of the Bighorn Desert View Intertie, through which water pumped outside of HDWD in the Means/Ames Valley subbasin was transferred to HDWD in 1995, 1996 and 2000. In 2000, 81% of the population of HDWD resided on top of the Warren Valley subbasin, with the remainder residing on top of the Means/Ames Valley subbasin. It is therefore assumed that the 81% of the return flow from total HDWD production would return to the Warren Valley subbasin. However, the proportion of HDWD's production that was extracted from each subbasin has been variable, with as little as 61% being extracted from the Warren Valley subbasin in 1996 and as much as 79% in 2000. Because a higher proportion of population than production in the HDWD service area has been in the Warren Valley subbasin, the consumptive use as a percent of production has been higher in the Means/Ames Valley subbasin than in the Warren Valley subbasin. The Bighorn Desert View Intertie operation had the further effect of increasing the consumptive use in the Means/Ames subbasin and reducing it in the Warren Valley subbasin because all of the production passing through the Intertie occurred in the Means/Ames Valley subbasin but 81% of the return flow went to the Warren Valley subbasin.

Table 5-5: Morongo Basin/Johnson Valley Area Historical Consumptive Use (Acre-feet/year)

Copper Mountain Valley						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Agricultural	0	0	0	0	0	0
Industrial	0	0	0	0	0	0
Municipal	700	800	800	700	800	800
Golf Courses	0	0	0	0	0	0
Recreational	0	0	0	0	0	0
Total	**700**	**800**	**800**	**700**	**800**	**800**

Johnson Valley						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Agricultural	N/A	N/A	N/A	N/A	N/A	0
Industrial	N/A	N/A	N/A	N/A	N/A	0
Municipal	N/A	N/A	N/A	N/A	N/A	30
Golf Courses	N/A	N/A	N/A	N/A	N/A	0
Recreational	N/A	N/A	N/A	N/A	N/A	0
Total	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**30**

Means/Ames Valley						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Agricultural	0	0	0	0	0	0
Industrial	0	0	0	0	0	0
Municipal	1,200	1,700	900	1,200	900	600
Golf Courses	0	0	0	0	0	0
Recreational	0	0	0	0	0	0
Total	**1,200**	**1,700**	**900**	**1,200**	**900**	**600**

Warren Valley						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Agricultural	0	0	0	0	0	0
Industrial	0	0	0	0	0	0
Municipal	600	200	1,000	700	800	1,100
Golf Courses	200	200	200	200	200	100
Recreational	0	0	0	0	0	0
Total	**800**	**400**	**1,200**	**900**	**1,000**	**1,200**

Total Morongo Basin/Johnson Valley Area*						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Agricultural	0	0	0	0	0	0
Industrial	0	0	0	0	0	0
Municipal	2,500	2,700	2,700	2,600	2,500	2,500
Golf Courses	200	200	200	200	200	100
Recreational	0	0	0	0	0	0
Total	**2,700**	**2,900**	**2,900**	**2,800**	**2,700**	**2,600**

*Johnson Valley is not included in the Morongo Basin/Johnson Valley Area totals because the supply is not included as noted in Chapter 4.

Figure 5-10 shows the total Morongo Basin/Johnson Valley Area consumptive use estimates during this time period. Consumptive use in the Morongo Basin/Johnson Valley area has stayed fairly constant in these years, fluctuating between about 2,600 acre-feet and about 2,900 acre-feet. About 95% of the consumptive use in the Morongo Basin/Johnson Valley area is municipal use, with the remainder being used for a golf course in the Warren Valley. The area contains only minimal agricultural, industrial, or recreational lakes uses.

Figures 5-11 through 5-13 show the consumptive use in the Copper Mountain Valley, Means/Ames Valley, and Warren Valley subbasins for each type of use from 1995 through 2000. The recent trends within each subbasin are discussed briefly below.

Copper Mountain Valley (Figure 5-11)

All of the production from the Copper Mountain Valley subbasin is for municipal uses. The consumptive use in the Copper Mountain Valley subbasin has been fairly stable in recent years, ranging from a low of 700 acre-feet in 1998 to a high of 800 acre-feet in 1996.

Means/Ames Valley (Figure 5-12)

Consumptive use in the Means/Ames Valley has been highly variable because of fluctuations in the production ratio of HDWD and the operation of the Bighorn Desert View Intertie. In 1996, the Means/Ames Valley consumptive use was very high because 39% of the HDWD pumping was out of the Means/Ames Valley subbasin and an additional 700 acre-feet was pumped from the subbasin and transferred to HDWD. However, from 1997-1999 the Bighorn Desert View Intertie did not operate and only 27 acre-feet were transferred in 2000. Furthermore, in 1997, 1999, and 2000 less than 30% of HDWD's production was out of the Means/Ames Valley subbasin. As a result of these differences in operation, the consumptive use in the Means/Ames Valley subbasin was 1,700 acre-feet in 1996 but 900 acre-feet or less in 1997, 1999, and 2000.

Warren Valley (Figure 5-13)

Consumptive use in the Warren Valley has been highly variable for the same reasons as in the Means/Ames Valley. The effects of these changes in operation have been the opposite in the Warren Valley than those in the Means/Ames Valley. In 1996, for example, while the Means/Ames Valley had a very high consumptive use, the Warren Valley subbasin had only about 400 acre-feet of consumptive use. In 1997, 1999 and 2000, by contrast, the Warren Valley had at least 1,000 acre-feet of consumptive use each year.

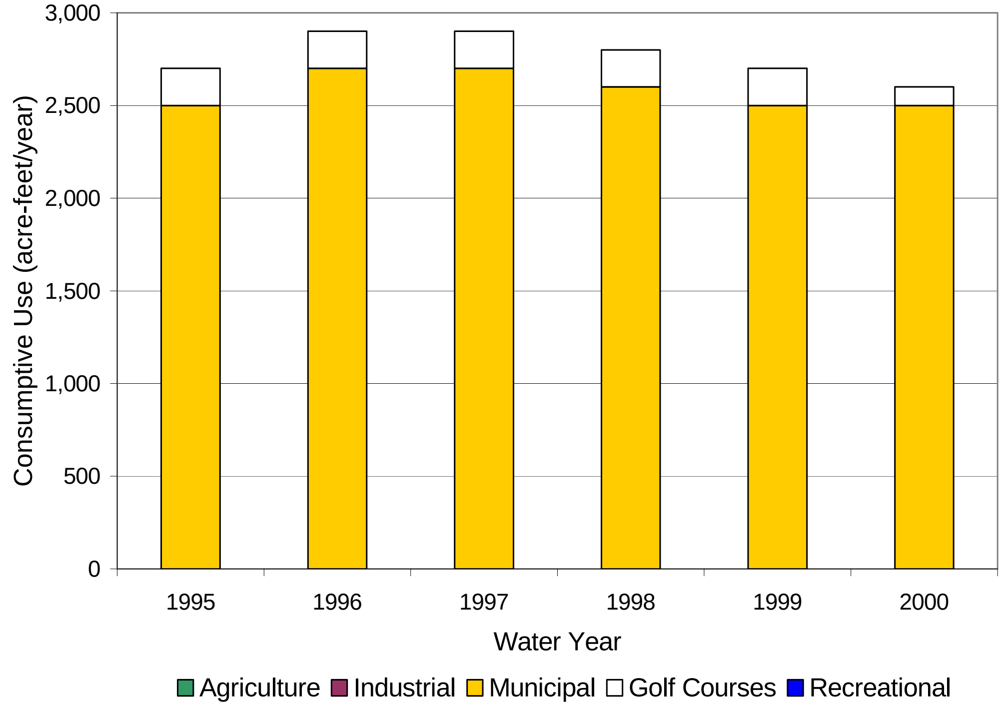


Figure 5-10: Morongo Basin/Johnson Valley Area Total Consumptive Use by Sector for 1995-2000

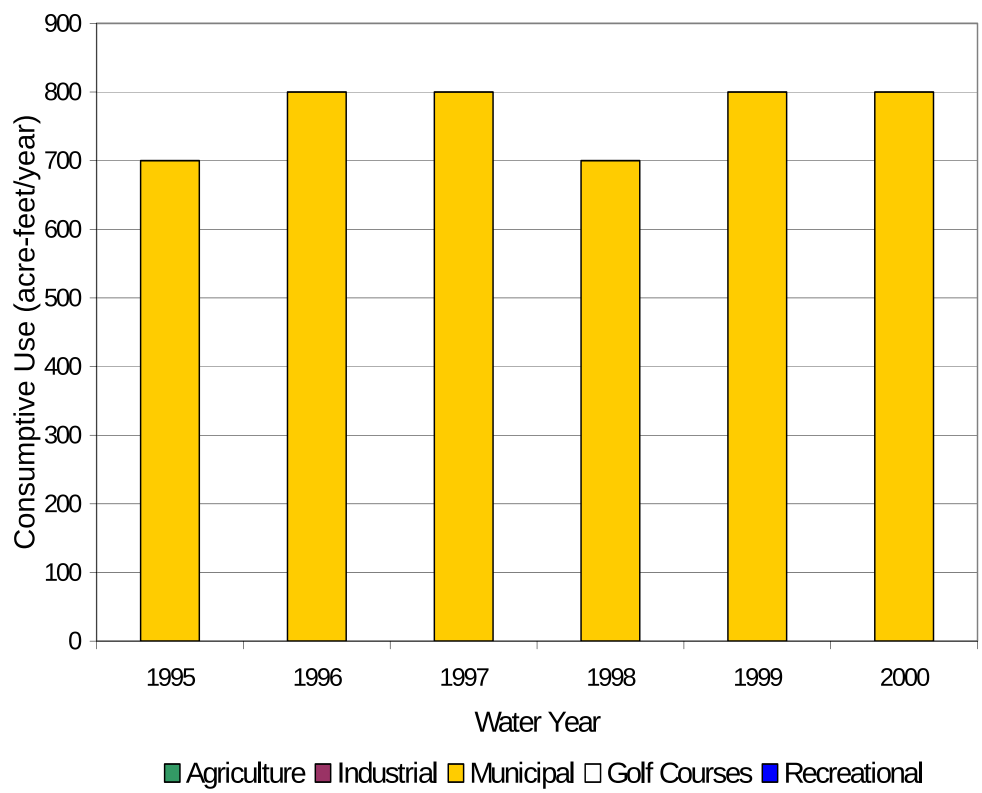


Figure 5-11: Copper Mountain Valley Subbasin Consumptive Use by Sector for 1995-2000

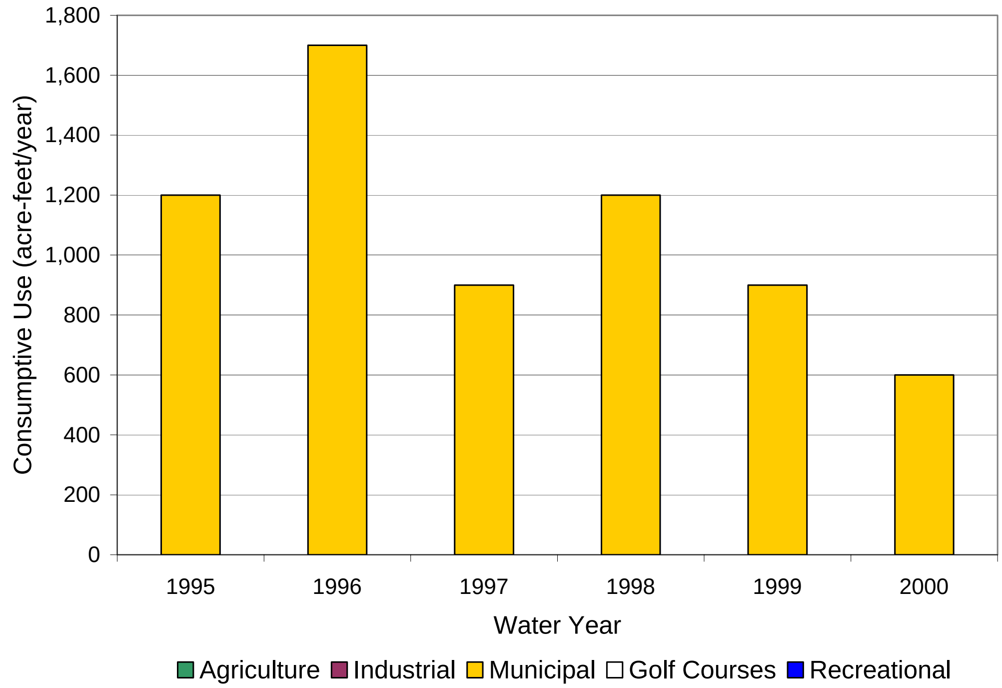


Figure 5-12: Means/Ames Valley Subbasin Consumptive Use by Sector for 1995-2000

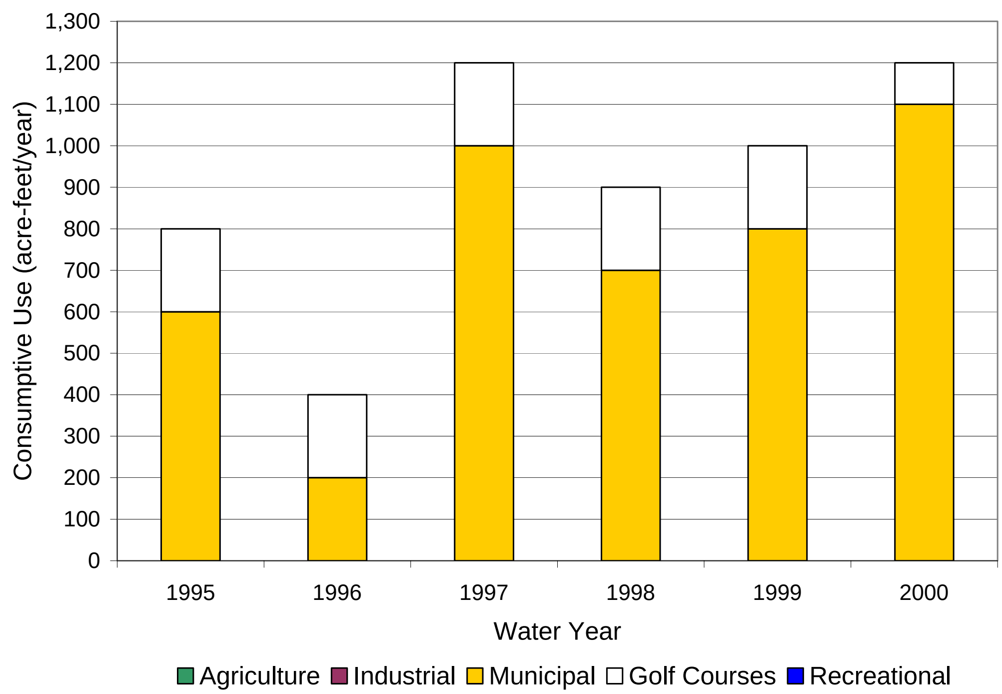


Figure 5-13: Warren Valley Subbasin Consumptive Use by Sector for 1995-2000

Current Water Balance

MWA's current water demand, as discussed above, is compared with the average annual water supply discussed in Chapter 4 to develop the water balance shown in Table 5-6.

Table 5-6: Year 2000 Average Annual Water Balance (Acre-feet/year)

	Net Average Annual Water Supply[1]	Consumptive Use Agricultural	Consumptive Use Urban[2]	Total	Surplus/ Deficit
Mojave Basin Area					
Alto	34,700	3,800	47,700	51,500	-16,800
Baja	5,600	17,700	10,500	28,200	-22,600
Centro	18,500	8,900	8,400	17,300	+1,200
Este	3,500	3,200	1,800	5,000	-1,500
Oeste	1,100	1,300	1,900	3,200	-2,100
Subtotal Mojave	63,400	34,900	70,300	105,200	-41,800
MB/JV Area					
Copper Mtn. Valley	600	0	800	800	-200
Johnson Valley	2,300	0	30	30	+2,270
Means/Ames Valley	600	0	600	600	0
Warren Valley	900[3]	0	1,200	1,200	-300
Subtotal MB/JV[4]	2,100	0	2,600	2,600	-500
Total	**65,500**	**34,900**	**72,900**	**107,800**	**-42,300**
			Average Annual SWP Supply:		**8,000**
			Surplus/Deficit with SWP Supply:		**-34,300**

[1]Net average annual water supply data as shown in Tables 4-2 and 4-5 of Chapter 4.
[2]Urban uses include municipal, industrial, golf course, and recreational water uses.
[3]Hi-Desert Water District reports unpublished USGS estimates of 200 acre-feet per year net average annual supply in the Warren Valley subbasin.
[4]Johnson Valley is not included in the Morongo Basin/Johnson Valley totals because the supply is not included as noted in Chapter 4.

As shown in Table 5-6, the average water deficit in the Mojave Basin Area without State Water Project (SWP) supply for the year 2000 is approximately 41,800 acre-feet per year. Baja, with a deficit of 22,600 acre-feet, and Alto, at 16,800 acre-feet, constitute most of the current water deficit. Centro currently has slightly more water supply than demand. Este has a water deficit of approximately 1,500 acre-feet per year and Oeste has a deficit of approximately 2,100 acre-feet per year.

Outside of the Johnson Valley, the Morongo Basin/Johnson Valley Area has an average water deficit of approximately 500 acre-feet per year without SWP supply. The Warren Valley subbasin has the largest deficit, at about 300 acre-feet per year.

Since 1999, an average of about 8,000 acre-feet per year of SWP water has been imported into the Mojave Water Agency. Of this amount, about 3,500 acre-feet has been purchased by the Hi-Desert Water District and delivered to the Warren Valley subbasin by the Morongo Basin Pipeline to offset the deficit and to add to groundwater in storage.

When the current average annual SWP delivery is included, the Mojave Water Agency currently has a long-term average annual water deficit of approximately 34,300 acre-feet per year.

Future Water Demand

Demographics

Table 5-7 shows the estimated 2000 population and projected future population for each subarea and the average annual percent increase between 2000 and 2020. These population estimates were determined using data provided by the Southern California Association of Governments and data contained in stakeholder surveys.

Table 5-7: Current and Projected Population Estimates

	2000	2005	2010	2015	2020	Annual Percent Change
Mojave Basin Area						
Alto	236,600	266,700	303,700	348,900	407,700	+2.8%
Baja	5,100	5,300	5,600	5,900	6,200	+1.0%
Centro	33,700	36,100	41,500	47,100	54,100	+2.4%
Este	6,000	6,800	8,100	9,400	11,300	+3.2%
Oeste	7,400	8,300	9,400	11,300	13,600	+3.1%
Subtotal Mojave	288,800	323,200	368,300	422,600	492,900	+2.7%
MB/JV Area*						
Copper Mtn. Valley	9,600	10,300	11,000	11,800	12,700	+1.4%
Johnson Valley	400	400	500	500	600	+2.0%
Means/Ames Valley	7,500	8,300	9,300	10,400	11,700	+2.2%
Warren Valley	14,700	16,600	18,600	21,000	23,600	+2.4%
Subtotal MB/JV	32,200	35,600	39,400	43,700	48,600	+2.1%
Total	**321,000**	**358,800**	**407,700**	**466,300**	**541,500**	**+2.6%**

*Morongo Basin/Johnson Valley Area subbasin populations represent the population served by each subbasin, not the population that overlies the subbasin. This assumption is consistent with the 1994 RWMP.

Consumptive Use

The following assumptions were used to estimate the future consumptive use through 2020 for various water uses:

- Industrial and recreational lakes water uses were assumed to remain constant at year 2000 levels. The one exception was industrial use in Alto, which was assumed to increase by 4,000 acre-feet due to the expected operation of the new Hi-Desert Power Project.
- Municipal water use was assumed to change in direct proportion to the population in each subarea. The population estimates used are shown in Table 5-6. Total water use was determined by multiplying these population estimates by per capita water use rates calculated for the year 2000.
- Golf course consumptive use was assumed to change in direct proportion with the change in municipal consumptive use.
- Agricultural consumptive use was estimated under two possible scenarios intended to provide a maximum and minimum estimate of future agricultural demand.

  Agriculture Scenario 1: assumes that agricultural water use does not change from the year 2000 estimates through 2020. Under this assumption, any current non-agricultural water deficit within the subarea and all increases in non-agricultural water uses would have to be supplied by imported water.

  Agriculture Scenario 2: assumes that rampdown under the Mojave Basin Area Judgment (1996) resumes in 2002 at 5% per year until balance is achieved between production rights and available supply as required by the Judgment. Non-agricultural water use was assumed to be met by existing non-agricultural Free Production Allowances and through voluntary transfers of agricultural free production allowance. It was assumed, however, that at least 1,300 acre-feet of agricultural consumptive use (2,100 acre-feet of production) would remain in Alto, 300 acre-feet of consumptive use (500 acre-feet of production) would remain in Oeste, and 600 acre feet of consumptive use (900 acre-feet of production) would remain in Baja.

These two scenarios result in significantly different estimates of future agricultural consumptive use, especially in Baja. Projected agricultural consumptive uses can be seen for each scenario in Table 5-8. Under Agriculture Scenario 1, the year 2000 values remain unchanged through the year 2020. Under Agriculture Scenario 2, there are significant decreases in agricultural consumptive use because of the assumption that agriculture will voluntarily transfer its free production allowance to non-agricultural uses in-lieu of purchasing replacement water. Figure 5-

14 graphically shows the projected future agricultural consumptive use in each subarea under Scenario 2.

Table 5-8: Projected Agricultural Consumptive Use (Acre-feet/year)

	Ag Scenario 1	Ag Scenario 2				
	All years	**2000**	**2005**	**2010**	**2015**	**2020**
Mojave Basin Area						
Alto	3,800	3,800	1,300	1,300	1,300	1,300
Baja	17,700	17,700	17,700	6,700	600	600
Centro	8,900	8,900	8,900	8,900	8,900	8,900
Este	3,200	3,200	3,200	3,200	3,200	1,400
Oeste	1,300	1,300	1,300	1,300	1,300	300
Subtotal Mojave	34,900	34,900	34,900	32,400	15,300	12,500
MB/JV Area						
Copper Mtn. Valley	0	0	0	0	0	0
Johnson Valley	0	0	0	0	0	0
Means/Ames Valley	0	0	0	0	0	0
Warren Valley	0	0	0	0	0	0
Subtotal MB/JV	0	0	0	0	0	0
TOTAL	**34,900**	**34,900**	**32,400**	**21,400**	**15,300**	**12,500**

It should be noted that agricultural use has already declined in every subarea relative to year 2000 levels. However, these data are still considered to be valid for planning purposes because Agriculture Scenarios 1 and 2 are intended to provide low and high estimates of future agricultural use. The Technical Advisory Committee for the RWMP Update has determined that Agriculture Scenario 2 is the most appropriate to be used as the basis for the Plan.

Mojave Basin Area

As a result of the differences in agricultural use, the two scenarios show very different pictures of future consumptive use in the Mojave Basin Area. Table 5-9 shows the projected consumptive use for the non-agricultural demand sectors in each subarea in the Mojave Basin Area. Table 5-8 also shows the total consumptive use for each subarea under each scenario when the agricultural estimates from Table 5-8 are added to the totals. The projected total consumptive use in the Mojave Basin Area can also be seen for each scenario in Figures 5-15 and 5-16. Between 2000 and 2020, municipal consumptive use is projected to increase by about 31,600 acre-feet, an increase of 2.6% per year. In addition, golf course and park use is projected to increase by about 1,700 acre-feet, and industrial use is projected to increase by about 4,000 acre-feet. Therefore, when agricultural consumptive use is held constant as in Agriculture

Scenario 1, the overall water demand would increase by about 37,300 acre-feet. Under Agricultural Scenario 2, however, much of the increase in municipal consumptive use is offset by reductions in agricultural use, resulting in a total increase of only about 14,900 acre-feet between 2000 and 2020.

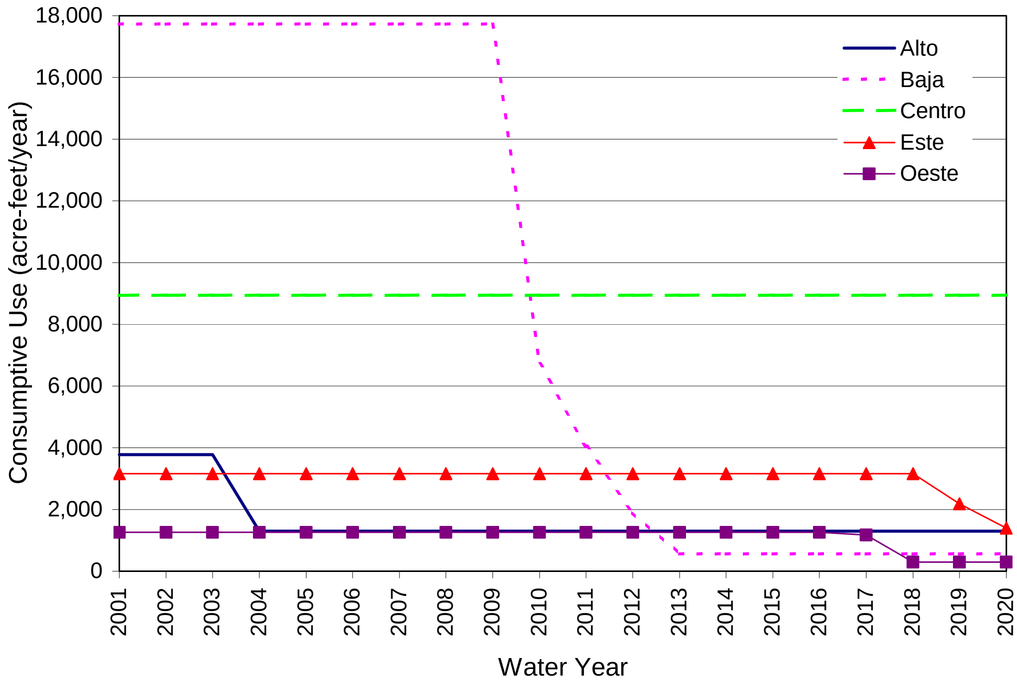


Figure 5-14: Agricultural Consumptive Use From 2001 Through 2020 Under Agriculture Scenario 2 Assumptions

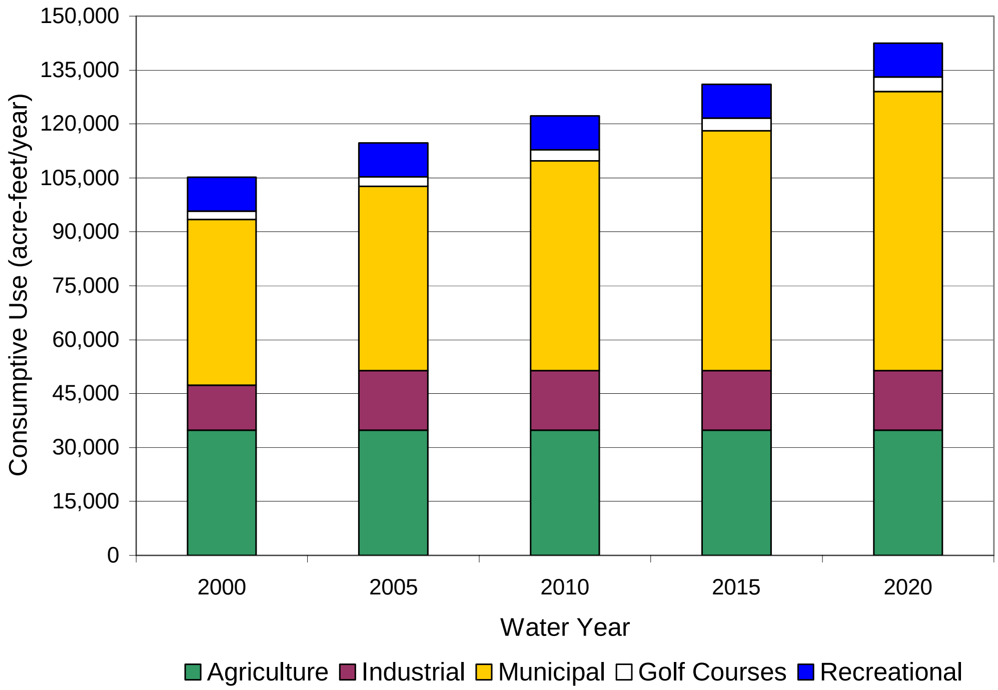


Figure 5-15: Mojave Basin Area Total Consumptive Use for the Year 2000 and Projections Through Year 2020 Under Agriculture Scenario 1

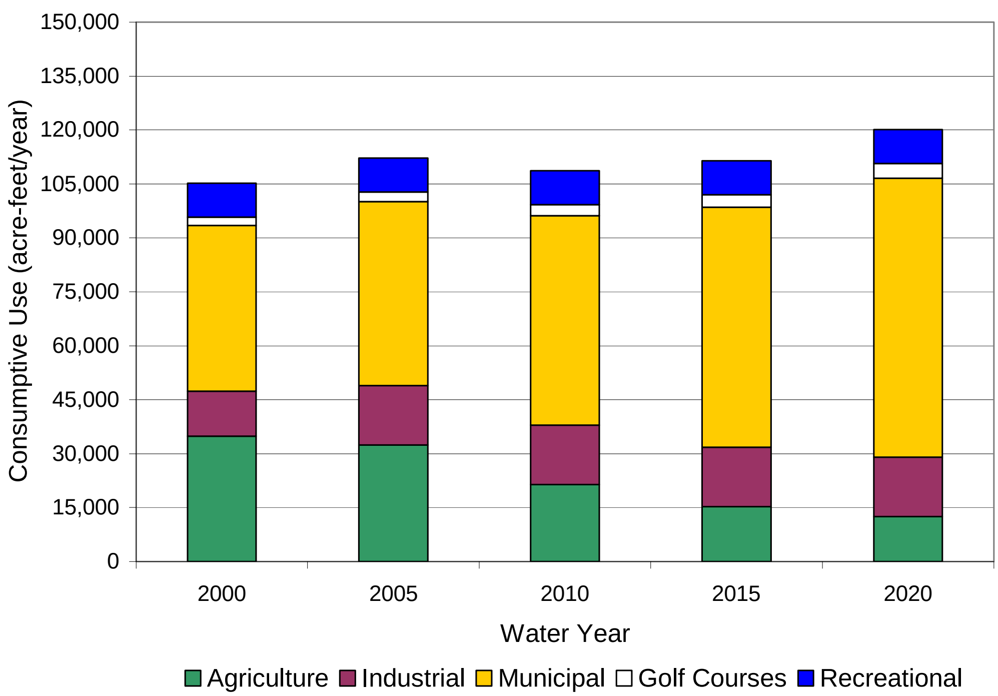


Figure 5-16: Mojave Basin Area Total Consumptive Use for the Year 2000 and Projections Through Year 2020 Under Agriculture Scenario 2

Table 5-9: Mojave Basin Area Current and Projected Consumptive Use (Acre-feet/year)

	2000	2005	2010	2015	2020
Alto					
Industrial	4,200	8,200	8,200	8,200	8,200
Municipal	34,400	38,700	44,100	50,700	59,200
Golf Courses	2,200	2,500	2,900	3,300	3,800
Recreational	6,900	6,900	6,900	6,900	6,900
Total: Including Ag Scenario 1	**51,500**	**60,100**	**65,900**	**72,900**	**81,900**
Total: Including Ag Scenario 2	**51,500**	**57,600**	**63,400**	**70,400**	**79,400**
Baja					
Industrial	5,500	5,500	5,500	5,500	5,500
Municipal	2,500	2,600	2,800	2,900	3,100
Golf Courses	0	0	0	0	0
Recreational	2,500	2,500	2,500	2,500	2,500
Total: Including Ag Scenario 1	**28,200**	**28,300**	**28,500**	**28,600**	**28,800**
Total: Including Ag Scenario 2	**28,200**	**28,300**	**17,500**	**11,500**	**11,700**
Centro					
Industrial	1,900	1,900	1,900	1,900	1,900
Municipal	6,300	6,700	7,700	8,800	10,100
Golf Courses	200	200	200	200	300
Recreational	0	0	0	0	0
Total: Including Ag Scenario 1	**17,300**	**17,700**	**18,700**	**19,800**	**21,200**
Total: Including Ag Scenario 2	**17,300**	**17,700**	**18,700**	**19,800**	**21,200**
Este					
Industrial	900	900	900	900	900
Municipal	900	1,000	1,200	1,400	1,700
Golf Courses	0	0	0	0	0
Recreational	0	0	0	0	0
Total: Including Ag Scenario 1	**5,000**	**5,100**	**5,300**	**5,500**	**5,800**
Total: Including Ag Scenario 2	**5,000**	**5,100**	**5,300**	**5,500**	**4,000**
Oeste					
Industrial	0	0	0	0	0
Municipal	1,900	2,200	2,500	2,900	3,500
Golf Courses	0	0	0	0	0
Recreational	0	0	0	0	0
Total: Including Ag Scenario 1	**3,200**	**3,500**	**3,800**	**4,200**	**4,800**
Total: Including Ag Scenario 2	**3,200**	**3,500**	**3,800**	**4,200**	**3,800**
Total Mojave Basin Area					
Industrial	12,500	16,500	16,500	16,500	16,500
Municipal	46,000	51,200	58,300	66,700	77,600
Golf Courses	2,400	2,700	3,100	3,500	4,100
Recreational	9,400	9,400	9,400	9,400	9,400
Total: Including Ag Scenario 1	**105,200**	**114,700**	**122,200**	**131,000**	**142,500**
Total: Including Ag Scenario 2	**105,200**	**112,200**	**108,700**	**111,400**	**120,100**

In the following sections, projected changes in consumptive use are discussed for each subarea.

Alto (Figures 5-17 and 5-18)

Figures 5-17 and 5-18 show projected consumptive use in Alto under each scenario. Municipal use is projected to increase by about 24,800 acre-feet between 2000 and 2020. This represents a growth rate of 2.8% per year on average. Consumptive use by golf courses and parks is projected to increase by about 1,600 acre-feet and industrial use is projected to increase by about 4,000 acre-feet. Therefore, total consumptive use would increase by approximately 30,400 acre-feet if agricultural use were to remain constant at its current total of about 3,800 acre-feet. If agricultural consumptive use were reduced to about 1,300 acre-feet, as it would be under Agriculture Scenario 2, total consumptive use in Alto would still increase by approximately 27,900 acre-feet.

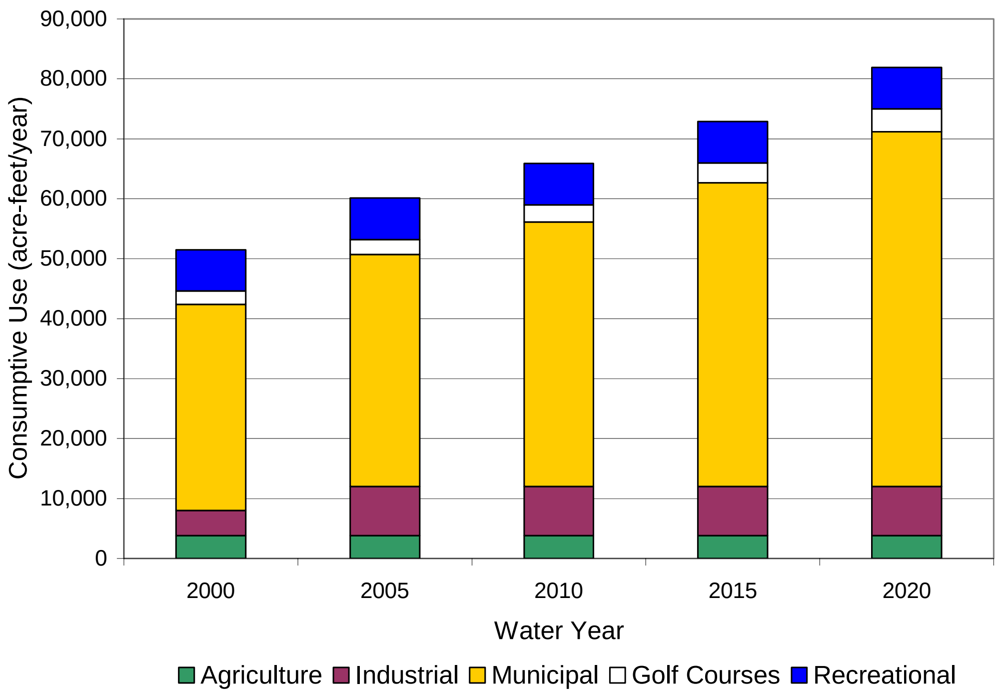


Figure 5-17: Alto Subarea Consumptive Use for the Year 2000 and Projections Through Year 2020 Under Agriculture Scenario 1

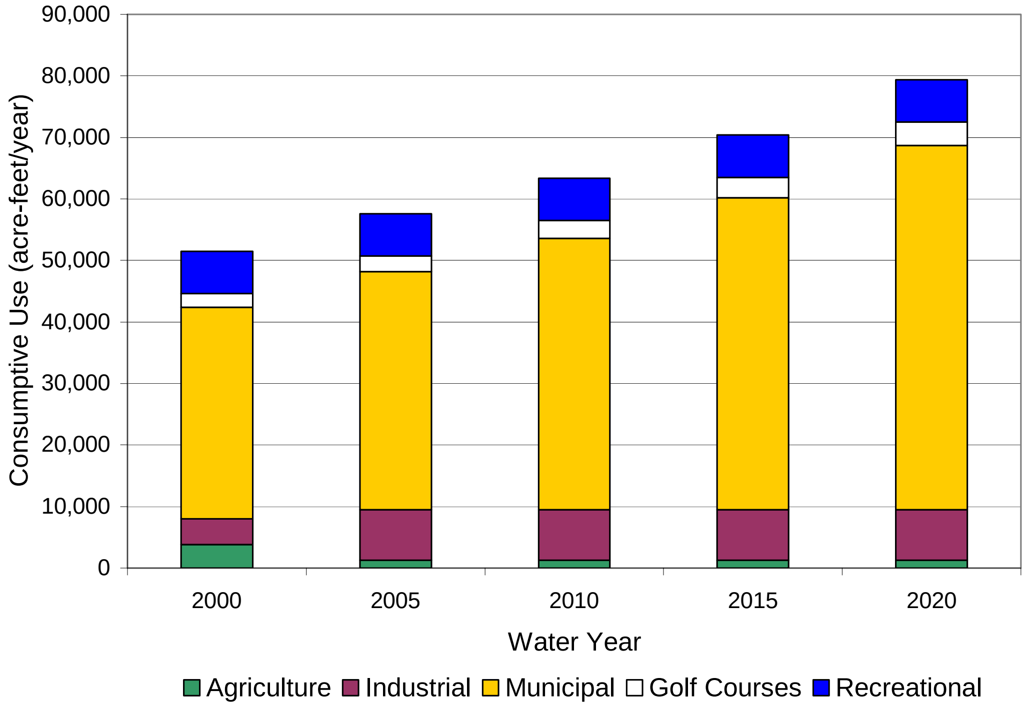


Figure 5-18: Alto Subarea Consumptive Use for the Year 2000 and Projections Through Year 2020 Under Agriculture Scenario 2

Baja (Figures 5-19 and 5-20)

Figures 5-19 and 5-20 show future consumptive use in Baja under each scenario. If agricultural consumptive use remains constant, as in Figure 5-18, total consumptive use is projected to increase by about 600 acre-feet due to a small increase in municipal water use, which is projected to increase at an annual average of 1.0%. Under Agriculture Scenario 2, as shown on Figure 5-20, agricultural consumptive use would be reduced to about 600 acre-feet by 2015 and remain constant at that level through 2020. This would cause the total consumptive use in the subarea to decline from about 28,200 to 11,700 acre-feet between 2000 and 2020.

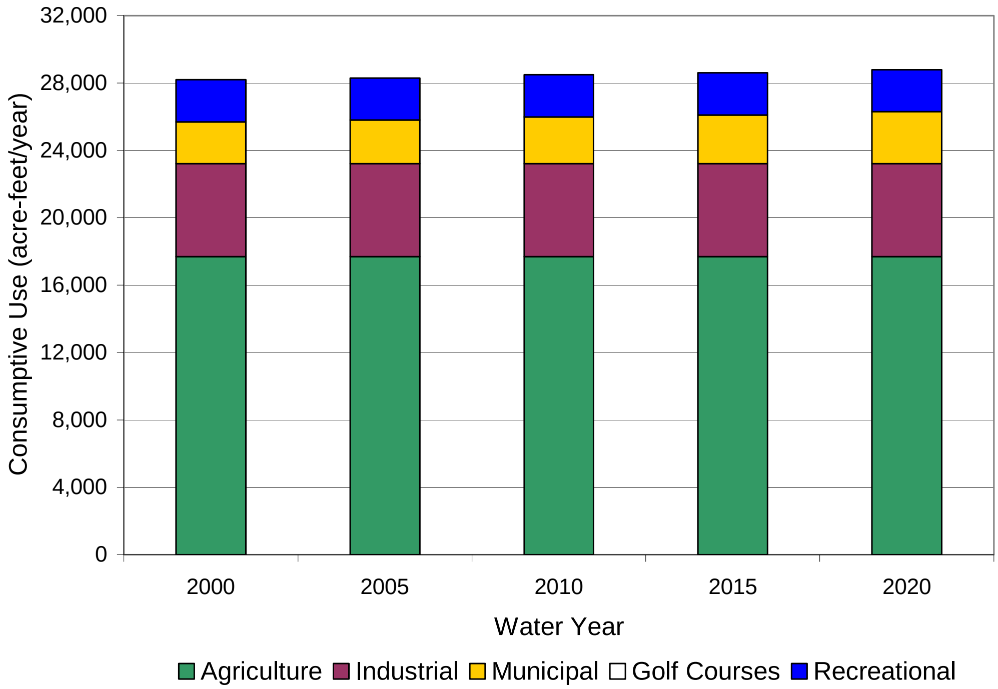


Figure 5-19: Baja Subarea Consumptive Use for the Year 2000 and Projections Through Year 2020 Under Agriculture Scenario 1

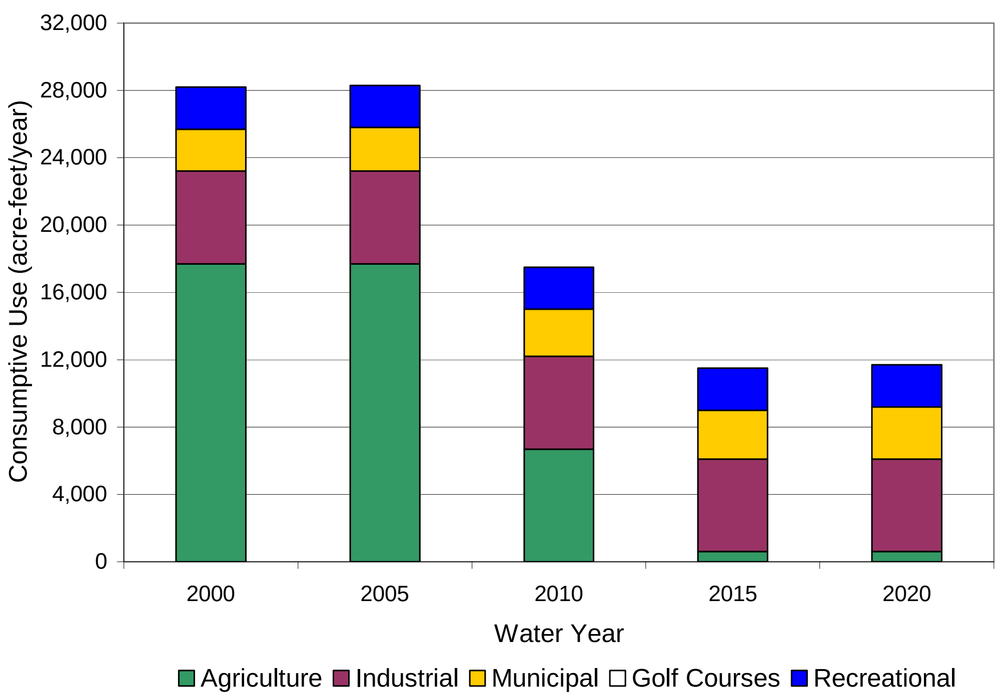


Figure 5-20: Baja Subarea Consumptive Use for the Year 2000 and Projections Through Year 2020 Under Agriculture Scenario 2

Centro (Figure 5-21)

No reduction in agricultural use is expected in Centro under either scenario. Figure 5-21 shows that municipal consumptive use for Centro is projected to increase by about 3,800 acre-feet and that golf course use is projected to increase by about 100 acre-feet between 2000 and 2020, assuming an average annual growth rate of 2.4%.

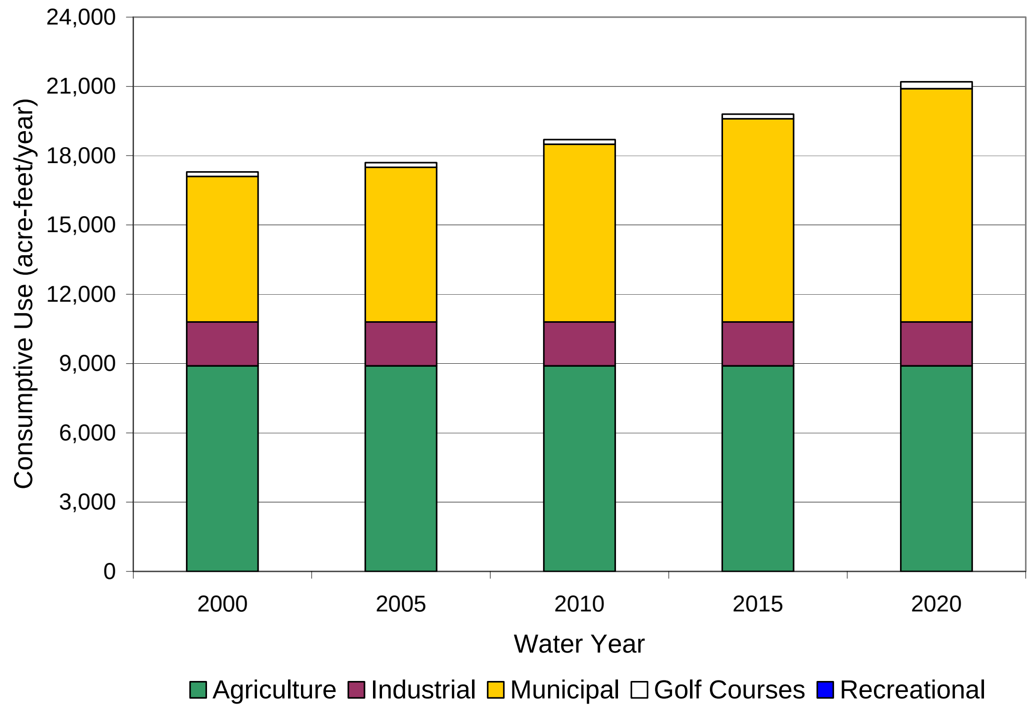


Figure 5-21: Centro Subarea Consumptive Use for the Year 2000 and Projections Through Year 2020 Under Agriculture Scenarios 1and 2

Este (Figures 5-22 and 5-23)

Figures 5-22 and 5-23 show projected consumptive use in Este under each scenario. Municipal consumptive use is projected to increase in Este by about 800 acre-feet between 2000 and 2020, assuming an annual average growth rate of 3.2%. Under Agriculture Scenario 2, agricultural consumptive use is projected to decrease by about 1,800 acre-feet, which would result in a net reduction in Este consumptive use of about 1,000 acre-feet between 2000 and 2020.

Oeste (Figures 5-24 and 5-25)

Figures 5-24 and 5-25 show the projected consumptive use in Oeste under each scenario. Municipal consumptive use is expected to increase by about 1,600 acre-feet between 2000 and 2020, assuming an annual average growth rate of 3.1%. Under Scenario 2, agricultural consumptive use would decline from about 1,300 acre-feet to approximately 300 acre-feet, resulting in a net increase in total annual consumptive use of about 600 acre-feet.

Morongo Basin/Johnson Valley Area

The Morongo Basin/Johnson Valley area contains very little agriculture. Table 5-10 shows the projected consumptive use for each subbasin in the Morongo Basin and Johnson Valley. Figure 5-26 shows the total projected Morongo Basin/Johnson Valley consumptive use projections. Between 2000 and 2020, municipal consumptive use is projected to increase from about 2,500 acre-feet to about 3,700 acre-feet (an increase of 2.1% per year). Golf course consumptive use is projected to increase by about 100 acre-feet. The total projected increase for the entire area is about 1,300 acre-feet between 2000 and 2020.

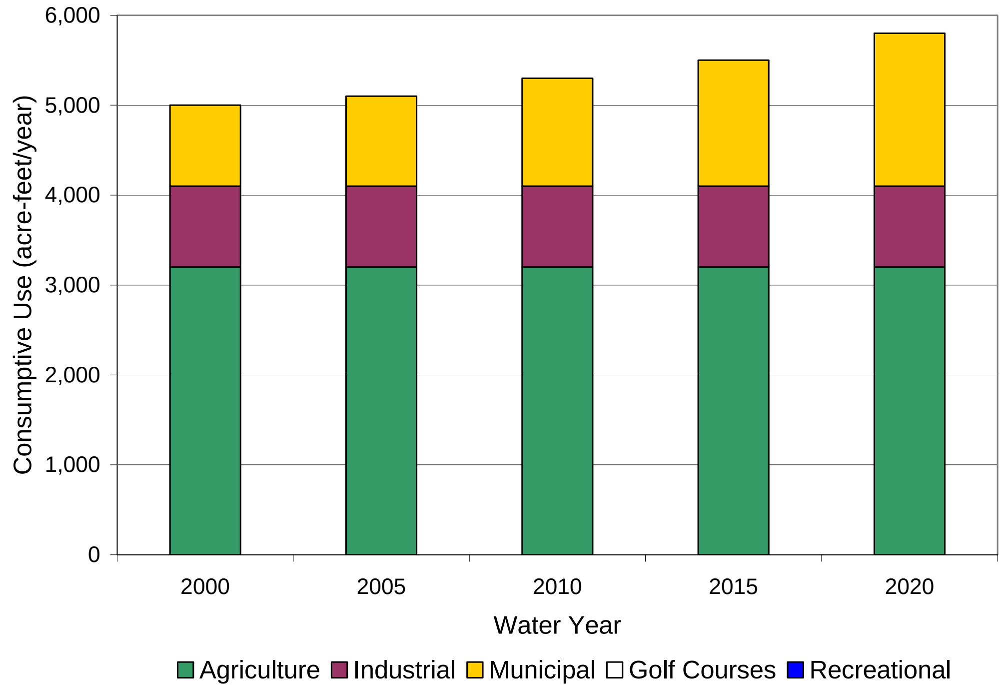


Figure 5-22: Este Subarea Consumptive Use for the Year 2000 and Projections Through Year 2020 Under Agriculture Scenario 1

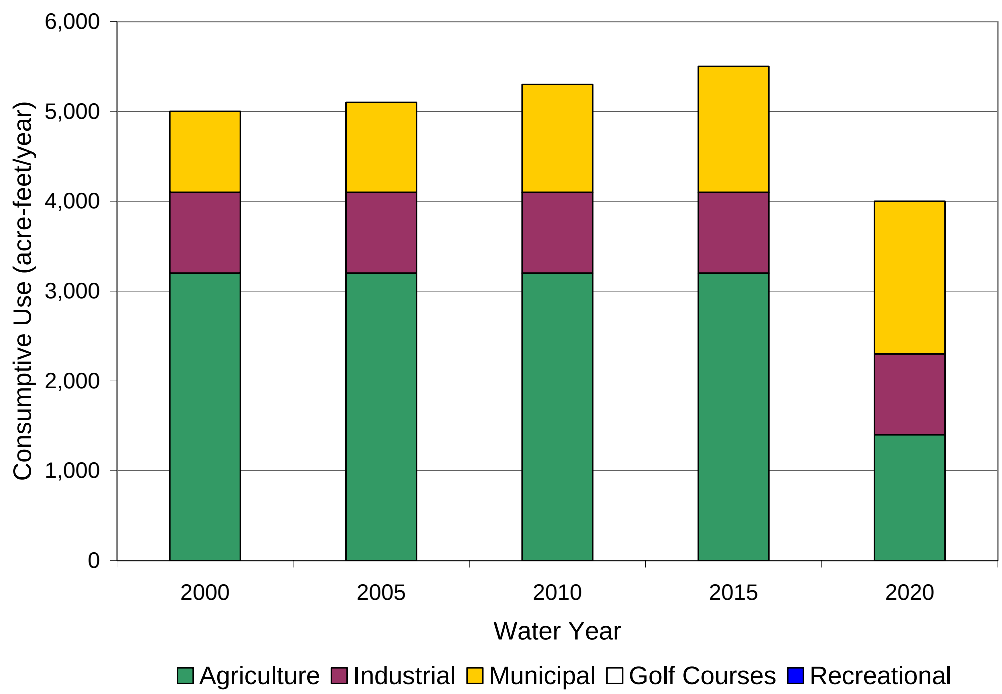


Figure 5-23: Este Subarea Consumptive Use for the Year 2000 and Projections Through Year 2020 Under Agriculture Scenario 2

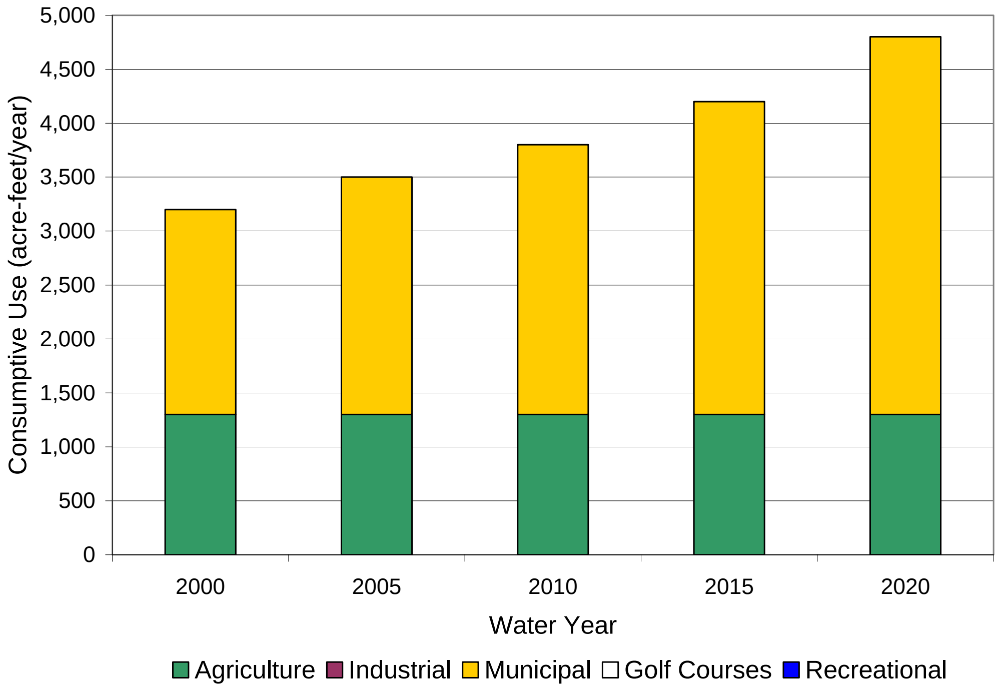


Figure 5-24: Oeste Subarea Consumptive Use for the Year 2000 and Projections Through Year 2020 Under Agriculture Scenario 1

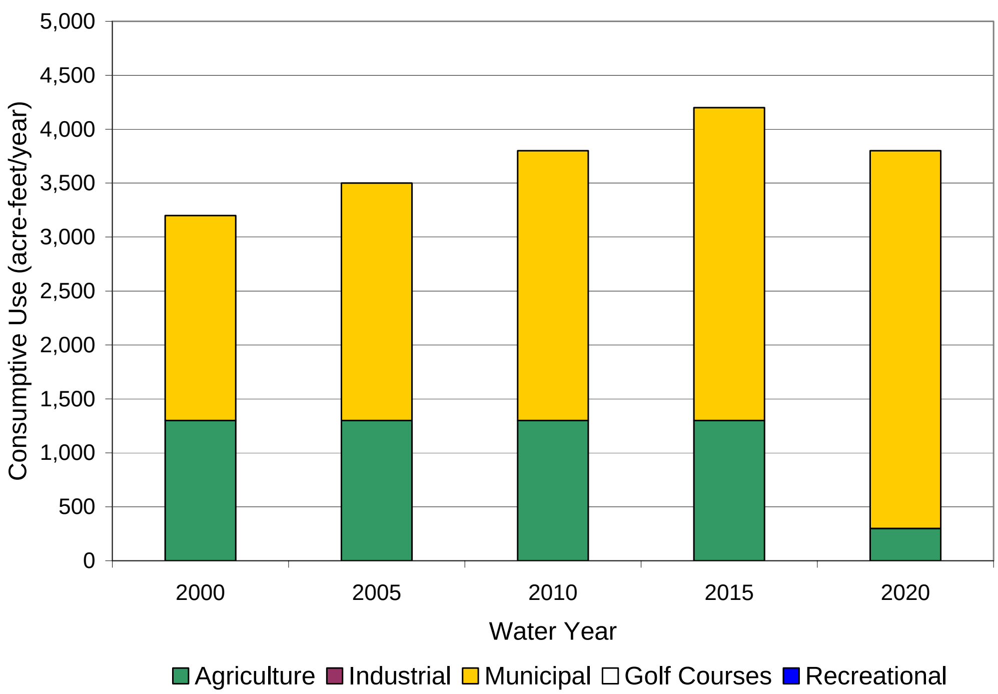


Figure 5-25: Oeste Subarea Consumptive Use for the Year 2000 and Projections Through Year 2020 Under Agriculture Scenario 2

Table 5-10: Morongo Basin/Johnson Valley Area Projected Consumptive Use (Acre-feet/year)

Copper Mountain Valley					
	2000	**2005**	**2010**	**2015**	**2020**
Agricultural	0	0	0	0	0
Industrial	0	0	0	0	0
Municipal	800	900	900	1,000	1,000
Golf Courses	0	0	0	0	0
Recreational	0	0	0	0	0
Total	**800**	**900**	**900**	**1,000**	**1,000**

Johnson Valley					
	2000	**2005**	**2010**	**2015**	**2020**
Agricultural	0	0	0	0	0
Industrial	0	0	0	0	0
Municipal	30	30	40	40	50
Golf Courses	0	0	0	0	0
Recreational	0	0	0	0	0
Total	**30**	**N/A**	**N/A**	**N/A**	**N/A**

Means/Ames Valley					
	2000	**2005**	**2010**	**2015**	**2020**
Agricultural	0	0	0	0	0
Industrial	0	0	0	0	0
Municipal	600	700	700	800	900
Golf Courses	0	0	0	0	0
Recreational	0	0	0	0	0
Total	600	700	700	800	900

Warren Valley					
	2000	**2005**	**2010**	**2015**	**2020**
Agricultural	0	0	0	0	0
Industrial	0	0	0	0	0
Municipal	1,100	1,300	1,400	1,600	1,800
Golf Courses	200[1]	200	200	300	300
Recreational	0	0	0	0	0
Total	**1,200**	**1,500**	**1,600**	**1,900**	**2,100**

Total Morongo Basin/Johnson Valley Area[2]					
	2000	**2005**	**2010**	**2015**	**2020**
Agricultural	0	0	0	0	0
Industrial	0	0	0	0	0
Municipal	2,500	2,900	3,000	3,400	3,700
Golf Courses	200	200	200	300	300
Recreational	0	0	0	0	0
Total	**2,700**	**3,100**	**3,200**	**3,700**	**4,000**

[1]For the purpose of projecting consumptive use, year 2000 golf course use in the Warren Valley is set at 200 acre-feet (the average from 1995-99), due to a temporary reduction in pumping during 2000 caused by mechanical problems with the well.
[2]Johnson Valley is not included in the Morongo Basin/Johnson Valley totals because the supply is not included as noted in Chapter 4.

Figures 5-27 through 5-29 show the projected future consumptive use in the Copper Mountain Valley, Means/Ames Valley, and Warren Valley subbasins.

Copper Mountain Valley (Figure 5-27)

Municipal consumptive use in the Copper Mountain Valley subbasin is projected to increase from about 800 acre-feet in 2000 to about 1,000 acre-feet in 2020, which represents a growth rate of 1.4% per year.

Means/Ames Valley (Figure 5-28)

Municipal consumptive use in the Means/Ames Valley subbasin is projected to increase by about 300 acre-feet between 2000 and 2020, from 600 to 900 acre-feet. This represents a growth rate of about 2.2% per year.

Warren Valley (Figure 5-29)

Municipal consumptive use in the Warren Valley subbasin is projected to increase at a rate of 2.4% per year, from about 1,100 acre-feet in 2000 to about 1,800 acre-feet in 2020. Golf course use is projected to increase by 100 acre-feet. The total projected increase in consumptive use is approximately 800 acre-feet.

Year 2020 Water Balance

Agriculture Scenario 1

Table 5-11 shows the projected total consumptive use under Agriculture Scenario 1 using the average annual water supply values presented in Chapter 4.

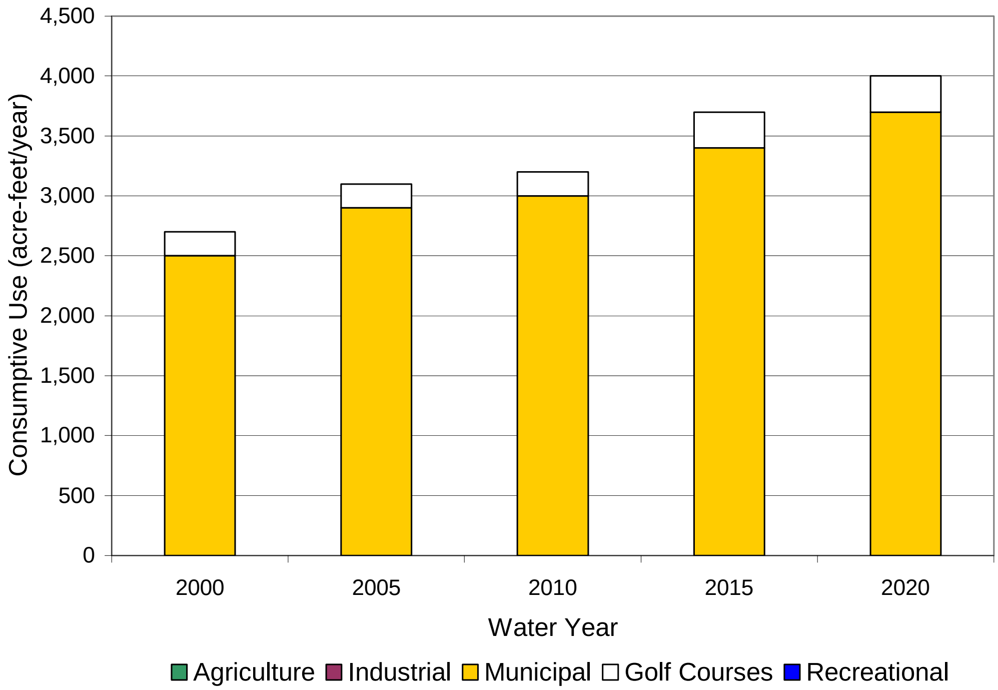


Figure 5-26: Morongo Basin/Johnson Valley Area Total Consumptive Use for the Year 2000 and Projections Through Year 2020

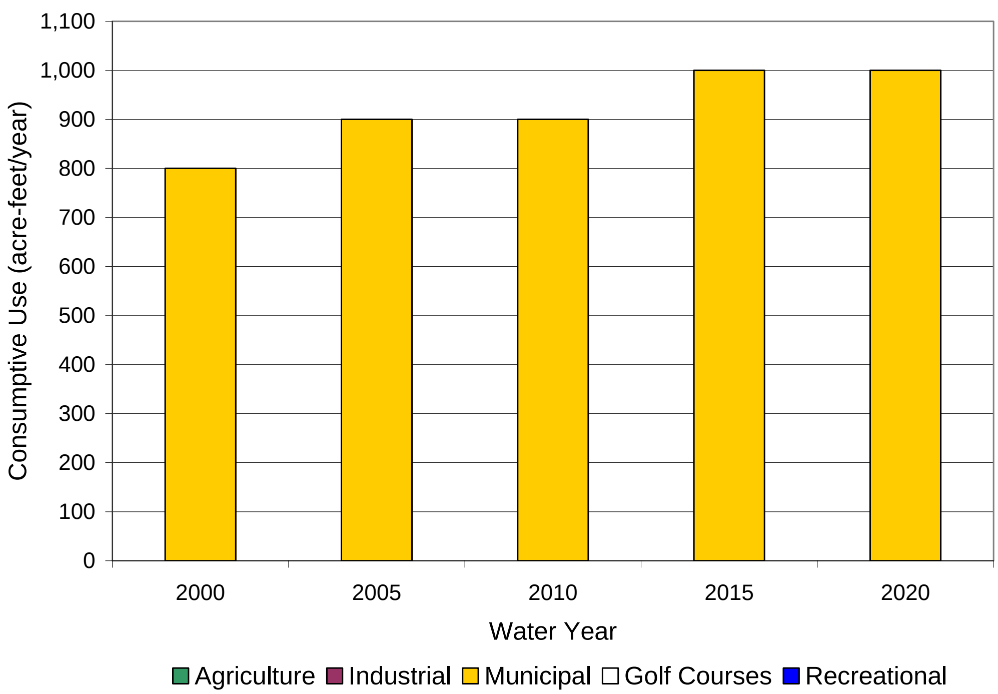


Figure 5-27: Copper Mountain Valley Subbasin Consumptive Use for the Year 2000 and Projections Through Year 2020

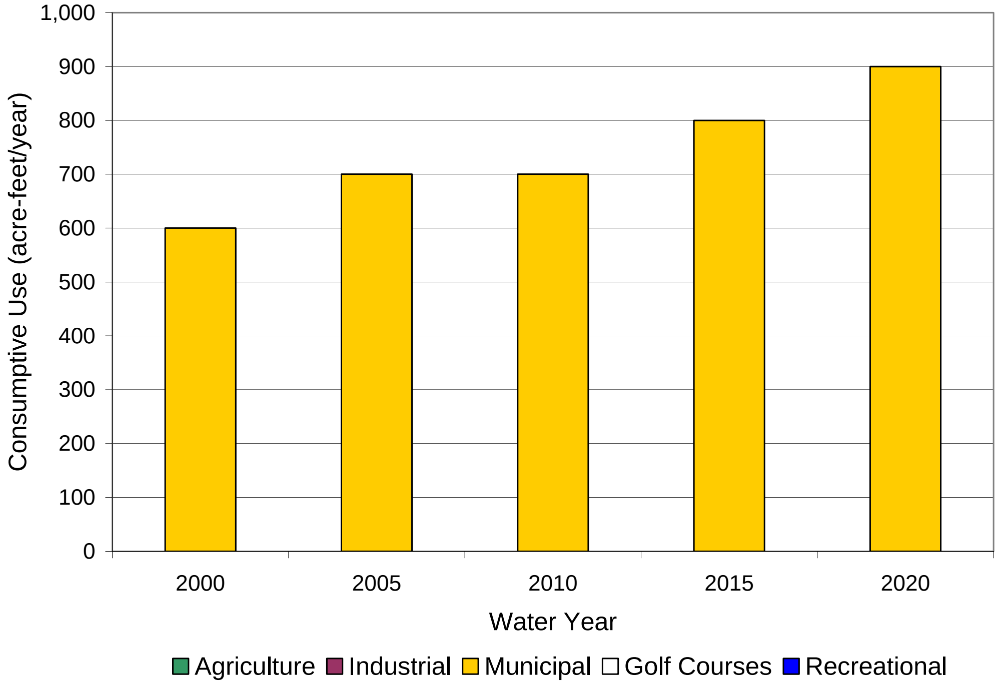


Figure 5-28: Means/Ames Valley Subbasin Consumptive Use for the Year 2000 and Projections Through Year 2020

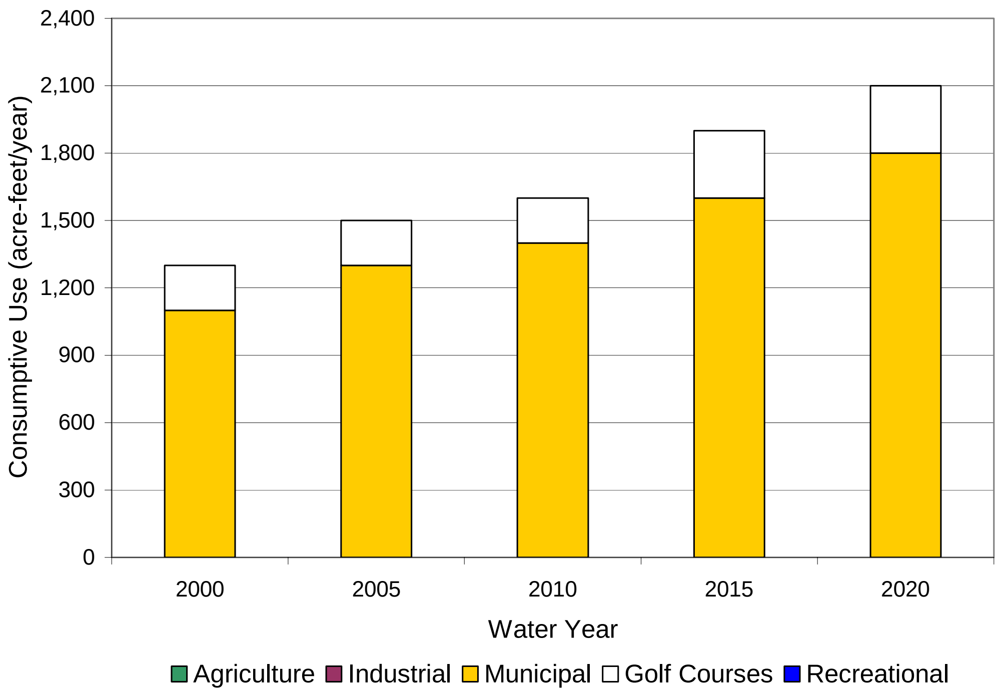


Figure 5-29: Warren Valley Subbasin Consumptive Use for the Year 2000 and Projections Through Year 2020

Table 5-11
Year 2020 Average Annual Water Balance Under Agriculture Scenario 1
(Acre-feet/year)

	Net Average Annual Water Supply[1]	Water Use Agricultural	Water Use Urban[2]	Water Use Total	Surplus/ Deficit
Mojave Basin Area					
Alto	34,700	3,800	78,100	81,900	-47,200
Baja	5,600	17,700	11,100	28,800	-23,200
Centro	18,500	8,900	12,300	21,200	-2,700
Este	3,500	3,200	2,600	5,800	-2,300
Oeste	1,100	1,300	3,500	4,800	-2,900
Subtotal Mojave	63,400	34,900	107,600	142,500	-79,100
MB/JV Area					
Copper Mtn. Valley	600	0	1,000	1,000	-400
Johnson Valley	2,300	0	50	50	+2,250
Means/Ames Valley	600	0	900	900	-300
Warren Valley	900[3]	0	2,100	2,100	-1,200
Subtotal MB/JV[4]	2,100	0	4,000	4,000	-1,900
Total	**65,500**	**34,900**	**111,600**	**146,500**	**-81,000**
			Average Annual SWP Supply:		**58,400**
			Surplus/Deficit with SWP Supply:		**-22,600**

[1]Net average annual water supply data as shown in Tables 4-2 and 4-5 of Chapter 4.
[2]Urban uses include municipal, industrial, golf course, and recreational water uses.
[3]Hi-Desert Water District reports unpublished USGS estimates of 200 acre-feet per year net average annual supply in the Warren Valley subbasin.
[4]Johnson Valley is not included in the Morongo Basin/Johnson Valley totals because the supply is not included as noted in Chapter 4.

All of the regions are projected to have larger water deficits in 2020 than they had in 2000. The largest difference occurs in Alto, where the average annual water deficit is projected to increase from 16,800 acre-feet in 2000 to 47,200 acre-feet in 2020. In Centro, the water demand is projected to exceed the average annual supply in 2020, causing the year 2000 water surplus to be replaced with a water deficit of about 2,700 acre-feet. Overall, under Agriculture Scenario 1, the Mojave Basin Area is projected to have a water deficit of 79,100 acre-feet per year on average in 2020.

In the Morongo Basin/Johnson Valley Area, all of the subbasins except for Johnson Valley are projected to have water deficits in 2020. The largest of these is in the Warren Valley, where an average annual deficit of about 1,200 acre-feet is projected. Excluding the Johnson Valley, the Morongo Basin/Johnson Valley Area is projected to have a total average annual deficit of about 1,900 acre-feet per year in 2020.

Including the water deficit expected in the Morongo Basin/Johnson Valley area, the Mojave Water Agency is projected to face an average annual water deficit of about 81,000 acre-feet per year under Agriculture Scenario 1. If MWA were to fully utilize its average annual SWP supply of 58,400 acre-feet per year, the total deficit would be approximately 22,600 acre-feet per year.

Agriculture Scenario 2

Table 5-12 compares the projected total consumptive use under Agriculture Scenario 2 with the average annual water supply.

Table 5-12
Year 2020 Average Annual Water Balance under Agriculture Scenario 2
(Acre-feet/year)

	Net Average Annual Water Supply[1]	Water Use Agricultural	Water Use Urban[2]	Water Use Total	Surplus/ Deficit
Mojave Basin Area					
Alto	34,700	1,300	78,100	79,400	-44,700
Baja	5,600	600	11,100	11,700	-6,100
Centro	18,500	8,900	12,300	21,200	-2,700
Este	3,500	1,400	2,600	4,000	-500
Oeste	1,100	300	3,500	3,800	-2,700
Subtotal Mojave	63,400	12,500	107,600	120,100	-56,700
MB/JV Area					
Copper Mtn. Valley	600	0	1,000	1,000	-400
Johnson Valley	2,300	0	50	50	+2,250
Means/Ames Valley	600	0	600	600	0
Warren Valley	900	0	2,100	2,100	-1,200
Subtotal MB/JV[3]	2,100	0	4,000	4,000	-1,900
Total	**65,500**	**12,500**	**111,600**	**124,100**	**-58,600**
				Average Annual SWP Supply:	**58,400**
				Surplus/Deficit with SWP Supply:	**-200**

[1]Net average annual water supply data as shown in Tables 4-2 and 4-5 of Chapter 4.
[2]Urban uses include municipal, industrial, golf course, and recreational water uses.
[3]Johnson Valley is not included in the Morongo Basin/Johnson Valley totals because the supply is not included as noted in Chapter 4.

In the Mojave Basin Area, Alto, Baja, Este and Oeste would all have smaller water deficits in 2020 under Agriculture Scenario 2 than they would under Agriculture Scenario 1. The largest difference is in Baja, which would have an average annual water deficit of only about 6,100 acre-feet. In Centro the projected average annual water deficits are the same under Agriculture Scenario 2 as in Agriculture Scenario 1. Because the Morongo Basin/Johnson Valley area has very little agriculture, the projected consumptive uses for all subbasins under Agriculture Scenario 2 are the same as for Agriculture Scenario 1.

Overall under Agriculture Scenario 2, the Mojave Basin Area would have an average annual water deficit of about 56,700 acre-feet per year in 2020. The Mojave Water Agency as a whole has a projected average annual water deficit of about 59,000 acre-feet per year. If MWA were to fully utilize its average annual SWP supply of 58,400 acre-feet per year, under the assumptions outlined above, the total deficit would be approximately 200 acre-feet per year.

Summary

Agriculture Scenarios 1 and 2 represent the low and high estimates of consumptive use in the Mojave Water Agency. Under Agriculture Scenario 1, the projected long-term average annual water deficit in the Mojave Water Agency in 2020 is about 22,600 acre-feet per year with full utilization of MWA's current SWP supply. Under Agriculture Scenario 2, the projected long-term average annual water deficit in 2020 is about 200 acre-feet per year. The Technical Advisory Committee for the RWMP Update has determined that Agriculture Scenario 2 is the most appropriate to be used as the basis for the Plan.

Dry Year and Multiple Dry Year Water Balance in 2020

Table 5-13 shows the projected total consumptive use under Agricultural Scenario 2 with the average annual dry year water supply values presented in Chapter 4. With the net natural water supply reduced to 22,900 acre-feet per year and the average State Water Project supply reduced to 43,200 acre-feet per year, the total MWA deficit during dry years is projected to be 58,000 acre-feet per year in an average dry year.

Table 5-13: Year 2020 Average Annual Dry Year Water Balance under Agriculture Scenario 2 (Acre-feet/year)

	Net Average Annual Dry Year Water Supply[1]	Water Use Agricultural	Water Use Urban [2]	Water Use Total	Surplus/ Deficit
Mojave Basin Area					
Alto	9,900	1,300	78,100	79,400	-69,500
Baja	-1,400	600	11,100	11,700	-13,100
Centro	11,000	8,900	12,300	21,200	-10,200
Este	2,450	1,400	2,600	4,000	-1,550
Oeste	150	300	3,500	3,800	-3,650
Subtotal Mojave	22,100	12,500	107,600	120,100	-98,000
MB/JV Area					
Copper Mtn. Valley	230	0	1,000	1,000	-770
Johnson Valley	880	0	50	50	+830
Means/Ames Valley	230	0	900	900	-670
Warren Valley	340	0	2,100	2,100	-1,760
Subtotal MB/JV[3]	800	0	4,000	4,000	-3,200
Total	**22,900**	**12,500**	**111,600**	**124,100**	**-101,200**
			Average Annual SWP Supply:		**43,200**
			Surplus/Deficit with SWP Supply:		**-58,000**

[1]Net average annual dry year water supply data as shown in Tables 4-3 and 4-6 of Chapter 4.
[2]Urban uses include municipal, industrial, golf course, and recreational water uses.
[3]Johnson Valley is not included in the Morongo Basin/Johnson Valley totals because the supply is not included as noted in Chapter 4.

Table 5-14 shows the projected total consumptive use under Agricultural Scenario 2 and average annual water supply during a multiple dry-year period (1988-1990) using values presented in Chapter 4. With the net natural water supply reduced to 4,010 acre-feet per year and the average State Water Project supply reduced to 22,900 acre-feet per year, the total MWA deficit during dry years is projected to be 97,190 acre-feet per year during the multiple dry-year period.

Table 5-14: Year 2020 Multiple Dry Year Average Annual Water Balance under Agriculture Scenario 2 (Acre-feet/year)

	Net Annual Multiple Dry Year Water Supply[1]	Water Use Agricultural	Water Use Urban [2]	Water Use Total	Surplus/ Deficit
Mojave Basin Area					
Alto	3,500	1,300	78,100	79,400	-75,900
Baja	-1,000	600	11,100	11,700	-12,700
Centro	-200	8,900	12,300	21,200	-21,400
Este	1,900	1,400	2,600	4,000	-2,100
Oeste	-300	300	3,500	3,800	-4,100
Subtotal Mojave	3,900	12,500	107,600	120,100	-116,200
MB/JV Area					
Copper Mtn. Valley	30	0	1,000	1,000	-970
Johnson Valley	130	0	50	50	+80
Means/Ames Valley	30	0	900	900	-870
Warren Valley	50	0	2,100	2,100	-2,050
Subtotal MB/JV[3]	110	0	4,000	4,000	-3,890
Total	**4,010**	**12,500**	**111,600**	**124,100**	**-120,090**
		Average Annual SWP Supply:			**22,900**
		Surplus/Deficit with SWP Supply:			**-97,190**

[1]Net average annual dry year water supply data as shown in Tables 4-4 and 4-6 of Chapter 4.
[2]Urban uses include municipal, industrial, golf course, and recreational water uses.
[3]Johnson Valley is not included in the Morongo Basin/Johnson Valley totals because the supply is not included as noted in Chapter 4.

These deficits represent the amount of groundwater overdraft that MWA can expect during a dry year and during a multiple dry-year period. However, because MWA overlies a very large groundwater basin, the Agency should be able to weather such dry periods with only a temporary decline in groundwater levels. If the supply and demand are in approximate long-term balance, as they are under Agriculture Scenario 2 with full utilization of MWA's projected 2020 SWP supply, groundwater levels could be maintained at relative long-term balance with no reduction in the ability to supply MWA water users.

Future Supply Versus Demand in 5-Year Increments

Table 5-15 shows the average annual surplus or deficit for each for each subarea in the Mojave Basin Area and subbasin in the Morongo Basin/Johnson Valley area in five-year increments through 2020. Tables 5-16 and 5-17 show the same data for an average annual dry year and an average annual multiple dry year. The data shown in these tables are equal to the supply values shown in Chapter 4 minus the incremental demand values shown in Tables 5-9 and 5-10.

Table 5-15: Average Annual Surplus or Deficit under Agriculture Scenario 2 in 5-Year Increments (Acre-feet/year)

	2000	2005	2010	2015	2020
Mojave Basin Area					
Alto	-16,800	-22,900	-28,700	-35,700	-44,700
Baja	-22,600	-22,700	-11,900	-5,900	-6,100
Centro	+1,200	+800	-200	-1,300	-2,700
Este	-1,500	-1,600	-1,800	-2,000	-500
Oeste	-2,100	-2,400	-2,700	-3,100	-2,700
Subtotal Mojave	-41,800	-48,800	-45,300	-48,000	-56,700
MB/JV Area					
Copper Mtn. Valley	-200	-300	-300	-400	-400
Johnson Valley	+2,270	+2,270	+2,260	+2,260	+2,250
Means/Ames Valley	0	-100	-100	-200	-300
Warren Valley	-400	-600	-700	-1,000	-1,200
Subtotal MB/JV*	-600	-1,000	-1,100	-1,600	-1,900
Total	**-42,400**	**-49,800**	**-46,400**	**-49,600**	**-58,600**
Average Annual SWP Supply:	**58,400**	**58,400**	**58,400**	**58,400**	**58,400**
Surplus/Deficit with SWP Supply:	**+16,000**	**+8,600**	**+12,000**	**+8,800**	**-200**

*Johnson Valley is not included in the Morongo Basin/Johnson Valley totals because the supply is not included as noted in Chapter 4.

Table 5-16: Average Annual Dry Year Surplus or Deficit under Agriculture Scenario 2 in 5-Year Increments (Acre-feet/year)

	2000	2005	2010	2015	2020
Mojave Basin Area					
Alto	-41,600	-47,700	-53,500	-60,500	-69,500
Baja	-29,600	-29,700	-18,900	-12,900	-13,100
Centro	-6,300	-6,700	-7,700	-8,800	-10,200
Este	-2,550	-2,650	-2,850	-3,050	-1,550
Oeste	-3,050	-3,350	-3,650	-4,050	-3,650
Subtotal Mojave	-83,100	-90,100	-86,600	-89,300	-98,000
MB/JV Area					
Copper Mtn. Valley	-570	-670	-670	-770	-770
Johnson Valley	+850	+850	+840	+840	+830
Means/Ames Valley	-370	-470	-470	-570	-670
Warren Valley	-960	-1,160	-1,260	-1,560	-1,760
Subtotal MB/JV*	-1,900	-2,300	-2,400	-2,900	-3,200
Total	**-85,000**	**-92,400**	**-89,000**	**-92,200**	**-101,200**
Average Annual SWP Supply:	**43,200**	**43,200**	**43,200**	**43,200**	**43,200**
Surplus/Deficit with SWP Supply:	**-41,800**	**-49,200**	**-45,800**	**-49,000**	**-58,000**

*Johnson Valley is not included in the Morongo Basin/Johnson Valley totals because the supply is not included as noted in Chapter 4.

Table 5-17: Average Annual Multiple Dry Year Surplus or Deficit under Agriculture Scenario 2 in 5-Year Increments (Acre-feet/year)

	2000	2005	2010	2015	2020
Mojave Basin Area					
Alto	-48,000	-54,100	-59,900	-66,900	-75,900
Baja	-29,200	-29,300	-18,500	-12,500	-12,700
Centro	-17,500	-17,900	-18,900	-20,000	-21,400
Este	-3,100	-3,200	-3,400	-3,600	-2,100
Oeste	-3,500	-3,800	-4,100	-4,500	-4,100
Subtotal Mojave	-101,300	-108,300	-104,800	-107,500	-116,200
MB/JV Area					
Copper Mtn. Valley	-770	-870	-870	-970	-970
Johnson Valley	+100	+100	+90	+90	+80
Means/Ames Valley	-570	-670	-670	-770	-870
Warren Valley	-1,250	-1,450	-1,550	-1,850	-2,050
Subtotal MB/JV*	-2,590	-2,990	-3,090	-3,590	-3,890
Total	**-103,890**	**-111,290**	**-107,890**	**-111,090**	**-120,090**
Average Annual SWP Supply:	**22,900**	**22,900**	**22,900**	**22,900**	**22,900**
Surplus/Deficit with SWP Supply:	**-80,990**	**-88,390**	**-84,990**	**-88,190**	**-97,190**

*Johnson Valley is not included in the Morongo Basin/Johnson Valley totals because the supply is not included as noted in Chapter 4.

6

WATER SHORTAGE CONTINGENCY PLANNING

This chapter describes water shortage planning efforts of the Mojave Water Agency and summarizes water shortage planning efforts of individual water purveyors in the MWA service area.

Cities and water agencies within MWA rely on large groundwater reserves to meet potable water supply needs. During previous drought periods, municipal water suppliers continued to draft from these reserves to meet customer needs without imposing restrictions on water use, but at rates exceeding natural replenishment in most areas. The large groundwater basin in the area serves as a reservoir and buffers the impacts of seasonal and year-to-year variations in precipitation and surface water deliveries. By 2020 when this Plan is fully implemented, the area aquifers are expected to be in balance due to the combination of water imports and/or production rampdown. During multiple-year droughts or State Water Project outages, the basin will continue to be pumped to meet demands. Actions of the MWA to address water shortages are summarized below.

Mojave Water Agency

The Mojave Water Agency was formed to manage declining groundwater levels within the Agency's service area. In this capacity, MWA has been planning and implementing projects to increase water supply reliability and prevent future water shortages. MWA became a State Water Project (SWP) contractor and has an annual entitlement of 75,800 acre-feet. This water is diverted from the California Aqueduct and distributed to recharge sites throughout the area (see Chapter 2) in order to replace groundwater withdrawn by producers. Deliveries from the SWP are variable and MWA's full entitlement is not available every year. During dry and multiple dry years, it is expected that SWP deliveries will be significantly reduced.

The Mojave Basin Judgment calls for charging producers for use above their production allowance and using these funds to import water so that over time extractions come into balance with available supplies. Production allowances may also be reduced to achieve this balance. Similar principles are employed in the Warren Valley Basin to achieve long-term balance of supply and demand. Once the basin is in balance it will be less impacted by fluctuations in deliveries of water from the SWP.

As part of this Plan, MWA will construct facilities to utilize the full SWP contract supplies. This will enable the MWA to recharge the groundwater basins in wetter years and therefore enable water purveyors to meet demands during dry years without exceeding safe yield. This Plan includes an estimate of the reliability of deliveries of water from the SWP. The volume of SWP water recharged to the basin is computed based on this reliability.

MWA is not a direct purveyor of municipal water supplies and does not have the authority to implement water shortage plans within its boundaries but relies instead on efforts of the individual cities and water agencies.

Cities and Water Agencies

To meet the requirements of the Urban Water Management Planning Act, plans must address a number of topics including current and future water supply availability, projected demands for the next 20 years, reliability of supplies, supply and demand comparisons, the potential for recycling, implementation of Demand Management (water conservation) Measures, and water shortage contingency planning.

Cities and water agencies within the MWA service area that have developed and adopted Urban Water Management Plans are listed below:

- Adelanto Water Authority (serving Adelanto)
- Apple Valley Ranchos Water Company (serving Apple Valley)
- Hesperia Water District (serving Hesperia)
- Hi-Desert Water District (serving Yucca Valley)
- Joshua Basin Water District (serving Joshua Tree)
- Southern California Water Company (serving Barstow, parts of Apple Valley and Lucerne Valley
- Victor Valley Water District (serving Victorville)

All of these entities have Water Shortage Contingency Plans included in their Urban Water Management Plans.

Water Shortage Contingency Plans of these entities utilize a variety of methods to reduce water demand including mandatory prohibitions on water wasting, voluntary water conservation measures, mandatory water conservation measures and prohibitions on certain uses of water during severe shortages, specific triggering mechanisms for determining the appropriate stage of alert, and water supply allotments for each stage of alert. The plans are summarized below.

Adelanto Water Authority

The Adelanto Water Authority (Authority) has adopted, via resolution, a four-stage plan of action to address a long-term drought condition or loss of supply. Stage 1 becomes effective when the Authority declares a water shortage exists and involves increased public outreach and education to seek a 10% reduction in water use through voluntary measures. Stage 2 is entered into when the Stage 1 reduction goal has not been met for two consecutive years of a drought. Public awareness efforts will continue and a survey will be conducted on Stage 1 efforts. The Authority will establish a water conservation advisory committee comprised of officials from the Authority and the City of Adelanto. Stage 3 goes into effect if the water shortage continues for four consecutive years; this stage recommends 10% mandatory and 20% voluntary reductions. A plan and ordinance to enforce penalties for excessive water use will be developed as part of Stage 3. The Authority will examine the impact conservation has on revenue and expenditures and propose corrective measures as necessary. In addition to the water conservation efforts of the Authority, the City of Adelanto has a water conservation ordinance (adopted in 1984) designed to achieve a 10% reduction in water use.

Apple Valley Ranchos Water Company

During a declared water shortage, Apple Valley Ranchos Water Company (AVR) would base individual customer allotments on a recorded base year. According to their plan, AVR, as a private water utility, is unable to enforce conservation stages, adopt ordinances or administer penalties or charges for excessive use. Their plan includes rules from the California Public Utilities Commission (CPUC) related to water conservation and discontinuation and restoration of service. The Town of Apple Valley adopted, via ordinance, a Water Conservation Plan that includes water regulations prohibiting wasteful water use practices including excessive runoff of landscape irrigation water and washing driveways and walkways with water. Penalties have been established for violation of water regulations. In accordance with CPUC rules, AVR has established a conservation memorandum account to offset loss of revenues due to conservation.

Hesperia Water District

The Hesperia Water District (HWD) and the City of Hesperia developed and adopted, via ordinances, a three-stage drought-related water shortage plan. Stage 1 is in effect during normal conditions and involves voluntary wise water use practices and mandatory timed irrigation systems and drought tolerant plants for new developments. Stage 2 is triggered in the event of a water supply shortage that threatens HWD's ability to provide water. During this stage, conservation measures will include at least the following: prohibiting runoff from irrigated landscapes, use of the most efficient agricultural irrigation practices, development of conservation plans by commercial facilities, irrigation of parks, golf courses and school grounds only between the hours of 11:00 p.m. and 5:00 a.m., requiring covers for swimming pools and prohibiting washing driveways, sidewalks and other hard surfaces with water. In the event of a disaster or other disruption in the water supply, Stage 3 will be in effect and mandatory conservation measures will be implemented. Measures include prohibiting landscape irrigation or filling of swimming pools, and suspension of issuance of new construction permits. The HWD Board of Directors will determine the appropriate stages of alert during noticed public hearings. Violations of mandatory water conservation measures may result in criminal penalties, monetary fines and discontinuation of service. To make up for decreased revenues associated with conservation, HWD will consider reducing operating and maintenance costs, deferring certain capital improvement projects until revenues increase, deferring certain purchases and utilizing facility replacement reserve funds.

Hi-Desert Water District

The Urban Water Management Plan for the Hi-Desert Water District is comprised of the Warren Valley Basin Management Plan and associated addenda. The plan contains a description of their Emergency Stage Response Plan (ESRP) to implement more stringent water conservation measures during times when water demand exceeds supply. The initial, although undefined, provisions of the ESRP are implemented when the water supply system reaches 80 percent of capacity for three consecutive days. When demand increases further, Stage 2 becomes effective and places increasing, yet undefined, restrictions on water use, particularly outdoor water use. If delivery capacity continues to be inadequate, Stage 3 becomes effective and requests unspecified, voluntary conservation measures until such time as delivery problems can be mitigated.

Joshua Basin Water District

The Joshua Basin Water District (District) has developed a four-stage plan for responding to water shortages. The plan was a component of their Urban Water Management Plan, adopted via ordinance. The plan includes voluntary and mandatory stages to address a reduction in water supply that exceeds 60%. The Stage 1 reduction goal of 10% is triggered when water supplies are 60-75% of normal. The Stage 2 reduction goal of 15% is triggered when water supplies are 45-60% of normal. The Stage 3 reduction goal of 20% is triggered when supplies are 40-50% of normal and Stage 4 reduction goal of 25% is triggered when supplies are 40% of normal. Stages of alert may be triggered by groundwater shortages, equipment failures or catastrophes. The

District has developed an allocation method that will be used by the General Manager to determine consumption limits by customer type in the event of a water supply shortage. During all declared water shortage emergencies, customers who exceed their established allotment will be required to pay a surcharge of two times the highest rate for excess water used during the first or second billing cycle and a surcharge of four times the highest rate for subsequent billing periods. Approximately 47% of the District's annual water revenues are from meter charges with water sales making up the remainder. The plan indicates annual water system revenue declines due to conservation during the 4 stages of alert range from 3% to 9%. Financial reserves of the District are adequate to offset these modest decreases in revenue.

Southern California Water Company

The Southern California Water Company (SCWC) has developed a water shortage contingency plan with four stages of action to address up to a 50% water supply shortage. Stage 1 is a voluntary effort to reduce demand by 10% through increased community outreach. Stage 2 addresses shortages of 10 to 20% and involves voluntary and mandatory water conservation efforts such as prohibitions on cleaning sidewalks and other hard surfaces with water, washing cars, irrigating non-permanent agriculture, uncorrected plumbing leaks, gutter flooding and filling swimming pools. SCWC is an investor-owned utility and is subject to regulation by the California Public Utilities Commission (CPUC) and must gain approval from CPUC prior to imposing water consumption regulations and restrictions. During stages when water shortages require restricting water use, SCWC will first obtain permission from the CPUC. Stage 3 consists of water allotments and mandatory conservation rules. Stage 4 intensifies all previous conservation efforts and monitors daily compliance with required reductions. The SCWC District Manager will determine the appropriate stage of alert during water supply shortages. Their plan includes Mandatory Water Conservation, Restrictions and Rationing Program rules from the CPUC. The CPUC authorizes utilities to establish memorandum accounts for revenues and expenses due to water conservation. A surcharge may be implemented to cover revenue reductions due to conservation.

Victor Valley Water District

The Victor Valley Water District's (VVWD) water shortage contingency plan has four stages of action to address up to a 50% water supply shortage. The Stage 1 demand reduction goal of 10% is triggered when water shortages are 10% or less. The Stage 2A demand reduction goal of 20% is triggered when water shortages are 11-20%. The Stage 2B reduction goal of 30% is triggered when water shortages are 21-35% and Stage 3 demand reduction goal of 50% and greater is triggered when water shortages are 36-50%. VVWD would address water supply shortages with voluntary and mandatory conservation efforts targeting specific water allocations associated with each of the stages of alert. Penalties have been set for non-compliance with the allocations set in each of the stages of alert. The plan was adopted via ordinance.

The District does not anticipate adverse financial impacts due to conservation during water supply shortages. Fixed monthly service charges account for approximately 30% of total revenue. Reduced pumping expenses would offset decreased revenues from water consumption charges. Penalties for exceeding water allotments in Stages 3 and 4 would provide additional revenues that would help offset revenues lost through conservation.

7

WATER CONSERVATION AND DEMAND MANAGEMENT MEASURES

This chapter describes the water conservation practices of the Mojave Water Agency, individual cities and water agencies, and groups of entities in the basin.

Coordinated Water Conservation Efforts

In addition to the water conservation efforts of individual water agencies and cities, there are a number of cooperative efforts underway in the basin. These efforts include cooperative partnerships between MWA and a number of individual entities and groups of entities such as water agencies, cities, colleges, other educational institutions, and the Mojave Desert Resource Conservation District. These partnerships, formed through Memoranda of Understanding (MOUs), are described below.

Alliance for Water Awareness and Conservation

Based on findings in Phase 2 of this Regional Water Management Plan in 2003, local stakeholders decided that a united regional water conservation program was needed to improve water use efficiency. To this end, the Alliance for Water Awareness and Conservation (AWAC) was formed in August of 2003. According to the enabling MOU, the purpose of the AWAC is to "provide a vehicle to attract support for a regional water conservation program and coordinate implementation of activities by forming partnerships to obtain common measurable goals."

Goals of the Alliance, as provided in the MOU, are listed below:

- Educate the local communities on the importance of water conservation.
- Provide the local communities with the tools to effectively reduce per capita consumption to targeted goals.
- Reduce regional water use by 10 percent gross per capita by 2010 and 15 percent gross per capita by 2015 (5 percent in the Morongo Basin by 2015) to achieve a sustainable, reliable supply to meet regional water demands.

The AWAC will determine the appropriate mix, market penetration, budget and schedule for implementation of demand management measures in order to achieve the desired water reduction goals. Initially the AWAC is targeting outdoor irrigation where there is the greatest potential for significant reduction in water use. The primary targeted audiences are:

- New and existing home owners
- Commercial, industrial and institutional water users
- Landscape suppliers
- Professional and commercial landscapers
- Retail water providers and cities
- Developers

Cities and water agencies, through the AWAC, will determine actual reductions in water use. This can be accomplished by establishing baseline annual per capita water use in the cities and comparing this to annual per capita water use data as programs are implemented.

Participants

Current participants in the Alliance for Water Awareness and Conservation are listed in the sidebar table.

Alliance for Water Awareness and Conservation Participants

City of Adelanto
Apple Valley Country Club
Town of Apple Valley
Apple Valley Ranchos Water Company
Baldy Mesa Water District
City of Barstow
Barstow College
Bighorn-Desert View Water Agency
Bureau of Land Management
Bureau of Reclamation
Copper Mountain College
City of Hesperia
Hi-Desert Water District
Mojave Desert & Mountain Waste Management JPA
Mojave Desert Resource Conservation District
Mojave Water Agency
Mojave Weed Management Area
San Bernardino County Special Districts, Water/Sanitation Division
Southern California Water Company
Victor Valley College
Victor Valley Wastewater Reclamation Authority
Victor Valley Water District
City of Victorville
Town of Yucca Valley

MWA and Lewis Center for Education and Research MOU

The MWA and the Lewis Center for Education and Research (LCER) have entered into an MOU for raising water awareness of the High Desert community. According to the MOU, topics include improving understanding of:

- the role water resources play in supporting beneficial uses by all consumers within the High Desert
- sensitive biotic components of the High Desert ecosystem that are dependant on surface and near surface water
- concerns and consequences related to a declining water table

- best resource conservation practices for reducing consumptive uses of water
- how land use activities can impact water supply, water quality and biotic resources

According to the MOU, the two entities are working together in order to:

- coordinate an educational program that will expose students and citizens throughout the region to the value and benefit natural water resources provide to the community, thereby increasing the community's understanding of the importance of long-term management of the region's water resources
- provide a learning environment for LCER students in an attempt to further understanding of the region's water resources and their role in the management of those resources
- establish specific time schedules prior to program development and implementation in order to carry out the objectives of the MOU

MWA and Mojave Desert Resource Conservation District MOU

The MWA and the Mojave Desert Resource Conservation District have entered into an MOU to heighten the public's awareness of ways to conserve water and convert high water use landscaping to low-maintenance trees and scrubs. This will be accomplished through at least the following:

- conducting a desert adaptive plant sale
- publishing educational materials
- developing demonstration projects

MWA and Mojave Weed Management Area MOU

The MWA, the Mojave Desert Resource Conservation District, and seventeen other entities have entered into an MOU to work to prevent and control weeds throughout the Mojave Desert in California. Invasive weed species can crowd out native species and increase evapotranspiration of water supplies. Weed control and prevention will be accomplished in many ways, but specifically the MWA has agreed to:

- participate in seeking grants to fund weed management efforts in cooperation with the Mojave Weed Management Area partners and other organizations attempting to manage weeds
- promote the control and treatment of weeds on MWA property
- support efforts to educate the public about weeds, their identification, prevention, and methods of control

MWA has provided funding to MDRCD for removal of invasive plants from the Mojave River riparian habitat.

MWA and Copper Mountain College MOU

The MWA and the Copper Mountain College have entered into an MOU to increase awareness about the need to manage and conserve the water resources of the Morongo Basin and to provide practical solutions to conserve water. The partners will work to achieve these goals through at least the following efforts:

- developing a college curriculum that will provide educational opportunities in the area of natural plant vegetation and conservation programs
- developing demonstration gardens

MWA and Barstow Community College MOU

Similar to the Copper Mountain College MOU, MWA and the Barstow Community College have entered into an MOU to increase awareness about the need to manage and conserve High Desert water resources and to provide practical solutions regarding water-wise habits. The partners will work to achieve these goals through at least the following efforts:

- developing a college curriculum and present workshops that advance public education related to water availability, quality, use, conservation-based best management practices, and the management practices that directly encourage High Desert water consumers to support a sustainable approach to water resource management
- developing a plan to expand the current demonstration garden

MWA and Victor Valley College MOU

Similar to the Copper Mountain College and Barstow Community College MOUs, MWA and the Victor Valley College have entered into a MOU to create a greater awareness about the need to manage and conserve High Desert water resources and to provide practical solutions that will promote efficient use of water. The partners will work to achieve these goals through at least the following efforts:

- developing a water conservation curriculum that will culminate in students receiving a Water Conservation Technician certificate
- developing a Conservation Outreach Day for the public with workshops on drip irrigation design and the use of adaptive plants
- expanding the GIS curriculum to facilitate water conservation mapping and other natural resource management projects

MWA Mojave Desert Resource Conservation District Demonstration Project

MWA, the Mojave Desert Resource Conservation District, and the Apple Valley Country Club are working cooperatively on a demonstration project to evaluate and reduce turf water use at a golf course. The project will replace two acres of turf with native and other drought-tolerant plants and monitor plant growth and water use over a one-year period. The project is intended to provide a tool to document, display and promote effective methods to save water, reduce costs and develop attractive desert adaptive landscapes.

Urban Water Management Plans

> *"The conservation and efficient use of urban water supplies are of statewide concern; however, the planning for that use and the implementation of those plans can best be accomplished at the local level." California Water Code*

In 1983, the California Urban Water Management Planning Act was added to the California Water Code (Division 6 Part 2.6) with the signing of Assembly Bill 797. The Act has been amended several times. The Act requires water suppliers with over 3,000 customers or that supply over 3,000 acre-feet of water annually to prepare Urban Water Management Plans (UWMP) and submit the plans to the California Department of Water Resources (DWR). The plans must be updated at least every five years in years that end in 0 or 5.

Changes made in late 2001 (Senate Bill 610) now require Urban Water Management Plans to include additional information. If updated plans were not submitted by December 31, 2001 or if plans submitted after January 1, 2002 do not contain the required additional information, the urban water supplier will be prohibited from receiving specified bond funds administered by DWR.

Cities and water agencies within the MWA boundaries have developed and adopted Urban Water Management Plans to comply with the Urban Water Management Planning Act in the California Water Code. Entities with adopted UWMPs are listed below:

- Adelanto Water Authority (serving Adelanto)
- Apple Valley Ranchos Water Company (serving Apple Valley)
- Hesperia Water District (serving Hesperia)
- Hi-Desert Water District (serving Yucca Valley)
- Joshua Basin Water District (serving Joshua Tree)
- Southern California Water Company (serving Barstow and parts of Apple Valley and Lucerne Valley)
- Victor Valley Water District (serving Victorville)

To meet the requirements of the Urban Water Management Planning Act, plans must address a number of topics including current and future water supply availability, projected demands for the next 20 years, reliability of supplies, supply and demand comparisons, the potential for recycling, penalties for wasting water, analysis of impacts on revenues from reductions in water deliveries, measures to overcome revenue impacts, Demand Management (water conservation) Measures and water shortage contingency plans. The following section describes the Demand Management Measures described in the Act.

Demand Management Measures

The Mojave Water Agency Act authorized MWA "to pursue all necessary water conservation measures," and "reduce the waste of water."

Fourteen Demand Management Measures (DMMs) are identified in Table 7 - 1. These measures represent the Best Management Practices that the California Department of Water Resources requires to be addressed in Urban Water Management Plans. The DMMs are intended to reduce current and future water demands through more efficient water use. Additional programs may be necessary during periodic water supply shortages. The DMM descriptions, methods to evaluate effectiveness and estimated water savings associated with the DMMs are taken from the "Memorandum of Understanding Regarding Urban Water Conservation in California" produced by the California Urban Water Conservation Council (CUWCC, 2002). Two agencies in the basin are members of the Council: the Hi-Desert Water District and the Southern California Water Company (which supplies water to the City of Barstow and parts of Apple Valley and Lucerne Valley). MWA adopted the DMMs in 1997.[37]

Table 7-1: Demand Management Measures

DMM	DMM Description
1	Water survey programs for single-family and multi-family customers
2	Residential plumbing retrofit
3	System water audits, leak detection, and repair
4	Metering and commodity rates for new connections and retrofit of existing connections
5	Large landscape conservation programs and incentives
6	High-efficiency washing machine rebate programs
7	Public information programs
8	School education programs
9	Conservation programs
10	Wholesale agency programs
11	Conservation pricing
12	Water conservation
13	Water waste prohibition
14	Residential ultra-low-flush toilet replacement programs

[37] Resolution 630-97, January 28, 1997

MWA is not a direct purveyor of drinking water and therefore is not required to implement the DMMs. In addition, MWA does not have the authority to implement programs in cities where water users are supplied water by their city or water agency. MWA is implementing some of the DMMs and is working with water agencies and cities both individually and collectively through the AWAC to promote the efficient use of water. Table 7-2 shows the implementation status of the DMMs for some of the drinking water purveyors in the basin.

Table 7-2: Implementation Status for DMMs

Demand Management Measures	1 Water survey programs for single-family and multi-family customers	2 Residential plumbing retrofit	3 System water audits, leak detection, and repair	4 Metering and commodity rates for new connections and retrofit of existing connections	5 Large landscape conservation programs and incentives	6 High-efficiency washing machine rebate programs	7 Public information programs	8 School education programs	9 Conservation programs for commercial, industrial, and institutional accounts	10 Wholesale agency programs	11 Conservation pricing	12 Water conservation coordinator	13 Water waste prohibition	14 Residential ultra-low-flush toilet replacement programs
Entity														
Adelanto WA	--	*	Y	Y	*	N	*	*	N	N/A	Y	*	Y	N
Apple Valley WC	Y	Y	Y	Y	Y	N	Y	Y	Y	N/A	Y	Y	Y	N
Hesperia WD	Y	Y	Y	Y	N	N	Y	Y	N	N/A	Y	Y	Y	N
Hi Desert WD	Y	Y	Y	Y	Y	N	Y	Y	N	N/A	Y	Y	Y	Y
Joshua Basin WD	+	Y	Y	Y	N	N	Y	N	N	N/A	Y	Y	Y	N
MWA	NA	N/A	N/A	N/A	N/A	N/A	Y	Y	N/A	Y	N/A	Y	N/A	N/A
Southern CA WC	+	N	Y	Y	+	N	Y	Y	+	N/A	Y	Y	Y	+
VVWD	--	N	Y	Y	N	N	Y	Y	N	N/A	Y	Y	N	Y

* Recommneded in 1997 UWMP
+ Recommneded in 2000 UWMP
N/A - Not applicable

Additional information from the Urban Water Management Plans is included in Table 7-3. Adelanto Water District, Joshua Basin Water District and the Southern California Water Company included schedules for implementation of additional DMMs.

Table 7-3: Summary of Conservation Planning

Entity	City Served	Document	Date	Number of DMMs Implemented	Number of DMMs Planned
Adelanto WA	Adelanto	UWMP	1997	4	5
Apple Valley WC	Apple Valley	UWMP	2000	10	
Hesperia WD	Hesperia	UWMP	2000	9	
Hi Desert WD	Yucca Valley	UWMP	2000	11	
Joshua Basin WD	Joshua Tree	UWMP	2000	7	1
MWA	N/A	RWMP	2004	4	
Southern CA WC	Barstow	UWMP	2000	7	4
VVWD	Victorville	UWMP	2000	7	

Listed below are descriptions of the 14 DMMs, implementation status, and an estimate of water savings.

DMM 1. Water Survey Programs for Single-Family and Multi-Family Customers

Residential surveys, carried out by agency staff or contractors, can identify some of the more common residential water wasting practices. A typical survey includes checking for leaking faucets and toilets, identifying older fixtures that do not meet current water conserving plumbing standards, checking irrigation systems for leaks and proper coverage, reviewing or developing irrigation schedules and setting irrigation controllers accordingly, and checking the water meter.

Implementation Status

This DMM is being implemented to some degree in 5 of the 7 water service areas.

Conservation Savings

A potential for water savings exists if the surveys identify water-wasting practices that can be changed. Water savings vary depending on the water fixture and the type of repair or retrofit. Estimates of anticipated water savings are given in Table 7-4 (CUWCC, 2002).

Table 7-4: Conservation Savings for DMM 1

Device	Pre-1980 Construction	Post-1980 Construction
Low-flow showerhead retrofit	7.2 gcd*	2.9 gcd
Toilet retrofit (five year life)	1.3 gcd	0.0 gcd
Leak repair	0.5 gcd	0.0 gcd
Landscape survey	10%	10%

*gcd = gallons per capita per day

DMM 2. Residential Plumbing Retrofit

Retrofitting residences with water efficient plumbing fixtures can be cost effective and reduce per capita indoor water use, particularly in residences constructed prior to 1992. Typical retrofit programs involve replacing old fixtures with low-flow showerheads and faucet aerators and installing toilet displacement devices or retrofitting with water conserving toilets (as needed).

Implementation Status

Plumbing fixture standards are being enforced throughout the basin. Retrofit programs are being implemented in 5 of the 7 water service areas.

Conservation Savings

Water savings vary depending on the water fixture replaced. Estimates of anticipated water savings are given in Table 7-5 (CUWCC, 2002).

Table 7-5: Conservation Savings for DMM 2

Device	Pre-1980 Construction	Post-1980 Construction
Low-flow showerhead retrofit	7.2 gcd*	2.9 gcd
Toilet retrofit	1.3 gcd	0.0 gcd

*gcd = gallons per capita per day

DMM 3. System Water Audits, Leak Detection, and Repair

Full-scale water system audits estimate water lost due to leaks in the supply system. If the audit results indicate a significant quantity of water is not accounted for, a leak detection and repair effort may be warranted. Methodology is described in the American Water Works Association (AWWA) Water Audit and Leak Detection Guidebook (AWWA, 1992). Customers should be advised whenever it appears possible that leaks exist on the customer's side of the meter.

Implementation Status

This DMM is being implemented in all 7 water service areas.

Conservation Savings

Leak detection and repair may result in water and energy savings for cities and water agencies. Customers may benefit from an effective program or may face repair costs if leaks are detected on their side of the water meter.

DMM 4. Metering and Commodity Rates for New Connections and Retrofit of Existing Connections

The most equitable way to charge for water is through rates based on the quantity consumed. This requires metering service connections and billing customers by volume of use. According to current law, all new connections must be metered. Programs can be developed to retrofit existing unmetered connections.

Implementation Status

All of the water service areas are metered and require water meter installation on new construction. Metered connections are billed by volume of use.

Conservation Savings

Metered water service connections save up to 20% compared to unmetered connections (CUWCC, 2002).

DMM 5. Large Landscape Conservation Programs and Incentives

Large irrigated landscapes represent areas where significant water savings may be made. Efforts to improve water use efficiency of large landscapes include designing and using evapotranspiration-based water use budgets, providing notices each billing cycle showing the relationship between the budget and actual consumption, providing notices at the start and end of the irrigation season alerting customers to check their irrigation systems, marketing landscape surveys to existing accounts with large landscapes, and providing information on climate-appropriate landscape design, efficient irrigation equipment to new customers and change-of-service customer accounts.

Surveys of all landscapes at cities and water agencies could be conducted and appropriate adjustments made as indicated from results of the survey. Climate-appropriate water efficient landscaping could be installed at city and water agency facilities, and dual metering where appropriate.

Implementation Status

This DMM is being implemented in 4 of the 7 water service areas.

Conservation Savings

Landscapes and/or irrigation equipment that are modified as a result of water audits could reduce water use by 15% (CUWCC, 2002).

DMM 6. High-Efficiency Washing Machine Rebate Programs

High-efficiency washing machines save water and energy needed to heat water. Energy service providers often offer financial incentive for the purchase of high-efficiency washing machines. Cities and water agencies could also offer a cost-effective financial incentive based on the marginal benefits of the water savings.

Implementation Status

This DMM is not currently being implemented.

Conservation Savings

The estimate of reliable annual water savings per replacement of a low-efficiency washing machine with a high-efficiency washing machine is 5,100 gallons (CUWCC, 2002).

DMM 7. Public Information Programs

Public information programs to promote the wise use of water and the related benefits are in place throughout the MWA service area. Programs include providing speakers to employees, community groups and the media; using paid and public service advertising; using bill inserts; providing information on customers' bills showing use in gallons per day for the last billing period compared to the same period the year before; providing public information to promote wise water use practices; and coordinating with other government agencies, industry groups, public interest groups, and the media.

Implementation Status

MWA, the AWAC and all cities and water agencies have public information programs.

Conservation Savings

There is no method to quantify the savings of this DMM.

DMM 8. School Education Programs

School education programs promote wise water use and related benefits. Programs include working with school districts and private schools in the area to provide instructional assistance, educational materials, and classroom presentations that identify urban, agricultural, and environmental issues and conditions in the local watershed. Education materials should meet the state education framework requirements, and grade appropriate materials should be distributed to grade levels K-3, 4-6, 7-8, and high school.

Implementation Status

This DMM is being implemented in 6 of the 7 water service areas.

Conservation Savings

There is no method to quantify the savings of this DMM.

DMM 9. Conservation Programs for Commercial, Industrial and Institutional Accounts

Water conservation efforts for commercial, industrial and institutional water users include replacement of existing high-water-using toilets with ultra-low-flush (1.6 gallons or less) toilets, water use surveys and customer incentives. Water use surveys include a site visit, an evaluation of all water-using apparatus and processes, and a customer report identifying recommended efficiency measures, their expected payback, and available agency incentives.

Implementation Status

This DMM is being implemented in 2 of the 7 water service areas.

Conservation Savings

Commercial water reduction from DMMs such as interior and landscape water surveys, plumbing codes, and other factors (includes savings accounted for in other DMMs) is estimated as 12% (CUWCC, 2002).

Industrial water reduction results from DMMs such as waste discharge fees, new technologies, water surveys, plumbing codes and other factors (including savings accounted for in other DMMs) is estimated at 15% (CUWCC, 2002). Institutional water reductions vary significantly.

DMM 10. Wholesaler Agency Programs

Implementation Status

MWA is assisting other agencies in the basin with water conservation through a number of cooperative efforts. These are discussed in the *Coordinated Water Conservation Efforts* section of this chapter.

Further water conservation could be achieved by the following means:

Regional Conservation Partnerships

- Develop partnerships where financial incentives or equivalent resources, are made available to advance water conservation efforts and effectiveness

- Explore financial support for all DMMs implemented by cooperating retail water agencies which can be shown to be cost-effective in terms of avoided cost of water from the wholesaler's perspective

Technical Facilitation

MWA can provide conservation-related technical support and information to all retail agencies through facilitation of groups such as the Alliance for Water Awareness and Conservation. Specific cooperative technical facilitation activities could include providing staff to work with retail agencies on DMM implementation, conducting or arranging workshops, and developing guidelines for:

- Calculating program savings, costs and cost-effectiveness
- DMM implementation measurement and reporting procedures
- Issues associated with water conservation activities for ULFT replacement, residential retrofits, surveys of commercial, industrial and institutional uses, residential and large turf irrigation, and conservation-related rates and pricing
- Encouraging and rewarding cost-effective investments in long-term conservation shown to advance regional water supply reliability and sufficiency.

Water Savings Assumptions

There is no method to quantify savings from this DMM.

DMM 11. Conservation Pricing

Conservation pricing provides incentives to customers to reduce average use, peak use, or both. Such pricing includes rates designed to recover the cost of providing service and billing for water and sewer service based on metered water use. Conservation pricing is also characterized by one or more of the following components: rates in which the unit rate increases as the quantity used increases (increasing block rates); seasonal rates or excess-use surcharges to reduce peak demands during summer months; or rates based on the long-term marginal cost or the cost of adding the next unit of capacity to the system.

Implementation Status

All of the cities and water agencies currently bill for water based on conservation priced commodity rates.

Conservation Savings

There is no method to quantify the savings of this DMM.

DMM 12. Water Conservation Coordinator

Water conservation coordinators and support staff (if necessary) perform a number of functions including coordination and oversight of conservation programs and DMM implementation, preparation of reports, promotion of water conservation issues to the city or water agency senior management, coordination of agency conservation programs with operations and planning staff, preparation of annual conservation budgets, and preparation of the conservation elements of the agency's Urban Water Management Plan.

Implementation Status

MWA and all of the cities and water agencies have staff that is dedicated to serving in this capacity.

Conservation Savings

There is no method to quantify the savings of this DMM.

DMM 13. Water Waste Prohibition

Water waste prohibitions involve enacted and enforced measures prohibiting gutter flooding, single pass cooling systems in new connections, nonrecirculating systems in all new conveyer car wash and commercial laundry systems, and nonrecycling decorative water fountains.

Implementation Status

Ordinances prohibiting water waste have been adopted in all of the water service areas.

Conservation Savings

There is no method to quantify the savings of this DMM.

DMM 14. Residential Ultra-Low-Flush Toilet Replacement Programs

Ultra-low-flush toilet replacement programs replace existing high-water-using toilets with ultra-low-flush (1.6 gallons or less) toilets in single-family and multi-family residences. Some programs involve requiring toilet replacement at time of resale.

Implementation Status

This DMM is currently being implemented in 3 of the water service areas.

Conservation Savings

Water savings depend on the type and number of toilets replaced.

8

STAKEHOLDER ASSESSMENT AND PUBLIC OUTREACH

Significant public outreach efforts were made during development of this Regional Water Management Plan. These efforts involved meetings with individuals, groups, a Technical Advisory Committee and evaluation of questionnaires. Outreach efforts were directed at stakeholders from local water agencies, state and federal agencies, municipalities, San Bernardino County, and 13 local community groups. Lists of stakeholders are included in Chapter 2 of this Plan. The assessment of stakeholders' concerns is described in the following section.

Assessment Approach

Stakeholders in the Mojave Water Agency (MWA) have a variety of issues related to potential water management activities. In an effort to identify those issues, several actions were taken as part of this planning process. Those actions included the following:

- review of existing data and reports provided by MWA and some stakeholders
- meetings with the MWA Technical Advisory Committee (TAC)
- individual and group meetings with stakeholders
- preparation and distribution of a written questionnaire; collection and review of responses

MWA arranged meetings with individual stakeholders or groups of related stakeholders. MWA selected those agencies thought to have critical issues that would benefit from individual discussions. The agencies that participated are as follows:

1. Victor Valley Wastewater Reclamation Authority
2. Baldy Mesa Water District
3. City of Barstow & Southern California Water Company
4. Joint Subarea Advisory Committee
5. City of Adelanto

6. City of Hesperia
7. Victor Valley Water District
8. Lahontan Regional Water Quality Control Board (Lahontan RWQCB)
9. Morongo Basin/Johnson Valley Area
    a. Joshua Basin Water District
    b. Hi-Desert Water District
    c. Bighorn-Desert View Water Agency
    d. San Bernardino County Special Districts
10. California Department of Fish and Game
11. San Bernardino County Special Districts

The written questionnaire was developed to provide an opportunity for all agencies and a greater number of individuals in MWA to provide input to the Regional Water Management Plan (RWMP) Update. The TAC provided review comments on the draft questionnaire and was instrumental in the development of the final version (Appendix D). The questionnaires were distributed in July 2001 in several ways: MWA mailed questionnaires directly to 26 entities, TAC members distributed copies to their constituent groups, and copies were distributed at other MWA meetings.

The following nineteen agencies and individuals submitted completed questionnaires:

Regional/Multiple Subareas

1. California Department of Fish and Game
2. County of San Bernardino Special Districts
3. Lahontan Regional Water Quality Control Board (RWQCB)
4. Southern California Water Company
5. Unknown (respondent’s name was not provided)

Morongo Basin/Johnson Valley Area

1. Bighorn-Desert View Water Agency
2. Hi-Desert Water District
3. Joshua Basin Water District

Alto Subarea

1. City of Adelanto
2. City of Hesperia
3. City of Victorville

4. Jess Ranch
5. Joe Monroe
6. Victor Valley Water District
7. Victor Valley Wastewater Reclamation Authority

Este Subarea

1. Chuck Bell / Este Subcommittee
2. Norman Nichols

Oeste Subarea

1. Paul Davis

Centro Subarea

1. City of Barstow

Baja Subarea

None submitted (several attempts were made to solicit a response)

The responses to the questionnaire varied, but they included several consistent themes. All of the responses to the questionnaire are summarized by subarea respondent in Appendix D.

Summary of Stakeholder Issues

The following is a summary of the key stakeholder issues, as developed from the individual/group meetings and questionnaires.

Regional/Multiple Subareas

1. California Department of Fish and Game (DFG)
   a. Highest priority for the RWMP Update is increasing and maintaining the flows from Alto to Centro subareas. Replacement water needs to be delivered in the Narrows to benefit the riparian habitat.
   b. RWMP Update should establish short-term actions in addition to long-term actions.
   c. DFG would like Alto Subarea water level raised to create spillover to Lower Narrows.
   d. RWMP Update should evaluate recharge at several locations: Rock Springs, upstream of Rock Springs, Transition Zone, and Silver Lakes area (south of Helendale Fault).
   e. RWMP Update should address the need for additional water quality data.

f. RWMP Update should address the needs of the existing riparian habitat. Minimum water levels for key habitats are included in Appendix H to the Judgment.
g. RWMP Update should address the viability of wastewater reclamation and its impact on riparian habitat.
h. RWMP Update should evaluate the viability of a diversion or dam at the lower end of the Mojave River upstream of Afton Canyon to retain storm water for use in the Baja Subarea.
i. RWMP Update should acknowledge the benefits of removing non-native vegetation in favor of native vegetation in the riparian habitat areas.
j. RWMP Update should evaluate the potential for MWA to assist with the funding of land purchases around sensitive riparian habitat.
k. Water quality concerns associated with the fish hatchery operations include: potential increases in levels of TDS and nutrients, and the potential for translocated pathogens from the State Water Project (SWP) water.

2. County of San Bernardino Special Districts
(See Morongo Basin/Johnson Valley Area, Alto Subarea, and Oeste Subarea)

3. Lahontan RWQCB
a. Highest priority for the RWMP Update is to address the long-term impacts of the increased salt levels associated with the delivery of SWP water.
b. Next year [2002], Lahontan RWQCB anticipates starting the process to revise the Basin Plan Objectives.
c. Would like a basin-wide water quality model to be used to evaluate alternative projects.
d. Would like the water quality model used to evaluate any proposed recycled water project.
e. Water conservation should be an integral part of the RWMP Update. MWA should take a leadership role in promoting water conservation.

4. Southern California Water Company
a. Southern California Water Company (SCWC) operates systems in Alto Subarea (Apple Valley), Centro Subarea (Barstow), and Este Subarea (Lucerne Valley).
b. RWMP Update should include provisions to provide adequate supplies of water to each area of the region.
c. RWMP Update should evaluate all the competing interests for water and develop a plan for the greatest good of the group.

d. Local soil conditions should be considered when selecting a recharge site to make sure recharge would not mobilize local contaminants that have been previously "locked" in the soil.
e. The quality of SWP water, as compared to existing and emerging contaminant standards, should be considered as part of the RWMP Update.
f. The storage capacity of a local basin should be utilized first for the benefit of local basin users. Once local needs are met, use of the storage capacity for others should be considered and this use should provide some benefit to the local users.

5. Unknown (respondent's name was not provided)
   a. The overdraft must be stopped.
   b. Projects and policies developed in the RWMP Update should be fair to all.

Morongo Basin/Johnson Valley Area

1. Bighorn-Desert View Water Agency
   a. District would like assistance with obtaining grant funding for system upgrades and replacements.

2. County of San Bernardino Special Districts
   a. County operates 2 service areas in this subarea.
      i. Zone 70 W-4 (Pioneertown)
      ii. Zone 70 W-1 (Landers)
   b. County would like assistance with obtaining grant funding for system upgrades and replacements.
   c. High levels of uranium and arsenic (Zone 70 W-4) are concerns.
   d. RWMP Update should address the issues of all regions within MWA.

3. Hi-Desert Water District
   a. Highest priority for RWMP Update is the extension of the Morongo Basin Pipeline and the construction of an additional recharge facility.
   b. Nitrate levels are a concern.
   c. Would like an evaluation of the potential for a conjunctive use project in the Mesa area included in the RWMP Update.
   d. RWMP Update should include a policy on how the SWP entitlement is to be allocated or shared.

e. RWMP Update should include an evaluation of a treatment facility at the terminal reservoir for the Morongo Basin Pipeline.

4. Joshua Basin Water District
   a. Highest priority for RWMP Update is the extension of the Morongo Basin Pipeline to the District and the construction of a recharge facility.
   b. District would like MWA assistance with obtaining grant funding for the pipeline extension and recharge facilities.
   c. Fluoride and salt levels are a minor concern.
   d. RWMP Update should address the need for additional SWP entitlement for the Morongo Basin/Johnson Valley Area.
   e. RWMP Update should include an evaluation of a treatment facility at the terminal reservoir for the Morongo Basin Pipeline.

Alto Subarea

1. Baldy Mesa Water District
   a. Significant urban growth and increased water demand are anticipated.
   b. Water quality issues should be addressed. Arsenic levels are above 10 ppb.
   c. How various stakeholders will gain access to MWA's SWP entitlement should be addressed.
   d. How treatment of SWP water can fit into the regional plan and how reliable it will be should be addressed.
   e. Would like MWA to jointly work with them to evaluate injection well feasibility and percolation basin feasibility. Oro Grande Wash and No Name Wash are identified recharge sites.
   f. Would like the potential of moving their production to the Mojave River area East of Hesperia to be evaluated. A transmission system from the River to the District would be required.

2. City of Adelanto
   a. Significant urban growth and increased water demand are anticipated.
   b. Highest priority for RWMP Update is to evaluate ways to recharge the Transition Zone to increase the reliability of the City's wells.
   c. Water quality issues should be addressed. The City's wells on the Mesa have high TDS and fluoride levels.
   d. How treatment of SWP water can fit into the regional plan and how reliable it will be should be addressed.
   e. Would like the potential for injection in the Mesa area to be evaluated.

3. City of Hesperia
    a. Significant urban growth and increased water demand are anticipated.
    b. Water levels have dropped an average of 8 feet over the past 2 years due to 2 years of dry weather and minimal Mojave River flows.
    c. Welcome the evaluation of a project to move Baldy Mesa Water District production to the Mojave River area East of the City. Feel such a project could be beneficial to the entire region.
    d. City has no water quality concerns.
    e. RWMP Update should be a regional plan, not a series of individual plans.
    f. A treatment facility for SWP water should be evaluated as a regional project.
    g. Direct use of SWP water for irrigation should be evaluated as an in-lieu project.
    h. Existing and proposed local stormwater retention/detention basins should be evaluated for their potential dual use as recharge facilities.
    i. Water conservation should be an integral part of the RWMP Update.
    j. RWMP Update should mention the Army Corps of Engineers proposal to make the Mojave River Forks Dam a retention basin.

4. City of Victorville
    a. RWMP Update needs to include alternatives for recharging the regional aquifer close to points of withdrawal.
    b. The need for a water treatment facility for SWP water needs to be evaluated in the RWMP Update.
    c. The RWMP Update process needs to be coupled with an aggressive public information program to educate the general public on the regional water supply issues.
    d. Recycled water and water conservation should be an integral part of the RWMP Update.

5. County of San Bernardino Special Districts
    a. County operates 5 service areas in this subarea.
        i. Zone 42 (Oro Grande) in Transition Zone
        ii. Zone 70 C (Silver Lakes) in Transition Zone
        iii. Zone 64 (Spring Valley Lake)
        iv. Zone 70 J (Oak Hills)
        v. Zone 70 L (Pinion Hills – Phelan Area) most of production is in Oeste and most of consumption is in Alto

b. Water quality issues: chromium VI (Zone 70 J), iron and magnesium (Zones 42 and 70 C), nitrate (Zone 64), arsenic (Zone 70 C), TDS (Zone 70 C), and fluoride (Zone 70 C).
c. Zone 42 (Oro Grande) would benefit from recharge in the Transition Zone as proposed by City of Adelanto. Wells almost run dry seasonally.
d. RWMP Update should address the issues of all regions within MWA.

6. Jess Ranch
   a. RWMP Update should include the concept of recharging large quantities of water in the Floodplain Aquifer via the Rock Springs facility and extracting that water for distribution to Alto, Este, and Morongo Basin/Johnson Valley users.
   b. RWMP Update should address consumptive use issues.
   c. Farmers need to be treated equitably.
   d. MWA should only be involved in the educational aspects of water conservation. MWA should focus on supplying supplemental water as a wholesaler.
   e. RWMP Update should address the potential of degrading local groundwater quality by recharging the aquifer with SWP water.
   f. RWMP Update should be an update to the existing plan and not a new plan. Any changes to the existing plan should be clearly identified.
   g. RWMP Update should focus on getting supplemental water flowing as soon as possible.
7. Joe Monroe
   a. The time should be taken to prepare an RWMP Update that provides for an adequate, equitable, and reliable water supply.
8. Victor Valley Water District

   a. Significant urban growth and increased water demand are anticipated.
   b. Water quality concerns include arsenic and temperature. 58% of well capacity is over 10 ppb level for arsenic. Are beginning to see some low levels of nitrate.
   c. RWMP Update focus should be on bringing in wet water.
   d. Would like to build treatment facility for SWP water for direct delivery and for injection.
   e. Percolation of SWP water is considered an option, but there is concern over where the water goes once it is recharged.

f. Relying on projects that would pump additional water from around the Mojave River may be problematic for two reasons: water quality may not be adequate and increased pumping may have a detrimental affect on riparian habitat.
g. The use of recycled wastewater should be evaluated. The impact on the make-up obligations of Alto producers must be included in the evaluation.
h. RWMP Update should include a policy on how the SWP entitlement is to be allocated or shared.
i. Groundwater banking programs should be addressed in the RWMP Update. Principles must be developed that clearly state how the stakeholders establish benefits from these programs and how the benefits will be equitably shared.
j. RWMP Update should be plan that provides regional guidance while maintaining local control of facilities.

9. Victor Valley Wastewater Reclamation Authority
   a. Highest priority for RWMP Update is to determine and support the highest and best use of recycled wastewater.
   b. Adjudication should recognize the benefits of wastewater reclamation.
   c. Adjustments to the Physical Solution would be helpful.
   d. Some of the Authority's main interceptors are reaching their capacity and/or design life.
   e. Sub-regional wastewater reclamation facilities would eliminate or greatly reduce the need for major interceptor rehabilitation and/or replacement.
   f. Recycled water from sub-regional facilities could be used for urban irrigation and groundwater recharge.
   g. Regional facility would continue to treat solids and could continue to provide flow to the Mojave River.

Este Subarea

1. Chuck Bell / Este Subarea Advisory Committee
   a. A recharge facility for SWP water via the Morongo Basin Pipeline must be a part of the RWMP Update.
   b. RWMP Update should include a wide range of options, recharge locations, financial incentive, etc.
   c. Some concern regarding increasing TDS levels.
2. Norman Nichols
   a. RWMP Update must treat farmers fairly and equitably.
   b. Some concern regarding increasing TDS levels.
   c. RWMP Update should include evaluation of groundwater storage programs in Este.

Oeste Subarea

1. County of San Bernardino Special Districts
   a. County operates 1 service area in this subarea
      i. Zone 70 L (Pinion Hills – Phelan Area) most of production is in Oeste and most of consumption is in Alto
   b. Water quality issues: MTBE
   c. RWMP Update should evaluate the potential to recharge SWP water in Sheep Creek.
   d. RWMP Update should address the issues of all regions within MWA.

2. Paul Davis
   a. RWMP Update must fully address the needs of the outlying areas such as Este and Oeste.
   b. Conservation needs to be a very important part of the RWMP Update.
   c. Minimal users should pay their fair share of costs for regional programs and improvements.

Centro Subarea

1. City of Barstow
   a. Centro is close to being in balance, but there is a significant amount of FPA not currently being used.
   b. TDS levels are a concern. Fourteen wells have TDS levels over 500 mg/l.
   c. Want to make sure that Alto Subarea users are doing their part to get Alto in balance.
   d. RWMP Update should focus on stopping the overdraft and reversing it if necessary.
   e. RWMP Update should clearly state how MWA allocates SWP entitlement and how much it will cost so that developers will be able to evaluate the viability of new development.
   f. RWMP Update should include Best Management Practices for each subarea.
   g. Concerned that water introduced at the Transition Zone is not reaching Barstow.
   h. RWMP Update should acknowledge the benefits of removing non-native vegetation in favor of native vegetation in the riparian habitat areas.
   i. Want to have assurances that the requirement for 23,000 acre-feet per year to pass through the Narrows is being met.
   j. SWP water delivered through the Mojave River Pipeline should be paid for on a postage stamp basis, not a railroad ticket basis.
   k. Recognize that VVWRA discharge is currently the primary recharge mechanism for Barstow. Are willing to have alternatives that would make use of SWP water for

Transition Zone flow and allow some upstream wastewater reclamation. Centro and Barstow must not be negatively impacted.

Baja Subarea

A formal response to the questionnaire was not received, but the following comments were among several received in discussions with TAC members.

1. RWMP Update needs to treat Baja interests fairly.
2. Concerned about the lack of water reaching Baja.
3. Concerned that increased development upstream will negatively impact local water supplies.
4. Concerned about a drop in local property values due to concerns about the water supply.
5. Would like to see support for obtaining grant funds to assist local farmers with water conserving improvements.
6. Would like to see MWA and USGS confirm that the aquifer in the Newberry Springs area is recharged from the Mojave River system.

Issues Common to All Stakeholders

The assessment and evaluation of the meetings and questionnaires point to several issues that are common to virtually all stakeholders. These issues, as articulated below, helped to develop the suite of project alternatives evaluated in detail during Phase 2 of the RWMP Update.

1. Groundwater overdraft needs to be stopped and local water levels recovered if it is financially viable to do so.
2. Purchase of additional SWP entitlement should be pursued, if it makes financial sense to do so.
3. Groundwater banking with agencies outside and inside MWA should be considered as long as they provide benefit to the local basin.
4. The RWMP Update should strive to maximize the use of recycled water while meeting the obligations of the Adjudication.
5. Water conservation should be a key component in the long-term water supply.
6. The RWMP Update should treat all water users fairly and equitably.
7. Continued open dialog and stakeholder involvement is critical to the development of an effective RWMP Update.

Key Water Management Issues

Identifying the key water management issues facing the Mojave Water Agency (MWA) service area is an important step in the Agency's planning process. Clearly articulating these issues helped define the water management actions and projects presented in the next chapter of this report.

The identification of the area's key water management issues stemmed from our evaluation of recent hydrogeologic data, our update of supply and demand estimates, and our stakeholder assessment process. The following six key water management issues emerged from this process:

1) **Demand Exceeds Supply**

   The projected year 2020 water balance shows a water deficit in the Mojave Basin area ranging from 57,200 acre-feet to 79,600 acre-feet. The projected 2020 deficit in the Morongo Basin/Johnson Valley Area is 1,900 acre-feet.

2) **Water Quality**

   Water quality problems affect drinking water supplies throughout the MWA service area. The key contaminants of concern include arsenic, nitrates, iron, manganese, chromium VI and TDS.

3) **Overdraft of the Groundwater Basins**

   Declining groundwater levels occur in all subareas of the Mojave Basin Area and in the Morongo Basin/Johnson Valley Area.

4) **Riparian Ecosystem Maintenance**

   All but two of the subareas (Oeste and Morongo Basin/Johnson Valley) have potential riparian maintenance issues to consider, such as invasive species and habitat preservation.

5) **Wastewater Infrastructure**

   Wastewater infrastructure issues affect the two subareas with the largest urban water demands within the Mojave Basin Area (Alto and Centro).

6) **Subarea Interaction**

   Many subareas within the MWA service area are impacted by activities in other subareas. These impacts include water supply and water quality issues.

Each subarea has a unique set of these key issues. To help identify the issues that are specific to each subarea, the following series of tables were developed. The tables also show the locations affected within the subarea and the aquifer(s) potentially impacted.

Table 8-1: Baja Subarea Water Management Issues

Issue	Specification	Location	Aquifer(s)
Demand Exceeds Supply	2020 deficit: 6,100 to 23,200 af/yr	Overall subarea	Floodplain & Regional
Water Quality	Arsenic > 10 ppb	• Military Base • Individual Homeowner Wells	Floodplain & Regional
	Local Organics	Same as above	Floodplain
	Boron	Same as above	Floodplain
	Chromium VI	Newberry Springs area	Floodplain
	Fluoride	Isolated areas	Floodplain & Regional
	High TDS	Isolated areas	Floodplain & Regional
Overdraft	• Largest historical decline of Mojave R. Basin subareas • Causing wells to run dry • Potentially causing degradation in water quality • Potential ground subsidence NE of Newberry Springs	Overall subarea	Floodplain & Regional
Riparian Ecosystem Maintenance	• Declining water levels have caused harm to riparian growth and sustainability • Issue – Keeping groundwater levels in appropriate root zone • Listed species negatively effected	Camp Cady	Floodplain
	Blowsand conditions and vegetation loss due to lowered water levels	Calico-Newberry Fault zone	Floodplain & Regional
Wastewater Infrastructure	Not an issue		
Subarea Interaction	Judgment requiring: - Minimum subsurface flow from Centro - Minimum subsurface flow toward Afton	Overall subarea	Floodplain

Table 8-2: Centro Subarea Water Management Issues

Issue	Specification	Location	Aquifer(s)
Demand Exceeds Supply	2020 deficit: 2,700 af/yr	Overall subarea	Floodplain & Regional
Water Quality	Arsenic > 10 ppb	Barstow and Harper Dry Lake areas	Floodplain & Regional
	TDS	Same as above. 14 wells have TDS levels over 500 mg/l.	Floodplain & Regional
	Fluoride	Barstow	Regional
	Nitrates	Barstow and isolated areas	Floodplain & Regional
Overdraft	• Causing wells to run dry • Potentially causing degradation in water quality • Potential ground subsidence near Harper Dry Lake	Harper Lake area	Regional
Riparian Ecosystem Maintenance	• Habitat health based on groundwater level • Per Judgment, gw levels for riparian have been set, but two of the monitoring wells have not been drilled. • Invasive species – eradicate phreatophytes because of their consumption.	Along Mojave River and Harper Lake Habitat Preserve	Floodplain & Regional
Wastewater Infrastructure	• ~9,000 af/yr • Alto discharges provide supply to Centro. • Several entities protesting change of point of discharge. DFG wants 8,500 af/yr plus 37% of additional water treated to continue to be discharged at present location.	Victorville area	Floodplain & Regional
Subarea Interaction	• Judgment requiring minimum subsurface flow from Alto and to Baja • VVWRA wastewater point of discharge issue related to meeting downstream flow requirements.	Overall subarea	Floodplain

Table 8-3: Alto Subarea Water Management Issues

Issue	Specification	Location	Aquifer(s)
Demand Exceeds Supply	2020 deficit: 46,000 to 48,500 af/yr	Overall subarea	Floodplain & Regional
Water Quality	Arsenic > 10 ppb	• Various locations. • 58% of Victor Valley WD well capacity > 10 ppb Arsenic.	Mostly Regional, but also some in Floodplain
	High TDS	Adelanto	Regional
		Silver Lakes	Floodplain
	Fluoride	Adelanto, Silver Lakes, and isolated areas	Regional
	Nitrates (low priority, below MCLs)	Victorville	Floodplain & Regional
	Manganese, Iron	North of SCLA, Oro Grande, and isolated areas	Floodplain & Regional
	Chromium VI, Iron, Manganese, Arsenic, others	Upper Part of Mojave Watershed	Regional
	Organics	SCLA	Regional
	High Temperature	Victorville	Regional
Overdraft	Causing wells to run dry	Apple Valley	Regional
	Potentially causing degradation in water quality	Victorville	Floodplain & Regional
		Adelanto	Floodplain & Regional
		Baldy Mesa	Regional
		Hesperia	Floodplain & Regional
Riparian Ecosystem Maintenance	• Habitat health based on groundwater level and Mojave River flows • Water level needs to be raised to return to and maintain habitat	Along Mojave River – 24-mile corridor from Spring Valley Lakes to the Helendale fault area	Floodplain
Wastewater Infrastructure	• Return flow policy • Need for additional infrastructure • Satellite treatment and recycle	Overall subarea	Floodplain & Regional
Subarea Interaction	• Judgment requiring minimum subsurface flow from Este and Oeste and subsurface and surface flow to Centro • Tied to VVWRA wastewater point of discharge issue	Overall subarea	Floodplain & Regional

Table 8-4: Oeste Subarea Water Management Issues

Issue	Specification	Location	Aquifer(s)
Demand Exceeds Supply	2020 deficit: 1,900 to 2,900 af/yr	Overall subarea	Regional
Water Quality	Arsenic > 10 ppb	Localized	Regional
	MTBE	Southern region	Regional
	Moderately high TDS Chromium VI	Near El Mirage Dry Lake	Regional
	Fluoride	Isolated areas	Regional
Overdraft	• Causing wells to run dry • Potentially causing degradation in water quality • Potential ground subsidence	Depression beneath El Mirage Dry Lake	Regional
Riparian Ecosystem Maintenance	None identified		
Wastewater Infrastructure	Not an issue		
Subarea Interaction	Judgment requiring subsurface flow from Oeste to Alto	Overall subarea	Regional

Table 8-5: Este Subarea Water Management Issues

Issue	Specification	Location	Aquifer(s)
Demand Exceeds Supply	2020 deficit: 500 to 2,300 af/yr	Overall subarea	Regional & Lucerne
Water Quality	High TDS	Near Rabbit Dry Lake	Regional
		Near Lucerne Dry Lake	Lucerne
	Fluoride	Isolated areas	Lucerne
	Arsenic > 10 ppb	Isolated areas	Lucerne
	Nitrate concentrations near BBARWA discharge	Near Hwy 247 and Camp Rock Road	Lucerne
Overdraft	• Causing wells to run dry • Potentially causing degradation in water quality • Potential ground subsidence near Lucerne Dry Lake	Overall Subarea	Lucerne
Riparian Ecosystem Maintenance	Springs along Helendale Fault support habitat (Rabbit Spring, Cushenberry Spring, & several unnamed springs)	Overall subarea	Regional & Lucerne
Wastewater Infrastructure	Not an issue		
Subarea Interaction	Judgment requiring subsurface flow from Este to Alto	Overall subarea	Regional

Table 8-6: Morongo Basin/Johnson Valley Water Management Issues

Issue	Specification	Location	Aquifer(s)
Demand Exceeds Supply	2020 deficit: 1,900 af/yr (Not including imported supply and Johnson Valley)	Overall subarea	Morongo Regional
Water Quality	Nitrates (septic contamination of recharged water)	Warren Valley Basin	Morongo Regional
	Arsenic > 10 ppb	Pioneertown	Morongo Regional
	Uranium	Pioneertown	Morongo Regional
	Iron & manganese	Pioneertown	Morongo Regional
	Fluoride	Isolated areas	Morongo Regional
	Moderate TDS	Warren Valley Basin	Morongo Regional
Overdraft		• Joshua Tree Subbasin – some decline • Warren Basin is now stabilized with imported water	Morongo Regional
Riparian Ecosystem Maintenance	None		
Wastewater Infrastructure	Treatment Plant being pursued for Warren Valley Basin	Warren Valley Basin	Morongo Regional
Subarea Interaction	Warren Valley Basin Judgment	Warren Valley Basin	Morongo Regional

A review of the tables above shows that the impacts caused by the six key issues are widespread in the MWA service area. This compilation of water management issues provides a tool for identifying linkages between specific issues and subareas. These linkages can be used to craft project alternatives and water management strategies that address the issues in an integrated manner.

Coordination of IWMP, GMP and UWMP with Other Agencies

In the development of this Integrated Water Management Plan, input was sought from other agencies in the Mojave Basin through the Technical Advisory Committee. The committee discussed the content of the plan and provided input during its development. Agendas and minutes from TAC meetings are included in Appendix E.

Method for Public Participation

MWA utilized numerous methods for informing the public about the development of its IWMP and describing means by which the public could have input into development of the plan. The methods are described below.

Technical Advisory Committee

MWA formed a Technical Advisory Committee (TAC) comprised of local stakeholders with an interest in the areas groundwater. The TAC met regularly during development of the Regional Water Management Plan, reviewing and providing comments and suggestions on the Plan. The following entities comprise the Technical Advisory Committee:

Apple Valley Ranchos
Baldy Mesa Water District
Bar-H Mutual Water Company
Bighorn Desert View Water Agency
California Department of Fish & Game
Citizens for a Better Community
City of Barstow
City of Hesperia
City of Victorville
County of San Bernardino Special Districts
Department of Water Resources
Hi-Desert Water District
Jess Ranch
Joshua Basin Water District
Jubilee Mutual Water Company
Lahontan Regional Water Quality Control Board
Mariana Ranchos County Water District
Mojave Basin Area Judgment Subarea Advisory Committees
Newberry Springs-Harvard Property Owners Association
Palisades Ranch
Rancho Los Flores
Silver Lakes Association
Southern California Water Company
Spring Valley Lakes Association
Town of Apple Valley
Victor Valley Wastewater Reclamation Authority
Victor Valley Water District

In addition, approximately 20 individuals participated. Other stakeholders in the Regional Water Management Plan Update process are listed in Chapter 2.

Newsletter

The Panorama, the newsletter of the MWA is published regularly and mailed to those on its growing distribution list. Regular updates on the development of the Regional Water Management Plan have been included. A copy of Volume 3, Issue 1 published in the winter of 2003 is included in Appendix F.

Website
MWA's web site (http://www.mojavewater.org/) contains information on MWA projects, water supplies and resources, water education, Watermaster, Agency publications, a calendar of events and general information about MWA. MWA will continue to provide this service.

Annual Symposia
MWA organized and held water symposia in Victorville in Spring 2003 and in Joshua Tree in Fall 2003. Water leaders and regulators participated in discussion and information sessions. The Agency plans to make the symposia an annual event.

Alliance for Water Awareness and Conservation
MWA is a member of the Alliance for Water Awareness and Conservation, a group of local water purveyors who are collaborating on demand management measures.

Speakers Bureau
MWA provides speakers to a variety of local and community groups on MWA's plans and projects.

MWA Community Liaison Officer
MWA will continue its outreach and education efforts through the position of the Community Liaison Officer.

Subarea Advisory Committees
The 1996 Mojave Basin Area Judgment stipulated formation of Subarea Advisory Committees for each of the five Subareas. The Committee for each area acts in an advisory capacity and studies, reviews and makes recommendations on all discretionary determinations made by the Watermaster which may affect that Subarea.

Written statement to the public
A copy of the statement (MWA Newsletter) on how interested agencies and other stakeholders could participate in the development of this Plan is included in Appendix F. Additional written statements include agendas for the TAC meetings that were mailed to the TAC members (Appendix E).

9

BASIN MANAGEMENT OBJECTIVES AND ALTERNATIVES

Mojave Water Agency

Basin Management Objectives (BMOs) and performance measures were developed as part of this Regional Water Management Plan (RWMP) Update using input from the Technical Advisory Committee (TAC) during two workshops in July and August 2002. Water supply projects and management actions were identified to provide a means to achieve these BMOs. Various combinations of these water supply projects and management actions were assembled into alternatives which were then evaluated for their ability to achieve the BMOs. This process is described in detail in this chapter.

Steps in Screening Process using Systems Approach

1. ***Define Problem***
   - ***Articulate Fundamental Objectives***
   - ***Establish Performance Measures***
2. ***Generate Alternatives***
3. ***Evaluate Alternatives***
4. ***Select Alternatives to Implement***

During Phase 2 of the RWMP Update the TAC screened and selected the best combinations of projects and management actions that address key MWA water issues using a four-step systems approach. The first step was to clearly articulate what MWA wants to accomplish through the update of the RWMP. The intended accomplishments are specified as Basin Management Objectives and performance measures. The BMOs spell out what MWA wants to accomplish, and the performance measures provide a tool to compare the relative success of alternative solutions in producing the desired results. Steps 2 through 4 are employed to generate alternative solutions, evaluate those alternatives, and ultimately select the best alternatives to implement.

The first step in this process was articulation of Basin Management Objectives and establishment of performance measures. The BMOs listed here were adopted by the TAC as a representative statement of what should be accomplished through the RWMP Update. The performance measures provide a set of indicators that can be used to help decide how effectively possible alternatives solutions provide the desired outcomes.

Basin Management Objectives

The Fundamental Basin Management Objectives developed with the TAC are presented below. The objectives established for the Mojave Water Agency Regional Water Management Plan (MWA RWMP) through 2020 are to:

Balance future water demands with available supplies recognizing the need to:

- stabilize the groundwater basin storage balance over long-term hydrologic cycles
- protect and restore riparian habitat areas as identified in Exhibit H of the Mojave Basin Area Judgment and the Department of Fish & Game management plan required by Exhibit H
- limit the potential for well dewatering, land subsidence, and migration of poor quality water
- maintain a sustainable water supply through extended drought periods; and
- select projects with the highest likelihood of being implemented.

Maximize the overall beneficial use of water throughout MWA by:

- supplying water in quantity and of quality suitable to the various beneficial uses
- addressing at a minimum Table 7-1 issues throughout the MWA service area recognizing the interconnection and interaction between different areas
- distributing benefits that can be provided by MWA in an equitable and fair manner
- ensuring that costs incurred to meet beneficial uses provide the greatest potential return to beneficiaries of the project(s)
- avoiding redirected impacts; and
- identifying sustainable funding sources including consideration of affordability.

Balancing future water demands with available supplies will increase water supply reliability by preventing continued overdraft of the groundwater. With groundwater storage stabilized, there will be groundwater available during surface water supply shortages and delivery interruptions. With a balanced basin, groundwater elevations will be relatively stable and be kept above historic low. This will reduce the potential for land subsidence and associated aquifer compaction. By limiting migration of poor quality water, available supplies will be of sufficient quality to meet drinking water objectives, thereby increasing long-term water supply reliability.

Performance Measures

For each part of the Basin Management Objectives, performance measures were proposed and discussed at the August TAC workshop. Input from this discussion is included below. The resulting performance measures can be grouped into six broad categories, as follows:

- Storage levels – relating to groundwater accessibility, environmental groundwater elevations, and subsidence potential
- Supply-demand balance – relating to water supply sustainability, mismatch between supply and demand, water supply operations and contingency plans
- Economics – relating to project costs, benefits related to water supply, mitigation requirements, and funding sources
- Water quality – relating to the suitability of water for a particular use, and expected changes in water quality
- Equity – relating to the fair and equitable distribution of benefits and costs
- Implementability – relating to the institutional complexity, potential redirected impacts, and environmental impact of proposed projects

A discussion of the Performance Measures proposed for use for the MWA Regional Water Management Plan Update is presented in Appendix B.

Projects and Management Actions

Phase 1 of the Regional Water Management Plan Update (RWMP Update) provided an array of projects and management actions that can both mitigate groundwater overdraft and meet the water supply needs of the MWA service area for the next two decades. Proposed projects and management actions were tailored to address at least one key water management issue in the basin, as well as help satisfy the Basin Management Objectives.

The purpose of this evaluation is to reasonably estimate specific parameters for **Supply Enhancement Projects** and **Management Actions** identified for the RWMP Update. These parameters were used to develop and evaluate **Alternatives** designed to address the key water management issues summarized above.

The following terms defined below are used throughout this document:

Supply Enhancement Project (Project) - A project providing water supply enhancement through groundwater recharge or an increase in groundwater recharge efficiency.

Management Action - An action improving water quality or environmental habitat. Additionally, an action increasing net water supply by implementing conservation, storage agreements, or water transfers.

Alternative - A combination of projects and/or management actions focused on addressing water management issues.

Methodology

To evaluate the relative impacts and benefits of an alternative, key parameters for the projects and management actions that compose an alternative are necessary. The following is a list of key parameters defined or estimated for each project and most management actions:

1. Project Location - by aquifer unit in the STELLA screening model presented below under the "MWA Screening Model" heading.
2. Recharge Capacity - acre-feet per year
3. Capital Cost - total cost in current (2003) dollars
4. Operation and Maintenance (O&M) Cost – dollars per year
5. Specific Issues - any known issues specific to that project
6. Facilities Required - new and existing facilities needed

The majority of the numbers presented in this document for cost and capacity are derived from a normalized unit cost analysis and should be considered rough estimates of actual design conditions. The costs reported in this document are for nominally-sized facilities and in many cases the projects were resized to match water supply needs in the screening model. The model evaluated multiple sizes and capacities of projects and management actions to spatially optimize recharge in the MWA service area for every alternative.

Normalized Project Cost Methodology

A large number of projects and management actions included in this document have not been studied in detail. Consequently, comparable cost estimates were not available. While further refinement of each potential project and management action is needed, a detailed analysis was beyond the scope of this Plan. To provide a reasonable estimate of capital and operating cost for comparing all projects, a normalized cost table was developed and applied to projects and management actions lacking detailed information.

The normalized cost table was created to provide a unit cost for varying recharge capacities, pipeline diameters, recharge areas, pumping requirements, etc. Unit costs were developed from data provided by MWA composed of contract bids, previous engineering estimates, design documents, and previous reports. Table 9-1 shows an abbreviated version of the normalized cost table with major cost categories shown. These estimates are reflective of relative costs of the various projects based on known parameters. Actual costs may differ once site specific information is developed.

Capital costs were developed based on estimates of pipeline diameters, pipeline lengths, capacity, and various factors specific to a project. In discussions with MWA, the overall project cost is usually 30 percent greater than the construction cost. Therefore, 30 percent was added to the estimated construction cost. This expenditure is associated with project implementation cost and includes geotechnical analysis, right of way, permitting, environmental mitigation, consulting services, and other associated costs.

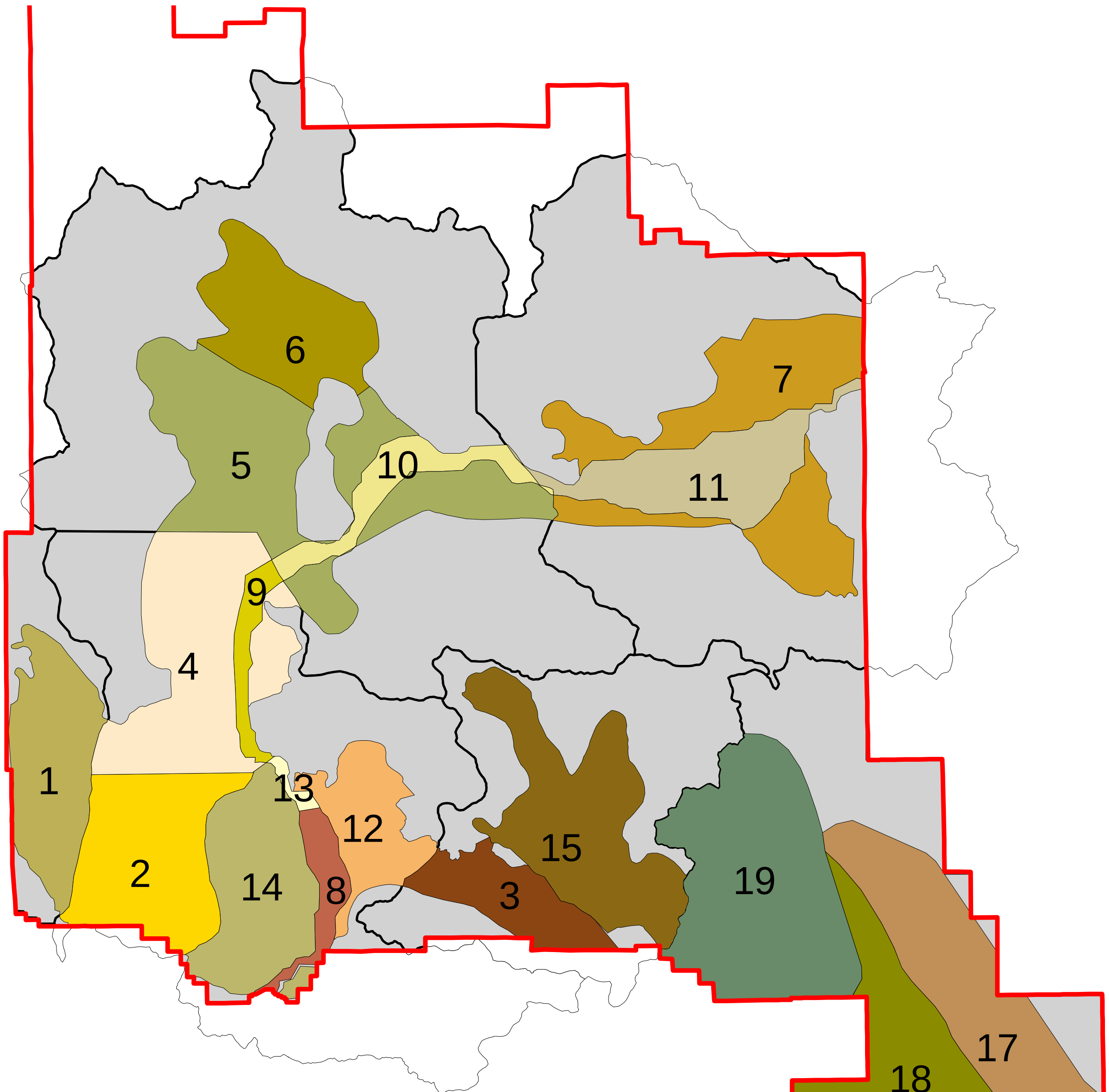
Operating and maintenance costs were developed from energy requirements, standard costs for maintenance of recharge areas and pipeline lengths, SWP water purchases, and various factors specific to a project.

Supply Enhancement Projects and Management Action Groupings

Specific groups of projects and management actions have been developed to facilitate discussions of alternatives and to provide organization. Table 9-2 presents supply enhancement projects and Table 9-3 presents management actions. Both tables list the specific **aquifer unit** each project or management action overlays. To model the water system, the Mojave River Basin floodplain and regional aquifers have been subdivided into 19 distinct but inter-connected aquifer units, as illustrated in Figure 9-1.

Supply enhancement projects are divided between projects that recharge groundwater utilizing State Water Project (SWP) water and projects that utilize other sources of water (Non-SWP). The SWP section is further divided by projects that recharge the floodplain aquifer and those that recharge areas other than the floodplain aquifer. The Non-SWP section is further divided by projects that increase recharge efficiencies within the MWA service area and projects that change a source of groundwater supply.

Management actions are divided into three groups: actions that treat or blend water supplies, actions that improve riparian health, and actions focused on conservation and storage agreements.



1. Oeste Regional
2. Alto West Regional
3. Este Regional
4. Transition Zone Regional
5. Centro Regional
6. Harper Lake Regional
7. Baja Regional
8. Alto Floodplain
9. Transition Zone Floodplain
10. Centro Floodplain
11. Baja Floodplain
12. Alto East Regional
13. Narrows Floodplain
14. Alto Mid Regional
15. Lucerne Basin
16. Warren Valley Subbasin
17. Copper Mountain Valley Subbasin
18. Means/Ames Valley Subbasin
19. Johnson Valley Subbasin

Schlumberger Water Services

Screening Model Aquifer Units

Mojave Water Agency
2004 Regional Water Management Plan

Figure 9-1

Date: February 2004

Prepared By: KTW

Table 9 - 1

Abbreviated Normalized Cost Table

(2003 dollars)

Description	Design Capacity (acre-feet/ year)	Peaking Factor	Operation Frequency	Recharge Pond Cost ($)	Pipeline Length (ft)	Pipeline Cost ($)	Capital Cost Estimate ($)	Annual O&M Estimate ($)	SWP Water Purchase ($)	Cost Summary: Capital Cost with 30% Contingency ($)	Cost Summary: Annual O&M and SWP Cost ($)
Kane Wash/ Newberry Springs Recharge Ponds	6,000	2.0	70%	$660,000	53,400	$3,500,000	$4,200,000	$50,000	$1,200,000	$5,500,000	$1,300,000
El Mirage Dry Lake Recharge Ponds	2,500	2.0	70%	$270,000	21,000	$1,300,000	$1,600,000	$30,000	$500,000	$2,100,000	$500,000
Sheep Creek Recharge Ponds	2,500	2.0	70%	$270,000	10,000	$600,000	$1,000,000	$140,000	$500,000	$1,300,000	$700,000
Oro Grande Recharge Ponds	8,000	2.0	70%	$880,000	0	$0	$1,600,000	$60,000	$1,600,000	$2,100,000	$1,700,000
Cedar Street Detention Basin	3,500	2.0	70%	$1,000,000	0	$0	$1,500,000	$70,000	$700,000	$2,000,000	$800,000
Antelope Valley Wash Recharge Ponds	3,500	2.0	70%	$780,000	0	$0	$1,300,000	$60,000	$700,000	$1,700,000	$800,000
Recharge Facilities South of Apple Valley	1,000	2.0	70%	$110,000	10,000	$600,000	$700,000	$130,000	$200,000	$900,000	$300,000
Lucerne Valley Recharge Ponds	5,000	2.0	70%	$550,000	5,000	$300,000	$900,000	$530,000	$1,000,000	$1,200,000	$1,600,000
Recharge Ponds West of Hellendale Fault	5,000	2.0	70%	$550,000	5,000	$300,000	$900,000	$530,000	$1,000,000	$1,200,000	$1,600,000
Means/Ames Recharge Ponds	2,500	2.0	70%	$270,000	10,000	$600,000	$900,000	$30,000	$500,000	$1,200,000	$500,000
Hi-Desert Water District Recharge Basin #3	6,400	2.0	70%	$700,000	7,500	$500,000	$1,200,000	$60,000	$1,280,000	$1,600,000	$1,300,000
Joshua Basin District Recharge and Pipeline	1,000	2.0	70%	$110,000	10,000	$600,000	$700,000	$30,000	$200,000	$900,000	$200,000
Minneola Recharge Ponds	3,600	2.0	70%	$390,000	22,000	$1,300,000	$1,700,000	$40,000	$720,000	$2,200,000	$800,000
Daggett Recharge Ponds	16,800	2.0	70%	$1,840,000	34,000	$2,700,000	$4,500,000	$110,000	$3,360,000	$5,900,000	$3,500,000
Recharge North of Helendale Fault	5,000	2.0	70%	$550,000	7,500	$500,000	$1,100,000	$50,000	$1,000,000	$1,400,000	$1,100,000
In-Lieu Supply to Silver Lakes	5,000	2.0	70%	$0	7,500	$500,000	$500,000	$20,000	$1,000,000	$700,000	$1,000,000
Mojave River Pipeline Extension - Transition Zone	2,500	2.0	70%	$270,000	26,000	$1,600,000	$1,900,000	$30,000	$500,000	$2,500,000	$500,000
Hesperia Lakes Recharge	3,000	2.0	70%	$330,000	16,000	$1,000,000	$1,300,000	$40,000	$600,000	$1,700,000	$600,000
Recharge Facilities South of Rock Springs Turnout	8,000	2.0	70%	$880,000	21,000	$1,700,000	$2,600,000	$60,000	$1,600,000	$3,400,000	$1,700,000

Table 9-2: Supply Enhancement Project

SWP	
Non-Floodplain Aquifer Recharge (14)	*Aquifer Unit*
Kane Wash Recharge Ponds	Baja Regional
El Mirage Recharge Ponds	Oeste Regional
Sheep Creek Recharge Ponds	Oeste Regional
AVEK	Centro Regional
Oro Grande Wash Recharge Ponds	Alto West Regional
Cedar Street Detention Basin	Alto Mid Regional
Antelope Valley Wash Recharge Ponds	Alto Mid Regional
Recharge Facilities South of Apple Valley	Alto East Regional
Recharge Ponds West of Helendale Fault	Este Regional
Lucerne Valley Recharge Ponds	Lucerne Valley
Means/Ames Valley Recharge Ponds	Means/Ames Valley
Hi-Desert Water District: Warren Valley Recharge	Warren Valley
Hi-Desert Water District Recharge Basin #3	Warren Valley
Joshua Basin District Recharge & Pipeline	Copper Mountain Valley
Floodplain Aquifer Recharge (12)	*Aquifer Unit*
Newberry Springs Recharge Ponds	Baja Floodplain
Minneola Recharge Ponds	Baja Floodplain
Daggett Recharge Ponds	Baja Floodplain
Lenwood Recharge Ponds	Centro Floodplain
Hodge Recharge Ponds	Centro Floodplain
Recharge Ponds North of Helendale Fault	Centro Floodplain
In-Lieu Supply to Silver Lakes	Transition Zone Floodplain
Mojave River Pipeline Extension - Transition Zone	Transition Zone Floodplain
Rock Springs Release	Alto Floodplain
Hesperia Lakes Recharge	Alto Floodplain
Recharge Facilities South of Rock Springs Turnout	Alto Floodplain
Release SWP from Silverwood Lake	Alto Floodplain
Non-SWP	
Increase Recharge Efficiency (5)	*Aquifer Unit*
Baja Storm Flow Retention - 2 locations	Baja Floodplain
Gates for Mojave River Dam	Alto Floodplain
Cushenbury Flood Detention Basin	Lucerne Valley
Injection Wells in Mesa Area of Adelanto	Alto Mid Regional
Injection Wells in Victorville Area	Alto Mid Regional
Change Source of Groundwater Supply (5)	*Aquifer Unit*
SCWC Moving Wells to Serve Barstow	Centro Floodplain
Hinkley Water Supply Augmentation by SCWC	Centro Floodplain
JBWD Wells	Copper Mountain Valley
New Supply for Pioneertown	Means/Ames Valley
Old Woman Springs Ranch Supply	Lucerne Valley

Table 9-3: Management Actions

Water Treatment and Blending (9)	*Aquifer Unit*
Regional Surface Water Treatment Plant	Alto West Regional
Blending local water with treated SWP	Alto Mid Regional
Blending local water with Floodplain Aquifer	Alto Mid Regional
Local Wastewater Treatment Plants (Alto)	Alto Mid Regional
VVWRA Reclamation	Alto Regional
HDWD Nitrate Removal Plant	Warren Valley
Yucca Valley Wastewater Treatment	Warren Valley
Local Wastewater Treatment Plant (Lucerne)	Lucerne Valley
Individual Wellhead Treatment	Entire MWA
Improve Riparian Health (2)	*Aquifer Unit*
Land Purchase to Protect Riparian Habitat	Baja Floodplain
Eradication of Non-native Plant Species	MWA Floodplain
Conservation and Storage Agreements (6)	*Aquifer Unit*
Agricultural Conservation Programs	Entire MWA
Urban Conservation Programs	Entire MWA
Storage agreements with agencies within MWA	Entire MWA
Banking water agreements with outside agencies	Entire MWA
Pre-delivering SWP Water	Entire MWA
Water (entitlement) exchanges	Entire MWA

Supply Enhancement Projects

This section provides a technical summary of specific parameters estimated for supply enhancement projects listed in Table 9 - 2. Supply enhancement projects have the potential to address the following key water management issues as discussed in Chapter 8.

- Demand exceeds supply
- Overdraft of the groundwater basins
- Localized water quality issues
- Subarea interactions

SWP/Non-Floodplain Aquifer Recharge

Kane Wash Recharge Ponds represents a proposed terminal point in the Mojave River Pipeline where water would percolate into ponds adjacent to Kane Wash in the lower Baja Subarea. This recharge facility has been discussed as a possible alternative or addition to the Minneola or Newberry Springs recharge facilities. Currently, the pipeline is constructed to a location northeast of Barstow.

Kane Wash/Newberry Springs Recharge Ponds

Location of Project:	Baja Regional Aquifer
Recharge Capacity:	6,000 acre-feet/year
Recharge Assumptions:	Technical Document No. 2 MWA Steady State Hydraulic Analysis of Mo River Pipeline, July 1999
Capital Cost:	$5,400,000
O&M and SWP Cost:	$1,300,000 per year
Cost Assumptions:	Normalized Cost Table
Specific Issues:	Appropriate location; Recharge potential of site
Facilities Required:	Mojave River Pipeline; New pipeline extension

El Mirage Dry Lake Recharge Ponds could address the significant drop in groundwater levels in this area of the Oeste Subarea. Perched groundwater, return flow from local daries, and other naturally-occuring contaminant are issues, and selecting an appropriate location that would accommodate recharge will require additional technical evaluation.

El Mirage Dry Lake Recharge Ponds

Location of Project:	Oeste Regional Aquifer
Recharge Capacity:	2,500 acre-feet/year
Recharge Assumptions:	Based on capacity for 18” pipe with a design flow rate of 5 cfs and peaking of 2; 70% of design flow assumed on annual basis
Capital Cost:	$2,000,000
O&M and SWP Cost:	$500,000 per year
Cost Assumptions:	Normalized Cost Table
Specific Issues:	Appropriate Location; Perched groundwater conditions
Facilities Required:	California Aqueduct Turnout #1; El Mirage Pipeline

Sheep Creek Recharge Ponds is the preferred project for recharging the regional aquifer in the Oeste Subarea. The 1994 RWMP identified three potential sites for recharge along Sheep Creek. Two of the sites are located south of the California Aqueduct and one is to the north. The site farthest south (upstream) is anticipated to have the greatest beneficial impact to the Phelan area (San Bernardino County Service Area 70L). Due to the relatively low permeability of soils in the region, distributing the recharge over a large area would be beneficial (Stamos et al. 2001).

Sheep Creek Recharge Ponds

Location of Project:	Oeste Regional Aquifer
Recharge Capacity:	2,500 acre-feet/year
Recharge Assumptions:	Based on capacity for 18" pipe with a design flow rate of 5 cfs and peaking factor of 2; 70% of design flow assumed on annual basis
Capital Cost:	$1,300,000
O&M and SWP Cost:	$700,000 per year
Cost Assumptions:	Normalized Cost Table
Specific Issues:	Appropriate Location; Water quality (MTBE)
Facilities Required:	California Aqueduct Turnout #1; El Mirage Pipeline; Pump station

Antelope Valley-East Kern Water Agency (AVEK) has taken an average of 1,372 acre-feet of water from 1991 to the present to supply a powerplant located in the Centro Subarea. It is assumed that this use remains constant through 2020.

Antelope Valley-East Kern Water Agency (AVEK)

Location of Project:	Centro Regional Aquifer
Recharge Capacity:	1,372 acre-feet/year
Recharge Assumptions:	Average water use from 1991 to the present; Table 4-5 RWMP Update
Capital Cost:	Not applicable
O&M and SWP Cost:	$270,000 per year
Cost Assumptions:	$200 acre-foot SWP water cost
Specific Issues:	Not applicable
Facilities Required:	Supply to existing powerplant

Oro Grande Wash Recharge Ponds are advantageous because the site is located upgradient from Baldy Mesa Water District (BMWD) and Victor Valley Water District (VVWD). MWA and USGS, working with VVWD and BMWD, initiated two pilot recharge projects along the Oro Grande Wash. The *Victorville Master Plan of Drainage* identifies the reach of the Wash just upstream of the California Aqueduct as a potential storm water detention basin. The Wash may be able to serve the dual purpose of a storm water detention basin and a recharge facility. VVWD has also recently selected a site further downstream on the Oro Grande Wash near the Green Tree Golf Course as a potential recharge location.

Oro Grande Wash Recharge Ponds	
Location of Project:	Alto Regional Aquifer – West
Recharge Capacity:	8,000 acre-feet/year
Recharge Assumptions:	USGS is currently conducting a pilot project to determine the recharge capacity of the wash; 8,000 acre-feet/year is assumed from USGS Model Run Dated 6/19/2002. MWA has conducted a separate demonstration recharge project approximately two miles upstream of the USGS site. VVWD has also recently selected a site further downstream on the Oro Grande Wash near the Green Tree Golf Course as a potential recharge location.
Capital Cost:	$2,100,000
O&M and SWP Cost:	$1,700,000 per year
Cost Assumptions:	Normalized Cost Table
Specific Issues:	Location relative to California Aqueduct
Facilities Required:	California Aqueduct (new turnout)

Cedar Street Detention Basin may provide the opportunity for recharge upgradient from City of Hesperia wells. The Hesperia Master Plan of Drainage identifies a potential site for a storm water detention basin at the east end of Cedar Street and southwesterly of the California Aqueduct. In addition to storm water detention, the 120-acre site might be able to accommodate groundwater recharge. The California Aqueduct would be the source of recharge water.

Cedar Street Detention Basin	
Location of Project:	Alto Mid Regional
Recharge Capacity:	3,500 acre-feet/year
Recharge Assumptions:	Assumed recharge capacity
Capital Cost:	$2,000,000
O&M and SWP Cost:	$800,000
Cost Assumptions:	Cost Normalization Table
Facilities Required:	California Aqueduct (new turnout)

Antelope Valley Wash Recharge Ponds could provide groundwater recharge upgradient from City of Hesperia wells. The Hesperia Master Plan of Drainage identifies a 65-acre site for a storm water detention basin in the Antelope Valley Wash south of Ranchero Road. In addition to storm water detention, the site might be able to accommodate groundwater recharge. The Morongo Basin Pipeline passes by this area and would be the source of recharge water.

Antelope Valley Wash Recharge Ponds	
Location of Project:	Alto Mid Regional
Recharge Capacity:	3,500 acre-feet/year
Recharge Assumptions:	Assumed recharge capacity
Capital Cost:	$1,700,000
O&M and SWP Cost:	$800,000
Cost Assumptions:	Cost Normalization Table
Facilities Required:	California Aqueduct (new turnout)

Recharge Facilities South of Apple Valley may provide opportunities for limited recharge utilizing the stream channels located south of Apple Valley that are crossed by the Morongo Basin Pipeline. If technically possible, these sites might provide some needed recharge to the Apple Valley area.

Recharge Facilities South of Apple Valley

Location of Project:	Alto Regional Aquifer – East
Recharge Capacity:	1,000 acre-feet/year
Recharge Assumptions:	Assumed recharge capacity; RWMP Update states this site may have the potential for limited recharge
Capital Cost:	$900,000
O&M and SWP Cost:	$300,000 per year
Cost Assumptions:	Normalized Cost Table
Specific Issues:	Recharge potential of site
Facilities Required:	Morongo Basin Pipeline

Lucerne Valley Recharge Ponds (East of Helendale Fault) provides an opportunity for recharge in the Este Subarea. Recharge sites have been contemplated both east and west of the Helendale Fault. The 1994 RWMP recommended constructing a facility east of the fault because the majority of groundwater pumping occurs east of the fault. MWA has purchased the land for a recharge facility, prepared preliminary construction plans, and performed the necessary environmental reviews.

Lucerne Valley Recharge Ponds (East of Helendale Fault)

Location of Project:	Lucerne Valley Subbasin
Recharge Capacity:	5,000 acre-feet/year
Recharge Assumptions:	From RWMP Update – MWA estimate
Capital Cost:	$1,200,000
O&M and SWP Cost:	$1,600,000 per year
Cost Assumptions:	Normalized Cost Table; includes annual O&M cost of $500,000 for using the Morongo Basin Pipeline under a joint-use agreement with MBP participants (estimate RWMP 1994); MWA has purchased land
Facilities Required:	Morongo Basin Pipeline; Potential recharge site purchased

Recharge Ponds West of Helendale Fault were evaluated to compare the relative effects of recharging in Este on each side of Helendale Fault.

Recharge Ponds West of Helendale Fault

Location of Project:	Este Regional Aquifer
Recharge Capacity:	5,000 acre-feet/year
Recharge Assumptions:	From RWMP Update – MWA estimate
Capital Cost:	$1,200,000
O&M and SWP Cost:	$1,600,000 per year
Cost Assumptions:	Normalized Cost Table; includes annual O&M cost of $500,000 for using the Morongo Basin Pipeline under a joint-use agreement with MBP participants (estimate RWMP 1994)
Facilities Required:	Morongo Basin Pipeline

Means/Ames Valley Recharge Ponds would serve Bighorn-Desert View, Hi-Desert, County Service Area 70 W-1, with potential benefit to Pioneertown.[38] Further study will determine benefits to the Joshua Basin Water District. The project consists of a feasibility study, extension of the Morongo Basin Pipeline between one and one and a half miles, recharge to the Pipes Wash, installation of monitoring wells, and installation of production wells.

Means/Ames Valley Recharge Ponds

Location of Project:	Means/Ames Valley Subbasin
Recharge Capacity:	2,500 acre-feet/year
Recharge Assumptions:	Based on capacity for 18" pipe with a design flow rate of 5 cfs and a peaking factor of 2; 70% of design flow assumed on annual basis
Capital Cost:	$1,100,000
O&M and SWP Cost:	$500,000 per year plus possible supplemental pumping cost
Cost Assumptions:	$200 acre-foot SWP cost
Facilities Required:	Morongo Basin Pipeline

Hi-Desert Water District: Warren Valley Recharge has been occurring since 1995. The average amount of SWP water Hi-Desert has utilized from 1995 to 2001 is 3,475 acre-feet/year.

Hi-Desert Water District: Warren Valley Recharge

Location of Project:	Warren Valley Subbasin
Historic Recharge:	3,475 acre-feet/year
Recharge Assumptions:	Average water use from 1995 to the present; Table 4-5 RWMP Update
Capital Cost:	Completed
O&M and SWP Cost:	$720,000 per year
Cost Assumptions:	Normalized Cost Table
Specific Issues:	Nitrate Leaching
Facilities Required:	Morongo Basin Pipeline

Hi-Desert Water District (HDWD) Recharge Basin #3 would extend the existing Morongo Basin Pipeline 7500 feet and provide recharge capability in Hydrogeologic Unit 1 of the HDWD. The project would provide the HDWD the ability to slightly lower the water levels in Hydrogeologic Unit 2 to reduce the impacts of contaminants (nitrate) that leach into the water from the upper zones of the aquifer.

Hi-Desert Water District (HDWD) Recharge Basin #3

Location of Project:	Warren Valley Subbasin
Recharge Capacity:	6,400 acre-feet/year
Recharge Assumptions:	RWMP Update
Capital Cost:	$1,600,000
O&M and SWP Cost:	$1,300,000 per year
Cost Assumptions:	Normalized Cost Table
Specific Issues:	Nitrate Leaching
Facilities Required:	Morongo Basin Pipeline; Pipeline extension

[38] E-mail correspondence with Hi-Desert Water District 1-3-03

Joshua Basin District Recharge & Pipeline would create a mechanism for the Joshua Basin Water District (JBWD) to make use of SWP water via the Morongo Basin Pipeline. The JBWD is a part of Improvement District M and therefore is paying a share of the debt associated with the construction of the Morongo Pipeline facilities. The project would provide needed recharge into the Copper Mountain Valley Subbasin**.**

Joshua Basin District Recharge & Pipeline

Location of Project:	Copper Mountain Valley Subbasin
Recharge Capacity:	1,000 acre-feet/year
Recharge Assumptions:	Assumed recharge capacity
Capital Cost:	$900,000
O&M and SWP Cost:	$200,000 per year plus possible supplemental pumping cost
Cost Assumptions:	Normalized Cost Table
Facilities Required:	Morongo Basin Pipeline; Pipeline extension

SWP/Floodplain Aquifer Recharge

Newberry Springs Recharge Ponds represents a proposed terminal point in the Mojave River Pipeline where water would percolate into ponds central to the lower Baja Subarea. This recharge facility has been discussed as a possible alternative or addition to the Minneola or Kane Wash recharge facilities. Currently, the pipeline is constructed to a location northeast of Barstow.

Newberry Springs Recharge Ponds

Location of Project:	Baja Regional Aquifer
Recharge Capacity:	6,000 acre-feet/year
Recharge Assumptions:	Technical Document No. 2 MWA Steady State Hydraulic Analysis of Mojave River Pipeline, July 1999
Capital Cost:	$5,400,000
O&M and SWP Cost:	$1,300,000 per year
Cost Assumptions:	Normalized Cost Table
Specific Issues:	Appropriate location; Recharge potential of site
Facilities Required:	Mojave River Pipeline; New pipeline extension

Minneola Recharge Ponds represents a potential terminal point in the Mojave River Pipeline supplying recharge to the Baja Floodplain Aquifer. The project would require construction of the Mojave River Pipeline from Daggett to this location.

Minneola Recharge Ponds

Location of Project:	Baja Floodplain Aquifer
Recharge Capacity:	3,600 acre-feet/year
Recharge Assumptions:	Technical Document No. 2 MWA Steady State Hydraulic Analysis of Mojave River Pipeline, July 1999
Capital Cost:	$2,200,000
O&M and SWP Cost:	$800,000 per year
Cost Assumptions:	Normalized Cost Table
Specific Issues:	Recharge potential of site
Facilities Required:	Mojave River Pipeline; Pipeline extension

Daggett Recharge Ponds are a current recharge option. The Mojave River Pipeline is currently being constructed beyond this location in the Baja Floodplain Aquifer.

Daggett Recharge Ponds

Location of Project:	Baja Floodplain Aquifer
Recharge Capacity:	16,800 acre-feet/year
Recharge Assumptions:	Technical Document No. 2 MWA Steady State Hydraulic Analysis of Mojave River Pipeline, July 1999
Capital Cost:	$227,400
O&M and SWP Cost:	$3,500,000 per year
Cost Assumptions:	Actual construction cost for completed facility
Specific Issues:	Facility completed
Facilities Required:	Mojave River Pipeline

Lenwood Recharge Ponds have been used for the delivery of Replacement Water, and for Makeup Water from the Alto Subarea, in compliance with the Judgment.

Lenwood Recharge Ponds

Location of Project:	Centro Floodplain Aquifer
Recharge Capacity:	9,000 acre-feet/year
Recharge Assumptions:	Technical Document No. 2 MWA Steady State Hydraulic Analysis of Mojave River Pipeline, July 1999
Capital Cost:	Completed
O&M and SWP Cost:	$1,900,000 per year
Cost Assumptions:	$200 acre-foot SWP water
Facilities Required:	Mojave River Pipeline

Hodge Recharge Ponds have been used for the delivery of Replacement Water, and for Makeup Water from the Alto Subarea, in compliance with the Judgment.

Hodge Recharge Ponds

Location of Project:	Centro Floodplain Aquifer
Recharge Capacity:	9,000 acre-feet/year
Recharge Assumptions:	Technical Document No. 2 MWA Steady State Hydraulic Analysis of Mojave River Pipeline, July 1999
Capital Cost:	Completed
O&M and SWP Cost:	$1,900,000 per year
Cost Assumptions:	$200 acre-foot SWP water
Specific Issues:	
Facilities Required:	Mojave River Pipeline

Recharge North of Helendale Fault was suggested as a potential project. To date, this project has not been modeled because the Centro Floodplain Aquifer is relatively balanced and existing recharge facilities (Hodge and Lenwood) are already operating.

Recharge North of Helendale Fault

Location of Project:	Centro Floodplain Aquifer
Recharge Capacity:	5,000 acre-feet/year
Recharge Assumptions:	Based on capacity for 24" pipe with a design flow rate of 10 cfs and a peaking factor of 2; 70% of design flow assumed on annual basis
Capital Cost:	$1,400,000
O&M and SWP Cost:	$1,100,000 per year
Cost Assumptions:	Normalized Cost Table
Facilities Required:	Mojave River Pipeline

In-Lieu Supply to Silver Lakes would augment current groundwater pumping with SWP supply to fill recreational lakes to be used in-lieu of the production of some or all of Silver Lakes' Base Annual Production (BAP), thereby leaving that amount of groundwater in storage. The proposal would swap up to 4,987 acre-feet of BAP for SWP supply. BAP currently allows extraction of 0.70 acre-feet for each acre-foot of BAP. Additional SWP supply would be stored in the existing Silver Lakes until released to percolate in the natural channel of Fremont Wash in the Transition Zone Floodplain Aquifer. This project would exist almost entirely on the private property of a willing participant, which may expedite implementation and minimize constraints and costs. Project would provide water in a location suitable for maintaining the TZ "water bridge", and could be compatible with plans for the reuse of treated water from County Service Area 70B.

In-Lieu Supply to Silver Lakes

Location of Project:	Transition Zone Floodplain Aquifer
Recharge Capacity:	5,000 acre-feet/year
Recharge Assumptions:	Correspondence with Silver Lakes Association
Capital Cost:	$700,000
O&M and SWP Cost:	$1,100,000 per year
Cost Assumptions:	Normalized Cost Table
Facilities Required:	Mojave River Pipeline

Mojave River Pipeline Extension - Transition Zone Recharge has the potential to benefit the riparian habitat in the Transition Zone as well as enhance the groundwater production reliability. Water for this recharge operation would be conveyed to the recharge site(s) in a new pipeline that would be an extension of the existing Mojave River Pipeline.

Mojave River Pipeline Extension - Transition Zone Recharge

Location of Project:	Transition Zone Floodplain Aquifer
Recharge Capacity:	2,500 acre-feet/year
Recharge Assumptions:	Based on capacity for 18" pipe with a design flow rate of 5 cfs and a peaking factor of 2; 70% of design flow assumed on annual basis
Capital Cost:	$2,500,000
O&M and SWP Cost:	$500,000 per year
Cost Assumptions:	Normalized Cost Table
Facilities Required:	Mojave River Pipeline

Rock Springs Release can discharge large volumes of SWP water from the Rock Springs Outlet to percolate into the Floodplain Aquifer. The construction of extraction wells and transmission pipelines would allow this stored water to be used where needed throughout MWA. Transmission facilities could be constructed to deliver the water to the City of Hesperia, Baldy Mesa WD, Victor Valley WD, and the Centro and Baja subbasins via the Mojave River Pipeline. The water could be used directly, blended with local waters to meet quality objectives, or recharged into local groundwater basins for future use.

Rock Springs Release	
Location of Project:	Alto Floodplain Aquifer
Recharge Capacity:	40,000 acre-feet/year
Recharge Assumptions:	MWA – capacity of Rock Springs Outlet
Capital Cost:	None assumed
O&M and SWP Cost:	$8,100,000
Cost Assumptions:	Cost Normalization Table; Current modeling effort does not include a distribution system downstream of the Rocks Spring Outlet (no capital cost)
Specific Issues:	Affecting ability to recharge with flood flows
Facilities Required:	Rock Springs Outlet

Hesperia Lakes Recharge would provide recharge south of the MWA's Rock Springs Turnout. The City of Hesperia operates fishing lakes at its park complex adjacent to Lake Arrowhead Road. Recharge of SWP water in the Mojave River channel near the site has been suggested as a possible project.

Hesperia Lakes Recharge	
Location of Project:	Alto Floodplain Aquifer
Recharge Capacity:	3,000 acre-feet/year
Recharge Assumptions:	USGS Model Run Dated 6/19/2002
Capital Cost:	$1,700,000
O&M and SWP Cost:	$600,000 per year
Cost Assumptions:	Normalized Cost Table
Specific Issues:	Morongo Basin Pipeline; Pipeline extension
Facilities Required:	Rock Springs Outlet; Wellfield; Distribution System

Recharge Facilities South of Rock Springs Turnout is similar in concept and location to the Hesperia Lakes Recharge. In order to maximize the use of the available storage in the Floodplain Aquifer, a pipeline would be constructed from the Morongo Basin Pipeline to a turnout located as far south (upstream) in the river channel as possible. The hydraulic pressure head available in the Morongo Basin Pipeline, approximately 400 feet, would limit the length of the pipeline to about four miles.

Recharge Facilities South of Rock Springs Turnout

Location of Project:	Alto Floodplain Aquifer
Recharge Capacity:	8,000 acre-feet/year
Recharge Assumptions:	Based on capacity for 30" pipe with a design flow rate of 15 cfs and peaking factor of 2; 70% of design flow assumed on annual basis
Capital Cost:	$3,400,000
O&M and SWP Cost:	$1,700,000 per year
Cost Assumptions:	Normalized Cost Table
Facilities Required:	Morongo Basin Pipeline; Pipeline extension; temporary levees in Mojave River Channel

Release SWP water from Silverwood Lake can introduce SWP water to areas upstream of the Rock Springs Outlet through Cedar Springs Dam. This alternative would require evaluation of the potential for impacts to/from land uses at the Los Flores ranch and the institutional arrangements necessary with the Department of Water Resources under their contract with the MWA. Large flows to the Mojave River can be accomplished through Cedar Springs Dam, which has a maximum discharge of 5,000 cfs.[39]

Release SWP water from Silverwood Lake

Location of Project:	Alto Floodplain Aquifer
Recharge Capacity:	25,000 acre-feet/year
Recharge Assumptions:	Max annual release (1983) from Table 4-5 of RWMP Update
Capital Cost:	None assumed
O&M and SWP Cost:	$5,200,000 per year
Cost Assumptions:	RWMP 1994 states there is a $9.25 per acre-foot SWP cost of using the California Aqueduct from MWA Turnout #3 to Silverwood Lake
Specific Issues:	Land use impacts (Los Flores Ranch); DWR operations; Affecting ability to recharge with flood flows; Federally-designated endanged Arroyo Toad
Facilities Required:	Cedar Springs Dam; temporary levees in Mojave River Channel

Baja Storm Flow Non-SWP\Increase Recharge Efficiency

Retention would construct seasonal (temporary) sand dams, dikes, or other facilities in the Mojave River channel that could enhance the natural recharge of the Floodplain Aquifer. Stakeholders have suggested that there are two or more locations in the vicinity of Daggett and Minneola that should be evaluated.

[39] Water Resources Analysis of the Upper Mojave River Basin - Alto Subarea, Todd 1993

Baja Storm Flow Retention

Location of Project:	Baja Floodplain Aquifer
Recharge Capacity:	2,000 acre-feet/year
Recharge Assumptions:	Assuming capture of 25% of average annual flow at Afton; average flow is heavily weighted by very large infrequent flow, which may quickly erode earthen detention barriers
Capital Cost:	None assumed
O&M Cost:	$130,000 per year
Cost Assumptions:	RWMP 1994
Specific Issues:	Environmental review; Streambed alteration agreement and 401/404 permits; Mojave Basin Area Judgment
Facilities Required:	None assumed

Gates for Mojave River Dam was studied in 1986 by the U.S. Army Corps of Engineers (USACE) to evaluate the feasibility of installing gates at the Mojave River (Forks) Dam to store up to approximately 62,700 acre-feet of storm water behind the dam for controlled release. USACE found that the modifications were technically and economically feasible at the time. However, they also noted that there was potential for adverse impacts to Federal listed endangered species downstream, and that significant opposition was expressed by several environmental organizations. Due to these concerns and because the County of San Bernardino and the Mojave Water Agency did not support the plan due to the cost of the project, USACE recommended that no action be taken to modify the Dam. The project is also inconsistent with current prohibitions in the Mojave Basin Area Judgement against interference with stormflows.

Gates for Mojave River Dam

Location of Project:	Alto Floodplain Aquifer
Recharge Capacity:	3,760 acre-feet/year
Recharge Assumptions:	USACE 1986
Capital Cost:	$9,000,000 – $30,000,000
O&M Cost:	$500,000 per year
Cost Assumptions:	USACE 1986
Specific Issues:	Environmental opposition; Endangered species; High cost; Adjudication restrictions
Facilities Required:	Mojave River Dam

Cushenbury Flood Detention Basin is proposed to capture runoff from the San Bernardino Mountains in the Lucerne Valley Subbasin. Currently, large storm flows drain to dry lake beds in the area that have low percolation rates. Consequently, the majority of water that drains to the lake beds is lost to evaporation and never enters the basin. The project would divert storm flows to detention basins with high rates of percolation to decrease losses from evaporation.

Cushenbury Flood Detention Basin	
Location of Project:	Lucerne Valley Subbasin
Recharge Capacity:	400 acre-feet/year
Recharge Assumptions:	Assumed capacity from discussion with MWA staff
Capital Cost:	$200,000
O&M Cost:	$80,000 per year
Cost Assumptions:	Normalized Cost Table
Specific Issues:	Environmental review; potential dust from dry lakes; potential Adjudication restrictions
Facilities Required:	Stormflow Diversion and Detention Basin

Injection Wells in the Mesa Area of Adelanto are proposed because the geology in the Mesa area is not conducive to surface recharge facilities. The technical and financial feasibility of using injection wells to recharge the aquifer in this location needs to be investigated.

Injection Wells in the Mesa Area of Adelanto	
Location of Project:	Alto Regional Aquifer – West
Recharge Capacity:	1,000 acre-feet/year
Recharge Assumptions:	USGS Model Run Dated 6/19/2002
Capital Cost:	$500,000
O&M and SWP Cost:	$350,000 per year
Cost Assumptions:	Initial assumption of one injection well; technical feasibility of project needs better quantification to determine financial aspects of operation
Specific Issues:	New wells
Facilities Required:	Injection Well, Distribution System

Injection Wells in the Victorville Area is under consideration by Victor Valley WD to inject treated SWP water in their wells to recharge the aquifer. This blending of SWP water with native groundwater is intended to lower some native constituent levels such as arsenic.

Injection Wells in the Victorville Area	
Location of Project:	Alto Regional Aquifer – West
Recharge Capacity:	1,000 acre-feet/year
Recharge Assumptions:	USGS Model Run Dated 6/19/2002
Capital Cost:	$500,000
O&M Cost:	$350,000 per year
Cost Assumptions:	Initial assumption of one injection well; technical feasibility of project needs better quantification to determine financial aspects of operation
Specific Issues:	New wells
Facilities Required:	Injection Well, Distribution System

Non-SWP\Change Source of Groundwater Supply

Southern California Water Company Moving Wells to Serve Barstow will improve the quality of the water it delivers to the City of Barstow. More such alternative supplies are planned. The new wells will be located up-river from the city and down-river from the Lenwood Recharge Facility.

Southern California Water Company Moving Wells to Serve Barstow

Location of Project:	Centro Floodplain Aquifer
Capacity:	Not applicable
Assumptions:	SCWC Project
Capital Cost:	Not applicable
O&M Cost:	Not applicable
Cost Assumptions:	SCWC Project
Facilities Required:	SCWC Wells

Hinkley Water Supply Augmentation by Southern California Water Company: Hinkley is overdrafted locally, and the school well has recently gone dry. SCWC already serves most of Barstow, Lenwood, and much of the surrounding area in Centro. MWA has been studying the area, and has budgeted funds for further analysis.

Hinkley Water Supply Augmentation by Southern California Water Company

Location of Project:	Centro Floodplain Aquifer to Regional Aquifer
Capacity:	To be determined
Assumptions:	To be determined
Capital Cost:	To be determined
O&M Cost:	To be determined
Cost Assumptions:	To be determined
Specific Issues:	To be determined
Facilities Required:	New wells; Distribution System

Joshua Basin Water District Wells will move some of the JBWD groundwater production to the Copper Mountain Valley Subbasin. Pumping from new wells in the underutilized Copper Mountain Valley Subbasin will allow the District to reduce pumping in the Joshua Tree Subbasin to the recognized safe yield.

Joshua Basin Water District Wells

Location of Project:	Copper Mountain Valley Subbasin
Capacity:	Not applicable
Assumptions:	JBWD Project
Capital Cost:	Not applicable
O&M Cost:	Not applicable
Cost Assumptions:	JBWD Project
Facilities Required:	*New wells; Distribution system*

New Supply for Pioneertown to replace the San Bernardino County Service Area W-4's water supply that does not meet health standards for several constituents including arsenic, uranium, iron, and manganese. One possible way for the community to receive water of acceptable quality would be for CSA W-4 to obtain its water from either HDWD or BDVWA.

New Supply for Pioneertown

Location of Project:	Means/Ames Valley Subbasin
Capacity:	To be determined
Assumptions:	To be determined
Capital Cost:	To be determined
O&M Cost:	To be determined
Cost Assumptions:	Unknown
Specific Issues:	Source of supply; identification of servicing entity
Facilities Required:	Distribution System

Old Woman Springs Ranch Supply is being evaluated by MWA as a potential source of water. MWA is discussing the purchase of Old Woman Springs Ranch in Johnson Valley for rights to its water basin for future groundwater production.

Old Woman Springs Ranch Supply

Location of Project:	Johnson Valley
Recharge Capacity:	To be determined
Recharge Assumptions:	To be determined
Capital Cost:	To be determined
O&M Cost:	To be determined
Cost Assumptions:	To be determined
Specific Issues:	To be determined
Facilities Required:	New wells; distribution System; possible wellhead treatment

Management Actions

This section provides a technical summary of specific parameters estimated for management actions listed in Table 9-3. Management actions have the potential to address the following key water management issues:

- demand exceeds supply
- riparian ecosystem maintenance issues
- localized water quality issues
- overdraft of the groundwater basins
- wastewater infrastructure issues

Water Treatment and Blending

Regional Surface Water Treatment Plant options were studied by Parsons, 2001. The proposed project would treat SWP water from the California Aqueduct for delivery to four agencies in Alto, which include Baldy Mesa Water District, Victor Valley Water District, Adelanto Water Authority and San Bernardino County Special Districts. The delivery would be considered an in-lieu groundwater recharge project by curtailing groundwater production in the Alto Basin.

Regional Surface Water Treatment Plant	
Location of Project:	Alto Regional Aquifer - West
Treatment Capacity:	up to 56,000 acre-feet/year
Treatment Assumptions:	Assumes recommended alternative (50 MGD Treatment Plant) constructed as stated in Alternatives for Water Supply from the California Aqueduct (Parsons 2001)
Capital Cost:	$107,000,000 (proportional cost assumed for smaller plants)
O&M Cost:	$3,300,000 per year
Cost Assumptions:	Data from recommended alternative (Parsons 2001), does not include injection or Silverwood options
Specific Issues:	High cost; would require internal SWP allocation
Facilities Required:	California Aqueduct (new turnout); Treatment plant

Blending Local Water with Treated SWP Water may be able to address some of the water quality concerns of Baldy Mesa WD, Victor Valley WD, and others.

Blending Local Water with Treated SWP Water	
Location of Project:	Alto Regional Aquifer - West
Capacity:	To be determined
Assumptions:	To be determined
Capital Cost:	To be determined
O&M Cost:	To be determined
Cost Assumptions:	To be determined
Specific Issues:	To be determined
Facilities Required:	Surface water treatment plant; Pipeline infrastructure

Blending Local Water with Floodplain Aquifer Water may be able to address some of the water quality and quantity concerns of Baldy Mesa WD, Victor Valley WD, and others.

Blending Local Water with Floodplain Aquifer Water	
Location of Project:	Alto Regional Aquifer - West
Capacity:	To be determined
Assumptions:	To be determined
Capital Cost:	To be determined
O&M Cost:	To be determined
Cost Assumptions:	To be determined
Specific Issues:	To be determined
Facilities Required:	Pipeline infrastructure

Local Wastewater Treatment Plant (Alto) is being considered for several communities in the Alto Subarea. This sub-regional treatment plant concept is an alternative to the large-scale expansion of the VVWRA treatment plant. VVWRA is encouraging this concept for several reasons: (1) several large diameter pipelines are reaching their expected service lives and will need to be replaced soon, (2) flow volumes will soon exceed the capacity of several existing pipelines, and (3) local treatment of the liquid portion of the wastewater flow would be cost-effective as long as VVWRA is allowed to sell the recycled water to the local purveyors.

Local Wastewater Treatment Plant (Alto)

Location of Project:	Alto Regional Aquifer
Treatment Capacity:	1,100 acre-feet/year (up to 11,000 acre-feet per year may be required)
Treatment Assumptions:	Based on plant capacity of 1.0 MGD (up to 10 MGD may be required)
Capital Cost:	$13,000,000
O&M Cost:	$1,000,000 per year
Cost Assumptions:	VVWRA Sewerage Facilities Update Year 2000 Amendment
Specific Issues:	Several locations proposed
Facilities Required:	Current sewer infrastructure; New treatment plants; Distribution system

VVWRA Reclamation will likely remain in the Alto Subarea as a supply to urban, recreational, and agricultural interests. Approximately 9.8 MGD is treated at the VVWRA regional treatment facility, which has a capacity of 11.0 MGD. The reclaimed water is then discharged directly into the Mojave River channel or percolated into the Mojave River Floodplain Aquifer. VVWRA and the Department of Fish and Game entered into a Memorandum of Understanding to provide discharge of approximately 9,000 acre-feet per year (24.7 acre-feet per day) to the Mojave River Channel to support riparian vegetation and habitat. VVWRA estimates that its capacity to collect and treat wastewater with the existing facilities will be surpassed by wastewater production in approximately 2006.[40] VVWRA estimates that the wastewater flow by 2020 will be approximately 18.62 MGD. This expansion of the current treatment plant is an alternative to the current plan for dealing with wastewater treatment requirements by constructing two sub-regional recycled water facilities by the year 2005, and another two by 2010. These facilities will provide additional wastewater treatment and at the same time, produce recycled water for the surrounding communities. Without the sub-regional treatment facilities, VVWRA will need to expand its collection system and treatment facilities to handle up to 20 MGD.

VVWRA Reclamation

Location of Project:	Alto/Transition Zone Regional Aquifer
Treatment Capacity:	10,000 acre-feet/year
Treatment Assumptions:	VVWRA Sewerage Facilities Update 2000 estimates an increase in wastewater flows of 10 MGD from 2000 to 2020
Capital Cost:	$28,000,000
O&M Cost:	$4,000,000 per year
Cost Assumptions:	VVWRA Sewerage Facilities Update 2000 – 20 MGD expansion estimate without subregional facilities
Specific Issues:	Non-degradation of groundwater quality; increases consumptive use which affects rampdown under the Mojave Basin Area Judgment
Facilities Required:	VVWRA Expansion

[40] Sewerage Facilities Plan Update, Year 2000 Amendment, Adopted by the VVWRA Board of Commissioners October 26, 2000.

Hi-Desert Water District Nitrate Removal Plant was recently constructed to improve the quality of the groundwater HDWD serves.

Hi-Desert Water District Nitrate Removal Plant

Location of Project:	Means/Ames Valley Subbasin
Treatment Capacity:	1,000 acre-feet/year
Treatment Assumptions:	HDWD states the plant allows for two wells to be put back in service, assuming each well produces 300 gpm (rough district average) then the total is approximately 1,000 acre-feet/year
Capital Cost:	Completed
O&M Cost:	
Cost Assumptions:	HDWD has recently constructed the plant
Facilities Required:	HDWD has recently constructed the plant

Local Wastewater Treatment Plant (Lucerne) Wastewater treatment in the region is currently provided by individual septic tank systems. It is likely that at some point in the future, a municipal wastewater treatment facility will have to be built.

Local Wastewater Treatment Plant (Lucerne)

Location of Project:	Lucerne Subbasin
Treatment Capacity:	1,100 acre-feet/year
Treatment Assumptions:	Based on plant capacity of 1.0 MGD
Capital Cost:	$13,000,000
O&M Cost:	$1,000,000 per year
Cost Assumptions:	Cost factors from VVWRA Sewerage Facilities Update Year 2000 Amendment
Facilities Required:	Current sewer infrastructure; New treatment plants; Distribution system

Local Wastewater Treatment Plant (Yucca Valley) Presently, Yucca Valley uses septic systems to process waste. The need for a local wastewater treatment facility is mainly due to the growing number of wells testing high in nitrate, which to some degree can be attributed to septic tanks. Hi-Desert Water District has been discussing the necessity of a wastewater treatment facility with a 20-year time frame for construction of a facility.[41]

Local Wastewater Treatment Plant (Yucca Valley)

Location of Project:	Means/Ames Valley Subbasin
Treatment Capacity:	1,100 acre-feet/year
Treatment Assumptions:	Based on plant capacity of 1.0 MGD
Capital Cost:	$13,000,000
O&M Cost:	$1,000,000 per year
Cost Assumptions:	Cost factors from VVWRA Sewerage Facilities Update Year 2000 Amendment
Facilities Required:	Current sewer infrastructure; New treatment plants; Distribution system

[41] Hi-Desert Water District website, 2003

Individual Wellhead Treatment is an option to address localized water quality issues and has been considered to treat elevated levels of arsenic and nitrate.

Individual Wellhead Treatment

Location of Project:	MWA
Treatment Capacity:	800 acre-feet/year
Treatment Assumptions:	Based on one well pumping continuously at 500 gallons per minute
Capital Cost:	$600,000
O&M Cost:	$40,000 per year
Cost Assumptions:	Estimates based on installation and operation costs of a standard Granular Activated Carbon system
Facilities Required:	Individual treatment devices

Improve Riparian Health

Land Purchase to Protect Riparian Habitat could possibly benefit the remaining riparian habitat in the Camp Cady area through a land purchase program. The general concept of the project is to reduce local pumping near the Mojave River in the Camp Cady area, allowing groundwater levels to increase due to the elimination of local cones of depression (drawdown) from local wells.

Land Purchase to Protect Riparian Habitat

Location of Project:	Baja Floodplain Aquifer
Conservation:	1,200 acre-feet/year
Conservation Assumptions:	Estimate of production of wells in 1997 that are in the vicinity of land purchase
Capital Cost:	$2,000,000
O&M Cost:	None assumed
Cost Assumptions:	Assumes purchase of 400 acres of land at $5,000/acre
Specific Issues:	Benefit from changing location of pumping needs further study
Facilities Required:	None assumed

Eradication of Non-Native Riparian Species in the Mojave River channel has been identified as a way to enhance the health of riparian habitat. Many of the non-native plants consume significant amounts of water. MWA is currently funding part of a cooperative effort to eradicate non-native species spearheaded by the Mojave Desert Resource Conservation District.

Eradication of Non-Native Riparian Species

Location of Project:	MWA Floodplain Aquifer
Conservation:	2,500 acre-feet/year
Conservation Assumptions:	Assumes all non-native species are eradicated and replaced with the same density of native species; consumption values and aerial densities from: Riparian Vegetation and its Water use During 1995 Along the Mojave River (USGS)
Capital Cost:	None Assumed
O&M Cost:	$730,000 per year
Cost Assumptions:	Based on the Pecos River Project in New Mexico; $182 dollars per/acre to remove salt cedars; assumes 4,000 acres in MWA
Specific Issues:	Feasibility of successfully eradicating non-native species; UC Davis studies have shown salt cedar is extremely resilient
Facilities Required:	None Assumed

Conservation and Storage Agreements

Agricultural Conservation Programs including educational programs and monetary support to implement Agricultural Efficient Water Management Practices, as identified by the Agricultural Water Management Council.

Urban Conservation Programs including educational programs and monetary support to implement Best Management Practices, as identified by the California Urban Water Conservation Council.

Storage Agreements with Agencies within MWA: Parties to the Judgment (including the MWA) can enter into storage agreements with the Mojave Basin Area Watermaster. The rules under which these types of agreements are possible are contained in the Rules and Regulations of the Mojave Basin Area Watermaster. These types of agreements provide parties to the Judgment the opportunity to store water for their future use or to meet future obligations under the Judgment.

Banking water agreements with outside agencies can provide benefits by cooperatively using available storage space in aquifers within the MWA service area. Groundwater banking typically involves importing surface water provided by a project partner (or partners) and storing the surface water in the groundwater basins underlying MWA. Typically, the partner banks their water during times of surplus for a right to take a portion of their water during a time of need. The potential benefits to MWA and area stakeholders from groundwater banking could be significant, including financial assistance to construct capital facilities, reduced pumping lifts and water supply for mitigation of overdraft conditions.

Currently, MWA and Metropolitan Water District of Southern California (MWD) are participating in a pilot study to bank MWD entitlement water from the California Aqueduct in the Mojave Water Agency during wet years in exchange for MWA entitlement during dry years. If this proves successful, the MWD and MWA might enter into longer-term agreements to bank water. Many details would need to be worked out by both agencies including the method to return water to MWD, infrastructure, accounting, and mitigation or avoidance of any negative affects.

Pre-delivering SWP water could be accomplished if MWA banks SWP water in subareas for future purchase and use by local pumpers. This would in essence be pre-delivering water to local pumpers for their use when needed.

Water (entitlement) exchanges are currently in place with the Solano County Water Agency (SCWA), another SWP contractor. Similar agreements could be pursued. The SCWA agreement allows MWA to receive entitlement deliveries from SCWA during hydrologic periods when SCWA has approved entitlement in excess of their needs. MWA will subsequently allow SCWA to utilize some of their approved entitlement during periods of drought, but not more than half of the quantity of SCWA entitlement that has previously been delivered to MWA.

The MWA Screening Model

The projects and management actions were grouped into alternatives that were evaluated to determine how well they mitigated the key management issues identified above. This evaluation was performed using a simulation model developed for this Plan. Using the results of the evaluation, two recommended alternatives have been selected and the projects and management actions included in those alternatives that have the highest priority for implementation have been identified.

The MWA Screening Model simulates the changes to groundwater hydrology, Mojave River flows, and pumping and return flow patterns that would result from implementation of the projects and management actions identified in the Phase 1 Report. The model was developed using the Stella 7.0 software, a simulation modeling package that allows model parameters to be changed and new results obtained quickly and easily.

To model the water system, the Mojave River Basin floodplain and regional aquifers have been subdivided into 14 distinct but inter-connected aquifer units. The Lucerne Valley, Copper Mountain Valley, Means/Ames Valley, and Warren Valley aquifers are modeled independently. The modeled aquifer units are shown in Figure 9 - 1. The model simulates groundwater storage and levels within each aquifer unit, groundwater flow between aquifer units, and leakance from the Mojave River into the aquifer units for the hydrologic period 1931-2001 using equations derived from the output of the USGS Modflow model of the Mojave River Basin.[42]

For each alternative, pumping and return flow quantities are determined for each sector within each subarea based on the amount of State Water Project (SWP) import and the Mojave Basin Area Judgment rules. These quantities are disaggregated among the subarea's aquifer units based on current pumping patterns and year 2020 population projections. The computed consumptive use is subtracted from the storage within each aquifer. MWA's SWP supplies are distributed to the alternative's SWP projects according to an algorithm that takes into account each project's demand and capacity and the capacities of the Mojave River and Morongo Pipelines. The model imposes projected 2020 demands on the historical hydrologic sequence. The model thus assumes that historical hydrology is a reasonable estimate of future hydrologic conditions.

[42] Stamos et al. 2001

The model is flexible enough to simulate a wide variety of proposed projects and management actions. For each new alternative, the input data can be modified and the model run in an hour or less, allowing for the easy evaluation of new alternatives.

Alternatives Overview

A total of 18 alternatives were evaluated in the course of this study. These include eight initial alternatives presented at the Technical Advisory Committee (TAC) meeting on February 19, 2003, eight revised alternatives presented at the TAC meeting on March 19, 2003, and two final alternatives developed based on the recommendations made at the March 19 meeting. The initial alternatives are labeled 'A' and 'B', and the revised and final alternatives are labeled 'C' and 'D.' The alternatives are further described below.

The following assumptions were common to each of these alternatives:

- 2020 demand assumptions from the Phase 1 report
- Implementation of the Mojave Basin Area Judgment (1996)
- Delivery of SWP water to the Antelope Valley-East Kern Water Agency (AVEK), to the Warren Valley subbasin for use by the Hi-Desert Water District (HDWD), and to the Hodge and Lenwood recharge ponds to meet Alto makeup obligations to Centro under the Judgment

The following seven additional primary factors can be used to distinguish between the alternatives:

- Representation of the Transition Zone
- Level of Judgment Implementation
- Agricultural demand (Scenario 1 or Scenario 2 from the Phase 1 Report)
- Amount of municipal conservation
- Presence and size of a regional water treatment plant in Alto
- Amount of Victor Valley Water Reclamation Authority (VVWRA) discharge that is used for reclamation
- Amount of SWP discharge into the Mojave River at Rock Springs

The 'A' and 'C' alternatives assume Agricultural Scenario 1 while the 'B' and 'D' Alternatives assume Agricultural Scenario 2. Alternatives A0, B0, C0, and D0 are year 2020 No Action alternatives, in which the only SWP imports are those that go to AVEK, HDWD, or to the Hodge and Lenwood recharge ponds for Alto Makeup to Centro.

Initial Alternatives

The initial alternatives include A0, A1, A2, B0, B1, B2, B3, and B4. Table 9 - 4 shows the principal characteristics that define each alternative. All of these alternatives assume full implementation of the Judgment by 2020, with consumptive use set to equal natural supply plus imports.

Alternatives A0 and B0 are No Action alternatives, which do not utilize any projects or management actions other than those in current use. Alternatives A1 and B1 attempt to meet each subarea's demands with SWP imports, including a large Rock Springs release. Alternatives A2 and B2 include a 56,000 AF/year capacity treatment plant in Alto. Alternatives B3 and B4 are similar to Alternative B1 except that they include 5% municipal conservation as well. All of the alternatives other than B4 assume that the first 9,700 acre-feet of VVWRA's discharge is released to the Mojave River, with the remaining being allocated to reclamation to golf course and municipal users. In Alternative B4 it is assumed that all VVWRA discharge is released to the Mojave River.

Table 9 - 4 shows the demands met under each alternative. Alternative A0 meets only 45% and Alternative B0 meets only 51% of the total MWA demand. In each of these No Action Alternatives, the Alto Baja, and Oeste subareas have less than 40% of their demands met.

Table 9-4: Initial Alternative Assumptions and Results

Alternative:	A			B				
	A0	A1	A2	B0	B1	B2	B3	B4
Common	AVEK, Hodge, Lenwood, Warren Valley							
Judgement Implementation	Full			Full				
Ag demand scenario	Ag Scenario 1			Ag Scenario 2				
Municipal Conservation	0%						5%	
Regional WTP			56K			56K		
Alto Reclamation		5.7K	11.0K		9.3K	11.0K	9.3K	
Rock Springs release		40K			40K		40K	40K
Demands Met (KAF/yr)								
Total	113	207	209	110	206	202	205	204
Percent Total	45%	82%	83%	51%	95%	93%	96%	98%
Agricultural	33	52	38	20	20	20	20	20
Municipal	68	129	154	70	153	162	152	152

Because they are trying to meet full municipal and agricultural demands under Agricultural Scenario 1, Alternatives A1 and A2 show significant shortages. Alternative A1 meets only 82% of total MWA demand, while Alternative A2 meets only 83%. Thus, these results indicate that it is impossible to meet full 2020 demands under Agricultural Scenario 1 with no conservation even while importing MWA's entire SWP supply. Conservation of almost 30 percent of municipal consumptive use would be required to avoid significant shortages under this scenario.

Alternatives B1, B2, B3, and B4 all meet at least 93% of total MWA demands. However, because SWP deliveries to the treatment plant in Alto are given priority, Alternative B2 has significant shortages in Baja, Oeste, and Este. Alternatives B3 and B4 have fewer shortages because they assume 5% municipal conservation.

The initial alternatives are formulated to balance supply and demand at the subarea level, but no attempt was made to select recharge projects that would balance each individual aquifer unit. As a result, although each subarea is in balance as a whole, many aquifer units show significant declines. In addition, the Transition Zone floodplain region shows unreasonable increases in elevation because no cap was placed on its available storage in the initial alternatives. This limitation in aquifer unit elevation has been resolved in the revised and final alternatives.

Revised and Final Alternatives

In response to the comments received at the February 19, 2003 TAC meeting, eight new alternatives were developed and presented at the March 19 TAC meeting: C0, C3, D0, D2, D3, D5, D6, and D7. Table 9 - 5 shows the principal characteristics that define these alternatives. All of these alternatives except for C3 assume full implementation of the Judgment by 2020, with consumptive use set to equal natural supply plus imports. Alternative C3 assumes that the rampdown of agricultural producers will remain at 80% in 2020. In Alternative C3, agricultural production is permitted to continue even if it results in drawdowns in the groundwater aquifers.

Table 9-5: Revised and Final Alternative Assumptions and Results

Alternative:	C		D							
	C0	C3	D0	D2	D3	D5	D5r	D6	D6r	D7
Common	AVEK, Hodge, Lenwood, Warren Valley									
Judgement Implementation	Full	80% Ag	Full							
Ag demand scenario	Ag Scenario 1		Ag Scenario 2							
Municipal Conservation	0%		0%	5%		20%*	10%*	20%*	10%*	20%*
Regional WTP				46K		26K	12K			
Alto Reclamation		6.3K		9.9K	8.7K	6.8K	8.7K	6.8K	8.7K	6.8K
Rock Springs release		10K			10K	10K	10K	10K	10K	40K

*Municipal conservation in the Morongo Basin/Johnson Valley Area is 5% in these alternatives

Demands Met (KAF/yr)										
Total	102	216	101	198	200	182	199	185	198	185
Percent Total	40%	85%	47%	95%	96%	98%	99%	100%	98%	100%
Agricultural	30	56	20	20	20	20	20	20	20	20
Municipal	59	138	63	153	148	131	146	131	145	131

The revised alternatives build off of the initial 'A' and 'B' alternatives. In these alternatives, the problem of unreasonably high elevation increases in the Transition Zone has been resolved by limiting the amount of recharge into the aquifer from the Mojave River such that the aquifer elevation could not exceed 2,510 feet. In addition, an attempt has been made in each alternative to select a combination of recharge projects for SWP water that would result in reasonable balance in each of the aquifers units.

Alternative D2 is a revised version of B2, with a 46,000 acre-foot/year regional water treatment plant in Alto and with 5 percent municipal conservation. Alternative D3 also has 5% municipal conservation but does not include a regional treatment plant. Alternatives D5, D6, and D7 include 20% municipal conservation in the Mojave River Basin. Alternative D5 includes a smaller 26,000 acre-foot/year regional treatment plant. Alternative D7 is the only new alternative with a large Rock Springs release.

After presentation of the results of these alternatives at the TAC meeting, it was decided to create two final alternatives that would be revisions of the D5 and D6 alternatives. D5r is similar to D5 except that it includes only 10% municipal conservation in the Mojave River Basin and the size of the Regional Treatment Plant has been reduced to 12,000 acre-feet/year capacity. D6r is similar to D6 except that the amount of municipal conservation is reduced to 10 percent. Table 9 - 6 shows the projects and management actions that were modeled in each of the revised and final alternatives. The following sections briefly describe each alternative's performance under different performance measures.

Demands Met

Table 9 - 6 shows the demands met under each revised and final alternative. Alternative C0 meets only 40% and Alternative D0 meets only 47% of the total MWA demand. In each of these No Action Alternatives, Alto, Baja, and Oeste have 50% or less of their demands met. The results of Alternative C3 demonstrate that it is not possible to meet 2020 demand levels while keeping agricultural free production allowance at 80% rampdown levels. In this alternative, only 85% of total MWA demands are met, and significant overdraft of the Baja Subarea occurs.

Alternatives D2, D3, D5, D5r, D6, D6r, and D7 all meet at least 95% of total MWA demand. However, Alternative D2 has significant shortages in Baja and Oeste due to the lack of flexibility offered by the inclusion of a large treatment plant in Alto. With 20% municipal conservation, Alternatives D5, D6, and D7 are able to meet very close to 100% of total MWA demand. At the intermediate level of 10% municipal conservation, Alternatives D5r and D6r are each able to meet at least 98% of total MWA demand, with no significant shortage in any subarea.

All action alternatives meet significantly more demand than do the No Action Alternatives. Alternative C3 supplies the most total demand because it is not constrained to achieve balance in the groundwater aquifers. Alternatives D2 and D3 meet more total demand than the other 'D' alternatives because they include less municipal conservation, while Alternatives D5, D6, and D7 meet the least demand of all the non-No Action Alternatives because they include the greatest municipal conservation.

Table 9-6: Representative Projects and Management Actions Included in each Revised and Final Alternatives

Project/Management Action	Subarea	C0	D0	C3	D2	D3	D5	D5r	D6	D6r	D7
		Alternative (volume is in average annual acre-feet)									
Additional Recharge Facilities South of Rock Springs Outlet	Alto				1,408	11,956	3,555		7,280		
Alto wellhead treatment	Alto			0*	0*	0*	0*	0*	0*	0*	0*
Antelope Valley Wash Recharge Ponds	Alto			7,702	1,665	5,231	5,688	5,640	6,471	7,157	3,458
Cedar Street Detention Basin Recharge	Alto			7,702	1,665	4,857		5,640	6,471	7,157	
Hesperia Lakes Recharge	Alto					2,242		6,345		7,885	
Mojave River Pipeline Extension - Transition Zone	Alto			5,602							2,527
Oro Grande Wash Recharge Ponds	Alto			11,203	3,805	11,956	5,688	8,601	12,133	12,015	6,762
Recharge Ponds South of Apple Valley	Alto			4,201		4,110	711	2,820	4,044	3,755	
Regional Surface Water Treatment Plant	Alto				40,670		24,559	11,963			
Silver Lakes In-Lieu Recharge	Alto								2,427	2,253	2,527
Rock Springs Release	Alto			7,348		7,444	7,256	7,155	8,164	7,591	31,762
Baja Stormflow Retention	Baja			2,000		2,000	2,000	2,000	2,000	2,000	2,000
Daggett Recharge Ponds	Baja			6,337							
Kane Wash/Newberry Springs Recharge Ponds	Baja				2,671	3,449	2,510	2,604	2,855	2,800	2,984
Alto Makeup (to Hodge and Lenwood)	Centro	1,984	1,984	890	1,369	915	909	909	909	908	
AVEK	Centro	1,372	1,372	1,372	1,372	1,372	1,372	1,372	1,372	1,372	1,372
Hinkley water supply	Centro			0*	0*	0*	0*	0*	0*	0*	0*
Cushenbury Wash Stormflow retention	Este			400				400	400	400	400
Lucerne Valley Recharge Ponds	Este			1,190							
Recharge Ponds West of Helendale Fault	Este			342	450	708	496	343	241	369	252
Hi-Desert WD: Warren Valley	MBJV	1,557	1,557	1,557	1,450	1,450	1,450	1,450	1,450	1,450	1,450
Joshua Basin District Recharge and Pipeline	MBJV			445	393	393	393	393	393	393	393
Means/Ames Recharge Ponds	MBJV						1,000	1,000	1,000	1,000	1,000
Pioneertown water supply	MBJV			0*	0*	0*	0*	0*	0*	0*	0*
Sheep Creek Recharge Ponds	Oeste			2,485	1,459	2,293	1,881	2,109	2,140	2,260	2,236
SUBTOTAL IMPORTS		4,913	4,913	60,777	58,377	60,374	59,467	60,744	59,750	60,762	59,122
Urban Conservation		0	0	0	8,142	8,142	31,417	15,900	31,417	15,900	31,417
VVWRA Reclamation		0	0	6,335	9,925	8,841	6,826	8,656	6,826	8,437	6,826

*This project does not represent a new water supply

Groundwater Storage

Table 9 - 7 shows the average annual change in groundwater storage in each subarea under each alternative. The Centro Subarea shows a surplus in all alternatives. In Alternative C3 there is a significant reduction in groundwater storage in Baja because there is not enough supply available to meet the agricultural production at 80% of Base Annual Production. Alternative D7 includes a large Rock Springs release, which is not effective in overcoming deficits in the Alto Regional aquifer and causes greater surpluses in Centro and Baja due to increased Mojave River flow downstream.

Alternatives D5 and D6 perform the best under this measure, with total net increases of 15,800 and 13,500 acre-feet/year, respectively and no deficits in any subarea. This occurs because the high 20% municipal conservation reduces the need for SWP supply to meet demand and allows a certain amount of SWP water to be imported for the purpose of replenishing the groundwater basins.

Table 9-7: Average Annual Change in Groundwater Storage

	Morongo	Este	Oeste	Alto	Centro	Baja	Total	Rank
No-Action Alternative C0	0	0	0	0	7,200	0	7,200	7
No-Action Alternative D0	0	100	0	0	6,600	0	6,700	9
C3	0	0	400	2,500	5,800	(10,900)	(2,200)	10
D2	0	100	500	1,100	5,400	(300)	6,800	8
D3	0	0	500	1,500	5,400	100	7,500	6
D5	1,000	600	500	2,600	10,000	1,100	15,800	1
D5r	1,000	100	500	1,300	7,400	200	10,500	3
D6	1,000	200	600	2,400	8,600	700	13,500	2
D6r	1,000	0	500	500	6,700	100	8,800	5
D7	1,000	(200)	400	(10,900)	12,800	6,400	9,500	4

Groundwater Levels

In all of the alternatives following the initial alternatives, an effort has been made to select recharge projects in locations that would achieve relative balance in all subareas in the aquifer. This has been achieved in all alternatives except for Alternatives C3, D2 and D7.

In Alternative C3, the floodplain and regional aquifers in Baja are significantly depleted because agricultural production is allowed to remain at levels that cannot be supported by the available supply. Figure 9 - 2 shows the groundwater levels in the Baja Regional aquifer under each alternative. In Alternative C3, the groundwater elevations drop 24 feet in this alternative, compared to 8 feet or less in each of the other alternatives.

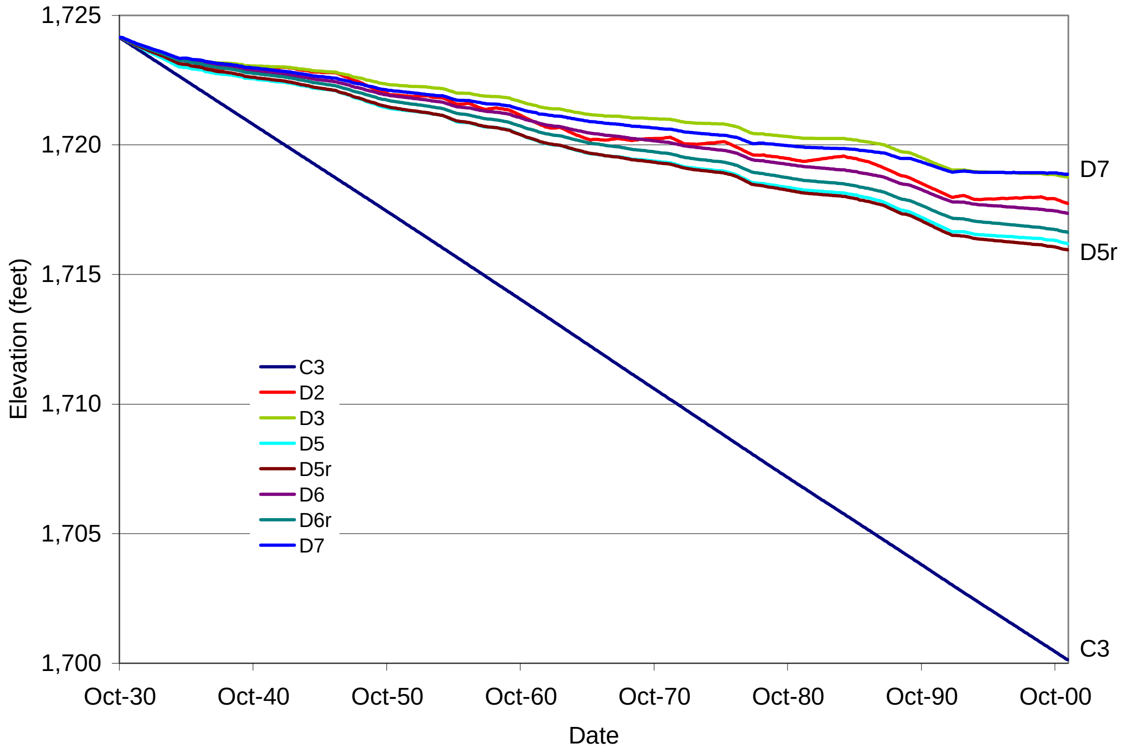


Figure 9-2: Time Series of Elevations in the Baja Regional Aquifer

In Alternative D2, there is not enough flexibility to balance all of the aquifers because such a large portion of the SWP supply is allocated to an Alto Treatment Plant. Figure 9 - 3 shows the groundwater levels in the Alto Floodplain Aquifer under each alternative. The groundwater levels in Alternative D2 drop 18 feet over the course of the model period compared to a decline of less than 8 feet for every alternative other than D7.

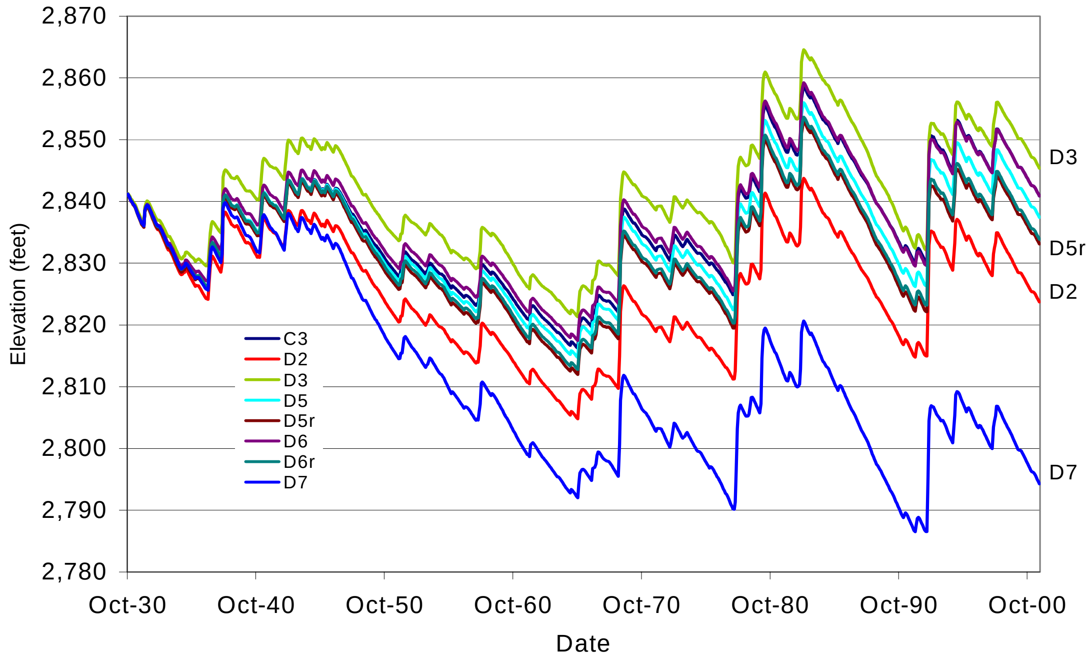


Figure 9-3: Time Series of Elevations in the Alto Floodplain Aquifer

In Alternative D7, the Alto West Regional, Mid-Regional, East Regional, and Floodplain aquifers are significantly depleted. This occurs because of the heavy reliance in this alternative on a Rock Springs release into the Mojave River to meet Alto's supply needs. In Alternative D7, the Alto Floodplain aquifer drops 47 feet in elevation over the course of the modeled period.

Subarea Interaction

Subarea interaction is measured by the amount of Mojave River flow and groundwater flow that passes from one subarea to another. Figure 9 - 4 shows the average annual Mojave River flows in each alternative. Alternative D7 has significantly higher river flows in all river reaches compared to the other alternatives because a large Rock Springs release has been included in the alternative. Several thousand acre-feet of additional outflow from the basin through Afton Canyon would occur annually due to this operation. All of the other alternatives have similar magnitude Mojave River flows on average.

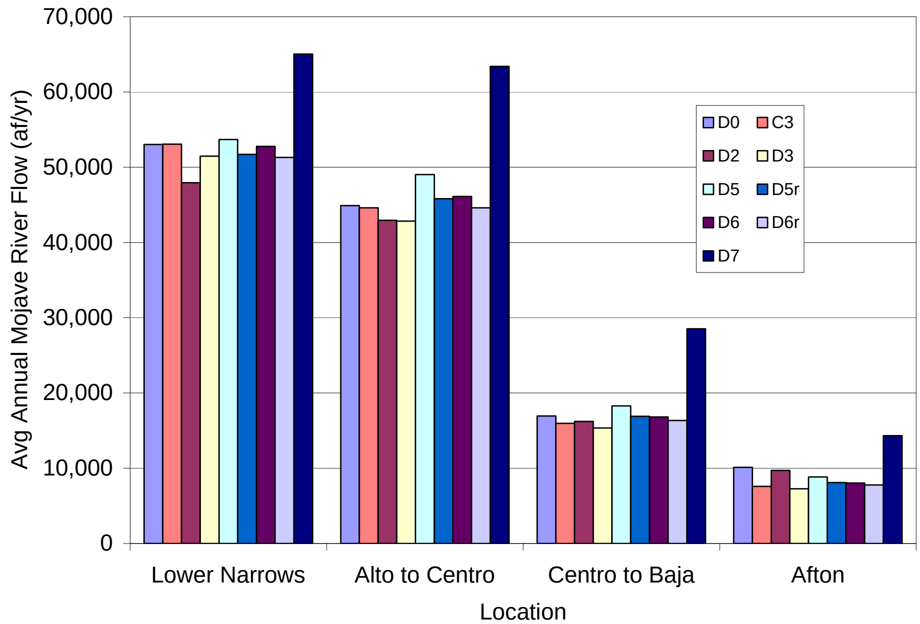


Figure 9-4: Average Annual Mojave River Flows

Figure 9 - 5 shows the average annual groundwater flows between subareas in each alternative. In Alternative D7 there is additional groundwater flow from Este and Oeste into Alto because the Alto regional aquifer has been depleted due to insufficient SWP recharge. Alternative C3 has the highest groundwater flows from Centro to Baja because Baja's aquifers are depleted. The other alternatives have similar magnitude groundwater flows.

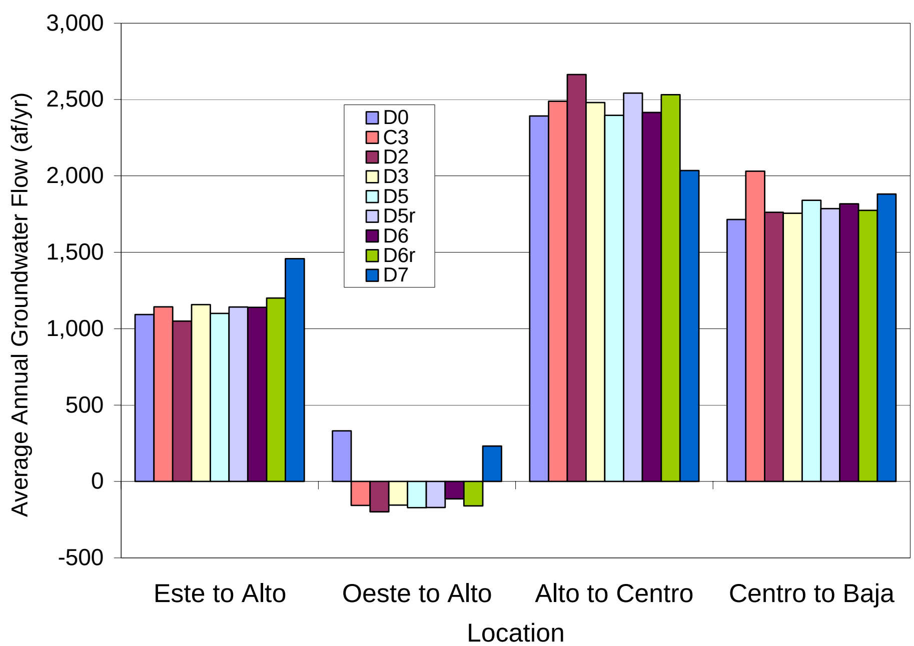


Figure 9-5: Average Annual Groundwater Flows

Water Quality

All of the alternatives were evaluated to estimate the effects that the proposed imports of SWP water would have on the water quality of each subarea. For each constituent, the estimated quality of SWP water was compared to the quality of the existing water and to the constituent's drinking water standard to determine the degree of improvement or detriment caused by the introduction of SWP water. SWP water is of higher quality than drinking water standards for all constituents.

For most constituents and in most subareas, the quality of SWP water was superior to the existing water quality. However, constituent concentrations in the SWP water were slightly higher than the existing concentrations of boron, nitrates, and TDS in Alto and of boron and nitrates in Oeste.

Alternative Cost

Table 9 - 8 shows the total estimated annualized capital and operating cost for each alternative. The alternatives that include an Alto Regional Treatment Plant (D2, D5, and D5r) have the highest costs.

Table 9-8: Annualized Cost of Each Alternative

Alternative	Annualized Cost ($ millions/year)
C3	$14.6
D2	$22.9
D3	$14.1
D5	$21.3
D5r	$20.8
D6	$15.9
D6r	$16.1
D7	$14.6

Recommended Alternatives

Alternatives D5r and D6r were identified as recommended alternatives to be carried forward for evaluation in greater detail in the programmatic environmental documentation. Each of these alternatives provide the following benefits:

- 99% of total MWA demand is met with no significant shortage in any subarea or demand sector
- include an attainable level of 10% municipal conservation
- provide water quality improvements over existing conditions
- all groundwater aquifer units are in balance
- each alternative provides benefits to all subareas without negatively impacting other areas

Common Features

A complete list of projects and management actions included in Alternatives D5r and D6r was shown in Table 9 - 6. These alternatives have many common features, including:

- 10% Municipal conservation in the Mojave River Basin, 5% in the Morongo Basin/Johnson Valley area
- Agricultural Scenario 2
- Reclamation of VVWRA discharge above 9,700 acre-feet/year
- Recharge of SWP water into the Alto Mid-Regional, East Regional, and Floodplain aquifers, and into the Baja Regional, Este Regional, Oeste Regional, Warren Valley, Copper Mountain Valley, and Means/Ames Valley aquifers
- Baja and Cushenberry Canyon stormflow retention or equivalent pond recharge projects
- Water supply augmentation for Hinkley and Pioneertown
- Alto wellhead treatment

The primary difference between the two alternatives is that Alternative D5r includes a 12,000 acre-foot/year capacity regional treatment plant in Alto. Alternative D6r includes in-lieu supply of SWP water to Silver Lakes (or the equivalent pond recharge projects)[43] and larger sized recharge facilities in all Alto aquifers.

Project and Management Action Priorities

An important goal of the RWMP Update was to identify those projects and management actions that would have the highest priority. For this purpose, each project and management action included in Alternatives D5r or D6r has been categorized as having High, Moderate, or Low Priority. The designation of priority for each project or management action was determined using the following criteria:

- whether it is an existing project or is already being pursued by MWA
- the level of current overdraft that the project attempts to mitigate
- expected growth in the subarea where the project will be applied

Table 9 - 9 shows the recommended priority of each project and management action. The projects that have the highest priority include implementing 10% municipal conservation, VVWRA wastewater reclamation, Alto wellhead treatment, a new water supply for Pioneertown, and the recharge of SWP water into the Warren Valley and into the Floodplain, West Regional, and Mid-Regional aquifers in Alto. Municipal conservation is considered to have the highest

[43] Equivalent pond recharge projects would involve additional facilities and easements at higher cost.

priority because measures will need to be initiated immediately in order to achieve 10% conservation by 2020. Recharge of SWP water into the Alto Floodplain, West Regional, and Mid-Regional aquifers will require feasibility studies to determine the optimal locations for building the necessary recharge facilities. Many such projects have been proposed, including projects at Oro Grande Wash, Antelope Valley, and Cedar Street in the West and Mid-Regional aquifers, and an Upper Mojave Wellfield Distribution System utilizing Rock Springs or Hesperia Lakes or other additional recharge facilities South of Rock Springs in the Floodplain aquifer.

Table 9-9: Recommended Priority for each Project or Management Action

Project or Action	Aquifer	Existing or Being Pursued?	Amount of Current Overdraft in Aquifer?	Expected Subarea Growth?	New Projects (not in 1994 plan)	Designed or Complete EIR	Comments	Priority
10% Municipal Conservation	All	No	High	High			5% in Morongo/Johnson ;Needs to start immediately	High
Wastewater Reclamation	All of Alto	Yes	High	High	√		VVWRA is actively pursuing	High
Alto Regional Treatment Plant	All of Alto	No	High	High	√		High expected cost	Moderate
Alto Wellhead Treatment	All of Alto	Yes	N/A	N/A	√		Addresses localized water quality problems; arsenic standard implementation by 2006	High
Recharge	Alto Floodplain	Yes	High	High		√	Rock Springs existing; feasibility studies needed	High
Recharge	Alto Mid-Regional	Yes	High	High	√		Feasibility studies needed	High
Recharge	Alto West-Regional	Yes	High	High	√		Feasibility studies needed; Oro Grande tests proceeding	High
Recharge	Alto East Regional	No	Moderate	High	√		Feasibility studies needed	Moderate
Recharge/ In-lieu Recharge	Transition Zone Floodplain	No	Low	High	√		Recharge not needed; assumes continued VVWRA recharge; limited drought buffer	Moderate
Recharge or Stormflow Retention	Baja Floodplain	No	High	Low	√		Feasibility studies needed	Moderate
Recharge	Baja Regional	Yes	High	Low		√	Feasibility studies needed	Moderate
Hinkley Water Supply	Centro Regional	No	N/A	N/A	√		Addresses water quality and quantity problems	Moderate
Recharge or Stormflow Retention	Este Regional	No	Moderate	Moderate			Feasibility uncertain; Judgment limitations for stormflow retention; listed County flood control project	Moderate
Recharge	Lucerne Valley	No	Low	Moderate		√	Feasibility studies needed; no current demand	Low
Recharge	Oeste Regional	No	Moderate	Moderate			Feasibility studies needed	Moderate
Recharge	Copper Mtn Valley	Yes	Moderate	Moderate			Feasibility studies in progress	Moderate
Pioneertown Water Supply	Means/Ames Valley	No	High	N/A			Addresses water quality and quantity problems; no potable water currently available	High
Recharge	Means/Ames Valley	No	Moderate	Moderate			Feasibility studies needed	Moderate
Recharge	Warren Valley	Yes	Low	Moderate			Existing facility, new facilities being investigated	High

10

MANAGEMENT ACTIONS

This chapter describes the Management Actions for Mojave Water Agency's implementation of the 2004 Regional Water Management Plan. These actions will be taken to help achieve the Basin Management Objectives described in Chapter 9 of this Plan.

The Management Actions neither supercede nor conflict with the Mojave Basin Judgment or the Warren Valley Judgment. All provisions of these Judgments are integral parts of the foundation of this Plan.

Inter-agency coordination and collaboration during development of this Plan took place through the Mojave Technical Advisory Committee (TAC). Committee members had an opportunity to review and comment on elements of the Plan including the Management Actions presented here. More information on the TAC is included in Chapter 8 of this Plan. The Agency is committed to continued inter-agency coordination as Plan elements are put into action both independently and by implementing agencies.

Management Authority

The California State Legislature authorized the formation of the Mojave Water Agency (MWA) in 1959 for the purpose of managing declining groundwater levels in the Mojave Basin Area, El Mirage Basin, and Lucerne Basin. The Legislature's act required the vote of residents within the boundaries of the proposed agency, which would finalize the creation of the agency. With the vote of the people, MWA was formed on July 21, 1960. MWA was expanded by annexation in 1965 to include the Johnson Valley and Morongo Basin areas.

The enabling act authorizes MWA to do "any and every act necessary, so that sufficient water may be available for any present or future beneficial use of the lands and inhabitants within MWA's jurisdiction." To fulfill this objective, the Agency currently performs the following:

- MWA acts as the wholesale administrator of State Water Project water delivered to parties within the MWA service area
- MWA is the current Court-appointed Watermaster for the Mojave Basin Area Judgment
- Monitoring programs and special studies throughout the Mojave Water Agency territory
- MWA has prepared this Regional Water Management Plan to plan water supplies and use in the Agency through 2020

As discussed in this Plan, the management authority of MWA is considerable in scope and areal extent, and extends to areas outside of the Court-administered judgments. The Mojave Basin Area Judgment requires that annual water production records be collected and verified by producers exceeding 10 acre-feet per year of production within each of the five subareas. Production outside the judgments includes groundwater use by several large landowners in the basin who were not parties to the Judgment and producers whose extractions are less than 10 acre-feet per year. More information on Minimal Producers can be found in the *Extraction Sites/Consumption* section later in this Chapter. MWA Ordinance 11 may provide a water charge structure for Minimal Producers. The Court has continuing jurisdiction and could order other controls in the future. The Warren Valley Basin is subject to a Court judgment that is administered by the Hi-Desert Water District acting as the Court-appointed Watermaster. Annual reports are developed by the Watermaster on water levels and matters that may impact safe yield.

Management Actions

The Management Actions consist of 60 specific actions that can be grouped into the following seven elements:

1. Monitoring
2. Improve characterization of the basin
3. Continue long-term planning
4. Groundwater protection
5. Construction and implementation
6. Financing
7. Public participation

The specific actions as grouped into these seven elements are presented below:

1) Monitoring

As regional groundwater manager, MWA has the authority for monitoring regional groundwater quantity and quality, and has implemented programs to accomplish this. The State Water

Resources Control Board is the primary State agency responsible for water quality management issues in California. Much of the responsibility for implementation of the SWRCB's policies is delegated to nine Regional Water Quality Control Boards. The Lahontan RWQCB and Colorado River RWQCB overlie MWA. Court-ordered requirements compel collection of data focused on components of the water balance, which the Agency measures, compiles, and disseminates. Cooperators in monitoring efforts include local water agencies, independent well owners, and the U.S. Geological Survey. Information collected or compiled by the Agency is utilized by local water managers and the Watermasters.

Role of the Mojave Basin Area Watermaster

By order of the Mojave Basin Area Judgment, the Mojave Basin Area Watermaster reports and interprets monitoring data to ensure that the mandates of the Judgment are enforced. The MWA Board acts as the Watermaster. Monitoring requirements are described in the Judgment After Trial (1996) and in the Mojave Basin Area Watermaster Annual Reports. Some components of the water budget called for in the Judgment, such as flows across subarea boundaries, must be estimated from collected data. The Watermaster is currently responsible for reporting the following types of data in the Mojave Basin Area:

- Verification of reported groundwater production
- Mojave River flows
- Precipitation
- Wastewater discharges
- Subsurface flow
- State Water Project and wastewater imports
- Groundwater levels
- Ungaged surface water inflows
- Consumptive use

A more detailed description of the Watermaster's monitoring activities can be found in Appendix H.

Action: MWA and the Watermaster will continue to perform monitoring activities prescribed by the Judgment, and will endeavor to improve methodologies to quantify components of the water budget and to facilitate integration of collected information with the MWA data set.

Groundwater Levels

MWA has several programs for groundwater level monitoring, and has been increasing in-house staff efforts for collection, compilation, and archiving an increasing quantity of collected data. This work is supplemented by efforts of the U.S. Geological Survey (USGS) as part of a cooperative water services program with MWA. There are 121 monitoring wells within the Mojave Basin Area from which water level and water quality samples are taken.

These include 53 wells from which the samples are taken annually and 46 wells from which samples are taken semi-annually. Monitoring wells are concentrated primarily near existing areas of production. Figure 10 - 1 shows the location of 191 wells with known well construction data including depth and perforation intervals collected from USGS and other sources.

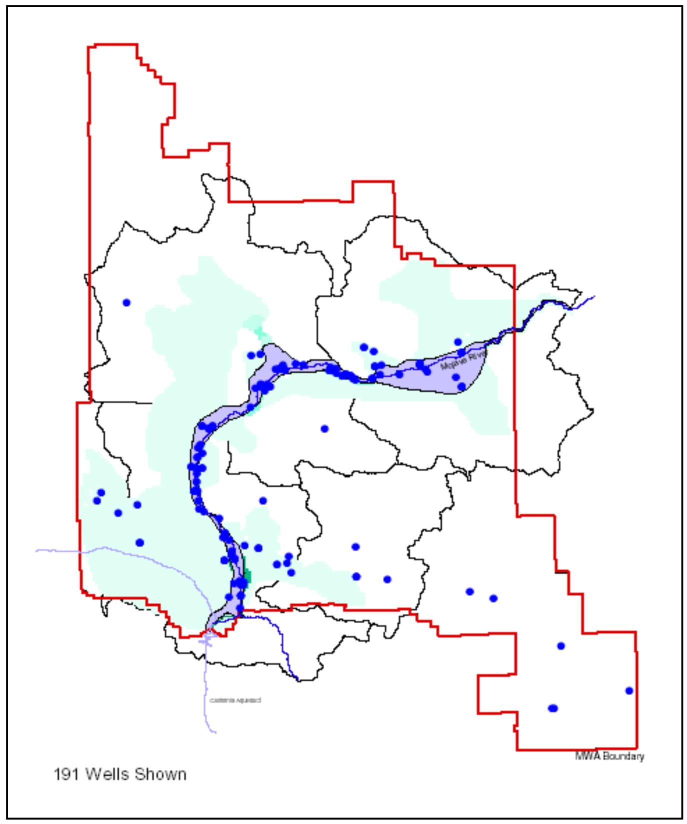


Figure 10-1: Well locations with known construction data

The Riverside County Superior Court Judgment After Trial of January 10, 1996[44] (the Judgment) ordered certain parties in the litigation to undertake certain actions. The Judgment requires the Watermaster to establish a Biological Resources Trust Fund for the benefit of the riparian habitat areas and species identified in the Judgment. The Judgment also refers to a Habitat Water Supply Management Plan (Conservation Plan) to be prepared by the CDFG for the benefit of these riparian habitat areas and species identified in the Judgment. These riparian habitat areas and species are listed in Exhibit H of the Judgment. The Conservation Plan was released in June 2004.

Groundwater levels were established in Exhibit H of the Judgment for key wells in the Mojave River floodplain. These wells, and their associated groundwater level target as measured from the ground surface to standing water are:

[44] City of Barstow et al v. City of Adelanto, Riverside County Superior Court. Case No. 208568

- wells H1-1 and H1-2 in the Victorville/Alto Zone (upper Narrows area) are to be maintained at 7 feet
- well H2-1 in the Lower Narrows/Transition zone is to be maintained at 10 feet
- well H3-1 in the Harvard/Eastern Baja Riparian Forest Habitat (Camp Cady area) is to be maintained at 7 feet. Well H3-2, also in the Camp Cady area, is to be maintained at 1 foot above ground surface to ensure adequate surface water habitat

Of these wells, only H3-1 has been installed; other monitoring is accomplished using surrogate wells or gaging stations.[45] If these water levels are not maintained, funds from the Biological Trust Fund will be expended on mitigation activities. MWA is continuing to coordinate with DFG, to further final well siting and installations.

MWA is working to increase use of water level measurements to better quantify the movement and storage of groundwater, and to effectively increase understanding of the ground water basins. This effort will include improvements to existing data collection programs through improved use of technology, including automated data collection processes and use of spatial database software. These processes should provide consistent data collection, a more geographically representative range of data, and measurements that are more discrete at depth and over time. Current efforts are focused on development of the Agency's Key Well program and a computerized geographic information database system. SCADA telemetry technologies are also being developed to obtain real-time data and control of the Agency's pipeline facilities and to minimize travel time of field staff.

Action: MWA will ensure that sufficient monitoring wells are installed around each recharge site to provide information needed to determine vertical and horizontal groundwater flow conditions and potential groundwater mounding in the vicinity of each site. In general, this means that monitoring points will be established around each recharge site, depending upon local conditions. Sites with complex geology may require multiple completion wells to monitor water levels in all affected strata. Movement of recharged water will be tracked to monitor recharge effectiveness.

Action: Existing monitoring wells will be maintained and gaps in data identified. The need for additional monitoring wells will be assessed and a plan developed for construction of additional wells if necessary. This assessment could lead to the identification and elimination of some superfluous measurement points.

[45] N. Caouette, personal communication, November 26, 2003

Action: MWA will work with the California Department of Fish and Game to continue development of wells needed for monitoring of biological resources at key locations.

Water Quality

MWA has initiated a monitoring effort to greatly enhance the cooperative water services program between MWA and USGS described above, which includes 65 wells from which the water quality samples are taken. Water quality samples are collected once a year from 23 water quality wells located in the floodplain aquifer and once every two years in 42 water quality wells located in the regional aquifer. Individual water purveyors monitor drinking water quality. Water quality enforcement responsibilities reside with the RWQCBs and the State Department of Health Services. MWA has initiated a concerted effort to expand its monitoring efforts in the Este Subarea through its basin conceptual model and Key Well Program. This program includes water level measurement and water quality testing at multiple locations across the subbasin. Such efforts will continue basin by basin throughout the MWA service area over the next several years.

Action: MWA will continue water quality monitoring efforts and will collect and summarize drinking water quality data from cities, coordinating these efforts with other entities including USGS, the State Department of Health Services, the Lahontan and Colorado River Regional Water Quality Control Boards, the State Department of Water Resources, and others. MWA will explore the viability of acting as a regional clearinghouse for this data. Data will be compiled, compared and tracked in a data management system. All data will be made available to area water purveyors. Needs for additional water quality sampling will be determined.

Action: MWA will begin implementation of a regional water quality model to be used as a predictive tool to manage the recharge of imported water. This is envisioned to be a multi-year effort, with the initial phases focused on data compilation, assessment, and conceptual model development.

Several state, regional and county agencies have jurisdiction and responsibility for monitoring water quality and contaminant sites. Programs administered by these agencies include contaminant cleanup, public outreach, and emergency spill response. The agencies include the Department of Toxic Substances, Department of Health Services, Regional Water Quality Control Board, U.S. Environmental Protection Agency and the County Division of Environmental Health. Much of the data is stored in publicly available databases.

MWA has commenced a project to develop a groundwater quality analysis system for the entire MWA service area. The project will include an evaluation of existing groundwater data and identification of data needs, the development of an information management system that will allow MWA to collect, reconcile, analyze, and access water quality information, and the development of a water quality and analysis system to meet MWA's long-term water quality objectives.

Once the system is developed it can be used in conjunction with regulatory agency databases to help identify areas with water quality problems and support efforts to remediate them.

Action: MWA will continue or begin coordination and data exchange with state, regional and county agencies to support efforts to ensure groundwater quality concerns are understood by the agencies and can be appropriately addressed. MWA will compile all reasonably available data including data on areas with known contaminants and/or poor quality groundwater and perform a trend analysis. This data, and the future modeling tool, will be used to site recharge and extraction facilities to maximize protection of water supplies.

Water Supply Measurement

Supply components of the water balance include streamflow, subsurface flow across subarea boundaries, and imported water supplies. As part of the cooperative water services program with MWA, the USGS operates and maintains the following gaging stations on the Mojave River:

- Deep Creek near Hesperia
- Mojave River at Lower Narrows near Victorville
- Mojave River near Barstow
- Mojave River at Afton

Flows from these gaging stations and the West Fork of the Mojave River (cooperatively funded by the U.S. Army Corps of Engineers) are reported to the Mojave Basin Area Watermaster and are used to determine annual water balances within each subarea as described in Chapter 11. Interflow between basins is estimated in this process. Flow from the Transition Zone into the Centro Subarea is a key part of the Watermaster's water balance. At one time, an additional gaging station was placed in the vicinity of the Transition Zone/Centro boundary. However, it was not possible to obtain reliable flow measurement at this station because of a lack of hydraulic control and shifting riverbed conditions. The Watermaster currently assumes the Mojave River flow at this location is equal to the base flow determined at the Lower Narrows plus the amount of reclaimed water discharged into the Mojave River by VVWRA.

Action: Because a reliable gaging station closer to the Alto/Centro boundary would improve the estimates of flow at that location, MWA will work to identify and maintain the most reliable measurement method practicable.

Action: MWA will assess current methods for estimating subsurface flow across subarea boundaries, and will develop additional monitoring points, follow through with plans to automate inventory of water supply components, or take other appropriate measures to improve the accuracy of these estimates.

Action: MWA will continue to account for and report quantities of water imported for groundwater replenishment. A data base application will also be developed to enhance current ability to inventory and value water within MWA storage programs.

Population Growth and Development

As reported in Chapter 5, MWA's population is expected to grow from about 321,000 in 2000 to about 541,500 in 2020. Water to meet the demands of most of this growth will be supplied by existing purveyors, importation of State Water Project water, or through purchase of Free Production Allowance under the terms of the Mojave Area Judgment. According to Mojave Water Agency Ordinance 11, new Minimal Producers who pump less than 10 acre-feet per year and who do not have a Free Production Allowance will be assessed the Replacement Water cost by the Mojave Water Agency for one acre-foot. The Agency would then import State Water Project water to replace the pumped water. However, Ordinance 11 is under review by the Court and has not yet been implemented pending a decision.

MWA will take the following steps to track the expected growth and ensure consistency with projected planned growth:

Action:MWA will work with cities, San Bernardino County, and water agencies to track building permits in order to monitor the pace of growth as compared to that projected in this Plan. This comparison will be made at least every five years. If actual growth varies significantly from the Plan benchmark, the pace of Plan implementainon will be adjusted or revisited.

Action:Under Senate Bills 221 and 610, the developers of new housing developments with 500 or more housing units, or commercial and industrial development with with equivalent demands, must receive written verification from the local water supply agency that a sufficient water supply exists to provide the needs of the new development. The Mojave Water Agency will provide information regarding regional water balances and avilability of supplemental supply to local purveyors to allow them to reach appropriate conclusions regarding the sufficiency of supply.

Action: New developments for which Free Production Allowance rights are acquired will have their production monitored by the Watermaster. Other developments will be assessed the Replacement Water cost by the Watermaster, who will request MWA to import State Water Project water to replace the pumped water.

Action:MWA will work with local planning agencies to ensure that areas that should be set aside to recharge the groundwater basin are reserved for that purpose and are not subject to development.

Alliance for Water Awareness and Conservation Participants

City of Adelanto
Apple Valley Country Club
Town of Apple Valley
Apple Valley Ranchos Water Company
Baldy Mesa Water District
City of Barstow
Barstow College
Bighorn-Desert View Water Agency
Bureau of Land Management
Bureau of Reclamation
Copper Mountain College
City of Hesperia
Hi-Desert Water District
Mojave Desert & Mountain Waste Management JPA
Mohave Desert Resource Conservation District
Mojave Water Agency
Mojave Weed Management Area
San Bernardino County Special Districts, Water/Sanitation Division
Southern California Water Company
Victor Valley College
Victor Valley Wastewater Reclamation Authority
Victor Valley Water District
City of Victorville
Town of Yucca Valley

Effectiveness of Water Conservation Measures

There are numerous reasons for evaluating water conservation measures:

- to provide a review or the program in context of its intended goals
- to allow for modification of programs that are not meeting intended goals
- better projection of water demands
- to document performance of pilot programs and for design of full-scale programs.

The Alliance for Water Awareness and Conservation (AWAC) was formed to help develop and implement a united regional water conservation program to maximize water use efficiency. As discussed in Chapter 7, the Alliance was formed in August 2003 and is composed of 24 local cities, water suppliers, and institutions, as well as regional resource management agencies. Goals of the Alliance are to:

1. Educate the local communities on the importance of water conservation.
2. Provide the local communities with the tools to effectively reduce per capita consumption to targeted goals.

3. Reduce regional water use by 10 percent gross per capita by 2010 and 15 percent gross per capita by 2015 (5 percent in the Morongo Basin by 2015) to achieve a sustainable, reliable supply to meet regional water demands.

Action: MWA will work with the Alliance for Water Awareness and Conservation (AWAC) and serve as a clearinghouse for water conservation measures and performance data. Water conservation programs will be evaluated through the AWAC and actions taken as needed. Evaluation will include at least the following:

- Summarize baseline water usage for water purveyors' 2000 Urban Water Management Plans
- Establish and summarize Demand Management Measures
- Track implementation of Demand Management Measures
- Tabulate per capita water use by member agency and subarea annually or at a reporting interval deemed appropriate by the Alliance

Action: Increased water conservation efforts will be identified and plans developed for implementation of cost effective demand management measures based on the reports on effectiveness.

Evapotranspiration

The Mojave Water Agency maintains a network of 14 weather stations collecting various weather data including temperature and precipitation. Approximately six of these stations have Class A evaporation pans that provide data on evaporation for the entire region. This provides information on both evaporation from open bodies of water and soil surfaces, and transpiration from the soil by plants. These evaporative processes are together referred to as "evapotranspiration", an important component in the overall water balance. MWA is planning to improve and supplement this part of local water use information by utilizing two technologies:

- the California Irrigation Management Information System (CIMIS)
- the Surface Energy Balance Algorithm for Land (SEBAL)

The California Irrigation Management Information System (CIMIS) is a repository of meteorological data collected from an integrated network of over 100 computerized weather stations located in key agricultural and municipal sites throughout the state. The system helps growers and turf managers in determining when to irrigate and how much water to apply.

The Surface Energy Balance Algorithm for Land (SEBAL) is a system that uses data from satellite-based sensors to compute energy balance to provide a refined estimate of evapotranspiration, a key component of the water balance.

Each of these technologies is described in more detail in Appendix H.

Action: MWA will review the adequacy of the existing evapotranspiration network and expand the number of measuring stations as necessary.

Action: MWA will continue to collect data on evapotranspiration and characterize its seasonal and areal distribution.

Action: MWA will work to improve the accuracy of areal evapotranspiration estimates through use of SEBAL or other appropriate technologies.

Action: MWA will make collected data available to agricultural and large urban landscape irrigators to encourage and facilitate the use of evapotranspiration data to increase irrigation efficiency.

Regional Water Level Changes and Land Subsidence

The USGS performed a study of land subsidence in the following four study areas using Interferometric Synthetic Aperture Radar (InSAR) methods[46]:

- El Mirage area (Oeste)
- Lockhart-Harper Lake area (Centro)
- Newberry Springs area (Baja)
- Lucerne Valley area (Este)

The study was performed as part of a cooperative program with the USGS. Results of the study indicate land subsidence has occurred in the area, which generally occurs during initial dewatering of compressible sediments.

Action: MWA will continue its cooperative land subsidence program, expanded to determine the relationship between groundwater levels and land surface elevation changes. Additional scrutiny should be given to areas where subsidence has occurred and where the depth to groundwater decreases below historic low levels.

---

[46] Sneed et al. 2003

Data Management

MWA has numerous data management systems existing or in development to support its various monitoring programs. It is imperative for the Agency to implement a data management system as a means to store, archive, and access data in a timely, unambiguous way meaningful to decision makers.

In its role as Mojave Basin Area Watermaster, MWA maintains records of producers, production wells, and annual production from stipulating parties' wells within the Mojave Basin Area. The Hi-Desert Water District performs these functions in its role of Warren Basin Watermaster. In cooperation with MWA, the USGS maintains a database to store river flow, water quality and water level data collected by MWA and USGS staff. Significant additional information is anticipated to be collected as part of this Plan to better characterize the groundwater system and the performance of recharge projects.

Action: MWA will continue development of a data management system based on a relational database structure to efficiently compile, store, archive, and access collected data. The system will be designed to provide data for a geographic information system and to accommodate data from additional collection efforts developed through implementation of this Plan.

Action: MWA will begin implementation of a regional water quality model. The project will include development of an information management system that will allow MWA to collect, reconcile, analyze, and access water quality information.

Action: MWA will make compiled data available to local water suppliers.

Extraction Sites/Consumption

In its role as Mojave Basin Area Watermaster, MWA collects and verifies production data within the Mojave Basin Area, with Hi-Desert Water District performing this role as Warren Basin Watermaster. The Judgment requires that annual water production records be collected and verified by producers exceeding 10 acre-feet per year of production within each of the five subareas. These records are used to document water usage and to determine Replacement Water and Makeup Water Obligations.

In addition, the MWA tracks well production as part of the Minimal Producer Program. Minimal Producers are defined as those producers who have an annual production of less than 10 acre-feet and are not subject to the Judgment. MWA estimates total production by Minimal Producers in each subarea of the Mojave Basin Area.

Action: Additional production wells will be constructed in the future to accommodate the expected increase in population. The Watermasters and MWA will collect data and verify the location and production from these new wells in addition to existing well production.

2) Improving Basin Understanding

Infiltration Rates

Numerous groundwater recharge projects will be required to meet the water balance objectives of this Plan. In order to understand the feasibility of, and best locations for, these projects, more data is needed as to the infiltration rates in different areas of the aquifer system. A pilot test project at the Oro Grande recharge site is already underway.

Action: MWA will expand infiltration pilot testing to identify suitable recharge sites capable of recharging groundwater at a rate adequate to meet forecasted needs.

Aquifer Characterization

Recharging the large quantities of water projected in this Plan will require extensive investigation of aquifer properties and storage capacities. Means to effect this aquifer characterization include geophysical testing, aquifer stress tests, and expanded monitoring networks. Methods for geophysical testing include surface geophysical methods such as seismic reflection and refraction, gravity surveys and resistivity imaging, and down-well methods such as electronic logging, pump testing, and other methods. These methods are used to develop a mapping of the aquifer flow system that can be used to optimize the interaction of groundwater recharge and extraction activities. New down-well technologies are available that can provide refined, depth-specific aquifer properties cost-effectively. MWA has employed many of these techniques in its exploration for suitable recharge sites.

Action: MWA will expand its aquifer characterization program to improve understanding of basin conditions, leading to more effective recharge project operations. Geophysical methods will be employed as appropriate to identify the sites most appropriate for groundwater recharge.

Action: MWA will employ new technologies that can develop high resolution, depth-specific aquifer characterization in the most cost-effective manner.

Action: MWA will expand its monitoring well network as appropriate to track aquifer response from pilot and full-scale groundwater recharge and production facilities.

Action: Data collected will be compatible and integrated with regional modeling and data management efforts.

Modeling

To date, three models of MWA's groundwater basins have been developed to aid in management of the water system:

- A groundwater simulation model of the Mojave River Basin developed in Modflow by the USGS[47]
- A groundwater simulation model of a portion of the Warren Basin by the USGS
- A screening model developed in Stella as part of this RWMP Update to estimate the effects of implementation of proposed projects and management actions

Modeling of the groundwater basin can be useful to help determine the best locations for recharge or extraction sites and to help optimize operation of the groundwater basin. The existing models described above provide insight into these questions, but have significant limitations. The existing models are appropriate for conceptual regional planning efforts, but more refined models will be necessary for in-depth analysis of a large-scale recharge system, or for site-specific analysis. The initial focus should be on additional data collection to support the detailed effort.

MWA is considering a multi-year effort to develop a more detailed flow model that incorporates considerations of water quality, in particular the effects of salinity on the groundwater basin.

Action: MWA will begin development of a regional water quality model. The initial efforts of this modeling program will be focused on data compilation, assessment, and conceptual model development. The model will make use of data contained in the existing models, and will be compatible with and integrated with data collected in the geophysical aquifer testing efforts.

---

[47] Stamos et al. 2001

Update Water Budget

The water budgets prepared annually by the Watermaster include groundwater flow, ungaged surface water inflows, deep percolation of precipitation estimates, and phreatophyte use in the riparian area. Each of these components are fixed estimates which could be improved with new information.

Action: MWA will develop improved estimates of water budget components to provide a refined assessment of subbasin interactions and water supply obligations under the Mojave Basin Area Judgment. A likely initial focus is improvement of evapotranspiration and consumptive use using the technologies discussed above in the Monitoring element. Improved groundwater level monitoring and modeling to provide a better estimate of subsurface flow is another component that might be implemented near-term.

Action: MWA will utilize their data systems to develop and produce annual Agency-wide progress reports on key water budget components including water inflows, outflows, and change in storage by subarea and make recommendations on how these quantities can be better measured.

3) Continue Long-Term Planning

Since its inception in the 1960s, the MWA has been developing and updating plans to guide the Agency as it carries out its mission to ensure sufficient water availability for present or future beneficial uses within the Agency's jurisdiction. The Agency will continue its commitment to long-term planning. The following section describes the planning efforts the Agency is focusing on.

Vulnerability Assessment

The California Department of Health Services has prepared a checklist of security measures for water utilities. According the checklist, recommended actions to better secure water related facilities include the following:

1. At offices, well houses, treatment plants and vaults, make it a rule that doors are locked and alarms set
2. Tell employees to ask questions of strangers at facilities
3. Limit access to facilities. Indicate restricted areas by posting “Employees Only” signs
4. Increase lighting in parking lots, treatment bays and other areas with limited staffing
5. Remove keys for equipment
6. Invite local law enforcement to become familiar with facilities and establish a protocol for reporting and responding to threats

7. Discuss detection, response, and notification issues with public health officials and establish a protocol
8. Establish a chain of command and emergency call list in case of emergencies
9. Provide copies of operational procedures to law enforcement and emergency management personnel
10. Limit access to water supply reservoirs
11. Fence and lock vulnerable areas

Action: MWA will inform and work cooperatively with groundwater purveyors in their efforts to ensure that minimum water security measures are in place. Additional security measures will be identified and implemented as necessary. MWA will implement these measures on its facilities where appropriate.

Review Land Use Plans

Land use plans in the basin are developed by a number of different entities including the county and each of the cities through their General Plans, General Plan Amendments and Public Facilities Element amendments.

Action: MWA will coordinate with local planning agencies to ensure that growth projections, proposed land use changes, and types of proposed developments are consistent with water planning efforts, as required by SB 221 and SB 610. Significant deviations from projected growth and water needs will be noted and corrective action taken. Corrective actions could include securing additional sources of water, or making a finding pursuant to SB221 or SB 610 that an adequate water supply does not exist and notifying the water purveyor.

Identify Post 2020 Water Supply

MWA has a State Water Project water contract for up to 75,800 acre-feet per year. The water supply-demand analysis performed as part of this Plan (Chapter 5) indicates that, assuming municipal conservation of 10 percent, the full available SWP supply will be needed by 2020. Preliminary estimates of future water demand, assuming current trends continue, indicate that an additional 60,000 to 100,000 acre-feet per year will be needed by 2050. MWA has initiated efforts to determine sources where this additional supply might be obtained. Potential options include pre-banking of existing supplies, new appropriations, water banking or exchange arrangements, water transfers, developing water conservation or desalination credits, and aggressive management of existing supplies, including exploring higher levels of conservation. MWA has recently negotiated a short-term groundwater banking arrangement with the

Metropolitan Water District, and discussions for a larger, long-term banking project are underway. The feasibility of the post-2020 options has yet to be examined.

Action: MWA will continue to research options for meeting post-2020 water needs, categorize and prioritize the options, and examine and implement the higher-priority options.

State Water Project

MWA has an annual State Water Project entitlement of 75,800 acre-feet per year. According to the Final State Water Project Reliability Report (DWR 2002), MWA should expect to receive an average of about 58,400 acre-feet per year each year if they request their full entitlement. As indicated in Chapter 5, MWA will need to utilize their entire SWP entitlement in order to bring the groundwater basin into balance in 2020.

Action: MWA will stay actively involved in State Water Project planning processes that are conducted by the Department of Water Resources and other water planning agencies. The expected reliability of State Water Project could be affected by changes in system operation or by modifications in planning models that are used to project SWP deliveries. MWA will advocate for operations that enhance its supply, track changes in SWP reliability, and adjust its plans accordingly.

Transportation Infrastructure

Future transportation facilities will need to be developed to handle the needs of a growing population. As facility needs are identified, their planning should be coordinated with the MWA to ensure that groundwater recharge areas are protected. MWA will work with the Southern California Association of Governments (SCAG) to this end.

SCAG is mandated by the federal government to develop plans for, among other things, transportation and growth management. One of the foremost activities of SCAG is the development of a comprehensive and coordinated Regional Transportation Plan. SCAG's Water Policy Task Force provides planning advice on water supply and water quality on issues affecting the long-term sustainability of communities and industry. Among its duties, the Task Force provides SCAG committees with water quality assessment information for regionally-significant transportation projects planned for future implementation. The Task Force is composed of officials (both elected and appointed) who participate actively in local government and in organizations concerned with water policy, planning and management.[48]

[48] SCAG web site

Action: MWA will work with the Water Policy Task Force to ensure that there is maximum coordination in order to protect high priority recharge sites from impervious surfaces and potential contaminating activities, and to plan for a sustainable water supply to support future development.

Regular Updates

This Regional Water Management Plan contains elements that address several planning procedures, including an Integrated Water Management Plan, an Urban Water Management Plan (UWMP) and Groundwater Management Plan. As required by the Urban Water Management Planning Act, California Water Code, Section 10610 et seq., the UWMP plan must be updated every five years in years ending in zero and five. Additionally, MWA will prepare biennial updates on the status of completion of the various aspects of the Groundwater Management Plan. These summary reports will be coordinated with, and tied to, the Agency's Capital Improvement Plan process. Updates on many of these activities are included in the Annual Reports of the Mojave Basin Area Watermaster.

MWA will produce the biennial updates on the other activities contained in these Management Actions. The information contained in the biennial updates should be used to evaluate how often it will be necessary to update the Groundwater Management Plan.

Action: MWA will produce a biennial report summarizing progress made in achieving Plan Actions for the previous two years, considering monitored performance of the water management system. Minor adjustments to planning assumptions, operations, or Actions will be adopted as necessary. If significant deviations from the Plan are determined to exist, the Plan will be revised in its entirety.

Action: MWA will perform a comprehensive update revision of the Regional Water Management Plan at least every ten years. The performance of implemented projects will be compared to original project objectives to ensure objectives were met.

Action: MWA will supplement the sections of the Regional Water Management Plan required for its Urban Water Management Plan every five years, in years ending in zero or five, consistent with law.

4) Groundwater Protection

The general goal of groundwater protection activities is to maintain the groundwater and the aquifer to ensure a reliable high quality supply. Activities to meet this goal include continued and increased monitoring, data sharing, education and coordination with other agencies that have local or regional authority or programs. MWA currently has no groundwater production wells that it operates, but could in the future. To increase its groundwater protection activities, MWA will take action as presented below.

Recharge Site Management Activities

Management activities for protection of recharge sites include:

- establishing Site Control Zones to protect the area immediately surrounding the site from potentially contaminating activities
- controlling access to recharge zones
- Well and recharge facility contruction standards
- researching and mapping pollution sites to minimize siting and operational conflicts

A more detailed description of recharge site activities is included in Chapter 3 of this Plan.

The Drinking Water Source Assessment and Protection (DWSAP) program was developed by the California Department of Health Services to meet requirements in amendments to the Safe Drinking Water Act. All wells providing public drinking water supplies must comply with this program. The DWSAP program is intended to address assessments and facilitate the development of protection programs for ground and surface waters. The Department of Health Services and larger water utilities perform these assessments for pre-2002 wells. The well owner is generally required to perform the assessment for newer wells. The DWSAP consists of the following:

- delineating the two-, five-, and ten-year time of travel capture zones for wells
- inventorying possible contaminating activities
- determining vulnerability of wells to potential contaminants

Action: For probable recharge locations, MWA will perform an inventory and map potential sources of contamination including toxic investigation sites, industrial sites, gas stations, dairies, and sites investigated by the RWQCBs, and use this information in selecting recharge sites and in planning recharge site operation in order to minimize the potential for water supply contamination. MWA will compile existing DWSAP reports developed for existing wells to aid in mapping potentially contaminating activities.

Action: MWA will coordinate with regional water quality agencies, including the U.S. EPA, California EPA, Lahontan and Colorado River RWQCBs, the California Department of Health Services, and San Bernardino County Health Services to identify potential water quality threats to candidate recharge sites, and compile this information into a data management system for use in selection of recharge sites.

Identification and Destruction of Abandoned Wells

The presence of abandoned groundwater wells represents a potential hazard to the quality of the groundwater basin. Abandoned and improperly destroyed wells can act as conduits for contaminants to reach drinking water supplies. It is vital for the long-term protection of the basin that abandoned wells be located and destroyed. Well records kept by the Agency and the Mojave Basin Area Watermaster can help in the process of identifying existing abandoned wells and in identifying wells that are abandoned (stop production) in the future.

While it is the landowner's responsibility to destroy an abandoned well, local water agencies should be proactive about making sure that abandoned wells are in fact destroyed. The destruction of abandoned groundwater wells should be performed in accordance with state standards. California Water Code Section 13750.5 requires that those responsible for the destruction of water wells possess a C-57 Water Well Contractor's License. Whenever a water well is destroyed, a report of completion must be filed with the California Department of Water Resources within 60 days of the completion of the work. The San Bernardino County Department of Public Health, Division of Environmental Health Services is responsible for permitting and inspecting construction and destruction of wells.

Action: MWA will work with the County to develop a plan to identify and destroy abandoned wells. Federal and State grants will be sought for these purposes, as appropriate. MWA will encourage local water agencies to actively search for existing abandoned wells in their service areas so that they can be destroyed. Consideration will be given to developing ordinances requiring protocols for identification of abandoned wells upon sale or transfer of property.

Hazardous Materials Response

Currently, city and county hazardous materials teams handle responses to hazardous materials incidents. Increased coordination between MWA and hazardous materials teams will allow for assessment of the potential for chemical spills to impact groundwater and recharge sites.

Action: MWA will establish notification protocols with hazardous materials response agencies so that the Agency can be immediately informed of a threat to vulnerable areas, and to delineate any potentially threatened water facilities to the responders.

Protection of Recharge Areas

Only a small portion (approximately 4%) of groundwater recharge in the MWA territory is from direct percolation of rainfall. Over 89 percent is from percolation in the Mojave River channel, ephemeral washes, and mountain fronts. The following efforts will be undertaken to protect recharge areas:

Action: Through review of General Plans and other land use plans, the MWA will identify potential projects that may have a significant impact on the quality or quantity of water supplies entering the basin through recharge sites, establish buffer zones, and provide this information to the planning agency. MWA will identify sites with high potential for recharge and proactively identify them to land use planning agencies. More information on land use planning efforts is provided in the Monitoring section of this chapter.

Action: MWA will continue to coordinate with watershed related entities including the Lahontan and Colorado River Regional Water Quality Control Boards, Mojave Desert Resource Conservation District and the U. S. Bureau of Land Management.

5) Construction and Implementation

Construction of projects by MWA within its service area is necessary to build, operate, maintain and replace the State Water Project facilities to which MWA is contractually obligated. These projects are necessary to fulfill MWA's contractual obligations with the State of California and to insure water availability to all of its residents.

Table 9-9 in the previous chapter shows the recommended priority of each project and management action. The projects that have the highest priority include implementing municipal conservation, VVWRA wastewater reclamation, Alto subarea wellhead treatment, a new water supply for Pioneertown, and the recharge of SWP water into the Warren Valley aquifer and into the Floodplain, West Regional, and Mid-Regional aquifers in the Alto subarea. Municipal conservation is considered to have the highest priority because measures will need to be initiated immediately in order to achieve 10 percent conservation by 2020. Recharge of SWP water into the Alto Floodplain, West Regional, and Mid-Regional aquifers will require feasibility studies to determine the optimal locations for building the necessary recharge facilities.

Projects and management actions with a high priority are those expected to begin implementation within the next five years. Those with a moderate priority are those expected to begin implementation within the next five to ten years, and those with lower priority will be pursued within a ten to twenty year timeframe.

Action: MWA will identify implementing agencies for high priority projects and management actions, and will coordinate with those agencies in putting them into service. High priority projects and management actions are those expected to begin implementation within the next five years, and include:

- Municipal conservation of 10 percent of consumptive use in the Mojave River Basin and 5 percent in Morongo Basin/Johnson Valley
- Wastewater reclamation in the Alto subarea
- Wellhead treatment in the Alto subarea
- Groundwater recharge in the Alto Floodplain aquifer
- Groundwater recharge in the Alto Mid-Regional aquifer
- Groundwater recharge in the Alto West-Regional aquifer
- Developing an alternative supply for Pioneertown
- Groundwater recharge in the Warren Valley
- Continue development of regional water banking arrangements

Action: MWA will identify implementing agencies for moderate priority projects and management actions, and will coordinate with those agencies in putting them into service. Moderate priority projects and management actions are those expected to begin implementation within the next five to ten years, and include:

- continued implementation of high priority projects and actions
- construction of a regional water treatment plant in the Alto subarea
- groundwater recharge in the Alto East-Regional aquifer
- direct or in-lieu groundwater recharge in the Transition Zone Floodplain aquifer

- groundwater recharge and/or stormwater retention in the Baja Floodplain aquifer
- address municipal water supply issues in the Hinkley area of the Centro Regional aquifer
- groundwater recharge and/or stormwater retention in the Este Regional aquifer
- groundwater recharge in the Oeste Regional aquifer
- groundwater recharge in the Copper Mountain Valley
- groundwater recharge in the Means/Ames Valleys

Action: MWA will identify implementing agencies for lower priority projects and management actions, and coordinate in putting them into service. Lower priority projects and management actions are those expected to begin implementation within the next ten to twenty years, and include:

- continued implementation of high and moderate priority projects and actions
- groundwater recharge in the Lucerne Valley

6) Financing

Implementing the Regional Water Management Plan (RWMP) will require an array of financing mechanisms, such as bonds, grants, or low interest loans. The Mojave Basin Area Judgment provides a revenue steam for purchasing imported water. Cost savings may be incurred through implementation of conservation and water reuse projects. In addition, cooperative funding agreements between MWA and other water managers in the MWA service area or cost-share agreements between MWA and local, state, or federal agencies may also provide funding for RWMP projects and management actions.

Action: As project and management actions in the RWMP are defined in more detail, MWA will conduct a review of federal, state, and regional funding sources as well as potential assessments, fees, and charges to develop a financing plan that comprises an array of financing mechanisms appropriate for each RWMP project or management action, including bond funding, low-interest loans and grants, and cooperative cost-share agreements.

Action: MWA will develop a multi-year Capital Improvement Program (CIP) using the RWMP as its basis. The plan will include a schedule, priority and cost for implementation.

Action: MWA will research and pursue grants, with an emphasis on Proposition 50 funds, and identify potential Federal funds to be used for CIP implementation.

Action: MWA will identify local cost-sharing partners among the benefiting entities and determine the best mix of debt, fees and charges for implementing projects and management actions.

7) Public Participation/Community Outreach

MWA formed a Technical Advisory Committee (TAC) comprised of local stakeholders and water purveyors. The TAC met regularly during development of the Regional Water Management Plan, reviewing and providing comments and suggestions on the Plan. TAC members are listed in Chapter 8. MWA will continue to consult with the TAC on project implementation and financing.

MWA is a member of the Alliance for Water Awareness and Conservation, a group of local water purveyors who are collaborating on demand management measures. MWA has also signed seven cooperation agreements or Memoranda of Understanding with local public entities to promote water conservation, as described in Chapter 7.

Action: MWA will continue to coordinate, participate in, and implement recommendations of the Alliance.

MWA has organized and held three water symposia with local water leaders and regulators in Victorville, Morongo Basin, and Lucerne Valley in 2003 and early 2004.

Action: The Agency plans to make the water symposium an annual event.

Action: MWA will continue its outreach and education efforts through continued funding of the Community Liaison Officer.

The Panorama, the newsletter of the MWA is published regularly and mailed to those on its growing distribution list. Regular updates on the development of the Regional Water Management Plan have been included. A copy of Volume 3, Issue 1 published in the winter of 2003 is included in Appendix F.

Action: MWA will continue to develop and publish its newsletter, *The Panorama*.

MWA has an established Speakers Bureau which provides Board members and Agency staff to address water related topics with local audiences.

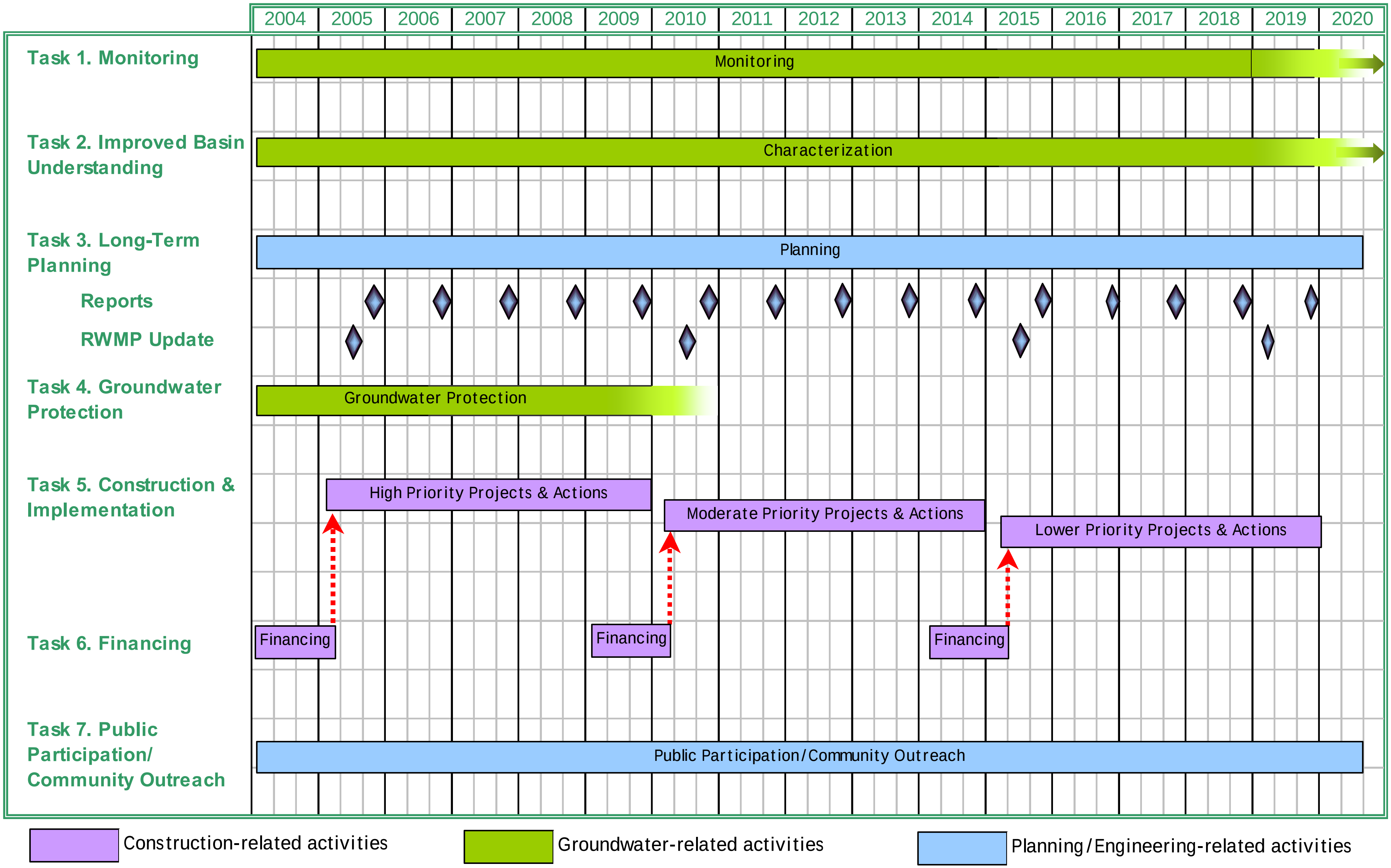
Action:MWA will maintain its Speakers Bureau to provide timely water related information to the public.

Action:MWA's web site (http://www.mojavewater.org/) contains information on MWA projects, water supplies and resources, water education, Watermaster, Agency publications, a calendar of events, meeting agendas, and general information about MWA. MWA will continue to provide this service.

Implementation Schedule

A schedule for implementation of the Management Action Plan is provided in Figure 10-2.

Figure 10 - 2. Master Schedule for MWA Management Action Plan



References

Apple Valley Ranchos Water Company (2000) *Urban Water Management Plan.* Apple Valley Ranchos Water Company, Apple Valley, CA

Bell, C. (2003) pers. comm.

Billhorn, T. (2003) pers. comm.

Bookman-Edmonston Engineering, Inc. (1994) *Mojave Water Agency Regional Water Management Plan*. Bookman-Edmonston Engineering, Inc., Glendale, CA.

Boyle Engineering Corporation (1993) *Regional Water Management Plan Johnson Valley/Morongo Basin Area.* Boyle Engineering Corporation, Newport Beach, CA.

City of Barstow (1997) *Utilities and Public Service Technical Report* City of Barstow General Plan – Part C, Chapter VI.2.

City of Hesperia (2000) *Hesperia Water District Urban Water Management Plan.* City of Hesperia, Hesperia CA

DWR (1967) *Mojave River Ground Water Basins Investigation Bulletin No. 84*. CA Department of Water Resources, Sacramento, CA.

DWR (1998) *California Water Plan Update Bulletin 160-98*. CA Department of Water Resources, Sacramento, CA.

DWR (2001) *Management of the California State Water Project Bulletin 132-01*. CA Department of Water Resources, Sacramento, CA.

DWR (2001b) *Data Provided by Division of Water Deliveries and Schedules*. CA Department of Water Resources, Sacramento, CA.

Eckhart, L. (2003) pers. comm.

Hanson, J. C. (1993) Preliminary Report on Analysis of the Flow of the Mojave River at Afton, CA, San Bernardino County, California. James C. Hanson, Consulting Civil Engineer, Sacramento, CA.

Hardt, W.F. (1971) *Hydrologic analysis of Mojave River Basin, California, Using Electric Analog Model.* U.S. Geological Survey, U.S. Geological Survey, Menlo Park, CA, August, 1971.

Hi-Desert Water District (2003) Home Page <http://www.hdwd.com>.

Hi-Desert Water District (2003) pers. comm.

Izbicki, J.A., Martin, Peter, and Michel, R.L. (1995) *Source, Movement and Age of Groundwater in the Upper Part of the Mojave River Basin, California, U.S.A.* Application of Tracers in Arid Zone Hydrology: International Association of Hydrological Sciences, no. 232, p. 43-56, Adar, E.M., and Leibundgut, Christian, eds. LAHS Publishers.

Izbicki, J.A., Radyk, J.C., and Michel, R.L. (2000) Water Movement Through a Thick Unsaturated Zone Underlying an Intermittent Stream in Western Mojave Desert, Southern California, U.S.A.: Journal of Hydrology, v. 238, p. 194-217.

Jones, B. (2003) pers. comm.

Joshua Basin Water District (2000) *Joshua Basin Water District 2000 Urban Water Management Plan.* Joshua Basin Water District, Joshua Tree, CA

Kennedy/Jenks/Chilton (1991) Warren Valley Basin Management Plan.

Lines, G. C., and Bilhorn, T. W. (1996) *Riparian Vegetation and its Water Use During 1995 Along the Mojave River, Southern California*. Water-Resources Investigations Report 96-4241, U.S. Geological Survey, Sacramento, CA.

Mojave Basin Area Judgment (1996) *Judgment After Trial, City of Barstow et al. Vs. City of Adelanto et al.* Superior Court Case No. 208568, Riverside County, CA.

Mojave Basin Area Watermaster (2001) *Seventh Annual Report of the Mojave Basin Area Watermaster for Water Year 1999-2000*. Mojave Basin Area Watermaster, Apple Valley, CA, April, 2001.

Moyle, W.R., Jr. (1984) *Bougher Gravity Anomaly Map of the Twentynine Palms Marine Corps Base and Vicinity, California*. Water-Resources Investigations Report 84-4004, U.S. Geological Survey, Sacramento, CA.

MWA (1996) Engineer's Report on Water Supply for Water Year 1994-1995. Mojave Water Agency, Apple Valley, CA.

MWA (1997) Engineer's Report on Water Supply for Water Year 1995-1996. Mojave Water Agency, Apple Valley, CA.

MWA (1998) Engineer's Report on Water Supply for Water Year 1996-1997. Mojave Water Agency, Apple Valley, CA.

MWA (1999) Engineer's Report on Water Supply for Water Year 1997-1998. Mojave Water Agency, Apple Valley, CA.

MWA (2000) Engineer's Report on Water Supply for Water Year 1998-1999. Mojave Water Agency, Apple Valley, CA.

MWA (2001) Engineer's Report on Water Supply for Water Year 1999-2000 (Draft). Mojave Water Agency, Apple Valley, CA.

MWA (2002) Engineer's Report on Water Supply for Water Year 2000-2001 (Draft). Mojave Water Agency, Apple Valley, CA.

San Bernadino County (1977) Hi-Desert Water District v. Yucca Water Company Ltd., Case Number 172103, San Bernardino, CA.

Smith, G.A. and Pimentel, M.I. (2000) Regional Water Table (1998) and Ground-Water-Level Changes in the Mojave River and the Morongo Ground-Water Basins, San Bernardino County, California. Water-Resources Investigations Report 00-4090, U.S. Geological Survey, Sacramento, CA.

Sneed, Michelle, Ikehara, Marti E., Stork, Sylvia V., Amelung, Falk, and Galloway, Devin L., (2003) *Water Resources Investigations Report 03-4015*, U.S. Geological Survey, Sacramento, CA.

So & Associates Engineers Inc. (2000) *Baldy Mesa Water District 2000 Urban Water Management Plan.* So & Associates Engineers Inc., Apple Valley, CA

So & Associates Engineers Inc. (2000) *Victor Valley Water District 2000 Urban Water Management Plan.* So & Associates Engineers Inc., Apple Valley, CA

Southern California Association of Governments (2003) Home Page <http://scag.ca.gov>.

Southern California Water Company (2000) *Southern California Water Company Urban Water Management Plan – Barstow System*, Southern California Water Company, Ontario, CA

Stamos, C.L., Martin, P., Nishikawa, T., and Cox, B.F. (2001) *Simulation of Ground-Water Flow in the Mojave River Basin, California*. Water-Resources Investigations Report 01-4002 Version 3, U.S. Geological Survey, Sacramento, CA.

Stamos, C.L., Nishikawa, T., and Martin, P. (2001b) *Water Supply in the Mojave River Ground-Water Basin, 1931-99, and the Benefits of Artificial Recharge.* Water Fact Sheet 122-01, U.S. Geological Survey, Sacramento, CA.

Todd Engineers (1993) Water Resources Analysis of the Upper Mojave River Basin - Alto Subarea, Todd Engineers, Emeryville, CA.

Urban Logic Consultants (1997) *City of Adelanto Urban Water Management Plan.* Urban Logic Consultants, Temecula, CA

USACE (1986) *Mojave River Dam, San Bernardino County, California, Final Feasibility Report.* U.S. Army Corps of Engineers, Los Angeles District, Los Angeles, CA, March 1986.

Victor Valley Wastewater Reclamation Authority (2000) *Sewerage Facilities Plan Update*, Victor Valley Wastewater Reclamation Authority, Victorville, CA.

Webb (2000) Consumptive Water Use Study and Update of Production Safe Yield Calculations for the Mojave Basin Area. Albert A. Webb Associates, Riverside, CA.