FINAL DRAFT

Southern California Water Recycling
Projects Initiative Phase II

Technical Memorandum #2

Water Quality Analysis

Cooperative Effort Funded and Managed by:

The United States Bureau of Reclamation

In Partnership with:

Big Bear Area Regional Wastewater Agency
California Department of Water Resources
Central Basin and West Basin Municipal Water Districts
City of Los Angeles
City of San Diego
Los Angeles County Sanitation Districts
Metropolitan Water District of Southern California
Orange County Sanitation District
San Diego County Water Authority
Santa Ana Watershed Project Authority
South Orange County Wastewater Authority

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Abbreviations and Acronyms

AFY	Acre-Feet per Year
APEs	Alkylphenol Ethoxylates
AWWA	American Water Works Association
BARWRP	Bay Area Regional Water Recycling Program
BBARWA	Big Bear Area Regional Wastewater Agency
BLM	United States Bureau of Land Management
CAFOs	Confined Animal Feeding Operations
CWA	*Clean Water Act*
CZMA	*Coastal Zone Management Act*
DBPs	Disinfection By-Products
DDT	Dichlorodiphenyltrichloroethane
DER	Florida Department of Environmental Regulation
DFW	Dallas/Fort Worth
DHS	California Department of Health Services
DMA	Dimethylamine
DO	Dissolved Oxygen
DWR	California Department of Water Resources
EDCs	Endocrine Disrupter Chemicals
EDSTAC	Endocrine Disrupter Screening and Testing Advisory Committee
EDTA	Ethylenediamine Tetraacetic Acid
EfOM	Effluent Organic Matter

FDA	Food and Drug Administration
FIFRA	*Federal Insecticide, Fungicide, and Rodenticide Act*
FY	Federal Fiscal Year
GAC	Granular Activated Carbon
HAA5	Haloacetic Acids
HAAs	Hormonally Active Agents
HAHs	Halogenated Aromatic Hydrocarbons
IEMT	Initiative Executive Management Team
Initiative	Southern California Water Recycling Projects Initiative
Interior	United States Department of the Interior
LACSD	Los Angeles County Sanitation Districts
LC_{50}	50 Percent Lethal Concentration
MCL	Maximum Contaminant Level
mg/L	Milligram per Liter
mgd	Million Gallons per Day
MWD	Municipal Water District
MWDSC	Metropolitan Water District of Southern California
MWRSA	Monterey Wastewater Reclamation Study for Agriculture
NDMA	N-Nitrosodiumethylamine
NF	Nanofiltration
NOM	Natural Organic Matter
NPDES	National Pollution Discharge Elimination System
NRL	Chino Basin Non-Reclaimable Line

NTA	Nitrilotriacetic Acid
OCSD	Orange County Sanitation District
OCWD	Orange County Water District
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PPCPs	Pharmaceuticals and Personal Care Products
ppm	Parts per Million
Reclamation	United States Bureau of Reclamation
RO	Reverse Osmosis
RWC	Recycled Water Contribution
RWQCB	California Regional Water Quality Control Board
SARI	Santa Ana Regional Interceptor
SAWPA	Santa Ana Watershed Project Authority
SCCWRRS	Southern California Comprehensive Water Reclamation and Reuse Study
SDCWA	San Diego County Water Authority
SMPs	Soluble Microbial Products
SOCWA	South Orange County Wastewater Authority
SWRCB	California State Water Resources Control Board
SWTR	Surface Water Treatment Rule
TDS	Total Dissolved Solids
Thiram	Tetramethylthiuram Disulfide
THMs	Trihalomethanes
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon

TOX	Total Organic Halides
U.S.	United States of America
UF	Ultrafiltration
UIC	Underground Injection Control
UOSA WRP	Upper Occoquan Sewage Authority's Regional Water Reclamation Plant
USDW	Underground Source Of Drinking Water
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UV	Ultraviolet Disinfection
WEF	Water Environment Federation
WET	Whole Effluent Toxicity
WHO	World Health Organization
WRP	Water Reclamation Plant
WWTP	Wastewater Treatment Plant

1 Introduction

1.1 Contents of this Section

Project Background
Objective of the Study
Plan of Study

1.2 Project Background

The Southern California Water Recycling Projects Initiative (the Initiative) is a multiyear planning study commencing in Federal fiscal year (FY) 2000. The project is funded as part of the Southern California Investigations Program and is managed out of Reclamation's Southern California Area Office. The Initiative is funded on a 50/50 percent cost sharing basis between Reclamation and 10 local agencies and the State of California Department of Water Resources, who together form the Initiative's Executive Management Team (IEMT). Table 1.1 lists the 11 members of the IEMT. The purpose of the IEMT is to formulate, guide, and manage the technical activities of the project.

The Initiative is composed of two major components, a project-specific work component and a regional component. The project-specific work component consists of identifying and funding recycled water planning projects, including projects developed as a result of the Southern California Comprehensive Water Reclamation and Reuse Study (SCCWRRS) effort. The regional component consists of performing work in the following categories; public information and education, financial support opportunities, and evaluation of regional concerns, including water quality. The purpose of this technical memorandum is to discuss the work performed as part of the water quality analysis.

TABLE 1.1
LIST OF IEMT MEMBERS

Big Bear Area Regional Wastewater Agency	Orange County Sanitation District
California Department of Water Resources	San Diego County Water Authority
Central Basin and West Basin MWD	Santa Ana Watershed Project Authority
City of Los Angeles	South Orange County Wastewater Authority
Los Angeles County Sanitation Districts	U.S. Bureau of Reclamation
Metropolitan Water District of Southern California	

1.3 Objective of the Study

The goal of the Initiative is to build upon the regional coalition efforts begun during SCCWRRS. This will be accomplished by continuing the work begun during SCCWRRS to assist local water and wastewater agencies in the final planning and documentation leading to implementation of their recycled water projects. The projects funded by the Initiative will include projects identified in SCCWRRS and new projects identified by local agencies since SCCWRRS has been completed. In addition, through the Initiative Reclamation continues to facilitate the regional partnership as well as investigate further the projects developed during SCCWRRS. The Initiative also assists local agencies in addressing regional concerns including:

- Development of a regional water quality issues analysis to investigate impediments to successful water recycling project implementation in southern California.
- Development of a program addressing a public information strategy designed to assist southern California water and wastewater agencies in successfully implementing their recycled water projects.
- Development of a compendium of successful project implementation strategies and provide a source list and a guide outlining how to apply for financial/funding options for recycled water projects.

1.4 Plan of Study

The Plan of Study for the Initiative Phase II includes five major tasks:

- Implementation of project-specific work.
- Implementation of regional work.
- Identification of project-specific work, allocation of funding, and preparation of Cooperative Agreements.
- Identification of tasks and budget allocation for the next phases of the Initiative.
- Administration of Initiative Phase II work identified in the Plan of Study.

The two largest items of work in Phase II are the project specific and regional work components. The remaining tasks are related to budget allocation, funding, and managing the work. The project-specific work consists of entering into cooperative agreements with the project sponsors, monitoring and reporting on the progress of these projects, and reviewing deliverables. This work will continue on an annual basis but will be dependent on funding allocation.

The regional work is defined as actions that benefit local agencies in the implementation of water recycling in southern California. During the development of the Plan of Study, the IEMT identified issues that need to be addressed during implementation of water recycling projects, including water quality impacts, methods to address public and regulatory agencies' concerns, funding considerations for future phases, and environmental impacts. The IEMT also identified broader "universal" issues that could be addressed on a regional or subregional basis to avoid duplication of effort by multiple agencies addressing the same concerns. The IEMT determined to focus the regional work on the following issues:

- Consideration of regional water quality issues and concerns related to implementation of a recycled water program throughout southern California with respect to public health, surface waters, groundwater, and receiving waters for brine and remaining effluent disposal.
- Preparation of an overall description of successful implementation strategies and approaches to obtain financial support for recycled water projects.

- Development of a program to address public perception issues regarding recycled water and its uses, and communication of the overall objectives for the Southern California Water Recycling Projects Initiative.

This technical memorandum focuses on the water quality issues component of the regional work. The water quality component examines water quality concerns related to public health, public perception, regulatory issues, and other resources that could be benefited or impacted by recycled water projects. The analysis focuses on contemporary water quality conditions that affect recycled water acceptance and use, such as industrial chemicals, natural pollutants, and pharmaceutical wastes existing in the wastewater. Potential impacts to surface water flows, groundwater levels, surface water and groundwater quality, and biological resources are also examined. In addition, public concerns regarding potential changes to public health risks associated with the use of recycled water, and resulting from conditions on waters and lands are discussed. The Water Quality Issues Analysis will consist of six major tasks as listed below and described in the following subsections.

- **Task 1:** Define alternative water recycling futures.
- **Task 2:** Define interactions with other water management projects.
- **Task 3:** Develop final scenarios.
- **Task 4:** Identify potential constraints and benefits of scenarios.
- **Task 5:** Conduct reconnaissance-level analysis of impacts, benefits, costs, and options for responding to the issues identified.
- **Task 6:** Prepare a summary report.

The following Technical memorandum describes the process and conclusions garnered from Tasks 1 and 2 in the water quality component of the regional work.

2 Water Quality Analysis Procedure

2.1 Contents of this Section

2.2 Introduction

In recent years, concerns have been raised by the public about potential water quality issues associated with the use of recycled water. These concerns have been focused on the potential that chemical or pharmaceutical constituents may remain in the recycled water and therefore, could cause public health or water quality problems. These concerns are being expanded due to regulatory and public pressure, which result from public health concerns. Additional issues of concern include brine disposal, salinity management, level of usage, and type of use. Local water recycling agencies are also concerned about the impacts of future changes or new regulation on recycled water projects.

In response to the concerns listed above, the IEMT developed a process to analyze water quality concerns. The objective of the water quality component of Phase II of the Initiative is to assist in developing a thorough scientific response to the public concerns about the use of recycled water. This effort is focused on informing the recycled water users, suppliers, and industry by providing a description of issues as well as a discussion and definition of a reasonable range of solutions. Specifically, the analysis examines the impacts of increased water recycling on receiving waters as well as public health and safety. In addition, the analysis will focus on water quality conditions that affect recycled water acceptance and use such as industrial chemicals, natural pollutants, and pharmaceutical constituents existing in the wastewater. The initial step in the development of the water quality analysis is described in this technical memorandum, which outlines how the process was developed as well as the steps this analysis will follow.

2.3 Development of the Water Quality Analysis

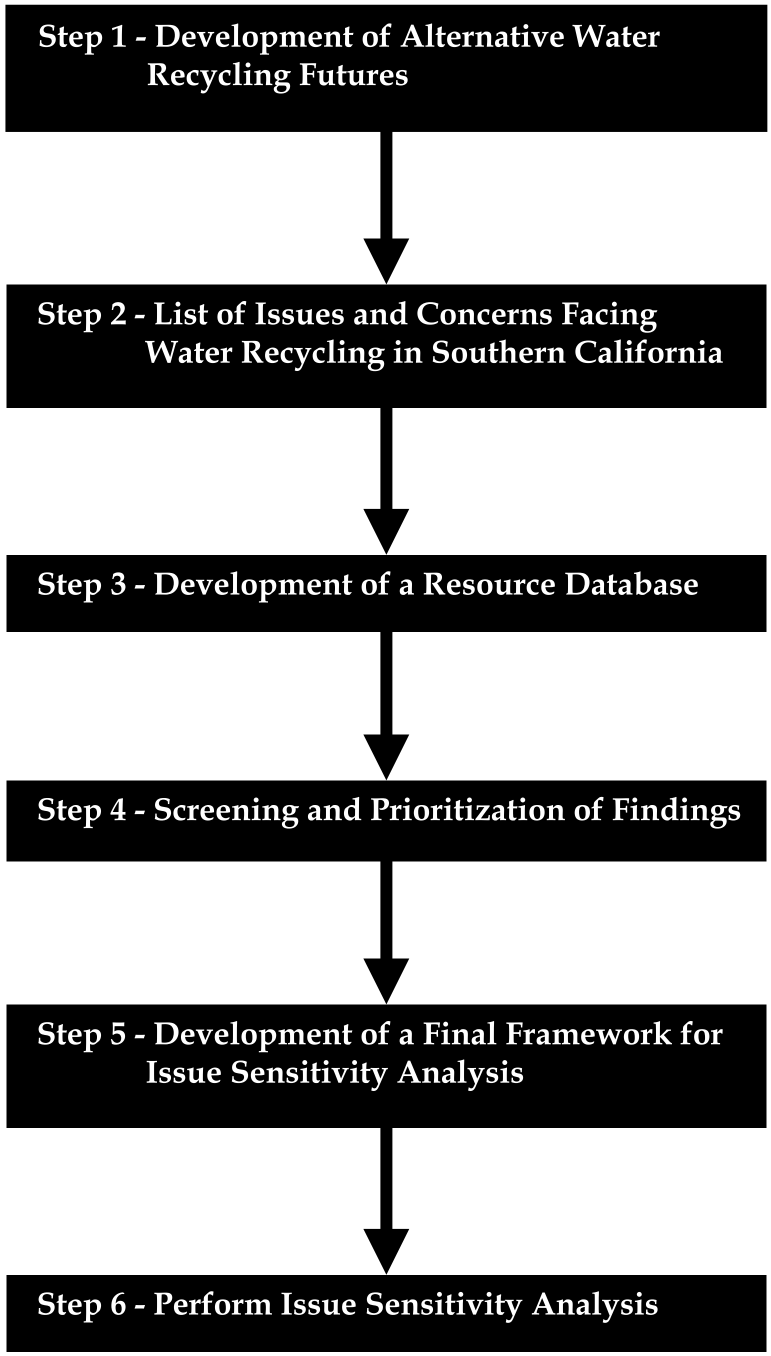
The water quality analysis was developed as a six-step process. This process is illustrated in Figure 2.1. The first step in the process was the development of the alternative water recycling futures. These futures were developed by outlining the purpose and needs for this analysis. It was evident after the purpose and needs were determined, that a more specific list of issues needed to be developed to address the concerns facing water recycling in southern California. Therefore, the next step in the process was to develop a list of issues, through a series of workshops. The issues were grouped together under six major concerns. These concerns were identified by the IEMT to be the key items facing recycled water use in southern California. The third step in the process was to develop a resource database. The resource database's purpose was to compile existing as well as ongoing work that related to the issues and concerns. The database was utilized to summarize the available information as well as to identify where informational gaps exist in the research.

After the available information was catalogued and informational gaps identified, the issues and concerns were screened and prioritized. The screening and prioritization process was the fourth step in the analysis. This step determined the issues that required additional analyses as well as the order that the concerns would be analyzed. The next step in the analysis process was to develop a final framework. This framework outlined how the issue sensitivity analysis was to be performed. The last step in the analysis was to perform the issues sensitivity analyses.

This technical memorandum describes the work performed and process for steps one through five. These steps encompass the development of the list of issues and concerns as well as the resource database. The remaining step (step six) will be described in the final report for the Initiative. The main focus of this technical memorandum will be to describe the available information on each of the concerns by addressing the list of issues that were developed. In addition, this memorandum will outline what information exists as well as where there are informational gaps. The remainder of the water quality analysis will be discussed in the final report. This final report will also provide information regarding the issue sensitivity analyses.

FIGURE 2.1

SIX STEP WATER QUALITY ANALYSIS PROCESS



Another component of the water quality analysis will be the development of technical memoranda discussing specific issues, concerns, and any conclusions. The findings from these technical memoranda will be summarized in the final report and their text will be attached in the appendices.

2.3.1 Step 1 - Alternative Water Recycling Futures

The initial step in the water quality analysis is to develop alternative water recycling futures. Alternative water recycling futures are scenarios that describe the future implications of how recycled water will be regulated and managed. These scenarios deal with the impacts of changing water chemistry, level of use, type of use, and environmental conditions on the ability to recycle water. In order to develop a linkage between the alternative water recycling futures and water recycling in southern California, a purpose and needs statement was developed.

The purpose and needs statement outlines the drivers for the alternative water recycling futures. The purpose of the alternative water recycling futures is to develop scenarios to quantify ranges of mass loadings and impacts, to develop comparisons of regulatory standards, as well as to develop costs. This purpose was determined by asking a number of questions including the following:

- What are the issues facing recycled water in southern California?
- How does the source of water effect the chemical composition of recycled water?
- How do changes in chemical composition of recycled water effect and result in impacts to the cost of producing recycled water?

The purpose and needs statements were subdivided based on more specific issues and concerns, which were developed by the IEMT.

2.3.2 Step 2 - Issues and Concerns Facing Water Recycling in Southern California

The IEMT developed a list of issues and concerns through a number of brainstorming sessions. Through these sessions the IEMT was able to provide input as well as their expert knowledge of the water recycling environment in southern California. Appendix A contains the minutes from the IEMT brainstorming sessions. The development of the list of issues focused the water quality analysis on specific issues and concerns related to recycled water. This approach to water recycling diverges from past efforts (i.e. SCCWRRS), which were focused on matching recycled water supplies with demands in the least costly way, thus developing a regional recycled water system. After the list of specific current and potential future issues facing water recycling in southern California was developed, the issues were grouped under one of six major categories of concerns. The categories of concern are brine, level of use, regulations, salinity, use type, and water chemistry. Table 2.1 provides a list of the specific concerns and issues facing water recycling in southern California.

2.3.2.1 Brine

The management of brine is an emerging issue that will increase in significance as water recycling is expanded in southern California. The significance of brine is based on the reality that as water recycling expands in the region, there will be an increase in brine production. This is important because increased concentrations and volume of brine discharge may impact the habitats and ecosystems near outfalls, or result in regulatory changes. There are a number of key issues that need to be addressed as part of the water quality analysis as it pertains to brine, these include but are not limited to the following questions:

- What are the effects of concentrating constituents of concern in brine flow?
- How does increased brine flow impact habitats?
- Does the use of seawater affect brine concentration and capacity in brinelines and outfall pipelines?
- What are alternative methods for brine disposal?
- What are the impacts, methods, and costs of brine disposal?

These issues need to be investigated in regards to ocean as well as inland discharges and production of brine. Other issues that are of concern regarding brine in southern California can be seen in Table 2.1 under the brine concern heading.

2.3.2.2 Level of Use

The second concern deals with the amount of water that can be recycled. This concern focuses on how much recycling can occur based upon impacts of salinity, assimilative capacity of

TABLE 2.1

ISSUES AND CONCERNS FACING WATER RECYCLING IN SOUTHERN CALIFORNIA

Brine
What are the effects of concentrating constituents of concern in brine flow?
How does brine concentration (and at what level) affect coastal habitats?
How does increased brine generation impact the ocean?
How does the use of seawater affect brine concentration and capacity in brinelines/outfall pipelines?
What are alternative methods for disposal (deep well injection)?
What are the impacts/methods/costs for disposal of increased brine?
What level of brine concentration affects habitat negatively?

Level of Use
What level of recycled water use will result in regulatory changes by agencies?
How much availability (existing and future) is there for use of recycled water (salt level, TOC (health concerns), nitrogen, physical operation of barrier)?
Can there be too much recycling (salt loading)?
How much availability is there for use of recycled water for production/assimilative capacity?
What are the effects of reducing influent salinity into system (leaching of soil)?
What are the effects of salinity on basin receiving waters and the environment?
What level of salinity is of concern / What are the costs associated with salinity on recycled water?
What upstream projects are being considered to change (either positively or negatively) salinity?
When and what type of upstream measures make source control a viable measure?
When does the cost of source control exceed the cost to RO MWDSC supply?
Which levels of concentration are a concern to stakeholders and users?
What are the effects of other constituents on recycled water (i.e. bromide, pharmaceuticals)?
How does the use of recycled water effect groundwater systems?
What are the impacts of high levels of recycling?
What effects does water conservation have on water reuse?
What level of discharge is required to protect existing riverine habitats (min and max flows)?
How will and what will be the effects of changes in the discharge regulations (including return flows) on recycled water use?

Regulations
How will and what will be the effects of changes in the discharge regulations (including return flows) on recycled water use?
How will changes in beneficial use designations in the basin plans affect recycled water use?
How will changes in regulations such as using drinking water goals as MCLs impact recycled water?
How will future regulations affect change in use of recycled water?
Will changes to regulations limit or expand recycled water use?
How do discharge requirements (existing and future) affect recycled water use?
How will changes in recycled water use affect water rights?
How will changes in the *Clean Water Act* affect recycled water use?
How will changes in the *Ocean Plan* affect recycled water use?
How will SWRCB handle appeals to permits and use beneficial use designations related to recycled water?
What are the effects of new discharge regulations on the environment?
What are the issues affecting use of recycled water for transport/storage/ potable use?

TABLE 2.1 (CONT.)

ISSUES AND CONCERNS FACING WATER RECYCLING IN SOUTHERN CALIFORNIA

Regulations (Cont.)
What level of recycled water use will result in regulatory changes by agencies?
What are the regional differences in groundwater management and regulations pertaining to recycled water?
What is the cost associated with discharging to meet more stringent regulations versus implementing recycled water projects?

Salinity
How much availability (existing and future) is there for use of recycled water (salt level, TOC (health concerns), nitrogen, physical operation of barrier)?
Can there be too much recycling (salt loading)?
How much availability is there for use of recycled water for production/assimilative capacity?
What are the effects of reducing influent salinity into system (leaching of soil)?
What are the effects of salinity on basin receiving waters and the environment?
What level of salinity is of concern / What are the costs associated with salinity on recycled water?
What upstream projects are being considered to change (either positively or negatively) salinity?
When and what type of upstream measures make source control a viable measure?
When does the cost of source control exceed the cost to RO MWDSC supply?
Which levels of concentration are a concern to stakeholders and users?

Use Type
What are the regional differences in groundwater management and regulations pertaining to recycled water?
How does water chemistry effect treatment processes for recycled water production?
What are constituents of concern for users?
How does transport/storage of recycled water affect the environment (based on different treatment levels)?
How does use of recycled water affect discharge both within and to the treatment plant?
How does use of recycled water affect discharge/runoff?
How does use of seawater desalination affect influent water quality?
What are the aesthetic concerns facing the use of toilet flushing including color, odor, and effects on plumbing mechanisms?
What are the barriers to use of recycled water for urban irrigation?
What are the effects of recharging recycled water (quality concerns positive and negative)?
What is the current and future potential market for toilet flushing and is the market cost effective?
How will changes in beneficial use designations in the basin plans affect recycled water use?
How will changes in regulations such as using drinking water goals as MCLs impact recycled water?
How will future regulations affect change in use of recycled water?

Water Chemistry
What are the effects of concentrating constituents of concern in brine flow?
What are the effects of other constituents on recycled water (i.e. bromide, pharmaceuticals)?
How does water chemistry effect treatment processes for recycled water production?
What are constituents of concern for users?
How much availability (existing and future) is there for use of recycled water (salt level, TOC (health concerns), nitrogen, physical operation of barrier)?

river and stream systems, groundwater basins and ecosystems, cost constraints, and regulatory changes. In addition, this concern focuses on what impacts water conservation and upstream source control has on water recycling. Also, the impacts of water recycling on riverine habitats due to changes in levels of wastewater discharges need to be investigated. Key issues that need to be addressed as part of the water quality analysis on the level of use concern include but are not limited to the following questions:

- What level of recycled water use will result in regulatory changes by agencies?
- Can there be too much recycling?
- How much availability is there for use of recycled water for production or assimilative capacity?
- What are the impacts of high levels of recycling?
- What level of discharge is required to protect riverine habitats (minimum and maximum flows)?

All of these issues, along with additional issues of concern contained in Table 2.1 under the level of use concern, need to be investigated in the context of maximizing water recycling in southern California.

2.3.2.3 Regulations

Changes in the regulatory environment are another major concern facing water recycling agencies in southern California. Regulatory constraints are important because of the potential impacts they impart on existing as well as future recycled water projects. It is important for water recycling agencies to understand both the current as well as proposed regulations as they plan for the future of water recycling programs. In addition, regulations must be examined at the federal, state, and local level. Regulatory changes that could affect the ability of recycled water projects to be implemented include changes to the Regional Water Quality Control Board's (RWQCB) basin plan as well as to the ocean plan objectives. Also, regulatory policy changes could result in additional wastewater treatment, such as tertiary treatment, nitrification-denitrification, or metals removal, thus affecting the effluent quality. There are a number of key issues that need to be addressed as part of the water quality analysis describing regulations including, but not limited to the following questions:

- How and what will be the effects of changes in the discharge regulations on recycled water use?
- How will changes in beneficial use designations in the basin plans affect recycled water use?
- How will California State Water Resources Control Board (SWRCB) handle appeals to permits and beneficial use designations related to recycled water?
- What level of recycled water use will result in regulatory changes by agencies?
- How will changes in regulations such as using drinking water goals as maximum contaminant levels (MCLs) impact recycled water?
- What is the cost associated with discharging to meet more stringent regulations versus implementing recycled water projects?

In addition to the issues listed above, Table 2.1 contains more issues under the regulatory concern. It is important to investigate issues that can affect regulations so water recycling agencies will have relevant information to provide to the public as well as regulators. This information must be based on sound scientific as well as empirical evidence to assist regulators in developing future regulations. In addition, this information could be utilized to assist in alleviating public concerns about a particular constituent.

2.3.2.4 Salinity

The fourth concern is salinity. Salinity is significant on a local as well as regional level. The local impacts of increased salinity include impacts to water quality, treatment systems, ecosystems and habitat, and potential regulatory changes. The salinity issue is an emerging issue of concern, especially due to stringent regulatory standards being implemented on dischargers. Additional regulations are a concern because as high salinity water supplies are imported into the southern California region, salinity concentrations in wastewater increases. This is due in part to the salt loadings in the Colorado River as well as in State Water Project water. In addition, salt levels increase as the water moves downstream and more wastewater enters the system making downstream users responsible for removing ever-increasing amounts of salt. The scope of the salinity issue requires that this concern be looked at on a local as well as regional level. Key issues that need to be addressed as part of the water quality analysis for salinity include but are not limited to the following questions:

- What are the effects of reducing influent salinity into system?
- What are the effects of salinity on basin receiving waters and the environment?
- What level of salinity is of concern?
- What are the costs associated with salinity on recycled water?
- What upstream projects are being considered to change salinity?
- When and what type of upstream measures make source control a viable measure?
- When does the cost of source control exceed the cost to reverse osmosis (RO) MWDSC supply?

In addition to the questions listed above, Table 2.1 provides more issues relating to salinity. The key regional issue that should be considered when investigating salinity is the effect of upstream Colorado River and CALFED salinity management programs. These upstream programs could reduce salinity of imported water supplies and thereby reduce salinity of the resulting wastewater.

2.3.2.5 Use Type

Use type is an issue of concern due to the different regulatory as well as markets constraints on recycled water. Recycled water can be utilized to supply a number of different use types including, urban and agricultural irrigation, commercial or industrial use, potable and non-potable water supply, and gray water. Each of these use types has different regulatory, chemical, constituent, and aesthetic requirements. There are a number of key issues that need to be addressed as part of the water quality analysis relating to use type, including but not limited to the following questions:

- What are constituents of concern for users?
- What are the aesthetics concerns facing the use of toilet flushing including color, odor, and effects on plumbing mechanisms?
- What are the barriers to use of recycled water for urban irrigation?
- What are the issues affecting use of recycled water for transport, storage, or potable use?
- What is the current and future potential market for toilet flushing and is the market cost effective?

- How will future regulations affect change in use of recycled water?

All of these issues, along with additional issues of concern are contained in Table 2.1 under the use type concern, need to be investigated in the context of maximizing water recycling in southern California. In addition, use type is important to investigate because future uses of recycled water will depend upon the ability of agencies to meet regulatory requirements as well as find suitable uses for the water. Recycled water use is important because it serves to assist in drought proofing areas by reducing use of potable water for non-vital uses.

2.3.2.6 Water Chemistry

Water chemistry is a major concern facing water recycling in southern California. It is significant due to emerging constituents of concern and more stringent regulation of constituents. The major obstacle facing water recycling agencies are perceived public concerns regarding constituents that may or may not pose a public health risk or are even present in the recycled water. These concerns have lead to the delayed implementation of a number of projects in southern California. In addition, public concerns are significant because regulators react to them by implementing new constraints on the recycled water agencies. Included in the potential recycled water quality concerns are constituents such as N-Nitrosodiumethylamine (NDMA), pharmaceutical residuals such as endocrine disrupters or antibiotics, metal compounds, and organic compounds. Key issues that need to be addressed as part of the water quality analysis for water chemistry include but are not limited to the following questions:

- What are the effects of other constituents on recycled water (i.e. bromide, pharmaceuticals)?
- How does water chemistry effect treatment processes for recycled water production?
- What are the effects of concentrating constituents of concern in brine flow?
- What are constituents of concern for users?
- How much availability (existing and future) is there for use of recycled water? (Salt level, TOC (health concerns), nitrogen, physical operation of sea water barrier)

In addition, to the questions listed above Table 2.1 provides more issues under the water chemistry concern.

2.3.3 Step 3 - Resource Database

The resource database was developed to determine what research information was available on the issues and concerns. The database is an effort to assemble known sources of information in a central location so that the historical as well as emerging science and technological advances relating to a particular issue can be easily compiled. In addition, the compilation of this information is an important component to determining what level of analysis is required for a particular issue or concern. The resource database was developed in three steps. The steps included identification of source material, cataloguing of source material, and developing summaries for the acquired source material.

2.3.3.1 Identification of Source Material

The initial step in the creation of the resource database process was to identify potential sources of information as well as what information was available. The resource search was limited to sources prepared after 1990 to reflect more recent findings and regulatory requirements. A majority of the sources are from information developed after 1998. The source material was primarily obtained from the following sources:

- American Water Works Association (AWWA) Journal and Conference Proceedings
- American Water Works Association Research Foundation
- AWWA Membranes, Desalting and Reuse Committee White Papers and Manuals
- Center for Sustainable Water (Arizona State University)
- Environmental Toxicology Chemistry
- Federal Register
- National Academy of Sciences
- National Center for Sustainable Water Supply
- National Water Research Institute
- University of California Library
- U.S. Department of the Interior
- Washington State Department of Ecology
- Water Environment Federation Journal and Conference Proceedings
- Water Environment Research Foundation

- WateReuse Research Foundation
- WateReuse Symposium Proceedings
- Water Science and Technology
- WEF Reuse Committees White Papers and Manuals

Selecting information from these agencies and professional organizations provided a selection of ongoing as well as existing projects and research.

2.3.3.2 Cataloguing of Source Material

The next step in the process was to compile the information into a useable format. It was determined that the most effective and efficient manner of synthesizing the acquired data was to compile and catalogue the information into a database. Using a database provided the ability to query for information on a particular subject. The resource database contains the following basic bibliographic information regarding each source:

- Author Name
- Title of Work
- Date Published
- Source of Material

The resource database is attached as Appendix B. The database also contains a field that matches the source to one or more of the six major concerns facing water recycling in southern California. This matching allows the database users to query for sources related to a specific concern. The source material is also cross-referenced to the specific issues contained in Table 2.1. The list of issues and concerns with the corresponding cross-referencing codes are included in Appendix B. In addition, the resource database has a field for specifying if the document provides information regarding a particular constituent of concern. The final field in the database is a library code, which enables the materials to be catalogued by subject matter.

2.3.3.3 Developing Summaries for the Acquired Source Material

The final step in the development of the resource database was to generate summaries of the source material. Each synopsis consists of the title name, author name, reference codes, library code, sponsoring agency, and a brief write-up of the relevant information contained within the document as it pertains to water recycling in southern California. The summaries of the source material are contained on the CD enclosed in Appendix C.

2.3.4 Remaining Steps - Summary of Findings Regarding Source Material

The next step in the water quality analysis was to develop the findings regarding the source material. These findings consist of determining what concerns have sufficient information and research to address the issues related to them. In addition, the findings highlight areas where supplementary research or information is required to address the issues and concerns. These findings seek to address the issues and concerns by determining the following:

- What is known or unknown regarding the issue?
- What are the impacts of the issue on the future of recycled water (what, where, how much)?
- Is there enough information to perform an issues sensitivity analysis?
- What is the level of effort required to perform an issues sensitivity analysis?
- How will development of an issues sensitivity analysis benefit the water recycling in the southern California region?

The focus of Section 3 of this technical memorandum is to provide the responses to these questions. The source material in Section 3 is composed of four discussions:

- **Regulations.** Describes prevalent regulations relating to water reuse in California, the United States, and internationally.
- **Use Type.** Describes the types of water reuse as well as potential future implications related to the level of water reuse.
- **Water Chemistry.** Describes a number of constituents of concern for water reuse and addresses the issue of brine management.
- **Salinity.** Describes and discusses the salinity problem in southern California including sources, impacts, and relevance to water reuse.

3 Summary of Findings from Source Material

3.1 Contents of this Section

Introduction
Regulations
Use Type
Water Chemistry
Salinity
Recommendations and Conclusions

3.2 Introduction

The use of recycled water will continue to expand in the future due to population growth, limited supply of freshwater resources, and water scarcity due to climatic and atmospheric conditions, such as droughts. It is important to determine what level of reuse is acceptable and safe to implement before water recycling levels increase. This is important because recycled water will assist in maintaining potable water supplies, meeting water supply needs for population growth, and in managing water supplies to meet climatic and atmospheric inducted phenomenon. The major concerns facing increased use of recycled water are:

- Aesthetics
- Health and safety
- Public perceptions
- Water quality; including the effects of salinity and other constituents on crops and manufacturing processes and feasible brine management opportunities in the future

It is important to address these concerns and provide the public with evidence regarding both the safety and the need for recycled water use. The following sections will describe four areas of importance to implementing water recycling projects. These are regulations, use type, water chemistry, and salinity. All of these issues are significant due to the impacts they have on the ability of semi-arid southern California to utilize recycled water. Figure 3.1 and Table 3.1 provide a schematic of the recycled water hydrodynamic cycle in southern California.

The process diagram (Figure 3.1) will be utilized in the following sections to illustrate where regulations, uses, water chemistry, and salinity impact the recycled water hydrodynamic system. The recycled water hydrodynamic cycle process diagram originates at the raw water source(s) of the system, whether it is a river (A1), reservoir (A2), groundwater basin (A3), or some combination of these sources. The diagram shows the typical path of water as it flows through various systems and indicates where it is used (D, E, F, G) and treated (B, C, H, I, K, M). There are four use types described in the diagram, they are habitat (D), agricultural use (E), urban irrigation (F), and municipal or industrial uses (G). Each of these use types, except agricultural and habitat, require some water treatment (B) of raw water. In addition, to standard water treatment, some users may require supplementary user specific treatment (C). Once water is used by one of the four use types (D, E, F, G), it is either discharged directly to a river (L) or the ocean (N); treated at a return flow WWTP/Pretreatment (H) and discharged to a river (L), the ocean (N), or a WWTP (I); or treated at a WWTP (I) and either discharged to a river (L), the ocean (N), or a WRP (K).

After the water is treated for reuse at a WWTP (I) or WRP (K), it can be supplied to users. Some applications, which have limited human contact such as fodder irrigation, can be supplied water that has undergone only secondary treatment. However, if the water undergoes tertiary or advanced treatment at a WRP (K), it can be supplied to a wider group of users including agricultural users (E), urban irrigation (F), municipal users (G), or industrial users (G), habitat for beneficial use (D), or be blended with raw or potable water for groundwater recharge (A3). Water utilized for urban irrigation (F), municipal uses (G), or industrial uses (G) may undergo further treatment (C) to produce water that is specifically suited for the intended use. In addition, water utilized for municipal (G) or industrial purposes (G) may undergo a post-use treatment process (H) before the water is discharged to surface waters (L or N). Water utilized for beneficial use of habitat (D) will return flow into surface waters (L or N).

Water that is recharged into a groundwater basin (A3) may intermingle through seepage with surface water (L) or the ocean (N). In addition, groundwater can be pumped and treated

(A3), after a sufficient detention time, which is determined and approved by the RWQCB and DHS. This water can be used as a potable water source that is supplied to end users (F).

Each time a treatment process (B, C, H, I, K, M) occurs in the system there is a potential for the creation of brine concentrate and residuals, which also impact the recycled water system. These residuals are important because they may require additional treatment (M) in the future. Another emerging source of concern in the implementation of recycled water projects is dry weather runoff (J). Dry weather runoff has two potential impacts that may effect recycled water; they are the effects on treatment processes due to constituents contained in runoff which may be seeping into the waste stream and the effects of the runoff on riverine (L) and oceanic (N) environments. These issues are both significant to recycled water because of the potential impact they could have on the ability to implement projects from a treatment and economic perspective.

TABLE 3.1

RECYCLED WATER FLOW DIAGRAM NODE DESCRIPTION

Node	Node Description
A1	River Supply Source
A2	Reservoir/ Surface Water Supply Source
A3	Groundwater Supply Source
B	Water Treatment Plant
C	User Specific Water Treatment Plant
D	Habitat User
E	Agricultural User
F	Urban Irrigation User
G	Municipal/Industrial User
H	Return Flow WWTP/ Pretreatment
I	Wastewater Treatment Plant
J	Dry Weather Runoff
K	Water Reclamation Plant
L	River Supply Source
M	Brine Treatment Plant
N	Ocean

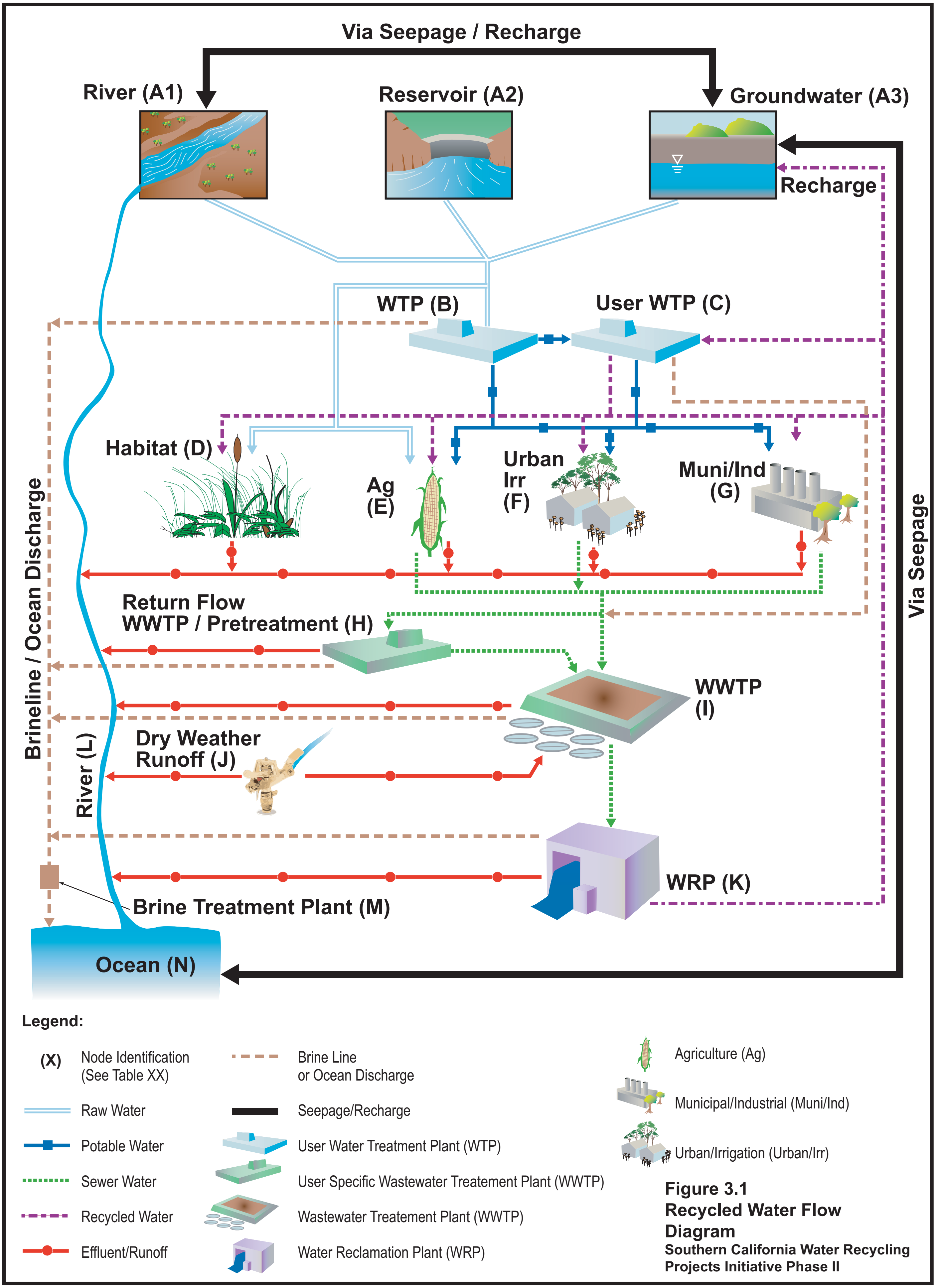


Figure 3.1
Recycled Water Flow Diagram
Southern California Water Recycling Projects Initiative Phase II

W052002001SCO157370.P2.T1.1B salinity2 ai 7/02

3.3 Regulations

3.3.1 Introduction

Recycled water has been used in many forms for hundreds of years. The first utilization of recycled water was to supply low quality wastewater as a water supply for crop irrigation. This type of reuse has continued without regulation during a majority of human history especially in undeveloped areas of the world where it continues to occur. However, there were concerns about pathogen exposure, especially associated with reuse for irrigation on food crops. It was not until the late 20th century that water reuse regulations were widely placed into effect in many parts of the world. California has had some form of water reuse regulations since the early 1900's. The first regulation of reuse occurred in California in 1906 when the California State Board of Health suggested that Oxnard use septic tank treatment of water before utilizing wastewater for crop irrigation. Table 3.2 outlines significant milestones in the development of water reuse guidelines and criteria.

Until the 1960's, water reuse regulations in California primarily focused on reuse as a supply source for irrigation of crops. In the 1960's, the focus of regulations shifted to concentrate more specifically on the protection of human health and prevention of contamination of the crops. In 1975, treatment reliability requirements were incorporated in the water reuse regulations and issued in the *Wastewater Reclamation Criteria*. The 1975 regulations set treatment requirements as well as water quality requirements for the effluent. The 1975 *Wastewater Reclamation Criteria* were amended in 1978 to include reuse of water for landscape irrigation and groundwater recharge. The most recent update to these regulations, done in 2000, set forth modifications of the treatment and water quality requirements, and included a dual water system requirement, cross connection control requirements, and use area requirements.

In addition to the guidelines set up in California, a number of other states in the United States (U.S.) have implemented water reuse regulations. Arizona established reuse guidelines in 1985 that are similar to those in California but are based on numeric values and not treatment processes. Florida first adopted its guidelines for *Reuse and Reclaimed Water and Land Application* in 1989.

On a Federal level, the U.S. Environmental Protection Agency (USEPA) published its first set of guidelines in 1992. These guidelines were entitled *Guidelines for Water Reuse* and were developed based on existing regulations in states such as California and Florida. The USEPA guidelines were designed to be used in a flexible manner with state regulations to encourage water reuse project implementation by recommending treatment processes, water quality limits, monitoring frequencies, setback distances, and other controls for reuse projects. Due to the built-in flexibility of these guidelines, individual state-adopted guidelines vary across the U.S.

The World Health Organization (WHO) released WHO guidelines as international rules adopted primarily to assist developing countries in implementing safer reuse of water. The WHO guidelines are less stringent than many guidelines that have been implemented in the U.S. or other developed countries. This is due to the focus of the guidelines on encouraging water reuse as a water source and a focus on direct-contact health concerns.

3.3.2 Application of Regulations on Reuse Projects

Regulations impact the location within the recycled water hydrodynamic system where water is treated for use, treated before discharge to surface waters, or recycled. Figure 3.1 and Table 3.1 provide a schematic of the recycled water hydrodynamic cycle in southern California. Figure 3.1 will be used to delineate where regulatory requirements are imposed on recycled water.

From the originating water source of the system, whether it is a river (A1), reservoir (A2), groundwater basin (A3), or some combination of the sources, each time water is used or treatment occurs, there is a potential for the need for regulatory compliance. Recycled water utilized for agricultural (E) must meet an undisinfected secondary standard treatment requirement. However, crops where recycled water comes in direct contact with the edible portion of the crop must be supplied with disinfected tertiary treated recycled water.

Table 3.2
Milestones in the Development of Water Quality Criteria and Reuse Implementation

Year	Water Reuse Milestone
1906	California State Board of Health suggested that Oxnard use septic tank treatment of water before utilizing wastewater for crop irrigation.
1907	California State Board of Public Health in its *April 1907 Bulletin* requested that local health authorities "watch irrigation practices" and not allow use of "sewage in concentrated form and sewage-polluted water … to fertilize and irrigate vegetables which are eaten raw, and strawberries."
1910	California State Board of Public Health in its *March 1910 Bulletin* issued the following statement supporting reuse, "In California, where water is so valuable for irrigation, the utilization of sewage for broad irrigation should be carefully considered."
1918	California State Board of Public Health adopted its *Regulation Governing Use of Sewage for Irrigation Purposes.* These regulations prohibited the use of raw sewage for crop irrigation and ,limited the use of treated effluents to irrigation of nonfood crops and food crops that were cooked before being eaten or did not come in contact with wastewater.
1926	Construction of 130,000 gpd activated sludge plant with subsequent rapid sand filtration and chlorination at Grand Canyon Village, Arizona.
1929	City of Pomona, California began using reclaimed wastewater for landscape and garden irrigation
1932	Large-scale landscape irrigation began at Golden State Park in San Francisco, California.
1933	California State Board of Public Health revises and renames regulations, *Regulations on the Use of Sewage for Irrigating Crops*. These regulations contain the first appearance of cross connection control regulations.
1942	Bethlehem Steel Company in Baltimore, Maryland began using chlorinated secondary effluent for primary metals cooling and steel processing
	Kaiser Steel Corporation began operation of 1st California wastewater treatment facility for industrial reuse of wastewater.
1949	The Water Pollution Control Act was passed which eliminated the permit system that constituted the statutory basis for California's *Regulations on the Use of Sewage for Irrigating Crops.*
1953	The *Regulations on the Use of Sewage for Irrigating Crops* were reissued as part of the California Administrative Code and entitled *Regulations Relating to Use of Sewage for Irrigating Crops*.
1960	California Legislature enacted laws designed to encourage water reclamation and reuse.
	City of Colorado Springs, Colorado began reusing water for landscape irrigation on golf courses, parks, cemeteries, and freeways.
1961	Irvine Ranch Water District began reusing water for irrigation, industrial and domestic uses.
1962	Recycled water is used for irrigation of citrus plants and to reduce saltwater intrusion into groundwater in La Soukra, Tunisia.
	Groundwater recharge with reclaimed wastewater at Whittier Narrows in Los Angeles area marked the first deliberate introduction of reclaimed wastewater into groundwater via surface spreading which served as sources of domestic water supply.

Table 3.2
Milestones in the Development of Water Quality Criteria and Reuse Implementation

Year	Water Reuse Milestone
1963	*Water Quality Criteria* , Second Edition edited by J.E. McKee and H.W. Wolf was published as Publication No. 3-A by the Resources Agency of California, State Water Resources Control Board, Sacramento, California.
1967	Tertiary treated effluent from Lake Tahoe, California was transported to a reservoir for recreational use and for irrigation of nearby ranches.
1968	Department of Public Health enacted the *Statewide Standards for the Safe Direct Use of Reclaimed Water for Irrigation and Impoundment*. These regulations focused on treatment and quality requirements intended to assure that the use of reclaimed water would not impose undue risks to the public health.
	Publication of *Water Quality Criteria (Green Book)* , Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration.
1969	City of Wagga Wagga, Australia begins using reusing water for landscape irrigation of sporting fields, lawns, and cemeteries.
	First deliberate use of reclaimed sewage effluent to directly supplement a town's potable water supply in Windhock, Namibia.
1970	Industrial reuse of water for pulp and paper at the Sappi Pulp and Paper Group's Enstra, South Africa facility.
1972	Publication of *Quality Criteria 1972 (Blue Book)* , National Academy of Sciences and National Academy of Engineering.
	Federal Water Pollution Control Act, PL. 92-500 (Clean Water Act) " To restore and maintain the chemical, physical, and biological integrity of the Nation's waters" - zero discharge of pollutants into navigable waters.
1973	World Health Organization developed a report recommending health criteria and treatment processes for water reuse applications, the *1973 WHO Guidelines.*
1975	The *Statewide Standards for the Safe Direct Use of Reclaimed Water for Irrigation and Impoundment* were renamed *Wastewater Reclamation Criteria* and included treatment reliability requirements.
1976	Publication of *Quality Criteria for Water (Red Book) by the* U.S. Environmental Protection Agency.
	Groundwater recharge of reclaimed wastewater by direct injection into the aquifers was initiated by the Orange County Water District in California.
1977	*Pomona Virus Study - Final Report*, Sanitation Districts of Los Angeles County was published.
	A major dual water distribution system was instituted by the Irvine Water District, California to irrigate farmland, residential areas, parks, golf courses, roadway median strips and other open spaces.
	St. Petersburg, Florida also began a dual water distribution system in which reclaimed water is supplied for industrial uses and irrigation of golf courses, parks and individual homes.
	The Dan Region Project is implemented in Tel-Aviv, Israel. This project recharges recycled water and then pumps out the recharged groundwater for crop irrigation.

Table 3.2
Milestones in the Development of Water Quality Criteria and Reuse Implementation

Year	Water Reuse Milestone
1978	Publication of State of California *Wastewater Reclamation Criteria*, Department of Health Services. These regulations contained both design and operational requirements to ensure appropriated level of treatment reliability. Specifically, treatment and reliability requirements were made more stringent for areas were public contact was likely. In addition, groundwater recharge was included in the regulations as an accepted use.
1982	Publication of *Quality Criteria for Water Reuse by the* National Research Council.
1983	The Florida Department of Environmental Regulation developed the *Land Application of Domestic Effluent in Florida*. This document contained suggested design and operational requirements for land application of recycled water.
1984	Health Effects Study - Final Report, County Sanitation Districts of Los Angeles County, California was published.
	Water recycling project in Shinjuku District of Tokyo, Japan provides water for toilet flushing in 19 high-rise buildings.
1985	Arizona adopted its *Comprehensive Water Reuse Regulations.* These regulations were based on numeric standards and did not prescribe specific treatment processes required to meet standards.
	Groundwater recharge by direct injection into the Hueco Bolson aquifers in El Paso ,Texas.
	The *Engelberg Report* is published by the WHO, which recommends revisions be made to the *1973 WHO Guidelines* because they are deemed to be overly conservative.
1987	*Monterey Wastewater Reclamation Study for Agriculture - Final Report*. Monterey Regional Water Pollution Control Agency, Pacific Grove, California was published.
	Report on "Studies on Health Aspects of Water Reclamation During 1974 to 1983 in Windhock, Namibia" published by the South African Water Research Commission.
1989	*Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture* published by the WHO. These guidelines are based solely on health risks associated with helminthic diseases and there intent is to introduce some treatment of wastewater in undeveloped countries tries prior to use.
	Reuse of Reclaimed Water and Land Application was adopted by State of Florida. This set of rules on reuse expanded on the manual developed in 1983.
	Recycled water is supplied for golf course irrigation in Consorci de la Costa Brava, Girona, Spain.
	Irrigation of gardens and toilet flushing in private residential dwellings is supply with recycled water in Shoalhaven Heads, Australia.

Table 3.2
Milestones in the Development of Water Quality Criteria and Reuse Implementation

Year	Water Reuse Milestone
1990	Publication of *California Municipal Wastewater Reclamation* in 1987, California State Water Resources Control Board, Office of Recycling, Sacramento, California.
1992	*City of San Diego Total Resource Recovery Project Health Effects Study - Final Summary Report*, Western Consortium for Public Health was published.
	Publication of EPA Manual *Guidelines for Water Reuse*, developed by USEPA and U.S. Agency for International Development. These guidelines included recommended treatment processes, water quality limits, monitoring frequencies, setback distances, and other controls for various water reuse applications.
1993	City of Denver's Potable Water Reuse Demonstration Project - Final Report.
1994	Publication of *Groundwater Recharge Using Waters of Impaired Quality,* National Research Council.
1995	Publication of *Developing Human Health-related Chemical Guidelines for Reclaimed Wastewater and Sewage Sludge Applications in Agriculture*, World Health Organization.
1996	Publication of *Use of Reclaimed Water and Sludge in Food Crop Production*, National Research Council.
	Publication of the California Potable Reuse Committee's *Indirect Potable Reuse of Advanced Treated Reclaimed Water by Surface Water Augmentation in California* by California Department of Health Services and California Department of Water Resources
1999	State of Florida updated the *Reuse of Reclaimed Water and Land Application, which sets down reuse rules.*
2000	Publication of State of California current *Water Recycling Criteria*, Department of Health Services. These criteria include new applications, modify treatment and water quality requirements, set requirements for dual water systems, include cross connection and control requirements, and include use area requirements.
	Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse published by National Water Research Institute. These guidelines recommend limits for design and operation of UV for disinfection.
2001	Arizona updates its *Comprehensive Water Reuse Regulations.* The revisions to the regulations removed a requirement for sampling for parasites and viruses and more closely resemble the EPA suggested guidelines.
	California Department of Health Services issues Draft revision to *Groundwater Recharge Rules*.
2002	California Department of Health Services issues proposed Draft revisions to *Title 17 - Cross Connection Control Regulations*.

Note:

This Table was developed from Table 1 in *Developing Comprehensive Wastewater Reuse Criteria* by Takashi Asano, et al, and from information contained in *The Ongoing Evolution of Water Reuse Criteria* by James Crook.

Once water is used and treated for reuse at a WWTP (I) or WRP (K) it can be supplied to users. Water utilized in some applications, which have limited human contact such as fodder irrigation, can be supplied water that has undergone only secondary treatment. However, if the water undergoes tertiary or advanced treatment at a WRP (K), it can be supplied to a wider group of users including agricultural users (E), urban irrigation (F), municipal users (G), or industrial users (G), habitat for beneficial use (D), or be blended with raw or potable water for groundwater recharge (A3). Water utilized for urban irrigation (F), municipal uses (G), or industrial uses (G) may undergo further treatment (C) to produce water that is specifically suited for the intended use. In addition, water utilized for municipal (G) or industrial purposes (G) may undergo a post-use treatment process (H) to meet discharge requirements or basin plan objectives for TDS or other constituents before the water is discharged to surface waters (L or N). Water utilized for beneficial use of habitat (D) will return flow into surface waters (L or N); therefore, water discharge to habitat must meet regulatory requirements or the habitat must be utilized to assist in meeting the water quality objectives, such as the use of a treatment wetland to remove constituents from the water.

Water that is recharged into a groundwater basin (A3) may intermingle through seepage with surface water and/or the ocean (L or N) so it is important that the water recharged into the basin conform to TDS and other water quality objectives set by the prevailing RWQCB. In addition, groundwater can be pumped and treated (A3), after a sufficient detention time, which is determined at the basin through hydrogeologic studies and approval from the RWQCB and DHS. This water can be used as a raw water source that is supplied to end users (F). All locations along the hydrodynamic system (B, C, H, I, K, and M) where water is treated to remove constituents must conform with RWQCB and DHS standards, criteria, and regulations to protect human health and the environment. In addition, these treatment locations may produce concentrated brine. This brine residual will need to be disposed of by either landfilling of the material or discharging it via a brineline to the ocean (N). Both of these disposal mechanisms are regulated by the State of California and involve complying with DHS and RWQCB requirements. All locations along the hydrodynamic system (D, E, F, G, H, I, J, K, and M) where water is either discharged to groundwater (A3), surface water (L), or the ocean (N) must also comply with DHS, SWQCB, or the prevailing RWQCBs requirements, criteria, and Basin and Ocean Plan Objectives. The following sections will outline the regulatory requirements that affect recycled water on a local, state, and Federal level.

3.3.3 Type of Regulations

There are three primary types of water reuse regulations in California. They are policies that regulate water reuse, water quality regulations, and public health regulations. The first type of regulation falls primarily under state and local jurisdiction while the remaining two types are under Federal in addition to the local and state jurisdiction.

Policies that Encourage Water Reuse

Table 3.3 provides a description of the policies that encourage water reuse in California. These guidelines were developed in response to water scarcity and growth issues facing California. Water reuse has emerged, as an important method of enabling California to continue to grow while meeting local, state, and Federal demands regarding water supply planning. This is especially true in southern California where, due to the semi-arid climate, the large urban populations rely on imported water transferred into the region for a majority of the water supply.

The use of recycled water in southern California is also vital to the state's ability to maintain water supply for existing and projected populations as the amount of water available from the State Water Project and Colorado River is reduced do to increased environmental protection. These reductions are necessary to meet requirements set down in CALFED and the Colorado River Compact 3.3 Agreement. Due to the importance of recycled water as a supply source, the state has instituted a number of policies to encourage the use of recycled water as a means to provide conservation of fresh waters. One of these policies is the *Reasonable Use Doctrine*, which prohibits the waste of water and encourages the use of recycled water where possible for greenbelt irrigation. In addition, the state has recently established the 2002 DWR Recycled Water Task Force. The establishment of this Task Force is another example of the State's continued encouragement and commitment to implement recycled water projects and plan for future water supply needs of the State of California.

Table 3.3
Policies that Encourage Use of Recycled Water

Governing Body	Regulation	Description
Federal	Clean Water Act Policy	The Policy encourages water reclamation through continuing support of information and education programs which utilize innovative water treatment and reuse technology. The Clean Water Act Policy also provides for research grants that support the development of methods for reclaiming and reusing water.
	U.S. Bureau of Reclamation Water Reuse Policy	Places a high priority on water reclamation in the western states. Authorizes the Secretary of Interior, through the Reclamation Projects Authorization and Adjustment Act of 1992, to undertake measures which stimulate demand for and eliminate obstacles to the use of reclaimed water. The Act also appropriates funds as necessary to carry out these measures.
State	California Water Code Water Recycling Act of 1991	Set goals for the beneficial reuse of water: 700,000 acre-ft of water per year by the year 2000 and 1,000,000 acre-ft of water per year by the year 2010. In order to achieve this goal, this Act requires retail water suppliers to identify potential uses for reclaimed water within their service areas, potential customers for reclaimed water service within their service areas, and within reasonable time, potential sources of reclaimed water.
	California Department of Water Resources 2002 Recycled Water Task Force	The 2002 Recycled Water Task Force was established by Assembly Bill 331(Goldberg), passed by the Legislature and approved by Governor Davis on October 7, 2001 (Water Code Section 13578). The Task Force is a cooperative effort of the California Department of Water Resources, the State Water Resources Control Board, and the Department of Health Services. The Task Force is charged with evaluating the current framework of State and local rules, regulations, ordinances, and permits to identify the opportunities, obstacles or disincentives to maximizing the safe use of recycled water. The recommendations of the Task Force must be reported to the Legislature by DWR before July 1, 2003.
	State Water Board Water Reclamation Policy	This policy commits both the State and Regional Water Boards to support reclamation and to undertake all possible steps to encourage development of water reclamation facilities. This policy also requires the Regional Water Board to conduct reclamation surveys and specifies actions to be implemented by the State and Regional Water Boards and other agencies. Guidelines exist for the State and Regional Water Boards' efforts in encouraging the development of reclaimed water.
	California Public Utilities Code Service Duplication Law	The law states that when a water supplier extends its facilities into the service area of another with the same type of service, this act constitutes a taking of property from the utility for a public purpose and must be compensated. The compensation must be mutually agreed upon and fixed in a court of law. This law applies to all reclaimed water utilities except those located in Los Angeles County who supply recycled water to their own recycled water and landfill facilities.
	California Water Code Urban Water Management Act	This act facilitates that the planning for reclamation facilities needed to meet the State goals for beneficial reuse of water would be undertaken by local agencies by requiring urban water agencies serving in excess of 3,000 customers or more than 3,000 acre-ft per year for municipal and industrial purposes to prepare the Urban Water Management Plan (UWMP). The UWMP includes a description of water reclamation and reuse activities in the provider's service areas. It also requires that purveyors, who exceed the minimum level of service and project a need for expanded or additional water supplies, prepare a plan which includes information on reclaimed water and its potential for use as a water source in the service area of the urban water supplier.
	California State Constitution Reasonable Use Doctrine	The "rule of reasonable use" applies a uniform prohibition on the waste of water by requiring that all rights to water be limited to that which is required for the specific beneficial use. An extension of this policy is the water reuse mandate. This mandate was enacted by the Legislature to encourage the use of recycled water by prohibiting use of potable water for specific purposes. The mandate requires the use of recycled water where it is available for landscape irrigation of greenbelts.

Water Quality Regulations

In addition to the policies that regulate water reuse, the state is also involved in ensuring that the recycled water produced not only meets water quality objectives to protect human health but also inhibits habitat and riverine degradation. Table 3.4 provides a list of water quality regulations that govern the production and use of recycled water. Included in this list are the USEPA and California *Antidegradation Policies*, which establish a standard that "no degradation of water quality should occur unless an important social or economic need exists that is in the best interest of the state." It is a result of the state's Antidegradation Policy, that the area RWQCBs developed the Ocean Plan, Bays and Estuaries, Inland Surface Water Plans and Basin Plans (Water Quality Plans).

An important feature of the Water Quality Plans are the beneficial use designations, which provide a mechanism for the RWQCBs to set numerical limits for water quality objectives. There are twenty-four beneficial use designations that have been defined by the SWQCB. These use types are listed and defined in Table 3.5 along with the beneficial uses that have been designated in each of the watersheds. The most common use designations in southern California are municipal and domestic supply (MUN), industrial service supply (IND), groundwater recharge (GWR), contact water recreation (REC-1), and non-contact water recreation (REC-2). Appendix D provides the beneficial use designations developed in each of the basin by the governing RWQCB. In addition, Appendix E provides the RWQCBs water quality objectives for surface waters, groundwaters, and the ocean by major constituents monitored for each of the regions.

Public Health Regulations

Public health regulations are the last type of policy, which regulate the use of recycled water in California. *Title 22* of the *California Health and Safety Code of Regulations* establishes the criteria for water quality standards and treatment reliability related to use of recycled water. These criteria were developed and are regulated by DHS. Table 3.6 provides a list of applicable public health regulations including guidelines for the level of treatment required for each type of recycled water use.

There are four levels of treatment, which are set based on the associated use of the recycled water. They are undisinfected secondary treatment, disinfected "23 standard" secondary treatment, disinfected "2.2 standard" secondary treatment, and tertiary treatment. These levels of required treatment were incorporated as revisions to the *Title 22* standards in 2000. This update made the use of primary effluent unacceptable even for previous acceptable uses such as irrigation of fodder, fiber, and seed crops. The updated regulations require this type of irrigation to be supplied with at least undisinfected secondary treated effluent. The new secondary standards are based on the amount and type of possible human contact with the effluent or use area requirements. Uses with a lower potential for incidental human contact require less stringent treatment before reuse than uses with human contact.

The disinfected secondary treatment standards are required when recycled water is served to areas with a higher frequency or more direct contact potential with humans. These standards are based on the total coliform level not exceeding either:

- 23 mg per 100 mL for areas with limited or no direct human contact or
- 2.2 mg per 100 mL for areas where incidental human contact may occur.

Table 3.7, developed by WateReuse, provides a breakdown of the different recycled water use types in California along with the level of treatment required for each specific use type. The total coliform limit and turbidity guidelines for each of the different use types and treatment levels are listed in Table 3.8.

In addition to the treatment levels required for recycled water use, Table 3.6 provides a synopses of the regulations and guidelines governing dual plumbing systems, cross connection controls, groundwater recharge, and reservoir augmentation. All of these guidelines are areas that DHS is monitoring to ensure that the public health and safety is protected.

The development of dual plumbing systems is an important mechanism used in California to increase the allocation of recycled water. The most important component of the California Health and Safety Code of Regulations dealing with dual plumbing systems is the protection against cross connection between the potable and recycled water systems. The cross connection control guidelines, established in Title 17, were developed to ensure that recycled

Table 3.4
Water Quality Regulations for Recycled Water

Governing Body	Regulation	Description
Federal	Water Pollution Control Act (Clean Water Act)	A NPDES permit is required for all reclaimed water discharges to surface waters. A single NPDES permit meets requirements for both state and federal law.
	U.S. Environmental Protection Agency Antidegradation Policies	This policy requires that deviations from established standards be justified as necessary to accommodate important social and economic development. Mandates State policy to be consistent with three principles: 1) Existing instream water uses, and water quality to protect those uses, be maintained. 2) Where the quality of water exceeds that necessary to support existing uses, a lowering of quality be allowed only to accommodate important social and economic development, but cannot be lowered below that needed to support existing uses. 3) Where high quality waters constitute an outstanding national resource (ONR), such as waters of national and state parks and wildlife refuges and water of exceptional or ecological significance, no lowering of quality be allowed.
State	California State Water Board Antidegradation Policies	Establishes a general principle of nondegradation, with flexibility to allow some changes in water quality which is in the best interests of the state. are allowed only where it is in the public interest and beneficial uses are not unreasonably affected. Incorporates the three principles set forth in the Federal Antidegradation Policy.
	Porter-Cologne Water Quality Control Act	Defines "reclaimed" or "recycled" water as water which, as a result of treatment of waste, is suitable for a direct beneficial use or controlled use that would otherwise not occur and is therefore considered a valuable resource. This act establishes the State Water Board and the Regional Water Boards as the principal state agencies responsible for water reclamation. This act empowers the Regional Water Boards to formulate and adopt a Water Quality Control Plan (Basin Plan) which designates beneficial uses and establishes water quality objectives which will ensure reasonable protection of beneficial uses and the prevention of nuisances.
	California State Water Board California Inland Surface Water Plan	This Plan is used as a guideline by the Regional Water Board and California Department of Fish and Game in accessing potential impacts of discharges to surface waters. The plan also promulgates numerical water quality objectives for inland surface waters to protect freshwater aquatic life and human health. USEPA *Region IX's Effluent Dominated Streams and Water Reclamation Policy* provides guidance on how to comply with the use-attainability provisions of the federal regulations when developing water quality standards for ephemeral streams and how to demonstrate the benefits of water reclamation use.
	California State Water Board California Ocean Plan	This plan sets forth the water quality requirements that are necessary to "ensure reasonable protection of beneficial uses and the prevention of nuisance." The standards set forth in the plan are not applicable to inland waters or enclosed bays and estuaries

Table 3.5
Beneficial Use Types from California Regional Water Quality Control Board

Beneficial Use Type	Description of Beneficial Use Type	Designated Uses within RWQCB Region[1]		
		Los Angeles RWQCB Region	Santa Ana RWQCB Region	San Diego RWQCB Region[2]
Municipal and Domestic Supply (MUN)	Includes uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.	X	X	X
Agricultural Supply (AGR)	Includes uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.	X	X	X
Industrial Process Supply (PROC)	Includes uses of water for industrial activities that depend primarily on water quality.	X	X	X
Industrial Service Supply (IND)	Includes uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.	X	X	X
Ground Water Recharge (GWR)	Includes uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.	X	X	X
Freshwater Replenishment (FRSH)	Includes uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity).	X		X
Navigation (NAV)	Includes uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.	X	X	X
Hydropower Generation (POW)	Includes uses of water for hydropower generation.	X	X	X
Contact Water Recreation (REC-1)	Includes uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and SCUBA diving, surfing, white water activities, fishing, or use of natural hot springs.	X	X	X
Non-contact Water Recreation (REC-2)	Includes the uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.	X	X	X
Commercial and Sport Fishing (COMM)	Includes the uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.	X	X	X
Aquaculture (AQUA)	Includes the uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.	X		X
Warm Freshwater Habitat (WARM)	Includes uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.	X	X	X
Cold Freshwater Habitat (COLD)	Includes uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.	X	X	X
Inland Saline Water Habitat (SAL)	Includes uses of water that support inland saline water ecosystems including, but not limited to, preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates.			
Estuarine Habitat (EST)	Includes uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).	X	X	X
Wetland Habitat (WET)	Uses of Water that support wetland ecosystems, including, but not limited to, preservation or enhancement of wetland habitats, vegetation, fish, shellfish, or wildlife, and other unique wetland functions which enhance water quality, such as providing flood and erosion control, stream bank stabilization, and filtration and purification of naturally occurring contaminants.	X	X	
Marine Habitat (MAR)	Includes uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).	X	X	X
Wildlife Habitat (WILD)	Includes uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.	X	X	X
Preservation of Biological Habitats of Special Significance (BIOL)	Includes uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection.	X	X	X
Rare, Threatened, or Endangered Species (RARE)	Includes uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.	X	X	X
Migration of Aquatic Organisms (MIGR)	Includes uses of water that support habitats necessary for migration, acclimatization between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish.	X		X
Spawning, Reproduction, and/or Early Development (SPWN)	Includes uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish. This use is applicable only for the protection of anadromous fish.	X	X	X
Shellfish Harvesting (SHELL)	Includes uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters and mussels) for human consumption, commercial, or sport purposes.	X	X	X

Note:
[1]All information regarding the beneficial use designations in each of the region as well as the definitions of beneficial uses are from the RWQCB Basin Plans for the Los Angeles, Santa Ana, and San Diego Regions.
[2] Wetland Habitat was not a designated use when the San Diego Basin Plan was developed and adopted.

Table 3.6
Public Health Regulations

Governing Body	Regulation	Description
State	California Water Code	This criteria, established by California Department of Health Services, sets water quality standards and treatment reliability for water reclamation operations.
	Water Quality Standards and Treatment Reliability Criteria (Title 22)	The water quality standards are bacteriological standards which are based on the degree of contact the public will have with the reclaimed water. Thus higher levels of public contact require tertiary or advanced treatment while lower levels of public contact require secondary treatment.
	Tertiary Treatment Criteria	Tertiary treatment consists of the following steps; secondary treatment, coagulation, clarification, filtration, and disinfection. Tertiary treatment is required for the following use type; food crops where contact with edible portion of the crop occurs, parks and playgrounds, school yards, residential landscaping, unrestricted access golf courses, nonrestricted recreational impounds, industrial cooling and air conditioning, flushing of toilets and urinals, decorative fountains, consolidation of backfill material around potable pipes, structural fire fighting and snow making. In addition, there should be no irrigation of reclaimed water within 50 feet and no impoundment of reclaimed water within 100 feet of any domestic water supply well.
	Secondary Treatment Criteria	There are three acceptable levels of secondary treatment each with its own list of suitable applications, the three levels of treatment are disinfected secondary where the median concentration of total coliform bacteria measured in the disinfected effluent does not exceed 2.2 per 100 mL, disinfected secondary where the median concentration of coliform bacteria measured in the disinfected effluent does not exceed 23 per 100 mL, and undisinfected secondary. Spray and mist control must be provided when utilizing secondary treated reclaimed water and no spray irrigation is permitted within 100 feet of a residence or place of public exposure.
	Disinfected Secondary 2.2 Standard	Suitable applications for the disinfected secondary 2.2 standard are food crops where food crop is above the ground and does not come in contact with reclaimed water, restricted recreational impoundments and fish hatcheries. In addition, the criteria states that no irrigation or impoundment of reclaimed water should occur within 100 feet of any domestic water supply well.
	Disinfected Secondary 23 Standard	Suitable applications for the disinfected secondary 23 standard are cemeteries, freeway landscaping, restricted access golf courses, ornamental nursery stock and sod farms, pasture for animals, industrial boiler feed, nonstructural fire fighting, backfill consolidation around nonpotable pipes, soil compaction, mixing concrete, dust control, flushing sewers and street cleaning. In addition, the criteria states that no irrigation or impoundment of reclaimed water should occur within 100 feet of any domestic water supply well.
	Undisinfected Secondary Standard	Suitable applications for the undisinfected secondary standard are orchards and vineyards when no contact occurs with edible portion of the crop and reclaimed water, crops not grown for human consumption, and processes food crops. In addition, the criteria states that no irrigation or impoundment of reclaimed water should occur within 150 feet of any domestic water supply well.
	California Water Code Cross Connection Control (Title 17)	This code requires all reclaimed water pipes installed after 1993 to be either purple in color or wrapped in purple tape. Facilities that have established markings for reclaimed water systems are exempt from this requirement. The water supplier has the primary responsibility for ensuring against reclaimed water entering the potable water system. Where dual systems exist at a facility the potable water system must be protected with a reduced pressure principle backflow device or a double check valve assembly backflow device. Blending of potable and reclaimed water at a site must be done through an approved air gap separation which must be at least double the diameter of the supply pipe, measured vertically above the top rim of the receiving vessel, and can not be less than one inch.

Table 3.6
Public Health Regulations

Governing Body	Regulation	Description
State	California Department of Health Services California Water Code Dual Plumbing Plan Design and Monitoring Criteria	A Dual Plumbing Plan is required where potable and reclaimed water are delivered to the same facility. The plan consists of a report providing the number, location and type of facilities in use proposing to use dual plumbed systems, average number of persons served by each facility, map showing boundaries of use site and locations of each facility served, dual system responsible party at each facility, specific use of reclaimed water, proposed piping system, type and location of outlets and fixtures available to public, backflow prevention method, and cross connection prevention method. In addition to the report, there must be inspected and tested for cross connections and a report written documenting the findings of the test. Any incidents of backflow or cross connection of reclaimed water into the potable water system must be reported to DHS within 24 hours of incident.
	California Department of Health Services Groundwater Recharge Guidelines	Current regulations for groundwater recharge are determined on a case by case basis by DHS; however, DHS has developed draft recharge regulations. These regulations stipulate that a project developed for the recharge of groundwater must meet either the treatment standards under the filtered wastewater or disinfected tertiary treatment definitions. For surface spreading recharge the groundwater must be retained underground for a minimum of 6 months prior to extraction for use as a water supply and shall not be extracted within 500 feet of the point of recharge. For groundwater injection the recycled water must be retained underground for a minimum of 9 months prior to extraction for use as a water supply and shall not be extracted within 2000 feet of the point of recharge. Recycled water can only compose 50% of the total amount of water recharged unless otherwise permitted by DHS.
	Proposed New Guidelines	The new guidelines apply only to planned projects; however, existing projects are encouraged to meet the requirements. Recycled water must meet MCL and shall not exceed any public health goal for a contaminant, or the level of the contaminant in the receiving groundwater, whichever is higher, unless approved by DHS. Existing project can continue as long as the total nitrogen in recycled water is 10 mg/L; however, no increase in recycled water contribution (RWC) can occur. If the RWC is to increased then the total nitrogen limit permitted is 3 mg/L. In addition, unregulated and unknown contaminant levels permitted in planned or where RWC is to be increased are required to meet a TOC of less than 0.5 mg/L per RWC instead of the existing limits of a TOC less than 1 mg/L per RWC. The DHS has a goal of the TOC being less than 0.1 mg/L per RWC. In addition, DHS will permit on an incremental basis the increase of the RWC up to 75 %+, if the project is proven to meet the DHS's water quality standards. Also the distance required before extraction can be reduced to up to 200 feet if the retention time required can be met and proven by tracer testing.
	California Department of Health Services Augmentation of Domestic Reservoir with Recycled Water	DHS conceptually approved a proposal to use highly treated reclaimed water for augmentation of a domestic water supply reservoir in 1994. The approval was contingent upon the following being met; all of the reclaimed water will be processed utilizing advanced water treatment processes including RO, a reliability assurance plan is established ensuring the reclaimed water delivered to the reservoir meets of exceeds federal drinking water standards, no more than 50% of the water drawn over a 36 month period will be reclaimed water, adequate steps will be taken to maximize retention and minimize short circuiting of the reservoir, and the water supply permit issued for the project will be conditional. An unconditional permit could be obtained after 3 years of successful operation of the project.
State	California Water Code Water Recycling in Landscape Act	A state mandated local program that requires any local public or private entity that produces reclaimed water and determines that within 10 years it will provide reclaimed water within the boundaries of a city of county agency, to notify the local city or county agency of the fact. The local agency must adopt and enforce a specified reclaimed water ordinance within 180 days of the notification unless the local agency adopted a reclaimed water ordinance or other regulation requiring the use of reclaimed water in its jurisdiction prior to January 2001. The new ordinance developed by the local agency must require that new development plan include infrastructure required to support the use of reclaimed water for the applications included in the reclaimed water purveyor's notification.

Table 3.7
Recycled Water Uses Allowed in California

	Treatment Level			
Irrigation	**Disinfected Tertiary Recycled Water**	**Disinfected Secondary-2.2 Recycled Water**	**Disinfected Secondary-23 Recycled Water**	**Undisinfected Secondary Recycled Water**
Food crops where recycled water contacts the edible portion of the crop, including all root crops	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Parks and playgrounds	**Allowed**	Not Allowed	Not Allowed	Not Allowed
School yards	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Residential landscaping	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Unrestricted access golf courses	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Any other irrigation uses not prohibited by other provisions of the California Code of Regulations	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Food crops where edible portion is produced above ground and not contacted by recycled water	**Allowed**	**Allowed**	Not Allowed	Not Allowed
Cemeteries	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Freeway landscaping	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Restricted access golf courses	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Ornamental nursery stock and sod farms	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Pasture for milk animals	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Nonedible vegetation with access control to prevent use as a park, playground or school yard	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Orchards with no contact between edible portion and recycled water	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Vineyards with no contact between edible portion and recycled water	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Non food-bearing trees, including Christmas trees not irrigated less than 14 days before harvest	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Fodder crops (e.g. alfalfa) and fiber crops (e.g. cotton)	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Seed crops not eaten by humans	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Food crops that undergo commercial pathogen-destroying processing before consumption by humans	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Ornamental nursery stock, sod farms not irrigated less than 14 days before harvest	**Allowed**	**Allowed**	**Allowed**	**Allowed**

	Treatment Level			
Supply for Impoundment	**Disinfected Tertiary Recycled Water**	**Disinfected Secondary-2.2 Recycled Water**	**Disinfected Secondary-23 Recycled Water**	**Undisinfected Secondary Recycled Water**
Non-restricted recreational impoundments, with supplemental monitoring for pathogenic organisms	**Allowed**[1]	Not Allowed	Not Allowed	Not Allowed
Restricted recreational impoundments and publicly accessible fish hatcheries	**Allowed**	**Allowed**	Not Allowed	Not Allowed
Landscape impoundments without decorative fountains	**Allowed**	**Allowed**	**Allowed**	Not Allowed

Notes:

Table developed by WateReuse and available on their website at *<http://www.watereuse.org/Pages/information.html>*.

Refer to the full text of the latest version of Title-22: California Water Recycling Criteria. This chart is only a guide to the September 1998 version.

Footnotes:

[1] With "conventional tertiary treatment." Additional monitoring for two years or more is necessary with direct filtration.

[2] Drift eliminators and/or biocides are required if public or employees can be exposed to mist.

[3] Refer to Groundwater Recharge Guidelines, California Department of Health Services.

Table 3.7
Recycled Water Uses Allowed in California

	Treatment Level			
Other Uses	**Disinfected Tertiary Recycled Water**	**Disinfected Secondary-2.2 Recycled Water**	**Disinfected Secondary-23 Recycled Water**	**Undisinfected Secondary Recycled Water**
Groundwater recharge	**Allowed under special case-by-case permits by RWQCBs[3]**			
Flushing toilets and urinals	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Priming drain traps	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Industrial process water that may contact workers	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Structural fire fighting	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Decorative fountains	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Commercial laundries	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Consolidation of backfill material around potable water pipelines	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Artificial snow making for commercial outdoor uses	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Commercial car washes not done by hand & excluding the general public from washing process	**Allowed**	Not Allowed	Not Allowed	Not Allowed
Industrial boiler feed	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Nonstructural fire fighting	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Backfill consolidation around nonpotable piping	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Soil compaction	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Mixing concrete	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Dust control on roads and streets	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Cleaning roads, sidewalks and outdoor work areas	**Allowed**	**Allowed**	**Allowed**	Not Allowed
Flushing sanitary sewers	**Allowed**	**Allowed**	**Allowed**	**Allowed**

	Treatment Level			
Supply for Cooling or Air Conditioning	**Disinfected Tertiary Recycled Water**	**Disinfected Secondary-2.2 Recycled Water**	**Disinfected Secondary-23 Recycled Water**	**Undisinfected Secondary Recycled Water**
Industrial or commercial cooling or air conditioning involving cooling tower, evaporative condenser, or spraying that creates a mist	**Allowed[2]**	Not Allowed	Not Allowed	Not Allowed
Industrial or commercial cooling or air conditioning not involving a cooling tower, evaporative condenser, or spraying that creates a mist	**Allowed**	**Allowed**	**Allowed**	Not Allowed

Notes:

Table developed by WateReuse and available on their website at *<http://www.watereuse.org/Pages/information.html>*.

Refer to the full text of the latest version of Title-22: California Water Recycling Criteria. This chart is only a guide to the September 1998 version.

Footnotes:

[1] With "conventional tertiary treatment." Additional monitoring for two years or more is necessary with direct filtration.

[2] Drift eliminators and/or biocides are required if public or employees can be exposed to mist.

[3] Refer to Groundwater Recharge Guidelines, California Department of Health Services.

Table 3.8
Water Quality Limits by Use Type

Treatment Level	Use Type	Total Coliform Limit	Turbidity
Undisinfected Secondary Standard	(1) Orchards where the recycled water does not come into contact with the edible portion of the crop. (2) Vineyards where the recycled water does not come into contact with the edible portion of the crop. (3) Non food bearing trees (Christmas tree farms are included in this category provided no irrigation with recycled water occurs for a period 14 days prior to harvesting or allowing access by the general public.) (4) Fodder and fiber crops and pasture for animals not producing milk for human consumption. (5) Seed crops not eaten by humans. (6) Food Crops that must undergo commercial pathogen destroying processing before being consumed by humans. (7) Ornamental nursery stock and sod farms provided no irrigation with recycled water occurs for a period of 14 days prior to harvesting, retail sale, or allowing access by the general public. (8) Flushing of sanitary sewers.	None Required	None Required
Disinfected Secondary-23 Recycled Water	(1) Cemeteries. (2) Freeway landscaping. (3) Restricted access golf courses. (4) Ornamental nursery stock and sod farms where access by the general public is not restricted. (5) Pasture for animals producing milk for human consumption. (6) Any nonedible vegetation where access is controlled so that the irrigated area cannot be used as if it were part of a park, playground, or school yard. (7) Landscape impoundments with decorative fountains. (8) Industrial boiler feed water. (9) Nonstructural fire-fighting. (10) Backfill consolidation around nonpotable piping (11) Soil compaction. (12) Mixing Concrete. (13) Dust Control and Cleaning of rood streets, sidewalks and outdoor work areas.	< 23 total coliform per 100 mL < 240 total coliform per 100 mL in more than one sample in any 30-day period	2 NTU
Disinfected Secondary-2.2 Recycled Water	(1) Restricted recreational impoundments and publicly accessible fish hatcheries (2) Food crops where edible portion is produced above ground and not contacted by recycled water	< 2.2 total coliform per 100 mL < 23 total coliform per 100 mL in more than one sample in any 30-day period	None Required
Disinfected Tertiary Recycled Water	(1) Food crops where recycled water contacts the edible portion of the crop, including all root crops (2) Parks and playgrounds. (3) School yards. (4) Residential landscaping. (5) Unrestricted access golf courses. (6) Any other irrigation uses not prohibited by other provisions of the California code of Regulations (7) Flushing Toilets and urinals. (8) Priming drain pipes. (9) Industrial process water that may come into contact with workers. (10) Structural fire fighting. (11) Decorative fountains. (12) Commercial laundry. (13) Consolidation of backfill around potable water pipelines. (14) Artificial snow making for commercial outdoor use (15) Commercial car washes, including hand washes if the recycled water is not heated, where the general public is excluded from the washing processes. (16) Industrial or commercial cooling or air conditioning involving cooling tower, evaporative condenser, or spraying that creates a mist.	≤ 2.2 total coliform per 100 mL < 23 total coliform per 100 mL in more than one sample in any 30-day period 240 total coliform per 100mL maximum CT value of 50 mg-min/L at all times with a modal CT of at least 90 min. or MS_2 bacteriophage or poliovirus concentration reduction of 5 logs	2 NTU

Note:
This table was developed from "California 's New Water Recycling Criteria and Their Effect on Operating Agencies" by James Crook, Laura Johnson, and Ken Thompson.

water lines are clearly marked and easily identifiable (typically by utilizing purple pipe) as well as to ensure that recycled water does not enter the potable water system. These guidelines require that a double check valve assembly backflow device be installed to protect against possible cross connection. The *Dual Plumbing Plan Design Criteria and Monitoring Criteria* also require that a plan be developed describing the recycled water system. Another component of the criteria requires that any incidents of cross connection must be disclosed to DHS within 24 hours from time of occurrence. In addition to these requirements, the Los Angeles Chapter of WateReuse is developing an operations manual for recycled water. This manual will provide information and operator training for recycled water projects in order to prevent the occurrence of incidents including cross connection of lines as well as unsafe use of recycled water.

DHS has released a draft of the proposed changes to *Title 17* for preliminary comments. This proposal shifts the cross connection control requirements from *Title 17* to *Title 22,* Chapter 19. In addition, the proposed draft reorganizes the requirements with the emphasis on hazard assessment and backflow prevention. Table 3.9 provides the updated hazard criteria with associated appropriate backflow prevention assemblies that are proposed as part of the draft changes to the cross connection control regulations.

Another major change to the cross connection controls regulations is the removal of a section that outlines the responsibility and scope of the agency's program. One key element of this proposal is the removal of language that defines where the agencies system ends and the user's responsibilities begin. This is particularly important to agencies because the systems have to be monitored annually and cross connection control tests performed every four years. Therefore, any additional monitoring will have an economic impact on the recycled water agency. Also, there is a potential for confusion regarding who is responsible for monitoring the systems. This ambiguity could result in negative public sentiment regarding recycled water system reliability and risk, if incidents occur which endanger human health or safety.

Another area of revision proposed for California's water reuse regulations are the rules that govern indirect potable reuse through groundwater recharge. DHS is currently in the process of receiving comments on draft changes to the Groundwater Recharge Regulations [August 2002 revision]. The proposed changes, if included in the regulations, would require that more stringent treatment standards be met regarding nitrogen removal, TOC concentrations, and MCLs. The updated regulations for use of recycled water for groundwater recharge must be filtered and disinfected and undergo tertiary treatment. The revised regulations would require that the MCLs be met and there be no exceedence of the concentrations for public health goals of a contaminant, or the level of the contaminant in the receiving groundwater, whichever is higher, unless approved by DHS. These changes would only apply to planned projects or existing projects which want to increase the recycled water contribution (RWC) for a project. In addition, the updated regulations require that for a "surface spreading project, all the recharge water shall be retained underground for a minimum of six months prior to extraction for use as a drinking water supply, and shall not be extracted within 500 feet of a point of recharge." The regulations also require that for a "subsurface injection project, all the recharge water shall be retained underground for a minimum of nine months prior to extraction for use as a drinking water supply, and shall not be extracted within 2000 feet of a point of recharge." The new guidelines allow for over RWC over the 50 percent level currently set. If RWC for a project is proposed to be over 50 percent, the following information must be provided regarding the to DHS:

1. GRRP operations, monitoring, and compliance data
2. A demonstration that the recharge water has reached at least one GRRP monitoring well for at least one year with an average RWC of at least 0.4 and the GRRP has been in compliance with the existing Department-specified maximum average RWC
3. A demonstration that the water quality data collected at the monitoring well used in the demonstration meets all the primary drinking water standards for the parameters specified and indicates that the GRRP is not causing the nonregulated contaminants specified to increase over the levels in the recycled water
4. Any additional analytical and/or treatment studies requested by the Department to make the determination
5. Validation of appropriate construction and siting of monitoring wells
6. Scientific peer review by an advisory panel that includes, as a minimum, a toxicologist, a registered engineering geologist or hydrogeologist, an engineer registered in California and experienced in the fields of wastewater treatment and public water supply, a microbiologist, and a chemist
7. An updated engineering report.

In addition, DHS requires that any project with greater than 50 percent RWC must use ultra-violet light treatment; however, the fluence (mJ/cm^2) and hydrogen peroxide addition dose (mg/L) have not been set. The updated final revisions of these regulations were not available

Table 3.9
Hazard Criteria and Appropriate Backflow Prevention Assemblies

Hazard	Backflow Prevention Assembly
Auxiliary supply that:	
A. is interconnected with the PWS	Air Gap Separation
B. not interconnected with the PWS and has piped water conveyed under pressure in a piping system less than 200 feet from the PWS distribution system	Reduced Pressure Principle
Fire Protection Systems	
Fire fighting system interconnected with PWS distribution system with an auxiliary water supply for fire fighting	Air Gap Separation
Fire fighting system supplied by the PWS with an interconnection to onsite storage facilities, pumps, or combined fire and industrial water	Reduced Pressure Principle
Marina or Port Facilities	Reduced Pressure Principle
Multiple service connections to the PWS at the premises	Double Check Valve
Recycled Water or Graywater	
Recycled water system that is	
A. interconnected to the PWS distribution system	Air Gap Separation
B. not interconnected to the PWS distribution system	Reduced Pressure Principle
System that produces, or collects and distributes, graywater, and is	
A. interconnected to the PWS distribution system	Air Gap Separation
B. not interconnected to the PWS distribution system	Reduced Pressure Principle
Residences using recycled water in an approved dual-plumbed use area established pursuant to sections 60313 through 60316, unless the water supplier (or the Department, if the pubic license water system is also the supplier of the recycled water) has approved the utilization of an alternative backflow protection plan that is inspected and tested pursuant to subsection 60316(a).	Double Check Valve
Buildings with a separate recycled water piping system along with a fire protection system interconnected to the PWS distribution system	Double Check Valve
Sewage and Hazardous or Potentially Hazardous Substances	
Waste water treatment, handling or pumping facility interconnected to public water system (PWS) distribution system	Air Gap Separation
Waste water treatment, handling or pumping facility or recreational vehicle dump station that is not interconnected to the PWS distribution system, except for a single- family residence that has a sewage lift pump	Reduced Pressure Principle
Premises with handling of substance conducted in any manner in which the substance may enter the PWS	Air Gap Separation
Piped irrigation system not interconnected with the PWS, into which fertilizers, herbicides, or pesticides are, or are intended to be, injected into the irrigation water	Reduced Pressure Principle
Piping system conveying a fluid not from an approved water supply that is:	
A. interconnected to the PWS distribution system	Air Gap Separation
B. not interconnected to the PWS distribution system	Reduced Pressure Principle
Storage facility not under control of the PWS	Air Gap Separation

Note:

This table was developed and presented as part of the Cross Connection Control Regulations Draft (Title 17) dated March 20, 2002, which is available on DHS website.

when this document was completed; however, the revised regulation should be published in 2002.

Another area where future regulation may potentially focus is the use of recycled water for planned indirect potable reuse through surface water augmentation. The use of recycled water for augmentation of domestic reservoir was conceptually approved by DHS in 1994 for a San Diego County Water Authority (SDCWA) project, the *San Diego Repurification Project*. There are similar projects that are either currently operating, such as at the Occoquan Reservoir in Virginia, or that have been studied in the past, such as the pilot plants in Colorado and Florida. The DHS provided conditional approval to the SDCWA project because the treatment systems proposed provided a safe and reliable potable water source. The treatment system proposed included reclaimed water treatment followed by advanced water treatment, blending and retention of the recycled water with raw water within the reservoir, and filtration and disinfection at a conventional water treatment plant prior to becoming potable water supply and distributed to customers. The DHS approval for this project was contingent on the following factors:

- All recycled water would be processed through an advanced water treatment system, which included RO membrane treatment or equivalent
- A reliability plan was developed outlining how the SDCWA would ensure that all water met or exceeded all Federal and state drinking water standards
- The amount of recycled water that was pulled from the reservoir for supply would not exceed 50 percent over a 36 month period
- Steps would be taken to maximize retention and minimize short-circuiting of the reservoir
- The permit for the project would be conditional but after three years of successful operation an unconditional permit could be applied for and issued for the project

This project has not been implemented due to continued public concerns. Another example of this type of project is the Upper Occoquan Sewage Authority's Regional Water Reclamation Plant (UOSA WRP). The UOSA WRP has been in operation since 1978 and discharges 54 mgd of recycled water into the Occoquan Reservoir, which is the primary water supply source for over 1 million people in northern Virginia.

In the future, the key issue in implementing this type of project will be the ability to overcome public concerns and negative public perception issues. Moreover, where DHS approved of the San Diego Repurification Project, there is a DHS concern regarding what is not known that could end up in the water supply from an indirect potable reuse project. With the emergence of concerns related to endocrine disrupters, antibiotics, and other contaminants, the ability to overcome public and regulatory concerns related to indirect potable reuse through surface water augmentation or even major groundwater recharge projects that use advanced treated recycled water, may be difficult until clear cut examples of safety are met. The focus for this type of project will be on developing favorable risk assessment analyses.

3.3.4 Recycled Water Regulations in Other States

Due to water scarcity and recent drought conditions, a number of states have considered water reuse projects and therefore have implemented regulations within the last ten years. Colorado, North Carolina, Utah, and Washington are all examples of states that have recently developed reuse regulations. In addition, California and Florida have revised reuse regulations. Table 3.10 outlines the reuse regulations in thirteen U.S. states. The table provides information detailing the treatment required, microbiological limits, and turbidity requirements for pasture irrigation, urban irrigation, and food crop irrigation in these states.

The regulations reflect issues of concern to regulators, local agencies, and the public. Seven of these issues are discussed below.

- **Acquisition of Water Rights for Conveyance.** The need to require acquisition of a water right in some states if the recycled water is conveyed from the WRP via a lake, river, or stream to the end-user. For example, Texas law declares that all waters that enter lakes, rivers, or streams are owned by the state and a water right must be granted for use of the water. Therefore, once an agency discharges water back into a lake, river, or stream it is once again owned by the state and an additional water right must be applied for to reuse the water. This issue came to the forefront in Texas due to a planned project to discharge recycled water into the Trinity River in the Dallas/ Fort Worth (DFW) area and allow it to flow approximately 50 miles downstream and be pumped into a lake for retention and blending. The blended water would then by pumped back upstream to users in the DFW area. The Texas Water Development Board (TWDB) agreed to potentially grant a water right to the project but the water right has the most junior status on the river basin. This type of water right issue has also appeared in Arizona and New Mexico. In these states, each state's Supreme Court has ruled that a water right is not required for reuse of water until the water is discharged into the natural environment, which is consistent with the Texas example.
- **Loss of Benefits from Effluent Discharge.** The impacts of flow reductions on downstream or beneficial users from increased reuse of recycled water, which results in decreased return flows to the riverine system. In the Texas example above, another issue emerged. Increasing reuse reduces the amount of return flow available for

Table 3.10
Comparison of Water Reuse Criteria in the U.S.

	Requirements for Specified Uses									
	Unrestricted Urban Uses			Food Crop (Eaten Raw) Irrigation			Pasture Irrigation			
	Required Treatment	Microbiological Limits	Turbidity/ Suspended Solids	Required Treatment	Microbiological Limits	Turbidity/ Suspended Solids	Required Treatment	Microbiological Limits	Turbidity/ Suspended Solids	Source of Information
Arizona	Secondary Filtration Coagulation Disinfected	23 fecal coliform/100 mL	5 NTU	Secondary Filtration Coagulation Disinfected	23 fecal coliform/100 mL	5 NTU	Secondary with Stabilization Ponds Aeration	1000 fecal coliform/100 mL Retention time in stabilization ponds of 20 days		Arizona Administrative Code *Title 18. Environmental Quality* *Chapter 11. Department of Environmental Quality Water Quality Standards* *Article 3. Reclaimed Water* (2001)
California	Secondary Filtration Disinfected	2.2 total coliform /100 mL	2 NTU	Secondary Filtration Disinfected	2.2 fecal coliform/100 mL 450 CT 5ppm min Cl Concentration	2 NTU	Undisinfected Secondary	23 total coliform/ 100 mL (if milking animals)		California Department of Health Services *Title 22 California Water Code* (2001)
Colorado	Secondary Filtration Disinfected	126 E. coli / 100 mL	3 NTU							Colorado Department of Public Health and Environment Water Quality Control Commission *Regulation No. 84 Reclaimed Domestic Wastewater Control Regulation* (2000)
Florida	Secondary Coagulation Filtration Disinfected	No detectable coliform/ 100 mL	5 mg/L TSS	Use Prohibited			Secondary Disinfected	200 fecal coliform/ 100 mL	10 mg/L TSS	Florida Department of Environmental Protection *Chapters 62-600 and 62-610* (1996)
Georgia	Secondary Coagulation Filtration Disinfected	23 total coliform/ 100 mL	3 NTU	Use Prohibited						Georgia Department of Natural Resources *Draft Design Guidelines for Water Reclamation and Urban Water Reuse* (2001)
Massachusetts	Secondary Filtration Disinfected	No detectable coliform/ 100 mL	2 NTU							Massachusetts Department of Environmental Protection *Interim Guidelines on Reclaimed Water* (2000)
Nevada	Secondary Coagulation Filtration Disinfected	2.2 total coliform / 100 mL	2 NTU				Secondary Disinfected	23 total coliform/ 100 mL	3 NTU	Nevada Division of Environmental Protection *Guidelines for Wastewater Treatment Plant Effluent Reuse* (1991)
New Jersey	Secondary Filtration Disinfected	2.2 total coliform / 100 mL	5 mg/L TSS	Secondary Filtration Disinfected	2.2 total coliform / 100 mL	5 mg/L TSS	Secondary	200 fecal coliform/ 100 mL		New Jersey Department of Environmental Protection *Reclaimed Water for Beneficial Reuse* (2000)
North Carolina	Tertiary	14 fecal coliform/ 100 mL	5 mg/L TSS	Use Prohibited			Tertiary	14 fecal coliform/ 100 mL	5 mg/L TSS	State of North Carolina Department of Environmental, Health & Natural Resources *Administrative Code Section: 15A NCAC 2H.0200- Waste Not Discharged to Surface Waters (1996)*
Oregon	Secondary Coagulation Clarification Filtration Disinfected	2.2 total coliform / 100 mL	2 NTU	Secondary Coagulation Clarification Filtration Disinfected	2.2 total coliform / 100 mL	2 NTU	Secondary	No Limit	No Limit	Oregon Department of Environmental Quality *Oregon Administrative Rules Division 55* (1991)
Texas	Not Specified	75 fecal coliform/ 100 mL	3 NTU	Use Prohibited			Secondary Disinfected Filtration	800 fecal coliform/100 mL	Not Specified	Texas Natural Resource Conservation Commission *Chapter 210 Use of Reclaimed Water* (1997)
Utah	Secondary Filtration Disinfected	14 fecal coliform/ 100 mL	2 NTU				Secondary Disinfected	200 fecal coliforms/ 100 mL	25 mg/L TSS	Utah Administrative Code *Rule 317-1-4 Utilization and Isolation of Domestic Wastewater Treatment Works Effluent* (2001)
Washington	Secondary Coagulation Filtration Disinfected	2.2 total coliform / 100 mL	2 NTU	Secondary Coagulation Filtration Disinfected	2.2 total coliform / 100 mL	2 NTU	Secondary Disinfected	23 total coliform/ 100 mL		Washington State Department of Health and Department of Ecology *Water Reclamation and Reuse Standards* (1997)
EPA Guidelines	Secondary Filtration Disinfected	No detectable coliform/ 100 mL	2 NTU	Secondary Filtration Disinfected	No detectable coliform/ 100 mL	2 NTU	Secondary Disinfected	200 fecal coliforms/ 100 mL	30 mg/L TSS	U.S. Environmental Protection Agency *Guidelines for Water Reuse* (1992)

downstream water right holders and impacts the ability of the system to meet water allotments. In the Texas example, upstream and downstream water users worked together to model and minimize the affect of the project on the river basin so that downstream users would not be negatively impacted. In addition, this issue is among the issues being discussed as part of the Water Sharing Plan for the Apolachicola-Chattahoochee-Flint River system between Alabama, Georgia, and Florida. Reuse projects planned in the Atlanta metropolitan area would result in a net loss to the Chattahoochee River; thus reducing the amount of available streamflow in the river exacerbating a water shortage and water quality situation downstream. Reduction in flows in rivers and streams is also especially important in southern California due to the semiarid climate. As an example, Orange County has submitted an application to obtain a water right on the Santa Ana River based on the historic availability of wastewater return flows in the river. If this water right is granted it could limit the amount of water reuse that can occur upstream on the Santa Ana River in the Inland Empire without construction of separate conveyance facilities. Currently, this water right application is under review by the state of California.

- **Disposal of Treatment Waste Streams.** The disposal of membrane concentrate is emerging as an issue for recycled water because of the use of membranes in advanced treatment and the processing of concentrates at wastewater treatment plants. The disposal issue is important due to the USEPA classifying membrane concentrate as an industrial waste. This classification is forcing states to regulate the disposal of concentrate to surface and ocean waters. In Florida, the state is investigating the prohibition of membrane concentrate discharge to surface waters. This prohibition is based on the Antidegradation Policy, which protects the designated beneficial uses of specific surface waters. Another component of this issue is toxicity. Disposal of concentrate can result in spikes in specific constituents resulting in increased toxicity, which harms aquatic habitat. Florida is leading the way in regulation of concentrate disposal, due to the large number of water and wastewater plants in the state that use membranes and produce concentrate. Currently, Florida permits discharges of concentrate if mixing zones are developed based on hydrographic studies, ambient water quality investigations, and impact modeling. In addition, the mixing zones cannot exceed existing regulatory requirements for the radii of area affected by the disposal. Ocean discharges in California must conform to the California Ocean Plan established by the California State Water Resources Control Board in accordance with Section 303(c)(1) of the Federal Clean Water Act and Section 13170.2(b) of the California Water Code. The plan describes waste management for waste discharges to the ocean and specifies water quality standards. Dilution is required at the ocean outfall to meet concentration limits for toxic substances. The California Ocean Plan requires that; the disposal of concentrate must not cause degradation of a "healthy and diverse marine environment"; rapid initial dilution and effective dispersion must be achieved to minimize localization of concentrated materials; outfalls should be located in open coast where interchange of water occurs; and a sufficient distance must be maintained between concentrate discharge and areas where special biological significance exists. Appendix F lists the areas where special biological significance exists in California.

- **Source Control of Constituents.** Source control of constituents is emerging as an issue for Title 22 permits in California. DHS is looking at the complete hydrodynamic system of a wastewater agency from source water to discharge. This analysis includes looking into upstream source control at the water treatment plant, determining what is entering the system from users, especially industries, as well as what constituents are present in the influent to the wastewater treatment plant. This issue is linked to development of risk assessments for recycled water projects as well as the significant number of constituents that have recently been found downstream of wastewater plants around the U.S. as a result of the USGS *Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams, 1999-2000: A National Reconnaissance Study.* This study identified a number of constituents in U.S. streams including endocrine disrupters or hormonally active agents, antibiotics, and pharmaceuticals and personal care products. The Orange County Sanitation District (OCSD) is currently working with DHS to identify source control issues; however, the revised OCSD *Title 22* permit will not have a requirement governing upstream source control measures.
- **Required Instream Flows for Habitat.** Water reuse agencies must work with environmentalists and regulators to develop solutions that protect the existing environment by providing adequate minimum flows while permitting discharges. Along the Los Angeles River, environmentalists and regulators are having contradictory opinions regarding wastewater effluent discharges, which compose 80 percent of the river's flow below the Glendale Narrows. Some environmentalists want the discharges removed from the river while regulators say that the discharges have created habitat that must be protected. The Los Angeles Department of Water and Power is undertaking a project, with planning contributions from Reclamation, to determine the minimum flow required to maintain habitat in the river. There are three issues of concern related to this issue: potential regulation of discharges that require treatment that is costly and provides little benefit to habitat; the inability to discharge water to the river requiring either total reuse of the effluent or developing an alternative discharge location; and loss of water supply for water reuse activities in northern Los Angeles County.
- **Discharge Toxicity, Treatment Options, and Unregulated Contaminants.** The USEPA is currently focusing research on toxicity testing, treatment options, and unregulated contaminants. Toxicity testing is being looked at to determine the long-term effects of exposure to low concentrations of toxics. The USEPA is also looking at new treatment technologies including the use of microfiltration and nanofiltration for water reclamation to remove pharmaceuticals, viruses, antibiotics, nitrates, and phosphates. The reliability of these advanced treatment options is important because as more contaminants are regulated at lower concentrations, these treatment options will be vital to the continuation and public acceptance of water reuse projects. Another area of possible future regulation is currently unregulated contaminates. Potential regulation of these contaminants will depend upon the health effects associated with exposure, treatment technologies available, and risk assessment.
- **Service Duplication Act.** The *Service Duplication Act* in California requires water reuse agencies that are supplying users within another water agency's boundaries to compensate that agency for the loss of customer revenue. This requirement could make supplying recycled water to some users economically infeasible if charges by the initial

water supply agency are high; thus limiting the amount of water that would be ultimately reused. This practice has been considered several times by the California legislature; however, no binding legislative changes have occurred.

3.3.5 Recycled Water Regulations in Other Countries

Water reuse around the world is linked to water supply availability and environmental concerns. The use of recycled water occurs primarily in areas where water scarcity occurs due to either lack of water supplies or climatic impacts. Northern European countries with smaller populations and extensive rainfall such as Austria, Denmark, Finland, Germany, Ireland, and Luxembourg have no reuse or regulations for reuse. In areas where large populations, environmental concerns, or water scarcity occur such as Belgium, Greece, Norway, Portugal, Sweden, Switzerland, the Netherlands, and the United Kingdom water reuse and reuse regulations and/or guidelines exist. Table 3.11 compares the regulations for California, the USEPA, WHO, Australia/New Zealand, Cyprus, Israel, Japan, New South Wales, and Tunisia.

Internationally there are two basic frameworks for water reuse criteria, those based on the State of California criteria or those based on the WHO guidelines. The California criteria are the most stringent and are the basis for a number of industrial countries' guidelines; however, these guidelines make safety the primary objective rendering them expensive to implement especially in developing countries. The WHO guidelines are used in developing countries as a basis for the use of recycled water and are meant to provide for the most basic health standards.

The WHO has provided guidelines for the use of recycled water since 1973. These initial guidelines were a result of a WHO-sponsored meeting of experts and consisted of the recommended treatment level required for specific use types, which were based on the use type and amount of human contact. Uses with direct human contact required removal of recognizable solids, significant removal of parasite eggs, and significant removal of bacteria and some viruses. These regulations were reviewed in 1985 and determined to be too conservative for many countries. The WHO recognized that most wastewater was treated prior to reuse to remove recognizable solids, some parasites, and bacteria. Therefore, the WHO guidelines were revised to focus on the removal of helminthic diseases because it was believed that this was the main remaining health risk. In 1989 the guidelines were revised and made less restrictive to accommodate the revised approach and make the guidelines more economically cost effective for developing countries. The revised guidelines were predicated on the fact that existing treatment in developed countries exceeded the WHO guidelines. The1989 guidelines rely on waste stabilization ponds with sufficient detention times to achieve microbiological quality goals for uses of recycled water where there is human contact. There is some evidence at existing facilities that the goal of less than 1000 fecal coliforms per 100 mL cannot be achieved in practice at the waste stabilization ponds in some countries.

Australia, Japan, Israel, and South Africa do not use WHO guidelines alone. Instead these nations and many industrialized nations use the WHO guidelines as a basis and add additional criteria to them to increase human health protection. However, the use of additional criteria is often controlled by economics. It is as a result of this situation that a number of experts recommend development of a third standard model, which rests somewhere between the higher risk avoidance and expense of the California criteria and the lower cost and less stringent WHO guidelines. Development of a middle ground criterion for reuse would provide for consistency between countries and make trade of agricultural goods and tourism safer.

3.3.6 Potential Regulations

There are three potential areas of regulation that could occur in the future, these include regulation of constituents, new treatment requirements, and protection against degradation of the environment. State and Federal regulators are focusing their efforts in these areas. In fact, the USEPA has identified three areas of study for the future, which include research into toxicity, treatment options, and unregulated contaminants. In addition, the RWQCBs are focusing regulatory efforts on developing TMDLs, meeting designated beneficial uses and protecting against degradation of the environment, and developing source control methods for improving water quality and removing constituents. The general public and environmental groups are concerned about ensuring that water reuse protects and does not degrade public health and safety or the environment. Beyond water quality and environmental protection, water reuse agencies also face other economic and regulatory issues that could affect the ability to recycle. These issues include additional project costs for

Table 3.11
Comparison of International Water Reuse Criteria

	Requirements for Specified Uses									Source of Information
	Unrestricted Urban Uses			Food Crop (Eaten Raw) Irrigation			Pasture Irrigation			
	Required Treatment	Microbiological Limits	Turbidity/ Suspended Solids	Required Treatment	Microbiological Limits	Turbidity/ Suspended Solids	Required Treatment	Microbiological Limits	Turbidity/ Suspended Solids	
California	Secondary Filtration Disinfected	2.2 total coliform /100 mL	2 NTU	Secondary Filtration Disinfected	2.2 fecal coliform/100 mL 450 CT 5ppm min Cl Concentration	2 NTU	Undisinfected Secondary	23 total coliform/ 100 mL (if milking animals)		California Department of Health Services *Title 22 California Water Code* (2001)
EPA Guidelines	Secondary Filtration Disinfected	No detectable coliform/ 100 mL	2 NTU	Secondary Filtration Disinfected	No detectable coliform/ 100 mL	2 NTU	Secondary Disinfected	200 fecal coliforms/ 100 mL	30 mg/L TSS	U.S. Environmental Protection Agency *Guidelines for Water Reuse* (1992)
World Health Organization	Series of Stabilization Ponds or Equivalent	200 fecal coliform/ 100 mL 1 intestinal nematodes/ L		Series of Stabilization Ponds or Equivalent	1000 fecal coliform/ 100 mL 1 intestinal nematodes/ L		Retention in Stabilization Ponds for 8-10 days or equivalent helminth and fecal coliform removal	1 intestinal nematodes/ L		World Health Organization *Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture* (1989)
Australia/ New Zealand	Tertiary with pathogen reduction	10 fecal coliforms/ 100 mL	2 NTU	Tertiary with pathogen reduction	10 fecal coliforms/ 100 mL	2 NTU	Secondary with pathogen reduction	1000 fecal coliforms/ 100 mL		Agriculture and Resource Management Council of Australia and New Zealand *Guidelines for Sewerage Systems: Use of Reclaimed Water* (2000)
Cyprus	Tertiary Filtration Disinfection	50 fecal coliforms / 100 mL	10 mg/L TSS	Secondary Disinfection Storage > 1 week (No irrigation of vegetables)	200 fecal coliforms/ 100 mL	30 mg/L TSS	Secondary (Storage > 1 week) or Tertiary Disinfection	1000 fecal coliforms/ 100 mL	30 mg/L TSS	Provisional Standards as taken from *The Status of Wastewater Reuse Practice in the Mediterranean Basin: Need for Guidelines* A.N. Angelikis (1999)
Israel	Secondary Disinfection	250 fecal coliforms/ 100 mL	30 mg/L TSS	Tertiary Soil Aquifer Treatment	2.2 fecal coliforms/ 100 mL	15 mg/L TSS	Secondary Disinfection	Not Specified	50 mg/L TSS	Ministry of Health Water Quality Criteria as taken from *The Status of Wastewater Reuse Practice in the Mediterranean Basin: Need for Guidelines* A.N. Angelikis (1999)
Japan	Tertiary Filtration	No detectable fecal coliform	Not Specified							Ministry of Construction *Draft Technical Guidelines for Wastewater Reclamation and Reuse* (1981) as taken from *Wastewater Reclamation and Rues in Japan: Overview and Implementation Examples* T. Asano (1996)
New South Wales	Secondary Coagulation Filtration	25 fecal coliform/ 100 mL	2 NTU	Use Prohibited			Secondary Coagulation Filtration	25 fecal coliform/ 100 mL	2 NTU	New South Wales Recycled Water Coordination Committee *New South Wales Guidelines for Urban and Residential Use of Reclaimed Wate* r (1993)
Tunisia	Secondary	1 intestinal nematode/ L	30 mg/L TSS	Use Prohibited			Series of Stabilization Ponds or Equivalent	1 intestinal nematode/ L	30 mg/L TSS	Tunisian Water Reuse Standards as taken from *The Status of Wastewater Reuse Practice in the Mediterranean Basin: Need for Guidelines* A.N. Angelikis (1999)

some agencies due to imposition of the *Service Duplication Act*, issues regarding water rights and the reuse of water, and issues associated with either too much or too little discharge occurring within riverine environments that convey recycled water. Also as water reuse is used to meet new water demands through either direct and/or indirect potable methods, stricter and more conservative regulations will be implemented on these types of projects.

Since the *Clean Water Act* was passed in 1972, the USEPA has been tasked with the effort "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." In an effort to meet this goal the USEPA is continuing to look for new points of concern as well as methods to test and treat water discharged into the environment. Currently, the USEPA is investigating regulation of additional or nonregulated constituents as well as stricter regulations on regulated constituents. The USEPA is also looking at advanced treatment options, increased monitoring, risk assessment development, and source control of constituents, including those constituents identified in streams by a recent USGS study. As more is known regarding the fate and impact of existing constituents in water and higher levels of treatment become cost effective, the assessment of the amount of acceptable and affordable risk associated with the constituents will drive regulation. A major component driving this debate will be public perception regarding the risks. Therefore, public information is a key component in developing sound scientific and economic regulations that provide for human health protection and acceptable risks. A vital component to educating young people and informing the public is explaining the hydrodynamic cycle of water and recycled water. This is especially relevant in southern California where water is used and recycled as it moves down the water supply system from northern California and the Colorado River Watersheds and within southern California.

One of the ways to regulate constituents is by TMDLs. Currently, TMDLs are under development in southern California by the RWQCBs that may affect NPDES permits either directly or indirectly. As water is reused in the hydrodynamic cycle, constituent loading increases. Therefore, runoff from irrigation sites using recycled water or treated effluent from industries using recycled water may not meet TMDLs. It is important that regulators assess the sources of the constituents correctly and do not impose unnecessary limitations on water reuse and wastewater discharge. In addition, water reuse agencies must work with environmentalists and regulators to develop solutions that protect the existing environment and allow use of recycled water.

Another issue that may drive regulation in California is water scarcity. As populations continue to grow and water sources are reduced, new uses of recycled water may become viable. This is evident in the willingness to consider groundwater recharge rates of over 50 percent on a case by case basis. However, without public acceptance, recycled water projects will not be implemented. Therefore, developing water reuse regulations that regulators, agencies, and the general public believe are acceptable is a vital component of the future of water reuse. A key component of this will be to define a successful strategy for educating, providing information, and gaining acceptance from the public for water reuse. Also, planned indirect potable reuse through surface water augmentation may at some point become viable; therefore it is important for water reuse agencies and regulators to work together to develop sound scientific and economic solutions for this type of reuse.

3.3.7 Recommendations

Water reuse regulations will continue to provide public health and environmental protection. This may include stricter regulations that provide for additional public health and safety for specific constituents. It is important that water reuse agencies work with regulators to develop regulations that provide acceptable risks, economical solutions, and protection of the public health and safety. Areas of study that would assist water reuse agencies in helping to shape future regulations include:

- Developing toxicity limits and assimilative capacities for outfalls for both brine and /or effluent discharges from reuse projects. A study into this toxicity should determine the effect of discharges on the marine environment, if degradation of the marine environment occurs, what specific constituents and concentrations cause degradation, and when will southern California reach discharge levels and concentrations where toxicity becomes an issue.
- Development of a public education and information program that explains the water and water reuse hydrodynamic cycle. It is important the public understands that

water reuse occurs in the natural environment and that as water treatment plants mimic natural processes so does water reuse and water reclamation plants.

- Investigation of potential upstream source control for users of recycled water. In this study source control would be looked at from a local as well as a regional water supply level.
- Work with regulators to develop economic and sound scientific criteria governing groundwater recharge and indirect potable reuse. One issue to investigate is how to successfully develop and plan an indirect potable reuse surface water augmentation project that will comply with current regulations as well as overcome negative public perception. In addition, it would be valuable to identify the mechanisms and environment that resulted in the unsuccessful implementation of past planned indirect potable reuse projects through surface water augmentation.
- Determine when the need for planned indirect potable reuse through surface water augmentation will occur due to water scarcity brought on by population development and develop a long-term plan to educate the public regarding this type of reuse.

3.4 Use Type

3.4.1 Introduction

The United Nations estimates that only two and a half percent of the world's water is freshwater and within the next 25 years two-thirds of the world's population will be living in areas that face water scarcity. Due to these facts, water reuse is emerging as a supplemental water supply in many parts of the world. This is also true in the United States where water reuse is being utilized to augment water supplies due to concerns over available freshwater for agricultural uses as well as water quality and environmental concerns.

The urbanization of populations, water scarcity issues, and inadequate fresh water supplies around the world have also resulted in recycled water use evolving from an irrigation supply mechanism for crops to a water supply mechanism for a range of uses. These uses are illustrated in the recycled water flow diagram in Figure 3.1. Recycled water is now utilized for a number of use types, which include urban irrigation (F), municipal and industrial uses including toilet flushing (G), groundwater recharge (A3), habitat/environmental use (D), and potable water supply. In addition, water reuse systems have evolved from supply of local users to large systems, which supply large quantities of recycled water to users over an extended area. Dual water systems are also being developed around the world to assist in ensuring the reliability of water supplies.

The implementation of recycled water projects throughout the world has occurred primarily in areas with large populations and water scarcity issues. This is also true in the U.S. where the states utilizing the largest amounts of recycled water either have water scarcity issues and/or large or expanding populations. The four U.S. states that supply a majority of the recycled water used in the U.S. are Arizona, California, Florida, and Texas. It is estimated that these four states recycled the following amounts of water in 2000:

- 210 mgd in Arizona
- 360 mgd in California
- 490 mgd in Florida
- 220 mgd in Texas

In conjunction with the increased amount and type of reuse, treatment of recycled water has also evolved. Initially untreated wastewater was used to irrigate crops but now water is treated using advanced membrane processes such as Reverse Osmosis (RO) and ultrafiltration (UF) to supply specific end-use requirements as well as to meet public health protection requirements. In addition, regulations and guidelines governing water reuse practices have also changed to incorporate advances in treatment technology as well as an increased understanding of water chemistry.

3.4.2 Factors Limiting Water Reuse

Key issues that drive the level of reuse are urbanization, population growth, and water scarcity. However, there are a number of issues that affect the potential for implementing water reuse projects or expanding the amount of water reused. These issues include water supply and demand and water quality concerns. Atmospheric and climatic issues, environmental concerns, economic constraints, and regulatory concerns are categories that also can affect project implementation.

3.4.2.1 Water Supply and Demand

Water supply and demand, as well as available infrastructure, limit the amount of water that can be reused. In *Bulletin 160-98, The California Water Plan* recycled water is identified with desalination as a supply mechanism to assist in meeting future water demands. In the 1998 update of *Bulletin 160*, the projected level of water reuse in 2000 was estimated as 485,000 acre-feet per year (afy) and reuse was projected to expand to 577,000 afy by 2020. However, the total amount of recycled water utilized in 2000, as reported by California Water Resources Control Board, Office of Water Recycling in the *California Municipal Wastewater Reclamation Survey*, was 401,420 afy. The discrepancy between the projected and survey estimates of water reuse are a function of the drought that drove water planners to estimate greater demands for water reuse than actually developed. *Bulletin 160-98* also projected that another 835,000 afy of additional reuse could be implemented by 2020, which sets the total of potential reuse at over 1.4 million afy in 2020. In addition to the state's projections of water reuse, Reclamation has also undertaken efforts to determine the potential amount of future reuse. Reclamation first based estimates on regional projects identified during a study process wherein Reclamation worked with over 70 water and wastewater agencies in southern

California and over 20 agencies in northern California to identify projects that those participating agencies were willing to pursue. As such, Reclamation's estimates were not actual "projections." Ultimately, Reclamation focused only on actual projects in some phase of planning and did not endeavor to make projections on reuse potential. Through Reclamation studies the following estimates of water reuse have been developed:

- *Southern California Comprehensive Water Reclamation and Reuse Study* identified 451,000 afy of additional reuse that could be implemented by 2010 in southern California.
- *Bay Area Regional Water Recycling Program* (BARWRP) identified 125,000 afy of additional reuse that could be implemented by 2010 in the Bay Area.
- *Southern California Water Recycling Projects Initiative* (Initiative) *Phase I* identified 791,520 afy of additional reuse in southern California based on projects agencies had identified as in the preplanning or planning stage.

The projects from Reclamation's studies are all based on identified water reuse agency demands, which are feasible to supply with recycled water. In addition, sufficient demand and users exist to expand the amount of recycling in California. Also, the *Bulletin 160-98* projections illustrate how drought and water scarcity drive the need and reliance on water reuse.

Identified projects illustrate where water reuse is possible; however, implementation of water reuse projects is based on economics, public acceptance, and regulatory constraints. Currently, recycled water is supplied to a number of different uses in California. Agricultural irrigation, urban irrigation, industrial/commercial use including toilet flushing, groundwater recharge, seawater intrusion, recreational impoundment, and habitat/ environmental use are the primary types of water reuse. Table 3.12 provides the amount of water California reused in 2000 by use type.

One key economic component that can limit the potential for reuse of water in an area is cost and existence of adequate infrastructure. Recycled water needs to be conveyed from the WRP to the user; therefore, the infrastructure costs are the additional treatment and conveyance costs as well as the cost for any necessary storage. The cost of infrastructure as well as the economics of developing recycled water projects can limit the potential for project implementation. Recycled water pricing has historically been at reduced levels to attract users. As recycled water has become valued as a mechanism to assist in conserving potable water as well as an alternative water supply, prices for reused water have increased. Price increases have ranged from recovering a portion or all of the operation and/or construction costs or some combination of cost recovery formulae. However, in a survey performed in 1997 it was estimated that water reuse agencies only recovered 75 percent of the cost of operating recycled water systems.

TABLE 3.12

WATER REUSE IN CALIFORNIA IN 2000 BY USE TYPE

Type of Water Reuse	Total Volume of Reuse (acre-feet per year)
Agricultural Irrigation	193,470
Urban Irrigation of Landscape and Impoundments	78,520
Industrial/Commercial Use	20,180
Groundwater Recharge	48,340
Seawater Barrier	10,140
Recreational Impoundment	17,920
Habitat/Environmental Use	25,940
Other or Mixed Use	6,910
Total	401,420

Note:
Table developed By the California Water Resources Control Board, Office of Water Recycling

The true economics of water reuse are not solely derived from cost recovery. The value of water reuse is also dependent on avoided costs for water supply, wastewater disposal, environmental degradation, and energy usage. In addition, recycled water provides reliable water supply to agencies facing water supply shortages. The use of recycled water can postpone the implementation of additional strategies to increase potable water supply, which are often costly to implement. Implementation of a water recycling project allows agencies to avoid one of the largest potential expenses; the reduction in wastewater disposal and the costs associated with it. This is especially important due to the more stringent regulatory requirements being set on disposal due to environmental regulations including the implementation of TMDLs. Additionally, there are extensive values associated with reliable water supplies during dry periods. These values appear as community income and employment that are based on the availability of water supplies. It is important to note that the recycled water supply value can be observed on a local, regional, or even national level depending on the characteristics and vitality of the economy it supports. Although recycled water systems are costly to implement, the implementation of a recycled water system can offset a number of other costs that face water agencies. In the end, development of a recycled water project depends on the value assigned by the local agency and whether the project is feasible under the set of circumstances that the agency is facing.

3.4.2.2 Water Quality

Water quality is a key factor in limiting the potential for reuse. As more stringent regulations and water quality criteria are put in place, the cost to treat water to meet these standards rises. In addition, reuse is also limited by specific water users' perceptions or water quality concerns. Table 3.13 provides a list of problems associated with specific types of water reuse. It is important to note that recycled water use is a reliable, consistent water supply when the recycled water system is designed and operated properly at the supply and the point of use.

Agricultural Irrigation

Agricultural irrigation, depending on the location, can make up between 60 to 80 percent of the water resources used in an area [Okun, 1996]. An effective way to meet this large consumptive use, while maintaining raw water supplies for potable uses, is to use recycled water. The use of recycled water for agricultural irrigation is the largest current recycled water use type around the world. This is also true in California where agricultural irrigation makes up 48 percent of the recycled water supplied in the state.

Agricultural uses are also the largest future demand for recycled water, especially as freshwater supplies are stretched to meet the needs of expanding populations around the world. However, there are some concerns associated with the use of recycled water for agriculture. These concerns include the effects of salinity, chlorine, boron, and other constituents on soil permeability and crop yield and public health concerns regarding contact and consumption. The effect and tolerance of salt, chlorine, and boron on agricultural crops are provided in Table 3.14. The effect of large-scale recycled water use on the groundwater,

TABLE 3.13

POTENTIAL OBSTACLES TO USING RECYCLED WATER BY USE TYPE

USE TYPE	SPECIFIC USE	ASSOCIATED PROBLEMS DUE TO CONSTITUENTS ADDED DURING RECYCLED WATER USE	SOLUTIONS/ TREATMENT OPTIONS
AGRICULTURAL IRRIGATION	Crop Irrigation	Permeability of soil may decrease due to carbonates and bicarbonates	Provide treatment to remove carbonates and bicarbonates.
		Canning of crops can be affected due to presence of constituents as well as due to concerns about human consumption	Provide treatment to address constituents of concern and provide human health protection.
		Lower yields and non-productivity can be induced by accumulation of ions such as boron, chloride, and sodium	Advanced softening treatment (e.g., high-pressure membrane) in wastewater treatment systems or add soil conditioners and occasionally leach soil to remove excessive minerals. Conduct upstream controls to reduce salinity in wastewater prior to treatment.
		Sensitivity of some crops such as flowers to nutrients	Biological nutrient removal processes (e.g., improved nitrification/ denitrification and phosphorus removal) in wastewater treatment.
		Biological damage may be caused by heavy metals such as cadmium, lead and mercury	Advanced treatment (e.g., ultrafiltration or reverse osmosis membrane or adsorption processes) in wastewater treatment systems.
		Clogging of irrigation heads may occur	Install pre-filters at users site.
		Groundwater quality may be impacted as well as undesirable vegetation growth and inferior fruit quality may be occur due to high nitrogen/ nitrate contents	Biological nutrient removal processes (e.g., improved nitrification/ denitrification) in wastewater treatment.
GROUNDWATER	Recharge/ Infiltration	Public perception concerns regarding the effect of recycled water on groundwater basin water quality	Develop public outreach program to address concerns.
MISCELLANEOUS	Fire Prevention	Periodic seasonal or diurnal shortage may result from inadequate storage or wastewater supply	Provide adequate storage to meet peak demands and seasonal variations in supply.
		Fire trucks may not allow reclaimed water in their pump trucks	Supply internal fire flow pumping system.

TABLE 3.13

POTENTIAL OBSTACLES TO USING RECYCLED WATER BY USE TYPE

USE TYPE	SPECIFIC USE	ASSOCIATED PROBLEMS DUE TO CONSTITUENTS ADDED DURING RECYCLED WATER USE	SOLUTIONS/ TREATMENT OPTIONS
URBAN IRRIGATION	Landscape/ Golf Course Irrigation	Spots of ferric chlorisis may be caused by low iron content	Foliar applications of iron sulfate or iron chelates.
		Permeability of soil may decrease due to salinity	Advanced softening treatment (e.g., high-pressure membrane) in wastewater treatment systems or add soil conditioners and occasionally leach soil to remove accumulated minerals.
		Unacceptable odors may occur during irrigation	Provide treatment o reduce potential for hydrogen sulfide and maintain chlorine levels below nuisance level. Conduct upstream salinity controls to reduce salinity in wastewater prior to treatment.
		Fungal infections may occur in fall resulting from excessive nitrogen contributions during summer irrigation	Fungicide application to prevent or eliminate infections.
	Water Features/ Fountains	Odor and other nuisances may result from constituents. Excessive algae may result from excessive nutrients	Provide adequate design and operation of system.
	Surface Water Augmentation	Adverse impacts on tourism and property values may result due to adverse public perception	Develop public outreach program to address concerns.
		Algal blooms/eutrophication may result from excess nutrient levels	Biological nutrient removal processes (e.g., improved nitrification/ denitrification, and phosphorus removal) in wastewater treatment.
TOILET FLUSHING	Toilet Flushing	Periodic seasonal or diurnal shortage may result from inadequate storage or supply	Provide adequate storage to meet peak demands and seasonal variations in supply.
	Sanitary Sewer Flushing	Potential risk to human health due to human (workers) contact	Provide required health protection and protective gear. Tertiary treatment may be required for use.
HABITAT	Wetlands	Public perception concerns regarding affect on water quality on wetland	Develop public outreach program to address concerns.
		Odor problems may result from constituents	Provide adequate design and operation of system.
		Algal blooms/eutrophication may result from excess nutrient levels	Provide adequate design and operation of system.
		Habitat may be adversely affected due to high concentration of heavy metals and synthetic organic compounds	Advanced treatment (e.g., ultrafiltration or reverse osmosis membrane or adsorption processes) in wastewater treatment systems. Enhance pretreatment control for commercial/industrial customer wastewater discharges

TABLE 3.13

POTENTIAL OBSTACLES TO USING RECYCLED WATER BY USE TYPE

USE TYPE	SPECIFIC USE	ASSOCIATED PROBLEMS DUE TO CONSTITUENTS ADDED DURING RECYCLED WATER USE	SOLUTIONS/TREATMENT OPTIONS
INDUSTRIAL/ COMMERCIAL	Carpet Dyeing	Dyeing process may be impacted. Other nuisances such as odor may occur	Evaluate water quality requirements. Pilot test batch products and provide additional treatment if required.
	Boiler Feed Water	Excessive scaling or corrosion may occur	Demineralize water prior to use.
	Commercial Car Washing	Excessive spotting may occur on vehicles	Soften wash water and demineralize final rinse water.
	Dust Control	Contamination of tanker trucks	Dedicate and label truck using non- –potable water or perform appropriate disinfection practices between switching between domestic and non-potable water use.
	Power Plant Cooling Water/ Evaporative Cooling	Precipitation of minerals in cooling towers may result due to high carbonate content	Provide adequate filtration to remove carbonate.
		Cooling process may be affected by potential ammonia and in rare cases nitrogen sensitivity	Improved nitrification/ denitrification in wastewater treatment.
		Excessive corrosion of soft metal may occur due to ammonia	Provide ammonia removal prior to use.
		Excessive scaling may occur	Reduce cycles or demineralize water prior to use.
	Chemicals Industry	Undesired constituents to chemical processing	Provide membrane filtration treatment to remove constituents.
	Textile Industry	Dye process may be interfered with by high concentrations of iron and zinc being deposited on the material	Provide treatment to remove iron and zinc.
		Dye process may be affected by high concentrations of metals	Advanced treatment (e.g., ultrafiltration or reverse osmosis membrane or adsorption processes) in wastewater treatment systems.
		Dye process may be affected by color in water resulting from high concentrations of iron and manganese	Provide treatment to remove iron and manganese.
	Petroleum and Coal Products	Undesired constituents to chemical processing	Provide membrane filtration treatment to remove constituents.

Table 3.14

Salt, Chlorine, and Boron Tolerance of Agricultural Crops

		Salinity			Chlorine		Boron		
Common Name[1]	**Botanical Name[2]**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Rating**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Rating**
Alfalfa	Medicago sativa				20	0.7	4.0-6.0	--	Tolerant
Apricot	Prunus armeniaca						0.5-7.5	--	Sensitive
Artichoke	Cynara scolymus	--	--	Moderately Sensitive			2.0-4.0	--	Moderately Tolerant
Artichoke, Jerusalem	Helianthus tuberosus	0.4	9.6	Moderately Sensitive			0.75-1.0	--	Sensitive
Asparagus	Asparagus officinalis	4.1	2	Tolerant			10.0-15.0	--	Very Tolerant
Avocado	Persea american						0.5-7.5	--	Sensitive
Barley	Hordeum vulgare	8	5	Tolerant	80	0.5	3.4	4.4	Moderately Tolerant
Bean	Phaseolus vulgaris	1	19	Sensitive	10	1.9	0.75-1.0	--	Sensitive
Bean, limab	P. lunatus						0.75-1.0	--	Sensitive
Bean, mung	Vigna radiata	1.8	20.7	Sensitive			0.75-1.0	--	Sensitive
Bean, snap	P. vulgaris						1	12	Sensitive
Beet, red	Beta Vulgaris	4	9	Moderately Tolerant	40	0.9	4.0-6.0	--	Tolerant
Blackberry	Rubus sp.						<0.5	--	Very Sensitive
Broadbean	Vicia Faba	1.6	9.6	Moderately Sensitive	15	1			
Broccoli	Brassica oleracea botrytis	2.8	9.2	Moderately Sensitive	25	0.9	1	1.8	Moderately Sensitive
Brussel Sprouts	B. oleracea gemmifera	--	--	Moderately Sensitive					
Cabbage	B. oleracea capitata	1.8	9.7	Moderately Sensitive	15	1	2.0-4.0	--	Moderately Tolerant
Carrot	Daucus carota	1	14	Sensitive	10	1.4	1.0-2.0	--	Moderately Sensitive
Cauliflower	Brassica oleracea botrytis	--	--	Moderately Sensitive			4	1.9	Moderately Tolerant
Celery	Apium graveolens	1.8	6.2	Moderately Sensitive	15	0.6	9.8	3.2	Very Tolerant
Cherry	P. avium						0.5-7.5	--	Sensitive
Clover, sweet	Melilotus indica						2.0-4.0	--	Moderately Tolerant
Corn, sweet	Zea mays	1.7	12	Moderately Sensitive	15	1.2	2.0-4.0	--	Moderately Tolerant
Cotton	Gossypium hirsutum	7.7	5.2	Tolerant	75	0.5	6.0-10.0	--	Very Tolerant
Cowpea	Vigna unguiculata	4.9	12	Moderately Tolerant	50	1.2	2.5	12	Moderately Tolerant
Cucumber	Cucumis sativus	2.5	13	Moderately Sensitive	25	1.3	1.0-2.0	--	Moderately Sensitive

Table 3.14

Salt, Chlorine, and Boron Tolerance of Agricultural Crops

		Salinity			Chlorine		Boron		
Common Name[1]	**Botanical Name[2]**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Rating**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Rating**
Eggplant	Solanum Melongena esculentum	1.1	6.9	Moderately Sensitive					
Fig, kadota	Ficus carica						0.5-7.5	--	Sensitive
Flax	Linum usitatissimum	1.7	12	Moderately Sensitive	15	1.2			
Garlic	A. sativum						0.75-1.0	--	Sensitive
Grape	Vitis vinifera						0.5-7.5	--	Sensitive
Grapefruit	C. x paradisi						0.5-7.5	--	Sensitive
Guar	Cyamopsis tetragonoloba	8.8	17	Tolerant					
Kale	Brassica oleracea acephala	--	--	Moderately Sensitive					
Kenaf	Hibiscus cannabinus	8.1	--	Moderately Tolerant					
Kohlrabi	B. oleracea gongylode	--	--	Moderately Sensitive					
Lemon	Citrus limon						<0.5	--	Very Sensitive
Lettuce	Lactuca sativa	1.3	13	Moderately Sensitive	10	1.3	1.3	1.7	Moderately Sensitive
Lupine	Lupinus hartwegii						0.75-1.0	--	Sensitive
Millet, foxtail	Setaria italica	--	--	Moderately Sensitive					
Muskmelon	Cucumis Melo	--	--	Moderately Sensitive			2.0-4.0	--	Moderately Tolerant
Mustard	Brassica juncea						2.0-4.0	--	Moderately Tolerant
Oats	Avena sativa	--	--	Moderately Tolerant			2.0-4.0	--	Moderately Tolerant
Okra	Abelmoschus esculentus	--	--	Sensitive					
Onion	Allium Cepa	1.2	16	Sensitive	10	1.6	0.5-7.5	--	Sensitive
Orange	C. sinensis						0.5-7.5	--	Sensitive
Parsley	Petroselinum crispum						4.0-6.0	--	Tolerant
Parsnip	Pastinaca sativa	--	--	Sensitive					
Pea	Pisum sativum	--	--	Sensitive			1.0-2.0	--	Moderately Sensitive
Peach	P. persica						0.5-7.5	--	Sensitive
Peanut	Arachis hypogaea	3.2	29	Moderately Sensitive			0.75-1.0	--	Sensitive

Table 3.14

Salt, Chlorine, and Boron Tolerance of Agricultural Crops

		Salinity			Chlorine		Boron		
Common Name[1]	**Botanical Name[2]**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Rating**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Rating**
Pecan	Carya illinoinenis						0.5-7.5	--	Sensitive
Pepper	Capsicum annuum	1.5	14	Moderately Sensitive	15	1.4	1.0-2.0	--	Moderately Sensitive
Persimmon	Diospyros kaki						0.5-7.5	--	Sensitive
Plum	P. domestica						0.5-7.5	--	Sensitive
Potato	Solanum tuberosum	1.7	12	Moderately Sensitive	15	1.2	1.0-2.0	--	Moderately Sensitive
Pumpkin	Cucurbita Pepo Pepo	--	--	Moderately Sensitive					
Radish	Raphanus sativus	1.2	13	Moderately Sensitive	10	1.3	1	1.4	Moderately Sensitive
Rice, paddy	Oryza sativa	3	12	Sensitive	30	1.2			
Rye	Secale cereale	11.4	10.8	Tolerant					
Safflower	Carthamus tinctorius	--	--	Moderately Tolerant					
Sesame	Sesamum indicum	--	--	Sensitive			0.75-1.0	--	Sensitive
Sorghum	Sorghum bicolor	6.8	16	Moderately Tolerant	70	1.6	7.4	4.7	Very Tolerant
Soybean	Glycine max	5	20	Moderately Tolerant					
Spinach	Spinacia oleracea	2	7.6	Moderately Sensitive	20	0.8			
Squash, scallop	Cucurbita Pepo Melopepo	3.2	16	Moderately Sensitive	30	1.6	2.0-4.0	--	Moderately Tolerant
Squash, zucchini	C. Pepo Melopepo	4.7	9.4	Moderately Tolerant	45	0.9			
Strawberry	Fragaria sp.	1	33	Sensitive	10	3.3	0.75-1.0	--	Sensitive
Sugarbeet	Beta vulgaris	7	5.9	Tolerant	70	0.6	4.9	4.1	Tolerant
Sugarcane	Saccharum officinarum	1.7	5.9	Moderately Sensitive	15	0.6			
Sunflower	Helianthus annuus	--	--	Moderately Sensitive			0.75-1.0	--	Sensitive
Sweet potato	Ipomoea Batatas	1.5	11	Moderately Sensitive	15	1.1	0.75-1.0	--	Sensitive
Tobacco	Nicotiana tabacum						2.0-4.0	--	Moderately Tolerant
Tomato	Lycopersicon Lycopersicum	2.5	9.9	Moderately Sensitive	25	1	5.7	3.4	Tolerant
Tomato, cherry	L. esculentum var cerasiforme	1.7	9.1	Moderately Sensitive					

Table 3.14

Salt, Chlorine, and Boron Tolerance of Agricultural Crops

		Salinity			Chlorine		Boron		
Common Name[1]	**Botanical Name[2]**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Rating**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Threshold dS/m[3]**	**Slope % per dS/m**	**Rating**
Triticale	X Triticosecale	6.1	2.5	Tolerant					
Turnip	Brassica Rapa	0.9	9	Moderately Sensitive	10	0.9	2.0-4.0	--	Moderately Tolerant
Vetch, purple	Vicia benghalensis				30	1.1	4.0-6.0	--	Tolerant
Walnut	Juglans regia						0.5-7.5	--	Sensitive
Watermelon	Citrullus lanatus	--	--	Moderately Sensitive					
Wheat	Triticum aestivum	6	7.1	Moderately Tolerant	60	0.7	0.75-1.0	3.3	Sensitive
Wheat, Durum	T. turgidum	5.9	3.8	Tolerant	55	0.5			

Note:

Table was complied from the George E. Brown Salinity Laboratory database for tolerance of agricultural crops.

Footnotes:

[1]These data serve only a guideline to relative tolerances among crops. Absolute tolerances vary, depending upon climate, soil conditions, and cultural practices.

[2]Botanical and common names follow the convention of Hortus Third (Liberty Hyde Bailey Hortorium Staff, 1976) where possible.

[3]In gypsiferous soils, plants will tolerate ECe about 2 dS/m higher than indicated.

surface water, and environment of an area is also unclear.

Municipal Use

The second largest use of recycled water in developing countries around the world is landscape or urban irrigation. In California, urban irrigation of landscapes and impoundments composes 26 percent of the overall reuse in the state. Urban irrigation includes the irrigation of freeway landscapes, parks, playgrounds, golf courses, and other landscaped areas. In some instances urban irrigation has been used to augment water supplies in water features and fountains. Other nonpotable uses include fire prevention, sanitary sewer flushing, construction water, and air conditioning. The major concerns facing the use of recycled water for urban irrigation are reliability, constituents, and aesthetics. Supply reliability is a concern for some agencies due to a lack of adequate seasonal or daily storage to meet peak demands. Aesthetic concerns vary with use and landscaping materials used; however, if recycled water is applied correctly and plants that are salt tolerant are used in landscaping then the use of recycled water is an appropriate alternative for potable water.

Industrial Use

Industrial use of recycled water most commonly falls into one of three major categories; heat dissipation, energy generation, and processing. Specific uses of recycled water include boiler feed make-up water, cooling tower water, and process water. Industrial users are the third largest user of recycled water in the world. In California, industrial users are the fifth largest use type comprising five percent of the recycled water used. The largest use for recycled water at industrial facilities is process cooling, which can compose over fifty percent of a facility's water use. The major concern facing industrial reuse of water is the effects that constituents in the recycled water have on facility processes and manufacture of materials. Due to this concern, a number of industrial users require "designer water", which has been treated to remove specific constituents. An example of water treated for use at a specific user is the West Basin Chevron RO WRP that was developed to provide low TDS recycled water to the Chevron Refinery for boiler feed make-up water.

Toilet Flushing

Toilet flushing with recycled water is widely acceptable in some parts of the world; however, it has not been put into wide application in the U.S. In Japan, toilet flushing is the hallmark of the water-recycling program composing 40 percent of the water reused. The success of the Japanese toilet-flushing program was due to its ability to provide large users for recycled water by implementing toilet flushing at large industrial buildings and apartment complexes. This worked well because it provided a mechanism to find a large user of recycled water that made system development feasible and replace large potable supply uses in urban area, where a majority of the country's population is based. Toilet flushing has also been implemented in Rouse Hill, Australia where a new community was constructed with dual plumbing provided for landscape irrigation, toilet flushing, and fire protection. In California, recycled water use for toilet flushing has not been widely accepted due to concerns over cross contamination with potable water, aesthetic and public health concerns, and supply reliability. However, toilet-flushing projects are becoming more acceptable and more projects are being implemented. In Irvine California, toilet flushing is encouraged at all new high-rise office buildings and is proposed for use in a new high rise in Oakland, California. Reliability is another major concern facing recycled water use for toilet flushing. Due to the nature of this use adequate supply reliability is required. In southern California some recycled water agencies face seasonal reliability problems due to a lack of adequate storage. Irvine Ranch WD and Fallbrook Public Utilities District are two agencies that are unable to meet all user demands during periods of the year due to insufficient recycled water capacity. However, shortages in capacity of recycled water could be rectified by these agencies if adequate storage or additional treatment capacity is developed. Construction and implementation of storage projects or expansion in WRP capacity are expensive due to cost of construction and siting issues.

Direct and Indirect Potable Uses

Direct potable reuse has not been accepted widely in the U.S.; however, direct reuse has been in effect since 1968 in Windhoek, Namibia. Direct reuse consists of supplying recycled water directly to the water supply system. While the direct reuse option is a more extreme mechanism, in arid regions such as Namibia it may be highly desired. This type of extreme reuse is unlikely in the U.S. due to health concerns and public perceptions. In the U.S. and other industrialized countries, indirect reuse is more commonly used as a method to augment water supplies.

Indirect reuse includes the augmentation of a surface water reservoir or groundwater aquifer wherein the recycled water can reside for a period of time, presently this is set at six months in California. However, there are some reservoir augmentation indirect reuse projects in the U.S. including the Upper Occoquan Sewage Authority's Regional Water Reclamation Plant (UOSA WRP) and the proposed San Diego County Water Authority (SDCWA) Repurification Project. The UOSA WRP has been in operation since 1978 and discharges 54 mgd of recycled water into the Occoquan Reservoir, which is the primary water supply source for over 1 million people in northern Virginia. In California, indirect groundwater recharge projects can be implemented but only after they gain approval from DHS and provide substantial information regarding the impacts of the project.

Indirect reuse includes groundwater recharge/seawater intrusion barriers, and recreational impoundments. Groundwater recharge/sea water intrusion is the forth largest use of recycled water around the world. In California this is the third largest use and composes fifteen percent of the total amount of water reused. Groundwater recharge includes both direct injection in groundwater aquifers and spreading of water in spreading grounds or basins. The DHS regulations for groundwater recharge in California currently limit the amount of recycled water that can be recharged into groundwater aquifers to a 50/50 blend with potable or raw water. In proposed changes to these regulations, this blending ratio could be increased to allow for a greater than 50 percent ratio of recycled water dependent on DHS approval of the project as safe for the potable water supply. The use of recycled water for groundwater recharge has been utilized in California since 1962 at several sites.

The major concerns facing the direct or indirect use of recycled water are health concerns and public perspective issues. Although DHS has proposed the use of recycled water for blending at a greater than 50 percent ratio there are still concerns about the effects of a higher blending ratio on water supply wells. Also, DHS is requiring that tests and studies be performed before a greater that 50 percent blending ratio is approved. Another major concern is public perception about this type of reuse, which has derailed a number of indirect potable use recycled water projects. The San Diego Repurification Project was abandoned due to public concerns regarding the safety of augmenting potable water supplies in a surface water reservoir. In addition, indirect potable use projects have faced opposition from the public in

Los Angeles due to concerns over the safety of the water and impacts that recharge would have on groundwater aquifers used for water supply.

Habitat/ Environmental Use

Environmental or habitat uses of recycled water include streamflow augmentation and marsh and wetland enhancement. Environmental uses compose six percent of the recycled water reuse in California and are the forth largest use type. Recycled water is used in environmental uses to create, restore, and enhance habitat. Recycled water is also used to augment dry weather runoff supplies for wetlands or streamflow. Wetlands can be used to provide additional treatment or polishing for recycled water. Environmental uses of recycled water are especially important in southern California due to the highly urbanized setting and arid conditions which make environmental restoration projects difficult without an adequate and reliable water source. The major concern facing recycled water for environmental uses is water quality. Currently, the Tillman WRP and Los Angeles/Glendale WRP discharge recycled water into the Los Angeles River. These discharges compose approximately 80 percent of the flow in the dry season. However, there have been concerns regarding the discharge as well as the potential reduction in discharge due to implementation of industrial and municipal use projects. These concerns are driven by issues regarding how much recycled water must be discharged into the river to maintain the existing habitat as well as whether or not the recycled water degrades the water quality in the river or whether dry weather runoff degrades the recycled water.

3.4.3 Recommendations

Recycled water use will continue to increase in the future due to population growth, limited supply of freshwater resources, and water scarcity. The major concerns facing increased use of recycled water include; aesthetic concerns; health and safety issues; public perceptions concerns; and water quality concerns. It is important to address these concerns and provide the public with evidence regarding both the safety and the need for recycled water use. Areas that could assist recycled water agencies in developing future water recycling projects that are acceptable to the public and regulators include:

- Determine the long term effects of the use of recycled water for landscape and agricultural irrigation on soil, surface water, and groundwater aquifers. A study could be undertaken to look at the long-term effects of recycled water use at California State Polytechnic University, Pomona. This campus has used recycled water for irrigation of campus landscaping and agricultural activities since December 1973. Currently, the Pomona WRP serves the campus with 1,184 afy of water for impoundment and agricultural, landscape, ornamental plant, and athletic field irrigation over a 500 acre area. Originally, recycled water at the campus was provided at a reduced rate and use of the water was liberal; however, the cost of the recycled water has increased without changes to the level of use. A study of the effects of water reuse could also develop water management strategies at the university that could be provided to local agencies as a "How to" manual for optimal use of the recycled water.
- Determine how much water reuse is too much reuse. A study could be developed to investigate the effects of full reuse, partial reuse, and intermediate reuse to determine if and at what level reuse becomes an issue with respect to the environment, public health and/or public perceptions, soil, water quality, and regulations. As part of this effort, methods to increase recycled water supply reliability to deal with seasonal and daily storage could be investigated. In addition, residual recovery and disposal could be investigated to deal with the expected increased use of membranes and production of brine that accompany increased reuse. In addition, the economics of reuse would be investigated to determine what effect they play in water supply optimization.
- Determine if upstream source control measures could reduce the impacts of constituents of concerns that affect agricultural production and manufacturing processes. Upstream source control could be investigated on a subwatershed, watershed, and/or a macro watershed basis, which would include imported water supplies. This study could investigate sewer, raw, and potable water source control measures as well as state-of-the-art methods of treating and disposing of the brine constituents including residual recovery of these constituents. In addition, the financial and economic impacts of using upstream source control measures could be analyzed to determine if implementing these solutions are economically viable.

- Develop a study to investigate increased recycled water contribution for groundwater recharge. This effort could assist in determining what ratio of recycled water is acceptable to meet DHS water quality and potable water safety concerns.

3.5 Water Chemistry

3.5.1 Introduction

Water quality is one of the keys to the success of water reuse projects because public acceptance is closely associated with water quality. Other water quality objectives, such as preventing environmental degradation, avoiding public nuisance, and meeting user requirements, must also be satisfied in implementing a successful water reuse program. As recycled water becomes an important water source in many regions, the environmental control of wastewater and recycled water becomes more important. Water chemistry also can be utilized to identify sources of contamination and constituents of concern. An example of this is removing nitrogen and phosphorus from recycled water before it is used for irrigation to prevent groundwater contamination.

3.5.2 Description and Sources of Constituents of Concern

The following section provides information describing the major constituents of concern as well as a description of the source and problems associated with these constituents. In addition, Table 3.15 provides a summary of this information in tabular format. Specifically, this table includes information regarding each constituent including a description, sources, impacts, and solutions and/or treatment options for removal. The constituents of concern discussed below are grouped under eight major topics, which include endocrine disrupters (EDCs), total organic carbon (TOC), pathogens, metals, nutrients, salinity, and brine.

Figure 3.1 and Table 3.1 delineate how brine or concentrate moves through the hydrodynamic system for reclaimed water. From the originating water source(s) of the system, whether it is a river (A1), reservoir (A2), groundwater basin (A3), or some combination of the sources, each time water is used and undergoes treatment, there is a potential for concentrate to be produced. Concentrate or brines are commonly discharged to a brine or ocean discharge pipeline (M). However, individual users may discharge concentrate to the sewer system (C) for treatment at the wastewater treatment plant (I). Concentrate is primarily produced at water (B), wastewater (I), and water reuse (K) treatment facilities and disposal of the concentrate is regulated as part of the facilities NPDES discharge permit. Concentrate can also be produced at facilities that provide pretreatment (C) or post treatment (H) for users before the effluent is returned to either surface water or the sewer system. In the future, brine or concentrate in discharge lines may have to undergo treatment (N) before discharge into the environment. This treatment (N) would be implemented to remove constituents of concern, such as radionuclides and hazardous substances, or for residual recovery. In addition, a brine treatment plant may be necessary to meet environmental requirements that prevent against habitat and ecosystem degradation.

3.5.2.1 Endocrine Disrupters

Description

Recent scientific studies have indicated that a diverse array of man-made and natural chemicals found in the environment may disrupt the endocrine systems of fish, wildlife, and possibly humans. Some of these chemicals are characterized as estrogenic, i.e. compounds that produce the same effects as naturally occurring estrogens. Estrogenic compounds have been identified using tests that indicate the compound binds to the estrogen receptor and elicits a response.

Hormonally active agents (HAAs) or endocrine disrupters include a wide variety of chemicals that mimic the actions of sex hormones and have been associated with adverse reproductive and developmental effects. Endocrine disrupter chemicals are natural or synthetic compounds that can interfere with normal endocrine system functions by mimicking the actions of naturally-occurring hormones, by blocking the receptors in cells that receive hormones, or by affecting synthesis, transport, metabolism, and excretion of hormones. The U.S. Environmental Protection Agency (USEPA) in the 1998 Endocrine Disrupter Screening and Testing Advisory Committee (EDSTAC) Final Report defined an endocrine disrupter as "an exogenous natural or anthropogenic agent that produces reversible or irreversible adverse effects at the level of individual, population and/or community by interfering with the synthesis, storage-release, secretion, transport-clearance, binding, action, or elimination of endogenous hormones in the body." In addition to the general discussion of endocrine disrupters, pharmaceuticals and personal care products (PPCPs), antibiotics, and pesticides will be discussed in greater detail.

Table 3.15

Constituents of Concern for Recycled Water Use

Constituent of Concern	Description	Sources	Impacts	Solutions/ Treatment Options
Endocrine Disrupters (EDCs) or Hormonally Active Agents (HAAs)	EDCs are natural and synthetic compounds that can interfere with normal endocrine system functions by mimicking the actions of naturally-occurring hormones, by blocking the receptors in cells that receive hormones, or by affecting synthesis, transport, metabolism, and excretion of hormones.	Wastewater effluents Urban runoff Confined animal feeding operations Groundwater contamination Industrial sources	Interferes with normal endocrine system of organisms resulting in significant negative impacts in the hormonal functioning. Accumulation in the environment, especially in biota for some EDCs. Potential mutagens and/or carcinogens.	Advanced treatment (e.g., ultrafiltration or reverse osmosis membrane or adsorption processes) in wastewater treatment systems. More efficient monitoring and source control in industrial operations. Collection and advanced treatment of urban runoff. Use of more biodegradable, less toxic, and environmentally benign chemicals in industries.
Pharmaceuticals and Personal Care Products (PPCPs)	A diverse group of bioreactive chemicals including pharmaceutical and the active ingredients in personal care products for both humans and animals.	Wastewater effluents Urban runoff	Accumulation in the environment, especially in biota, due to slow (or no) biodegradation. Some PPCPs may behave as EDCs. Some PPCPs may be mutagenic and/or carcinogenic.	Advanced treatment (e.g., ultrafiltration or reverse osmosis membrane processes) in wastewater treatment systems. Collection and diversion of urban runoffs.
Antibiotics	Human and veterinary antibiotics.	Wastewater effluents Urban runoff Confined animal feeding operations	Accumulation in the environment. Modification in the spectrum of naturally-occurring organisms due to selective antibiotic activity.	Advanced treatment (e.g., ultrafiltration or reverse osmosis membrane or adsorption processes) in wastewater treatment systems. Collection and advanced treatment of wastes from confined animal feeding operations.
Pesticides	Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest (i.e. any insects, mice and other animals, unwanted plants (weeds), fungi, or microorganisms like bacteria and viruses).	Agricultural runoff Wet-weather urban runoff Domestic wastewater	Accumulation in the environment, especially in biota, due to slow (or no) biodegradation. Some pesticides proven to be toxic and carcinogenic. Contamination of groundwaters (due to infiltration) and surface waters (due to runoff) from agricultural sources where pesticides were applied.	Effective collection and treatment of agricultural or urban runoff. Use of more biodegradable, less toxic and environmentally benign pesticides. Advanced treatment (e.g., nanofiltration or ultrafiltration membrane or adsorption processes) in wastewater treatment systems.

Table 3.15

Constituents of Concern for Recycled Water Use

Constituent of Concern	Description	Sources	Impacts	Solutions/ Treatment Options
Total Organic Carbon (TOC)	Total organic carbon is a measure of the organically bound carbon in a water or wastewater sample.	Natural organic matter from drinking water treatment processes Anthropogenic compounds added by domestic or industrial water users such as organic micropollutants Soluble microbial products derived from wastewater treatment processes	Treating for TOC reduces the potential for health hazards by lowering the concentrations of micropollutants and SMPs in the water.	Advanced treatment (e.g., ultrafiltration or reverse osmosis membrane, advanced oxidation or adsorption processes) in wastewater treatment systems.
Disinfection By-Products (DBPs)	By-products formed by reactions of disinfectants with organic and inorganic constituents in the source water.	Disinfected wastewater effluents Produced from chlorine based oxidants as well as ozone or ultraviolet light	Suspected carcinogens and mutagens to many organisms. Fairly persistent in the environment due to slow biodegradation.	Implement non-chemical based disinfection processes such as ultraviolet light, or high-pressure membrane systems to be used for reduction in organic precursors and target microorganisms.
Organic Micropollutants	Chemicals that are developed by industrial or other activities that use water and discharge wastewater.	Wastewater effluents Urban runoff Industrial sources Groundwater contamination	Accumulation in the environment, especially in biota, due to slow (or no) biodegradation. Groundwater contamination Majority of synthetic micropollutants are suspected mutagens and/or carcinogens.	Advanced treatment (e.g., ultrafiltration or reverse osmosis membrane, advanced oxidation or adsorption processes) in wastewater treatment systems. More efficient monitoring and source control in industrial operations. Collection and advanced treatment of urban runoff.
NDMA	N-nitrosodimethylamine (NDMA)is a defined carcinogen that has historically been associated with the production of rocket fuels, antioxidant additives for lubricants, softeners of copolymers in the rubber industry, and trace amounts in cured meat products such as bacon and smoked fish.	Industrial sources Wastewater effluents Groundwater contamination	Suspected carcinogen and mutagen although more studies needed for health effects. Groundwater contamination from industrial sources and wastewater effluents.	Advanced treatment (e.g., ultrafiltration or reverse osmosis membrane or advanced oxidation processes) in wastewater treatment systems. More efficient monitoring and source control at industrial operations. Replace chlorination with ultraviolet light or other disinfection processes to avoid formation.

Table 3.15

Constituents of Concern for Recycled Water Use

Constituent of Concern	Description	Sources	Impacts	Solutions/ Treatment Options
Soluble Microbial Products (SMPs)	Soluble microbial products (SMPs) are organic polymeric products released from biomass during biological wastewater treatment processes.	Wastewater effluents	Major portion of SMPs are relatively more biodegradable than synthetic chemicals; thus accumulated less in the environment. Exception is the humus type residues from microbial activity in biological treatment systems. Some naturally occurring SMPs (mainly humic and fulvic acids) are not considered to have negative impacts on organisms.	Tertiary treatment (e.g., ultrafiltration or reverse osmosis membrane, or adsorption processes) of secondary effluents in wastewater treatment systems.
Pathogens	Pathogens are either bacteria, viruses, or parasites.	Wastewater effluents Urban runoff Confined animal feeding operations Natural sources (e.g., animal and plant excretes and decaying organisms)	Health effects (e.g., diseases, etc).	Advanced treatment (e.g., ultrafiltration or reverse osmosis membrane or effective disinfection processes such as ozone or ultraviolet light) in wastewater treatment systems. Collection, and diversion of urban runoffs for further advanced treatment.
Metals	Metals include cadmium, copper, lead, nickel, silver, selenium, mercury, chromium, arsenic, calcium, zinc, and cyanide.	Wastewater effluents Urban runoff Industrial sources	Accumulation in the environment, especially in marine biota and sediments due to complexation and further precipitation. Heavy metals generally are toxic to organisms through bioaccumulation in the tissues.	Advanced treatment (e.g., ultrafiltration or reverse osmosis membrane or adsorption processes) in wastewater treatment systems. Collection and diversion of urban runoffs for further advanced treatment. More efficient monitoring and source control at industrial operations.

Table 3.15
Constituents of Concern for Recycled Water Use

Constituent of Concern	Description	Sources	Impacts	Solutions/ Treatment Options
Nutrients	Nitrogen and phosphorus.	Agricultural drainage/runoff Wastewater effluents Urban runoff Industrial sources Septic systems	Nutrients may result in microbial regrowth, oxygen depletion (due to microbial activity), and eutrophication in receiving waters. Nutrients may cause groundwater contamination through infiltration.	More efficient biological nutrient removal processes (e.g., improved nitrification/denitrification and phosphorus removal) in wastewater treatment. Collection and diversion of urban runoffs for further advanced treatment. More efficient monitoring and source control in industrial operations. Use of more biodegradable detergents and fertilizers. Effective collection of agricultural runoff/drainage.
Salinity	Salinity is used to denote the presence of sodium (Na+) and/or other cations and/or other anions.	Wastewater effluents Agricultural and urban runoff Water Reuse Industrial sources Self-regenerating water softening or conditioning appliances	Deterioration of water quality which results in difficulties in the treatment and production of reclaimed water or drinking water. High-TDS reclaimed waters to be used for irrigation are detrimental to soil, plants, crops, etc. Sodium may cause soil permeability problems.	Advanced softening treatment (e.g., high-pressure membrane) in wastewater treatment systems. Prevention of agricultural runoff to surface waters and more effective use of fertilizers. Regulation and public education regarding the use of self-regenerating water softening or conditioning appliances.
Brine	Brine or membrane concentrate disposal is a water stream where constituents have been concentrated due to membrane processes such as reverse osmosis. Constituents in brine range from salt, coagulants, antiscalants, disinfection chemicals, dechlorination chemicals, membrane-cleaning chemicals to metals, DBPs, and pathogens.	Water treatment Wastewater treatment Industrial pretreatment	High concentration of contaminants in brine may be toxic to organisms in receiving waters due to sudden shock effect of high concentrations. Significant quantities of pathogens may be present in brine. Ammonia is of concern due to its toxicity. Heavy metal may bioaccumulate in marine biota.	Brine disposal methods with less negative environmental impacts, which is mostly site-specific. Studies to determine how to control toxicity issues at outfalls need to be performed for each specific outfall location to prevent degradation of ecosystems.

Sources and Solutions

Several groups of known or suspected EDCs exist, and some have been evaluated in numerous studies to identify their effects on the endocrine system. Some pharmaceuticals, personal care products, industrial chemicals, and naturally occurring hormones may disrupt the endocrine system. Some of the more commonly identified EDCs are:

- Natural estrogens (i.e., 17P-estradiol, estrone, phytoestrogens and animal steroids)
- Synthetic (xenobiotic) estrogens
- Hormones and metabolites (estradiols, testosterone, progesterone)
- Organochlorine pesticides
- Pharmaceuticals and Personal Care Products
- Halogenated aromatic hydrocarbons (HAHs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Phthalates (plasticizers)
- Phenols
- Bisophenol A
- Dioxin
- Polychlorinated biphenyls (PCBs)
- DDT
- Alkylphenols
- Alkylphenol ethoxylates (APEs)
- Coprostanol (fecal steroid)
- Antidepressants
- Cadmium
- Lead

Table 3.16 provides a more extensive list of known or suspected endocrine disrupting chemicals. Little is known about the extent of environmental occurrence, transport, and ultimate fate of many synthetic organic chemicals after their intended use, particularly hormonally active chemicals, and PPCPs. One reason for this general lack of data is that, until recently, there have been few analytical methods capable of detecting these compounds at the low concentrations, which might be expected in the environment.

TABLE 3.16

LIST OF KNOWN/SUSPECTED ENDOCRINE DISRUPTING CHEMICALS

17a-ethinylestradiol	Dicofol	Methoxychlor
17b-estradiol	Dieldrin	Metiram Complex
2,4,5-T	Dimethrin	Metribuzin
2,4-D	Dioxins	Mirex
Acetochlor	Diphenylethers	Nitrofen
Alachlkor	Diphenyltoluenes	Oxchlordane
Aldicarb	Endosulfan	PAHs
Aldrin	Endothall	Parathion
Alkyphenols	Endrin	PBBs
Allethrin	Esbiothrin	PBCs
Amitrole	Esfenvalerate	PCP
Androstenedione	Estrogen	Penta-nonylphenols
Atrazine	Estrone	Permethrin
Atrazine	Fenpropathrin	Perthane
Benomyl	Fenvalerate	Phenothrin
Bifenthrin	Flucythinate	Phthalate esters
Bioallethrin	Flucythrinate	Polycarbonate
Bis-phenol-A	Furans	Polychlorinated dibenzothiophenes
B-sitosterol	Genistein	Polystyrenes
Cadmium	Heptachlor	PVC
Captan	Heptaclor epoxide	Pyrethrine
Captofol	Hexachlorobenzene	Pyrethroids
Carbaryl	Hexachlorobutiene	Resmethrin
Chlordane	HPTE	Styrene
Cholrpyrifos	Kadethrin	Surfactants
Cyanizine	Kelthane	Tefluthrin
Cyfluthrin	Kepone	Temephos
Cypermethrin	Lead	Tetramethrin
BDCP	Lindane	Toxaphene
DCPA	Malathion	Tralomethrin
DDD	Mancozeb	Trans-nonachlor
DDE	Maneb	Tributyltin
Dichlorodiphenyltrichloroethane	Mercury	Trifluralin
Deltamethrin	Mestranol	Vinclozlin
DES	Methomyl	Zearalenone
Di(2-ethylhexyl) phthalate	Methomyl	Zineb

Recent research has focused on the effects of EDCs on reproduction and the reproductive systems of mammalian vertebrates. A panel convened by the National Academy of Sciences, concluded that environmental halogenated aromatic hydrocarbons (HAHs) probably have contributed to declines in some wildlife populations, including fish and birds of the Great Lakes, and juvenile alligators of Lake Apopka, and possibly to diseases and deformities in mink in the United States, river otters in Europe, and marine mammals in European waters. In addition, such contaminants, along with inbreeding of a population in a confined habitat, might have contributed to the poor reproductive success of the endangered Florida panther and the increased embryonic mortality of the snapping turtle in the Great Lakes. Many studies have indicated that the EDCs interact with reproductive systems at even "low" levels to cause modifications of gender ratios (i.e. male to female), reduction of male hormones that may cause changes in male sex organs, and in some specific species a transformation of gender.

Because most EDCs and HAAs are large, organic compounds, they will preferentially accumulate in sediments and biota. Many EDCs are also persistent organic chemicals, and can be globally distributed over time, by weather patterns on both soil and water. However, the aquatic environment is likely to be the component most directly affected by EDCs and HAAs. Many EDCs are found in sediment, which may act as a source of exposure to benthic invertebrates as well as demersal fish. Predators that ingest fish including other fish, raptors, and mammals may be exposed to EDCs by ingesting affected prey. EDCs may also affect terrestrial wildlife, particularly if EDCs can be found in measurable quantities in the soil.

Human exposure to EDCs and HAAs can occur from a variety of sources. For example, eating food that contains PCBs or Dichlorodiphenyltrichloroethane (DDT), and using commercial products such as cleaners, pesticides, and food additives are ways in which humans may come in contact with these compounds.

EDCs and HAAs may not be removed completely during conventional wastewater treatment processes and thus may enter the environment at concentrations that could cause effects. However, advanced treatment plants with membrane processes such as ultrafiltration (UF) and reverse osmosis (RO) are capable of removing EDCs and HAAs to a great extent or totally.

Although EDCs and HAAs are not currently regulated at a national level, the public has shown concern about this issue. The problems associated with EDCs and HAAs are still being defined at the national level. Some local agencies are beginning to define the problem. Las Vegas is one of the first large urbanized areas in the United States where studies have been conducted to determine the present of these chemicals in the drinking water supply.

Pharmaceuticals and Personal Care Products

Description

One diverse group of bioactive chemicals receiving comparatively little attention as potential environmental pollutants includes the pharmaceuticals and active ingredients in personal care products, both for humans and animals. PPCPs include the following:

- Diagnostic agents
- Nutraceuticals
- Clofibric acid (cholesterol-lowering drug)
- Phenazone and fenofibrate (blood lipid-regulating compounds)
- Ibuprofen and diclofenac (analgesics)
- Ephedrine
- Synthetic estrogen 17a-ethynylestradiol (found in the oral contraceptive pill)
- Cholesterol (plant and animal steroid)
- Anti-inflammatory medicine
- Antiepileptic medicines
- Antidepressants
- Anticonvulsants
- X-ray contrast media
- Aspirin
- Caffeine
- Nicotine
- Fragrances
- Sun-screen agents
- N, N-diethyltoluamide (insect repellant)

Sources and Solutions

As opposed to the conventional, persistent priority pollutants, PPCPs need not be persistent even if they are continually introduced to surface waters, at low parts-per-trillion/parts-per-billion concentrations (ng-µg/L). Even though some PPCPs are extremely persistent and introduced to the environment in very high quantities, others act as if they were persistent because their continual infusion into the aquatic environment serves to sustain perpetual life-cycle exposures for aquatic organisms. Aquatic pollution is considered to be significant because aquatic organisms are captive to continual life cycle and multigenerational exposure. The possibility for continual but undetectable or unnoticed effects on aquatic organisms is important because effects could accumulate so slowly that change goes undetected until the cumulative level of these effects result in major impacts to the organism.

The big unknown is whether the combined low concentrations from each of the numerous PPCPs and their transformation products have any significance with respect to ecological function, while recognizing that immediate effects could escape detection if they are subtle and may only be detected under conditions of significant long-term cumulative consequences. Another question is whether the pharmaceuticals remaining in water used for domestic purposes poses long-term risks for human health after lifetime ingestion via potable waters multiple times a day in very low, subtherapeutic doses of numerous pharmaceuticals.

The hypothesis is further complicated by the fact that while the concentration of individual drugs in the aquatic environment could be low (sub-parts per billion or sub-nanomolar, often referred to as micropollutants), the presence of numerous drugs sharing a specific mode of action could lead to significant effects through additive exposures. It is also significant that drugs, unlike pesticides, have not been subjected to the same scrutiny regarding possible adverse environmental effects. Drugs have been discharged to the environment for many decades via effluent from wastewater treatment plants (WWTPs). Certain pharmaceuticals are designed to modulate endocrine and immune systems and cellular signal transduction and as such have potential as endocrine disrupters in the environment. Exposure to PPCPs in the environment, especially for aquatic organisms, may differ from that of pesticides and other industrial chemicals in one significant respect. Exposures for aquatic organisms may be of a more chronic nature because PPCPs are constantly infused into the environment, whereas pesticide fluxes are more sporadic and have greater spatial heterogeneity. It is quite apparent that little information exists from which comprehensive risk assessments can be developed for the vast majority of PPCPs.

The majority of PPCPs introduced into the environment are into aquatic systems while the terrestrial environment receives only a secondary input. The primary source for terrestrial exposure is most likely from disposal of biosolids from WWTPs and from animal wastes both applied to land and stored in open-air pits (waste lagoons), and other possible sources for veterinary pharmaceuticals resulting from animal dips and direct deposition of dung from medicated animals. PPCPs can also be introduced to landfills. The first reported incidence of leachates carrying pharmaceuticals from a landfill occurred in 1995. In addition, a study published by researchers at the University of Georgia has linked potential health problems from the use of biosolids as fertilizer.

PPCPs and their bioactive metabolites can be continually introduced to the aquatic environment as complex mixtures via a number of routes but primarily by both untreated wastewater and recycled water. In contrast to agrochemicals, most of these products are disposed or discharged into the environment on a continual basis via domestic/industrial wastewater systems and wet-weather runoff. The dosed user first subjects the bioactive ingredients to metabolism, and then the excreted metabolites and unaltered parent compounds are subjected to further transformations in WWTPs. However, many of these compounds survive biodegradation, eventually being discharged into receiving waters. In addition, metabolic conjugates can even be converted back to their free parent forms. Many of these PPCPs and their metabolites are ubiquitous and display persistence in, and bioconcentration from, surface waters on par with those of the widely recognized organochlorine pollutants. Additionally, by way of continual infusion into the aquatic environment, those PPCPs that might have low persistence can display the same exposure potential as truly persistent pollutants since their transformation and removal rates can be compensated by their replacement rates.

A striking difference between the release into the environment of pharmaceuticals and pesticides is that pharmaceuticals have the potential for direct release into the environment anywhere that humans live or visit. Even areas considered relatively pristine (e.g., national parks) are subject to pharmaceutical exposures due to discharge of wastewater effluent into surface water or groundwater.

Although the microbiota of WWTPs may have been exposed to many PPCPs for a number of years, two factors work against the effective microbial removal of these substances from WWTPs. First, the concentrations of most drugs are probably so low that the lower limits for enzyme affinities may not be met. Second, new drugs are introduced to the market each year with some deriving from new classes that have not been seen before.

Removal efficiencies are greatly affected by the extent to which a particular plant uses primary, secondary, and tertiary technologies which vary with location. The biodegradative fate of most compounds in WWTPs is governed by the availability of nongrowth limiting (enzyme-saturating) substrate concentrations. These organisms are more prevalent in sediments, and therefore degradation of PPCPs may occur more prevalently in the receiving waters and sediments than in WWTPs.

Also, new drugs are introduced to the market each year and some of these drugs are from entirely new classes never seen before by the microbiota of a WWTP. Each of these presents a new challenge to biodegradation in both WWTPs and streams. Under these conditions, only the dilution of the effluent into the receiving water serves to reduce the concentration.

In general, most pharmaceuticals resist extensive microbial degradation (e.g., mineralization). Although some parent drugs often show poor solubility in water and have preferential sorption to suspended particles which are discharged with effluent stream. Enhanced biological degradation with specialized microorganisms, tertiary treatment with ozone or advanced oxidation, membrane technologies, or activated carbon adsorption may effectively remove PPCPs in water reclamation plants (WRPs).

Antibiotics

Description

Although little is known of the occurrence and effects of pharmaceuticals in the environment, more data exists for antibiotics than for any other therapeutic class. This is a result of the extensive use of antibiotics in both human therapy and animal husbandry. The information on antibiotics is more developed because of direct effects on native microbiota and consequent alteration of microbial community structure, and development of resistance in potential human pathogens. Human and veterinary antibiotics found in waters include:

- Fluoroquinolones
- Sulfonamides (sulfonamethazine, sulfamerazine, sulfathiazole, sulfachloropyridazine, and sulfadimethozine)
- Penicillin
- Tetracyclines (tetracycline, oxytetracycline and chlortetracycline)
- Vancomycin
- Beta-lactams
- Macrolides
- Azithromycin
- Streptomycin
- Erythromycin

Sources and Solutions

Antibiotics are introduced to the environment mainly by WWTPs discharges, stormwater runoff, and seepage into groundwater, especially from confined animal feeding operations (CAFOs). To date, most attention has been focused on the application of animal wastes to land, primarily because of the suspected introduction of antibiotics and nutrients. Antibiotics can be removed from water at wastewater treatment plants through the use of advanced treatment such as ultrafiltration, reverse osmosis, or adsorption processes onto carbon sources. In addition, collection systems and advanced treatment of wastes from CAFOs can reduce the runoff of antibiotics into the environment.

Pesticides

Description

The USEPA defines a pesticide as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest (i.e. any insects, mice and other animals, unwanted plants (weeds), fungi, or microorganisms like bacteria and viruses)." The term pesticides refer to not only insecticides, but also to herbicides, fungicides, and various other substances used to control pests. Under *the Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA), a pesticide is also any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant. Table 3.17 provides a list of the most commonly used pesticides.

Sources and Solutions

Some of the pesticides of concern for recycled water include:

- Organochlorine pesticides (endosulfan, lindane, methoxychlor, atrazine, chlordane, endrin, simazine, DDT)
- Toxaphene
- Triclosan (antimicrobial disinfectant)

A majority of pesticides are removed from the effluent via adsorption onto solid particles during wastewater and water reuse treatment processes. However, more hydrophilic-character pesticides may escape conventional treatment. Tertiary treatment processes such as membranes or granular activated carbon (GAC) adsorption in reclamation plants may effectively remove the remaining pesticides.

Another concern associated with pesticides is the seepage of pesticides into groundwaters from golf courses or agricultural lands irrigated with recycled water. However, this concern exists regardless of the source water utilized for irrigation.

3.5.2.2 Total Organic Carbon

Description

Total organic carbon (TOC) is a measure of the organically bound carbon in a water or wastewater sample. The *USEPA National Primary Drinking Water Regulations* definition is "Total Organic Carbon (TOC) means total organic carbon in mg/L measured using heat, oxygen, ultraviolet irradiation, chemical oxidants, or combinations of these oxidants that convert organic carbon to carbon dioxide." TOC is used to measure even the presence of small concentrations of organic matter. It is used as an indicator or precursor for DBPs and unregulated contaminants in water.

TABLE 3.17

USEPA LIST OF TYPES OF PESTICIDES

Type of Pesticide	Use of Pesticide
Algicides	Control algae in lakes, canals, swimming pools, water tanks, and other sites
Antifouling agents	Kill or repel organisms that attach to underwater surfaces, such as boat bottoms
Antimicrobials	Kill microorganisms (such as bacteria and viruses)
Attractants	Attract pests (for example, to lure an insect or rodent to a trap. However, food is not considered a pesticide when used as an attractant)
Biocides	Kill microorganisms
Disinfectants and sanitizers	Kill or inactivate disease-producing microorganisms on inanimate objects
Fungicides	Kill fungi (including blights, mildews, molds, and rusts)
Fumigants	Produce gas or vapor intended to destroy pests in buildings or soil
Herbicides	Kill weeds and other plants that grow where they are not wanted
Insecticides	Kill insects and other arthropods
Miticides (also called acaricides)	Kill mites that feed on plants and animals
Microbial pesticides	Microorganisms that kill, inhibit, or out compete pests, including insects or other microorganisms
Molluscicides	Kill snails and slugs
Nematicides	Kill nematodes (microscopic, worm-like organisms that feed on plant roots)
Ovicides	Kill eggs of insects and mites
Pheromones	Biochemicals used to disrupt the mating behavior of insects
Repellents	Repel pests, including insects (such as mosquitoes) and birds
Rodenticides	Control mice and other rodents
Defoliants	Cause leaves or other foliage to drop from a plant, usually to facilitate harvest
Desiccants	Promote drying of living tissues, such as unwanted plant tops
Insect growth regulators	Disrupt the molting, maturity from pupal stage to adult, or other life processes of insects
Plant growth regulators	Substances (excluding fertilizers or other plant nutrients) that alter the expected growth, flowering, or reproduction rate of plants

Sources and Solutions

Recycled water TOC derives from a mixture of compounds from three major origins:

- NOM from drinking water treatment processes
- Anthropogenic compounds added by domestic or industrial water users such as organic micropollutants
- SMPs derived from wastewater treatment processes

Drinking water with higher TOC levels may correlate to higher levels of TOC in reclaimed water. Thus, regulations should consider local drinking water concentrations and NOM type, which may vary widely depending on geological location. Treating water for TOC reduces the potential health hazards by reducing the concentrations of micropollutants and SMPs in the water. Advanced treatment methods, such as ultrafiltration and reverse osmosis, provide the best removal of these organic compounds.

Disinfection By-Products

Description

Disinfection by-products are created from reactions of disinfectants with organic and inorganic constituents in the source water. DBPs can be harmful and are most commonly produced from the use of chlorine-based oxidants as well as ozone and/or ultraviolet light. Trihalomethanes (THMs), haloacetic acids (HAA5), bromate, and haloacetonitriles are DBPs that are either already regulated or under consideration for regulation. THMs and HAA5 are the most commonly formed DBPs during drinking water treatment processes.

Sources and Solutions

If chlorine-based disinfectants are used in water, wastewater, or water reuse treatment plants, chlorinated and/or brominated disinfection by-products are formed by the reactions between chlorine and organic material (i.e., effluent organic matter [EfOM] and/or natural organic matter [NOM]) present in waters. Commonly found DBPs include:

- THMs
- Chlorinated phenols and derivatives
- HAA5
- Haloketones
- Haloacetonitriles

- Other halogenated organic and/or inorganic compounds

DBPs are potential carcinogens and mutagens. Due to limitations in analytical measurements, generally only about 50 percent of the total organic halides (TOX) formed can be identified and quantified.

The organic residuals in WWTP effluents are of general concern because they are a potential precursor for DBPs and may comprise compounds that could cause health concern. NOM, organic material present in natural groundwaters and surface waters, are derived from organic material from local and non-local ecosystem sources. Biorecalcitrant NOM comprises a significant portion of EfOM in WWTP effluent.

In addition to halogenated DBPs produced in water, wastewater, and water reuse disinfection processes, synthetic halogenated organic compounds are added during water use from domestic or industrial sources. Halogenated compounds can be removed through a variety of removal mechanisms without the use of high-pressure membrane processes (such as reverse osmosis). Strict anaerobic conditions are often necessary to remove the most refractory halogenated compounds.

Organic Micropollutants

Description

Organic micropollutants are defined as chemicals that are developed by industrial or other activities that use water and discharge wastewater. The *Report of the Scientific Advisory Panel on Groundwater Recharge with Reclaimed Wastewater* issued by the State Water Resources Control Board, Department of Water Resources, and Department of Health Services indicated that approximately 90 percent by weight of the total organic carbon in treated municipal wastewater effluent are unidentified. The unidentified organics in effluent may be associated with synthetic organic micropollutants, or soluble microbial products released during biological processes. One of the health concerns related to the unidentified organics is that an unknown but small fraction of them may be mutagenic or carcinogenic. Synthetic organic micropollutants are also of concern for chronic health effects because of the potential presence of endocrine disrupters, which are also a type of organic micropollutants. It is difficult to quantify trace amounts of organic micropollutants in recycled water, surface water, or groundwater using a single analytical parameter. Synthetic organic micropollutants are typically present at levels of three or more orders of magnitude less than TOC.

Some organic micropollutants in wastewater and recycled water effluents include:

- Ethylenediamine tetraacetic acid (EDTA)
- Nitrilotriacetic acid (NTA)
- Carboxyalkylphenoxy ethoxy carboxylates
- Poly (propoxy)
- Poly (ethoxy)
- Poly (ethoxy)(propoxy) compounds
- Small aliphatic dicarboxylic acids and aldehydes
- Caffeine (stimulant)
- Tri(2-chloroethyl)phosphate (fire retardant)
- 4-nonylphenol (nonionic detergent metabolite)
- Benzo(a) pyrene
- Di (2-ethylhexyl) phthalate

A majority of these chemicals are resistant to biological degradation; therefore, concentrations of these chemicals may not be reduced significantly during treatment. Some of the chemicals may be partially biodegradable resulting in the formation of by-products, which may have completely different toxic or mutagenic characteristics compared with the parent compounds.

Sources and Solutions

In areas where water recycling includes either direct or indirect groundwater recharge, if the groundwater in the area is used for potable use, the public frequently has concerns about micropollutants in aquifers. However, health effects studies in California using epidemiological and mortality data from areas where public water supplies are characterized by untreated groundwater from aquifers recharged with reclaimed water have not shown any adverse health effects.

A study performed on organic materials in tertiary treated recycled water at the OCSD Water Factory 21 Plant identified EDTA as the most prominent and refractory compound found in both granular activated carbon (GAC) and chlorinated GAC effluents (110 and 140 μg/L, respectively). Other compounds identified included Nitrilotriacetic acid (NTA), carboxyalkylphenoxy ethoxy carboxylates, poly (propoxy), poly (ethoxy), or poly (ethoxy) (propoxy) compounds, small aliphatic dicarboxylic acids and aldehydes, all at μg/L levels. Approximately 50 synthetic and natural organic residues in tertiary effluents at concentrations ranging from 0.5 μg/L to 140 μg/L were identified. Approximately 80 percent of all chromatographically separated compounds were positively or tentatively identified. The identified compounds are estimated to account for approximately 10 percent of the total dissolved organic carbon.

The most effective control mechanism to reduce the presence of organic micropollutants is to monitor and control industrial effluent concentrations to the wastewater system. Another effective mechanism for control is the collection and treatment of surface water runoff into streams or groundwater. If the organic micropollutants cannot be controlled at the source then advanced treatment technologies such as ultrafiltration, reverse osmosis, advanced oxidation or adsorption processes can be used.

N-nitrosodimethylamine (NDMA)

Description

N-nitrosodimethylamine (NDMA) is one of the micropollutants that has recently been found in wastewater effluent. It is a defined carcinogen that has historically been associated with the production of rocket fuels, antioxidant additives for lubricants, softeners of copolymers in the rubber industry, and can be found in trace amounts in cured meat products such as bacon and smoked fish.

Sources and Solutions

In WWTPs, most NDMA generating reactions occur between a source of nitrite and a secondary, tertiary, or quaternary amine compound in a mildly acidic solution (amines are nitrogen compounds). Amine sources that have been identified as precursors for NDMA include dimethylamine (DMA) and tetramethylthiuram disulfide (Thiram). Polymers (polyelectrolytes) used as coagulant aids in wastewater and recycled water treatment are also a potential amine source. Many herbicides contain the DMA salt including Thiram, which is used in seed fungicides and animal repellents. Chlorination or chloramination of potable water, wastewater, and recycled water may also form NDMA.

Monitoring and controlling the discharges to the wastewater system at industrial operations can prevent the generation of NDMA. Also, ultraviolet disinfection (UV) can be utilized instead of chlorination to avoid the formation of NDMA in water and wastewater treatment plants. At WRPs, advanced treatment technologies such as ultrafiltration and reverse osmosis can be utilized to remove it from the effluent stream.

Soluble Microbial Products

Description

Soluble microbial products (SMPs) are organic polymeric products released from biomass during biological wastewater treatment processes.

Sources and Solutions

Release of SMPs at wastewater treatment plants may be due to nutrient limitations, lysis, decay, and inhibition of biomass. A major portion of SMPs is generally readily biodegradable and thus removed within the biological treatment systems. Other SMPs may be moderately biodegradable or biorecalcitrant resulting in the accumulation within the receiving waters. Furthermore, the biorecalcitrant portion of SMPs, such as humus-type material, is reactive with chlorine used for disinfection resulting in the formation of DBPs.

3.5.2.3 Pathogens

Description

Pathogens found in recycled water can be classified into three main groups: bacteria, viruses, and parasites. Table 3.18 provides a list of the common pathogens present in untreated wastewater.

Bacteria are single-celled prokaryotic eubacteria (0.2 to 10 μm in length) that are not usually pathogenic. Viruses are obligate parasitic particles that do not synthesize new compounds but redirect the host cell to produce viral particles. Viruses produce infection and disease and range in length from 0.01 to 0.3 μm. In recycled water the parasites of primary health concern are helminths and protozoa. Helminths are parasitic worms that have human hosts and can cause serious illness. Protozoa are single-celled eukaryotic microorganisms without cell walls and are usually intestinal parasites that replicate in the host.

TABLE 3.18

PATHOGENS POTENTIALLY PRESENT IN UNTREATED DOMESTIC WASTEWATER

Bacteria	Viruses	Parasites	
		Helminths	**Protozoa**
Campylobacter jejuni	Adenovirus	Ancylostoma duodenale (hookworm)	Cryptosporidium parvum
Coliform	Astrovirus	Ascaris lumbricoides (roundworm)	Giardia lamblia
Enterococcus	Calicivirus	Echinococcus granulosis (tapeworm)	Balantidium coli
Escherichia coli (E. coli)	Coronavirus	Enterobius vermicularis (pinworm)	Entamoeba histolytica
Legionella pneumophila	Enteroviruses	Necator americanus (roundworm)	
Pseudomonas Aeruginosa (P. Aeruginosa)	Hepatitis A	Schistosoma	
Salmonella typhi	Norwalk Virus	Strongyloides stercoralis (threadworm)	
Shigella	Parvovirus	Taenia (tapeworm)	
Streptococci	Reovirus	Trichuris trichiura (whipworm)	
Vibrio cholerae	Rotavirus		

Sources and Solutions

The primary source for pathogens in recycled water is human excretion. Most bacterial pathogens can be effectively removed through normal disinfection processes. In addition, using filtration followed by disinfection can inactivate many viruses. Based on current scientific knowledge of the transmission of excreted pathogens, helminth infection poses the greatest health risk followed by bacterial and protozoal disease, with viral disease providing the lowest risk. The level of risk is based on persistence of the pathogen in the environment, long length of latency or development stage, low infective dose, weak host immunity, and minimal concurrent transmission through other routes. As new technologies are developed, it will become feasible in the future to routinely monitor recycled waters for Adenoviruses, Rotaviruses, Norwalk Viruses, Hepatitis A Virus, Cryptosporidium, and Giardia, as well as other pathogens.

Analysis of the risk associated with exposure to recycled water performed in 1996 by Dr. Joan Rose at the University of South Florida showed that the probability of infection following a single exposure to 100 ml of the water was between 10^{-6} (1 in a million) and 10^{-8} (1 in 100 million) for landscape irrigation. In addition, epidemiological evidence has proven utilizing untreated wastewater for irrigation causes significant excess infection with intestinal nematodes, while utilizing recycled water for irrigation shows no such increase in risk of infection. Also, both the *Pomona Virus Study* and *the Monterey Wastewater Reclamation Study for Agriculture* (MWRSA) demonstrated conclusively that virtually pathogen-free effluents could be produced from municipal wastewater via tertiary treatment and extended disinfection with chlorine. A major result of these studies was the demonstration that food crops irrigated with recycled water do not require cooking to prevent adverse environmental or health effects.

Another study, conducted by the County Sanitation Districts of Los Angeles County, evaluated the potential health effects associated with groundwater recharge with recycled water. The health effects study was designed to provide a comprehensive assessment of the use of recycled water for groundwater replenishment at the Whittier Narrows Groundwater Recharge Project located in the Montebello Forebay in Los Angeles County, which had been in operation since 1962. The study concluded that no measurable adverse impacts resulted from the recharge project on the groundwater's quality or to the health of the population who were ingesting this water. To evaluate the study's findings further, the State of California appointed an independent Panel of experts in 1986. The Panel concluded that the risks associated with the current Whittier Narrows Groundwater Replenishment Project were minimal and probably not dissimilar from those that could be hypothesized for commonly used surface waters.

The risk to public health from pathogens associated with water reuse has also been investigated. To determine the risk, a database was developed using published reports from water and wastewater agencies in California and included enteric virus data from 424 unchlorinated secondary effluent samples in which 283 samples (67 percent) were virus positive and 814 chlorinated tertiary (filtered) effluent samples with 7 positive samples (1 percent). The risk of virus infection from exposure to recycled water was determined by applying risk assessment procedures to existing data on viral concentrations in recycled water. The USEPA's Surface Water Treatment Rule (SWTR) was used as a point of reference to evaluate the safety of water reuse. Acceptable risks for this evaluation were defined as meeting the 10^{-4} infection risk criterion at least 95 percent of the time, as well as by the expectation estimate using Monte Carlo methods. The study found that recycled water is reliable more than 95 percent of the time for all of the effluents examined for the water quality criterion required for golf course irrigation, food crop irrigation, and groundwater recharge.

Full-scale microbiological monitoring of a treatment train at the Upper Occoquan Sewage Authority Facility demonstrated that the high-pH chemical treatment process was an effective barrier for removal and inactivation of viruses (99.99 percent), bacteria (99.9999 percent), and enteric protozoa (99.9 percent). Cryptosporidium was of particular concern for three reasons:

- The oocyst is extremely resistant to disinfection and can not be killed with routine disinfection procedures
- The disease is not treatable
- The risk of the mortality ranges between 50 and 85 percent in the immunocompromised populations

Therefore, the inactivation of Cryptosporidium is important to any recycled water system that may impact potable water supplies. Water reclamation plants may not always maximize removal of pathogens, especially Giardia and Cryptosporidium. Some results from plants in Florida showed that facilities that provided nitrification appeared to be more effective in removing these pathogens. The results from the monitoring showed that 58 percent of the samples contained Giardia and 23 percent of the samples contained Cryptosporidium, which is significant because both of these pathogens can result in impacts to human health.

Removal of pathogens is possible utilizing effective disinfection processes such as ozone or ultraviolet disinfection or other advanced treatment processes such as ultrafiltration or reverse osmosis. In addition, pathogen exposure can be reduced by collection, diversion, and advanced treatment of urban stormwater runoff. The key component to prevention of health effects related to pathogens is that the advanced treatment processes used are effective in removing the harmful organisms.

3.5.2.4 Metals

Description

The metals contained in water, which result in health concerns, include cadmium, lead, and mercury. Through NPDES permits the USEPA and SWQCB/ RWQCBs established discharge limitations for concentrations (mg/L) of a number of metals including arsenic, cooper, lead, mercury, cadmium, chromium, nickel, selenium, silver, and zinc. These limitations are based on requirements to protect identified beneficial uses of each surface water.

Sources and Solutions

Metals either occur naturally in the environment or enter the hydrodynamic cycle at discharge locations. Industries are sometimes a source of concentrated metals to the wastewater system. Metals are removed either during primary clarification (especially metals complexed with particles) or by adsorption onto biomass in biological treatment systems. Trace amounts of metals can be further removed in tertiary treatment by coagulation, flocculation, and sedimentation or filtration. Membrane processes are also effective in removing the remaining metals from secondary treatment.

3.5.2.5 Nutrients

Description

Nutrients, mainly nitrogen and phosphorus, in wastewater effluent and recycled water result in significant problems in receiving waters including eutrophication, oxygen depletion, increase in water turbidity due to algae growth, and modification in the natural biota of receiving waters.

Sources and Solutions

Nitrogen and phosphorus in receiving waters originate from three principal sources:

- Wastewater treatment effluents
- Fertilizers eroded from both agricultural and urban/suburban land
- Stormwater runoff from impervious (paved) urban areas that are contaminated with nitrogen

Nitrogen may be removed during wastewater treatment with biological nitrification and denitrification processes. Similarly, phosphorus may be removed either via a biological process (through the use phosphorus accumulating organisms) or chemical precipitation. However, the biological processes used to remove nitrogen and phosphorus are sensitive processes that are impacted by operational variations (e.g., wastewater characteristics, inhibition effects). Furthermore, complete removal of these nutrients is not achievable with these biological processes.

Tertiary treatment as a polishing step in the water recycling process can remove the remaining nutrient concentrations remaining after secondary treatment. When soil systems are involved in water reclamation, ammonia nitrogen may be adsorbed onto the soil where subsequent transformations leading to denitrification may occur. Nitrified recycled waters can have a negative impact on groundwater since nitrate is not well retained by soils. Nitrates at low concentrations can maintain anoxic conditions and prevent the development of anaerobic conditions. However, ammonia nitrogen also may be removed by vegetation irrigated with recycled water.

3.5.2.6 Salinity

Description

Salinity is used to denote the presence of sodium (Na^+) and/or other cations and/or other anions. Salinity is frequently measured as milligram/liter (mg/L) of Total Dissolved Solids (TDS), or as electrical conductance of an aqueous solution (micromhos/centimeter). Concentration of one or more primary specific constituents, such as sodium or chloride, also is used as a measure of salinity.

Sources and Solutions

Increased salinity may be due to: urban, industrial, and commercial activities; automatic water softeners; large cooling towers; deterioration of the sewer system and subsequent infiltration of saline water; wastewater and water reuse treatment processes such as pH control; and the declining source water quality due to prolonged drought conditions or upstream land management practices. One approach to salinity control involves a combination of operational and structural control measures, such as encouraging practices upstream in the hydrodynamic cycle to reduce salinity production. Measures that can be utilized range from the removal of self-regenerating water softeners to establishment of best management practices for mining and agricultural activities. The alternative to upstream source control is the implementation of the partial removal of dissolved salts prior to or following wastewater treatment.

3.5.2.7 Brine

Description

Brine or membrane concentrate disposal is a water stream where constituents have been concentrated due to membrane processes such as reverse osmosis. Constituents in brine range from salt, coagulants, antiscalants, disinfection chemicals, dechlorination chemicals, membrane-cleaning chemicals to metals, DBPs, and pathogens.

Sources and Solutions

Brine is produced by industries; dairies and other agricultural uses; water, wastewater, and water reuse treatment plants; groundwater remediation plants; and ocean and groundwater desalination plants. The following section discusses methods that can be utilized for brine disposal.

3.5.3 Brine Disposal Methods

In areas of limited water supplies and poor groundwater quality, membrane technology enables development of marginal water supplies which would not otherwise be available for potable use. Associated with the application of membrane technology is the disposal of the concentrate reject generated from the process. Finding environmentally acceptable methods of disposal for the concentrate presents a problem for many facilities. The methods of concentrate disposal typically considered are:

- Discharge to Surface Waters
- Discharge to Sewers
- Disposal by Land Application
- Deep Well Injection
- Evaporation Ponds
- Mechanical Evaporation
- Halophyte Evaporation

In addition to these concentrate disposal methods, two additional concepts assist in determining where to site facilities. Facilities can be co-sited or established so that cogeneration occurs. Siting desalination or other brine disposal facilities with electric or other power generating facilities also reduces costs for infrastructure, permitting, and disposal pipelines. In addition, cogeneration also takes advantage of reductions of energy costs by utilizing the exhaust steam to power plant facilities.

In many cases, concentrate is discharged to a brackish or saltwater surface water body. Three of the primary obstacles, from a regulatory standpoint, surrounding membrane concentrate disposal are the classification of membrane concentrate and the perceived toxicity of concentrate and the subsequent required testing procedures.

Historically, membrane concentrate disposal has not been in the forefront of regulatory concern and public interest. With the development of more stringent surface water quality standards and increased public awareness, however, the process for permitting the concentrate disposal has become more complex. Detailed and comprehensive evaluations of the concentrate and surface water receiving body are required.

Another important issue is that the concentrate waste is site specific as it reflects a concentration of those chemical species present in the site-specific water. The controlling regulations are the most stringent ones that apply. These are frequently local regulations as opposed to state and Federal regulations. The site-specific nature makes it more difficult to use generalizations about the concentrate and its disposal. Specific disposal issues include the following:

- Need for clarity in permitting guidelines and procedures
- Appropriateness of some regulatory controls
- Time and cost of permitting
- Cost of disposal

Federal laws applicable to membrane concentrate disposal are listed below:

- *Clean Air Act*
- *Clean Water Act*
- *Coastal Zone Management Act*

- *Comprehensive Environmental Response, Compensation, and Liability Act*
- *Hazardous Materials Transportation Act*
- *Occupational Safety and Health Act*
- *Resource Conservation and Recovery Act*
- *Safe Drinking Water Act*
- *Solid Waste Disposal Act*
- *Toxic Substances Control Act*

However, all of these laws may not apply in every specific disposal situation. Membrane plants that discharge residuals to surface waters must apply for an NPDES permit. The NPDES permits are in five-year durations and generally contain numerical effluent limitations for specific pollutant parameters. Membrane plants located in a state with an approved NPDES program may be subject to requirements more stringent than Federal law. In addition to effluent limitations, NPDES permits typically impose various requirements involving operation and maintenance, monitoring, reporting, and record keeping.

Concentrate disposal systems for water reuse plants should be:

- An integral part of the planning, design, permitting, and operational considerations
- Developed with consideration given to the regulatory criteria that can potentially create substantial economic impacts to these systems
- Developed by considering what system best fits the specific treatment plant
- Developed with consideration given to the cost effectiveness of permitting, construction, and operation

It is becoming increasingly difficult to obtain approval for disposal that directly and/or indirectly affects freshwaters. This is a result of both increased environmental concerns about the effects of existing discharges and the increasing use of membrane filtration processes which result in larger amounts of brine being produced. Due to these environmental concerns, there will be more evaluations regarding the effects of increased mass loadings.

There are three main regulations outlining the permitting of brine disposal in California; the *Portor-Cologne Water Quality Control Act*, SWQCB/RWQCB *Basin Plans*, and the Water Recycling Criteria. Brine concentrate is divide into three categories; Wastewater, Industrial, and General. NPDES permits in the state require monitoring for TSS, TDS, total residual chlorine, EC, pH, temperature, and ammonia. In addition, WET testing may be required and is tailored to the receiving water ecosystem. In receiving waters that are freshwater the test species are *C. dubua* and *P. promelas* and in saltwater the testing species are *Mysids* and *Silverside*. *Selenastrum* is a third species that is sometimes used to test for nutrient overload in fresh and saltwater conditions.

3.5.3.1 Discharge to Surface Waters

The most popular method, by far, for disposal of membrane concentrate is discharge to surface water. Ocean discharges comprise a majority of the surface water discharges currently in use in southern California. Membrane concentrate may be post-treated to remove toxic constituents and/or aerated to increase the dissolved oxygen concentration. Subsequent to post-treatment, the concentrate is conveyed to the discharge point where it is released into the receiving body. Adequate mixing with the receiving body ensures the membrane concentrate does not create localized water quality differences. Typically, there is no TDS limit on ocean discharging due to the high TDS of ocean water. However, discharge to other surface waters will likely have some restrictions on the TDS level of the membrane concentrate. The feasibility of implementing discharge to surface water for membrane concentrate disposal is contingent upon the ability to obtain adequate permitting and associated economics.

The most important factor in determining the feasibility of membrane concentrate disposal by discharging to surface water is the availability of a suitable body of water for membrane concentrate of a given quality. Characteristics determining the suitability of a specific body of water for acceptance of membrane concentrate include: water quality of both membrane concentrate and the water body; volume of the water body; environmental sensitivity of the water body; proximity of the water body to the membrane treatment facility; and flow rate of the membrane concentrate. Given a suitable body of water for a given membrane concentrate quality and quantity, surface water disposal may be a feasible alternative.

Discharging membrane concentrate to surface water may require post-treatment depending on membrane concentrate quality and discharge permit guidelines. Additional facilities required for membrane concentrate discharge to surface water include a conveyance system to transport membrane concentrate to the discharge point and an outfall structure at the discharge point.

Post-treatment of membrane concentrate most commonly includes aeration and static mixing to increase the dissolved oxygen (DO) concentration of the concentrate stream prior to discharging into surface water. Additional post-treatment may include appropriate processes to remove any constituent in the concentrate stream that may be harmful to the receiving surface water.

Conveyance infrastructure required to transport the membrane concentrate to the discharge point usually are closed pipelines. Design of the conveyance system should address materials of construction, time required for transportation, and pumping costs. The materials used to construct the conveyance system are an important consideration due to the corrosivity of the membrane concentrate resulting from high TDS concentrations. The time required for conveyance of the membrane concentrate to the discharge point is also a key consideration in applications where sparingly soluble salts (such as carbonates, sulfates, and silicates) are supersaturated. Given a sufficient amount of time, precipitation of these salts may occur in the conveyance system resulting in scaling of infrastructure surfaces. The shorter the time membrane concentrate resides in the conveyance system, the smaller the chance sparingly soluble salts will precipitate and cause operational difficulties. Finally, the pumping system is a critical consideration during the design of a membrane concentrate conveyance system. Depending on the energy of the membrane concentrate exiting membrane treatment and the energy requirements for conveyance of the membrane concentrate to the discharge point, a pumping system may or may not be required.

Regulatory issues involved with discharging membrane concentrate to surface water primarily involve obtaining a NPDES permit and any permits associated with conveyance to the discharge site. In some cases, individual states have implemented their own NPDES guidelines that must be followed. Requirements for obtaining an NPDES permit include determination of membrane concentrate quality and quantity. In addition, reporting guidelines to the regulating agency are to be determined prior to issuance of an NPDES permit. An NPDES permit will only be issued if requirements imposed by national and state authorities are met. These requirements are dependent on the body of water being discharged into as well as secondary treatment standards. Additional information regarding the application process for an NPDES permit is provided in *USEPA NPDES Permit Writers' Manual*.

Qualifications for obtaining a permit to discharge membrane concentrate to an ocean outfall are slightly more stringent. Given a satisfactory environmental impact study, a temporary permit may be issued during design and construction of the treatment facility based on acceptable membrane concentrate quality and quantity, and suitable outfall design. However, the permanent discharge permit generally will not be issued until the full-scale facility has passed rigorous membrane concentrate quality tests to determine constituent concentrations. In addition, the membrane concentrate quality must pass a bioassay test prior to issuance of an ocean discharge permit. There have been instances where a permanent permit was not issued for an ocean outfall based on results from the bioassay tests on membrane concentrate.

The *Coastal Zone Management Act* (CZMA) requires all Federal permittees who affect a state's coastal zone to comply with state guidelines regarding coastal zone management. These guidelines could affect any ocean discharge requiring one or more Federal permits. The coastal zone includes states adjacent to the Great Lakes, and all East, West, and Gulf Coast states.

In Florida concentrate can be discharged into any Class III waterway, which is defined as any waters that are open ocean, coastal, rivers, canals, and streams, or lake estuaries, bays and lagoons. In all cases a site-specific hydrographic study, ambient water quality investigation, and impact modeling must be performed to substantiate that the dilution of the discharge occurs within the established mixing zones for parameters in noncompliance with Class III water standards. Due to the regulatory criteria and physiographic characteristics of Class II (i.e. water allotted for shellfish propagation and harvesting) water bodies, the optimal discharge location for reverse osmosis concentrate is open ocean or coastal waters. Surface water discharges are not permittable into Class I waters (i.e., potable water supplies) or Class II waters.

In California, concentrate disposal to surface waters is permitted under the NPDES permits issued by each RWQCB. The constituent limits are based on protection of identified beneficial uses and goals of Basin Plans.

3.5.3.2 Discharge to Sewers

Brine from membrane plants may also be discharged to sewage systems. Brine from desalting plants if disposed to local sewage systems could have detrimental effects on the water reclamation plants due to elevated levels of TDS both in the influent and effluent from the recycled water plants. Brine dischargers to sewage systems also include some effluent from industries and dairies which also affect the ability of the WWTP to meet discharge requirements. In California, concentrate can be disposed into a sewer system. It is the responsibility of the receiving utility to monitor the concentrate load and ensure that the WWTP maintains compliance with required constituent levels in the effluent.

3.5.3.3 Disposal by Land Application

Land application for disposal of membrane concentrate includes both irrigation and rapid infiltration systems. Other processes such as overland flow, wetland application, subsurface application, and aquaculture are only applicable for very small flows and are not economically feasible at the more typical flows for membrane concentrate disposal. Figure 3.2 shows general schematics for both irrigation and rapid infiltration alternatives.

Rapid infiltration systems allow membrane concentrate to percolate through the soil at a relatively high loading rates (4 to 80 inches per week depending on soil permeability) eventually recharging groundwater, recharging surface water, or being collected by wells and used for other purposes. Most soil types have capacity for removing heavy metals and phosphorus, but no capacity for removal of dissolved salts, such as sodium and chloride, which pass through the soil and enter groundwater. Therefore, rapid infiltration systems are typically used to treat low TDS membrane concentrate that may have high concentrations of heavy metals or phosphorus.

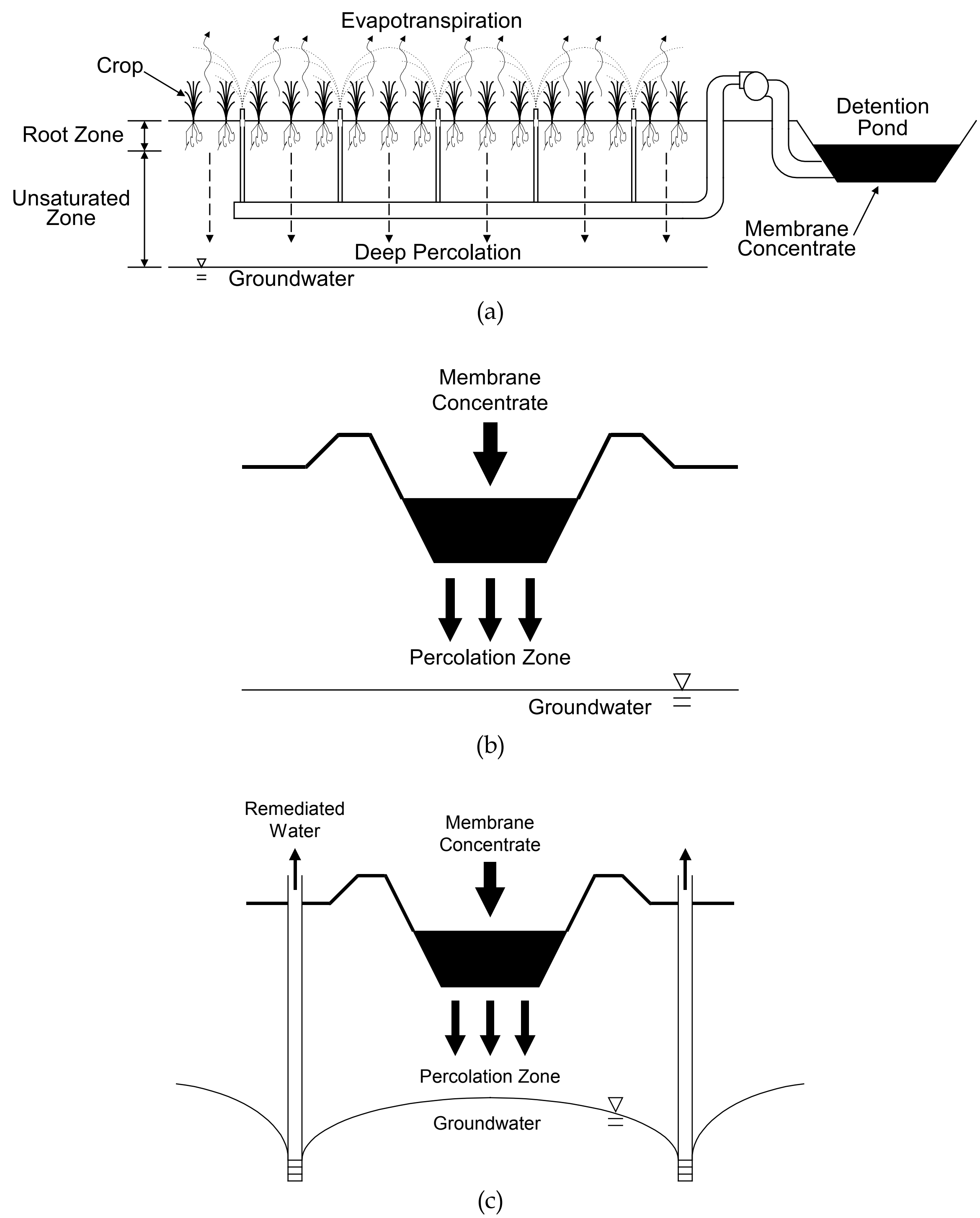
Finding a suitable site is another issue associated with using rapid infiltration for membrane concentrate disposal. A site with highly permeable soil (sand or loamy sand) must be available. In addition, groundwater below the site must have a higher concentration of every constituent as compared to the remediated concentrate water and the groundwater is not mass-load limited. If the groundwater has lower concentrations than the remediated concentrate water, rapid infiltration would not be a feasible alternative due to potential degradation of groundwater quality. Operation of a rapid infiltration system should include a rest period, typically between 5 and 20 days, to allow the applied water to completely drain from the soil and restore aerobic conditions. This is especially important when vegetation is planted in the rapid infiltration basins to maintain soil permeability.

Disposal of membrane concentrate by irrigation may also achieve conservation of potable water by irrigating a plot of land with membrane concentrate instead of potable water. Remediation of the membrane concentrate is achieved through evapotranspiration of the water by the irrigated plants and storage of the salts below the root zone and above the groundwater. This technique is commonly employed on golf courses, public parks, and roadway medians. In instances where no suitable existing application is available, a plot of land may be acquired to grow a specie of plant that is suitable for the soil, climate, and membrane concentrate quality. Irrigation is typically used to dispose of low-TDS membrane concentrate streams such as those from nanofiltration (NF) softening plants and some brackish groundwater reverse osmosis plants. Issues associated with implementation of an irrigation system for membrane concentrate disposal include: site selection, selection of appropriate vegetation, concentrate pretreatment, hydraulic loading rate, land requirements, and distribution technique. Each of these issues is discussed in detail below.

- **Site Selection.** Irrigation as a means for membrane concentrate disposal is attractive if the soil has a sufficient permeability and groundwater quality would not be compromised.
- **Selection of Appropriate Vegetation.** Selection of appropriate vegetation for irrigation with membrane concentrate depends on many application-specific factors including: concentrate quality and quantity, geographical location, soil composition, site setting (e.g. urban, residential, etc.), and land availability.
- **Pretreatment**. Pretreatment requirements depend on the type of vegetation irrigated, the degree of public contact, and the method of application. Typically, the concentrate is aerated to increase the DO concentration prior to conveyance to a detention pond. Increased levels of DO serve to prevent stagnation and algae growth in the detention pond. Additional pretreatment may be required if there is anticipation of substantial contact with the public. More stringent guidelines may be imposed on the concentrate water quality to protect the public health, possibly requiring additional pretreatment.

FIGURE 3.2

LAND APPLICATION ALTERNATIVES



(A) IRRIGATION, (B) RAPID INFILTRATION, (C) RAPID INFILTRATION WITH RECOVERY

Of particular concern regarding disposing of membrane concentrate through irrigation is the concentration of sodium, calcium, and magnesium cations in the concentrate stream. A high concentration of sodium compared to calcium and magnesium can adversely affect the permeability characteristics of soil with a significant clay component. High sodium concentrations, relative to calcium and magnesium, tend to cause dispersion of aggregates composed of many individual clay particles. When this happens, the tiny clay particles tend to move with the water and seal the soil preventing additional water movement by clogging pores. Soils with higher percentages of clay (especially clays prone to shrinking and swelling with changing moisture content) are more vulnerable.

- **Hydraulic Loading Rates.** Factors affecting the hydraulic loading rate include precipitation, evapotranspiration, percolation, and runoff. Typically, runoff from an irrigation application is not allowed and can be prevented by controlling application rates or constructing a berm or underground collection system around the perimeter of the irrigation site.
- **Land Requirements.** Land requirements for disposal of membrane concentrate through irrigation depend on the plant species being irrigated, storage requirements, and buffer zones.

Permitting required for land application of membrane concentrate is dependent upon site, feedwater, and concentrate water characteristics. If a land application site has potential for significant runoff, an NPDES permit will likely be required for the return flows. A waste discharge permit also will be required for land treatment.

California allows land application of concentrate in some regions of the state as long as water quality requirements are met in that region. Florida regulations related to discharges of concentrate by land application require (1) a site-specific hydrogeological study to determine the shallow aquifer hydraulic, sedimentological and ambient groundwater quality characteristics of the proposed application site, (2) identification of all potable and nonpotable wells within 0.5 miles of the site, and (3) impact modeling to determine water level changes that would occur due to the proposed applications. An example of a medium sized land application is the Greater Pine Island Water Association (GPIWA) percolation ponds on Pine Island, Florida. This project consists of two ponds with an area of 5.3 acres, which are monitored quarterly for water quality and daily for dissolved chlorides, TDS, and pH to ensure compliance with water quality standards in the permit. An example of a small sized land application system is the french-drain type exfiltration gallery in operation at Burgess Island, Lee County, Florida. The system is monitored quarterly for compliance with permit limits for certain heavy metals, radionuclides, pH, conductivity, dissolved chlorides, and TDS.

Halophyte Irrigation

One type of land application that is viable in some regions is halophyte irrigation. Halophyte or "salt-plants" thrive in saline water. There are a number of different types of halophytes, which can be utilized for landscaping, gazing, windbreaks, or habitat and wildlife development. Therefore, in areas where the potential of salt contamination of groundwater is minimal the use of halophyte landscaping or farms is a viable disposal option. Siting is an important consideration to using halophytes because halophytes take up only a portion of the salt contained in saline water leaving the remaining salt to be deposited in the soil profile or brine ponds.

One potential concentrate disposal mechanism is to use halophyte farms. This application has been investigated by the University of Arizona. In this study it was determined that halophyte farms irrigated with concentrate at a five percent leaching rate will be productive for over 100 years in southern Arizona without affecting the quality of the underlying groundwater any more than conventional irrigation. The study determined that for southern Arizona, halophyte is the best method for concentrate disposal.

3.5.3.4 Deep Well Injection

Deep-well injection is a disposal alternative that ultimately stores the liquid waste in subsurface geologic formations. A well is used to convey the liquid waste some distance below the ground surface where it is released into a geologic formation. Well depth is typically less than 8,000 feet and depends on the class of well used.

Implementation issues for membrane concentrate disposal by deep-well injection include site availability, well classification, membrane concentrate compatibility, and public perception. Before deep-well injection is considered an appropriate site must be located. The site must have favorable underground geology conducive to deep-well injection. Favorable geology includes a porous injection zone capable of sustaining adequate injection rates over the life of the membrane facility. In addition, an impermeable layer is required to prevent the migration of the injected concentrate into an underground source of drinking water (USDW). A USDW is defined as any underground aquifer containing water with TDS less than 10,000 mg/L. The site should also be a sufficient distance from any wells penetrating the impermeable layer that may serve as a pathway through the impermeable layer and into a USDW.

Another implementation issue for deep-well injection is determining the applicable class of well for a given site and waste quality. Five different classes of wells exist categorized by the liquid waste origin and characteristics. A description of each well class is included in Table 3.19. The two classes of wells applicable to disposing of membrane concentrate are Class I and Class V wells.

In practically all cases, a Class I injection well is required because the injectate (membrane concentrate) is typically of lower quality than the water into which it is being injected. For a Class V well to be applicable, the injectate must be less than 10,000 mg/L TDS and less concentration than the groundwater into which it is being injected. As a result of this stringent qualification, a Class V injection well is extremely difficult, but not impossible, to permit.

TABLE 3.19
DESCRIPTION OF DEEP-WELL CLASSES

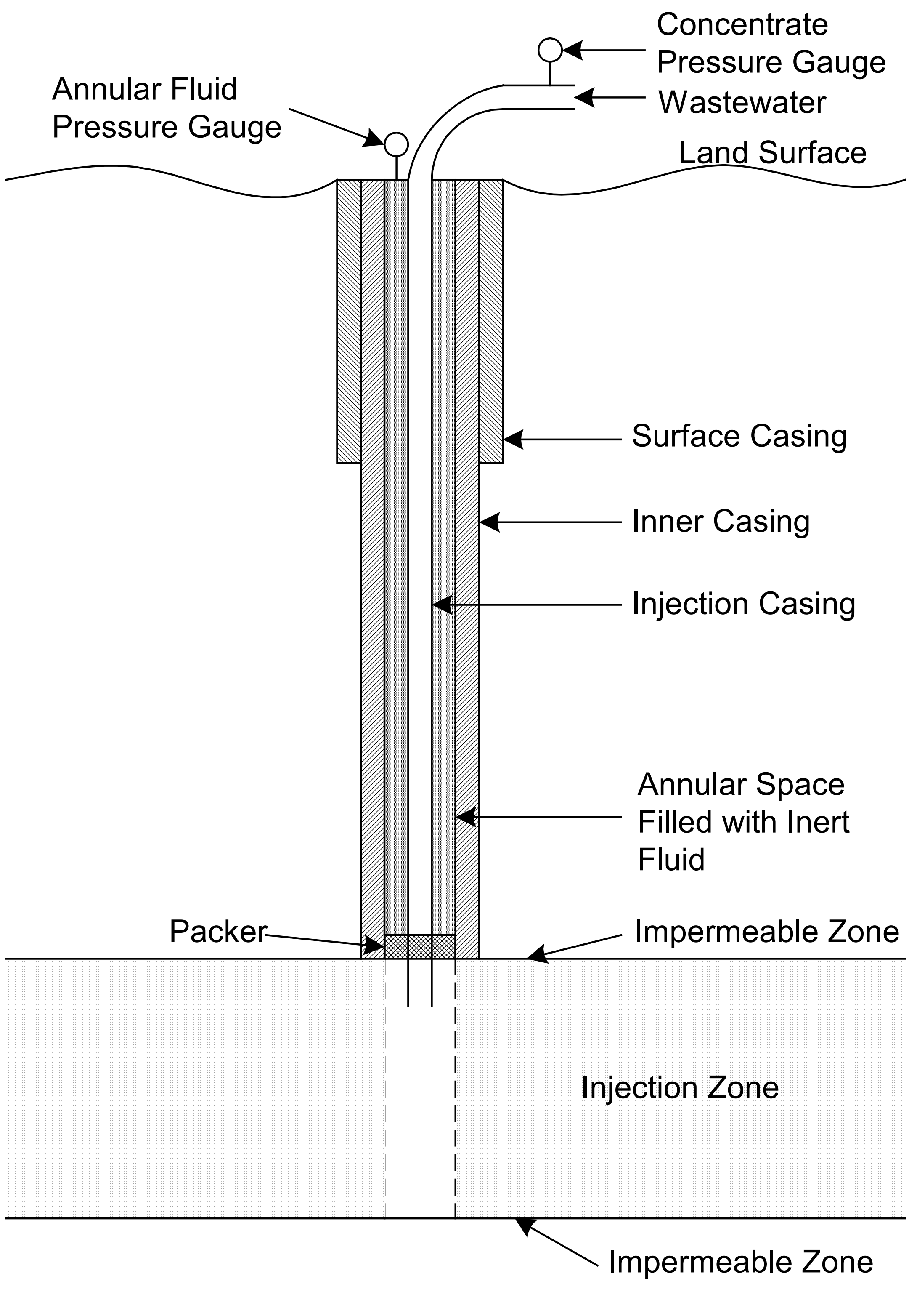
Deep-Well Class	Description
I	Injectate equal to or greater than 10,000 mg/L TDS Geologic confining layer present to prevent contamination of upper level USDW Injectate may have a poorer quality than the USDW into which it is being injected
II	Wells used in the recovery of natural gas or oil
III	Wells used to mine sulfur by the Frasch process
IV	Wells used to dispose of radioactive waste
V	Injectate is of greater quality than the water into which it is being injected Injectate is less than 10,000 mg/L TDS

A schematic of a Class I injection well is shown in Figure 3.3. A typical Class I injection well consists of concentric pipes that extend several thousand feet below from the ground surface into a highly saline, permeable injection zone, which is confined vertically by impermeable strata. Some constraints when using deep-well injection include:

- Injection may not be feasible in areas where seismic activity could potentially occur and cause seepage at faults.

FIGURE 3.3

TYPICAL DEEP-WELL INJECTION SCHEMATIC



- Injected wastes must be compatible with the mechanical components of the injection well system and the natural formation water. Pretreatment of injectate may be required to ensure compatibility with geologic formation and water being injected into.
- High concentrations of suspended solids (typically >2 ppm) can lead to plugging of the injection area of the well.
- Organic carbon may serve as an energy source for indigenous or injected bacteria resulting in rapid population growth and subsequent fouling.
- Concentrate streams containing constituents above their solubility limits (e.g., silica) may require pretreatment before injection into a well.

Implementation of deep-well injection for disposal of membrane concentrate can be a public perception problem. In some instances, environmental groups opposing disposal of wastes by deep-well injection have been successful in convincing the general public that deep-well injection poses a significant risk of groundwater contamination, regardless of the precautions taken. Depending on the persuasion of the general public, deep-well injection may not be acceptable regardless of engineering precautions taken to ensure public health. Regulations governing the permitting of injection wells reside at the state level. However, most states have adopted the Underground Injection Control (UIC) guidelines set forth in *the Drinking Water Act of 1979*. Some states may have more stringent guidelines, but, at a minimum, the UIC guidelines must be met. In California, deep well injection is permitted but concentrate disposal by this method must comply with the UIC program.

Permitting a Class V injection well has already been shown to be very difficult. To obtain a Class V injection well permit, the membrane concentrate being disposed of may not increase the concentration of any constituent of the water into which it is being injected. This requirement prevents a Class V injection well permit from being issued in practically all scenarios associated with membrane concentrate disposal. In some states, membrane concentrates from municipal and industrial facilities must be disposed of in Class I wells. However, reclassification of the waste to allow disposal in a Class V well has been successful in a few cases. Although the permit requirements for a Class I injection well are less stringent than those for a Class V injection well, the permitting process is by no means simple. Subpart B, Section 146.12 of the UIC regulations states, "All Class I wells shall be sited in such a fashion that they inject into a formation which is beneath the lowermost formation containing, within one-quarter mile of the well bore, an underground source of drinking water." In addition, impermeable strata of geology must be located above the injection zone to prevent the migration of the injectate into an overlying USDW. Extensive geologic modeling may be required to demonstrate the effectiveness of the impermeable strata in preventing this migration. In many cases, geologic investigations are required to collect data used for the modeling purposes.

Once suitable geology is determined to be present, a test well is drilled and completed and used to confirm adequate injection capacity. The test well is typically completed to Class I standards, but initially permitted as a Class II well to expedite the permit process. If the well is determined suitable for deep-well injection, it can be reclassified as a Class I well.

The cost associated with deep-well injection of membrane concentrate depends on a number of different factors including: permitting costs, site location, flow rate of membrane concentrate, permeability of geology, depth of injection zone, concentrate pretreatment, and well type. The permitting process for an injection well is a labor-intensive process, in many cases requiring extensive geologic investigations and permit applications. The permitting process involves drilling a test well that is completed to Class I standards. As a result, significant expenses are incurred in the permitting process.

Small diameter injection wells are a high cost alternative to surface water discharge and land application, but are an option were other disposal methods are not permitted. Florida regulations require the following before concentrate disposal can occur (1) hydraulic testing of the injection zone, (2) pressure test of casings and tubing, (3) directional surveys during drilling, (4) a radioactive tracer survey of the injection zone, (5) an overdrill of 10 inches for the final casing and 5 inches minimum for other casing strings, (6) extensive geophysical logging, (7) video surveys of final casing, tubing, and open-hole intervals, and (8) a final casing wall thickness of at least 0.5 inches. An example of a small diameter injection well concentrate disposal project is the Southern States/Burnt Store Utilities, Charlotte County, Florida. The system consists of an injection well and a dual monitoring well, which is monitored monthly for TDS, gross alpha, radium 226/228, sulfate, magnesium, iron, pH, carbonate, bicarbonate, calcium, potassium, TKN, chloride, sodium, temperature.

3.5.3.5 Evaporation Ponds

Evaporation ponds rely on solar energy to evaporate water from the membrane concentrate stream, leaving behind precipitated salts, which are ultimately landfilled. Evaporation ponds are optimal in arid climates having high net evaporation rates, which decreases the pond area required, compared to humid climates with low net evaporation rates. The practicality of evaporation ponds is not limited by membrane concentrate quality.

In the most common case, membrane concentrate is conveyed to the evaporation ponds where it is spread out over a large area and allowed to evaporate. Multiple ponds are constructed to allow continual receipt of membrane concentrate while some ponds are taken offline for periodic maintenance. Periodic maintenance includes allowing the evaporation pond to be idle to desiccate the precipitated salts. Once the precipitated salts have reached a satisfactory consistency, the ponds are cleaned by removing and transporting the precipitated salts to a landfill for ultimate disposal.

An option for decreasing the pond area required is to include mechanical misting equipment which sprays the concentrate into the atmosphere in tiny droplets, increasing the surface area of the membrane concentrate and substantially increasing evaporation. The inclusion of misting equipment has been shown to decrease the area of evaporation ponds by 90 percent in some instances.

Factors affecting the feasibility of implementing evaporation ponds for membrane concentrate disposal include membrane concentrate quality and flow rate, geographical location, and site location. Membrane concentrate flow rate is the primary factor affecting the area required for the evaporation ponds. The greater the flow rate of membrane concentrates, the larger the area required for evaporation ponds.

Although fairly simple to construct and operate, evaporation ponds may pose a public nuisance problem. The highly concentrated brine solution in the ponds tends to emit noxious odors depending on the constituents of the brine solution. Therefore, the ponds should be sited away from residential areas, if possible. In addition, large evaporation ponds are attractive to many birds that frequent water. In some cases, high concentrations of metals in evaporation ponds have caused toxic effects in waterfowl and amphibians inhabiting evaporation ponds, which can pose a public relations problem preventing operation of the ponds.

Evaporation ponds must be lined to prevent seepage into the groundwater, or the ponds would be considered a Class V injection well, which would require the ponds to meet the stringent permitting required for the Class V wells, as described above. If misting equipment is included to reduce the required area of the evaporation ponds then the issue of "salt drift" may need to be addressed. California permits the use of evaporation ponds for concentrate disposal; however, the state is reconsidering the continued operation of these types of ponds throughout the San Joaquin Valley. Concentrate disposal utilizing this method requires that MCLs be met.

3.5.3.6 Mechanical Evaporation

Mechanical evaporation can treat membrane concentrate by converting the water component to steam, leaving behind a wet salt to be landfilled. Many different options for mechanical evaporation equipment exist, such as:

- Single-effect evaporator
- Multiple-effect evaporator
- Vapor compression evaporator
- Vertical tube falling film brine concentrator
- Horizontal tube spray film brine concentrator
- Forced-circulation crystallizer

The most common combination of equipment to accomplish full evaporation of membrane reject streams is a vertical tube falling film brine concentrator followed by a forced-circulation crystallizer. This arrangement of evaporation equipment is typically the most economical.

Besides cost, the primary obstacle in implementing mechanical evaporation for the disposal of membrane concentrate is the size and complexity of the equipment. For example, a falling film brine concentrator for a 1.3 million gallon per day (mgd) concentrate stream is approximately 100 feet in height. In addition to the large size of mechanical evaporation equipment, evaporators and crystallizers are relatively complex to operate compared to other methods of membrane concentrate disposal. Reliance on mechanical compressors results in lower reliability than other methods of concentrate disposal that are less mechanically intensive.

An option for decreasing the amount of mechanical equipment involved is to replace the forced-circulation crystallizer with solar evaporation ponds. The falling film brine concentrator would be used to reduce the volume of the membrane concentrate prior to solar evaporation. The 200,000 to 300,000 mg/L TDS brine would then be pumped to a solar evaporation pond for additional volume reduction.

Permit requirements are minimal for operation of mechanical evaporation equipment for membrane concentrate disposal. Depending on the zoning regulations and height of the falling film brine concentrator, a variance to allow a structure in excess of the regulated maximum height may be required.

3.5.3.7 Existing and Future Impacts of Brine Disposal

Environmental impacts of brine disposal include changes in land-use, visual and acoustic disturbances, emission to the air and water, and changes in the target environment. The impact that brine disposal has on the environment depends on the sensitivity of the habitat. The disposal of membrane concentrate is often a leading factor in determining the cost effectiveness of a project. The USEPA has initiated the classification of membrane concentrate as an industrial wastewater. As a result Florida's Department of Environmental Regulation (DER) views concentrate from a more stringent and therefore more costly regulatory perspective.

Impact to Marine Ecosystem

Brine disposal into the marine systems may consist of components such as:

- Corrosion products
- Antiscaling additives (polycarbonic acids, poly-phosphates)
- Antifouling additives (mainly chlorine and hypochlorite)
- Halogenated organic compounds formed after chlorine addition
- Antifoaming additives
- Anticorrosion additives

- Oxygen scavengers (sodium bisulfite)
- Oxygen deficiency
- Acid heat
- Concentrate

Concentrations and loads may vary depending on the brine disposal method. In general, it is difficult to completely identify and quantify the composition of brine. These chemicals can not be discharged directly into the receiving waters and must be neutralized before discharge as required by the RWQCBs. In addition, membrane plant discharges have the following types of potential adverse effects:

- Higher salt concentrations than the receiving water salt concentrations
- Higher temperatures than the receiving water temperature
- Higher turbidity than the receiving water turbidity
- Lower oxygen levels than of the receiving water oxygen levels
- High concentrations of organics and metals

These constituents can affect the marine environment by adversely affecting marine organisms that cannot exist in highly saline environments, cannot resist temperature fluctuations, or cannot survive high turbidity or lower oxygen levels. In addition, brine may cause the migration of fish to other areas. Elevated temperatures and increased salinity reduce the overall concentration of dissolved oxygen in the water which restricts the types of life forms to those that are capable of existing in this environment. In addition, extreme temperature changes can modify the rate at which biological processes occur influencing movement, maturity, development, and growth of organisms.

Toxicity of Concentrate

Federal water quality regulations (NPDES) as well as many state water quality regulatory programs require that discharges to surface waters not contain toxic substances in toxic amounts. As such, surface water discharge of membrane concentrate is required to meet Federal and state standards for acute and chronic toxicity. Since a wide variety of constituents in such concentrates may exhibit toxic characteristics either alone or in combination with others, toxicity testing is required. The USEPA regulations require that discharges meet the 96 hour LC_{50} for vertebrate and invertebrate species indigenous to the receiving waters (not acutely toxic). The 96 hour LC_{50} is that concentration of pollutants/constituents in the effluent which is lethal to 50 percent of the test organisms after 96 hours of exposure. The Florida Department of Environmental Regulation's (FDER) definition of acute toxicity is more restrictive because it requires discharges to be one-third of the 96 hour LC_{50}. This more restrictive requirement is due to the large number of water treatment plants that utilize membrane treatment processes as well as the sensitivity of the water supply environment in Florida. Although ion toxicity is currently not a problem in California, it does have relevance as a potential factor that could affect surface water discharges if the 96 hour LC_{50} test is made more restrictive in the future to protect marine environments.

Since the variety of constituents in any discharge may have unknown toxic characteristics and concentrations, toxicity is tested by whole effluent bioassays. These tests consist of controlled exposure of sensitive (usually juvenile) test organisms to various dilutions of the effluent. The 96 hour LC_{50} is statistically derived from the numbers of dead organisms at the end of the 96 hour exposure period.

Another toxicity concern is associated with common ion toxicity (such as sodium, potassium, calcium, magnesium, strontium, chloride, sulfate, bicarbonate, borate, and bromide). Common ion toxicity occurs wherever the tested water, regardless of salinity level, has a sufficient excess amount of one or more common ions than the balanced water at the same salinity. It is a type of toxicity different from that due to toxic substances such as heavy metals and pesticides. Whole Effluent Toxicity (WET) test is utilized as an indicator of the toxicity of a discharge to the receiving waters. There have been numerous failed WET tests in Florida, primarily at water treatment plants that use membranes to treat groundwater.

The failed WET tests in Florida may be a significant problem because existing plants are failing, which makes operating permit status uncertain. A report published in 2001 entitled *Major Ion Toxicity in Membranes Concentrates* indicates that a causal relationship may exist between common ion toxicity and failed WET tests. The report concluded that occurrence of major ion toxicity is restricted to groundwater sources and brackish water reverse osmosis, membrane softening, and electrodialysis processes and could become a problem in other parts of the U.S. The report also concluded that major ion toxicity in membrane concentrate is not caused by the membrane process itself but results from the nature of the groundwater. Regulatory and technical approaches to facilitate concentrate permitting were also reviewed in the report; however, to date the state of Florida has not adopted new permitting approaches. There are regulatory possibilities that would facilitate surface water discharge permitting for cases where common ion toxicity is proven. Solutions include providing high dispersion diffusers or allowing for mixing zones around the effluent outlet. But there still needs to be additional research performed to reach a better understanding of this issue.

In California, WET testing requirements are set in the NPDES permit for the specific discharger and these requirements differ based on the governing RWQCB and location. Thus far, ion toxicity does not appear to be a problem in California; however, this may be a result of differing testing requirements and discharge conditions. California concentrate dischargers are primarily permitted under either an industrial or wastewater NPDES permit and WET testing requirements are set based on the discharge location, which in California is primarily the ocean.

3.5.4 Existing and Future Research Needs

Water chemistry is of vital importance to the public acceptance of water reuse projects. In addition, understanding water chemistry assists agencies in providing health protection through the development of new treatment alternatives and identification of new indicator organisms. Also, an understanding of water chemistry assists in the advancement of treatment technologies and reduction of costs for new technologies. The preceding section has provided information relating to the description, sources, associated problems, solutions, and treatment options for constituents of concern, which are summarized in Table 3.15 and Table 3.20. There are still a number of issues that need further investigation. Areas of study that would assist water reuse agencies in developing more efficient and economic treatment and brine disposal methods while maintaining public health protection include:

- Development of a study to determine the impact of concentrate disposal on southern California ecosystems both marine and freshwater. Toxicity is emerging as an issue due to increased use of membrane processes. As more stringent treatment is required to remove constituents of concern, the use of membrane treatment will continue to expand. The result of the use of additional membrane processes will be increased amounts and concentrations of constituents in brine, which will result in increased regulatory focus on concentrate or brine disposal. Issues related to concentrate disposal and toxicity are already emerging in the state of Florida. In Florida, state regulators are concerned about the effects of concentrate disposal on ecosystems; therefore, extensive hydrographic studies are required to be performed to illustrate that impacts to the ecosystem are minimal before a disposal permit will be issued. A study could be undertaken in southern California to look at the effects of concentrate disposal on ecosystems that could assist local agencies in illustrating the effects of concentrate disposal for NPDES permitting.

- Development of economical resource recovery methods of constituents from concentrate or brine. As more membrane treatment is used and the associated concentrates produced, resource recovery may need to be implemented to reduce concentrations of constituents in discharges to meet NPDES permits. Implementation of resource recovery will reduce the disposal of concentrate as well as resulting impacts to the environment. In addition, concentrate may contain constituents of concern including radionuclides and hazardous substances, which will need to be removed from the concentrate before disposal. Also, the RWQCBs are looking into source control issues for the permitting of discharges, which may require the implementation of source control mechanisms upstream. One potential solution for source control could be resource recovery of constituents before disposal or at their input sources.
- Development of wastewater technologies to promote health protection while maximizing conservation and reuse. This would include the development of new indicators of pathogenic microorganisms, which are easier and more cost effective for analysis. Also included in this work, would be an investigation into the appropriate treatment processes and operating conditions required to assure that the removal or inactivation of measurable levels of viable pathogens occurs. Another issue that could be investigated as part of this work is the concentration and health significance of organic constituents in recycled waters. The effects of process selection on particle-size distribution in wastewater and the relationship between particle size and turbidity and the effect of particle size distribution on disinfection of recycled water could also be studied.
- Determining what are the long-term effects of HAAs and EDCs in southern California. Epidemiological research could be undertaken on groups representing a wide cross section of the population to determine the effects of water reuse and disease transmission. Included in this effort would be research into the effects of excreta use on aquaculture and the related bacterial infections. In addition, research into the health effects of water reuse on agricultural workers and consumers of fish could be undertaken. Also included would be an analysis of the effectiveness of methods to control and limit human exposure under real life conditions.

Table 3.20

Treatment Methods to Prevent/Remove Constituents of Concern

Constituent of Concern	Treatment Mechanism								
	Standard Treatment [1]	Microfiltration	Ultrafiltration	Nanofiltration	Reverse Osmosis	Ultraviolet Light	Ozone	Nitrification/ Denitrification	Carbon Adsorption
Endocrine Disrupters or Hormonally Active Agents	●		●	●	●				●
Pharmaceuticals and Personal Care Products	●		●	●	●		●		●[2]
Antibiotics	●		●	●	●				●
Pesticides	●		●	●	●				●[2]
Total Organic Carbon	●		●	●	●		●	●	●
Disinfection By-Products	●				●	●			●
Organic Micropollutants	●		●	●	●		●		●
NDMA	●		●	●	●	●[3]	●		
Soluble Microbial Products	●		●	●	●		●		●
Pathogens									
Bacteria	●	●	●	●	●				
Viruses	●		●	●	●				
Parasites	●	●	●	●	●				
Metals	●		●	●	●				●
Nutrients	●				●			●	
Salinity	●				●				

Notes:

[1] Represents basic secondary or tertiary treatment required to meet regulations.

[2] Provides only partial removal of some constituents.

3.6 Salinity

3.6.1 Introduction

High salinity in the water supply is a major concern to water purveyors in that it limits beneficial uses of their waters. Amongst its many bad habits, high salinity water causes the breakdown and premature corrosion of some pipes and equipment, negatively impacts the environment, and harms salt-sensitive landscapes and agricultural crops, and limits the beneficial uses of recycled water. Moreover, due to the additive nature of water uses, the more that water flows through users, the higher the salinity can become. Recycled water comes at the end of the water use line and as such has some of the highest salinity concentrations in the community water supply. Higher salinity recycled supplies can be very limited in use from the agronomic (certain landscape uses), regulatory (such as groundwater recharge or stream augmentation), and technical (such as industrial uses like carpet dying and cooling tower uses). These limitations can have secondary impacts as well. For example, runoff from recycled water uses, such as landscape irrigation, can violate water quality standards established by the Regional Water Quality Control Board. Overcoming these limitations can include additional expenses. Blending saline recycled water with higher quality water or applying reverse osmosis or membrane filtration might be used to reduce salinity concentrations and gain the beneficial uses. Salinity mitigation is expensive and may even lead to a decision not to use the recycled water. Additionally, where membrane filtration can be applied to remove the salinity, these treatment processes produce a highly concentrated brine solution, which can also cause water quality issues or the need for extensive pipeline systems to convey the brine to the ocean for discharge. Lastly, there may even be an increased concern with ocean discharge from the regulatory perspective, rendering the salinity removal issues an even more expensive prospect.

The purpose of this section of the technical memorandum is to describe the issues associated with sources of salinity in the water supply, including recycled water supplies, in southern California; discuss concerns about use of water with high salinity concentrations; and identify items that should be further evaluated or considered to identify methods that will support using recycled water. Information from many sources including the 1999 Salinity

Management Study (Salinity Management Study) completed by MWDSC and Reclamation. The Salinity Management Study included the results of numerical and economic analyses presented in detailed tabular format. Those data are summarized in this memorandum and the tables are included for reference.

3.6.2 Description of "Salinity"

The term "salinity" is used to describe the presence of sodium (Na^+) and/or other cations (such as calcium (Ca^{2+}), potassium (K^+), and magnesium (Mg^{2+})); with chloride (Cl^-); and/or other anions (such as sulfate (SO_4^2), carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), and nitrate (NO_3^-)).

Salinity is frequently measured as "milligram/liter" of Total Dissolved Solids (TDS), or as electrical conductance of an aqueous solution ("micromhos/centimeter"). Concentration of one or more primary specific constituents, such as sodium or chloride, also is used as a measure of salinity. This technical memorandum refers to TDS concentrations as the measure of salinity.

3.6.3 General Sources of Salinity

Generally, precipitation in the form of rainfall or snowmelt does not include salts as the water leaves the clouds. However, as the precipitation flows over and through soils, salts are leached from the rock and soil and the runoff mixes with chemicals applied to the soil or chemicals from structures placed on the soil. Sometimes groundwater with naturally occurring high salinity occurs in perched aquifers or deeper connate aquifers. Seepage from these sources into adjacent streams also causes high salinity in streams. Finally, mixing of freshwater streams in tidal zones and brackish estuarine water increases salinity within the mixing zone. This zone can extend several miles into a watershed depending upon the hydrodynamics of the estuary.

As the water is diverted from the streams or groundwater and is used for irrigation or municipal/industrial uses, chemicals are added to the water stream. Many of these chemicals include high concentrations of salts, especially effluent streams from irrigation activities with chemical applications and municipal activities that discharge water from cooking, cleaning, manufacturing, and/or water softener backwash streams.

Each time water is used, there is a potential for significant increases in salinity concentrations. Municipal uses can increase TDS from the water supply to the wastewater effluent by 200 to 400 mg/l. Agricultural uses can add as much or more depending upon land uses like dairies and feedlots, fertilizer and other chemical applications, antecedent soil salinity, and evaporation of water from the soil surface.

As the water flows through the watershed, the salinity increases as water flows through soils, gains water from saline groundwater seepage, and is diverted, used, and discharged multiple times. In the lower portions of the watershed, the high salinity concentrations in the water supply will only continue to increase as water is used either once and discharged back to the stream - or multiple times through recycling prior to discharge back to the stream. The water in streams may be used and recycled by multiple communities before it reaches downstream end users. Each use and reuse of the water contributes additional salinity to the streamflow.

Figure 3.1 and Table 3.1 delineate how salinity moves through the hydrodynamic system for reclaimed water. From the originating water source(s) of the system, whether it is a river (A1), reservoir (A2), groundwater basin (A3), or some combination of the sources, each time water is used, there is a potential for salinity to be added to the system or removed through treatment. Depending on the salinity in these sources, soil content, and chemicals utilized, water from agricultural uses (E) can either be allowed to runoff to surface waters or percolate into groundwater (if the water quality meets basin objectives), or will be treated (H) to meet water quality objectives and allowed to return flow to surface waters (L or N). Raw water that is treated (B) may undergo further treatment (C) to reduce salinity for end users (F) by either utilizing a package treatment plant unit or through water softening. Reclaimed water utilized for municipal, or industrial uses (G) may require further treatment (C) to reduce salinity so that the water does not have negative impacts on the intended use such as turf burning or scale production in boilers. In addition, reclaimed water utilized for municipal or industrial purposes (G) may undergo a post-use treatment process (H) to remove salinity or other constituents added to the water as a result of the use before it is discharged to surface waters (L or N). This additional treatment (H) is primarily required to meet discharge permits or basin plan objectives. All locations along the hydrodynamic system where water is treated to remove salinity or other constituents (B, C, H, I, and K) will produce concentrated brine. This brine residual will need to be disposed of through either landfilling of the material, discharging it to the sewer system for treatment (I) or by discharging it via a brineline to the ocean (N). In addition, future regulations may require resource recovery as well as treatment of the brine stream (N) before discharge to surface waters (L or N).

3.6.3.1 Sources of Salinity in Southern California Water Supplies

The water supplies in southern California primarily consists of water imported from the Sacramento-San Joaquin Rivers Delta, the Lower Colorado River, and Owens Valley; local runoff; local groundwater; and in the past few years, from water imported from the southern Sierra Nevada streams. The salinity characteristics of these sources vary throughout the year. In most areas of southern California, water supplied to users is a blend of several sources. Salinity concentrations of the most widely used sources are summarized in the Table 3.21 and in the following subsections.

3.6.3.2 Salinity in the Colorado River

The Colorado River flows over 1,400 miles from the Rocky Mountains to the Gulf of California. Figure 3.4 provides a map of the Colorado River Basin. Salinity concentrations increase as the water flows through the watershed from natural and human-activity sources. Natural sources of salinity in the Colorado River include sediment, seepage from saline groundwater, and evaporation. Sediment from ancient marine deposits erodes and enters the stream during extended or intense storm events. Erosion increases as soil is disturbed by agricultural and mining activities in the upper watershed. Storm events convey constituents from the eroding soils to the middle and lower reaches of the Colorado River. Salts also enter the river through seepage from naturally occurring saline springs, groundwater, and discharge of water recovered during oil exploration activities. Salinity concentrations also increase as water evaporates primarily from the reservoirs as well as the river surface.

The Salinity Management Study cited a study by U.S. Geological Survey (USGS) that estimated the naturally occurring salt load averaged about 10.5 billion pounds/year upstream of Lake Mead (formed by Hoover Dam). This currently represents about 50 to 60 percent of

TABLE 3.21

AVERAGE SALINITY CONCENTRATIONS IN WATER SOURCES USED IN SOUTHERN CALIFORNIA

Water Source	Range of Salinity (mg/l, as TDS)	Long-Term Salinity Average (mg/l, as TDS)
Colorado River, at Parker Dam	500 - 900	700
State Water Project, delivered in East and West Branch of California Aqueduct	50 - 500	330
Owen Valley Supply	50 - 300	less than 250
Local Groundwater and Surface Waters in southern California	100 - 1,000	depends upon basin
Transferred Water from Sierra Nevada tributaries to San Joaquin Valley	30 - 200	less than 250
Treated Water from Desalination Plants	0 - 100	0 - 100 depending upon treatment process. Generally blended with water characterized by higher salinity concentrations

Note:

This table was derived from information contained within the *Salinity Management Study Final Report* published by Metropolitan Water District of Southern California and the United States Bureau of Reclamation and from information contained within the *2002 CALFED Bay Area Blending Phase I Study*.

the total salt load into the Colorado River upstream of Lake Mead.

The remaining salt load introduced upstream of Lake Mead is from agricultural activities and municipal and industrial uses. Irrigation was initiated in the 1860s and expanded rapidly through the 1920s. Over 85 percent of the existing irrigated acreage in the upper basin has been in place since 1920s. Irrigated acreage in the lower watershed did not occur at significant levels until construction of Boulder Canyon Project in the 1930s and other water supply projects funded through Department of the Interior (Interior) programs. Tailwater and return flows from the irrigated land convey salts from dissolved fertilizers, plant material, other materials applied to the land, and accumulated salts flushed from the soils.

Municipal and industrial users in the basin increase salt through use of the water that is subsequently discharged into the river as wastewater effluent. The USGS study cited by the Salinity Management Study indicated that less three percent of the salinity in the Colorado River Basin was caused by municipal and industrial sources. The low contribution rate is due to two factors: relatively small population in the watershed and a relatively low salinity

FIGURE 3.4

MAP OF THE COLORADO RIVER BASIN

generation rate.

Diversions to municipal and industrial uses that do not result in discharges back into the river can increase salinity by reducing the amount of water that dilutes the salinity concentration. Elimination of discharges can occur due to consumptive uses including irrigated crops, industrial uses such as beverage industries or cooling towers, or recycled water uses.

Salinity Standards in the Colorado River

In 2001, Interior published *Quality of Water, Colorado River Basin, Progress Report No. 20* (Progress Report). This report indicated that prior to development in the watershed, salinity in spring runoff flows in the upper watershed was frequently below 200 mg/l. However, salinity in the lower watershed could exceed 1,000 mg/l in the summer months when flows were low. As reservoirs were constructed in the watershed, seasonal flow variations were reduced because the reservoirs served to mix the high salinity flows with the stored spring runoff flows that are characterized by low salinity. In addition, the reduction in flow variations also may reduce erosion rates downstream of the reservoirs.

In the 1960s, the Federal and state governments initially evaluated numerical salinity standards to protect water quality in the Colorado River. This effort was initiated concurrently with allocation of the Colorado River flows to the Colorado River Basin States (Wyoming, Colorado, Utah, Nevada, Arizona, New Mexico, and California) and Mexico. It was determined that salinity had increased, and could continue to increase as lands in the upper watershed were developed.

In 1974, Congress provided authorization and funding for limited salinity management programs in the Colorado River watershed on a site-specific basis. The programs implemented under the *1974 Colorado River Basin Salinity Control Act* (PL 93-320) were identified under two titles, as described below.

- **Title I:** Provisions for programs downstream of Imperial Dam, including 1) desalting facilities near Yuma, Arizona to reduce salinity from drainage flows from the Mohawk Irrigation and Drainage District, 2) lining of the Santa Clara Slough in Mexico to convey brine to the Gulf of California, 3) increased irrigation efficiency in Wellton Mohawk Irrigation and Drainage District to reduce drainage flows by 110,000 acre-feet, 4) management of groundwater pumping along Arizona-Sonora border, and 5) improved lining of a portion of the Coachella Canal to reduce the amount of seepage. The overall concept of these improvements would allow drainage water treated by the Yuma desalter to be blended with non-treated drainage water and returned to the Colorado River. This could provide up to 73,000 acre-feet of water when the Colorado River does not have adequate flows. The lined Santa Clara Slough is used to convey irrigation return flows when the desalter is not operating. The costs of Title I improvements were to be funded by Federal government and not paid for by users in the Colorado River system.

- **Title II:** Provisions for programs upstream of Imperial Dam, including 1) implementation of a salinity control policy, 2) planning and implementation of programs described in 1972 *Colorado River Water Quality Improvement Program*, 3) creation of the Colorado River Basin Salinity Control Advisory Council and with representatives appointed by state governors. The membership is relatively consistent between the Advisory Council and the Colorado River Basin Salinity Control Forum. The costs of Title II improvements were to be 75 percent funded by the Federal government and not paid for by users, and 25 percent funded by both the Upper Colorado River Basin Fund and the Lower Colorado River Basin Fund (with not more than 15 percent funded by the upper basin). The portions paid for by the users were to be repaid over 50 years without interest. The Federal government is funding the largest portion because much of the salinity is from Federal lands or lands with Federal water projects.

The evaluation funded by this legislation was summarized in the 1975 Water Quality Standards for Salinity, Including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System published by the Colorado River Basin Salinity Control Forum. The report was adopted by all of the watershed states and the USEPA. The criteria were based on flow-weighted average annual salinity concentrations in the lower river in 1972, as calculated by Reclamation. The following numerical salinity criteria were established.

- 723 mg/l below Hoover Dam
- 747 mg/l below Parker Dam
- 879 mg/l below Imperial Dam

The criteria include provisions for periodic increases of salinity due to fluctuations in river flows as long as salinity control measures are being planned and implemented. The control measures considered were to remove 1,452,000 billion pounds of TDS each year. Controls are funded through several agencies including; the U.S. Department of Agriculture, which implemented on-farm voluntary cost-share program to reduce salt loads from agricultural lands in portions of Colorado, Utah, and Wyoming; the U.S. Bureau of Land Management

(BLM), which implemented programs for watershed improvements and rangeland management in portions of Colorado, Utah, and Wyoming; and the USGS, U.S. Fish and Wildlife Service, and USEPA who fund other activities in the watershed. Salinity control downstream of Imperial Dam is controlled by an agreement between the United States and Mexico through Minute 242 of the International Boundary and Water Commission. The criteria provides for a maximum incremental increase in average annual salinity upstream of Morelos Dam of not more than 115 mg/l (plus or minus 30 mg/l) over the average annual salinity at Imperial Dam. This agreement also established minimum flows into Mexico.

The Act was amended by PL 98-569 in 1984 to incorporate cost-effectiveness analyses for salinity control alternatives, construction of salinity control facilities in the Lower Gunnison Unit and at the Dolores Project, additional studies for salinity control, measures to mitigate loss of wildlife due to implementation of salinity controls, and the establishment of voluntary on-farm cooperative salinity control programs. The amendments also required that BLM implement salinity controls on public lands, modify the cost allocation and reimbursement equations, and deauthorize salinity controls in the Crystal Geyser Unit due to high costs.

In 1996, PL 103-127 amended the role of U.S. Department of Agriculture through authorizing conservation programs as Environmental Quality Incentives Program. As part of this program, studies were undertaken in 1996 including salt-routing studies using Reclamation's Colorado River Simulation System model. The goal identified in the studies is to maintain the flow-weighted average annual salinity at or below the numeric criteria summarized above in the near term. This goal was established to eliminate the fluctuations due to changes in runoff volumes in the watershed. If this type of program is not implemented, the modeling indicated that by the Year 2015 salinity concentrations may increase to the levels listed below.

- 756 mg/l (criteria 723 mg/l) below Hoover Dam
- 775 mg/l (criteria 747 mg/l) below Parker Dam
- 892 mg/l (criteria 879 mg/l) below Imperial Dam

Historically, salinity variations have occurred; however, the criteria set for salinity at Hoover Dam of 723 mg/l has not been exceeded. This is evident from Figure 3.5 which provides the USGS data for water at Hoover Dam. Salinity values at Hoover Dam are important because it is located upstream of Parker Dam where water is diverted for use in southern California.

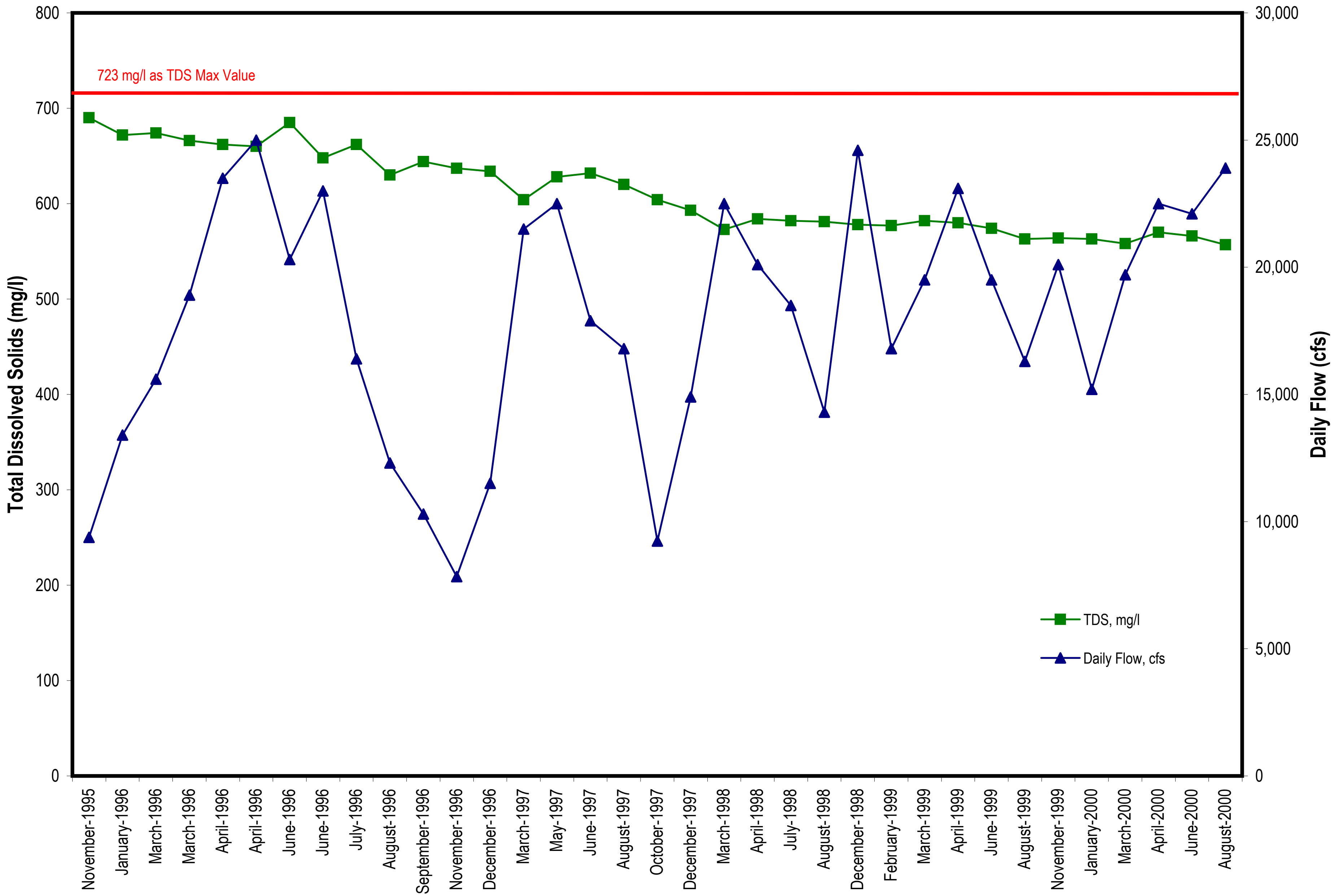
The 1996 Department of Agriculture studies indicated that if land use continued to change in the watershed and water demands increased, the salinity criteria (723 mg/l) would be exceeded within 20 years. The model predicted salinity concentrations assuming no controls, controls identified following the 1975 study, and additional controls to maintain the numeric criteria in 2015. It was determined that an additional 2,952,000,000 pounds per year of TDS must be controlled to maintain the salinity criteria in 2015. In addition, the 1996 studies indicated that since the *1975 Water Quality Standards for Salinity* report, programs had been implemented to remove over 1,243,000,000 pounds per year of salt.

In 1995, Public Law 104-20 authorized an entirely new way of implementing salinity control. Reclamation's Basin wide Salinity Control Program opens the program to competition through a "Request for Proposal" process, which has greatly reduced the cost of salinity control. The average cost of salinity control measures has dropped from about $70 per ton to $30 per ton.

Prepared in accordance with the requirements of the *Clean Water Act*, the 1999 Review, Water Quality Standards for Salinity, Colorado River System (Review) found that the Colorado River Basin Salinity Control Program has fallen somewhat behind schedule and that the program needed to be accelerated. The Review found that nearly 45,000 tons worth of new controls would need to be implemented each year to maintain the standards. This program goal is the combined target for the participating agencies within Interior and USDA. In Reclamation's annual presentation to the Colorado River Basin Salinity Control Advisory Council (October 1999), Reclamation presented an analysis of the program's overall progress. The analysis showed that the program has been able to meet or exceed its 45,000 ton-per-year target mainly because of the twofold increase in efficiency achieved by Reclamation's new Basin wide Salinity Control Program. Annually, this program is limited by predominantly budget rather than program opportunity. Moreover, this program does not deal at all with Federal rangeland contributions to the Colorado River salinity concentrations.

FIGURE 3.5

Total Dissolved Solids in Colorado River at Hoover Dam (1995-2000)



3.6.3.3 Salinity in the State Water Project Supply

The State Water Project captures and stores water on the Feather River. The majority of the State Water Project water is conveyed in the Sacramento River to the Delta and diverted in the southern portion of the Delta at the Banks Delta Pumping Plant. The pumps lift water into the California Aqueduct, which extends to southern California where water is diverted into local agency systems.

Salinity in the State Water Project's water primarily originates from seawater intrusion in the Delta and runoff and tailwater return flows upstream of the Delta, especially from the San Joaquin River. Periods with low salinity occur when Sacramento River flows are high in the winter. The effect that high flows from the San Joaquin River have on salinity vary based upon runoff water quality from irrigated agricultural lands. Salinity is generally higher in the summer when tributary flows are low and seawater intrusion increases due to the reversal of flows by the Delta export pumps, which move flows from the Delta towards the southern Delta. Figure 3.6 illustrates how salinity in the Delta can vary from less than 50 mg/l to over 500 mg/l

The State Water Project contract includes a provision to use reasonable measures to deliver water with salinity on a monthly basis of less than 440 mg/l, as TDS and less than 300 mg/l on an average over 10-year basis. As the water moves through the State Water Project system from northern California into southern California, salinity changes. Salinity can increase in the San Joaquin Valley due to the flow of water from Cantua Creek and Arroyo Pasajero, which are streams located along the western side of the San Joaquin Valley. These streams overflow into the California Aqueduct during flood events because there is not adequate drainage under the Aqueduct structure. However, salinity can decrease if water from the eastside of the San Joaquin Valley, including tributary rivers and the Friant-Kern Canal, is pumped into the Aqueduct through the Kern Intertie because the water from the eastside of the San Joaquin Valley contains little salinity. Figure 3.7 provides a schematic of the State Water Project System. After water in the State Water Project is pumped over the Tehachapi Mountains, salinity levels vary depending upon the conveyance facility. In the West Branch, salinity increases due to flows from Piru Creek, located along the west branch. This tributary drains into the canal. However, salinity in the West Branch is more variable than in the East Branch due to several factors. One of the major factors is the blending of water that occurs in Pyramid and Castaic lakes, which are located north of Los Angeles. Water can be conveyed and stored in these reservoirs during periods of low Delta salinity and used for blending purposes when higher salinity water is provided in the summer. However, other reservoirs on the system, such as Lake Silverwood on the East Branch do not provide as much storage, and therefore, is more reactive to Delta salinity.

Salinity in the Delta may also increase as more urban treated wastewater effluent discharges into the Delta tributaries. In addition, there is concern that water from higher surface water and groundwater sources may be purchased and conveyed for users of the California Aqueduct, which may increase the blended salinity concentrations on a short-term basis.

The recommendations of the CALFED program include implementation of the San Joaquin Valley Drainage Management Program to implement irrigation changes that will reduce saline discharges, consider salt disposal from the San Joaquin Valley, and modification of Delta export operations to reduce pumping during periods when salinity concentrations in the Delta are extremely high.

3.6.3.4 Salinity in Owens Valley Water Supply

The Los Angeles Department of Water and Power constructed conveyance facilities to divert surface and groundwater from Owens Valley to southern California in the early 1900s. This system can be seen on Figure 3.7 and is labeled the Los Angeles Aqueduct. Although the amount of water diverted has recently been reduced to mitigate environmental problems, this water continues to be part of the Los Angeles area water supply. The salinity of this water supply is generally less than 250 mg/l but can range from 50 to 300 mg/l in value.

3.6.3.5 Salinity in Groundwater and Local Surface Water Supplies

Salinity in the local groundwater and stream channels is influenced both by natural salinity sources in the soils and by discharges from local users and can range from less than 100 mg/l to over 1,000 mg/l. In areas with a high level of historical and existing agricultural activities, salinity concentrations in the groundwater have increased over naturally occurring levels.

FIGURE 3.6

Total Dissolved Solids Banks Pumping Plant (1986-1997)

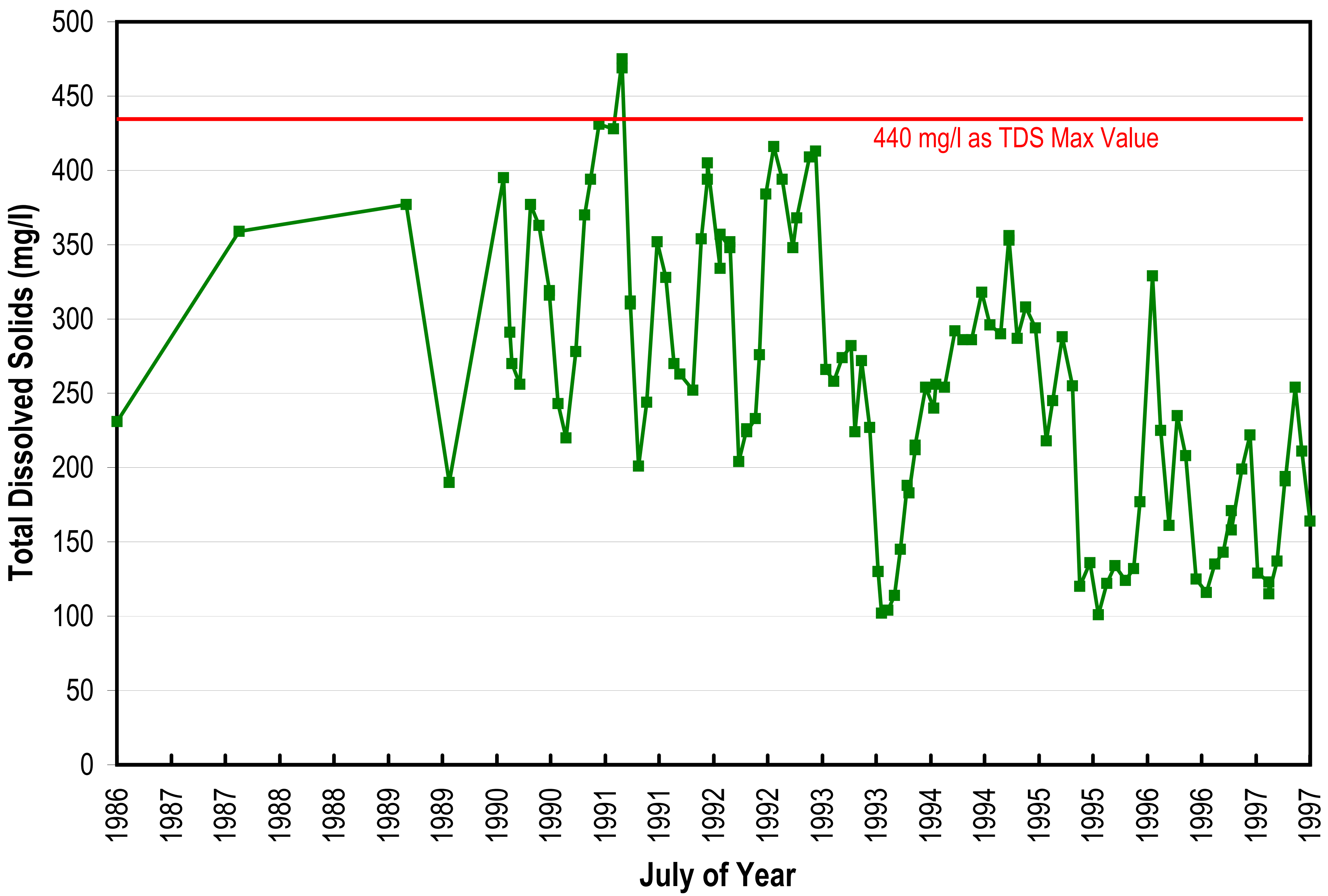


FIGURE 3.7

SCHEMATIC OF STATE WATER PROJECT

Salinity concentrations also are affected by discharge of effluent streams from municipal and industrial users. Salinity increases from 200 to 400 mg/l through municipal uses due to cooking and cleaning activities. Additionally, use of self-regenerating water softeners can add significant amounts of salts to the effluent streams.

Water quality regulatory agencies, including the Santa Ana Regional Water Quality Control Board, have begun to implement regulations that will reduce the amount of salts discharged to the local water supplies. For example, in the Chino Basin upstream of Prado Dam, where waste products from dairies have increased salinity significantly, the Regional Water Quality Control Board has implemented provisions to reduce application rates of waste products and related salt loadings as well as runoff from municipal areas onto the dairy lands. These provisions are designed to reduce salt loadings into surface water and groundwater bodies in the Chino Basin. Most of the basin plans established by the Los Angeles, Santa Ana, and San Diego Regional Water Quality Control Boards include objectives for TDS for groundwater recharge ranging from 330 to 700 mg/l for direct recharge to 330 to 1,500 mg/l for indirect recharge. Overall more than 10 percent of the useable aquifers in southern California are characterized by groundwater with salinity concentrations in excess of 1,000 mg/l. Table 3.22 provides the salinity ranges permitted by the Los Angeles, San Diego, and Santa Ana RWQCBs.

3.6.3.6 Salinity in Other Imported Surface Water Supplies

Salinity may be reduced through implementation of water transfer programs. Under these programs, water from the Sierra Nevada or the Delta, during periods of low salinity concentrations could be diverted for other water users and sold for storage in southern California reservoirs. The transferred water then could be blended with higher salinity water. These types of transfers have occurred on an interim basis by utilizing the State Water Project facilities to convey the water. Recommendations from CALFED include additional evaluation of these programs in conjunction with other programs to assist in reducing the level of salinity in water utilized in southern California so that water quality standards can be met and the product water is acceptable for use by the public.

TABLE 3.22

PERMITTED SALINITY VALUES IN SOUTHERN CALIFORNIA BY THE REGIONAL WATER QUALITY CONTROL BOARDS

Regional Water Quality Control Board	Range of Inland Surface Water- Water Quality Objectives for Salinity (mg/l, as TDS)	Range of Groundwater - Water Quality Objectives for Salinity (mg/l, as TDS)
Los Angeles Region	250-2,000	250-3,000
San Diego Region	300-2,100	500-3,500
Santa Ana Region	110-2,000	220-2,000

Note:

This table is based on values obtained from Chapter 3 of Los Angeles and San Diego RWQCBs Basin Plans and chapter 4 of the Santa Ana RWQCB Basin Plan.

3.6.3.7 Salinity in Delivered Water Supplies

Many water wholesalers and retail purveyors blend water supplies with a range of salinity concentrations to provide users with desirable water quality. However, some water purveyors do not have alternative water supplies and cannot reduce salinity through blending. Therefore, purveyors with multiple sources, such as MWDSC, may be able to maintain a TDS concentration of less than 300 mg/l while purveyors that rely solely upon a high salinity source or that do not have facilities to blend water may provide water with salinity concentrations of more than 500 mg/l. This issue becomes exacerbated for purveyors of surface water and groundwater located in the lowest elevations of the watershed or basin where most of the water supplies are comprised of effluent that includes salinity added from upstream users as well as from Delta or Colorado River water supplies.

3.6.3.8 Salinity in Recycled Water Supplies

Water reused for municipal and industrial activities can result in salinity concentrations increasing by 200 to 400 mg/l. For example, in areas served primarily by State Water Project water, salinity of effluent used for irrigation could have a salinity concentration of up to 900 mg/l. Then as runoff from the irrigated acreage flows into surface water or seeps into groundwater sources, which are used for water supplies in the lower reaches of the basin, salinity increases to more than 1,200 mg/l unless the water supply is naturally diluted with other water sources or blended with other supplies. Therefore, the next municipal user downstream has a water source with a potential salinity of 1,200 mg/l.

To reduce salinity concentrations in recycled water for industrial uses, effluent is frequently treated by advanced treatment processes. These processes include membrane filtration and reverse osmosis. However, treatment processes to reduce salinity usually result in production of a "brine" stream, which consists of a high concentration of salts, metals, and other constituents. Disposal of the brine stream becomes the mechanism to remove salts from the basin and becomes an issue as it is conveyed and ultimately discharged to the ocean.

3.6.4 Identified Concerns and Costs Due to High Salinity

Sensitivity to salinity concentrations is dependent upon the type of water users. This section describes the sensitivity of each type of user to salinity concentrations and ranges of economic impacts that occur due to high salinity concentrations.

3.6.4.1 Impacts of High Salinity Water on Municipal Users

The California Department of Health Services recommends the following drinking water salinity concentrations.

- 500 mg/l (as TDS) for MCL
- 1000 mg/l (as TDS) for upper level of the MCL
- 1500 mg/l (as TDS) for short-term level of the MCL

The USEPA established a MCL of 500 mg/l for TDS. Users with sensitivity to salts can be adversely affected if salinity concentrations are high in drinking water or water used for cooking. Because salinity includes many constituents, users may be sensitive to one or more of the constituents, rather than the commutative effects of the TDS.

IMPACTS OF HIGH SALINITY CONCENTRATIONS ON MUNICIPAL USERS

- **Chemical reactions may effect cooking, cleaning efforts, and manufacturing processes**
- **Cast iron and galvanized steel pipe in older buildings may need to be replaced**
- **Seals in pumps, appliances, and faucets may need to be replaced more frequently**
- **Specialized landscape plants may be harmed by high salinity and soil permeability may decrease in clay soils**

The Salinity Management Study evaluated the economic impacts of using high salinity water supplies on municipal users. The impacts primarily occurred due to higher rate of replacing plumbing fixtures and water heaters, and need for point-of-use water treatment facilities as well as purchase of bottled water. In addition, high salinity recycled water can harm some specialized landscape plants. This is an important consideration in so far as landscape uses for recycled water are a major beneficial use in southern California.

Replacement of Plumbing Facilities

Galvanized steel and cast-iron pipes in older buildings are subject to corrosion and may require replacement, as water supplies become more saline. Buildings constructed recently (primarily since the early 1970s) usually include copper and plastic pipes, which are not subject to corrosion from saline waters. Many of the older homes have undergone replacement of pipes through remodeling efforts and/or to replace damaged pipes due to corrosion. Faucets are frequently lined with plastic or made of materials that are less susceptible to corrosion. Therefore, high salinity concentrations may not effect these faucets. Recently, faucets made in Europe and other countries have been used in many homes. These faucets are not necessarily designed for high salinity waters and frequently have a high corrosion potential. Therefore, faucets and other fixtures that are not designed to handle water with a high saline content will require more frequent replacement and be more costly to maintain.

Water heaters are generally glass-lined, but include sacrificial anodes to reduce the potential for corrosion. High salinity can accelerate the corrosion rate and can increase the potential need to replace the tank earlier than in areas with lower salinity. Many other appliances, such as washing machines and toilets, are designed with equipment that is not subject to corrosion. However, salts can precipitate on surfaces, such as flushing mechanisms and pump seals, and require more frequent replacement on this type of equipment. The precipitate also can cause a scale on water heaters that would increase the energy requirement to heat the water; therefore, reducing energy efficiency.

Water Treatment at Point-of-Use

Users of high salinity water supplies frequently use water softeners, point-of-use home filtration systems, and bottled water provided by retailers that use filter systems. The local treatment systems, including the filtration processes for bottled water, usually discharge salts into the wastewater system. Therefore, the user's water has lower salinity, but the overall salt load in a watershed is not reduced and maybe increased through the use of chemicals in the water softening or filtration processes.

Impacts of Salinity on Landscape Users

Landscape plants that are salt tolerant are popular with municipal users because they are generally more tolerant of high variable water application rates, fertilizer rates, and a wide variety of chemical constituents. However, many plants in older landscapes and botanical gardens may be sensitive to rising salinity concentrations in the future, especially concentrations higher than 1,000 mg/l. Golf courses in southern California generally can use water supplies with salinity concentrations over 1,000 mg/l. However, it has been reported that areas with shorter grass, including the greens and tees, may be more sensitive to high salinity concentrations.

3.6.4.2 Impacts of High Salinity Water on Industrial Users

Many industries incorporate water as part of the product, as in beverages, manufacturing processes as in paper production, or cooling. Therefore, salinity requirements can vary widely. Frequently industries will provide local water treatment consisting of membrane filtration or reverse osmosis to generate high purity process streams; however, high levels of treatment may not be applied to all of the water supplies. Therefore, increased salinity concentrations will result in increased cost for advanced treatment, due to the cost of salinity disposal in the effluent or brine stream as well as the additional cost to treat water with higher salinity levels.

The cost of cooling processes is related to the number of cycles that can occur before fresh water is added to the cooling cycle. The number of cycles is related to the amount of evaporation and salinity concentration at the end of the cycle. If the salinity concentration in the feed water is relatively high, the number of cycles will be reduced. This will lead to higher feed water and disposal costs for the industry and higher water demands and effluent streams for the community. If the industry provides salinity removal to incoming water supplies, the cooling water also may be economically treated to reduce salinity and increase the number of cooling cycles.

As with municipal users, industries are also required to meet higher effluent standards, including industries that discharge to municipal wastewater systems. Therefore, industries are also considering implementing point source treatment processes that reduce the level of salts in the effluent. However, this type of process creates a concentrated brine effluent, which requires special disposal efforts and transfers the salinity problem to the discharge location.

Use of Recycled Water by Industrial Users

Frequently, use of recycled water may be advantageous to industries. Industries that use raw surface water supplies will need to provide standard water treatment methods, including clarification and flocculation/sedimentation. Use of recycled water eliminates the need to provide the traditional water treatment processes. In some areas, recycled water purveyors are providing industries with ″designer water″ which is treated to meet specific water quality requirements.

3.6.4.3 Impacts of High Salinity Water by Agricultural Users

High salinity concentrations can affect crop yield by reducing or increasing the ability of minerals and nutrients to be absorbed by the plant and thereby adversely affecting growth rates. Salt deposits on leaves through irrigation can cause damage that reduces photosynthesis. High salinity can also reduce soil permeability causing perched groundwater that will suffocate the plant roots.

High salinity in the water supplies increases the amount of salts absorbed in the soil mantle. In many soils, salts will not leach through the root zone and require "flushing flows." The flushing flows are applied to the soils prior to planting or when permanent crops are dormant to mobilize salts absorbed to the soil particles. This water either flows off of the soil or is collected in subsurface drains prior to discharge into surface waters. Salts also can flow through the soil mantle into the groundwater. The saline groundwater can eventually seep into the surface waters or accumulate in confined or semi-confined aquifers.

Typical salt tolerances for crops grown in southern California, as described in the Salinity Management Study, are summarized in Table 3.23

3.6.5 Existing and Future Issues Related to Salinity Loadings in Southern California

Salinity loadings are projected to increase in southern California as population growth continues and salinity concentrations increase in imported water supplies. Population growth will require additional water supplies, which may be met by increasing importation of water from the Delta, water transfers from other users, increased conservation, increased conjunctive management of ground and surface waters, or increasing the use of recycled water and other local supplies like dry weather runoff reuse and ocean water desalination. All of these methods could increase salinity loadings within the southern California basins. In addition, salt loadings could increase if salinity concentrations in Delta or Colorado River water supplies increase. Lastly, increased water use efficiency, groundwater clean-up, and brackish and ocean water desalination will lead to increased brine production and the need for increased brine disposal options.

Due to regulatory requirements, increased importation of Colorado River water supplies are not anticipated in the future. However, agriculture to urban transfers are still being considered as part of the solution to the *Colorado 4.4 Plan* designed to bring southern California's Colorado River supplies in line with their legal entitlements. Increased importation of Delta water may occur through transfer of water from users that can transfer water from the Delta. The transferred water that is exported from the Delta would be conveyed through the State Water Project facilities into southern California. Salinity concentrations in the exported Delta water may not increase as compared to existing conditions. However, as the amount of water imported into southern California increases, the total amount of mass salt will increase through continuing and increasingly intensive uses at the imported water sources.

Salinity loadings in local surface waters and groundwater may also increase if the salinity concentrations are raised in the Colorado River water supplies. The Salinity Management Study and other evaluations completed by Reclamation and others indicate that the amount of irrigated acreage using Colorado River supplies will increase upstream of Parker Dam. In addition, population growth in the upper Colorado River basins will increase the amount of salinity loadings from discharge of effluent.

TABLE 3.23

TYPICAL VALUES FOR SALT TOLERANCE IN CROPS GROWN IN SOUTHERN CALIFORNIA

Crop Type	Specific Crop	TDS Tolerance (mg/l)
Fruit Orchards		
	Citrus	768
	Persimmons	768
	Apples	725
	Avocado	555
Vineyards		
	Grapes	640
Field Crops		
	Cucumbers	1,087
	Tomatoes	1,067
	Squash	853
	Corn	726
	Potatoes	725
	Strawberries	427
	Beans	427
Turf		
	Bermuda Grass	2,944
	Fescue	1,864
Florist Crops		
	Bulbs/Tubers	2,560
	Poinsettias	1,728
	Roses	1,472
	Carnations	1,280
	Gladiolas	840

Note:

This table was derived from Table 5 in Technical Appendix 3 of the *Salinity Management Study Final Report* published by Metropolitan Water District of Southern California and the United States Bureau of Reclamation.

Salinity concentrations in local surface waters and groundwater may also rise as water recycling is expanded to meet new water demands. Each time that water supplies are reused as compared to effluent discharge to surface waters that flow to the ocean, the amount of salt in the effluent stream will increase. In addition, as population increases there will be higher mass salinity loadings in effluent streams based upon a relatively constant per capita mass loading. This increased salinity will be discharged to surface waters as treated effluent. The increased effluent salinity will also raise the amount of salts applied to irrigation sites that use recycled water. It is anticipated that this would not directly affect groundwater recharge facilities because regulatory requirements limit the amount of salts that can be applied to recharge facilities.

3.6.5.1 Actions to Reduce Salinity in the Southern California Basins

As described above, salinity loadings and the impacts on local surface water and groundwater and other water supplies vary throughout the study area. Salinity loadings in some basins, including in Ventura County, San Fernando, and the Los Angeles' West Basin, are affected by application of imported water to irrigated lands, discharge of wastewater effluent, and application of salts through agricultural use of the land. In these areas, both the groundwater and surface waters are impacted through increasing salt concentrations. If recycled water is used for irrigation or other agricultural uses, the rate of salinity increase could be higher. In other areas, groundwater recharge activities using Delta and Colorado River waters supplies and recycled water increase the salinity loadings in the groundwater. The saline groundwater can seep into the surface water streams and affect the designated beneficial uses. At this time, the water suppliers address this issue in several ways. First, water supplies with higher salinity concentrations are blended with supplies imported from the Owens Valley, Sierra Nevada, or the Delta during low salinity periods, which reduces both salinity concentrations and loadings.

Another method under consideration is using surface water and groundwater desalination treatment ("desalters"). The desalters produce a treated water supply with low or nonexistent salinity concentration. This enables the treated water to be blended with more saline water to reduce salinity for the user. The treated water can also be discharged to groundwater recharge facilities or at surface water discharges to blend with local groundwater and surface waters and reduce the overall salinity concentrations. The brine flows from the desalters vary from 10 to 25 percent of the influent stream and generally are characterized by salinity concentrations of more than 2,500 mg/l. The brine flows are generally conveyed to the ocean or into another wastewater treatment plant that discharges effluent directly to the ocean.

Desalination can also be used to treat wastewater streams prior to discharge into surface waters or groundwater or prior to recycling. This could result in reduced salt loading and salinity concentrations in water supplies, which are diverted from the local surface waters, groundwater, and recycled water.

Methods in the Colorado River to reduce salinity upstream of Lake Mead are on-going as part of the *Title II*, *Colorado River Basin Salinity Control Act* program at Reclamation Upper Colorado Region. These actions include improved irrigation efficiency to reduce both the volume and concentration of salt loads from return flows and tailwater return, reduction in drainage flows from irrigated lands, and continued regulation of effluent discharges into the Colorado River. These actions have reduced salinity concentrations for users of Colorado River water in Utah, Nevada, and Arizona. Historically, Interior has funded significant portions of these efforts; however, funds have not always been available consistently.

Los Angeles Basin Salinity Management Issues

This area includes portions of Los Angeles and Ventura Counties located in the Los Angeles Regional Water Quality Control Board (Los Angeles RWQCB). Agencies under the Los Angeles RWQCB jurisdiction rely upon water primarily from the State Water Project and local groundwater supplies, although Colorado River water also enters this region. Treated wastewater effluent from these areas is primarily discharged to local receiving streams.

The Los Angeles RWQCB has adopted criteria for TDS as well as chlorides, sulfate, and boron for groundwater and surface waters within the region. TDS criteria are different for each stream and can be found Appendix E. Effluent quality has exceeded the criteria in numerous cases; however, it must be noted that frequently, high salinity concentrations in the water supplies may cause the effluent to become non-compliant with salinity requirements. Some communities have implemented strict industrial waste pretreatment limits for salinity, which has led to brine production from industrial wastewater treatment processes.

In addition, water softeners for commercial and residential use are a problem in this area. In some communities, self-regenerating softeners that discharge to the sanitary sewer system have been banned. However, if the softeners are replaced by rental softeners, there will be a discharge of brine from an industrial facility in the area where the softeners are recharged.

Some communities have implemented groundwater treatment to provide a higher quality water supply. The effluent from the groundwater treatment processes must also be discharged or conveyed from the region. This effluent usually includes higher levels of salinity than background stream concentrations.

With respect to recycled water projects, concerns about salinity occur for irrigation, groundwater recharge, and industrial uses without industrial pre-treatment. Salinity concentrations will increase through use; therefore, runoff from lands irrigated with recycled water and industrial effluent generally will have higher salinity concentrations than treated wastewater effluent. This could lead to non-compliance for these discharges. In addition, recycled water used for groundwater recharge may increase or decrease aquifer salinity concentrations depending upon the background salinity in the area (as influenced by seepage from the applied water or through stream channels) and the amount of water recharged as compared to the total volume of the aquifer.

Within this basin, salinity sources vary with geography. In the San Fernando Valley, the majority of salinity enters the basin through discharge of irrigation runoff, wastewater effluent, and seepage from applied water by users of water imported from the State Water Project, Owens Valley, and/or Colorado River. Salinity sources from upgradient groundwater flows into the sub-basin also contribute some salinity to stream channels through seepage. The streams convey recycled water, runoff, and seepage from the sub-basin to lower Los Angeles River basins. In fact downstream of the Glendale Narrows the Los Angles River's streamflow is comprised mostly of recycled water, with approximately 80 percent of the flow originating from recycled water discharges from the Tillman WRP and the Los Angeles/ Glendale WRP.

In the San Gabriel portion of the basin, the majority of salinity is due to stream and groundwater flows into the sub-basin as well as discharges from users of State Water Project and Colorado River water supplies. Salinity is removed from the basin by streams that convey runoff, effluent, and groundwater seepage. A large portion of the effluent is conveyed through pipelines to the ocean for discharge. Another portion of the wastewater is recycled for groundwater recharge following salinity reduction. Brine from the desalination processes of the wastewater treatment plants and industrial treatment/pre-treatment processes is conveyed to the ocean in a separate brine pipeline.

In the southern portion of Los Angeles County, salinity in the water supply is due to the use of State Water Project and Colorado River water. Effluent from this area is conveyed to the ocean for disposal. The groundwater is generally characterized by high salinity due to seawater intrusion and higher salinity groundwater flows towards the ocean.

As population continues to increase in this basin, the reliance of imported water and/or groundwater recharge also will increase. To continue to provide high quality and reliable water supplies, additional actions will need to be considered. Water supply programs to reduce salinity in water supplies may be considered, including upstream programs to remove salinity prior to entering southern California. Another option may be desalination of local groundwater supplies or recycled water streams to reduce the reliance upon State Water Project and Colorado River supplies when salinity concentrations are high. These programs would require facilities to remove salinity from the basins. Previous studies identified the need for brine disposal pipelines from Ventura County and San Fernando Valley to improve salinity concentrations in surface water and groundwater. Figure 3.8 provides a map of the existing and proposed brinelines in southern California.

Upper Santa Ana Basin Salinity Management Issues

This area includes a portion of Orange County where salinity concentrations are high in surface water and groundwater due to discharges from users of Colorado River water supplies. Salinity moves between the groundwater and Santa Ana River main channel and tributaries. The high salinity in the river has eliminated many native species that require low salinity water and has allowed nuisance species, such as *arundo donax*, an invasive species, to proliferate.

To protect these resources, the Santa Ana RWQCB has adopted TDS criteria for each basin. To meet these criteria, communities have required industrial pre-treatment and banned commercial use of self-generating water softeners. In addition, assimilative capacity studies for TDS are required prior to use of recycled water for irrigation and/or groundwater recharge. If the recycling action would increase salinity, these activities are not allowed unless desalination occurs. If the groundwater basin has remaining assimilative capacity, the TDS of the discharge may not exceed the concentration in the water supply by more than 250 mg/l. Groundwater desalters have been implemented to remove high concentrations of salinity from groundwater.

The SAWPA is participating with many agencies, including the Santa Ana RWQCB, to develop and implement an overall strategy to manage salinity throughout the basin. One method is to use brine pipelines to convey high salinity flows to the ocean. The Santa Ana Regional Interceptor (SARI) and Chino Basin Non-Reclaimable Line (NRL) are the existing pipelines. Other measures include working with the U.S. Corps of Engineers (USACE) to use stormwater flows to dilute salinity in the groundwater, especially upstream of Prado Dam on the Santa Ana River. Additional desalters are being evaluated in the upper and lower Santa Ana River basin to reduce groundwater salinity concentrations.

Lower Santa Ana Basin Salinity Management Issues

This area includes western and southern portions of Orange County that are within the San Diego RWQCB. Surface water and groundwater in this area are related to flows from the Upper Santa Ana Basin and therefore, contain high concentrations of salinity. Seawater intrusion along the coast also has significantly increased groundwater salinity concentrations to more than 1,000 mg/l.

Water supplies for this area include groundwater from upgradient basins with high salinity concentrations, Santa Ana River, State Water Project, and Colorado River. This area has a high use of recycled water for irrigation and groundwater recharge. However, to meet TDS criteria for discharge of the recycled water, the effluent is frequently blended with raw water supplies to reduce the salinity. These practices allow the use of recycled water to improve water supply reliability, but require use of additional raw water supplies The high salinity levels in the wastewater effluent cause concerns regarding the ability to discharge flows into

Figure 3.8
Map of Existing and Proposed Brinelines in Southern California
Southern California Comprehensive Water Reclamation and Reuse Study

local receiving waters. It is difficult to discharge water in areas located near the coast because the receiving waters are classified as fresh water, and the San Diego RWQCB is concerned about increases in salinity. Therefore the San Diego RWQCB has implemented fresh water requirements to establish discharge criteria even though the salinity concentrations result in a brackish water condition.

San Diego Basin Salinity Management Issues

This area includes western San Diego County and is located within the San Diego RWQCB. Local streams in the area generally have TDS concentrations of about 250 mg/l. The water supplies for this area are primarily State Water Project and Colorado River water. Most of the salinity imported into the basin is contained in the wastewater effluent.

The basin in this area is relatively small and is characterized by minimum natural recharge. Therefore, use of recycled water within the basin is evaluated in detail to protect the surface water and groundwater resources. Wastewater effluent frequently has salinity concentrations of more than 1,000 mg/l. The San Diego RWQCB has adopted regulations that require recycled water used for groundwater recharge to not exceed the objectives established for each individual groundwater aquifer.

If recycled water is used for groundwater recharge, communities have to implement provisions to lower the overall salinity. In an effort to meet salinity requirements, communities have considered blending the recycled water with State Water Project water, reducing infiltration/inflow of high salinity groundwater near the coast into the sanitary sewers, desalination of the recycled water, and regulating industrial discharges and commercial use of self-generating water softeners. Previous studies have considered use of desalination units and construction of brine pipelines to convey high salinity waters to the ocean.

3.6.5.2 NEXT STEPS

The Salinity Management Study included a general quantitative analysis of mass salt loadings for southern California. This analysis needs to be updated to reflect proposals under CALFED, water transfers programs, and projections in water importation volumes from the

Colorado River and Owens Valley. The analysis also should consider the use of desalinated brackish water for municipal, industrial, and agricultural water supplies. This analysis should be basin specific and consider recycled water projections developed under SCCWRRS and the Initiative studies. This analysis could use the surface water and groundwater salinity concentrations as identified in the Salinity Management Study and other studies being completed by Reclamation and USACE in some of the basins. This analysis should include various levels of recycled water to determine the sensitivity of the salt balance to recycled water use for irrigation, groundwater recharge, and industrial use assuming current treatment and disposal methods. This analysis would predict salinity concentrations in surface water and groundwater and compare the projected concentrations to salinity objectives and requirements presented in the Salinity Management Study. This analysis also would project the range of salt mass loadings and total brine flow production from recycled water and desalter operations.

Following development of salinity loadings and concentration projections, basin wide costs could be developed to determine the range of costs associated with different levels of water supply salinity. Unit costs presented in the Salinity Management Study could be used for unit costs to replace pipelines and appliances. Updated cost estimates should be considered for the cost of desalters because the costs of membrane filtration and reverse osmosis have been declining in recent years. A range of brine conveyance and disposal concepts may need to be considered that will reflect disposal into wastewater systems as well as conveyance of brine to the ocean. A sensitivity analysis could be completed that would include application of desalters to wastewater treatment prior to recycling in agricultural and/or municipal uses, as well as expanded use of desalters for groundwater treatment and use of recycled water for groundwater recharge. It should be emphasized that this analysis would not be a facility

ITEMS TO BE CONSIDERED IN UPDATED QUANTITATIVE SENSITIVITY ANALYSIS

- **Projected salinity in Colorado River water under several scenarios for upper basin salinity management**
- **Projected salinity in State Water Project water under the recommended CALFED Record of Decision actions, including water transfers and water quality improvements in the San Joaquin River**
- **Projected salinity in local groundwater and surface water basins under various recycled water scenarios, including use for groundwater recharge, irrigation, and industries**
- **Projected salinity in local groundwater and surface water basins under various desalter scenarios**
- **Projected salinity production from desalters and ocean desalination under various scenarios**

plan, but rather a conceptual analysis of methods and costs to reduce salinity loadings in southern California through treatment of imported and local water supplies.

This analysis also could consider methods to reduce salinity in the Colorado River water supply in the upper basin states. The evaluation would be based upon information presented in the Salinity Management Study and recent studies completed under projects partially funded by Reclamation to improve agricultural practices.

The results of this analysis would provide a range of actions and costs that may be required if the use of recycled water increases in southern California and that increased use results in an increase in salinity concentrations in local water supplies. The results also can be used to provide a range of actions that may need to be considered due to implementation of CALFED actions to provide reliable water supplies from the Delta, and overall water supply actions to meet the increased water demands of southern California in the future.

3.7 Recommendations and Conclusions

The Southern California Water Recycling Projects Initiative was developed to determine topics of concern to local water recycling agencies and develop recommendations of areas of study that would assist agencies in addressing these topics. The concerns identified by the water quality of the Initiative were grouped under four major topics, which are regulations, use type, water chemistry, and salinity. Table 3.24 provides a description of each of the recommendations by topic. In addition, the preliminary recommendations for topics requiring further investigation are outlined below in abbreviated form by topic.

Regulations

Water reuse regulations will continue to provide public health and environmental protection. Areas of study that would assist water reuse agencies in helping to shape future regulations include:

- Develop toxicity limits and assimilative capacities for outfalls for both brine and effluent discharges from reuse project and potential alternative solutions to associated issues.
- Development of a public education and information program that explains the water and water reuse hydrodynamic cycle.
- Investigation of potential upstream source control for users of recycled water.
- Work with regulators to develop economic and sound scientific criteria governing groundwater recharge and indirect potable reuse.
- Determine when the need for planned indirect potable reuse through surface water augmentation will occur due to water scarcity brought on by population development and develop a long-term plan to educate the public regarding this type of reuse.

Use Type

Recycled water use will continue to increase in the future due to population growth, limited supply of freshwater resources, and water scarcity. Areas that could assist recycled water agencies in developing future water recycling projects that are acceptable to the public and regulators include:

- Determine the long term effects of the use of recycled water for landscape and agricultural irrigation on soil, surface water, and groundwater aquifers.
- Determine if there can be too much reuse and how much water reuse that represents.

- Determine if upstream source control could reduce the impacts of constituents of concerns that affect agricultural production and manufacturing processes.
- Develop a study to investigate increased recycled water contribution for groundwater recharge.

Water Chemistry

Water chemistry is of vital importance to the public acceptance of water reuse projects. Areas of study that would assist water reuse agencies in developing more efficient and economic treatment and brine disposal methods while maintaining public health protection include:

- Development of a study to determine the impact of concentrate disposal on southern California ecosystems both marine and freshwater.
- Development of economical resource recovery methods of constituents from concentrate or brine.
- Development of wastewater technologies to promote health protection while maximizing conservation and reuse.
- Determine what are the long-term effects of HAAs and EDCs in southern California.

Salinity

The analysis in the Salinity Management Study needs to be updated to reflect proposals under CALFED, water transfers programs, and projections in water importation volumes from the Colorado River and Owens Valley. The update would include the following information:

- Projected salinity in Colorado River water under several scenarios for upper basin salinity management.
- Projected salinity in State Water Project water under the recommended CALFED Record of Decision actions, including water transfers and water quality improvements in the San Joaquin River.
- Projected salinity in local groundwater and surface water basins under various recycled water scenarios, including use for groundwater recharge, irrigation, and industries.
- Projected salinity in local groundwater and surface water basins under various desalter scenarios.
- Projected salinity production from desalters and ocean desalination under various scenarios.

The next water quality task for the Initiative is to determine which areas or recommendations suggested for further study will be undertaken.

TABLE 3.24
RECOMMENDATIONS BY TOPIC FOR ADDITIONAL WATER QUALITY ANALYSIS

Regulations	Use Type	Water Chemistry	Salinity
Developing toxicity limits and assimilative capacities for outfalls for both brine and /or effluent discharges from reuse projects. A study into this toxicity should determine the effect of discharges on the marine environment, if degradation of the marine environment occurs, what specific constituents and concentrations cause degradation, and when will southern California reach discharge levels and concentrations where toxicity becomes an issue. Another issue that is interrelated to toxicity and that could be investigated is resource recovery of constituents.	Determine the long-term effects of the use of recycled water for landscape and agricultural irrigation on soil, surface water, and groundwater aquifers. A study could be undertaken to look at the long-term effects of recycled water use at California State Polytechnic University, Pomona. This campus has used recycled water for irrigation of campus landscaping and agricultural activities. Originally, recycled water at the campus was provided at a reduced rate and use of the water was liberal; however, the cost of the recycled water has increased without changes to the level of use. A study of the effects of water reuse could also develop water management strategies at the university that could be provided to local agencies as a "How to" manual for optimal use of the recycled water.	Development of a study to determine the impact of concentrate disposal on southern California ecosystems both marine and freshwater. Toxicity is emerging as an issue due to increased use of membrane processes. As more stringent treatment is required to remove constituents of concern, the use of membrane treatment will continue to expand. The result of the use of additional membrane processes will be increased amounts and concentrations of constituents in brine, which will result in increased regulatory focus on concentrate or brine disposal. Issues related to concentrate disposal and toxicity are already emerging in the state of Florida. In Florida, state regulators are concerned about the effects of concentrate disposal on ecosystems; therefore, extensive hydrographic studies are required to be performed to illustrate that impacts to the ecosystem are minimal before a disposal permit will be issued. A study could be undertaken in southern California to look at the effects of concentrate disposal on ecosystems that could assist local agencies in illustrating the effects of concentrate disposal for NPDES permitting.	Update the Salinity Management Study general quantitative analysis of mass salt loadings for southern California. This analysis needs to be updated to reflect proposals under CALFED, water transfers programs, and projections in water importation volumes from the Colorado River and Owens Valley. The analysis also should consider the use of desalinated brackish water for municipal, industrial, and agricultural water supplies. This analysis should be basin specific and consider recycled water projections developed under SCCWRRS and the Initiative studies. Projected salinity in Colorado River water under several scenarios for upper basin salinity management Projected salinity in State Water Project water under the recommended CALFED Record of Decision actions, including water transfers and water quality improvements in the San Joaquin River. Projected salinity in local groundwater and surface water basins under various recycled water scenarios, including use for groundwater recharge, irrigation, and industries. Projected salinity in local groundwater and surface water basins under various desalter scenarios. Projected salinity production from desalters and ocean desalination under various scenarios.

TABLE 3.24
RECOMMENDATIONS BY TOPIC FOR ADDITIONAL WATER QUALITY ANALYSIS

Regulations	Use Type	Water Chemistry	Salinity
Development of a public education and information program that explains the water and water reuse hydrodynamic cycle. It is important the public understands that water reuse occurs in the natural environment and that as water treatment plants mimic natural processes so does water reuse and water reclamation plants.	Determine how much water reuse is too much reuse. A study could be developed to investigate the effects of full reuse, partial reuse, and intermediate reuse to determine if and at what level reuse becomes an issue with respect to the environment, public health and/or public perceptions, soil, water quality, and regulations. As part of this effort, methods to increase recycled water supply reliability to deal with seasonal and daily storage could be investigated. In addition, residual recovery and disposal could be investigated to deal with the expected increased use of membranes and production of brine that accompany increased reuse. In addition, the economics of reuse would be investigated to determine what effect they play in water supply optimization.	Development of economical resource recovery methods of constituents from concentrate or brine. As more membrane treatment is used and the associated concentrates produced, resource recovery may need to be implemented to reduce concentrations of constituents in discharges to meet NPDES permits. Implementation of resource recovery will reduce the disposal of concentrate as well as resulting impacts to the environment. In addition, concentrate may contain constituents of concern including radionuclides and hazardous substances, which will need to be removed from the concentrate before disposal. Also, the RWQCBs is looking into source control issues for the permitting of discharges, which may require the implementation of source control mechanisms upstream. One potential solution for source control could be resource recovery of constituents.	
Work with regulators to develop economic and sound scientific criteria governing groundwater recharge and indirect potable reuse. One issue to investigate is how to successfully develop and plan an indirect potable reuse surface water augmentation project that will comply with current regulations as well as overcome negative public perception. In addition, it would be valuable to identify the mechanisms and environment that resulted in the unsuccessful implementation of past planned indirect potable reuse projects through surface water augmentation.	Determine if upstream source control measures could reduce the impacts of constituents of concerns that affect agricultural production and manufacturing processes. Upstream source control could be investigated on a subwatershed, watershed, and/or a macro watershed basis, which would include imported water supplies. This study could investigate sewer, raw, and potable water source control measures as well as state-of-the-art methods of treating and disposing of the brine constituents including residual recovery of these constituents. In addition, the financial and economic impacts of using upstream source control measures could be analyzed to determine if implementing these solutions are economically viable.	Development of wastewater technologies to promote health protection while maximizing conservation and reuse. This would include the development of new indicators of pathogenic microorganisms, which are easier and more cost effective for analysis. Also included in this work, would be an investigation into the appropriate treatment processes and operating conditions required to assure that the removal or inactivation of measurable levels of viable pathogens occurs. Another issue that could be investigated as part of this work is the concentration and health significance of organic constituents in recycled waters. The effects of process selection on particle-size distribution in wastewater and the relationship between particle size and turbidity and the effect of particle size distribution on disinfection of recycled water could also be studied.	

TABLE 3.24
RECOMMENDATIONS BY TOPIC FOR ADDITIONAL WATER QUALITY ANALYSIS

Regulations	Use Type	Water Chemistry	Salinity
Investigation of potential upstream source control for users of recycled water. In this study source control would be looked at from a local as well as a regional water supply level.	Develop a study to investigate increased recycled water contribution for groundwater recharge. This effort could assist in determining what ratio of recycled water is acceptable to meet DHS water quality and potable water safety concerns.	Determining what are the long-term effects of HAAs and EDCs in southern California. Epidemiological research could be undertaken on groups representing a wide cross section of the population to determine the effects of water reuse and disease transmission. Included in this effort would be research into the effects of excreta use on aquaculture and the related bacterial infections. In addition, research into the health effects of water reuse on agricultural workers and consumers of fish could be undertaken. Also included would be an analysis of the effectiveness of methods to control and limit human exposure under real life conditions.	
Determine when the need for planned indirect potable reuse through surface water augmentation will occur due to water scarcity brought on by population development and develop a long-term plan to educate the public regarding this type of reuse.			

Appendix A
Minutes from Brainstorming Sessions

Southern California Water Recycling Projects Brainstorming Session

ATTENDEES:

Steve Kasower, U.S.B.R.	Andy Hui, MWDSC
Steve Schindler, BBARWA	Wendy Sevenandt, OCSD
Bob Colven, BBARWA	F. Cesar Lopez, Jr., SDCWA
Don Eads, BBARWA	Mark Norton, SAWPA
Bill VanWagoner, LADWP	Gwen Buchholz, CH2MHILL
Earle Hartling, LACSD	Scott Lynch, CH2MHILL
Lori James, LACSD	Anne Lynch, CH2MHILL

ROM: Anne Lynch

DATE: November 14, 2001

Water Quality Issues

The meeting began with the distribution of the Purpose and Needs Statements for Task 1, a Diagram of Alternative Recycling Projections, Table 1 (Issues and Concerns), and Table 1A. Next, the general purpose of the water quality task, the purpose of Task 1A (Alternative Water Recycling Futures), and the needs of Task 1A were outlined. The specific purpose for Task 1 and Task 1A were provided as a reference and guidemap to assist in maintaining the focus on what is being developed and defined in task 1. The objective of the water quality component of the Initiative is to inform the recycled water users, suppliers, and industry by providing a description of issues and a discussion and definition of a reasonable range of solutions. Specifically, the analysis will examine the impacts of increased water recycling on receiving waters as well as public health and safety. In addition, the analysis will focus on contemporary water quality conditions that affect recycled water acceptance and use such as industrial chemicals, natural pollutants, and pharmaceutical wastes existing in the wastewater.

The purpose and needs of Task 1A, alternative water recycling futures, is to develop scenarios to quantify ranges of mass loadings and impacts, to develop comparisons of regulatory standards, as well as to develop costs. The needs of Task 1A were outlined by proffering a number of questions including the following:

- What are the issues facing recycled water in southern California?
  -How does the source of water effect the chemical composition of recycled water?
  -How do changes in chemical composition of recycled water effect and result in impacts to the cost of producing recycled water?

- How should total volume ranges for recycled water be quantified?
- How should the use of recycled water (use percentage by geographical area) be quantified?

An initial step in meeting the purpose and needs of Task 1A is to identify the issues facing recycled water in southern California. In past efforts (i.e. SCCWRRS), the focus of the work was on determining the availability of recycled water as well as developing a regional recycled water system. However, the Initiative's focus is on identifying issues affecting the use of recycled water. The Initiative will describe alternative water recycling future scenarios based on the inter-linking and interdepedence of supply, demand, water management conditions, and the issues facing the use of recycled water. This interdependence of issues with conditions was illustrated in the alternative recycling projections diagram. The diagram illustrates how demand, supply, and water management conditions will be utilized to develop scenarios. These scenarios will provide a backdrop for the alternative water recycling futures analysis.

The initial step in the development of the scenarios is to outline the issues and concerns facing water recycling in southern California. Tables 1 and 1A were developed to facilitate a discussion on the issues and concerns facing recycled water in southern California. Amendments to the list of issues and concerns from Tables 1 and 1A that were discussed during the meeting are outlined below:

Other Constituents of Concern

- Wendy Sevenandt stated she wanted a discussion of water chemistry and the related process problems included in the constituent of concerns list. Specifically, silica's affect on MF/RO processes should be added to the list.

- Cesar Lopez stated he wanted a discussion of TOC, which is the best indicator of contamination. Cesar wanted to include this constituent of in the list of concerns and specifically, how it impacts the reclaimabilty of water.
- Bill VanWagoner stated he wanted a discussion of the impacts resulting from the change in regulations regarding the use of drinking water public health goals as MCLs included in the constituent of concerns list.
- Steve Schindler stated he wanted a discussion on fluoride and how blending of water, especially during drought, intensifies water quality problems added to the constituent of concerns list.
- Wendy Sevenandt stated she wanted a discussion of hardness and NH^{4+} and how they impact toxicity at treatment plant outfalls. This impact is an issue due to the requirement that freshwater species be used as indicator species in tests of treatment plant outfall's discharge conformance with regulatory standards. OCSD is attempting to get the indicator species changed to a saltwater species. Earle Hartling pointed out that inland treatment plants were moving toward the use of NDN processes to remove ammonia toxicity concerns.

Use Types

- Earle Hartling suggested starting the analysis by focusing on end use type. Focusing on end use will create a treelike structure from which the analysis can expand taking into account water quality, regulations, and treatment levels for each specific use type.
- Gwen Buchholz proposed developing a number of matrices including (1) end use versus water chemistry, (2) end use versus regulations, and (3) end use versus sources.
- Gwen Buchholz proposed developing tables listing the constituents of concern for each specific industrial, agricultural, irrigation, and habitat use. The tables will include type of use with a general discussion of issues as well as special onsite applications for each specific use type. Volume of use would be the driver. Examples of the tables include an industrial use table with uses such as paper mills (color issue), cooling towers (ammonia), carpet dyeing (chlorine, ammonia), metal fishing, chip manufactures, concrete mixing. A table on irrigation use would include categories such as schools, cemeteries, freeway medians, and golf courses. Agricultural uses would include animal as well as crop

applications. Cal Poly Pomona would be a good source of information on potential uses and concerns for agriculture.

- Earle Hartling stated that, although Los Angeles is an urban area, there were agricultural runoff issues along Coyote Creek due to runoff from feed lots.
- Irrigation with recycled water could be impacted by seawater desalination due to the fact that it produces water with chlorine and bromine problems.
- One concern facing injection of recycled water is the life expectancy of the wells. Reclamation and WRD are currently studying this issue.
- Additional concerns raised by Earle Hartling in the discussion included the following questions: Do we need to study upstream source control to make the recycled water a more lucrative product? Do we need to determine whom the water is serving? Should the analysis look into pretreatment of upstream users? How and what flow should be bypassed around the recycled water plants to discharge locations? For example, LACSD has been successful in getting the product RID banned from stores in Los Angeles County due to the impacts of use of this product on the treatment plants (just 6 users concentrated in an area can effect the ability of the plant to meet treatment requirements).
- Under Groundwater Issues, the following issue needs to be included, " How will future regulations affect/change use of recycled water?"
- Concern #1 under Groundwater Issues needs to be amended to read, " How much availability is there for use of recycled water for production /assimilative capacity?"
- Concern #1 under the Surface Water Issue needs to be amended to read, "What are the issues affecting use of recycled water for transport/storage/potable use?"
- Concern #2 under the Industrial Issue needs to be amended to read, " How does use of recycled water affect discharge both within and to the treatment plant?"
- Under Industrial Issues, the following issue needs to be included, "What is the current and future potential market for toilet flushing and is the market cost effective?"
- Under Industrial Issues, the following issue needs to be included, "What are the aesthetic concerns facing the use of toilet flushing including color, odor, and effects on plumbing mechanisms?"
- Concern #2 under the Irrigation Issue needs to be amended to read, "How does use of recycled water affect discharge/runoff?"

- Concern #2 under the Agricultural Issue needs to be amended to read, "How does use of recycled water affect discharge/runoff?"
- The Toilet Flushing Issue Category needs to be deleted and moved under the Industrial Issue.

Source/Regimes

- Earle Hartling pointed out the cascade effect of salt in the region as water is reused and moves down through the basin. TDS values range from 400 ppm in inland communities, increase to 650 ppm in downstream communities, and increase to 800 ppm by the time water is discharged to the ocean. The increase in TDS values make recycling water more costly in downstream communities due to the need to remove higher volumes of salts. The Initiative should analyze how the movement of water effects salinity.
- Gwen Buchholz asked if the source control issue had been previously studied. Earle Hartling stated that source control had not been analyzed due to the complex nature and interaction of water and wastewater agencies in the area as well as the political and institutional barriers that exist as a result. LACSD did investigate providing MWDSC recycled water for distribution; however, MWDSC is not in the recycled water business. Also, LACSD is not permitted by the authorizing statue to build pipelines so the agency can not sell water directly to end-users. Steve Kasower pointed out that the closest analysis, to source control, that has been performed is developing and describing the future brinelines needs for the area, which was done as a part of the SCCWRRS. The current focus of studies on salinity is how to control the problem at the point of use. In the past, this included studying the installation of treatment units specifically for drinking water use and providing reduced levels of treatment at the distribution source/plant. However, DHS has not permitted the use of individual treatment units due to concerns regarding maintenance. In the future, the driver for individual treatment units at the point of use would be attacks on the water supply.
- Cost is the driver for source control. The cost of salinity control is already an issue facing the region; however, the issue of estimating the total cost of salinity control in the region has never been done. The question, "When does the cost to RO MWDSC supply exceed the cost of source control?", needs to be analyzed to get a complete picture of the

cost/benefits ratio for potential source control projects. The alternative water recycling futures scenarios will include alternatives such as source control as well as analyze the cost for additional brinelines and treatment in order to encourage an increased interest among area agencies for a regional discussion on source control.

- Water softeners, especially the self-regenerating models, are creating a problem for treatment plants by adding additional salts to the basin. There has been some effort to attempt the regulation of these softeners; however, the softener industry has a strong lobby. Economics may provide the only lever that can be utilized to combat the political power of the softener industry thus resulting in tougher regulations.
- Cesar Lopez stated that the Desalination Research and Innovation Project (DRIP) is looking into brackish water desalination including sources of flow such as the Colorado River, recycled water, groundwater, and agricultural return flows. This is an ongoing study being managed by Mike Claisse from MWDSC out of the La Verne office. The study would be a good source to provide an avoided cost for the salinity analysis.
- MWDSC and SDCWA are working together to reduce salinity in the San Diego region by blending water to maintain a 500 mg/L salinity level in the water MWDSC provides to the county. SDCWA has found that their member agencies would prefer receiving a greater proportional of Colorado River water because it is easier to treat than the State Water Project water, which has TOC and bromide problems.
- Steve Kasower discussed Reclamation's Colorado River Salinity Management Program, which is funded under *Title II of the Colorado Salinity Control Act*. In the past, the program funded large-scale salinity management and treatment programs. However, due to the high cost of these programs, Reclamation is now funding local projects. Reclamation funds these projects through an RFP process. This program is currently budget constrained leaving many proposed projects unfunded. The local projects have shown success in not only reducing the cost of salinity management in the region, but in holding salinity levels constant, even with increased upstream development.
- The largest contributor to salinity on the Colorado River is the BLM whose lands contribute 70% of the salinity to the basin. The BLM lands currently have no BMPs in place to assist in controlling salinity. Steve Kasower described a 2004 Reclamation new start planning program proposal to examine the economic effects of implementing upper

basin salinity management on the lower Colorado River Basin. A portion of the work done in the Initiative will be included as part of this study.

- Southern California Coastal Water Research Project is an independent group focused on pure ocean research. Steve Kasower stated that this group might be a good source of information of the effects of brine concentration on coastal waters.
- Andy Hui stated that the analysis regarding seawater desalination should focus on water quality not on developing costs. He also stated that other studies are focusing on the potential of seawater desalination as an alternative source for water and this should not be the focus of this analysis. Steve Kasower agreed that cost information could be obtained from other sources if available. Steve Schindler pointed out that the report would not suffer from the inclusion of a discussion on seawater desalination, but if the discussion were not included the report would be incomplete.
- Earle Hartling postulated that Concern # 1 under seawater desalination is a moot point as most desalination plants will be located along the coast and will have available funding to build an independent ocean outfall. It will be cheaper for a plant to build both the intake and outfall lines at the same time during construction; therefore, the desalination plants will not affect the capacity in the brineleines/outfalls. Steve Kasower pointed out that in Orange County the seawater desalination plant proposed by Poseidon anticipated using the Orange County ocean outfall.
- Concern #3 under the Imported Water Supply needs to be amended to read, " What upstream projects are being considered to change salinity (either positively or negatively)?"
- Under the Surface Water Issue add the following issue, " What are constituents of concern and at what levels?"
- Under the Seawater Desalination Issue add the following issue, "What are constituents of concern and at what levels?"

Appendix B
Resource Database

Resource Database

The Resource database was developed to synthesize the acquired data and compile the information into a database. The resource database in Appendix B-1 contains the following bibliographic information regarding each publication:

- **Funding Organization** – This column provides information, if available, regarding the source of funding for the work described in the publication. This is most commonly used for technical organizations that fund research into a particular topic, which is described in the listed publication.
- **Website Address (If Applicable)** - This column provides the website address of the sponsoring organization or the website from which the publication was obtained.
- **Contact Phone Number** – This column provides the phone number of the contact that provided the publication.
- **Contact Email or Address** - This column provides the contact's email or mailing address.
- **Author (Last and First) Name** - These two columns provide the name of the author of the publication. Where there is more than one author, the primary author or first author listed on the publication is used.
- **Year Published**
- **Source of Material (Publication)** – This provides either the name of the publisher, sponsoring organization, or the conference for which the paper was prepared.
- **Article or Paper Name**
- **Filename** – This column provides information identifying whether or not the paper was obtained in a hard or an electronic format. If the publication was obtained in electronic format the filename or electronic source is also provided.
- **Article Paper Available (Y/N)** – This column provides information on whether or not the publication has been received and incorporated into the cataloged material. A "Y" indicates that the information has been received and incorporated while a "N" indicates the information has not been received and incorporated.

- **Research Completed (Y/N)** – This column provides information regarding whether or not the research described in the publication is ongoing or has been completed. A "Y" denotes that the research is complete and a "N" denotes that the research is ongoing.
- **Brine, Level of Use, Regulations, Use Type, Salinity, Water Chemistry** – These six columns provide information regarding the focus of the publication. An "X" is placed under one or more of the topic headings that are discussed in the publication. This matching allows the database users to query for sources related to a specific concern.
- **Reference Codes for Concerns** - These seven columns provide the codes that match the issues and concerns developed by the IEMT. Appendix B-2 provides a list of these codes and there associated issue or concern.
- **If Applicable, Constituent of Concern** - This column provides information regarding whether the publication is focused on discussing one or more particular constituents.
- **Article Summary Available (Y/N)** – A "Y" in this column indicates that a summary of the publication was developed while a "N" indicates that the summary was not developed. Source summaries are enclosed on the CD included as Appendix C. Source summaries were only developed for approximately the initial 240 sources identified. The remaining publications were compiled for use in the Phase III of the Initiative.
- **Filename of Summary** – This column provides the electronic filename of the summary, if available.
- **Miscellaneous Comments** - This column provides a field to input relevant information regarding the subject of the publication.

Appendix B-1
Resource Database

APPENDIX B-1
RESOURCE DATABASE

												Check if Topic Applies to Concern Below																
Funding Agency	Website Address (If Applicable)	Contact Phone Number	Contact Email or Address	Author Last Name	Author First Name	Year Published	Source of Material (Publication)	Article or Paper Name	Filename	Article/Paper Available (Y/N)	Research Completed (Y/N)	Brine	Level of Use	Regulations	Use Type	Salinity	Water Chemistry	Reference Code for Concerns							If Applicable, Constituent of Concern	Article Summary Available (Y/N)	Filename of Summary	Miscellaneous Comments
				Mickley	Michael	2001	U.S. Bureau of Reclamation	Membrane Concentrate Disposal: Practices and Regulations	Hard Copy Only	Y	Y	X				X	X	B1	B2	B5	W1	S10				N		Membrane Concentrate Disposal
USBR/MWDSC				Bookman-Edmonston		1999	MWD/USBR	Salinity Management Study. Final Report. Long Term Strategy and Recommended Action Plan,	Hard Copy Only	Y	Y					X		S2	S4	S5	S6	S7	S9			Y	Salinity Manage Study-MWD-USBR1999.doc	
USBR/MWDSC				Bookman-Edmonston		1999	MWD/USBR	Salinity Management Study. Final Report. Technical Appendices.	Hard Copy Only	Y	Y					X		S2	S4	S5	S6	S7	S9	R3		Y	Salinity Manage Study appendices-MWD-USBR1999.doc	
AWWARF	AWWARF.com	303-347-6130	kmartin@awwarf.com				Research Project	Characterizing Salinity Contributions in Sewer Collection Systems and Reclaimed Water Distribution Systems to Develop Salinity Management Strategies	RFP Available	Y	Y					X		S6	S10						Salinity	N		
			OCWD, CA	Mills	William R.	1995	OCWD Annual Report for year 1995	Annual Report: OCWD Wastewater Reclamation, Talbert Barrier, and Recharge Project	Hard Copy Only	Y	Y		X		X		X	W4	W5	U10	L13					Y	OCWD-1995.doc	Prepared for the California Regional Water Quality Board.
WERF	www.wef.org		Jami Montgomery, jmontgomery@werf.org			On-going		Workshop on Molecular Approaches for Alternatives in Indicator Monitoring and Pathogen Assessment	Interim Project Report available	Y	Y						X	W4							Pathogens	N		Pathogens
				Morton	A. J.	1996	Desalination V. 108:(1-3). Pp. 1-10. February 1997	Environmental Impacts of Seawater Distillation and Reverse Osmosis Processes	Electronic Copy: Morton et al-1996.pdf	Y	Y	X						B2	B3	B4					TDS	Y	Morton et al - 1996.doc	
				Bartels	Craig R.	2000	AWWA Step Up To The Future Annual Conference 2000	Economic and Energy Performance Analysis of a Large-Scale Surface Water Desalting Process	Electronic Copy: AWWA Step Up To The Future Annual Conference. 2000 Proceedings, mon14-2.pdf	Y	Y	X	X					L10	B6							Y	Bartels et al-2000.doc	
WateReuse				Brandt	Norris	1999	WateReuse	Water Softeners - Where Are We Headed?	Hard Copy Only	Y	Y	X						B1	B6						Water Softeners	N		
			Boyle Engr. Corp., CA	Everest	William R.	1998	AWWA Proceedings. of Membrane Technologies in the Water Industry	Potential Southern California Benefits from Desalination of Brackish Groundwaters	Electronic Copy: Everest et al 1991.pdf	Y	Y	X				X		B1	B6	S2	S5	S6	S7	S9		Y	Everest et al -1991 AWWA.doc	
	www.coastal.ca.gov/web/desalrpt/dchap3.html			California Coastal Commission			California Coastal Commission	Chapter Three of Seawater Desalination in California: Potential Environmental Impacts/Coastal Act Issues	Hard Copy Only	Y	Y	X	X					B1	B2	B3	B7	L6				Y	Chpt 3 Seawater Desal in CA.doc	Seawater Desalination in California
				Whiting	David	1997	AWWA Membrane Conference Proceedings, 1997	Toxicity from Major-Seawater-Ion "Imbalance"	Electronic Copy: Whiting et al-1997.pdf	Y	Y	X					X	W2	B3	B6						Y	Whiting et al - 1997.doc	
				Oudrick	Frank B.	1997	AWWA Membrane Conference Proceedings 1997	Behavior of Seawater Reverse Osmosis Brine Ocean Discharges	Electronic Copy: Oudrick and Carns-1997.pdf	Y	Y	X						B1	B2	B3	B4					Y	Oudrick and Carns-1997.doc	Case Studies
				Weinberg	Edward R	1997	AWWA Membrane Conference Proceedings 1997	A Comparison of the Laboratory Analysis and Receiving Water Effects of a Reverse Osmosis Concentrate Discharge	Electronic Copy: Weinberg-1997.pdf	Y	Y	X						B1	B2	B6	B7					Y	Weinberg-1997.doc	Discharge to a Canal in Florida
				Acquaviva	D. J.	1995	AWWA Membrane Technology Conference. Proceedings, 1995	Establishment of Mixing Zones for Acute Toxicity and Other Water Quality Parameters for an R.O. Concentrate Discharge, Offshore Sanibel Island, Florida	Electronic Copy: Acquaviva et al-1995.pdf	Y	Y	X		X				B2	B3	B7	R6	R9				Y	Acquaviva et al - 1995.doc	
				Mickley	Mike	1995	AWWA Membrane Technology Conference. Proceedings, 1995	Membrane Concentrate and Common Ion Toxicity	Electronic Copy: Mickley et al-1995.pdf	Y	Y	X		X	X		X	W1	W2	W4	U2	R1	R14	B1	and B2, B7	Y	Mickley - 1995.doc	
				Mavrov	V.	1996	Desalination V. 108:(1-3). Pp. 159-166. February 1997.	Desalination of Surface Water to Industrial Water with Lower Impact on the Environment. Part 1: New Technological Concept.	Electronic Copy: Mavrov et al-1996.pdf	Y	Y	X	X		X			U2	L7	B1						Y	Mavrov-1996.doc	Feasibility of New Technology
				Hopner	T.	1997	Desalination V. 108:(1-3). Pp. 11-18. February 1997.	Elements of Environmental Impact Studies on Coastal Desalination Plants	Electronic Copy: Hopner et al-1996.pdf	Y	Y	X						B1	B2	B3	B4	B5	B6	B7		Y	Hopner et al - 1996.doc	Brine Disposal Environmental Impacts
Capistrano Beach Water District				Everest	William R.	1998	Desalination V. 117:(1-3). Pp. 197-202. September 1998	Groundwater Reclamation by Innovative Desalting in Orange County, California	Electronic Copy: Everest et al 1998.pdf	Y	Y	X						B2	B4							Y	Everest et al - 1998.doc	
Mekorot Water Company				Glueckstern	P.	1997	Desalination V. 108:(1-3). Pp. 19-26. February 1997.	Optimized Brackish Water Desalination Plants with Minimum Impact on the Environment	Electronic Copy: Glueckstern et al-1996.pdf	Y	Y	X						B5	B6	B7						Y	Glueckstern et al-1996.doc	
				Weinberg	Edward R	1999	AWWA Membrane Technology Conference. 1999	A Methodology for Calculating Actual Dilution of a Membrane Concentrate Discharge To Tidal Receiving Waters	Electronic Copy: AWWA Membrane Technology Conference. 1999, 02-02.pdf	Y	Y	X				X		B6	S6							Y	Weinberg-1999.doc	
				Patel	Mehul V.	1999	AWWA Membrane Technology Conference. 1999	Options for Treatment and Disposal of Residuals Produced by Membrane Processes in the Reclamation of Municipal Wastewater	Electronic Copy: AWWA Membrane Technology Conference. 1999, 02-01.pdf	Y	Y	X				X		S6	B5	B7					Membrane Concentrate	Y	Patel et al-1999.doc	
				Burkstaller	John	2001	AWWA New Horizons in Drinking Water Annual Conference., 2001	Elements of a Brackish Water Resources Master Plan for El Paso, Texas	Electronic Copy: AWWA New Horizons in Drinking Water Annual Conference. 2001, ACE01-TUE27-04.pdf	Y	Y	X						B5								Y	Burkstaller-2001.doc	
		(913) 458-3421	freemansd@bv.com	Freeman	Scott	2002	AWWA WEF Water Sources Conference 2002	Issues in the Application of Membranes for Water Reclamation	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu2_2.pdf	Y	Y	X						B6								Y	Freeman et al-2002.doc	
AWWARF				Mickley	Mike	1993	AWWA Membrane Conference Proceedings, 1993	Membrane Concentrate Disposal	Electronic Copy: Mickley et al 1993.pdf	Y	Y	X				X	X	B1	B2	B5	W1	S10				Y	Mickley et al - 1993.doc	
				Acquaviva	D. J.	1997	AWWA Membrane Conference Proceedings 1997	Reverse Osmosis Concentrate Disposal Alternatives for Small and Medium-Sized Systems in Southwest Florida	Electronic Copy: Acquaviva-1997.pdf	Y	Y	X						B5								Y	Acquaviva et al - 1997.doc	
USBR				Turner	Charles D.	1997	AWWA Membrane Conference Proceedings, 1997	Designing for Brine Reject Utilization	Electronic Copy: Turner et al-1997.pdf	Y	Y	X						B5								Y	Turner et al 1997.doc	
			Mickley & Associates	Mickley	Mike	1991	AWWA Proceedings. of Membrane Technologies in the Water Industry	Disposal of Membrane Concentrate Wastes: An AWWARF Project Status Report	Electronic Copy: Mickley and Hamilton-1991.pdf	Y	Y	X						B1	B6							Y	Mickley and Hamilton-1991.doc	
			Boyle Engr. Corp., CA	Ma	Julius Y.	1998	AWWA Proceedings. of Membrane Technology Conference	Brine Disposal to Local Sewerage System-An Unique Problem Facing Southern California's Blooming Desalting Market	Hard Copy Only	Y	Y	X						B1	B3	B5	B6					Y	Ma-1993.doc	
CH2MHILL	CH2 Website:|Bus Groups|WBG|Technologies|Reuse|Concentrate Disposal White Paper	N/A	N/A	Colvin	Christian	2001	CH2M Website	RO/NF Membrane Concentrate Disposal	On-line	Y	Y	X						B5							Salinity	Y	Colvin- 2001.doc	
Middle East Desalination Research Center				Ahmed	M	2000	Desalination V. 130:(2) Pp. 155 - 168.	Use of Evaporation Ponds for Brine Disposal in Desalination Plants	Electronic Copy: Ahmed et al-2000.pdf	Y	Y	X						B5								Y	Ahmed et al - 2000.doc	

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University of Arizona Environmental Research Laboratory				Riley	James J.	1997	Desalination vol. 110, no. 3, pp. 197-211	Halophyte Irrigation: An Overlooked Strategy for Management of Membrane Filtration Concentrate	Electronic Copy: Riley et al-1997.pdf	Y	Y	X						B5								Y	Riley et al-1997.doc	Tucson Halophyte Irrigation
Anglian Water Services Ltd.				Squire	D.	1996	Desalination vol. 108, no. 1-3 pp. 143-147; Second annual meeting of the European desalination society on desalination and the environment held in Genoa, Italy, October 20-23, 1996	Disposal of Reverse Osmosis Membrane Concentrate	Electronic Copy: Squire et al-1996.pdf	Y	Y	X	X					B1	B5	B6	B7	L17				Y	Squire et al - 1996.doc	
Sweetwater Authority				Everest	W. R.	1995	Desalination vol. 102, no. 1 pp. 107-117; Proceedings of the 1994 biennial conference and exposition. Membrane and desalting technologies	Desalting Residuals: A Problem or a Beneficial Resource?	Electronic Copy: Everest et al-1995.pdf	Y	Y	X		X		X		B5	B6	B7	R5	R6	S1			Y	Everest et al - 1995.doc	Southern California
				Buris	O. K.	1990	International Desalination Association	The ABCs of Desalting	Hard Copy Only	Y	Y	X						B3	B5							N		
				Morin	O. J..			Zero Discharge Facility - Comparison with other Reverse Osmosis Brine Disposal Methods	Hard Copy Only	Y	Y	X						B4	B5							N		
WERF	www.werf.org		Mary Strawn mstrawn@werf.org	Reardon	Roderick	On-going		Membrane Treatment of Secondary Wastewater Effluent for Subsequent Use	Interim Report Available	Y	N (In Progress)	X				X		B1	B6	S6	W1					N		Membranes
				Morin	O. J..	1991	AWWA Conference Proceedings Membrane Technologies	Desalting Cost Update	Electronic Copy: Morin et al-1991.pdf	Y	Y	X				X		S6	B6							Y	Morin et al -1991.doc	
				Priel	Aaron	2001	World Water and Environmental Engineering, November/December 2001	Big Plant Cheap at the Price	Hard Copy Only	Y	Y	X						B6								Y	Priel-2001.doc	
				Ibrahim	Eva A.	1993	AWWA Membrane Conference Proceedings, 1993	Cost and Performance of RO and EDR Pilot Plant Operation	Electronic Copy: Ibrahim et al-1993.pdf	Y	Y	X				X		B6	B7	S5	S8					Y	Ibrahim et al - 1933.doc	Membrane Pilot Tests to Treat Brackish Groundwater
				Andrews	L. S.	1991	Proceedings. of the 1991 AWWA Annual Meeting. Orlando, Fla.: AWWA	Permitting the Discharge of Reverse Osmosis Concentrate to a Surface Water	Electronic Copy: Andrews et al-1991.pdf	Y	Y	X		X				B1	B5	B6	R1					Y	Andrews - 1991 AWWA.doc	Two Case Studies from Florida
AWWARF				Kenna	Eric	1999	Proceedings. of AWWA Annual Conference	Survey of Membrane Concentrate Reuse and Disposal	Electronic Copy: Kenna and Zander-1999.doc	Y	Y	X						B6	B7							Y	Kenna and Zander-1999.doc	Membrane Concentrate Reuse
				Graves	Mark	2001	AWWA Membrane Technology Conference. 2001	Desalination for Texas Water Supply	Electronic Copy: AWWA Membrane Technology Conference. 2001, w2-2.pdf	Y	Y	X	X			X		L7	S6	B6					TDS	Y	Graves et al-2001.doc	
				Oreskovich	Robert W.	2001	AWWA Membrane Technology Conference. 2001	Desalting a High TDS Brackish Water for Hatteras Island, North Carolina	Electronic Copy: AWWA Membrane Technology Conference. 2001, w2-3.pdf	Y	Y	X				X		S6	B6						TDS	Y	Oreskovich-2001.doc	
				Brown	Douglas R.	2001	AWWA Membrane Technology Conference. Proceedings, 2001	Pilot Testing Answers Questions Regarding Taste and Concentrate Trace Elements	Electronic Copy: AWWA Membrane Technology Conference. Proceedings, 2001	Y	Y	X						B1								Y	Brown et al-2001.doc	
				Mandrup-Poulsen	Jan	1997	AWWA Membrane Conference Proceedings 1997	Dealing with Membrane Concentrate Disposal in Florida	Electronic Copy: Mandrup-Poulsen-1997.pdf	Y	Y	X		X				R6	B1	B2	B6					Y	Mandrup-1997.doc	Concentrate Rules
			R.E.P Associate Hutcheon Engineers, West Palm Beach, FL	Potts	John E.	1993	AWWA Membrane Conference Proceedings, 1993	Toxicity Testing of Brackish Concentrate - Do Current Regulations Apply?	Electronic Copy: Potts et al-1993.pdf	Y	Y	X		X				B1	B2	B3	B7	R6				Y	Potts et all - 1993.doc	Surface Water Discharge
				Pontius	Frederick W.	1996	J. of AWWA, No:5, pp.44-52	Regulations Governing Membrane Concentrate Disposal	Hard Copy Only	Y	Y	X		X				R4	R5	R6	R11	B5	B6			Y	Pontius et al-1996.doc	Membrane Concentrate Disposal Regulations
				Guillette	Louis		AWWA Annual Conference Proceedings	Wildlife As Sentinels of Environmental Endocrine Disruption	Copy Ordered	N	Y														Endocrine Disrupters	N		
				Smith	B. E.	1990	Desalination, Vol. 78, No. 1, p 59-70, July 1990	Use of Solar Ponds in the Disposal of Desalting Concentrate	No Copy, Must Be Ordered	N																N		
				Carlson	Mark	2002	AWWA Annual Conference Proceedings	Treatment of Endocrine Disrupters	Copy Ordered	N	Y														Endocrine Disrupters	N		
				Xingchao	Jian	1998	China Environmental Science vol. 18, no. 4, pp. 353-355	Treating the Nanofiltration Concentrate of a Tertiary Effluent from a Municipal Wastewater Treatment Plant by Ozonation and Aerobic Biotreatment	No Copy, Must Be Ordered	N																N		
				Fleischer	E. J..	1996	1996 American Desalting Association Biennial Conference and Exposition	Successful Permitting for the Discharge of Membrane Concentrate from a Large Municipal Reverse Osmosis Plant: the City of Chesapeake Experience	No Copy, Must Be Ordered	N																N		
				Tabak	H. H..	1981	Developmental and Industrial Microbiology	Steroid Hormones as Water Pollutants II: Studies on Persistence and Stability of natural Urinary and Synthetic Ovulation-inhibiting Hormones in Treated and Untreated Wastewaters	Copy Ordered	N	Y														Endocrine Disrupters	N		
EPA						1999	Federal Register	Research Plan for Endocrine Disrupters	Copy Ordered	N	Y														Endocrine Disrupters	N		
				del Bene	J. V..	1993	Desalination vol. 97, no. 1-3 pp. 365-372; Proceedings of the IDA and WRPC world conference on desalination and water treatment, November 3-6, 1993, Yokohama, Japan.	Ocean Brine Disposal	No Copy, Must Be Ordered	N																N		
				Bowdoin	P	1990	Desalination, Vol. 78, No. 1, p 49-58, July 1990	Irrigation with Membrane Plant Concentrate: Fort Myers Case Study	No Copy, Must Be Ordered	N																N		
				Safe	Stephen		AWWA Annual Conference Proceedings	Evidence of Endocrine Disrupters Impact on Human Health	Copy Ordered	N	Y														Endocrine Disrupters	N		

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Funding Agency	Website Address (If Applicable)	Contact Phone Number	Contact Email or Address	Author Last Name	Author First Name	Year Published	Source of Material (Publication)	Article or Paper Name	Filename	Article/Paper Available (Y/N)	Research Completed (Y/N)	Check if Topic Applies to Concern Below: Brine	Level of Use	Regulations	Use Type	Salinity	Water Chemistry	Reference Code for Concerns							If Applicable, Constituent of Concern	Article Summary Available (Y/N)	Filename of Summary	Miscellaneous Comments
				Huang	C. H..			Estrogenic Hormones in Effluent from Conventional and Advanced Wastewater Treatment Plants	Copy Ordered	N	N														Endocrine Disrupters	N		
				Purdom	C. E.	1994	Chemistry and Ecology	Estrogenic Effects from Sewage Treatment Works	Copy Ordered	N	Y														Endocrine Disrupters	N		
				Mabrook	B.	1994	Desalination V. 97:(1-3). Pp. 453-465. August 1994	Environmental Impact of Waste Brine Disposal of Desalination Plants, Red Sea, Egypt	No Copy, Must Be Ordered	N																N		
				Mickley	M. C..	1996	The international Desalination and Water Reuse Quarterly, 5(4), February/March 1996, pp. 56-61	Environmental Considerations for the Disposal of Desalination Concentrates	No Copy, Must Be Ordered	N																N		
				Weyer	Peter		AWWARF Online Seminar	Endocrine Disrupters and Pharmaceutically Enhanced Compounds in Drinking Water	Copy Ordered	N	Y														Endocrine Disrupters	N		
EPA						1998	Federal Register	Endocrine Disrupter Screening and Testing Advisory Committee Final Report	Copy Ordered	N	Y														Endocrine Disrupters	N		
				Skehan	S.T.	1990	Desalination, Vol. 78, No. 1, p 41-47, July 1990	Disposal of Concentrate from Brackish Water Desalting Plants by Use of Deep Injection Wells	No Copy, Must Be Ordered	N																N		
				Walker	C. W..	1996	1996 American Desalting Association Biennial Conference and Exposition	Deep Well Disposal of Concentrate: the Collier County, Florida Experience	No Copy, Must Be Ordered	N																N		
				Sedlack	David		AWWA Annual Conference Proceedings	Analytical Challenges in Identifying Endocrine Disrupters in Water	Copy Ordered	N	Y														Endocrine Disrupters	N		
				Pontek	R. S.	1996	1996 American Desalting Association Biennial Conference and Exposition	An Innovative Solution to Blend Membrane Softening By-Product with Secondary Wastewater Effluent for Golf Course Irrigation	No Copy, Must Be Ordered	N																N		
				Wolfe	S	1996	1996 American Desalting Association Biennial Conference and Exposition	A Test Protocol for Membrane Concentrate Toxicity Resulting from an Imbalance of Seawater Ions	No Copy, Must Be Ordered	N																N		
				Crook	James	1993	AWWA Annual Conference Proceedings	Water Reuse: Past, Present, and Future	Hard Copy Only	Y	Y		X	X	X			L2	L4	L11	L13	R1	R5	R12	U1, U5, U6, and U9	Y	Crook and Okun-1993.doc	
				Okun	Daniel A.	2000	WateReuse Symposium Proceedings 2000	Water Reclamation and Unrestricted Nonpotable Reuse: A New Tool in Urban Water Management	Electronic Copy: WateReuse Symposium Proceedings 2000, 08.pdf	Y	Y		X		X			L15	L2	U3	U11					Y	Okun-2000.doc	Water Conservation and Dual Systems
				Worley	Wendy G.	1999	Proceedings. of AWWA Annual Conference	Who's Doing What in Water Conservation: Results of the 1999 Benchmarking Study	Electronic Copy: Worley-1999.doc	Y	Y		X					L15								Y	Worley-1999.doc	
			IRWD, CA	Young	Ronald E.	1993	AWWA Annual Conference Proceedings	Reclaimed Water Management	Hard Copy Only	Y	Y		X				X	L15	W2							Y	Young and Parsons-1993.doc	
CH2M HILL				CH2M HILL	CH2M HILL	1999	CH2M HILL Power Point Presentation	City of Albuquerque Reclaimed Water Projects, Water Resources Strategy Implementation	Electronic Copy: Albuquerque CH2M HILL-1999.doc	Y	Y		X		X			U10	L1							Y	Albuquerque-CH2M HILL-1999.doc	
City of Phoenix				Conroy	Aimee	2001	WateReuse Symposium Proceedings 2001	A Water Reuse Partnership for Today, Tomorrow and the 21st Century: The Roosevelt Irrigation District Exchange Agreement	Electronic Copy: WateReuse Symposium Proceedings, 031.pfd	Y	Y			X				R7								Y	Conroy et al-2001.doc	Water Rights
				Grinnell	Gary	1996	Proceedings. of Water Reuse Conference	The Role of Water Reuse in the City of Las Vegas	Abstract Available	Y	Y		X					L2								Y	Grinnell et al-1996.doc	Abstract Only
			Black & Veatch, Boston	Crook	James	1997	Water Resources Conference Proceedings, AWWA, Pacific Northwest Section, pp 487-501	Water Reuse Comes of Age	Abstract Available	Y	Y		X	X	X			L2	L4	L11	L13	R1	R5	R12	U1, U5, U6, and U9	Y	Crook et al-1997 Water Resources Conf.doc	Similar to LU2000 Abstract Only
				Crockett	Christopher S.	2001	AWWA WQTC 2001	Source Water Protection for Large Watersheds	Electronic Copy: AWWA WQTC 2001 Conference Proceedings	Y	Y		X					L9								Y	Crockett-2001.doc	Issues with Ownership and Stakeholders
				Maddaus	Lisa	2001	AWWA New Horizons in Drinking Water Annual Conference., 2001	Water Conservation and Drought Management	Electronic Copy: AWWA New Horizons in Drinking Water Annual Conference. 2001, ACE01-WED14-05.pdf	Y	Y		X					L15								Y	Maddaus et al-2001.doc	
MWDSC						2000	MWDSC	The Regional Urban Water Management Plan for the Metropolitan Water District of Southern California	Hard Copy	Y	Y	X	X	X	X			B1	L2	L15	R1	U2	U14			Y	MWDSC-2000.doc	
			R. W.. Beck Inc., Seattle, WA	Cuthbert	Richard W.	1999	Journal AWWA, Volume:91, Issue:8, pp.50-57	Setting Reclaimed Water Rates	Hard Copy Only	Y	Y		X		X			L2	L14	U9	U14					Y	Cuthbert et al-1999 JAWWA.doc	Rate Setting
				Cuthbert	Richard W.	1998	AWWA Annual Conference Proceedings, 1998	Reclaimed Water Rates: Alternative Strategies for Developing Reclaimed Water Charges	Electronic Copy: Cuthbert et al-1998.pdf	Y	Y		X					R13	L2	L14	U9	U14				Y	Cuthbert et al-1999 JAWWA.doc	Rate Setting
				Walker-Coleman	Lauren	2001	WateReuse Symposium Proceedings 2001	Reclaimed Water Rates in Florida	Electronic Copy: WateReuse Symposium Proceedings, 019.pdf	Y	Y		X					L2	L14	U9	U14					Y	Walker-Coleman-2001.doc	Florida Water Rates
				Longoria	Raymond	2000	AWWA Water Reuse Conference Proceedings 2000	Rate Setting for Industrial Reuse in San Marcos, Texas	Electronic Copy: AWWA Water Reuse Conference Proceedings 2000, TU6-2.pdf	Y	Y		X					L2	L14	U14						Y	Longoria et al-2000.doc	Industrial Use Rate Setting
				Chesnutt	Thomas W.	1997	AWWA Annual Conference Proceedings, 1997	Valuing Conservation	Electronic Copy: Chestnutt et al-1997.pdf	Y	Y		X					L15								Y	Chestnutt et al-1997.doc	Valuation for Water Conservation
				Sheikh	Bahman	1998	AWWA Water Reuse Conference Proceedings 1998	Accounting for the Benefits of Water Reuse	Electronic Copy: Sheikh et al-1998.pdf	Y	Y		X	X				R5	L15	L2						Y	Sheikh et al-1998.doc	Calculating Value of Recycled Water for Various Uses
				Leserman	James R.	1997	AWWA Annual Conference Proceedings, 1997	Economics of Water Reclamation for Groundwater Recharge and Injection	Electronic Copy: Leserman-Ferry-1997.pdf	Y	Y		X		X			U1	U10	L13	L2	L4				Y	Leserman and Ferry -1997.doc	Southern California Project
				Grotke	Eric J.	1998	AWWA Annual Conference Proceedings, 1998	South Hutchinson Island Water Reclamation Facility, Financial Impacts to Local Water Systems	Electronic Copy: Grotke et al-1998.pdf	Y	Y		X	X				R13	R5	L15	L2	L16				Y	Grotke et al -1998.doc	
				Pekelney	David M.	1999	Proceedings. of AWWA Annual Conference	Economic Analysis of Regional Water Recycling Investments	Electronic Copy: Pekelney et al-1999.doc	Y	Y		X					L2	L14							Y	Pekelney et al-1999.doc	Economic Issues
				Freeman	Craig C.	1998	AWWA Water Reuse Conference Proceedings 1998	Water Recycling in California: A Survey of Motivating Factors and Financing Mechanisms	Electronic Copy: Freeman-1998.pdf	Y	Y		X	X				R1	R6	R13	L15	L2				Y	Freeman -1998.doc	Survey Data

APPENDIX B-1
RESOURCE DATABASE

Funding Agency	Website Address (If Applicable)	Contact Phone Number	Contact Email or Address	Author Last Name	Author First Name	Year Published	Source of Material (Publication)	Article or Paper Name	Filename	Article/Paper Available (Y/N)	Research Completed (Y/N)	Check if Topic Applies to Concern Below: Brine	Level of Use	Regulations	Use Type	Salinity	Water Chemistry	Reference Code for Concerns							If Applicable, Constituent of Concern	Article Summary Available (Y/N)	Filename of Summary	Miscellaneous Comments
			CH2M HILL	CH2M HILL	CH2M HILL	2001	CH2M HILL's Internal Information on Reuse Cost Issues	CH2M HILL's Internal Information on Reuse Cost Issues	Electronic Copy: CH2M HILL-2001.ppt	Y	Y		X		X			U2	L12							Y	CH2M HILL-2001.doc	Cost Evaluation and Comparisons for Various Recycled Water Projects
				Mills	Richard A.	1996	Water Science & Technology, Vol:33 No:10-11, pp.59-70	A Retrospective Assessment of Water Reclamation Projects	Electronic Copy: Mills and Asano-1996.doc	Y	Y		X		X			L2	U4	U9						Y	Mills and Asano-1996.doc	Problems of Recycled Water Projects in California
Orange County Water District				Woodside	Greg	2001	WateReuse Symposium Proceedings 2001	OCWD's Biomonitoring Demonstration Project Fish as an Indicator of Source Water Quality	Electronic Copy: WateReuse Symposium Proceedings, 028.pdf	Y	Y		X					L16								Y	Woodside-2001.doc	Biomonitoring
WERF	www.werf.org		Dean Carpenter dcarpenter@werf.org	Hyde	James	On-going		Newport Bay TMDL Study	Interim Report Available	Y	N (In Progress)	X		X	X			L6	R1	R8	R11	U4			Pathogens	Y	Hyde et al-2000.doc	TMDL's
Irvine Ranch Water District				Hyde	James	2000	AWWA Water Reuse Conference Proceedings 2000	Impact of Multiple TMDL's on the Newport Bay Watershed	Electronic Copy: AWWA Water Reuse Proceedings, m3-3.pdf	Y	Y		X					L14	L16							Y	Hyde et al-2000.doc	Sediment, Nutrients, Pathogens, and TMDL
WERF	www.werf.org		Margaret Stewart mstewart@werf.org	Thornton	Kent	On-going		Strategies for Sustainable Water Resource Management	Interim Report Available	Y	N (In Progress)		X			X	X	L2	W5	S1						N		Sustainability
Southwest Florida Water Management District	http://www.swfwmd.state.fl.us/	352-796-7211				2001	Southwest Florida Water Management District	Reclaimed Water Guide	Have CD	Y	Y			X	X			U1	U9	R6	R15					Y	SWFWMD Guide - 2002.doc	Mark McNeal/TPA Worked on this Project
				Crook	James	2002	AWWA WEF Water Sources Conference 2002	The Ongoing Evolution of Water Reuse Criteria	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu1_1.pdf	Y	Y			X				R1	R4	R5	R6	R7				Y	Crook-2002.doc	Regulations
				Angelakis	A. N.	1999	Water Research, Vol:33 No:10 pp.2201-2217	The Status of Wastewater Reuse Practice in the Mediterranean Basin: Need for Guidelines	Electronic Copy: Angelakis et al-1999.doc	Y	Y			X	X			R4	R5	U3						Y	Angelakis et al-1999.doc	
				Chang	Andrew C.	1996	Water Science & Technology, Vol:33 No:10-11 pp.463-472	Developing Human Health-Related Chemical Guidelines for Reclaimed Wastewater Irrigation	Electronic Copy: Chang et al-1996.doc	Y	Y			X	X		X	W2	W4	W5	U9	R4	R5			Y	Chang et al-1996.doc	Regulations for Irrigation
				Asano	Takashi	1998	Proceedings. of Water Reuse Conference	Developing Comprehensive Wastewater Reuse Criteria	Electronic Copy: Asano et al-1998.pdf	Y	Y			X			X	W2	W3	W4	R4	R5				Y	Asano et al-1998.doc	Water Quality-Health Effects
WHO				Akin	E.	1987	World Health Organization	Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture	Hard Copy Only	Y	Y			X	X			R6	R4	U1	U3					Y	Akin et al-WHO 1987.doc	WHO Health Guidelines
The Ministry of National Infrastructures	www.mni.gov					2002	State of Israel	Ministry of National Infrastructures Wastewater Treatment and Reuse	Hard Copy Only	Y	Y			X				R14							Israel Water Reuse Regulations	N		
UMIST				Young	Robert	2002		Water Reuse as a Component of an Integrated Strategy for Reducing Cyprus's Water Shortages	Hard Copy Only	Y	Y			X				R14							Cyprus Regulations	N		
				Asano	Takashi	1996	Water Science & Technology, Vol:34 No:11, pp.219-226	Wastewater Reclamation and Reuse in Japan: Overview and Implementation Examples	Electronic Copy: Asano et al-1996.doc	Y	Y			X	X		X	U8	U11	W4	R12	R15	R4			Y	Asano et al-1996.doc	Water Recycling in Japan
Department of Civil Engineering, University Of California Davis				Asano	Takashi	2002		Lessons Learned From The Japanese Water Reuse Experiences	Hard Copy Only	Y	Y			X				R14							Japanese Regulations	N		
				Salgot	Miquel	1996	Water Science & Technology, Vol:34 No:11 pp.261-267	Existing Guidelines and Regulations in Spain on Wastewater Reclamation and Reuse	Electronic Copy: Salgot and Pascual-1996.doc	Y	Y			X				R1	R4	R6						Y	Salgot and Pascual-1996.doc	Regulations in Spain
New South Wales Government Interdepartmental Committee				Anderson	John	1993	New South Wales Government Interdepartmental Committee	New South Wales (NSW) Guidelines for Urban and Residential Use of Reclaimed Water		Y	Y			X	X			R1	R5	R12	U1	U8	U11	U9		Y	Anderson et all - NSW 1993.doc	
Agricultural and Resource Management Council of Australia and New Zealand, et al							Agricultural and Resource Management Council of Australia and New Zealand, et al	Guidelines for Sewerage Systems - Use of Reclaimed Water		Y	Y			X	X			R1	R6	R11	R12	U1	U2	U3		Y	Australia and New Zealand Guidelines - 2000.doc	Water Recycling Regulations for Australia and New Zealand
				Angelakis	A. N.	2001		Wastewater Reclamation and Reuse in Eureau Countries: With Emphasis on Criteria Used		Y	Y			X	X			R1	R4	R6	R11	R12	R14	U1	U3, U6, U9	Y	Angelakis et al-2001.doc	Water Recycling Regulations in Europe
				Angelakis	A. N.	2001	Water Policy, Vol:3 pp.47-59	Wastewater Reclamation and Reuse in Eureau Countries	Electronic Copy: Angelakis and Bontoux-2001.doc	Y	Y			X	X			R1	R4	R5	R14	U9				Y	Angelakis and Bontoux-2001.doc	Water Recycling and Regulations in Europe
				Pontius	Frederick W.	1995	AWWA Membrane Technology Conference. Proceedings, 1995	Federal and State Regulations Governing Membrane Concentrate Disposal	Electronic Copy: Pontius et al-1995.pdf	Y	Y			X				R8	R9	R14						Y	Pontius et al-1995.doc	Summary of Regulations for Specific States
				Crook	James	1996	Water Science & Technology, Vol:33 No:10-11 pp.451-462	Water Reclamation and Reuse Criteria in the US	Electronic Copy: Crook and Surampalli-1996.doc	Y	Y			X				R1	R4	R5	R11	R15				Y	Crook and Surampalli-1996.doc	
USEPA						1992	EPA Guidelines for Water Reuse	EPA Suggested Guidelines for Reuse of Municipal Wastewater		Y	Y			X	X			R1	R5	U2						Y	EPA Guidelines - 1992.doc	
NWRI & AWWA						2000	NWRI & AWWA	Ultraviolet Disinfection - Guidelines for Drinking Water and Water Reuse		Y	Y			X	X			R3	R4	F5	U2					Y	NWRI AWWA-2000.doc	
AWWA						1994	AWWA	Dual Water Systems		Y	Y			X	X			R1	R4	R5	R15	U2	U3	U9	U14	Y	Dual Water Systems - AWWA 1994.doc	
USEPA				Matthews	Robert L.	1992	USEPA Technical Report	Manual: Guidelines for Water Reuse; EPA/625/R-92/004	Abstract Available	Y	Y			X				R6	R15							Y	Matthew et al-1992.doc	Guidelines for Water Recycling from USEPA Abstract Only
				Thompson	Heather D.	2000	AWWA Step Up To The Future Annual Conference 2000	Competing Interests for Water" What Role are the Endangered Species Playing	Electronic Copy: AWWA Step Up To The Future Annual Conference. 2000 Proceedings, tue14-2.pdf	Y	Y			X				R11								Y	Thompson et al-2000.doc	Endangered Species
				Miller	James W	2000	AWWA Step Up To The Future Annual Conference 2000	How Does the Endangered Species Act (ESA) Affect our Water Rights?	Electronic Copy: AWWA Step Up To The Future Annual Conference. 2000 Proceedings, thu10-1.pdf	Y	Y			X				R4	R6							N		
				Meyerhoff	Richard	2002	AWWA WEF Water Sources Conference 2002	Water Resources Conflicts: Development of Alternative Performance Outcomes for Effluent Dependent Water in the Arid West	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, rm3-3.pdf	Y	Y		X	X				L16	R8							N		Establishing Criteria for Wastewater Effluent
EPA	www.EPA.gov					2002	EPA	Drinking Water Contaminants	Hard Copy Only	Y	Y			X			X	W2	W3	W4	R14				Contaminants in Drinking Water	N		
EPA	www.EPA.gov					2002	EPA	Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule	Hard Copy Only	Y	Y			X				R14							Water Quality Standards	N		
				Crook	James	1994	Proceedings. of Water Reuse Symposium	Water Quality Considerations for Nonpotable Water Reuse	Abstract Available	Y	Y			X			X	R3	R4	W2	W4					Y	Crook and Gorder-1994.doc	Abstract Only
						2002	State of Arizona	Reclaimed Water Quality Standards	Hard Copy Only	Y	Y			X				R14							Arizona Regulations	N		
				Crook	James	2002		Water Reclamation and Reuse Criteria	Hard Copy Only	Y	Y			X				R14								N		
				WateReuse Association of California		1997	WateReuse Association of California	Groundwater Recharge Workshop. Draft Title 22, California Code of Regulations as of March 1997		Y	Y			X				R6	R12	R14						Y	Groundwater Recharge Workshop-1997.doc	

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				Reich	Kenneth D.	2000	AWWA Water Reuse Conference Proceedings 2000	Groundwater Injection of Recycled Water in a Liquid Hydrocarbon Recovery System - Regulatory Aspects of Saving 1 MGD of Potable Water in the West Coast Basin	Electronic Copy: AWWA Water Reuse Conference Proceedings 2000, TU5-6.pdf	Y	Y			X	X			U1	R7	R14	R15					Y	Reich et al-2000.doc	Groundwater Injection
				Kontos	Nick	1996	Water Science & Technology, Vol:33 No:10-11 pp.473-486	Environmental Assessment for Wastewater Reclamation and Reuse Projects	Electronic Copy: Kontos and Asano-1996.doc	Y	Y			X				L13	R1	R4	R5	R11				Y	Kontos and Asano-1996.doc	Environmental Assessment of Recycled Water
				Crook	James	2001	Proceedings. of AWWA Annual Conference	California's New Water Recycling Criteria and their Effect on Operating Agencies	Electronic Copy: Crook et al-2001.pdf	Y	Y			X				R1	R4	R5	R11	R14				Y	Crook et al-2001.doc	California Water Recycling Regulations
				Johnson	Laura J.	2000	AWWA Water Reuse Conference Proceedings 2000	Trends in Water Reuse Regulations	Electronic Copy: AWWA Water Reuse Conference Proceedings 2000, M3-1.pdf	Y	Y			X				R1	R4	R15	R14					N		Regulation Comparison by State
		(760) 246-8638	Daniel Gallagher dan@vvwra.com	Gallagher	Daniel	2001	WateReuse Symposium Proceedings 2001	Reclamation in the Mojave Desert: Should This be Difficult?	Abstract Available Only, 032.pdf	Y	Y		X	X				R7	R10	R11	R4	L16				N		Water Rights
				Hartling	Earle C.	1998	AWWA Water Reuse Conference Proceedings 1998	Overcoming Impediments to Water Recycling	Electronic Copy: Hartling-1998.pdf	Y	Y		X	X	X			U9	U12	R1	R7	R14	L10			Y	Hartling-1998.doc	Water Recycling in Los Angeles, California
						2002	CA DHS Web site	Standards for Perchlorate in Drinking Water	Electronic Copy: DHS Perchlorate-2002.mht	Y	Y			X	X			U13	R3	R6					Perchlorate	Y	DHS Regulations for Perchlorate - 2002.doc	
AWWA						1992		Guidelines for Distribution of NonPotable Water		Y	Y			X	X			R1	R5	R12	U2	U9				N		
CSWRCB						2000	CSWRCB	Porter-Cologne Water Quality Control Act		Y	Y			X	X			R1	R2	R6	R8	R9	R10	R12	U8 and U11	N		
State of California							State of California Code	Title 22. California Code of Regulations. Division 4. Environmental Health. Chapter 3. Recycling Criteria		Y	Y			X	X			R1	R4	R5	R12	R15	U1	U2	U3, U10, and U14	Y	CA Draft Title 22.doc	
State of California							State of California Code	Title 22. California Code of Regulations. Division 4. Environmental Health. Chapter 3. Recycling Criteria and Amendments to Title 17 Division 1 Chapter 5 Subchapter 1		Y	Y			X	X			R1	R4	R5	R12	R15	U1	U2	U3, U9, U10, and U14	Y	CA Draft Title 22 and Amend to Title 17-2001.doc	
Dublin San Ramon Services District				Cathemer	Louis	2001	WateReuse Symposium Proceedings 2001	Connecting Recycled Water Customers in Northern California - Building of the Experience of Southern California	Abstract Available Only, 030.pdf	Y	Y			X				R8	R7							N		Permitting, CWA Compliance
				Robertson	J. Allen	2000	AWWA WQTC 2000	Regulatory Incentives for Source Water Protection	Electronic Copy: AWWA WQTC 2000 Conference Proceedings	Y	Y		X	X				R3	R4	L9						N		
				Geselbracht	James	2000	AWWA Water Reuse Conference Proceedings 2000	Meeting TOC Requirements for California Groundwater-Recharge Projects	Electronic Copy: AWWA Water Reuse Proceedings, w1-1.pdf	Y	Y		X		X		X	U4	L13	R1						N		
				Staples	Michele A.	1992	Desalination, Vol:88, No:1-3, pp.189-199	How to Promote Water Reclamation and Reuse Through the California Water Rights System	Electronic Copy: Staples-1992.mht	Y	Y			X				R7								Y	Staples-1992.doc	Abstract Only
			WateReuse Association of California	MacLaggan	Peter M.	1994	Tech Report for WateReuse Association of California	California Water Policy: When is it a Waste and Unreasonable Use Not to Reclaim Water?	Abstract Only	Y	Y			X				R4	R5	R6	R13					Y	MacLaggan-1994.doc	Abstract Only
				MacLaggan	Peter M.	1995		Water Reclamation: A Summary of California Laws and Regulations	Hard Copy	Y	Y			X				R4	R5	R6	R13					Y	MacLaggan-1995.doc	
				York	David W.	2000	AWWA Water Reuse Conference Proceedings 2000	Water Reuse: At the Intersection of Environmental Programs	Electronic Copy: AWWA Water Reuse Conference Proceedings 2000, TU5-1.pdf	Y	Y			X			X	W2	R14	R15					TOC and Pathogens	N		Florida Regulations and Concerns
Sarasota County Natural Resources Dept., Sarasota FL				Kimes	J. K..	1994	Desalination vol. 102, no. 1 pp. 87-92; Proceedings of the 1994 biennial conference and exposition. Membrane and desalting technologies	The Regulation of Concentrate Disposal in Florida	Electronic Copy: Kimes et al-1994.pdf	Y	Y	X		X	X			R4	R7	R8	R13	R14	B5	U1		Y	Kimes-1994.doc	Florida Regulations for Brine Disposal
State of Florida						1996	State of Florida	State of Florida Chapter 62 Sections 600, 601, 610, 620		Y	Y			X	X			R1	R2	R3	R5	F15	U1	U2	U3, U9, and U14	Y	Florida Chapter 62.doc	
Florida Department of Environmental Protection				York	David W.	1998	AWWA Water Reuse Conference Proceedings 1998	Reuse in Florida: Moving Toward the 21st Century	Electronic Copy: York and Wadsworth-1998.pdf	Y	Y	X		X			X	W5	R1	R6	B5					Y	York et al-1998.doc	Direction of Regulations for Uses
				Garrigues	Robert M	1998	Proceedings. of Water Reuse Conference	City of West Palm Beach Reuse Feasibility Study	hard copy only	Y	Y		X	X	X			U10	L13	R4	R5					Y	Garrigues et al-1998.doc	
			CH2M HILL	Hall	Ken C.	2001	AWWA Water Reuse Conference Proceedings 2000	Guidelines for Potable Water Reuse in Georgia: Public Health, Water Supplies, and Vested Interests	Electronic Copy: Hall-CH2M HILL-2001.doc	Y	Y			X			X	R1	R4	R14	W4	R5				Y	Hall-CH2M HILL-2001.doc	Regulations in Georgia
Georgia Department of Natural Resources							Georgia Department of Natural Resources	Design Guidelines for Water Reclamation and Urban Water Reuse	Hard Copy Only	Y	Y			X				R1	R2	R3	R5	R15	U1	U2	U3, U9 and U14	Y	Georgia Design Guidelines -2001.doc	
Texas Water Development Board				Hoffman	H. W.	2000	AWWA Water Reuse Conference Proceedings 2000	Water Reuse in Texas A State Level Perspective	Electronic Copy: Hoffman-2000.pdf	Y	Y		X	X				L2	R5	R7						Y	Hoffman-2000.doc	Future Water Recycling Potential in Texas
				Plummer	Alan H.	2001	Proceedings. of AWWA Annual Conference	Reclaimed Water As a Water Supply Strategy in the State of Texas	Electronic Copy: Plummer and Coonan-2001.doc	Y	Y			X	X			R1	R4	R5	R6	U14				Y	Plummer and Coonan-2001.doc	Historical Perspective of Reuse in Texas
Texas Natural Resources Conservation Commission						1997	Texas Natural Resource Conservation Commission	Chapter 210: Use of Reclaimed Water	Hard Copy Only	Y	Y			X	X			R6	U9							Y	Texas NRCC ch 210 - 1997.doc	
				Miyamoto	S	2000	Texas A&M University Agricultural Research Center	El Paso Guidelines for Landscape Uses of Reclaimed Water with Elevated Salinity	Hard Copy Only	Y	Y			X	X			R4	R5	U3	U9					N		
Massachusetts Department of Environmental Protection							Massachusetts Department of Environmental Protection	Reclaimed Water Use: the Massachusetts Approach		Y	Y			X	X			R1	R2	R3	R5	U2	U3	U6	U9 and U14	Y	Massachusetts - Reclaimed Water.doc	
				Slater	Alan D.	2002	AWWA WEF Water Sources Conference 2002	Reclaimed Water Use: the Massachusetts Experience	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu1-5.pdf	Y	Y			X	X			R4	R5	U9	U11					N		Massachusetts Regulations for Uses of Recycled Water
Nevada Division of Environmental Protection								WTS-38: Guidance Documents for Design of Treated Effluent Reuse Sites	Hard Copy Only	Y	Y			X				R1	R2	R3	R5	R15	U1	U2	U3, U9 and U14	Y	Nevada Guidance WTS-38.doc	State Regulations
State of Nevada						1991	Nevada Administrative Code (NAC)	Nerved Administrative Code 455A.275	Hard Copy Only	Y	Y			X	X			R1	R2	R3	R5	R15	U1	U2	U3, U9, U14	Y	Nevada Admin Code.doc	State Regulations
Nevada Division of Environmental Protection						1991		WTS-9: Guidelines for Wastewater Treatment Plant Effluent Reuse	Hard Copy Only	Y	Y			X	X			R1	R2	R3	R5	U2	U3	U6	U9 and U14	Y	Nevada Guidelines WTS-9.doc	State Regulations

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				Okamura	Kyle R.	2002	AWWA WEF Water Sources Conference 2002	City of Henderson - "Fore"ging Ahead into the Future	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu8-2.pdf	Y	Y			X				R6	R7							N		Henderson, Nevada Regulations
State of New Jersey, Department of Environmental Protection						December, 1999 - Revised April 2000	Division of Water Quality	Technical Manual for Reclaimed Water for Beneficial Reuse	Hard Copy Only	Y	Y			X	X			R1	R2	R3	R5	U2	U3	U6	U9 and U14	Y	New Jersey Manual - 1999.doc	State Regulations
State of North Carolina Department of Environment, Health and Natural Resources						1996	Division of Environmental Management	Administrative Code Section: 15A NCAC 2H .0200 - Waste Not Discharged to Surface Waters	Hard Copy Only	Y				X	X			R1	R2	R3	R5	U2	U3	U6	U9 and U14	Y	North Carolina - Admin Code 15A.doc	State Regulations
				Shafer	Michael B.	2002	AWWA WEF Water Sources Conference 2002	Planning for Reuse In North Carolina	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu3-2.pdf	Y	Y			X	X			U6	U8	R5	R6					N		North Carolina Regulations
			CDM, Seattle, WA	Van Ripper	Craig R.	1993	AWWA Annual Conference Proceedings	Water Reuse to the Rescue: From Legislation and Regulations to Fast-Track Design and Construction	Hard Copy Only	Y	Y		X	X	X			R1	R4	R5	R7	L15	U14			Y	Van Riper et al-1993.doc	Washington State
				Van Riper	Craig	1998	AWWA Water Reuse Conference Proceedings 1998	Evolution of Water Reuse Regulations in Washington State	Electronic Copy: Van Riper et al-1998.pdf	Y	Y			X				R1	R5	R6	R7					Y	Van Riper et al-1998.doc	Regulations in Washington State
		(509) 456-2490 or (360) 407-7472	Washington State, Dept. of Health, Office of Environmental Health, Division of Drinking Water, 1500 W 4th Ave, Suite 305 Spokane, WA 99204	Washington State Dept of Health Office of the Secretary & Dept. of Ecology		1997	Washington State Dept of Health Office of the Secretary & Dept. of Ecology Report	Water Reclamation and Reuse Standards	Electronic Copy: Washington State-1997.pdf	Y	Y			X	X			R4	R5	R6	R11	U9				Y	Washington State-1997.doc	Water Recycling Standards for the State of Washington
State of Utah						2002	Utah Administrative Code	Rule R317-1. Definitions and General Requirements		Y	Y			X	X			R1	R2	R3	R5	U2	U3	U6	U9 and U14	Y	Utah Adm Code R317-1.doc	State Regulations
South Carolina Department of Health and Environmental Control						1990	Domestic Wastewater Division, Bureau of Water Pollution Control	Land Treatment of Domestic Wastewater: Planning, Design and Monitoring Guidance for Slow-rate Irrigation Projects	Hard Copy Only	Y	Y			X	X			R1	R2	R3	R5	U2	U3	U6	U9 and U14	Y	South Carolina - Land Treatment 1990.doc	State Regulations
Oregon Department of Environmental Quality						1991	Oregon Department of Environmental Quality	Oregon Administrative Rules Chapter 340, Division 55 - Department of Environmental Quality		Y	Y			X	X			R1	R2	R3	R5	U2	U3	U6	U9 and U14	Y	Oregon Admin Rules.doc	
Colorado Department of Public Health and Environment							Colorado Department of Public Health and Environment	Colorado Department of Public Health and Environment Water Quality Control Commission Regulation No. 84 - Reclaimed Domestic Wastewater Control Regulations		Y	Y			X				R1	R2	R3	R5	R15	U1	U2		Y	Colorado Reg No. 84-2000.doc	Also U3, U9 and U14
State of California							State of Arizona Code	Title 18. Environmental Quality. Chapter 11. Department of Environmental Quality Standards. Article 3. Reclaimed Water Quality Standards.		Y	Y			X	X			R1	R2	R3	R5	R15	U1	U2	U3, U9, and U14	Y	AZ Title 18.doc	
			Marin Municipal Water District, Corte Madera, CA	Feil	Kenneth F.	1990	Tech Report for Marin Municipal Water District, CA	Reclaimed Water Manual and Onsite User Requirements	Abstract Available	Y	Y			X				R6								Y	Feil-1990.doc	Water Recycling Manual Abstract Only
City of San Diego						1989	PPS Ground Services	Recycled Water Rules and Regulations	Hard Copy	Y	Y			X				R4	R5							Y	PPS Ground Services -1989.doc	
USDOI	http://www.usbr.gov			U.S. Department of Interior		2001	U.S. Department of Interior	Quality of Water. Colorado River Basin. Progress Report No. 20.	Hard Copy Only	Y	Y					X		S2	S4	S5	S7	S8	S10		Salinity	Y	Quality of Water Colorado River Basin_Jan01.doc	
				Ganesh	Rajagopalan	2002	AWWA WEF Water Sources Conference 2002	Feasibility of Using Municipal Reclaimed Water Systems for Once Through Cooling	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu10-2.pdf	Y	Y					X		S1	S3	S7						N		
The New York Times	www.nytimes.com			Blakslee	Sandra	2002	N Y Times	Restoring an Ecosystem Torn Asunder by a Dam	Hard Copy Only	Y	Y					X		S4	S5						Salinity on Colorado River	N		
				Toth	Lisa	2000	AWWA Water Reuse Conference Proceedings 2000	Salt Migration Study: Evaluating Effects of Recycled Water Application on a Downstream Water Supply	Electronic Copy: AWWA Water Reuse Conference Proceedings 2000, TU1-3.pdf	Y	N (In Progress)					X		S5							Salinity	Y	Toth et al-2000.doc	
				Sheikh	Bahman	2002	AWWA WEF Water Sources Conference 2002	Economic Impacts of Salt from Industrial and Residential Sources	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu17-2.pdf	Y	Y	X				X		S1	S2	S5	S6	S7	B5	B6	Salinity	N		Salinity
				McIntyre	Randy	2002	AWWA WEF Water Sources Conference 2002	Returned Reuse Water - Impacts and Approaches of Pollutant Concentration Buildup	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu8_2.pdf	Y	Y		X			X		L3	L7	L8	L14	S2	S4	S10		N		Four Case Studies
WateReuse				Toth	Lisa	1999	WateReuse	Is Your Watershed too Salty? Conducting a Salt Migration Study to Determine the Effect of Recycled Water Irrigation on a Downstream Water Supply	Hard Copy Only	Y	Y					X		S4	S5						Salinity	N		For Information Purposes Only
				Miyamoto	S	2000	Texas A&M University Agricultural Research Center	Potential Alternatives for Saline Water Handling Options	Hard Copy Only	Y	Y					X		S4	S5							N		
				Balliew	John E.	2000	AWWA Water Reuse Conference Proceedings 2000	Implementing a Reuse Program with High Salinity Reclaimed Water	Electronic Copy: AWWA Water Reuse Conference Proceedings 2000, TU1-1.pdf	Y	Ongoing		X			X		S1	L7	S2					Salinity	Y	Balliew et al-2000.doc	Salinity Issues in El Paso
				Froehlich	Dennis Anthony	2000	WateReuse Symposium Proceedings 2000	Salinity and Nitrogen Modeling for Water Conservation at the Tucson Ajo Detention Basin Environmental Restoration	Electronic Copy: WateReuse Symposium Proceedings 2000, 34.pdf	Y	Y				X	X		S4	U4	U6					Salinity and Nitrogen	Y	Froechlich-2000.doc	Modeling
City of Port Heueneme, CA		(805)986-6566	City of Port Heueneme, CA	Passanisi	Jim	2000	AWWA Annual Conference Proceedings	EDR, NF & RO at a Brackish Water Reclamation Facility	Electronic Copy: AWWA Annual-2000 Passanisi et al.pdf	Y	Y	X				X		B1	B4	S2	S6				Salt Loading to NF	Y	AWWA Annual-2000 Passanisi et al.doc	City of Port Hueneme, California
Irvine Ranch Water District				Spangenberg	Carl W.	2000	AWWA Water Reuse Conference Proceedings 2000	Recycled and Nonpotable Water Quality System Master Plan	Electronic Copy: AWWA Water Reuse Conference Proceedings 2000, W2-4.pdf	Y	Y	X				X		B6	S6							Y	Spangenberg-2000.doc	Permitting and Salinity
				Fipps	Guy	1995	Proceedings. of the First International Conference on Water Resources Engineering: Texas Water '95: Volume 1	Options for Saline Water Disposal - Irrigation Case Studies	Abstract Available	Y	Y					X		S1	S2	S5						Y	Fipps-1995.doc	Abstract Only
				Kennedy	John C.	1994	Proceedings. of Water Reuse Symposium	Salinity and Water Reuse in San Diego	Abstract Available	Y	Y					X		S1	S5	S6	S7					Y	Kennedy et al-1994.doc	Abstract Only

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				Ninemire	Steve	1995	Everything Under the Sun: 1995 International Exposition and Technical Conference Proceedings. Phoenix, AZ	Water Quality and the Use of Effluent Water	Abstract Available	Y	Y					X		S2	S3	S5						Y	Ninemire-1995.doc	Abstract Only
				Roohk	David L	1997	Water Resources Conference Proceedings, AWWA, Pacific Northwest Section, pp 515-526	Water Reuse and Groundwater Quality Protection	Abstract Available	Y	Y		X		X	X		S2	S6	L8	U10					Y	Roohk D.-1997 Water Resources Conf.doc	Abstract Only
			Boyle Engr. Corp., CA	Kartinen	Ernest O.	1998	AWWA Proceedings. of Membrane Technology Conference	Summary and Comparison of Seawater Desalting Projects in California	Hard Copy Only	Y	Y				X	X		S7	U7							Y	Kartinen-1993.doc	
	www.irwd.com	(949) 453-5300	Irvine Ranch Water District, 15600 Sand Canyon Avenue, Irvine, California 92618-3102	Irvine Ranch Water District		1999	Irvine Ranch Water District (IRWD)	IRWD Annual Water Quality Report - A report on reclaimed water quality for calendar year 1998	Electronic Copy: IRWD-1999.pdf	Y	Y					X	X	S8	W3	W4	W5				Salinity	Y	IRWD-1999.doc	IRWD Report on Recycled Water Quality for Calendar Year 1998
				Akiyoshi	Eric	2000	AWWA Water Reuse Conference Proceedings 2000	Salinity Management of Reclaimed Water Supplies	Electronic Copy: AWWA Water Reuse Conference Proceedings 2000, TU1-2.pdf	Y	Y			X		X		S10	L17						Salinity	Y	Akiyoshi-2000.doc	
				Jackson	Jo Ann	1991	Proceedings. of the 65th Annual Florida Water Resources Conference: Managing Florida's Water Resources--A Vision of the Future	Impact of Chlorides and Total Dissolved Solids on Reuse Feasibility	Abstract Available	Y	Y					X		S1	S5						Salinity and TDS	Y	Jackson-1991.doc	Salinity and TDS Abstract Only
			CH2M HILL	Brubaker	Greg	2001	CH2M HILL Draft Technical Memorandum	Alternatives for Beneficial Reuse of Effluent, Draft Technical Memorandum Prepared for Loudoun County Sanitation Authority	Electronic Copy: Brubaker&Kirk-CH2M HILL-2001.doc	Y	Y				X			U9	U5							Y	Brubaker&Kirk-CH2M HILL-2001.doc	
			East Bay Municipal Utility District	Johnson	Laura J.	2000	AWWA Annual Conference Proceedings	Water Reclamation Strategies to Compete in a Potable Water World	Electronic Copy: AWWA Annual-2000 Johnson et al.pdf	Y	Y		X		X		X	U1	U9	U11	W5	L2				Y	Johnson et al-2000 AWWA Annual.doc	East Bay Municipal Utility District Recycled Water Program
			Metropolitan Water District of Southern California	Bruno	Jeanne-Marie	1993	AWWA Annual Conference Proceedings	Water Reclamation in California: Metropolitan's Commitment	Hard Copy Only	Y	Y		X		X			L2	U11							Y	Bruno and Adams-1993.doc	
			City of Scottsdale, AZ	Vernon	William	2000	AWWA Annual Conference Proceedings	Scottsdale Water Campus: Reuse Solutions Using Microfiltration and Reverse Osmosis	Electronic Copy: AWWA Annual-2000 Vernon and Alexander.pdf	Y	Y		X		X			U10	L14							Y	AWWA Annual-2000 Vernon and Alexander.doc	City of Scottsdale, Arizona Water Campus Project
			South Bay Water Recycling, Environmental Services Dept. City of San Jose, CA	Rosenblum	Eric	1999	Water Science & Technology, Vol:40 No:4-5 pp.51-57	Selection and Implementation of Nonpotable Water Recycling in "Silicon Valley" (San Jose Area) California	Electronic Copy: Rosenblum-1999.doc	Y	Y		X		X	X		S5	S7	L16	U9					Y	Rosenblum-1999.doc	
				Williams	Rod	1998	AWWA Water Reuse Conference Proceedings 1998	Urban Water Reuse in Australia, A Selection of Case Studies and Demonstration Projects	Electronic Copy: Williams-1998.pdf	Y	Y			X	X			R15	U1	U3	R1					Y	Williams-1998.doc	Four Case Studies and Regulations in Australia
				Michalczyk	Bert	1998	AWWA Water Reuse Conference Proceedings 1998	Environmental and Facilities Planning for a Recycled Water Project in the San Ramon Valley	Electronic Copy: Michalczyk et al-1998.pdf	Y	Y		X	X	X			L6	R1	R7	U6	U13	U14			Y	Michalczyk et al-1998.doc	Recycled Water Project in the San Ramon Valley
				Jackson	Jo Ann	1998	Proceedings. of Water Reuse Conference	Investigation of the Use of Reclaimed Water as a Regional Alternative Water Supply	Electronic Copy: Jackson-1998.pdf	Y	Y		X		X			U4	U6	L2	L13					Y	Jackson-1998.doc	
				Cross	Phil	1998	Proceedings. of Water Reuse Conference	Water Conserve II: Past, Present and Future	Electronic Copy: Cross et al-1998.pdf	Y	Y		X		X			L2	L15	U4	U6					Y	Cross et al-1998.doc	
				Filice	Frank V.	1996	AWWA Annual Conference Proceedings, 1996	Trends In Public Attitudes Toward Reuse of Reclaimed Water in the San Francisco Bay Area	Electronic Copy: Filice-1996.pdf	Y	Y		X	X	X			R1	R5	U8	U11	U9	L11			Y	Filice-1996.doc	Public Attitudes in Bay Area
			Public Utilities Dept., City of St. Petersburg, FL	Johnson	William D.	1995	AWWA Annual Conference Proceedings	Responsible Recycling	Hard Copy Only	Y	Y		X		X			U6	U9	L2	L13	L15				Y	Jackson-1998.doc	
				Galuska	Craig M.	2001	AWWA New Horizons in Drinking Water Annual Conference., 2001	Water Reuse Cooperation Blooms in the Desert	Electronic Copy: AWWA New Horizons in Drinking Water Annual Conference. 2001, ACE01-TUE12-03.pdf	Y	Y		X	X	X			L2	L15	R7	U1	U5	L11	L14		Y	Galuska et al-2001.doc	Nevada
City of Tucson, Arizona			Malcolm Pirnie, Phoenix, AZ	Papadimas	Spyridon	2000	AWWA Annual Conference Proceedings	Evaluation of Reclaimed Water System Alternatives for City of Tucson Using Cybernetic Hydraulic Model	Electronic Copy: AWWA Annual-2000 Papadimas et al.pdf	Y	Y				X			U4								Y	AWWA Annual-2000 Papadimas et al.doc	City of Tucson Water Reclamation System Planning Alternatives
				Asano	Takashi	2001	WateReuse Symposium Proceedings 2001	Water Reuse - A Future Perspective	Electronic Copy: WateReuse Symposium Proceedings, 013B.pdf	Y	Y				X			U1	U9							N		Future Uses
Irvine Ranch Water District				Thompson	Kenneth	2000	AWWA Water Reuse Conference Proceedings 2000	Falling Into The "Gap"	Electronic Copy: AWWA Water Reuse Conference Proceedings 2000, W3-4.pdf	Y	Y				X			U8	U6							Y	Thompson and Vazirnia-2000.doc	
El Paso Water Utilities, Texas				Balliew	John E.	1993	AWWA Annual Conference Proceedings	Wastewater Reuse in an International Border Community	Hard Copy Only	Y	Y				X			U9	U10							Y	Balliew-1993.doc	
City of Santa Monica, California				Antich	Anthony	2000	WateReuse Symposium Proceedings 2000	The Santa Monica Urban Runoff Recycling Facility and the Sustainable Environment	Electronic Copy: WateReuse Symposium Proceedings 2000, 33.pdf	Y	Y			X	X			R9	U8							Y	Antich et al-2000.doc	Eliminate Runoff to Ocean Environment
Irvine Ranch Water District				Young	Ronald E.	1988	AWWA Annual Conference Proceedings	Irvine Ranch Water Reclamation Expands	Hard Copy Only	Y	Y		X		X			U5	U9	L14	L15					Y	Young-1988.doc	
				Okun	Daniel A.	1996	Desalination, Vol:106, Issues 1-3, pp. 205-212	Water Reclamation and Nonpotable Reuse: An Option for Meeting Urban Water Supply Needs	Electronic Copy: Okun-1996.pdf	Y	Y				X			U5	U6	U9						Y	Okun-1996.doc	
				Tanji	K.K.	1995	Proceedings. of the First International Conference on Water Resources Engineering: Texas Water '95: Volume 1	Irrigation With Marginal Quality Waters: Issues	Abstract Available	Y	Y				X			U1	U2							Y	Tanji-1995.doc	Abstract Only
				Van Leeuwen	J. Hans	1994	Proceedings. of the Recycled Water Seminar, Newcastle, New South Wales, Australia	Water Reclamation: Selection of Unit Processes	Abstract Available	Y	Y		X		X			U2								Y	Leeuwen-1994.doc	Abstract Only
				Bouwer	Herman	1994	Proceedings. of Water Reuse Symposium	Water Reuse and Groundwater Recharge	Abstract Available	Y	Y				X		X	U2	U8	U9	W4					Y	Bouwer-1994.doc	Abstract Only
			Black & Veatch, Boston	Crook	James	1996	Water Reuse Conference Proceedings, AWWA, pp 745-761	Water Reuse Strategy for Santiago, Chile	Abstract Available	Y	Y		X					U3	U5							Y	Crook et al-1996 Water Reuse Conf.doc	Abstract Only

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												Brine	Level of Use	Regulations	Use Type	Salinity	Water Chemistry											
Water Environment Research Foundation				Bosch	Rich ten	2002	AWWA WEF Water Sources Conference 2002	New Tools to Help Manage Water Quality in Open Reclaimed Water Storage Reservoirs	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu5-1.pdf	Y	Y			X	X			U4	R12							N		
NRC						1998	NRC	Issues in Potable Reuse. The Viability of Augmenting Drinking Water Supplies with Reclaimed Water	Hard Copy	Y	Y		X	X	X		X	L1	L12	R3	R4	R12	U2	U3	U4, U13, U14, W2, AND W4	Y	NRC - 1998.doc	
Water Sanitation and Health				Carr	Richard	2002	WHO	Public Health Implications of Water Reuse in the Food and Beverage Industry	Hard Copy Only	Y	Y		X		X			U3	L2							N		
WERF	www.werf.org		Bonnie Baily bbailey@werf.org	Miller	Gerald	On-going		Impact of Storage on Nonpotable Reclaimed Water: Seasonal and Long Term	Interim Project report Available	Y	N (In Progress)			X	X			R12	U4							N		Storage Issues
				Ammerman	David	2000	AWWA Water Reuse Conference Proceedings 2000	Using Reclaimed Water for Residential Toilet Flushing: A Pilot Project	Electronic Copy: AWWA Water Reuse Conference Proceedings 2000, W3-6.pdf	Y	Y				X			U8	U11							Y	Ammerman et al-2001.doc	Toilet Flushing
				Asano	Takashi	2000	WateReuse Symposium Proceedings 2000	Beyond Agricultural Irrigation: A Case of Urban Water Recycling in Japan	Electronic Copy: WateReuse Symposium Proceedings 2000, Abstract only, 28.pdf	Y	Y				X			U11	U8							Y	Asano-2000.doc	Non-potable Recycling in Japan, Toilet Flushing
				Richardson	Thomas G.	1998	Proceedings. of Water Reuse Conference	Reclaimed Water for Residential Toilet Flushing: Are We Ready?	Electronic Copy: Richardson-1998.pdf	Y	Y				X			U2	U7	U8	U11					Y	Richardson-1998.doc	
				Surendran	S.	1998	AWWA Water Reuse Conference Proceedings 1998	Development of In-House Water Reclamation Systems for Large Institutions	Electronic Copy: Surendran et al-1998.pdf	Y	Y				X			U5	U8	U11						Y	Surendran et al - 1998.doc	Grey water
				Hartmann	Julie	2001	Civil Engineering	Oakland High-Rise to Use Recycled Water	Hard Copy Only	Y	Y				X			U8	U11							Y	Hartmann-2001.doc	High-Rise Use of Toilet Flushing in Oakland
			Dept. of Envr. Engr., U. of North Carolina, Chapel Hill	Okun	Daniel A.	1997	Journal AWWA, Volume:89, Issue:11, pp.52-64	Distributing Reclaimed Water Through Dual Systems	Hard Copy Only	Y	Y		X	X	X			U8	U9	U10	L2	L17	R6	R12		Y	Okun-1997.doc	
	www.watereuse.org			Sheikh	Bahmam	1999	www.watereuse.org	Tertiary-Treated Reclaimed Water for Irrigation of Raw-Eaten Vegetables	Electronic Copy: Sheikh et al-1999.doc	Y	Y		X	X	X		X	W2	W4	U3	L14	R14				Y	Sheikh et al-1999.doc	Irrigation of Raw-Eaten Vegetables
				Al Salem	Saqer S.	1996	Water Science & Technology, Vol:33 No:10-11, pp.345-353	Environmental Considerations for Wastewater Reuse in Agriculture	Electronic Copy: Al Salem-1996.pdf	Y	Y		X		X	X	X	U3	U14	L2	L6	S1	S5	W4		Y	Al Salem-1996.doc	
City of Santa Rosa				Cort	Robin P.	1998	AWWA Water Reuse Conference Proceedings 1998	How Much can Santa Rosa Expand its Water Reuse Program?	Electronic Copy: Cort et al-1998.pdf	Y	Y		X		X			L4	L13	U4	U6	U14				Y	Cort et al-1998.doc	Agricultural use vs. geysers project
CH2M HILL		714-429-2020	CH2M HILL/ SCO	CH2M HILL		2001	CH2M HILL's Feasibility Evaluation for an Industrial Client	Reuse of Mill Effluent to Cultivate Hardwood Trees	CH2M Florida Hardwd.pdf	Y	Y				X		X	W2	U2	U3	U6					Y	CH2M Florida Hardwd.doc	Reuse of Mill Effluent to Cultivate Hardwood Trees; Project from Reuse SOQ
CH2M HILL		714-429-2020	CH2M HILL/ SCO	CH2M HILL		2001	CH2M HILL's Design/Build/Operate Project for an Industrial Client	Reuse of Industrial Wastewater for Poplar Tree Production	CH2M HILL Albany.pdf	Y	Y				X	X	X	W2	W3	S1	S3	U2	U3	U6	Nitrogen	Y	CH2M HILL Albany.doc	Project from Reuse SOQ
	www.watereuse.org			Sheikh	B.		www.watereuse.org	Hygienic Evaluation of Reclaimed Water Used to Irrigate Food Crops-A Case Study	Electronic Copy: Sheikh et al.pdf	Y	Y				X		X	W2	W4	W5	U3	U14			Pathogens	Y	Sheikh et al.doc	Impact of Pathogens in Food Crop Irrigation
				Friedler	Eran	2001	Water Policy, Vol:3, pp.29-39	Water Reuse-an Integral Part of Water Resources Management: Israel as a Case Study	Electronic Copy: Friedler-2001.pdf	Y	Y				X		X	U3	U4	U14	W2	W4	W5		BOD	Y	Friedler-2001.doc	
				Powell	David E.	2000	WateReuse Symposium Proceedings 2000	Case Study and Economic Evaluation : El Dorado Irrigation District Recycled Water Program	Electronic Copy: WateReuse Symposium Proceedings 2000, Abstract only, 39.pdf	Y	Y			X	X			U9	R2	U5						Y	Powell-2000.doc	Urban Irrigation Costs
WateReuse Association	http://www.watereuse.org/Pages/information.html					1999	WateReuse Association	Use of Recycled Water to Augment Potable Supplies: An Economic Perspective	Hardcopy Only	Y	Y			X	X			R12	U14						Project Economics	Y	WateReuse Augment Potable Supply - 1999.doc	
				Thompson	Donald M.	1999	Proceedings. of AWWA Annual Conference	Balancing Environmental and Potable Water Quality Needs in Indirect Potable Reuse Projects	Electronic Copy: Thompson et al-1999.pdf	Y	Y				X		X	U2	U10	W2	W3	W5			Iron and Phosphorus	Y	Thompson et al-1999.doc	Iron and Phosphorus
			NRC	Crook	James	1999	Journal AWWA, Volume:91, Issue:8, pp.40-49	Potable Use of Reclaimed Water	Hard Copy Only	Y	Y		X		X		X	U3	U10	U9	W2	L11	L12			Y	Crook et al-1999 JAWWA.doc	
			Upper Occoquan Sewage Authority, Centreville, VA	Robbins	Millard H.		AWWA Annual Conference Proceedings	Supplementing a Surface Water Supply with Reclaimed Water	Hard Copy Only	Y	Y		X		X			U4	U5	L14						Y	Robbins-1993.doc	UOSA
				Beverly	Sharon D.	2002	AWWA WEF Water Sources Conference 2002	Indirect Potable Reuse and Aquifer Injection of Reclaimed Water	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu12-3.pdf	Y	Y				X		X	W4	U1	U10						N		
				Matheis	Mary Aileen	2000	WateReuse Symposium Proceedings 2000	Wetlands Water Supply: Why not Recycled Water?	Electronic Copy: WateReuse Symposium Proceedings 2000, 37.pdf	Y	Y			X	X			U4	U6	U12	R6	R1	R10		Nitrogen and Phosphorus	N		Public Opinion
				Rall	Kathy	2001	WateReuse Symposium Proceedings 2001	Percolation and Beyond: The Restoration of a Habitat	Electronic Copy: WateReuse Symposium Proceedings, 016.pdf	Y	Y		X		X			U1	L13	U4						N		Groundwater Recharge
				Carpenter	Guy W.	2000	WateReuse Symposium Proceedings 2000	Team Development and Operation of a Community Recharge	Electronic Copy: WateReuse Symposium Proceedings 2000, Abstract only, 43.pdf	Y	Y		X	X	X			L13	R11	U10						Y	Carpenter et al-2000.doc	Recharge in Wildlife Habitat; Abstract of UT4401
				Miller	Phillip	2001	WateReuse Symposium Proceedings 2001	Recycled Water for Lake Elsinore: A New Perspective	Electronic Copy: WateReuse Symposium Proceedings, 005.pdf	Y	Y				X		X	U10	U4	W4					Nutrients	N		Lake Restoration
Washington State Dept of Ecology		Donna Lynch (360) 407-7529	dlyn461@ecy.wa.gov	Washington State Dept of Ecology		2000	Washington State Dept of Ecology Report	Water Reclamation and Reuse-The Demonstration Projects	Electronic Copy: Washington State-2000.pdf	Y	Y		X	X	X			U4	U6	L16	L17	R6	R11	R13		Y	Washington State-2000.doc	Water Recycling Demonstration Projects
				Colbath	Russell	2002	AWWA WEF Water Sources Conference 2002	Water Reclamation for Non-Traditional uses Industrial Applications and Wetland Construction	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu3-3.pdf	Y	Y				X			U4	U9							N		
WERF	www.werf.org		Margaret Stewart mstewart@werf.org	Warren-Hicks	William	On-going		Develop Technically Based Site-Specific Measures for Identifying the Ecological Impacts Associated With Nutrients	Interim Report Available	Y	N (In Progress)		X		X			L16	U4						Nutrients	N		Nutrients
				Mujeriego	Rafael	1996	Water Science & Technology, Vol:33 No:10-11, pp.335-344	Agronomic and Public Health Assessment of Reclaimed Water Quality for Landscape Application	Electronic Copy: Mujeriego et al-1996.doc	Y	Y		X		X	X	X	U9	L3	L6	W4	W5	S5	S10	Nutrients, Metals, and Salinity	Y	Mujeriego et al-1996.doc	
				Bloetscher	Frederick	1998	AWWA Annual Conference Proceedings, 1998	Innovative Uses of Reclaimed Water Reduce Stress on Hollywood Water Supply	Electronic Copy: Bloetscher et al-1998.pdf	Y	Y		X		X			U3	U9	L13						Y	Bloetscher et al-1998.doc	Hollywood, Florida
				Dorn	Ronald	1997		Use of Reclaimed Wastewater for Snoqualmie Ridge, Washington	dorn-1997.pdf	Y	Y			X	X			R3	U9	U3						Y	Dorn - 1997.doc	

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				Farebee	David L	1996	Water Reuse Conference Proceedings, AWWA, pp 1095-1106	The Balancing Act: Achieving Total Reuse	Abstract Available	Y	Y				X			U4	U9							Y	Farabee et al-1996 Water Reuse Conf.doc	Abstract Only
			California DHS	Crook	James	2000	AWWA Annual Conference Proceedings	New and Improved Draft Groundwater Recharge Criteria in California	Electronic Copy: AWWA Annual-2000 Crook et al.pdf	Y	Y		X	X	X		X	W2	W4	L13	U6	R1	R6	R11	U1, U2, U10	Y	AWWA Annual-2000 Crook et al.doc	California DHS Groundwater Recharge Criteria
				McGovern	Lucia	2001	WateReuse Symposium Proceedings 2001	A Blue Ribbon Panel Review of Injecting 100% Recycled Water into the West Coast Basin Seawater Barrier	Electronic Copy: WateReuse Symposium Proceedings, 035.pdf	Y	Y		X		X		X	W3	L2	L13	U1	U10				Y	McGovern-2001.doc	Saltwater Barrier
				Close	Christine	2001	WateReuse Symposium 2001	Recharge Feasibility Assessment for the City of Phoenix North Gateway Water Reclamation Plant	Electronic Copy: WateReuse Symposium. 2001, 033.pdf	Y	Y		X	X	X			U10	L13	R15	U4					Y	Close et al-2001.doc	
				Chalmers	Bruce	2000	Water Quality Technology Conference 2000 Proceedings	Protecting Southern California's Groundwater the Alamitos Barrier Recycled Water Project	Electronic Copy: Water Quality Technology Conference Proceedings 2000, P-13f.pdf	Y	Y		X		X			L13	L2	U1						Y	Chalmers et al-2000.doc	Seawater Barrier
				Corneille	Richard	2000	WateReuse Symposium Proceedings 2000	The Groundwater Replenishment System a Supplemental Source of High Quality Water for Orange County Project Development Phase Update	Electronic Copy: WateReuse Symposium Proceedings 2000, Abstract only, 23.pdf	Y	Y		X		X			L2	U10	L13						N		
				Ng	Hoover H.	1998	AWWA Water Reuse Conference Proceedings. 1998	Los Angeles' New Groundwater Recharge Project	Electronic Copy: Ng et al-1998.pdf	Y	Y		X		X			L13	U1	U10						Y	Ng-1998.doc	East Valley Project
				Bouwer	Herman	1998	AWWA Water Reuse Proceedings 1998	Artificial Recharge for Reuse and Storage	Electronic Copy: Bouwer-1998.pdf	Y	Y		X		X	X		U1	U4	U10	S4	S5	L13			Y	Bouwer-1998.doc	Soil Aquifer Treatment
Orange County Water District				Chalmers	Bruce R.	2000	AWWA Annual Conference Proceedings	Selection of a Microfiltration Process for the Groundwater Replenishment System, The Largest Advanced Recycled Water Treatment Plant in the World	Electronic Copy: AWWA Annual-2000 Chalmers et al.pdf	Y	Y		X		X			L13	U10							Y	AWWA Annual-2000 Chalmers et al.doc	GWRS Project for OCWD (currently in design phase)
CH2M HILL				CH2M HILL	CH2M HILL	2001	CH2M HILL Report	Reuse Plan Update for the Medford Regional Water Reclamation Facility prepared for the City of Medford	Electronic Copy: City of Medford-CH2M HILL-2001.doc	Y	Y		X	X	X			L13	U10	R11						Y	City of Medford-CH2M HILL-2001.doc	
Plum Creek Wastewater Authority, Colorado				Grotheer	Tim	2000	AWWA Annual Conference Proceedings	Plum Creek Wastewater Authority Regional Reuse Master Plan Update	Electronic Copy: AWWA Annual-2000 Grotheer et al.pdf	Y	Y		X	X	X		X	U10	L14	L2	W5	R12	U2			Y	AWWA Annual-2000 Grotheer et al.doc	Plum Creek Wastewater Authority Reuse Master Plan
				Rigby	Martin G.	1991	Proceedings. AWWA Annual Conference	Direct Injection of Recycled Water Into Potable Aquifers	Abstract Available	Y	Y		X		X			U10	L13							Y	Rigby and Mills-1991.doc	OCWD WF-21 Abstract Only
				Frost	Lonnie K.	1993	American Water Resources Association: Proceedings. of the Symposium on Effluent Use Management , pp 13-22	The Town of Gilbert's Operational Experience With Recharge and Recovery of Reclaimed Water	Abstract Available	Y	Y				X			U1	U10							Y	Frost et al-1993.doc	Abstract Only
				Chalmers	R. Bruce	2001	AWWA New Horizons in Drinking Water Annual Conference., 2001	The Groundwater Replenishment System: A New, Reliable, Cost-Effective Source of Water for Southern California	Electronic Copy: AWWA New Horizons in Drinking Water Annual Conference. 2001, ACE01-WED27-01.pdf	Y	Y		X	X	X			R12	L2	L13	U11	U6				N		
				Cearley	Dan	2002	AWWA WEF Water Sources Conference 2002	Fountain Hills Sanitary District: Resource Management Based on Direct Reuse and Aquifer Storage and Recovery	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, rm1_2_3.pdf	Y	Y				X			U1	U4							N		
NCSWS	www.eas.asu.edu/~civil/ncsws	480-727-7605	National Center for Sustainable Water Supply (NCSWS)	NCSWS		2001	Ongoing Research Project Summary-NCSWS	Investigation on Soil-Aquifer Treatment for Sustainable Water Reuse	Electronic Copy: NCSWS Research Project Summary White paper.pdf	Y	N (In Progress)						X	W2	W3	W4	W5				Nitrogen, Pathogens, Organics, Trace Organics, and Endocrine Disrupters	Y	NCSWS Research Project Summary White paper.doc	Soil-Aquifer Treatment
				Crook	James	1994	Proceedings. of Water Reuse Symposium	Assessment of Water Reclamation and Reuse Research Needs	Abstract Available	Y	Y						X	W2	W4							Y	Crook et al-1994.doc	Abstract Only
WE&T						2002	USGS	USGS: Chemical Contamination of U.S. Waters Widespread; Effects Unknown	Hard Copy Only	Y	Y						X	W2	W3	W4					Contaminants in U.S. Waterways	N		
WERF	www.werf.org		Bonnie Bailey bbailey@werf.org	Hartley	Troy	On-going		Water Reuse - Understanding Public Perception and Participation	Interim Report Available	Y	N (In Progress)				X		X	U9	W4							N		Public Perceptions
NWRI				Harry	Ridgway	2001	NWRI	Rejection of Pharmaceuticals by Reverse Osmosis Membranes: Quantitative Structure Activity Relation (QSAR) Analysis	Hard Copy	Y	Ongoing						X	W3	W4							Y	Ridgway-2001.doc	
California Water Law and Policy Reporter						2002	California Water Law and Policy Reporter	New United States Geological Survey Study Examines the Unintentional Medication of Water Supplies	Hard Copy	Y	Y						X	W2	W4							N		
CDC	www.cdc.gov		Ronald Ash zzash@washburn.edu	Ash	Ronald	2002	CDC	Antibiotic Resistance of Gram-Bacteria in Rivers, United States	Hard Copy Only	Y	Y						X	W2	W3	W4					Antibiotics in U.S. Waterways	N		
				Ternes	Thomas A.	2002	Environemntal Science Technology	Removal of Pharmaceuticals During Drinking Water Treatment	Electronic Copy	Y	Y						X	W2	W3	W3	W4	W5			Pharmaceuticals	N		
National Academies		202-334-2138	Cheryl Greenhouse			1999	The National Academies	Research Needed to Reduce Scientific Uncertainty About Effects of Hormonally Active Agents in the Environment	Electronic Copy: National Academies-1999.mht	Y	Y						X	W4	W2						Endocrine Disrupters (hormonally active agents)	Y	National Academies - 1999.doc	
USGS						2000	USGS	National Reconnaissance of Emerging Contaminants in the Nation's Waters	Electronic Copy: USGS-2000.mht	Y	Y						X	W2	W4						Endocrine Disrupters	Y	USGS-2000.doc	
				Christian	Kris	1998	Water Environment and Technology	Human Estrogen Could Be Causing Adverse Effects on Fish	Hard Copy Only	Y	Y						X	W2	W4						Endocrine Disrupters	Y	Christian-1998.doc	
AWWA				Trussell	R. Rhodes	2001	Journal AWWA	Endocrine Disrupters and the Water Industry	Hard Copy Only	Y	Y						X	W2	W4						Endocrine Disrupters	N		
				Dessof	Alan	1992	Water Environment and Technology	Endocrine Disrupters Need Further Research, Peers Say	Hard Copy Only	Y	Y						X	W2	W4						Endocrine Disrupters	Y	Dessoff-1992.doc	
				Hun	Tara	1998	Water Environment and Technology	Studies May Indicate Drugs in Water May Come From Effluent Discharges	Hard Copy Only	Y	Y						X	W2	W4						Endocrine Disrupters	Y	Hun-1998.doc	
Environmental Agency of Great Britain				Desbrow	C.	1998	Environmental Science Technology	Identification of Estrogenic Chemicals in STW Effluents	Hard Copy Only	Y	Y						X	W2	W4						Endocrine Disrupters	N		
National Research Council						1999	National Academy of Sciences	Hormonally Active Agents in the Environment	Hard Copy Only	Y	Y						X	W2	W4						Endocrine Disrupters	N		
U.K. Department of the Environment				Harries	Jule E.	1997	Environmental Toxicology Chemistry	Estrogenic Activity in Five United Kingdom Rivers Detected by Measurement of Vitellogenesis in Caged Male Trout	Hard Copy Only	Y	Y						X	W2	W4						Endocrine Disrupters	N		
Southern Nevada Water Authority				Roefer	Peggy	2000	Journal AWWA, Volume:92, Issue:8, pp.52-58	Endocrine Disrupting Chemicals in Source Water	Hard Copy Only	Y	Y						X	W2	W4						Endocrine Disrupters	Y	Roefer et al-2000.doc	
EPA						2000	Federal Register	Endocrine Disrupter Screening Program - Report to Congress	Hard Copy Only	Y	Y			X			X	W2	W4	R1	R3	R4	R5	R11	Endocrine Disrupters	N		
Ministry of Education and Research (BMBF) Germany				Ternes	T. A.	1999	Science Total Environment	Behavior and Occurrence of Estrogens in Municipal Sewage Treatment Plants	Hard Copy Only	Y	Y						X	W2	W4						Endocrine Disrupters	N		
EPA						1998	Federal Register	Announcement of Drinking Water Contaminants List	Hard Copy Only	Y	Y			X			X	R8	R3	W2	W4				Endocrine Disrupters	N		

APPENDIX B-1
RESOURCE DATABASE

Check if Topic Applies to Concern Below

Funding Agency	Website Address (If Applicable)	Contact Phone Number	Contact Email or Address	Author Last Name	Author First Name	Year Published	Source of Material (Publication)	Article or Paper Name	Filename	Article/Paper Available (Y/N)	Research Completed (Y/N)	Brine	Level of Use	Regulations	Use Type	Salinity	Water Chemistry	Reference Code for Concerns							If Applicable, Constituent of Concern	Article Summary Available (Y/N)	Filename of Summary	Miscellaneous Comments
U. K. Department of the Environment				Harries	Jule E.	1996	Environmental Toxicology Chemistry	A Survey of Estrogenic Activity in United Kingdom Inland Waters	Hard Copy Only	Y	Y						X	W2	W4							N		
USGS				Kolpin	Dana	2002	Environ. Sci. Tech.	Pharmaceuticals, Hormones, and Other Contaminants in U.S. Streams, 1999-2000: A National Reconnaissance	Electronic Copy: Kolpin et al-2002.pdf	Y	Y						X	W2	W4						Endocrine Disrupters	N		Occurrence data on endocrine disrupters
CH2M HILL	www.ch2m.com (internal web site)		Daniel Karen	Karen	Daniel	2002	Internal White Paper	Endocrine Disrupting Chemicals: Short Review of the Hypothesis, Agency Activity, and Recent Scientific Literature	Electronic Copy: Karen-2002.pdf	Y	Draft Document						X	W4	W2						Endocrine Disrupters	Y	Karen-2002.doc	
USEPA				Daughton	Christian	1999	Environmental Health Perspectives	Pharmaceuticals and Personal Care Products in the Environment: Agents of Subtle Change?	Electronic Copy: Daughton-1999.mht	Y	Y						X	W2	W4						Endocrine Disrupters (PPCPs)	Y	Daughton-1999.doc	Evaluation of PPCPs, very good review paper
CALFED				Spies	Robert			A Survey of Endocrine Disrupting Chemicals and Occurrence of Fish Reproductive Dysfunction in the CALFED Area	Hard Copy	Y	Research Proposal						X	W2	W4						Endocrine Disrupters	Y	Spies et al.doc	Occurrence Study
Wisconsin State Laboratory of Hygiene			Wisconsin State Laboratory of Hygiene, Madison, WI	Hemming	Jocelyn D.C.	2001	AWWA WQTC Conference Proceedings	Assessment of Source and Drinking Waters for Estrogenic Endocrine Disruption	Electronic Copy: AWWA WQTC-2001 Hemming et al.pdf	Y	Y						X	W2	W4						Endocrine Disrupters	Y	AWWA WQTC-2001 Hemming et al.doc	Introduction Has a Literature Review
						2002	Newsweek	What's Killing the Frogs	Hard Copy	Y	Y						X	W2	W4							N		For Information Only
The New York Times	www.nytimes.com			Cushman	John	2002	N Y Times	New Study Adds to Debate on EPA Rules for Pesticide	Hard Copy Only	Y	Y						X	W2	W3	W4					Pesticides	N		
WERF	www.wef.org		Renee Johnson johnson.renee@epa.gov	McGovern	Patricia	2002		Endocrine Disrupters: The Next Generation of Regulatory Concern	Hard Copy Only	Y	Y						X	W2	W3	W4					Endocrine Disrupters	N		
CH2MHILL		714-429-2020 ext. 2232		Soroushian	Fred	1993	CH2MHILL	Complying with Water Quality based Limits for Metals Source Control and treatment Options for Water Reclamation Plants	Hardcopy Only	Y	Y				X		X	W3	U2						Metals	Y	Soroushian - Limits for Metals 1993.doc	
				Adin	A	1999	Water Science & Technology, Vol:40 No:4-5 pp.67-74	Particle Characteristics: A Key Factor in Effluent Treatment and Reuse	Electronic Copy: Adin-1999.doc	Y	Y						X	W2	W4							Y	Adin-1999.doc	Particles in Recycled Water
AWWARF				Drewes	Jorg E.	1999	Water Science & Technology, Vol:40 No:4-5 pp.391-398	Behavior and Characterization of Residual Organic Compounds in Wastewater Used for Indirect Potable Reuse	Electronic Copy: Drewes and Fox-1999.doc	Y	Y						X	W3	W4						Residual Organic Compounds	Y	Drewes and Fox-1999.doc	Residual Organic Compounds
National Center for Sustainable Water Supply				Drewes	Jorg E.	2000	AWWA Water Reuse Conference Proceedings 2000	The Impact of Divalent Cations in Source Water on Residual DOC Concentration in Indirect Potable Reuse Systems	Electronic Copy: AWWA Water Reuse Conference Proceedings 2000, W1-1a.pdf	Y	Y						X	W4	W3						Organic Compounds	Y	Drewes-2000.doc	Impact on Residual DOC Concentration
National Center for Sustainable Water Supply & County Sanitation Districts of Los Angeles County				Fox	Peter	2000	AWWA Water Reuse Conference Proceedings 2000	Watershed Analysis of Water Reuse Systems	Electronic Copy: Fox et al-2000.pdf	Y	Y						X	W2	W3	W4					Natural organic matter, synthetic organic compounds, nutrients, pathogens	Y	Fox et al-2000.doc	Watershed quality vs reclaimed water quality
				Fujita	Yoshiko	1996	Water Environment Research, Vol:68, No:5, pp.867-876	Identification of Wastewater Dissolved Organic Carbon Characteristics in Reclaimed Wastewater and Recharged Groundwater	Hard Copy Only	Y	Y						X	W2	W4						Organic Compounds Identified in the Water Factory-21 Recycled Water and Recharged Groundwater	Y	Fujita et al-1996.doc	
NWRI				Ding	Wang-Hsien	1996	Fresenius' Journal of Analytical Chemistry, Vol:354, pp.48-55	Identification of Organic Residues in Tertiary Effluents by GC/EI-MS, GC/CI-MS and GC/TSQ-MS	Hard Copy Only	Y	Y						X	W2	W4						Organic Compounds Identified in the Water Factory-21 Recycled Water	Y	Ding et al-1996.doc	
				Drewes	Joerg E.	1999	Proceedings. of AWWA Annual Conference	Drinking Water TOC Impacts on Reclaimed Water and Consequences for Regulations of Water Reuse Systems	Electronic Copy: Drewes et al-1999.pdf	Y	Y						X	W2	W4						TOC	Y	Drewes et al-1999.doc	Impact of Drinking Water TOC Levels
				Pai	Punda	2002	AWWA WEF Water Sources Conference 2002	Challenges of Meet High Reclaimed Water Quality in Clark County, Nevada	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu2_4.pdf	Y	Y						X	W4								Y	Pai et al-2002.doc	
				Spotts	Peter N.	2002	Christian Science Monitor	What's in the Water?	Hard Copy Only	Y	Y						X	W2	W4							Y	Spotts-2002.doc	
				Drewes	Joerg E.	1998	Water Research, Vol:32 No:10 pp.3125-3133	Behavior of DOC and AOX Using Advanced Treated Wastewater for Groundwater Recharge	Electronic Copy: Drewes and Jekel-1998.doc	Y	Y						X	W2	W4	W3					DOC and AOX	Y	Drewes and Jekel-1998.doc	DOC and AOX
				Olivieri	A. W..	1998	Proceedings. of Water Reuse Conference 1998	Comparative Chemical Risk Assessment of Repurified Water from an Advanced Water Treatment Facility and a Raw Drinking Water Supply	Electronic Copy: Olivieri et al-1998.pdf	Y	Y			X			X	W2	W3	W4	W5	R5	R6	R12		Y	Olivieri et al - 1998.doc	Risk Assessment in San Diego, California
				Freeman	Scott	1995	AWWA Membrane Technology Conference. Proceedings, 1995	An Update on Membrane Water Reuse Projects	Electronic Copy: Freeman-Crook-1995.pdf	Y	Y						X	W3								Y	Freeman and Crook - 1995.doc	Case Studies of Selected Arizona Projects
City of San Diego				Olivieri	A. W.	2000		Microbial Challenge Studies at the Aqua 2000 Research Center	Hardcopy	Y	Y						X	W3	W4	W5					Microorganisms/ Pathogens	Y	Olivieri et al - 2000.doc	
Napa Sanitation District				Fraser	John	1998		Algae Laden Pond Effluent- Tough Duty for Reclamation Filters	Electronic Copy: Fraser and Pan-1998.pdf	Y	Y						X	W4	W3						Algae	Y	Fraser et al - 1998.doc	
West Basin MWD				Abi-Samra	B. C.	2001	Proceedings. of AWWA Annual Conference	The Use of MF and RO to Treat Secondary Wastewater Plant Effluent and Provide High Quality Reclaimed Water	Electronic Copy: Abi-Samra et al-2001.pdf	Y	Y						X	W3	W5							Y	Abi-Samra et al-2001.doc	Membranes
Black and Veatch				Freeman	Scott. D. N.	1995	Desalination, Vol:103, pp.19-30	Recent Developments in Membrane Water Reuse Projects	Electronic Copy: Freeman and Morin-1995.doc	Y	Y				X		X	U2	W3							Y	Freeman and Morin-1995.doc	
				Mujeriego	Rafael	1999	Water Science & Technology, Vol:40 No:4-5 pp.1-9	The Role Advanced Treatment in Wastewater Reclamation and Reuse	Electronic Copy: Mujeriego and Asano-1999.doc	Y	Y				X		X	U2	W4							Y	Mujeriego and Asano-1999.doc	Advanced Treatment Technologies for Water Recycling
				Adin	Avner	1998	Water Science & Technology, Vol:37 No:10 pp.79-90	The Role of Physical-chemical Treatment in Wastewater Reclamation and Reuse	Electronic Copy: Adin and Asano-1998.doc	Y	Y						X	W3	W4							Y	Adin and Asano-1998.doc	Pathogens and Treatment Effectiveness
CH2M HILL				Fleischer	Ed	1999	CH2M HILL TM	Review of Membrane Processes for Water Reclamation Applications, TM prepared for Loudoun County Sanitation Authority	Electronic Copy: Fleischer-CH2M HILL-1999.doc	Y	Y						X	W3	W4							Y	Fleischer-CH2M HILL-1999.doc	Membranes in Water Recycling
			Dept. Of Civil & Envr. Engr., U. Of Cincinnati	Cicek	Nazim	1998	Journal AWWA, Volume:90, Issue:11, pp.105-113	Using a Membrane Bioreactor to Reclaim Wastewater	Hard Copy Only	Y	Y						X	W2	W4							Y	Cicek et al-1998.doc	
UOP Fluid Systems, CA				Filteau	Gerard H.	1995	AWWA Annual Conference Proceedings	Membrane Separation Experience in Municipal Wastewater Reuse	Hard Copy Only	Y	Y						X	W3	W4							Y	Filteau and Klinko-1988.doc	
CH2M HILL				Lozier	Jim	2001	CH2M HILL White Paper	Membrane Processes in Municipal Wastewater Reclamation: An Update	Electronic Copy: Lozier&Bergman-CH2M HILL-2001.doc	Y	Y				X		X	W3	W4	U2	U5					Y	Lozier&Bergman-CH2M HILL-2001.doc	Comparison of membrane processes with respect to their use in reclamation
				Sollner	Anke I.	2000	WateReuse Symposium Proceedings 2000	Water Reuse Systems - Membranes Versus Groundwater Recharge - Balancing Treatment Alternatives and Water Quality Considerations	Electronic Copy: Sollner et al-2000.pdf	Y	Y		X				X	W3	W4	L12					DOC as NOM, AOX, SMP, DBPs, and SOCs	Y	Sollner et al-2000.doc	Membranes vs. SAT

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Funding Agency	**Website Address (If Applicable)**	**Contact Phone Number**	**Contact Email or Address**	**Author Last Name**	**Author First Name**	**Year Published**	**Source of Material (Publication)**	**Article or Paper Name**	**Filename**	**Article/Paper Available (Y/N)**	**Research Completed (Y/N)**	**Brine**	**Level of Use**	**Regulations**	**Use Type**	**Salinity**	**Water Chemistry**	**Reference Code for Concerns**							**If Applicable, Constituent of Concern**	**Article Summary Available (Y/N)**	**Filename of Summary**	**Miscellaneous Comments**
City of Scottsdale, Arizona				Clune	Jim	2001	WateReuse Symposium 2001	Operational and Water Quality Results from a Large Scale Indirect Potable Reuse Facility in Scottsdale Arizona	Electronic Copy: WateReuse Symposium Proceedings 2001, Abstract only, 036.pdf	Y	Y				X		X	W3	W4	U2					TOC, TS, and Microbes	Y	Clune et al-2001.doc	Water Quality for Indirect Potable Reuse
CH2M HILL				CH2M HILL	CH2M HILL	1997	CH2M HILL Power Point Presentation	Potable Water Reuse Technology & Application, presented to Georgia Potable Water Reuse Task Force	Electronic Copy: Georgia-CH2M HILL-1997.doc	Y	Y				X		X	W3	U10							Y	Georgia-CH2M HILL-1997.doc	Treatment Technologies
				Thompson	Ken	1992	Desalination, Vol:88, No:1-3, pp.201-214	City of San Diego Potable Reuse of Reclaimed Water: Final Results	Electronic Copy: Thompson et al-1992.mht	Y	Y						X	W4								Y	Thompson et al-1992.doc	Potential Health Risks Abstract Only
				Lauer	W. C..	1990	J. of Toxicology and Environmental Health, Vol:30, No:4, pp.305-321	Comprehensive Health Effects Testing Program for Denver's Potable Water Reuse Demonstration Project	Electronic Copy: Lauer et al-1990.mht	Y	Y						X	W2								Y	Lauer et al-1990.doc	Health Effects and Toxicology
				Ganoulis	Jacques	1996	Water Science and Technology, Vol:33, No:10 11, pp.297-302	Risk Analysis of Wastewater Reclamation and Reuse	Electronic Copy: Ganoulis and Papalopoulou-1996.mht	Y	Y						X	W2								Y	Ganoulis and Papalopoulou-1996.doc	Health-Risk Analysis
				Alexander	Kevin	2001	AWWA Membrane Technology Conference. 2001	Optimum Reverse Osmosis for the Groundwater Replenishment System Fountain Valley, California	Electronic Copy: Alexander et al-2001.pdf	Y	Y		X			X	X	S6	S9	L7	W2	W3	W5		GWR System	Y	Alexander et al-2001.doc	
				McEwen	Brock	1996	Proceedings. of Water Reuse Conference	Indirect Potable Reuse: Committee Report	Abstract Available	Y	Y				X		X	W3	W5							Y	McEwen and Richardson-1996.doc	
				Dawes	Thomas M.	1999	AWWA Membrane Technology Conference. 1999	Meeting the Demand for Potable Water in Orange County in the 21st Century: The Role of Membrane Processes	Electronic Copy: Dawes et al-1999.pdf	Y	Y		X		X		X	U10	W3	W4	L8	L13				Y	Dawes et al-1999.doc	
				Le Gouellec	Yann A	2001	AWWA Water Quality Technology Conference Proceedings, 2001	Treatment Requirements for Microfiltration Residuals Intended for Recycle	Electronic Copy: AWWA Water Quality Technology Conference. Proceedings, WQTC01-Wed07-02.pdf	Y	Y						X	W3								Y	Le Goellec et al-2001.doc	
				Sethi	Sandeep	2001	AWWA New Horizons in Drinking Water Annual Conference., 2001	Evaluation of Microfiltration for Microbial Removal in Reuse Applications: Performance Assessment from Three Pilot Studies	Electronic Copy: Sethi et al-2001.pdf	Y	Y						X	W3	W4						Microbials (Coliforms)	Y	Sethi et al-2001.doc	Use of MF for reclamation purposes
				Randall	Andrew Amis	2000	AWWA Step Up To The Future Annual Conference 2000	Changes in Biostability by Nanofiltration	Electronic Copy: AWWA Step Up To The Future Annual Conference. 2000 Proceedings, mon10-5.pdf	Y	Y						X	W3							TDS Effect on Nanofiltration	N		
NWRI						1993	NWRI	Fouling and Module Design Workshop	Hard Copy	Y	Y						X	W3								Y	Fouling Workshop-1993.doc	
NWRI						1999	NWRI	Non-Potable Water Recycling	Hard Copy	Y	Y		X	X	X		X	L11	R5	R12	R13	R14	U2	U3	U4, W2, W3, AND W4	Y	NWRI Workshop 1999.doc	
NWRI				Belfort	Georges	1994	NWRI	Dean Vortex Instabilities for Reducing Concentration Polarization and Fouling and for Developing New Membrane Module Designs	Hard Copy	Y	Y						X	W3								Y	Belfort at all-1994.doc	
AMWA	www.EPA.gov					2002	AMWA	Draft EPA Report Urges Expansion of Health Effects Database	Hard Copy Only	Y	Y						X	W2	W3	W4					DBP	N		
						1998	NWRI	Microfiltration II Conference Proceedings	Hard Copy Only	Y	Y			X			X	R14	W2							Y	Microfiltration II - 1998.doc	
				York	David. W	1998	Proceedings. of Water Reuse Conference	Protozoan Pathogens: A Comparison of Reclaimed Water and Other Irrigation Waters	Electronic Copy: York and Burg-1998.pdf	Y	Y			X			X	W4	R4						Protozoan Pathogens	Y	York and Burg-1998.doc	Protozoan Pathogens
Florida Department of Environmental Protection				Rose	Joan B.	1996	Water Research, Vol:30 No:11, pp.2785-2797	Removal of Pathogenic and Indicator Microorganisms by a Full-Scale Water Reclamation Facility	Electronic Copy: Rose et al-1996.doc	Y	Y						X	W2	W4							Y	Rose et al-1996.doc	Pathogens
				Rose	Joan B.	1999	Water Science & Technology, Vol:40 No:4-5 pp.247-252	Public Health Evaluation of Advanced Reclaimed Water for Potable Applications	Electronic Copy: Rose et al-1999.doc	Y	Y						X	W2	W4						Microorganisms/ Pathogens	Y	Rose et al-1999.doc	Microorganisms/Pathogens
				York	David W.	2002	AWWA WEF Water Sources Conference 2002	Pathogens in Reclaimed Water: The Florida Experience	Electronic Copy: AWWA WEF Water Sources Conference Proceedings 2002, reu17_1.pdf	Y	Y						X	W4							Pathogens	Y	York et al-2002.doc	
AWWARF				Kaplan	Louis	2002	AWWARF	Evaluation of Sources of Pathogens and NOM in Watersheds	Hard Copy Only	Y	Y						X	W2	W3	W4					Pathogens	N		
WERF	www.werf.org		Bonnie Bailey bbailey@werf.org	Rose	Joan.	On-going		Reduction of Pathogens, Indicator Bacteria, and Alternative Indicators by Wastewater Treatment and Reclamation Processes	Interim Report Available	Y	N (In Progress)				X		X	U2	W4						Pathogens	N		Pathogens
WERF	www.werf.org		Jami Montgomery, jmontgomery@werf.org	Blum	Paul	On-going		Understanding the Viability of Pathogens During Disinfection	Interim Report Available	Y	N (In Progress)						X	W4							Pathogens	N		Pathogens
				Hull	Victor	2002	Sarasota Flordia Herald Tribune	Study Finds Germs in Reclaimed Wastewater	Hard Copy Only	Y	Y						X	W2	W3	W3	W4	W5			Cryptosporidium and Giardia	N		
Reedy Creek Energy Services				Kohl	H. Robert	1993	AWWA Membrane Conference Proceedings, 1993	Reclamation of Secondary Effluent with Membrane Processes	Electronic Copy: Kohl et al-1993.pdf	Y	Y			X				R6	W3	W4	W5	U3	S5		Nitrogen and Phosphorus	Y	Kohl et al -1993.doc	
San Antonio Water Systems	SAWS.org	210-704-7529	kdiehl@saws.org	Allianza			Internal Report	Preliminary Assessment of Recycled Water Quality & Leaf Damage	Hard Copy Only	N	Y					X		S10							Salinity	N		
WERF	www.werf.org		Bonnie Baily bbaily@werf.org	Mantovani	Pier	On-going		Nonpotable Water Reuse Management Practices	Interim Project Report available	N	N (In Progress)				X			U2								N		System Management
WERF	www.werf.org		Jeff Moeller jmoeller@werf.org	Wallace	Scott.	On-going		Feasibility, Design Criteria, and O&M Requirements for Small Scale Constructed Wetland Wastewater Treatment Systems	Interim Report Available	N	N (In Progress)															N		
CH2M HILL				Leaf	William	2001	CH2M HILL	Endocrine Disrupters and Pharmaceutically Active Compounds	Electronic Copy	N	Y				X		X	W2	W4	U3					Endocrine Disrupters	N		
WERF	www.werf.org		Jami Montgomery, jmontgomery@werf.org	Adham	Samer		WERF Web-Site	Emerging Treatment Technologies of Water Reclamation	Final Report Available	N	Y				X			U2								N		Treatment Technology
AWWARF	awwarf.com	303-347-6188	crayburn@awwarf.com	Zander	Amy	2000	AWWARF	Current Management of Membrane Plant Concentrate		N	Y	X						B5							Salinity	N		
WERF	www.werf.org		Jeff Moeller jmoeller@werf.org	Fitzpatrick	James	On-going		Assessment of Availability and Use of Hydrodynamic, Runoff, and Fate and Transport Models	Interim Report Available	N	N (In Progress)		X		X			U4	L16							N		Fate and Transport

Appendix B-2
List of Concerns by Category

APPENDIX B-2
LIST OF CONCERNS BY CATEGORY

Codes	Brine
B1	What are the effects of concentrating constituents of concern in brine flow?
B2	How does brine concentration (and at what level) affect coastal habitats?
B3	How does increased brine generation impact the ocean?
B4	How does the use of seawater affect brine concentration and capacity in brinelines/outfall pipelines?
B5	What are alternative methods for disposal (deep well injection)?
B6	What are the impacts/methods/costs for disposal of increased brine?
B7	What level of brine concentration affects habitat negatively?

Codes	Level of Use
L1	What level of recycled water use will result in regulatory changes by agencies?
L2	How much availability (existing and future) is there for use of recycled water (Salt level, TOC (health concerns), nitrogen, physical operation of barrier)?
L3	Can there be too much recycling (salt loading)?
L4	How much availability is there for use of recycled water for production/assimilative capacity?
L5	What are the effects of reducing influent salinity into system (leaching of soil)?
L6	What are the effects of salinity on basin receiving waters and the environment?
L7	What level of salinity is of concern / What are the costs associated with salinity on recycled water?
L8	What upstream projects are being considered to change (either positively or negatively) salinity?
L9	When and what type of upstream measures make source control a viable measure?
L10	When does the cost of source control exceed the cost to RO MWDSC supply?
L11	Which levels of concentration are a concern to stakeholders and users?
L12	What are the effects of other constituents on recycled water (i.e. bromide, pharmaceuticals)?
L13	How does the use of recycled water effect groundwater systems?
L14	What are the impacts of high levels of recycling?
L15	What effects does water conservation have on water reuse?
L16	What level of discharge is required to protect existing riverine habitats (min and max flows)?
L17	How will and what will be the effects of changes in the discharge regulations (including return flows) on recycled water use?

Codes	Regulations
R1	How will and what will be the effects of changes in the discharge regulations (including return flows) on recycled water use?
R2	How will changes in beneficial use designations in the basin plans affect recycled water use?
R3	How will changes in regulations such as using drinking water goals as MCLs impact recycled water?
R4	How will future regulations affect change in use of recycled water?
R5	Will changes to regulations limit or expand recycled water use?
R6	How do discharge requirements (existing and future) affect recycled water use?
R7	How will changes in recycled water use affect water rights?
R8	How will changes in the Clean Water Act affect recycled water use?
R9	How will changes in the Ocean Plan affect recycled water use?
R10	How will SWRCB handle appeals to permits and use beneficial use designations related to recycled water?
R11	What are the effects of new discharge regulations on the environment?
R12	What are the issues affecting use of recycled water for transport/storage/ potable use?
R13	What is the cost associated with discharging to meet more stringent regulations versus implementing recycled water projects?
R14	What level of recycled water use will result in regulatory changes by agencies?
R15	What are the regional differences in groundwater management and regulations pertaining to recycled water?

APPENDIX B-2
LIST OF CONCERNS BY CATEGORY

Codes	Use Type
U1	What are the regional differences in groundwater management and regulations pertaining to recycled water?
U2	How does water chemistry effect treatment processes for recycled water production?
U3	What are constituents of concern for users?
U4	How does transport/storage of recycled water affect the environment (based on different treatment levels)?
U5	How does use of recycled water affect discharge both within and to the treatment plant?
U6	How does use of recycled water affect discharge/runoff?
U7	How does use of seawater desalination affect influent water quality?
U8	What are the aesthetic concerns facing the use of toilet flushing including color, odor, and effects on plumbing mechanisms?
U9	What are the barriers to use of recycled water for urban irrigation?
U10	What are the effects of recharging recycled water (quality concerns positive and negative)?
U11	What is the current and future potential market for toilet flushing and is the market cost effective?
U12	How will changes in beneficial use designations in the basin plans affect recycled water use?
U13	How will changes in regulations such as using drinking water goals as MCLs impact recycled water?
U14	How will future regulations affect change in use of recycled water?

Codes	Salinity
S1	How much availability (existing and future) is there for use of recycled water (Salt level, TOC (health concerns), nitrogen, physical operation of barrier)?
S2	Can there be too much recycling (salt loading)?
S3	How much availability is there for use of recycled water for production/assimilative capacity?
S4	What are the effects of reducing influent salinity into system (leaching of soil)?
S5	What are the effects of salinity on basin receiving waters and the environment?
S6	What level of salinity is of concern / What are the costs associated with salinity on recycled water?
S7	What upstream projects are being considered to change (either positively or negatively) salinity?
S8	When and what type of upstream measures make source control a viable measure?
S9	When does the cost of source control exceed the cost to RO MWDSC supply?
S10	Which levels of concentration are a concern to stakeholders and users?

Codes	Water Chemistry
W1	What are the effects of concentrating constituents of concern in brine flow?
W2	What are the effects of other constituents on recycled water (i.e. bromide, pharmaceuticals)?
W3	How does water chemistry effect treatment processes for recycled water production?
W4	What are constituents of concern for users?
W5	How much availability (existing and future) is there for use of recycled water (Salt level, TOC (health concerns), nitrogen, physical operation of barrier)?

Appendix C
Summaries of Sources

The source summaries are enclosed on the attached CD.

Appendix D
Regional Water Quality Control Board
Beneficial Use Tables

Appendix D-1
Los Angeles Regional Water Quality Control Board

Table 2-1. Beneficial Uses of Inland Surface Waters.

WATERSHED[a]	Hydro. Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
VENTURA COUNTY COASTAL STREAMS																									
Los Sauces Creek	401.00	P*	I	I	I	I				I	I			I	I				E			I	I		
Poverty Canyon	401.00	P*	I	I	I	I				I	I			I	I				E			I	I		
Madranio Canyon	401.00	P*	I	I	I	I				I	I			I	I				E			I	I		
Javon Canyon	401.00	P*	I	I	I	I				I	I			I	I				E			I	I		E
Padre Juan Canyon	401.00	P*	I	I	I	I				I	I			I	I				E			I	I		
McGrath Lake c	403.11									Ed	Ed	P					E		E		Ee				E
Big Sycamore Canyon Creek	404.47	P*				I				I	I			I	E				E			P	P		E
Little Sycamore Canyon Creek	404.45	P*								I	I			I					E		E		P		
VENTURA RIVER WATERSHED												E													
Ventura River Estuary c	402.10							E		E	E	E		E			E	E	E		Ee	Ef	Ef	E	E
Ventura River	402.10	P*	E		E	E	E			E	E			E	E				E		E	E	E		E
Ventura River	402.20	E	E	E	E	E	E			E	E			E	E				E		Eg	E	E		E
Cañada Larga	402.10	P*		I	I	I	I			I	I			I	I				E			I	I		
Lake Casitas	402.20	E	E	E	E	P	P		P	Ph	E			E	E				E		E				
Lake Casitas tributaries	402.20	E*			P	E				E	E			E	E				E		P	E	E		E
Coyote Creek below dam	402.20	P*				E				P				E	E				E			E	E		E
San Antonio Creek	402.20	E	E	E	E	E				E	E			E	E				E			E	E		E
San Antonio Creek	402.32	E	E	E	E	E	E			E	E			E	E				E			E	E		E
Lion Creek	402.31	I*	I	I	I					I	I			I	I				E						
Reeves Creek	402.32	I*	I	I	I	I				I	I			I	I				E			I	I		
Mirror Lake	402.20	P*				E				P	E			E					E						E
Ojai Wetland	402.20	P*								P	E			E					E						E
Matilija Creek	402.20	P*				E				E	E				E				E			E	E		E
Murietta Canyon Creek	402.20	P*				E				E	E				E				E			E	E		E
North Fork Matilija Creek	402.20	E*	E	E	E	E				E	E			E	E				E		E	E	E		E
Matilija Reservoir	402.20	E			E	E	E			E	E			E	E				E			E	E		E
SANTA CLARA RIVER WATERSHED																									
Santa Clara River Estuary c	403.11							E		E	E	E					E	E	E		Ee	Ef	Ef		E
Santa Clara River	403.11	P*	E	E	E	E	E			E	E			E	E				E		E	E			E
Santa Clara River	403.21	P*	E	E	E	E	E			Ed	E			E					E		E	E			E
Santa Clara River	403.31	P*	E	E	E	E	E			Ed	E			E					E		E	E			E
Santa Clara River	403.41	P*	E	E	E	E	E			E	E			E					E		E	E			E
Santa Clara River	403.51	P*	E	E	E	E	E			E	E			E					E		E				E
Santa Clara River (Soledad Cyn)	403.55	E*	E	E	E	E	E			E	E			E					E		Ei				E
Santa Paula Creek	403.21	P	E	E	E	E	E			E	E			E	E				E		E	E	E		

E: Existing beneficial use
P: Potential beneficial use
I: Intermittent beneficial use
E, P, and I shall be protected as required
* Asterixed MUN designations are designated under SB 88-63 and RB 89-03. Some designations may be considered for exemptions at a later date. (See pages 2-3,4 for more details).

Footnotes are consistent on all beneficial use tables.

a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries. Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody. Any regulatory action would require a detailed analysis of the area.
c Coastal waterbodies which are also listed in Coastal Features Table (2-3) or in Wetlands Table (2-4).
d Limited public access precludes full utilization.
e One or more rare species utilize all ocean, bays, esturaries, and coastal wetlands for foraging and/or nesting.
f Aquatic organisms utilize all bays, estuaries, lagoons and coastal wetlands, to a certain extent, for spawning and early development. This may include migration into areas which are heavily influenced by freshwater inputs.
g Condor refuge.
h Water contact recreational activities prohibited by Casitas MWD.
i Soledad Canyon is the habitat of the Unarmored Three-Spine Stickleback.

Table 2-1. Beneficial Uses of Inland Surface Waters (Continued).

WATERSHED[a]	Hydro. Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
SANTA CLARA RIVER WATERSHED (CONT)																									
Sisar Creek	403.21	P	E	P	E	E				E	E			E	E				E		Eg		E		E
Sisar Creek	403.22	P	E	P	E	E				E	E			E	E				E		Eg		E		E
Sespe Creek	403.31	P	E	E	E	E				E	E			E	E				E	E	E	E	E		E
Sespe Creek	403.32	P	E	P	E	E				E	E			E	E				E	E	Eg	E	E		E
Timber Creek	403.32	P*				E				E	E				E				E	E	E	E	E		E
Bear Canyon	403.32	P*				E				E	E			E	P				E	E	E	E	E		E
Trout Creek	403.32	P*				E				E	E			E	E				E		E	E	E		E
Piedra Blanca Creek	403.32	P*				E				E	E				E				E		E	E	E		E
Lion Canyon	403.32	P*				E				E	E			E	E				E			E	E		E
Rose Valley Creek	403.32	P*				E				E	E			E	E				E				E		E
Howard Creek	403.32	P*				E				E	E				E				E	E	E	E	E		E
Tule Creek	403.32	P*				E				P	E				P				E	E	E	E	E		E
Potrero John Creek	403.32	P*				E				E	E				P				E		E	E	E		E
Hopper Creek	403.41	P*	E		E	E	E			E	E			E	E				E		Eg				E
Piru Creek	403.41	P	E	E	E	E	E			E	E			E	E				E		Eg	E	E		E
Piru Creek	403.42	P	E	E	E	E	E			E	E			E	E				E		Eg		E		E
Lake Piru	403.41	P	E	E	E	E	P			E	E			E	E				E		E		E		
Lake Piru	403.42	P	E	E	E	E	P		P	E	E			E	E				E		E		E		
Pyramid Lake	403.42	E	E	E	E	E	P		E	E	E			E	E				E		E				
Cañada de los Alamos	403.43	I*			I	I	I			I	I			I	I				E		E				
Gorman Creek	403.43	I*			I	I				I	I			I	I				E		P				
Lockwood Creek	403.42	I*			I	I				I	I			I	I				E						
Lockwood Creek	403.44	I*			I	I	I			I	I			I	I				E						
Tapo Canyon	403.41	P*			P					P	E			E					E						
Castaic Creek	403.51	I	I	I	I	I	I			I	E			I					E		E				
Castaic Lagoon	403.51	E*	E	E	E	E	E			E	E			E					E						
Castaic Lake	403.51	E	E	E	E	E	E		E	E	E			E	I				E		E		E		
Elderberry Forebay	403.51	E	E	E	E	E	E		E	Ek	E			E					E		E		E		
Elizabeth Lake Canyon	403.51	I	I	I	I	I	I			I	E			I					E						
San Francisquito Canyon l	403.51	I	I	I	I	I	I			I	I			I					E		E		I		E
South Fork (Santa Clara River)	403.51	I*	I	I	I	I	I			I	I			I					E						
Drinkwater Reservoir	403.51	P*				E				Pk	E			P					E		E				E
Bouquet Canyon	403.51	E I	E I	P I	P I	E	P			Em	E			E	E				E				P		E
Bouquet Canyon	403.52	P	P	P	E	E	P			Em	E			E	E				E		E				E
Dry Canyon Creek	403.51	I	I	I	I	I	I			I	I			I					E						
Dry Canyon Reservoir j	403.51	E	E	E	E	P	P		P	Pk	E			E					E						
Bouquet Reservoir	403.52	E	E	E	E	E	E		P	Pk	E			E					E						

E: Existing beneficial use
P: Potential beneficial use
I: Intermittent beneficial use
E, P, and I shall be protected as required
* Asterixed MUN designations are designated under SB 88-63 and RB 89-03. Some designations may be considered for exemptions at a later date. (See pages 2-3,4 for more details).

Footnotes are consistent on all beneficial use tables.
a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries. Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody. Any regulatory action would require a detailed analysis of the area.
g Condor refuge.

j Out of service.
k Public access to reservoir and its surrounding watershed is prohibited by Los Angeles County Department of Public Works.
l The majority of the reach is intermittent; there is a small area of rising ground water creating perennial flow.
m Access prohibited by Los Angeles County Department of Public Works in the concrete-channelized areas.

Table 2-1. Beneficial Uses of Inland Surface Waters (Continued).

WATERSHED[a]	Hydro. Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
SANTA CLARA RIVER WATERSHED (CONT)																									
Mint Canyon Creek	403.51	I	I	I	I	I	I			Im	I			I					E						
Mint Canyon Creek	403.53	I*	I	I	I	I	I			Im	I			I					E						
Agua Dulce Canyon Creek	403.54	I*	I	I	I	I	I			I	I			I					E		E				
Agua Dulce Canyon Creek	403.55	I*			I	I	I			I	I			I					E						
Aliso Canyon Creek	403.55	P*			P	E				E	E			E					E						E
Lake Hughes	403.51	P	P	P	P	P	P			E	E			E					E						
Munz Lake	403.51	P*	P	P	P	E	P			E	E			E					E						
Lake Elizabeth	403.51	P	P	P	P	P	P			E	E			E					E		E				
CALLEGUAS-CONEJO CREEK WATERSHED																									
Mugu Lagoon c	403.11							E		Pn	E	Ed					E	E	Eo	E	Ee,p	Ef	Ef	Ed	E
Calleguas Creek Estuary c	403.11							P		Pn	E	E					E		E		Ee,p	Ef	Ef		E
Calleguas Creek	403.11	P*			E	E	E			E	E			E	E				E		Ep				E
Calleguas Creek	403.12	P*	E	E	E	E				Eq	E			E					E						
Revolon Slough	403.11	P*	P		E	E				Eq	E			E					E						E
Beardsley Wash	403.61	P*					E			E	E			E					E						
Conejo Creek	403.12	P*	E	E	E	E				Eq	E			E					E						
Conejo Creek	403.63	P*				I	I			I	I			I					E				E		
Arroyo Conejo	403.64	P*				I	I			I	I			I					E		E				
Arroyo Conejo	403.68	P*				I	I			I	I			I					E						
Arroyo Santa Rosa	403.63	P*				I	I			I	I			I					E						
Arroyo Santa Rosa	403.65	P*				I	I			I	I			I					E						
North Fork Arroyo Conejo	403.64	P*			E	E				E	E			E					E				E		
Arroyo Las Posas	403.12	P*	P	P	P	E				E	E			E	P				E						
Arroyo Las Posas	403.62	P*	P	P	P	E	E			E	E			E	P				E						
Arroyo Simi	403.62	P*	I			I	I			I	I			I					E		E				
Arroyo Simi	403.67	I*	I			I	I			I	I			I					E						
Tapo Canyon Creek	403.66	I*		P	P	I				I	I			I					E						
Tapo Canyon Creek	403.67	I*		P	P	I				I	I			I					E						
Gillibrand Canyon Creek	403.66	P*				I	I			I	I			I					E						
Gillibrand Canyon Creek	403.67	P*				I				I	I			I					E						
Lake Bard (Wood Ranch Reservoir)	403.67	E	E	E	E	P				Pr	Er			E					E						
LOS ANGELES COUNTY COASTAL STREAMS																									
Arroyo Sequit	404.44	P*				I				E	E			E	E				E		E	E	E		E
San Nicholas Canyon Creek	404.43	P*								I	I			I					E						

E: Existing beneficial use
P: Potential beneficial use
I: Intermittent beneficial use
E, P, and I shall be protected as required
* Asterixed MUN designations are designated under SB 88-63 and RB 89-03. Some designations may be considered for exemptions at a later date. (See pages 2-3,4 for more details).

Footnotes are consistent on all benefical use tables.
a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries
Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody. Any regulatory action would require a detailed analysis of the area.
c Coastal waterbodies which are also listed in Coastal Features Table (2-3) or in Wetlands Table (2-4).
d Limited public access precludes full utiliazation.
e One or more rare species utilize all ocean, bays, esturaries, and coastal wetlands for foraging and/or nesting.
f Aquatic organisms utilize all bays, estuaries, lagoons and coastal wetlands, to a certain extent, for spawning and early development. This may include migration into areas which are heavily influenced by freshwater inputs
m Access prohibited by Los Angeles County DPW in the concrete-channelized areas.
n Area is currently under control of the Navy: swimming is prohibited.
o Marine habitats of the Channel Islands and Mugu Lagoon serve as pinneped haul-out areas for one or more species (i.e., sea lions).
p Habitat of the Clapper Rail.
q Whenever flow conditions are suitable.
r Public access prohibited by Calleguas MWD.

Table 2-1. Benefical Uses of Inland Surface Waters (Continued).

WATERSHED[a]	Hydro. Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
LA COUNTY COASTAL STREAMS (CONT)																									
Los Alisos Canyon Creek	404.42	P*								I	I			I					E		E				
Lachusa Canyon Creek	404.42	P*								I	I			I					E						
Encinal Canyon Creek	404.41	P*								I	I			I					E		E				
Trancas Canyon Creek	404.37	E*								Em	E			E					E		E				
Dume Lagoon c	404.36							E		E	E	E					E		E		Ee	Pf	Pf		E
Dume Creek (Zuma Canyon)	404.36	E*								E	E			E	E				E		E	P	P		
Ramirez Canyon Creek	404.35	I*								I	I			I					E				P		
Escondido Canyon Creek	404.34	I*								I	I			I					E		E				
Latigo Canyon Creek	404.33	I*								I	I			I					E		E				
Solstice Canyon Creek	404.32	E*								E	E			E					E			P	P		
Puerco Canyon Creek	404.31	I*								I	I			I					E						
Corral Canyon Creek	404.31	I*								I	I			I					E						
Carbon Canyon Creek	404.16	P*								I	I			I					E						
Las Flores Canyon Creek	404.15	P*								I	I			I					E						
Piedra Gorda Canyon Creek	404.14	P*								I	I			I					E						
Pena Canyon Creek	404.13	P*								I	I			I	E				E						
Tuna Canyon Creek	404.12	P*								I	I			I					E						
Topanga Lagoon c	404.11							E		E	E	E					E		E		Ee	Ef	Ef		E
Topanga Canyon Creek	404.11	P*								I	I			E	E				E			P	I		
Santa Ynez Canyon	405.13	P*								I	E			I					E		E				
Santa Ynez Lake (Lake Shrine)	405.13	P*								Pk	E			E					E						
Santa Monica Canyon Channel	405.13	P*								Ps	I			P					P						
Rustic Canyon Creek	405.13	P*								I	I			I					E						
Sullivan Canyon Creek	405.13	P*								I	I			I					E						
Mandeville Canyon Creek	405.13	P*								I	I			I					E						
Coastal Streams of Palos Verdes	405.11	P*				I				I	I			I					E		E				
Canyon Streams trib. to Coastal Streams of Palos Verdes	405.12	P*				I				I	I			I					E		Et				
Bixby Slough and Harbor Lake	405.12	P*								E	E			E					E		E				E
Los Cerritos Wetlands c	405.15							E		E	E	E					E		E		Ee	Pf	Pf	E	E
Los Cerritos Channel Estuary c	405.12		E					E		Es	E	E					E	E	E		Ee	Ef	Ef	E	
Sims Pond	405.15	P*								P	E			P					E						E
Los Cerritos Channel to Estuary	405.15	P*								P	I			I					E						
Colorado Lagoon	405.12									E	E	E		P					E					E	
Madrona Marsh	405.12									P	E			P					E						E
Stone Canyon Reservoir	405.13	E*	E	E		P				Pk	E			E					E						
Hollywood Reservoir	405.14	E*	E	E		P				Pk	E			E					E						
Franklin Canyon Reservoir	405.14	E*								Pk,u				Pu											
Upper Franklin Canyon Reservoir	405.14	E*	E	E		P				P	E			E					E						E

E: Existing beneficial use
P: Potential beneficial use
I: Intermittent beneficial use
E, P, and I shall be protected as required
* Asterixed MUN designations are designated under SB 88-63 and RB 89-03. Some designations may be considered for exemptions at a later date. (See pages 2-3,4 for more details).

Footnotes are consistent on all benefical use tables.
a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries
Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody. Any regulatory action would require a detailed analysis of the area.
c Coastal waterbodies which are also listed in Coastal Features Table (2-3) or in Wetlands Table (2-4).
e One or more rare species utilize all ocean, bays, esturaries, and coastal wetlands for foraging and/or nesting.
f Aquatic organisms utilize all bays, estuaries, lagoons and coastal wetlands, to a certain extent, for spawning and early development. This may include migration into areas which are heavily influenced by freshwater inputs.

k Public access to reservoir and its surrounding watershed is prohibited by the Los Angeles Department of Water and Power.
m Access prohibited by Los Angeles County DPW in the concrete-channelized areas.
s Access prohibited by Los Angeles County DPW.
t Rare applies only to Agua Magna Canyon & Sepulveda Canyon areas.
u These reservoirs are covered and thus inaccessible.

Table 2-1. Benefical Uses of Inland Surface Waters (Continued).

WATERSHED[a]	Hydro. Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
MALIBU CREEK WATERSHED																									
Malibu Lagoon c	404.21							E		E	E						E	E	E		Ee	Ef	Ef		E
Malibu Creek	404.21	P*								E	E			E	E				E		E	E	E		E
Cold Creek	404.21	P*								E	E				P				E		E		P		E
Las Virgenes Creek	404.22	P*								Em	E			E	P				E		E	P	P		E
Century Reservoir	404.21	P*								E	E			E					E						E
Malibou Lake	404.24	P*						E		E	E			E					E		E				E
Medea Creek	404.23	P*				I				Im	I			I	P				E		E				E
Medea Creek	404.24	I*				I				Em	E			E					E						E
Lindero Creek	404.23	P*								I	I			I					E						
Triunfo Creek	404.24	P*								Im	I			I					E						
Triunfo Creek	404.25	P*				I				Im	I			I					E		E				
Westlake Lake	404.25	P*						E		E	E			E					E						
Potrero Valley Creek	404.25	P*				I				I	I			P					E						
Lake Eleanor Creek	404.25	P*				I				I	I			I					E						
Lake Eleanor	404.25	P*				E				E	E			E					E		E				E
Las Virgenes (Westlake) Reservoir	404.25	E	E	E	E					Pk,v	E			P					E						
Hidden Valley Creek	404.26	I*				I				I	I			I					E						
Lake Sherwood	404.26	P*				E		E		E	E			E					E						E
BALLONA CREEK WATERSHED																									
Ballona Creek Estuary c,w	405.13							E		E	E	E					E	E	E		Ee	Ef	Ef	E	
Ballona Lagoon/ Venice Canals c	405.13							E		E	E	E					E	E	E		Ee	Ef	Ef	E	E
Ballona Wetlands c	405.13									E	E						E		E		Ee	Ef	Ef		E
Del Rey Lagoon c	405.13							E		E	E	E					E		E		Ee	Ef	Ef		E
Ballona Creek to Estuary	405.13	P*								Ps	E			P					P						
Ballona Creek	405.15	P*								Ps	E			P					E						
DOMINGUEZ CHANNEL WATERSHED																									
Dominguez Channel Estuary c,w	405.12							P		Es	E	E					E	E	E		Ee	Ef	Ef		
Dominguez Channel to Estuary	405.12	P*								Ps	E			P					P		E				
LOS ANGELES RIVER WATERSHED																									
Los Angeles River Estuary c,w	405.12		E					E		E	E	E					E	E	E		Ee	Ef	Ef	P	E
Los Angeles River to Estuary	405.12	P*	P	P		E				Es	E			E				E	E		E	P	P	Ps	
Los Angeles River	405.15	P*	P			E				Es	E			E					P						
Los Angeles River	405.21	P*	P			E				E	E			E					E						E
Compton Creek	405.15	P*				E				Es	E			E					E						E

E: Existing beneficial use
P: Potential beneficial use
I: Intermittent beneficial use
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* Asterixed MUN designations are designated under SB 88-63 and RB 89-03. Some designations may be considered for exemptions at a later date. (See pages 2-3,4 for more details).

Footnotes are consistent on all beneficial use tables.
a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries
Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody.
Any regulatory action would require a detailed analysis of the area.
c Coastal waterbodies which are also listed in Coastal Features Table (2-3) or in Wetlands Table (2-4).
e One or more rare species utilize all ocean, bays, esturaries, and coastal wetlands for foraging and/or nesting.
f Aquatic organisms utilize all bays, estuaries, lagoons and coastal wetlands, to a certain extent, for spawning and early development.
This may include migration into areas which are heavily influenced by freshwater inputs.

k Public access to reservoir and its surrounding watershed is prohibited by LADWP.
m Access prohibited by Los Angeles County DPW in the concrete-channelized areas.
v Public water supply reservoir. Owner prohibits public entry.
w These areas are engineered channels. All references to Tidal Prisms in Regional Board documents are functionally equivalent to estuaries.
s Access prohibited by Los Angeles County DPW.

Table 2-1. Benefical Uses of Inland Surface Waters (Continued).

WATERSHED[a]	Hydro. Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
LA RIVER WATERSHED (CONTINUED)																									
Rio Hondo below Spreading Grounds	405.15	P*				I				Pm	E			P					I						
Rio Hondo to Spreading Grounds	405.15	P*				I				Im	E			P					I						
Rio Hondo	405.41	P*				I				Im	E			P					I		E				E
Alhambra Wash	405.41	P*				I				Pm	I			P					P		E				
Rubio Wash	405.41	P*				I				Im	I			I					E		P				
Rubio Canyon	405.31	P*				E				I	I			I					E		E				E
Eaton Wash	405.41	P*				I				I	I			I					E						
Eaton Wash (below dam)	405.31	P*				I				Im	I			I					E						
Eaton Wash (above dam)	405.31	P*				I				I	I			I					E						
Eaton Dam and Reservoir	405.31	P*				I				P	Id			I					E						
Eaton Canyon Creek	405.31	P*				E				E	E			E					E		E		E		E
Arcadia Wash (lower)	405.41	P*				I				Pm	I			P					P						
Arcadia Wash (upper)	405.33	P*				I				Pm	I			P					P						
Santa Anita Wash (lower)	405.41	P*				I				Pm	E			P					P		E				
Santa Anita Wash (upper)	405.33	P*				E				Em	E			E					E		E				
Little Santa Anita Canyon Creek	405.33	P*				I				I	I			I					E						
Big Santa Anita Reservoir	405.33	P*				E				Px	E			E	E				E						
Santa Anita Canyon Creek	405.33	E*				E				E	E			E	E				E		E		E		E
Winter Creek	405.33	P*				I				I	E			I					E						E
East Fork Santa Anita Canyon	405.33	P*				E				E	E			E	E				E				E		E
Sawpit Wash	405.41	I				I				Im	I			I					E						
Sawpit Canyon Creek	405.41	P*				I				I	I			I					E		E				
Sawpit Dam And Reservoir	405.41	P*				I				Px	I			I					E						
Monrovia Canyon Creek	405.41	I				I				I	I			I					E						E
Arroyo Seco S. Of Devil's Gates. (L)	405.15	P*								I	I			P					P						
Arroyo Seco S. Of Devil's Gates (U)	405.31	P*								Im	I			P					P		E				
Devil's Gate Reservoir (lower)	405.31	P*				I				Im	I			I					E						
Devil's Gate Reservoir (upper)	405.32	I*				I				I	I			I					E						
Arroyo Seco	405.32	E	E	E		E				Em	E			E	E				E						E
Millard Canyon Creek	405.32	E*	E	E		E				E	E			E					E		E				E
El Prieto Canyon Creek	405.32	I	I	I		I				I	I			I					E						
Little Bear Canyon Creek	405.32	P*				I				I	I			I	I				E						E
Verdugo Wash	405.24	P*				I				Pm	I			P					P						
Halls Canyon Channel	405.24	P*	I	I		I				Im	I			I					E						
Snover Canyon	405.32	I	I	I		I				Im	I			I					E						
Pickens Canyon	405.24	I*				I				Im	I			I					E						
Shields Canyon	405.24	I	I	I		I				Im	I			I					E						

E: Existing beneficial use
P: Potential beneficial use
I: Intermittent beneficial use
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* Asterixed MUN designations are designated under SB 88-63 and RB 89-03. Some designations may be considered for exemptions at a later date. (See pages 2-3,4 for more details).

Footnotes are consistent on all beneficial use tables.
a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries
Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody.
Any regulatory action would require a detailed analysis of the area.
m Access prohibited by Los Angeles County DPW in concrete-channelized areas.
x Owner prohibits entry.

Table 2-1. Benefical Uses of Inland Surface Waters (Continued).

WATERSHED[a]	Hydro. Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
LA RIVER WATERSHED (CONT)																									
Dunsmore Canyon Creek	405.24	I	I	I		I				I	I			I					E						
Burbank Western Channel	405.21	P*								Pm	I			P					P						
La Tuna Canyon Creek	405.21	P*				I				Im	I			I					E						
Tujunga Wash	405.21	P*				I				Pm	I			P	P				P						
Hansen Flood Control Basin & Lakes	405.23	P*				E				E	E			E	E				E		E				
Lopez Canyon Creek	405.21	P*				I				Im	I			I					E						
Little Tujunga Canyon Creek	405.23	P*				I				I	E			I	I				E		E				
Kagel Canyon Creek	405.23	P*				I				Im	I			I					E						
Big Tujunga Canyon Creek	405.23	P*				E				E	E			E	E				E		E		E		E
Upper Big Tujunga Canyon Creek	405.23	P*				E				E	E			I	P				E						E
Haines Canyon Creek	405.23	P*				I				Im	I			I					E		E				
Vasquez Creek	405.23	P*				E				E	E			P	P				E						E
Clear Creek	405.23	P*				E				E	E			E	E				E						E
Big Tujunga Reservoir	405.23	P*				E				Pk	E			E	P				E				E		
Mill Creek	405.23	P*				E				E	E			E	E				E						E
Pacoima Wash	405.21	P*				E				Pm	E			E					E		E				
Pacoima Reservoir	405.22	P*				E				E	E			E					E						
Pacoima Canyon Creek	405.22	P*				E				E	E			E	E				E		E		E		E
Stetson Canyon Creek	405.22	P*				I				Pm	E			P					P						
Wilson Canyon Creek	405.22	P*				I				Em	E			I					E						
May Canyon Creek	405.22	P*				I				I	E			I					E						
Sepulveda Flood Control Basin	405.21	P*				E				E	E			E					E						E
Bull Creek	405.21	P*				I				Im	I			I					E						
Los Angeles Reservoir	405.21	E	E	E		P				Pk	E			E					E		E				
Lower Van Norman Reservoir	405.21	E*	E	E		E				E	E			E					E		E				
Solano Reservoir	405.21	E*								Pk,u				Pu					E						
Caballero Creek	405.21	P*				I				Im	I			I					E						
Aliso Canyon Wash and Creek	405.21	P*				I				Im	I			I					E						
Limekiln Canyon Wash	405.21	P*				I				Im	I			I					E						
Browns Canyon Wash and Creek	405.21	P*				I				Im	I			I					E						
Arroyo Calabasas	405.21	P*								Pm	I			P					P						
McCoy Canyon Creek	405.21	P*				I				I	I			I					E						
Dry Canyon Creek	405.21	P*				I				Im	I			I					E						
Bell Creek	405.21	P*				I				Im	I			I					E						
Chatsworth Reservoir y	405.21	E	E	E						P	E			E					E						
Dayton Canyon Creek	405.21	P*				I				I	I			I					E						

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P: Potential beneficial use
I: Intermittent beneficial use
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Footnotes are consistent on all beneficial use tables.
a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries
Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody.
Any regulatory action would require a detailed analysis of the area.
k Public access to reservoir and its surrounding watershed is prohibited by Los Angeles Department of Water and Power.
m Access prohibited by Los Angeles County DPW in concrete-channelized areas.
u This reservoir is covered and thus inaccessible.
y Currently dry and no plans for restoration.

Table 2-1. Benefical Uses of Inland Surface Waters (Continued).

WATERSHED[a]	Hydro. Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
LOS ANGELES RIVER WATERSHED (CONT)																									
ISOLATED LAKES AND RESERVOIRS:																									
Eagle Rock Reservoir	405.25	E*								Pk,u				Pu											
Echo Lake	405.15	P*								P	E			P					E						
El Dorado Lakes	405.15	P*								E	E			P					E						E
Elysian Reservoir	405.15	E*	E	E						Pk	E			P					E						
Encino Reservoir	405.21	E*	E	E						Pk	E			P					E						
Ivanhoe Reservoir	405.15	E*	E	E						Pk	E			P					E						
Lincoln Park Lake	405.15	P*								P	E			P					E						
Silver Lake Reservoir	405.15	E*	E	E						Pk	E			P					E						
Toluca Lake	405.21	P*								Pk	E			P					E						
SAN GABRIEL RIVER WATERSHED																									
San Gabriel River Estuary c,w	405.15		E					E		E	E	E					E	E	E		Ee	Ef	Ef	P	
San Gabriel River: Firestone Blvd-Esutary	405.15	P*								Em	E			P					P						
San Gabriel River: Whittier N-Firestone	405.15	P*	P	P		I				Em	E			I					E		E				
San Gabriel River	405.41	P*				I				Im	I			I					E						
San Gabriel River	405.42	E	E	E	E	E				E	E			E	E				E		E				
San Gabriel River: Main Stem z	405.43	E	E	E	E	E				E	E			E	E				E				E		
North Fork San Gabriel River	405.43	For uses please see UPPER SAN GABRIEL TRIBUTARIES below																							
West Fork San Gabriel River	405.43	For uses please see UPPER SAN GABRIEL TRIBUTARIES below																							
East Fork San Gabriel River	405.43	For uses please see UPPER SAN GABRIEL TRIBUTARIES below																							
Coyote Creek to Estuary	405.15	P*	P	P						Pm	I			P					P		E				
Whittier Narrows Flood Control Basin	405.41	P*				E				E	E			E					E		P				
Legg Lake	405.41	P*				E				E	E			E	E				E						E
San Jose Creek	405.41	P*				I				Pm	I			I					E						
San Jose Creek	405.51	P*				I				Pm	I			I					E						
Puente Creek	405.41	P*				I				P	I			P					P						
Thompson Wash	405.52	P*				I				Im	I			I					E						
Thompson Creek	405.53	P*				I				I	I			I					E		E				
Thompson Creek Dam & Reservoir	405.53	P*				I				Px	I			I					E		E				
Walnut Creek Wash	405.41	P*				I				Im	I			I					E						E
Big Dalton Wash	405.41	P*				I				Pm	I			P					P						
Big Dalton Canyon Creek	405.41	P*				I				I	I			I					E						E
Mystic Canyon	405.41	P*				I				I	I			I					E						
Big Dalton Dam & Reservoir	405.41	P*				E				Px	E			E					E						

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P: Potential beneficial use
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Footnotes are consistent on all beneficial use tables.
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c Coastal waterbodies which are also listed in Coastal Features Table (2-3) or in Wetlands Table (2-4).
e One or more rare species utilize all ocean, bays, esturaries, and coastal wetlands for foraging and/or nesting.
f Aquatic organisms utilize all bays, estuaries, lagoons and coastal wetlands, to a certain extent, for spawning and early development. This may include migration into areas which are heavily influenced by freshwater inputs.
k Public access to reservoir and its surrounding watershed is prohibited by the Los Angeles Department of Water and Power.

w These areas are engineered channels. All references to Tidal Prisms in Regional Board documents are functionally equivalent to estuaries.
m Access prohibited by Los Angeles County DPW in concrete-channelized areas.
x Owner prohibits entry.
u This reservoir is covered and thus inaccessible.
z Listed twice in this table (see next page).

Table 2-1. Benefical Uses of Inland Surface Waters (Continued).

WATERSHED[a]	Hydro. Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
SAN GABRIEL RIVER WATERSHED (CONT)																									
Bell Canyon Creek	405.41	P*				I				I	I			I					E						
Little Dalton Wash	405.41	P*				I				Pm	I			P					P						
Little Dalton Canyon Creek	405.41	P*				I				I	I			I					E						E
San Dimas Wash (lower)	405.41	P*				I				Im	I			I					E		E				
San Dimas Wash (upper)	405.44	P*				E				Im	I			I					E						
San Dimas Dam and Reservoir	405.44	E*				E				Px	E			E	E				E						
San Dimas Canyon Creek	405.44	E*				E				E	E			E	E				E						E
West Fork San Dimas Canyon	405.44	E*				E				E	E			E	P				E						E
Wolfskill Canyon	405.44	E*				E				E	E			E	P				E		E				E
Puddingstone Dam and Reservoir	405.52	E*			E	E				E	E			E	E				E		E				
Puddingstone Wash	405.41	E*				I				Im	I			I					E						
Marshall Creek and Wash	405.41	E*				I				Im	I			I					E						
Marshall Creek and Wash	405.53	E*				I	I			Im	I			I					E		E				E
Live Oak Wash	405.52	E*				I	I			I	I			I					E						
Live Oak Creek And Wash	405.53	E*				I	I			I	I			I					E						
Live Oak Dam and Reservoir	405.53	E*				E	E			E	E			E					E						
Emerald Creek And Wash	405.53	E*				I	I			Im	I			I					E						
Santa Fe Flood Control Basin	405.41	P*				I				P	I			I					E						E
Bradbury Canyon Creek	405.41	P*				I				I	I			I					E						
Spinks Canyon Creek	405.41	P*				I				I	I			I					E						
Maddock Canyon Creek	405.43	P*				I				I	I			I					E						
Van Tassel Canyon	405.43	P*				I				I	I			I					E		E				
Fish Canyon Creek	405.43	P*	I			E				E	E			E					E		E		E		E
Roberts Canyon Creek	405.43	P*				I				I	I			I					E		E				E
Morris Reservoir	405.43	E	E	E	E	E			E	P	E			E	E				E				E		
San Gabriel Reservoir	405.43	E	E	E	E	E			E	E	E			E	E				E						
UPPER SAN GABRIEL RIVER TRIBUTARIES																									
San Gabriel River: Main Stem z	405.43	E	E	E	E	E				E	E			E	E				E						E
Cattle Canyon Creek	405.43	P*				E				E	E			E	E				E		E		E		E
Coldwater Canyon Creek	405.43	P*				E				E	E			E	E				E		E		E		E
Cow Canyon Creek	405.43	P*				E				E	E			E	E				E		E		E		E
East Fork San Gabriel River	405.43	P*				E				E	E			E	E				E		E		E		E
Allison Gulch	405.43	P*				E				E	E			E	E				E				E		E
Fish Fork	405.43	P*				E				E	E			E	E				E				E		E

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P: Potential beneficial use
I: Intermittent beneficial use
E, P, and I shall be protected as required
* Asterixed MUN designations are designated under SB 88-63 and RB 89-03. Some designations may be considered for exemptions at a later date. (See pages 2-3,4 for more details).

Footnotes are consistent on all benefical use tables.
a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries
Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody.
Any regulatory action would require a detailed analysis of the area.
m Access prohibited by Los Angeles County DPW in concrete channelized areas.
x Owner prohibits entry.
z Also listed on previous page.

Table 2-1. Benefical Uses of Inland Surface Waters (Continued).

WATERSHED[a]	Hydro. Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
SAN GABRIEL RIVER WATERSHED (CONT)																									
North Fork San Gabriel River	405.43	P*				E				E	E			E	E				E		E		E		E
Bichota Canyon	405.43	P*				E				E	E			E	E				E		P		E		
Coldbrook Creek	405.43	P*				I				I	I			I					E				E		
Cedar Creek	405.43	P*				E				E	E			E	E				E		E		E		E
Crystal Lake	405.43	P*								E	E			E	E				E				E		
Soldier Creek	405.43	P*				I				I	I			I					E				E		
West Fork San Gabriel River	405.43	P*				E				E	E			E	E				E		E		E		E
Bear Creek	405.43	P*				E				E	E			E	E				E		E		E		E
Cogswell Reservoir	405.43	P*				E				E	E			E	E				E				E		
Devils Canyon Creek	405.43	P*				E				E	E			E	E				E				E		E
ISLAND WATERCOURSES																									
Anacapa Island	406.10	P*								P				P					E		E				
San Nicolas Island	406.20	P*								P				P					E		Eaa				
Santa Barbara Island	406.30	P*								E	E			P					E		E				
Santa Catalina Island	406.40	E*				E				E	E			E					E		E				
Middle Ranch System	406.40	P*				E				E	E			E					E		E				
San Clemente Island	406.50	E*				E				E	E			E					E		E				
SAN ANTONIO CREEK WATERSHED ab																									
San Antonio Dam And Reservoir	481.23	E*				E				E	E			E					E						
San Antonio Canyon Creek	481.23	E		E	E	E			E	E	E			E	E				E				E		

E: Existing beneficial use
P: Potential beneficial use
I: Intermittent beneficial use
E, P, and I shall be protected as required
* Asterixed MUN designations are designated under SB 88-63 and RB 89-03. Some designations may be considered for exemptions at a later date. (See pages 2-3,4 for more details).

Footnotes are consistent on all benefical use tables.
a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries. Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody. Any regulatory action would require a detailed analysis of the area.
aa Habitat of the Channel Island Fox.
ab This watershed is also in Region 8 (801.23).

Table 2-2. Beneficial Uses of Ground Waters[ac]

DWR Basin No.[ad]	BASIN	MUN	IND	PROC	AGR	AQUA
	PITAS POINT AREA ae	E	E	P	E	
4-1	OJAI VALLEY					
	Upper Ojai Valley					
	West of Sulfur Mountain Road	E	E	E	E	
	Central area	E	E	E	E	
	Sisar area	E	E	E	E	
4-2	Lower Ojai Valley					
	West of San Antonio--Senior Canyon Creeks	E	E	E	E	
	East of San Antonio--Senior Canyon Creeks	E	E	E	E	
4-3	VENTURA RIVER VALLEY					
	Upper Ventura	E	E	E	E	
	San Antonio Creek area	E	E	E	E	
	Lower Ventura	P	E	P	E	
	VENTURA CENTRAL af					
4-4	Santa Clara--Piru Creek area					
	Upper area (above Lake Piru)	P	E	E	E	
	Lower area east of Piru Creek	E	E	E	E	
	Lower area west of Piru Creek	E	E	E	E	
	Santa Clara--Sespe Creek area					
	Topa Topa (upper Sespe) area	P	E	P	E	
	Fillmore area					
	Pole Creek Fan area	E	E	E	E	
	South side of Santa Clara River	E	E	E	E	
	Remaining Fillmore area	E	E	E	E	E
	Santa Clara-Santa Paula area					
	East of Peck Road	E	E	E	E	
	West of Peck Road	E	E	E	E	
	Oxnard Plain					
	Oxnard Forebay	E	E	E	E	
	Confined aquifers	E	E	E	E	
	Unconfined and perched aquifers	E	P		E	
	VENTURA CENTRAL (CONT.)					
4-6	Pleasant Valley					
	Confined aquifers	E	E	E	E	
	Unconfined and perched aquifers	P	E	E	E	
4-7	Arroyo Santa Rosa	E	E	E	E	
4-8	Las Posas Valley					
	South Las Posas area					
	NW of Grimes Cyn Rd. and LA Ave. & Somis Rd.	E	E	E	E	
	E of Grimes Cyn Rd and Hitch Blvd.	E	E	E	E	
	S of LA Ave between Somis Rd and Hitch Blvd.	E	E	E	E	
	Grimes Canyon Rd. and Broadway area	E	E	E	E	
	North Las Posas area	E	E	E	E	
4-5	UPPER SANTA CLARA					
	Acton Valley	E	E	E	E	
	Sierra Pelona Valley (Agua Dulce)	E	E		E	
	Upper Mint Canyon	E	E	E	E	
	Upper Bouquet Canyon	E	P	P	E	
	Green Valley	E	P	P	E	
	Lake Elizabeth-Lake Hughes area	E	P	P	E	
4-4.07	EASTERN SANTA CLARA					
	Santa Clara-Mint Canyon	E	E	E	E	
	South Fork	E	E	E	E	
	Placerita Canyon	E	E	E	E	
	Santa Clara-Bouquet and San Francisquito Canyons	E	E	E	E	
	Castaic Valley	E	E	E	E	
	Saugus Aquifer	E				
4-9	SIMI VALLEY					
	Simi Valley Basin					
	Confined aquifers	E	E	E	E	
	Unconfined aquifers	E	E	E	E	
	Gillibrand Basin	E	E	P	E	
4-10	CONEJO VALLEY	E	E	E	E	

E: Existing beneficial use
P: Potential beneficial use
See pages 2-1 to 2-3 for descriptions of beneficial uses.

Footnotes are consistent for all beneficial use tables.

ac Beneficial uses for ground waters outside of the major basins listed on this table and outlined in Fig. 1-9 have not been specifically listed. However, ground waters outside of the major basins are, in many cases, significant sources of water. Furthermore, ground waters outside of the major basins are either potential or exisitng sources of water for downgradient basins, and as such, beneficial uses in the downgradient basins shall apply to these areas.

ad Basins are numbered according to California Department of Water Resources (DWR) Bulletin No. 118-80 (DWR, 1980).

ae Ground waters in the Pitas Point area (between the lower Ventura River and Rincon Point) are not considered to comprise a major basin and, accordingly, have not been designated a basin number by the DWR or outlined on Fig. 1-9.

af The Santa Clara River Valley (4-4), Pleasant Valley (4-6), Arroyo Santa Rosa Valley (4-7), and Las Posas Valley (4-8) Ground Water Basins have been combined and designated as the Ventura Central Basin (DWR, 1980).

Table 2-2. Beneficial Uses of Ground Waters (Continued).[ac]

DWR Basin No.[ad]	BASIN	MUN	IND	PROC	AGR	AQUA
4-11	LOS ANGELES COASTAL PLAIN					
	Central Basin	E	E	E	E	
	West Coast Basin	E	E	E	E	
	Hollywood Basin	E	E	E	E	
	Santa Monica Basin	E	E	E	E	
4-12	SAN FERNANDO VALLEY					
	Sylmar Basin	E	E	E	E	
	Verdugo Basin	E	E	E	E	
	San Fernando Basin					
	West of Highgway 405	E	E	E	E	
	East of Highway 405 (overall)	E	E	E	E	
	Sunland-Tujunga area [ag]	E[ah]	E	E	E	
	Foothill area [ag]	E	E	E	E	
	Area encompassing RT-Tujunga-Erwin-N. Hollywood-Whithall-LA/Verdugo-Crystal Springs-Headworks-Glendale/Burbank Well Fields	E	E	E	E	
	Narrows area (below confluence of Verdugo Wash with the Los Angeles River)	E	E	E	E	
	Eagle Rock Basin	E	E	E	E	
4-13	SAN GABRIEL VALLEY					
	Raymond Basin					
	Monk Hill sub-basin	E	E	E	E	
	Santa Anita area	E	E	E	E	
	Pasadena area	E	E	E	E	
	Main San Gabriel Basin					
	Western area [ai]	E	E	E	E	
	Eastern area [ai]	E	E	E	E	
	Puente Basin	E	E	E	E	

DWR Basin No.[ad]	BASIN	MUN	IND	PROC	AGR	AQUA
4-14	UPPER SANTA ANA VALLEY					
8-2aj	Live Oak area	E	E	E	E	
	Claremont Heights area	E	E	E	E	
	Pomona area	E	E	E	E	
	Chino area	E	E	E	E	
	Spadra area	E	E	E	E	
4-15	TIERRA REJADA	E	P	P	E	
4-16	HIDDEN VALLEY	E	P		E	
4-17	LOCKWOOD VALLEY	E	E		E	
4-18	HUNGRY VALLEY AND PEACE VALLEY	E	P	E	E	
4-19	THOUSAND OAKS AREA	E	E	E	E	
4-20	RUSSELL VALLEY					
	Russell Valley	E	P		E	
	Triunfo Canyon area	P	P		E	
	Lindero Canyon area	P	P		E	
	Las Virgenes Canyon area	P	P		E	
4-21	CONEJO-TIERRA REJADA VOLCANIC AREA [ak]	E			E	
	SANTA MONICA MOUNTAINS-SOUTHERN SLOPES [al]					
	Camarillo area	E	P		E	
	Point Dume area	E	P		E	
4-22	Malibu Valley	P	P		E	
	Topanga Canyon area	P	P		E	
	SAN PEDRO CHANNEL ISLANDS [am]					
	Anacapa Island	P	P			
	San Nicolas Island	E	P			
	Santa Catalina Island	E	P		E	
	San Clemente Island	P	P			
	Santa Barbara Island	P	P			

E: Existing beneficial use
P: Potential beneficial use
See pages 2-1 to 2-3 for descriptions of beneficial uses.

Footnotes are consistent for all beneficial use tables.

ac Beneficial uses for ground waters outside of the major basins listed on this table and outlined in Fig. 1-9 have not been specifically listed. However, ground waters outside of the major basins are, in many cases, significant sources of water. Furthermore, ground waters outside of the major basins are either potential or exisitng sources of water for downgradient basins, and as such, beneficial uses in the downgradient basins shall apply to these areas.

ad Basins are numbered according to DWR Bulletin No. 118-80 (DWR, 1980).

ag The category for the Foothill Wells area in the old Basin Plan incorrectly grouped ground water in the Foothill area with ground water in the Sunland-Tujunga area. Accordingly, the new categories, Foothill area and Sunland-Tujunga area, replace the Foothill Wells area.

ah Nitrite pollution in the groundwater of the Sunland-Tujunga area currently precludes direct MUN uses. Since the ground water in this area can be treated or blended (or both), it retains the MUN designation.

ai All of the ground water in the Main San Gabriel Basin is covered by the beneficial uses listed under Main San Gabriel Basin-eastern area and western area. Walnut Creek, Big Dalton Wash and Little Dalton Wash separate the eastern area from the western area (see dashed line on Fig. 2-17). Any ground water upgradient of these areas is subject to downgradient beneficial uses and objectives, as explained in Footnote ac

aj The border between Regions 4 and 8 crosses the Upper Santa Ana Valley Ground Water Basin.

ak Ground water in the Conejo-Tierra Rejada Volcanic Area occurs primarily in fractured vocanic rocks in the western Santa Monica Mountains and Conejo Mountain areas. These areas have not been delineated on Fig. 1-9.

al With the exception of ground water in Malibu Valley (DWR Basin No. 4-22), ground waters along the southern slopes of the Santa Monica Mountains are not considered to comprise a major basin and accordingly have not been designated a basin number by DWR or outlined on Fig. 1-9.

am DWR has not designated basins for ground waters on the San Pedro Channel Islands.

Table 2-3. Benefical Uses of Coastal Features.

Table Page 1

COASTAL FEATURE [a]	Hydro. Unit No.	MUN	IND	PROC	NAV	POW	REC1	REC2	COMM	WARM	COLD	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET [b]
VENTURA COUNTY COASTAL																				
Nearshore +			E		E		E	E	E				E	E	Ean	Ee	Ef	Ef	E	
Offhore Zone					E		E	E	E				E	E		Ee	Ef	Ef	E	
Rincon Beach	401.00				E		E	E	E				E	E			E		E	
Ventura River Estuary c	402.10				E	*	E	E	E	E		E	E	E		Ee	Ef	Ef	E	E
Ventura Keys (Marina)	403.11				E		E	E	E				E	E						
Ventura Marina	403.11		E		E		E	E	E				E	E					E	
Santa Clara River Estuary c	403.11				E		E	E	E			E	E	E		Ee	Ef	Ef		E
Mandalay Beach	403.11				E		E	E	E				E	E		Ee			E	
McGrath Lake c	403.11						Ed	Ed	P			E		E		Ee				E
Edison Canal Estuary	403.11		E				Eao	E					E	E		Ee				
Channel Islands Harbor	403.11		E		E		Eap	E	E				E	E						
Mandalay Bay (Marina)	403.11		E		E		Eaq	E					E	E						
Port Hueneme (Harbor)	403.11			E	E		E	E	E				E	E						
Ormond Beach	403.11		E		E	E	E	E	E				E	E		Ee		P	E	
Ormond Beach Wetlands c	403.11						E	E				E		E		Ee				E
Mugu Lagoon c	403.11				E		Pn	E	Ed			E	E	Eo	E	Ee,p	Ef	Ef	Ed	E
Calleguas Creek Estuary c	403.11				P		Pn	E	E			E		E		Ee,p	Ef	Ef		E
LOS ANGELES COUNTY COASTAL																				
Nearshore Zone +			E		E		E	E	E				E	E	Ean	Ee	Ef	Ef	Ear	
Offshore Zone			E		E		E	E	E				E	E		Ee	Ef	Ef	E	
Nicholas Canyon Beach	404.43				E		E	E	E				E	E				P	E	
Trancas Beach	404.37				E		E	E	E				E	E				P	E	
Zuma County (Westward)Beach	404.36				E		E	E	E				E	E				P	Ear	
Dume State Beach	404.36				E		E	E	E				E	E				P	E	
Dume Lagoon c	404.36				E		E	E	E			E		E		Ee	Pf	Pf		E
Escondido Beach	404.34				E		E	E	E				E	E				P	E	
Dan Blocker Memorial (Corral) Beach	404.31				E		E	E	E				E	E				P	E	

E: Existing beneficial use
P: Potential beneficial use
I: Intermittent beneficial use
E, P, and I shall be protected as required
\+ Nearshore is defined as the zone bounded by the shoreline and a line 1000 feet from the shoreline or the 30-foot depth contours, whichever is further from the shore line. Longshore extent is from Rincon Creek to the San Gabriel River Estuary.

Footnotes are consistent for all beneficial use tables.

a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries. Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody. Any regulatory action would require a detailed analysis of the area.
c Coastal waterbodies which are also listed in Inland Surface Waters Table (2-1) or in Wetlands Table (2-4).
d Limited public access precludes full utilization.
e One or more rare species utilize all ocean, bays, esturaries, and coastal wetlands for foraging and/or nesting.
f Aquatic organisms utilize all bays, estuaries, lagoons and coastal wetlands, to a certain extent, for spawning and early development. This may include migration into areas which are heavily influenced by freshwater inputs.
n Area is currently under control of the Navy: swimming is prohibited.
o Marine Habitats of the Channel Islands and Mugu Lagoon serve as pinniped haul-out areas for one or more species (i.e., sea lions).
p Habitat of the Clapper Rail.
an Areas of Special Biological Significance (along coast from Latigo Point to Laguna Point) and Big Sycamore Canyon and Abalone Cove Ecological Reserves and Point Fermin Marine Life Refuge.
ao Water contact recreation activites are prohibited by the Southern California Edison Co.
ap Water contact recreational activities are limited to the beach area at the harbor by Marina Authorities.
aq Water contact recreational activities are limited by City of Oxnard to within the easement area of each home.
ar Areas exhibiting large shellfish populations include Malibu, Point Dume, Point Fermin, White Point and Zuma Beach.

Los Angeles Regional Water Quality Control Board

Table 2-3. Benefical Uses of Coastal Features (Continued).

Table Page 2

COASTAL FEATURE [a]	Hydro. Unit No.	MUN	IND	PROC	NAV	POW	REC1	REC2	COMM	WARM	COLD	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET [b]
LOS ANGELES COUNTY COASTAL (CONT)																				
Puerco Beach	404.31				E		E	E	E				E	E				P	E	
Amarillo Beach	404.21				E		E	E	E				E	E				P	E	
Malibu Beach	404.21				E		E	E	E				E	E			E	Eas	Ear	
Malibu Lagoon c	404.21				E		E	E				E	E	E		Ee	Ef	Ef		E
Carbon Beach	404.16				E		E	E	E				E	E				P	E	
La Costa Beach	404.16				E		E	E	E				E	E				P	E	
Las Flores Beach	404.15				E		E	E	E				E	E				P	E	
Las Tunas Beach	404.12				E		E	E	E				E	E				P	E	
Topanga Beach	404.11				E		E	E	E				E	E				P	E	
Topanga Lagoon c	405.11				E		E	E	E			E		E		Ee	Ef	Ef		E
Will Rogers State Beach	405.13				E		E	E	E				E	E				P	E	
Santa Monica Beach	405.13				E		E	E	E				E	E			E	Eas	E	
Venice Beach	405.13				E		E	E	E				E	E		E	E	Eas	E	
Marina Del Rey							E													
Harbor	405.13				E		E	E	E				E	E					E	
Public Beach Areas	405.13				E		E	E	E				E	E		E				
All other Areas	405.13				E		P	E	E				E	E		E			E	
Entrance Channel	405.13				E		E	E	E				E	E		E			E	
Ballona Creek Estuary c,w	405.13				E		E	E	E			E	E	E		Ee	Ef	Ef	E	
Ballona Lagoon/Venice Canals c	405.13				E		E	E	E			E	E	E		Ee	Ef	Ef	E	E
Ballona Wetlands c	405.13						E	E				E		E		Ee	Ef	Ef		E
Del Rey Lagoon c	405.13				E		E	E	E			E		E		Ee	Ef	Ef		E
Dockweiler Beach	405.12		E		E		E	E	E				E	E				P		
Manhattan Beach	405.12				E		E	E	E				E	E				P	E	
Hermosa Beach	405.12				E		E	E	E				E	E				Eas	E	
King Harbor	405.12		E		E		E	E	E				E	E		E				
Redondo Beach	405.12		E		E		E	E	E				E	E		E	E	Eas	E	
Torrance Beach	405.12				E		E	E	E				E	E			E	Eas	E	
Point Vicente Beach	405.11				E		E	E	E				E	E				P	E	
Royal Palms Beach	405.11				E		E	E	E				E	E				P	E	

E: Existing beneficial use
P: Potential beneficial use
I: Intermittent beneficial use
E, P, and I shall be protected as required

Footnotes are consistent for all beneficial use tables.

a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries
Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody.
Any regulatory action would require a detailed analysis of the area.

c Coastal waterbodies which are also listed in Inland Surface Waters Table (2-1) or in Wetlands Table (2-4).

e One or more rare species utilize all ocean, bays, esturaries, and coastal wetlands for foraging and/or nesting.

f Aquatic organisms utilize all bays, estuaries, lagoons and coastal wetlands, to a certain extent, for spawning and early development.
This may include migration into areas which are heavily influenced by freshwater inputs.

ar Areas exhibiting large shellfish populations include Malibu, Point Dume, Point Fermin, White Point and Zuma Beach

as Most frequently used grunion spawning beaches. Other beaches may be used as well.

w These areas are engineered channels. All references to Tidal Prisms in Regional Board documents are functionally equivalant to estuaries.

Table 2-3. Benefical Uses of Coastal Features (Continued).

COASTAL FEATURE [a]	Hydro. Unit No.	MUN	IND	PROC	NAV	POW	REC1	REC2	COMM	WARM	COLD	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET [b]
LOS ANGELES COUNTY COASTAL (CONT)																				
Whites Point County Beach	405.11				E		E	E	E				E	E				P	E	
Cabrillo Beach	405.12				E		E	E	E				E	E			E	Eas	E	
Los Angeles-Long Beach Harbor																				
Outer Harbor	405.12				E		E	E	E				E			E			P	
Marinas	405.12		E		E		E	E	E				E			E			P	
Public Beach Areas	405.12				E		E	E	E				E	E		E		P	E	
All Other Inner Areas	405.12		E		E		P	E	E				E			Ee			P	
Dominguez Channel Estuary c,w	405.12				P		E	E	E			E	E	E		Ee	Ef	Ef		
Los Angeles River Estuary c,w	405.12		E		E		E	E	E			E	E	E		Ee	Ef	Ef	P	E
Alamitos Bay	405.12		E		E		E	E	E			E	E	E		E			E	E
Los Cerritos Wetlands c	405.15				E		E	E	E			E		E		Ee	Pf	Pf	E	E
Los Cerritos Channel Estuary c	405.12		E		E		E	E	E			E	E	E		Ee	Ef	Ef	E	
San Gabriel River Estuary c,w	405.15		E		E		E	E	E			E	E	E		Ee	Ef	Ef	P	
Long Beach Marina	405.12						P	E	E				E			E			E	
Public Beach Areas	405.12				E		E	E	E				E			E		P		
All other Areas	405.12						P	E	E				E			E			P	
Marine Stadium	405.12						P	E	E				E			E			E	
Long Beach	405.12				E		E	E	E				E	E			E	Eas	E	
ISLANDS: NEARSHORE ZONES+																				
Anacapa Island	406.10				E		E	E	E				E	Eo	Eat	E		P	E	
San Nicolas Island	406.20				E		E	E	E				E	Eo	Eat	E		P	E	
Begg Rock Nearshore Zone	406.20						E	E	E				E	Eo	Eat	E		P	E	
Santa Barbara Island	406.30				E		E	E	E				E	Eo	Eat	E		P	E	
Santa Catalina Island	406.40	P*			E		E	E	E				E	Eo	Eat	E		P	E	
San Clemente Island	406.50				E		E	E	E				E	Eo	Eat	E		P	E	

E: Existing beneficial use
P: Potential beneficial use
I: Intermittent beneficial use
E, P, and I shall be protected as required
* Asterixed MUN designations are designated under SB 88-63 and RB-03 Some designations may be considered for exemptions at a later date (See pages 2-3 and 2-4 for more details).
\+ Nearshore is defined as the zone bounded by the shoreline and a line 1000 feet from the shoreline or the 30-foot depth contours, whichever is further from the shore line.

Footnotes are consistent for all beneficial use tables.

- a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries. Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.
- b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody. Any regulatory action would require a detailed analysis of the area.
- c Coastal waterbodies which are also listed in Inland Surface Waters Table (2-1) or in Wetlands Table (2-4).
- e One or more rare species utilize all ocean, bays, esturaries, and coastal wetlands for foraging and/or nesting.
- f Aquatic organisms utilize all bays, estuaries, lagoons and coastal wetlands, to a certain extent, for spawning and early development. This may include migration into areas which are heavily influenced by freshwater inputs.
- o Marine Habitats of the Channel Islands and Mugu Lagoon serve as pinniped haul-out areas for one or more species (i.e., sea lions).
- w These areas are engineered channels. All references to Tidal Prisms in Regional Board documents are functionally equivalant to estuaries.
- as Most frequently used grunion spawning beaches. Other beaches may be used as well.
- at Areas of Special Biological Significance or ecological reserves.

Table 2-4. Beneficial Uses of Significant Coastal Wetlands *.

WATERSHED[a]	Hydro. Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
Ventura River Estuary c	402.10							E		E	E	E		E			E	E	E		Ee	Ef	Ef	E	E
Santa Clara River Estuary c	403.11							E		E	E	E					E	E	E		Ee	Ef	Ef		E
McGrath Lake c	403.11									Ed	Ed	P					E		E		Ee				E
Ormond Beach Wetlands c	403.11									E	E						E		E		Ee				E
Mugu Lagoon c	403.11							E		Pn	E	Ed					E	E	Eo	E	Ee,p	Ef	Ef	Ed	E
Dume Lagoon c	403.36							E		E	E	E					E		E		Ee	Pf	Pf		E
Malibu Lagoon c	404.21							E		E	E						E	E	E		Ee	Ef	Ef		E
Topanga Lagoon c	404.11							E		E	E	E					E		E		Ee	Ef	Ef		E
Ballona Lagoon/Venice Canals c	405.13							E		E	E	E					E	E	E		Ee	Ef	Ef	E	E
Ballona Wetlands c	405.13									E	E						E		E		Ee	Ef	Ef		E
Del Rey Lagoon c	405.12							E		E	E	E					E		E		Ee	Ef	Ef		E
Los Cerritos Wetlands c	405.15							E		E	E	E					E		E		Ee	Pf	Pf	E	E

* This list may not be all inclusive. More areas may be added as information becomes available.

E: Existing beneficial use

P: Potential beneficial use

I: Intermittent beneficial use

E, P, and I shall be protected as required

Footnotes are consistent for all beneficial use tables.

a Waterbodies are listed multiple times if they cross hydrologic area or subarea boundaries.
Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

b Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody.
Any regulatory action would require a detailed analysis of the area.

c Coastal waterbodies which are also listed in Inland Surface Waters Table (2-1) or in Coastal Features Table (2-3).

d Limited public access precludes full utilization.

e One or more rare species utilize all ocean, bays, esturaries, and coastal wetlands for foraging and/or nesting.

f Aquatic organisms utilize all bays, estuaries, lagoons and coastal wetlands, to a certain extent, for spawning and early development.
This may include migration into areas which are heavily influenced by freshwater inputs.

n Area is currently under control of the Navy: swimming is prohibited.

o Marine Habitats of the Channel Islands and Mugu Lagoon
serve as pinniped haul-out areas for one or more species (i.e., sea lions).

p Habitat of the Clapper Rail.

Appendix D-2
San Diego Regional Water Quality Control Board

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Orange County Coastal Streams																
Moro Canyon	1.11	+	●						O	●		●		●		
unnamed intermittent coastal streams	1.11	+	●						O	●		●		●		
Emerald Canyon	1.11	+	●						O	●		●		●		
Boat Canyon	1.11	+	●						O	●		●		●		
Laguna Canyon	1.12	+	●						O	●		●		●		
Blue Bird Canyon	1.12	+	●						O	●		●		●		
Rim Rock Canyon	1.12	+	●						O	●		●		●		
unnamed intermittent coastal streams	1.13	+	●						O	●		●		●		
Hobo Canyon	1.13	+	●						O	●		●		●		
Aliso Creek Watershed																
Aliso Creek	1.13	+	●						O	●		●		●		
English Canyon	1.13	+	●						O	●		●		●		
Sulphur Creek	1.13	+	●						O	●		●		●		
Wood Canyon	1.13	+	●						O	●		●		●		
Aliso Creek Mouth	1.13	See Coastal Waters- Table 2-3														

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Dana Point Watershed																
unnamed intermittent coastal streams	1.14	+	●						O	●		●		●		
Salt Creek	1.14	+	●						O	●		●		●		
San Juan Canyon	1.14	+	●						O	●		●		●		
Arroyo Salada	1.14	+	●						O	●		●		●		
San Juan Creek Watershed																
San Juan Creek	1.25	+	●	●					●	●		●	●	●		
Morrell Canyon	1.25	+	●	●					●	●		●	●	●		
Decker Canyon	1.25	+	●	●					●	●		●	●	●		
Long Canyon	1.25	+	●	●					●	●		●	●	●		
Lion Canyon	1.25	+	●	●					●	●		●	●	●		
Hot Spring Canyon	1.25	+	●	●					●	●		●	●	●		
Cold Spring Canyon	1.25	+	●	●					●	●		●	●	●		
Lucas Canyon	1.25	+	●	●					●	●		●	●	●		
Aliso Canyon	1.25	+	●	●					●	●		●	●	●		
Verdugo Canyon	1.25	+	●	●					●	●		●	●	●		
Bell Canyon	1.25	+	●	●					●	●		●	●	●		
Fox Canyon	1.25	+	●	●					●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
		BENEFICIAL USE														
San Juan Creek Watershed - continued																
Dove Canyon	1.24	+	●	●					●	●		●	●	●		
Crow Canyon	1.25	+	●	●					●	●		●	●	●		
San Juan Creek	1.26	+	●	●					●	●		●	●	●		
Trampas Canyon	1.26	+	●	●					●	●		●	●	●		
Canada Gobernadora	1.24	+	●	●					●	●		●	●	●		
Canada Chiquita	1.24	+	●	●					●	●		●	●	●		
San Juan Creek	1.28	+	●	●					●	●		●	●	●		
San Juan Creek	1.27	+	●	●					●	●		●	●	●		
Horno Creek	1.27	+	●	●					●	●		●	●	●		
Arroyo Trabuco Creek	1.22	+	●	●					●	●		●	●	●		
Holy Jim Canyon	1.22	+	●	●					●	●		●	●	●		
Falls Canyon	1.22	+	●	●					●	●		●	●	●		
Rose Canyon	1.22	+	●	●					●	●		●	●	●		
Hickey Canyon	1.22	+	●	●					●	●		●	●	●		
Live Oak Canyon	1.22	+	●	●					●	●		●	●	●		
Arroyo Trabuco Creek	1.23	+	●	●					●	●		●	●	●		
Tijeras Canyon	1.23	+	●	●					●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters[1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Juan Creek Watershed - continued																
Arroyo Trabuco Creek	1.27	+	●	●					●	●		●	●	●		
Oso Creek	1.21	+	●	●					●	●		●	●	●		
La Paz Creek	1.21	+	●	●					●	●		●	●	●		
San Juan Creek Mouth	1.27	See Coastal Waters- Table 2-3														
Orange County Coastal Streams																
Prima Deshecha Canada	1.31	+	●						O	●		●		●		
unnamed intermittent coastal streams	1.30	+	●						O	●		●		●		
Segunda Deshecha Canada	1.32	+	●						O	●		●		●		
San Mateo Creek Watershed																
San Mateo Creek	1.40	+							O	●		●		●	●	
Devil Canyon	1.40	+							O	●		●		●		
Cold Spring Canyon	1.40	+							O	●		●		●		
San Mateo Canyon	1.40	+							O	●		●		●	●	
Los Almos Canyon	1.40	+							O	●		●		●		
Wildhorse Canyon	1.40	+							O	●		●		●		
Tenaja Canyon	1.40	+							O	●		●		●		
Bluewater Canyon	1.40	+							O	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Mateo Creek Watershed - continued																
Nickel Canyon	1.40	+							O	●		●		●		
Christianitos Creek	1.40	+							O	●		●		●		
Gabino Canyon	1.40	+							O	●		●		●		
La Paz Canyon	1.40	+							O	●		●		●		
Blind Canyon	1.40	+							O	●		●		●		
Talega Canyon	1.40	+							O	●		●		●		
San Mateo Creek Mouth	1.40	See Coastal Waters- Table 2-3														
San Onofre Creek Watershed																
San Onofre Creek	1.51	+	●						●	●		●	●	●		
San Onofre Canyon North Fork	1.51	+	●						●	●		●	●	●		
Jardine Canyon	1.51	+	●						●	●		●	●	●		
San Onofre Canyon South Fork	1.51	+	●						●	●		●	●	●	●	
San Onofre Creek Mouth	1.51	See Coastal Waters- Table 2-3														
unnamed intermittent coastal streams	1.51	+	●						●	●		●	●	●		
Foley Canyon	1.51	+	●						●	●		●	●	●		
Horno Canyon	1.51	+	●						●	●		●	●	●		
Las Flores Creek	1.52	+	●						●	●		●	●	●	●	

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Onofre Creek Watershed - continued																
Piedra de Lumbre Canyon	1.52	+	●						●	●		●	●	●	●	
unnamed intermittent coastal streams	1.52	+	●						●	●		●	●	●		
Aliso Canyon	1.53	+	●						●	●		●	●	●	●	
French Canyon	1.53	+	●						●	●		●	●	●	●	
Cocklebur Canyon	1.53	+	●						●	●		●	●	●		
Santa Margarita River Watershed																
Santa Margarita River	2.22	●	●	●					●	●		●	●	●	●	
Murrieta Creek	2.31	●	●	●	●				O	●		●		●		
Bundy Canyon	2.31	●	●	●	●				O	●		●		●		
Slaughterhouse Canyon	2.31	●	●	●	●				O	●		●		●		
Murrieta Creek	2.32	●	●	●	●				O	●		●		●		
Murrieta Creek	2.52	●	●	●	●	●			O	●		●		●		
Cole Canyon	2.32	●	●	●	●				O	●		●		●		
Miller Canyon	2.32	●	●	●	●				O	●		●		●		
Warm Springs Creek	2.36	●	●	●	●				O	●		●		●		
Diamond Valley	2.36	●	●	●	●				O	●		●		●		
Goodhart Canyon	2.36	●	●	●	●				O	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters[1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Santa Margarita River Watershed - continued																
Pixley Canyon	2.36	●	●	●	●				O	●		●		●		
Warm Springs Creek	2.35	●	●	●	●				O	●		●		●		
Domenigoni Valley	2.35	●	●	●	●				O	●		●		●		
Warm Springs Creek	2.34	●	●	●	●				O	●		●		●		
Warm Springs Creek	2.33	●	●	●	●				O	●		●		●		
French Valley	2.33	●	●	●	●				O	●		●		●		
Santa Gertrudis Creek	2.42	●	●	●	●	O			●	●		●	●	●		
Long Valley	2.42	●	●	●	●	O			●	●		●	●	●		
Glenoak Valley	2.42	●	●	●	●	O			●	●		●	●	●		
Tucalota Creek	2.43	●	●	●	●	O			●	●		●	●	●		
Willow Canyon	2.44	●	●	●	●	O			●	●		●	●	●		
Lake Skinner	2.41	See Reservoirs & Lakes- Table 2-4														
Tucalota Creek	2.41	●	●	●	●	O			●	●		●	●	●		
Crown Valley	2.41	●	●	●	●	O			●	●		●	●	●		
Rawson Canyon	2.41	●	●	●	●	O			●	●		●	●	●		
Tucalota Creek	2.42	●	●	●	●	O			●	●		●	●	●		
Santa Gertrudis Creek	2.32	●	●	●	●				O	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Santa Margarita River Watershed - continued																
Long Canyon	2.32	●	●	●	●				O	●		●		●		
Temecula Creek	2.93	●	●	●	●	●			O	●		●		●		
Kohler Canyon	2.93	●	●	●	●	●			O	●		●		●		
Rattlesnake creek	2.93	●	●	●	●	●			O	●		●		●		
Temecula Creek	2.92	●	●	●	●	●			O	●		●		●		
Chihuahua Creek	2.94	●	●	●	●	●			O	●		●		●		
Chihuahua Creek	2.92	●	●	●	●	●			O	●		●		●		
Cooper Canyon	2.92	●	●	●	●	●			O	●		●		●		
Iron Spring Canyon	2.92	●	●	●	●	●			O	●		●		●		
Temecula Creek	2.91	●	●	●	●	●			O	●		●		●		
Culp Valley	2.91	●	●	●	●	●			O	●		●		●		
Temecula Creek	2.84	●	●	●	●	●			●	●		●	●	●		
Tule Creek	2.84	●	●	●	●	●			●	●		●	●	●		
Million Dollar Canyon	2.84	●	●	●	●	●			●	●		●	●	●		
Cottonwood Creek	2.84	●	●	●	●	●			●	●		●	●	●		
Temecula Creek	2.83	●	●	●	●	●			●	●		●	●	●		
Long Canyon	2.83	●	●	●	●	●			●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters[1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Santa Margarita River Watershed - continued																
Vail Lake	2.81	See Reservoirs & Lakes- Table 2-4														
Wilson Creek	2.63	●	●	●	●	●			O	●		●		●		
Wilson Creek	2.61	●	●	●	●	●			O	●		●		●		
Cahuilla Creek	2.73	●	●	●	●	●			O	●		●		●		
Hamilton Creek	2.74	●	●	●	●	●			O	●		●		●		
Hamilton Creek	2.73	●	●	●	●	●			O	●		●		●		
Cahuilla Creek	2.72	●	●	●	●	●			O	●		●		●		
Cahuilla Creek	2.71	●	●	●	●	●			O	●		●		●		
Elder Creek	2.71	●	●	●	●	●			O	●		●		●		
Cahuilla Creek	2.61	●	●	●	●	●			O	●		●		●		
Wilson Creek	2.81	●	●	●	●	●			●	●		●	●	●		
Lewis Valley	2.62	●	●	●	●	●			O	●		●		●		
Arroyo Seco Creek	2.81	●	●	●	●	●			●	●		●	●	●		
Arroyo Seco Creek	2.82	●	●	●	●	●			●	●		●	●	●		
Kolb Creek	2.81	●	●	●	●	●			●	●		●	●	●		
Temecula Creek	2.81	●	●	●	●	●			●	●		●	●	●		
Temecula Creek	2.51	●	●	●	●	●			O	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Santa Margarita River Watershed - continued																
Temecula Creek	2.52	●	●	●	●	●			O	●		●		●		
Pechanga Creek	2.52	●	●	●	●	●			O	●		●		●		
Rainbow Creek	2.23	●	●	●					●	●		●	●	●		
Rainbow Creek	2.22	●	●	●					●	●		●	●	●		
Sandia Canyon	2.22	●	●	●					●	●		●	●	●		
Walker Basin	2.22	●	●	●					●	●		●	●	●		
Santa Margarita River	2.21	●	●	●					●	●		●	●	●	●	
DeLuz Creek	2.21	●	●	●					●	●		●	●	●	●	
Cottonwood Creek	2.21	●	●	●					●	●		●	●	●		
Camps Creek	2.21	●	●	●					●	●		●	●	●		
Fern Creek	2.21	●	●	●					●	●		●	●	●		
O'Neill Lake	2.13	See Reservoirs & Lakes- Table 2-4														
Santa Margarita River	2.13	●	●	●	●				●	●		●	●	●	●	
Wood Canyon	2.13	●	●	●	●				●	●		●	●	●		
Santa Margarita River	2.12	●	●	●	●				●	●		●	●	●	●	
Santa Margarita River	2.11	●	●	●	●				●	●		●	●	●	●	
Pueblitos Canyon	2.11	●	●	●	●				●	●		●	●	●	●	

● Existing Beneficial Use

O Potential Beneficial Use

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Santa Margarita River Watershed - continued																
Newton Canyon	2.11	●	●	●	●				●	●		●	●	●		
Santa Margarita Lagoon	2.11	See Coastal Waters- Table 2-3														
San Luis Rey River Watershed																
San Luis Rey River	3.32	●	●	●			●	●	●	●		●		●		
Johnson Canyon	3.32	●	●	●			●	●	●	●		●		●		
San Luis Rey River	3.31	●	●	●			●	●	●	●		●		●		
Canada Aguanga	3.31	●	●	●			●	●	●	●		●		●		
Dark Canyon	3.31	●	●	●			●	●	●	●		●		●		
Bear Canyon	3.31	●	●	●			●	●	●	●		●		●		
Cow Canyon	3.31	●	●	●			●	●	●	●		●		●		
Blue Canyon	3.31	●	●	●			●	●	●	●		●		●		
Rock Canyon	3.31	●	●	●			●	●	●	●		●		●		
Agua Caliente Creek	3.31	●	●	●			●	●	●	●		●		●		
Canada Agua Caliente	3.31	●	●	●			●	●	●	●		●		●		
Canada Verde	3.31	●	●	●			●	●	●	●		●		●		
Ward Canyon	3.31	●	●	●			●	●	●	●		●		●		
Lake Henshaw	3.31	See Reservoirs & Lakes- Table 2-4														

● Existing Beneficial Use

O Potential Beneficial Use

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Luis Rey River Watershed - continued																
West Fork San Luis Rey River	3.31	●	●	●			●	●	●	●		●		●		
Fry Creek	3.31	●	●	●			●	●	●	●		●		●		
Iron Springs Creek	3.31	●	●	●			●	●	●	●		●		●		
Buena Vista Creek	3.31	●	●	●			●	●	●	●		●		●		
Cherry Canyon	3.31	●	●	●			●	●	●	●		●		●		
Bertha Canyon	3.31	●	●	●			●	●	●	●		●		●		
Hoover Canyon	3.31	●	●	●			●	●	●	●		●		●		
Buck Canyon	3.31	●	●	●			●	●	●	●		●		●		
Bergstrom Canyon	3.31	●	●	●			●	●	●	●		●		●		
San Ysidro Creek	3.31	●	●	●			●	●	●	●		●		●		
Matagual Creek	3.31	●	●	●			●	●	●	●		●		●		
Carrizo Creek	3.31	●	●	●			●	●	●	●		●		●		
Carrista Creek	3.31	●	●	●			●	●	●	●		●		●		
Kumpohui Creek	3.31	●	●	●			●	●	●	●		●		●		
San Luis Rey River	3.31	●	●	●			●	●	●	●		●		●		
San Luis Rey River	3.23	●	●	●				●	●	●		●	●	●		
Wigham Creek	3.23	●	●	●				●	●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters[1,2]	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Luis Rey River Watershed - continued																
Prisoner Creek	3.23	●	●	●				●	●	●		●	●	●		
Lusardi Canyon	3.23	●	●	●				●	●	●		●	●	●		
Cedar Creek	3.23	●	●	●				●	●	●		●	●	●		
San Luis Rey River	3.22	●	●	●				●	●	●		●	●	●		
Bee Canyon	3.22	●	●	●				●	●	●		●	●	●		
Paradise Creek	3.22	●	●	●				●	●	●		●	●	●		
Hell Creek	3.22	●	●	●				●	●	●		●	●	●		
Horsethief Canyon	3.22	●	●	●				●	●	●		●	●	●		
Potrero Creek	3.22	●	●	●				●	●	●		●	●	●		
Plaisted Creek	3.22	●	●	●				●	●	●		●	●	●		
Yuima Creek	3.22	●	●	●				●	●	●		●	●	●		
Sycamore Canyon	3.22	●	●	●				●	●	●		●	●	●		
Pauma Creek	3.22	●	●	●				●	●	●		●	●	●		
Doane Creek	3.22	●	●	●				●	●	●		●	●	●		
Chimney Creek	3.22	●	●	●				●	●	●		●	●	●		
French Creek	3.22	●	●	●				●	●	●		●	●	●		
Lion Creek	3.22	●	●	●				●	●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Luis Rey River Watershed - continued																
Harrison Canyon	3.22	●	●	●				●	●	●		●	●	●		
Jaybird Creek	3.22	●	●	●				●	●	●		●	●	●		
Frey Creek	3.22	●	●	●				●	●	●		●	●	●		
Agua Tibia Creek	3.22	●	●	●				●	●	●		●	●	●		
San Luis Rey River	3.21	●	●	●					●	●		●	●	●		
Marion Canyon	3.21	●	●	●					●	●		●	●	●		
Magee Creek	3.21	●	●	●					●	●		●	●	●		
Castro Canyon	3.21	●	●	●					●	●		●	●	●		
Trujillo Creek	3.21	●	●	●					●	●		●	●	●		
Pala Creek	3.21	●	●	●					●	●		●	●	●		
Gomez Creek	3.21	●	●	●					●	●		●	●	●		
Couser Canyon	3.21	●	●	●					●	●		●	●	●		
Double Canyon	3.21	●	●	●					●	●		●	●	●		
Rice Canyon	3.21	●	●	●					●	●		●	●	●		
San Luis Rey River	3.12	+	●	●					●	●		●		●	●	
Keys Creek	3.12	+	●	●					●	●		●		●		
Moosa Canyon	3.15	+	●	●					●	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Luis Rey River Watershed - continued																
unnamed intermittent streams	3.16	+	●	●					●	●		●		●		
Moosa Canyon	3.14	+	●	●					●	●		●		●		
Moosa Canyon	3.13	+	●	●					●	●		●		●		
Turner Lake	3.13	See Reservoirs & Lakes- Table 2-4														
South Fork Moosa Canyon	3.13	+	●	●					●	●		●		●		
Moosa Canyon	3.12	+	●	●					●	●		●		●		
Gopher Canyon	3.12	+	●	●					●	●		●		●		
South Fork Gopher Canyon	3.12	+	●	●					●	●		●		●		
San Luis Rey River	3.11	+	●	●					●	●		●		●	●	
Pilgrim Creek	3.11	+	●	●					●	●		●		●	●	
Windmill Canyon	3.11	+	●	●					●	●		●		●		
Tuley Canyon	3.11	+	●	●					●	●		●		●		
Lawerence Canyon	3.11	+	●	●					●	●		●		●		
Mouth of San Luis Rey River	3.11	See Coastal Waters- Table 2-3														
San Diego County Coastal Streams																
Loma Alta Creek	4.10	+							O	●		●		●		
Loma Alta Slough	4.10	See Coastal Waters- Table 2-3														

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Diego County Coastal Streams - continued																
Buena Vista Lagoon	4.21	See Coastal Waters- Table 2-3														
Buena Vista Creek	4.22	+	●	●					●	●		●		●		
Buena Vista Creek	4.21	+	●	●					●	●		●		●	●	
Agua Hedionda	4.31	See Coastal Waters- Table 2-3														
Agua Hedionda Creek	4.32	●	●	●					●	●		●		●		
Buena Creek	4.32	●	●	●					●	●		●		●		
Agua Hedionda Creek	4.31	●	●	●					●	●		●		●		
Letterbox canyon	4.31	●	●	●					●	●		●		●		
Canyon de las Encinas	4.40	+							O	●		●		●		
San Marcos Creek Watershed																
Batiquitos Lagoon	4.51	See Coastal Waters- Table 2-3														
San Marcos Creek	4.52	+	●						●	●		●		●		
unnamed intermittent streams	4.53	+	●						●	●		●		●		
San Marcos Creek Watershed																
San Marcos Creek	4.51	+	●						●	●		●		●		
Encinitas Creek	4.51	+	●						●	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
		BENEFICIAL USE														
Escondido Creek Watershed																
San Elijo Lagoon	4.61	See Coastal Waters- Table 2-3														
Escondido Creek	4.63	●	●	O				●	●	●		●	●	●		
Lake Wohlford	4.63	See Reservoirs & Lakes- Table 2-4														
Lake Dixon	4.62	See Reservoirs & Lakes- Table 2-4														
Escondido Creek	4.62	●	●	O					●	●		●	●	●		
Reidy Canyon	4.62	●	●	O					●	●		●	●	●		
Escondido Creek	4.61	●	●	O					●	●		●	●	●		
San Dieguito River Watershed																
Santa Ysabel Creek	5.54	●	●	●	●				●	●		●	●	●		
Jim Price Creek	5.54	●	●	●	●				●	●		●	●	●		
Santa Ysabel Creek	5.53	●	●	●	●				●	●		●	●	●		
Witch Creek	5.53	●	●	●	●				●	●		●	●	●		
Sutherland Lake	5.53	See Reservoirs & Lakes- Table 2-4														
Bloomdale Creek	5.53	●	●	●	●				●	●		●	●	●		
Santa Ysabel Creek	5.52	●	●	●	●				●	●		●	●	●	●	
Lake Poway	5.52	See Reservoirs & Lakes- Table 2-4														
Black Canyon	5.52	●	●	●	●				●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Dieguito River Watershed - continued																
Scholder Creek	5.52	●	●	●	●				●	●		●	●	●		
Temescal Creek	5.52	●	●	●	●				●	●		●	●	●		
Bear Creek	5.52	●	●	●	●				●	●		●	●	●		
Quail Canyon	5.52	●	●	●	●				●	●		●	●	●		
Carney Canyon	5.52	●	●	●	●				●	●		●	●	●		
Santa Ysabel Creek	5.51	●	●	●	●				●	●		●	●	●		
Boden Canyon	5.51	●	●	●	●				●	●		●	●	●		
Clevenger Canyon	5.51	●	●	●	●				●	●		●	●	●		
Santa Ysabel Creek	5.32	●	●	●	●				O	●		●		●	●	
Tims Canyon	5.32	●	●	●	●				O	●		●		●		
Schoolhouse Canyon	5.32	●	●	●	●				O	●		●		●		
Rockwood Canyon	5.35	●	●	●	●				O	●		●		●		
Guejito Creek	5.35	●	●	●	●				O	●		●		●		
unnamed intermittent streams	5.36	●	●	●	●				O	●		●		●		
Rockwood Canyon	5.32	●	●	●	●				O	●		●		●		
Santa Maria Creek	5.41	●	●	●	●				●	●		●		●		
Hatfield Creek	5.45	●	●	●	●				●	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

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[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Dieguito River Watershed - continued																
Hatfield Creek	5.44	●	●	●	●				●	●		●		●		
Wash Hollow Creek	5.43	●	●	●	●				●	●		●		●		
Wash Hollow Creek	5.44	●	●	●	●				●	●		●		●		
Hatfield Creek	5.42	●	●	●	●				●	●		●		●		
Santa Teresa Valley	5.46	●	●	●	●				●	●		●		●		
unnamed intermittent streams	5.47	●	●	●	●				●	●		●		●		
Hatfield Creek	5.41	●	●	●	●				●	●		●		●		
Santa Maria Creek	5.32	●	●	●	●				O	●		●		●		
unnamed intermittent streams	5.33	●	●	●	●				O	●		●		●		
unnamed intermittent streams	5.34	●	●	●	●				O	●		●		●		
San Dieguito River	5.32	●	●	●	●				O	●		●		●	●	
unnamed Tributary	5.32	●	●	●	●				O	●		●		●	●	
San Dieguito River	5.21	●	●	●	●				●	●	●	●	●	●	●	
Highland Valley	5.31	●	●	●	●				O	●		●		●		
Lake Hodges	5.21	See Reservoirs & Lakes- Table 2-4														
San Dieguito Reservoir	5.21	See Reservoirs & Lakes- Table 2-4														
Warren Canyon	5.21	●	●	●	●				●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

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Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Dieguito River Watershed - continued																
San Bernardo Valley	5.21	●	●	●	●				●	●		●	●	●	●	
unnamed intermittent streams	5.24	●	●	●	●				●	●		●	●	●		
unnamed intermittent streams	5.23	●	●	●	●				●	●		●	●	●		
unnamed intermittent streams	5.22	●	●	●	●				●	●		●	●	●		
San Dieguito River	5.11	+	O	O					●	●		●		●		
Lusardi Creek	5.12	+	O	O					●	●		●		●		
Lusardi Creek	5.11	+	O	O					●	●		●		●		
La Zanja Canyon	5.11	+	O	O					●	●		●		●		
Gonzales Canyon	5.11	+	O	O					●	●		●		●		
San Dieguito Lagoon	5.11	See Coastal Waters- Table 2-3														
Los Penasquitos Creek Watershed																
Los Penasquitos Lagoon	6.10	See Coastal Waters- Table 2-3														
Soledad Canyon	6.10	+	●	●					O	●		●	●	●		
Carol Canyon	6.10	+	●	●					O	●		●	●	●	●	
Miramar Reservoir	6.10	See Reservoirs & Lakes- Table 2-4														
Los Penasquitos Creek	6.20	+	●	O					●	●		●	●	●		
Rattlesnake Creek	6.20	+	●	O					●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

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[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Los Penasquitos Creek Watershed - continued																
Poway Creek	6.20	+	●	O					●	●		●	●	●		
Beeler Creek	6.20	+	●	O					●	●		●	●	●		
Chicarita Creek	6.20	+	●	O					●	●		●	●	●		
Cypress Canyon	6.20	+	●	O					●	●		●	●	●		
Los Penasquitos Creek	6.10	+	●	●					O	●		●	●	●		
unnamed Tributary	6.10	+	●	●					O	●		●	●	●	●	
Carmel Valley	6.10	+	●	●					O	●		●	●	●		
Deer Canyon	6.10	+	●	●					O	●		●	●	●		
McGonigle Canyon	6.10	+	●	●					O	●		●	●	●		
Bell Valley	6.10	+	●	●					O	●		●	●	●		
Shaw Valley	6.10	+	●	●					O	●		●	●	●		
San Diego County Coastal Streams																
unnamed intermittent coastal streams	6.30	+							O	●		●		●		
Rose Canyon Watershed																
Rose Canyon	6.40	+		O					●	●		●	●	●		
San Clemente Canyon	6.40	+		O					●	●		●	●	●	●	

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
		BENEFICIAL USE														
Tecolote Creek Watershed																
Tecolote Creek	6.50	+							O	●		●		●		
San Diego River Watershed																
San Diego River	7.41	●	●	●	●				●	●		●	●	●		
Coleman Creek	7.42	●	●	●	●				●	●		●	●	●		
Eastwood Creek	7.42	●	●	●	●				●	●		●	●	●		
Jim Green Creek	7.42	●	●	●	●				●	●		●	●	●		
Mariette Creek	7.42	●	●	●	●				●	●		●	●	●		
Boring Creek	7.42	●	●	●	●				●	●		●	●	●		
Bailey Creek	7.42	●	●	●	●				●	●		●	●	●		
Coleman Creek	7.41	●	●	●	●				●	●		●	●	●		
Setenec Creek	7.42	●	●	●	●				●	●		●	●	●		
Setenec Creek	7.41	●	●	●	●				●	●		●	●	●		
Temescal Creek	7.41	●	●	●	●				●	●		●	●	●		
Paine Bottom	7.41	●	●	●	●				●	●		●	●	●		
Orinoco Creek	7.41	●	●	●	●				●	●		●	●	●		
Iron Springs Canyon	7.41	●	●	●	●				●	●		●	●	●		
Dye Canyon	7.41	●	●	●	●				●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Diego River Watershed - continued																
Richie Creek	7.41	●	●	●	●				●	●		●	●	●		
Cedar Creek	7.41	●	●	●	●				●	●		●	●	●		
Sandy Creek	7.41	●	●	●	●				●	●		●	●	●		
Dehl Creek	7.41	●	●	●	●				●	●		●	●	●		
Kelly Creek	7.41	●	●	●	●				●	●		●	●	●		
Cuyamaca Reservoir	7.43	See Reservoirs & Lakes- Table 2-4														
Little Stonewall Creek	7.43	●	●	●	●				●	●		●	●	●		
Boulder Creek	7.41	●	●	●	●				●	●		●	●	●		
Azalea Creek	7.41	●	●	●	●				●	●		●	●	●		
Johnson Creek	7.41	●	●	●	●				●	●		●	●	●		
Sheep Camp Creek	7.41	●	●	●	●				●	●		●	●	●		
San Diego River	7.31	●	●	●	●				●	●		●	●	●		
El Capitan Reservoir	7.31	See Reservoirs & Lakes- Table 2-4														
Isham Creek	7.31	●	●	●	●				●	●		●	●	●		
Sand Creek	7.31	●	●	●	●				●	●		●	●	●		
Conejos Creek	7.31	●	●	●	●				●	●		●	●	●		
King Creek	7.31	●	●	●	●				●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Diego River Watershed - continued																
West Fork King Creek	7.31	●	●	●	●				●	●		●	●	●		
Echo Valley	7.31	●	●	●	●				●	●		●	●	●		
Peutz Valley	7.31	●	●	●	●				●	●		●	●	●		
Chocolate Canyon	7.32	●	●	●	●				●	●		●	●	●		
Alpine Creek	7.33	●	●	●	●				●	●		●	●	●		
Chocolate Canyon	7.31	●	●	●	●				●	●		●	●	●		
San Diego River	7.15	O		●					●	●		●	●	●	●	
San Diego River	7.12	O		●					●	●		●	●	●	●	
Lake Jennings	7.12	See Reservoirs & Lakes- Table 2-4														
Quail Canyon	7.12	O		●					●	●		●	●	●		
Wildcat Canyon	7.12	O		●					●	●		●	●	●		
San Vicente Creek	7.23	●	●	●	●				●	●		●	●	●		
Swartz Canyon	7.23	●	●	●	●				●	●		●	●	●		
Klondike Creek	7.23	●	●	●	●				●	●		●	●	●		
San Vicente Creek	7.22	●	●	●	●				●	●		●	●	●		
Darney Canyon	7.22	●	●	●	●				●	●		●	●	●		
Longs Gulch	7.22	●	●	●	●				●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Diego River Watershed - continued																
San Vicente Reservoir	7.21	See Reservoirs & Lakes- Table 2-4														
West Branch San Vicente Creek	7.21	●	●	●	●				●	●		●	●	●		
Padre Barona Creek	7.24	●	●	●	●				●	●		●	●	●		
Wright Canyon	7.24	●	●	●	●				●	●		●	●	●		
Featherstone Canyon	7.24	●	●	●	●				●	●		●	●	●		
Padre Barona Creek	7.12	O		●					●	●		●	●	●		
Foster Canyon	7.21	●	●	●	●				●	●		●	●	●		
San Vicente Creek	7.12	O		●					●	●		●	●	●		
Slaughterhouse Canyon	7.12	O		●					●	●		●	●	●		
Las Coches Creek	7.14	O		●					●	●		●	●	●		
Rios Canyon	7.14	O		●					●	●		●	●	●		
Los Coches Creek	7.12	O		●					●	●		●	●	●		
Forrester Creek	7.13	O		●					●	●		●	●	●		
Forrester Creek	7.12	O		●					●	●		●	●	●		
Sycamore Canyon	7.12	+	●	●					●	●		●	●	●	●	
unnamed tributary	7.12	+	●	●					●	●		●	●	●	●	
Clark Canyon	7.12	+	●	●					●	●		●	●	●	●	

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC 1	REC 2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Diego River Watershed - continued																
West Sycamore Canyon	7.12	+	●	●					●	●		●	●	●		
Quail Canyon	7.12	+	●	●					●	●		●	●	●		
Little Sycamore Canyon	7.12	+	●	●					●	●		●	●	●		
Spring Canyon	7.12	+	●	●					●	●		●	●	●	●	
Oak Canyon	7.12	+	●	●					●	●		●	●	●		
San Diego River	7.11	+	●	●					●	●		●	●	●	●	
unnamed Tributary	7.11	+	●	●					●	●		●	●	●	●	
Alvarado Canyon	7.11	+	●	●					●	●		●	●	●		
Lake Murray	7.11	See Reservoirs & Lakes- Table 2-4														
Murphy Canyon	7.11	+	●	●					●	●		●	●	●	●	
Shepherd Canyon	7.11	+	●	●					●	●		●	●	●		
Murray Canyon	7.11	+	●	●					●	●		●	●	●		
Mouth of San Diego River	7.11	See Coastal Waters- Table 2-3														
San Diego County Coastal Streams																
unnamed intermittent coastal streams	8.10	+							O	●		●		●		
Powerhouse Canyon	8.21	+							O	●		●		●		
Chollas Creek	8.22	+							O	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
San Diego County Coastal Streams - continued																
South Chollas Valley	8.22	+							O	●		●		●		
Seventh St. Channel	8.31	+							O	●		●		●		
unnamed intermittent streams	8.31	+							O	●		●		●		
Paradise Creek	8.32	+							O	●		●		●		
Paradise Valley	8.32	+							O	●		●		●		
Sweetwater River Watershed																
Sweetwater River	9.35	●	●	●	●				●	●		●	●	●		
Stonewall Creek	9.35	●	●	●	●				●	●		●	●	●		
Harper Creek	9.35	●	●	●	●				●	●		●	●	●		
Cold Stream	9.35	●	●	●	●				●	●		●	●	●		
Japacha Creek	9.35	●	●	●	●				●	●		●	●	●		
Juaquapin Creek	9.35	●	●	●	●				●	●		●	●	●		
Arroyo Seco	9.35	●	●	●	●				●	●		●	●	●		
Sweetwater River	9.34	●	●	●	●				●	●		●	●	●		
Descanso Creek	9.34	●	●	●	●				●	●		●	●	●		
Samagatuma Creek	9.34	●	●	●	●				●	●		●	●	●		
Sweetwater River	9.31	●	●	●	●				●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Sweetwater River Watershed - continued																
Viejas Creek	9.33	●	●	●	●				●	●		●	●	●		
Viejas Creek	9.31	●	●	●	●				●	●		●	●	●		
Loveland Reservoir	9.31	See Reservoirs & Lakes- Table 2-4														
Taylor Creek	9.31	●	●	●	●				●	●		●	●	●		
Japatul Valley	9.32	●	●	●	●				●	●		●	●	●		
Sweetwater River	9.21	●	●	●	●				●	●	●	●		●	●	
unnamed tributary	9.21	●	●	●	●				●	●	●	●		●	●	
Lawson Creek	9.21	●	●	●	●				●	●		●		●		
Beaver Canyon	9.21	●	●	●	●				●	●		●		●		
Wood Valley	9.21	●	●	●	●				●	●		●		●		
Sycuan Creek	9.25	●	●	●	●				●	●		●		●		
North Fork Sycuan Creek	9.26	●	●	●	●				●	●		●		●		
North Fork Sycuan Creek	9.25	●	●	●	●				●	●		●		●		
Denesa Valley	9.23	●	●	●	●				●	●		●		●		
Harbison Canyon	9.23	●	●	●	●				●	●		●		●		
Galloway Valley	9.24	●	●	●	●				●	●		●		●		
Mexican Canyon	9.21	●	●	●	●				●	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Sweetwater River Watershed - continued																
unnamed intermittent streams	9.22	●	●	●	●				●	●		●		●		
Steel Canyon	9.21	●	●	●	●				●	●		●		●		
Sweetwater Reservoir	9.21	See Reservoirs & Lakes- Table 2-4														
Coon Canyon	9.21	●	●	●	●				●	●		●		●		
Sweetwater River	9.12	+		●					O	●		●		●		
Spring Valley	9.12	+		●					O	●		●		●		
Wild Mans Canyon	9.12	+		●					O	●		●		●		
Long Canyon	9.12	+		●					O	●		●		●		
Rice Canyon	9.12	+		●					O	●		●		●		
Telegraph Canyon	9.11	+		●					O	●		●		●		
San Diego County Coastal Streams																
unnamed intermittent coastal streams	10.10	+							O			●				
Otay River Watershed																
Jamul Creek	10.34	●	●	●	●				●	●		●		●		
Jamul Creek	10.33	●	●	●	●				●	●		●		●		
Jamul Creek	10.36	●	●	●	●				●	●		●		●		
Dulzura Creek	10.37	●	●	●	●				●	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

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[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Otay River Watershed - continued																
Dulzura Creek	10.36	●	●	●	●				●	●		●		●	●	
Dutchman Canyon	10.36	●	●	●	●				●	●		●		●		
Pringle Canyon	10.36	●	●	●	●				●	●		●		●		
Sycamore Canyon	10.36	●	●	●	●				●	●		●		●		
Hollenbeck Canyon	10.36	●	●	●	●				●	●		●		●		
Lyons Valley	10.35	●	●	●	●				●	●		●		●		
Cedar Canyon	10.36	●	●	●	●				●	●		●		●		
Little Cedar Canyon	10.36	●	●	●	●				●	●		●		●		
Jamul Creek	10.31	●	●	●	●				●	●		●		●	●	
Lower Otay Reservoir	10.31	See Reservoirs & Lakes- Table 2-4														
unnamed tributary	10.31	●	●	●	●				●	●		●		●	●	
Upper Otay Reservoir	10.32	See Reservoirs & Lakes- Table 2-4														
Proctor Valley	10.32	●	●	●	●				●	●		●		●		
Otay River	10.20	+	●	O					O	●		●		●	●	
O'Neal Canyon	10.20	+	●	O					O	●		●		●		
Salt Creek	10.20	+	●	O					O	●		●		●		
Johnson Canyon	10.20	+	●	O					O	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

\+ Excepted From MUN (See Text)

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[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Otay River Watershed - continued																
Wolf Canyon	10.20	+	●	O					O	●		●		●		
Dennery Canyon	10.20	+	●	O					O	●		●		●		
Pogi Canyon	10.20	+	●	O					O	●		●		●		
Tijuana River Watershed																
Tijuana River	11.11	+		O					O	●		●		●	●	
Moody Canyon	11.11	+		O					O	●		●		●		
Smugglers Gulch	11.11	+		O					O	●		●		●		
Goat Canyon	11.11	+		O					O	●		●		●		
Tijuana River Estuary	11.11	See Coastal Waters- Table 2-3														
Spring Canyon	11.12	+	●	O					O	●		●		●		
Dillon Canyon	11.12	+	●	O					O	●		●		●		
Finger Canyon	11.12	+	●	O					O	●		●		●		
Wruck Canyon	11.12	+	●	O					O	●		●		●		
unnamed intermittent streams	11.12	+	●	O					O	●		●		●		
unnamed intermittent streams	11.21	+							●	●		●		●		
Tijuana River	11.21	+							●	●		●		●		
Tecate Creek	11.23	+							●	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

+ Excepted From MUN (See Text)

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[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Tijuana River Watershed - continued																
Cottonwood Creek	11.60	●	●	●	●		●		O	●		●		●	●	
Kitchen Creek	11.60	●	●	●	●		●		O	●		●		●		
Long Canyon	11.60	●	●	●	●		●		O	●		●		●		
Troy Canyon	11.60	●	●	●	●		●		O	●		●		●		
Fred Canyon	11.60	●	●	●	●		●		O	●		●		●		
Horse Canyon	11.60	●	●	●	●		●		O	●		●		●		
La Posta Creek	11.70	●	●	●	●		●		●	●		●		●		
Simmons Canyon	11.70	●	●	●	●		●		●	●		●		●		
La Posta Creek	11.60	●	●	●	●		●		O	●		●		●		
Morena Reservoir	11.50	See Reservoirs & Lakes- Table 2-4														
Morena Creek	11.50	●	●	●	●		●		●	●		●		●		
Long Valley	11.50	●	●	●	●		●		●	●		●		●		
Bear Valley	11.50	●	●	●	●		●		●	●		●		●		
Cottonwood Creek	11.30	●	●	●	●		●		●	●		●	●	●	●	
Hauser Creek	11.30	●	●	●	●		●		●	●		●	●	●		
Salazar Canyon	11.30	●	●	●	●		●		●	●		●	●	●		
Barrett Lake	11.30	See Reservoirs & Lakes- Table 2-4														

● Existing Beneficial Use

O Potential Beneficial Use

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Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Tijuana River Watershed - continued																
Boneyard Canyon	11.30	●	●	●	●		●		●	●		●	●	●		
Skye Valley	11.30	●	●	●	●		●		●	●		●	●	●		
Pine Valley Creek	11.41	●	●	●	●		●		●	●		●	●	●		
Indian Creek	11.41	●	●	●	●		●		●	●		●	●	●		
Lucas Creek	11.41	●	●	●	●		●		●	●		●	●	●		
Noble Canyon	11.41	●	●	●	●		●		●	●		●	●	●		
Los Rasalies Ravine	11.42	●	●	●	●		●		●	●		●	●	●		
Paloma Ravine	11.42	●	●	●	●		●		●	●		●	●	●		
Bonita Ravine	11.42	●	●	●	●		●		●	●		●	●	●		
Chico Ravine	11.42	●	●	●	●		●		●	●		●	●	●		
Madero Ravine	11.42	●	●	●	●		●		●	●		●	●	●		
Los Gatos Ravine	11.42	●	●	●	●		●		●	●		●	●	●		
Boiling Spring Ravine	11.42	●	●	●	●		●		●	●		●	●	●		
Agua Dulce Creek	11.42	●	●	●	●		●		●	●		●	●	●		
Escondido Ravine	11.42	●	●	●	●		●		●	●		●	●	●		
Scove Canyon	11.41	●	●	●	●		●		●	●		●	●	●		
Pine Valley Creek	11.30	●	●	●	●		●		●	●		●	●	●		

● Existing Beneficial Use

O Potential Beneficial Use

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[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters[1,2]	Hydrologic Unit Basin Number	BENEFICIAL USE														
		MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Tijuana River Watershed - continued																
Oak Valley	11.30	●	●	●	●		●		●	●		●	●	●		
Nelson Canyon	11.30	●	●	●	●		●		●	●		●	●	●		
Secret Canyon	11.30	●	●	●	●		●		●	●		●	●	●		
Horsethief Canyon	11.30	●	●	●	●		●		●	●		●	●	●		
Espinosa Creek	11.30	●	●	●	●		●		●	●		●	●	●		
Wilson Creek	11.30	●	●	●	●		●		●	●		●	●	●		
Pats Canyon	11.30	●	●	●	●		●		●	●		●	●	●		
Cottonwood Creek	11.23	+							●	●		●		●		
Dry Valley	11.23	+							●	●		●		●		
BobOwens Canyon	11.23	+							●	●		●		●		
McAlmond Canyon	11.24	+							●	●		●		●		
McAlmond Canyon	11.23	+							●	●		●		●		
Rattlesnake Canyon	11.23	+							●	●		●		●		
Potrero Creek	11.25	+							●	●		●		●		
Little Potrero Creek	11.25	+							●	●		●		●		
Potrero Creek	11.23	+							●	●		●		●		
Grapevine Creek	11.23	+							●	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

+ Excepted From MUN (See Text)

[1] Waterbodies are listed multiple times if they cross hydrologic area or sub area boundaries.

[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-2. BENEFICIAL USES OF INLAND SURFACE WATERS

Inland Surface Waters [1,2]	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRSH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
		BENEFICIAL USE														
Tijuana River Watershed - continued																
Bee Canyon	11.22	+							●	●		●		●		
Bee Creek	11.23	+							●	●		●		●		
Mine Canyon	11.21	+							●	●		●		●		
unnamed intermittent streams	11.81	+							●	●		●		●		
unnamed intermittent streams	11.82	+							●	●		●		●		
Campo Creek	11.84	+							●	●		●		●		
Diabold Canyon	11.84	+							●	●		●		●		
Campo Creek	11.83	+							●	●		●		●		
Miller Creek	11.83	+							●	●		●		●		
Campo Creek	11.82	+							●	●		●		●		
Smith Canyon	11.82	+							●	●		●		●		
unnamed intermittent streams	11.85	+							●	●		●		●		

● Existing Beneficial Use

O Potential Beneficial Use

+ Excepted From MUN (See Text)

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[2] Beneficial use designations apply to all tributaries to the indicated waterbody, if not listed separately.

Table 2-3. BENEFICIAL USES OF COASTAL WATERS

Coastal Waters	Hydrologic Unit Basin Number	BENEFICIAL USE														
		IND	NAV	REC1	REC2	COMM	BIOL	EST	WILD	RARE	MAR	AQUA	MIGR	SPWN	WARM	SHELL
Pacific Ocean		●	●	●	●	●	●		●	●	●	●	●	●		●
Mission Bay		●		●	●	●		●	●	●	●		●			●
San Diego Bay [1]		●	●	●	●	●	●	●	●	●	●		●			●
Coastal Lagoons																
Tijuana River Estuary	11.11			●	●	●	●	●	●	●	●		●			●
Mouth of San Diego River	7.11			●	●	●		●	●	●	●		●			●
Los Penasquitos Lagoon [2]	6.10			●	●		●	●	●	●	●		●			●
San Dieguito Lagoon	5.11			●	●		●	●	●	●	●		●			
Del Mar Boat Basin	5.11	●	●	●	●	●			●	●	●		●	●		●
Batiquitos Lagoon	4.51			●	●		●	●	●	●	●		●			
San Elijo Lagoon	5.61			●	●		●	●	●	●	●		●			
Aqua Hedionda Lagoon	4.31	●		●	●	●		●	●	●	●	●	●			●

[1] Includes the tidal prisms of the Otay and Sweetwater Rivers.
[2] Fishing from shore or boat permitted, but other water contact recreational (REC-1) uses are prohibited.

● Existing Beneficial Use

Table 2-3. BENEFICIAL USES OF COASTAL WATERS

Coastal Waters	Hydrologic Unit Basin Number	BENEFICIAL USE														
		IND	NAV	REC 1	REC 2	COMM	BIOL	EST	WILD	RARE	MAR	AQUA	MIGR	SPWN	WARM	SHELL
Coastal Lagoons - continued																
Buena Vista Lagoon [2]	4.21			●	●		●	O	●	●	●				●	
Loma Alta Slough	4.10			●	●			●	●	●	●					
Mouth of San Luis Rey River	3.11			●	●				●	●	●		●			
Oceanside Harbor	3.11	●	●	●	●	●			●	●	●		●	●		●
Santa Margarita Lagoon	2.11			●	●			●	●	●	●		●			
Aliso Creek Mouth	1.13			●	●				●	●	●					
Dana Point Harbor	1.14	●	●	●	●	●			●	●	●		●	●		●
San Juan Creek Mouth	1.27			●	●				●	●	●		●			●
San Mateo Creek Mouth	1.40			●	●		●		●	●	●		●			
San Onofre Creek Mouth	1.51			●	●				●	●	●		●			

1 Includes the tidal prisms of the Otay and Sweetwater Rivers.
2 Fishing from shore or boat permitted, but other water contact recreational (REC-1) uses are prohibited.

● Existing Beneficial Use
O Potential Beneficial Use

Table 2-4. BENEFICIAL USES OF RESERVOIRS AND LAKES

Reservoirs & Lakes	Hydrologic Unit Basin Number	BENEFICIAL USE												
		MUN	AGR	IND	PROC	GWR	FRSH	REC 1	REC 2	WARM	COLD	WILD	RARE	POW
O'Neill Lake	2.13	●	●	●	●			●	●	●	●	●	●	
Lake Skinner	2.42	●	●	●	●	O		● [1]	●	●		●		
Vail Lake	2.81	●	●	●	●	●		● [1]	●	●		●		
Turner Lake	3.13	●	●	●				O	●	●				
Lake Henshaw	3.31	●	●	●	●		●	● [1]	●	●		●	●	●
San Dieguito Reservoir	5.21	●	●	O				●	●	●	●	●		
Lake Dixon	4.62	●	●	O				● [1]	●	●	●	●		
Lake Wohlford	4.63	●	●	O				● [1]	●	●	●	●		●
Lake Hodges	5.21	●	●	●	●			● [1]	●	●	●	●	●	
Lake Poway	5.52	●	●	●	●			● [1]	●	●	●	●		
Sutherland Lake	5.53	●	●	●	●			● [1]	●	●	●	●	●	
Miramar Reservoir	6.10	●		●				● [1]	●	●		●		●
Lake Murray	7.11	●		●				● [1]	●	●	●	●		●
Lake Jennings	7.12	●		●				● [1]	●	●	●	●		
San Vicente Reservoir	7.21	●	●	●	●			● [1]	●	●	●	●		
El Capitan Reservoir	7.31	●	●	●	●			● [1]	●	●	●	●	●	
Cuyamaca Reservoir	7.43	●	●	●	●			● [1]	●	●	●	●	●	
Sweetwater Reservoir	9.21	●	●	●	●			●	●	●		●		
Loveland Reservoir	9.31	●	●	●	●			●	●	●	●	●		
Lower Otay Reservoir	10.31	●	●	●	●			● [1]	●	●	●	●		
Upper Otay Reservoir	10.32	●	●	●	●			●	●	●	●	●		
Lake Barrett	11.30	●	●	●	●		●	●	●	●	●	●	●	
Morena Reservoir	11.50	●	●	●	●		●	● [1]	●	●	●	●	●	

[1] Fishing from shore or boat permitted, but other water contact recreational (REC-1) uses are prohibited.

● Existing Beneficial Use

O Potenetial Beneficial Use

Table 2-5. BENEFICIAL USES OF GROUND WATERS

Ground Water		Hydrologic Unit Basin Number	BENEFICIAL USE MUN	AGR	IND	PROC	FRSH	GWR
SAN JUAN HYDROLOGIC UNIT		**1.00**						
Laguna	HA	1.10						
San Joaquin Hills	HSA [1]	1.11	●	●				
Laguna Beach	HSA [1]	1.12	●	●				
Aliso	HSA [2]	1.13	●	●				
Dana Point	HSA [1]	1.14	+	●				
Mission Viejo	HA	1.20						
Oso	HSA	1.21	●	●	●			
Upper Trabuco	HSA	1.22	●	●	●			
Middle Trabuco	HSA	1.23	●	●	●			
Gobernadora	HSA	1.24	●	●	●			
Upper San Juan	HSA	1.25	●	●	●			
Middle San Juan	HSA	1.26	●	●	●			

1 These beneficial uses do not apply to all lands on the coastal side of the inland boundary of the right-of-way of Pacific Coast Highway 1, and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of HA 1.10 are as shown.

2 These beneficial uses do not apply westerly of the easterly boundary of the right-of-way of Interstate Highway 5 and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of the hydrologic area are as shown.

● Existing Beneficial Use
O Potential Beneficial Use
+ Excepted From MUN (see text)

Table 2-5. BENEFICIAL USES OF GROUND WATERS

Ground Water			Hydrologic Unit Basin Number	BENEFICIAL USE					
				MUN	AGR	IND	PROC	FRSH	GWR
Lower San Juan	HSA	[3]	1.27	●	●	●			
Ortega	HSA		1.28	●	●	●			
San Clemente	HA		1.30						
Prima Deshecha	HSA	[2]	1.31	●	●				
Segunda Deshecha	HSA		1.32	+					
San Mateo Canyon	HA	[2]	1.40	●	●	●			
San Onofre	HA	[2]	1.50	●	●				

2 These beneficial uses do not apply westerly of the easterly boundary of the right-of-way of Interstate Highway 5 and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of the hydrologic area are as shown.

3 These beneficial uses do not apply to all lands on the coastal side of the inland boundary of the right-of-way of Pacific Coast Highway 1 west of the San Juan Creek channel and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of HA 1.20 are as shown.

● Existing Beneficial Use
O Potential Beneficial Use
+ Excepted From MUN (see text)

Table 2-5. BENEFICIAL USES OF GROUND WATERS

Ground Water		Hydrologic Unit Basin Number	BENEFICIAL USE					
			MUN	AGR	IND	PROC	FRSH	GWR
SANTA MARGARITA HYDROLOGIC UNIT		**2.00**						
Ysidora	HA [2]	2.10	●	●	●	●		
Deluz	HA	2.20	●	●	●			
Murrieta	HA	2.30	●	●	●	●		
Alud	HA	2.40	●	●	●			
Pechanga	HA	2.50	●	●	●			
Wilson	HA	2.60	●	●	O			
Cave Rocks	HA	2.70	●	●				
Aguanga	HA	2.80	●	●	●			
Oakgrove	HA	2.90	●	●				
SAN LUIS REY HYDROLOGIC UNIT		**3.00**						
Lower San Luis	HA [2]	3.10	●	●	●			
Monserate	HA	3.20						
Pala	HSA	3.21	●	●	●			
Pauma	HSA	3.22	●	●	●			
La Jolla Amago	HSA	3.23	●	●	●	●		
Warner Valley	HA	3.30						
Warner	HSA	3.31	●	●	●		●	
Combs	HSA	3.32	●	●	●			

2 These beneficial uses do not apply westerly of the easterly boundary of the right-of-way of Interstate Highway 5 and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of the hydrologic area are as shown.

● Existing Beneficial Use

O Potential Beneficial Use

Table 2-5. BENEFICIAL USES OF GROUND WATERS

Ground Water		Hydrologic Unit Basin Number	BENEFICIAL USE MUN	AGR	IND	PROC	FRSH	GWR
CARLSBAD HYDROLOGIC UNIT		**4.00**						
Loma Alta	HA [2]	4.10	+		●			
Buena Vista Creek	HA	4.20						
El Salto	HSA [2]	4.21	●	●	O			
Vista	HSA	4.22	●	●	●			
Aqua Hedionda	HA	4.30						
Los Monos	HSA [2]	4.31	●	●	●			
Los Monos	HSA [5]	4.31	O	O	O			
Los Monos	HSA [6]	4.31	O	●	O			
Buena	HSA	4.32	●	●	●			
Encinas	HA	4.40	+					

2 These beneficial uses do not apply westerly of the easterly boundary of the right-of-way of Interstate Highway 5 and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of the hydrologic area are as shown.

5 These beneficial use designations apply to the portion of HSA 4.31 bounded on the west by the easterly boundary of Interstate Highway 5 right-of-way; on the east by the easterly boundary of El Camino Real; and on the north by a line extending along the southerly edge of Agua Hedionda Lagoon to the easterly end of the lagoon, thence in an easterly direction to Evans Point, thence easterly to El Camino Real along the ridge lines separating Letterbox Canyon and the area draining to the Marcario Canyon.

6 These beneficial use designations apply to the portion of HSA 4.31 tributary to Agua Hedionda Creek downstream from the El Camino Real crossing, except lands tributary to Marcario Canyon (located directly southerly of Evans Point), land directly south of Agua Hedionda Lagoon, and areas west of Interstate Highway 5.

● Existing Beneficial Use
O Potential Beneficial Use
+ Excepted From MUN (see text)

Table 2-5. BENEFICIAL USES OF GROUND WATERS

Ground Water			Hydrologic Unit Basin Number	BENEFICIAL USE MUN	AGR	IND	PROC	FRSH	GWR
CARLSBAD HYDROLOGIC UNIT - Continued			**4.00**						
San Marcos	HA		4.50						
Batiquitos	HSA	[2,7]	4.51	●	●	●			
Batiquitos	HSA	[8]	4.51	O	O	O			
Richland	HSA	[2,7]	4.52	●	●	●			
Twin Oaks	HSA	[2,7]	4.53	●	●	●			
Escondido	HA		4.60						
San Elijo	HSA	[2]	4.61	O	●	●			
Escondido	HSA		4.62	●	●	●			
Lake Wohlford	HSA		4.63	●	●	●			

2 These beneficial uses do not apply westerly of the easterly boundary of the right-of-way of Interstate Highway 5 and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of the hydrologic area are as shown.

7 These beneficial used do not apply to HSA 4.51 and HSA 4.52 between Highway 78 and El Camino Real and to all lands which drain to Moonlight Creek and to Encinitas Creek and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of the subarea are as shown.

8 These beneficial use designations apply to the portion of HSA 4.51 bounded on the south by the north shore of Batiquitos Lagoon, on the west by the easterly boundary of the Interstate Highway 5 right-of-way, on the north by the subarea boundary and on the east by the easterly boundary of El Camino Real.

● Existing Beneficial Use
O Potential Beneficial Use

Table 2-5. BENEFICIAL USES OF GROUND WATERS

Ground Water		Hydrologic Unit Basin Number	BENEFICIAL USE					
			MUN	AGR	IND	PROC	FRSH	GWR
SAN DIEGUITO HYDROLOGIC UNIT		**5.00**						
Solana Beach	HA [2]	5.10	●	●	●			
Hodges	HA	5.20	●	●	●			
San Pasqual	HA	5.30	●	●	●			
Santa Maria Valley	HA	5.40						
Ramona	HSA	5.41	●	●	●	●		
Lower Hatfield	HSA	5.42	●	●	●			
Wash Hallow	HSA	5.43	●	●	●			
Upper Hatfield	HSA	5.44	●	●	●			
Ballena	HSA	5.45	●	●	●			
East Santa Teresa	HSA	5.46	●	●	●			
West Santa Teresa	HSA	5.47	●	●	●			
Santa Ysabel	HA	5.50	●	●				

[2] These beneficial uses do not apply westerly of the easterly boundary of the right-of-way of Interstate Highway 5 and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of the hydrologic area are as shown.

● Existing Beneficial Use

O Potential Beneficial Use

Table 2-5. BENEFICIAL USES OF GROUND WATERS

Ground Water			Hydrologic Unit Basin Number	BENEFICIAL USE					
				MUN	AGR	IND	PROC	FRSH	GWR
PENASQUITOS HYDROLOGIC UNIT			**6.00**						
Miramar Reservoir	HA	2,9	6.10	●	●	●			
Poway	HA		6.20	●	●	O			
Scripps	HA		6.30	+					
Miramar	HA	10	6.40	+		O			
Tecolote	HA		6.50	+					
SAN DIEGO HYDROLOGIC UNIT			**7.00**						
Lower San Diego	HA		7.10						
Mission San Diego	HSA	2	7.11	O	●	●	●		
Santee	HSA		7.12	●	●	●	●		
El Cajon	HSA		7.13	●	●	O	O		
Coches	HSA		7.14	●	●	●	O		
El Monte	HSA		7.15	●	●	●	O		
San Vicente	HA		7.20	●	●				
El Capitan	HA		7.30	●	●				
Boulder Creek	HA		7.40	●	●				

2 These beneficial uses do not apply westerly of the easterly boundary of the right-of-way of Interstate Highway 5 and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of the hydrologic area are as shown.

9 These beneficial uses do not apply to all lands which drain to Los Penasquitos Canyon from 1.5 miles west of Interstate Highway 15 and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of the hydrologic area are as shown.

10 These beneficial uses do not apply west of Interstate Highway 15. The beneficial uses for the remainder of the hydrologic area are as shown.

● Existing Beneficial Use
O Potential Beneficial Use
+ Excepted From MUN (see text)

Table 2-5. BENEFICIAL USES OF GROUND WATERS

Ground Water		Hydrologic Unit Basin Number	BENEFICIAL USE MUN	AGR	IND	PROC	FRSH	GWR
PUEBLO SAN DIEGO HYDROLOGIC UNIT		**8.00**						
Point Loma	HA	8.10	+					
San Diego Mesa	HA	8.20	+					
National City	HA [2]	8.30	●					
SWEETWATER HYDROLOGIC UNIT		**9.00**						
Lower Sweetwater	HA	9.10						
Telegraph	HSA	9.11	O	●	O			
La Nacion	HSA	9.12	●	●	●			
Middle Sweetwater	HA	9.20	●	●	●			
Upper Sweetwater	HA	9.30	●	●				
OTAY HYDROLOGIC UNIT		**10.00**						
Coronado	HA	10.10	+					
Otay Valley	HA	10.20	●	●	●			
Otay Valley	HA [11]	10.20	+		●			
Dulzura	HA	10.30	●	●	●			

2 These beneficial uses do not apply westerly of the easterly boundary of the right-of-way of Interstate Highway 5 and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of the hydrologic area as shown.

11 This beneficial use designation applies to the portion of Otay HA (10.20), limited to lands within and tributary to Salt Creek on the east and Poggi Canyon on the west and including the several smaller drainage courses between these tributaries of the Otay River.

● Existing Beneficial Use
O Potential Beneficial Use
+ Excepted From MUN (see text)

Table 2-5. BENEFICIAL USES OF GROUND WATERS

Ground Water		Hydrologic Unit Basin Number	BENEFICIAL USE MUN	AGR	IND	PROC	FRSH	GWR
TIJUANA HYDROLOGIC UNIT		**11.00**						
Tijuana Valley	HA	11.10						
San Ysidro	HSA [12]	11.11	●	●	●			
Water Tanks	HSA	11.12	O	O	O			
Potrero	HA	11.20	●	●	●			
Barrett Lake	HA	11.30	●	●				
Monument	HA	11.40	●	●				
Morena	HA	11.50	●	●				
Cottonwood	HA	11.60	●	●				
Cameron	HA	11.70	●	●				
Campo	HA	11.80	●	●	●			

12 These beneficial uses do not apply west of Hollister Street and this area is excepted from the sources of drinking water policy. The beneficial uses for the remainder of the hydrologic area are as shown.

● Existing Beneficial Use

O Potential Beneficial Use

Appendix D-3
Santa Ana Regional Water Quality Control Board

Table 3-1 BENEFICIAL USES

OCEAN WATERS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
NEARSHORE ZONE*																						
San Gabriel River to Poppy Street in Corona del Mar	+		X			X		X	X	X					X	X	X	X	X		801.11	
Poppy Street to Southeast Regional Boundary	+					X		X	X	X				X	X	X	X	X	X		801.11	
OFFSHORE ZONE																						
Waters Between Nearshore Zone and Limit of State Waters	+		X			X		X	X	X					X	X	X	X				

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from MUN (see text)

* Defined by Ocean Plan Chapter II A.1.: "Within a zone bounded by shoreline and a distance of 1000 feet from shoreline or the 30-foot depth contour, whichever is further from shoreline..."

Table 3-1 BENEFICIAL USES - Continued

BAYS, ESTUARIES, AND TIDAL PRISMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Anaheim Bay - Outer Bay	+					X		X	X					X	X	X	X	X			801.11	
Anaheim Bay - Seal Beach National Wildlife Refuge	+							X[1]	X					X	X	X	X	X		X	801.11	
Sunset Bay - Huntington Harbour	+					X		X	X	X					X	X	X	X			801.11	
Bolsa Bay	+							X	X	X				X	X	X	X	X	X		801.11	
Bolsa Chica Ecological Reserve	+							X	X					X	X	X	X	X		X	801.11	
Lower Newport Bay	+					X		X	X	X					X	X	X	X	X		801.11	
Upper Newport Bay	+							X	X	X				X	X	X	X	X	X	X	801.11	
Santa Ana River Salt Marsh	+							X	X					X	X	X		X		X	801.11	
Tidal Prism of Santa Ana River (to within 1000' of Victoria Street) and Newport Slough	+							X	X	X					X	X		X			801.11	
Tidal Prism of San Gabriel River - River Mouth to Marina Drive	+		X					X	X	X					X	X		X	X	X	845.61	
Tidal Prisms of Flood Control Channels Discharging to Coastal or Bay Waters	+							X	X	X					X			X			801.11	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from MUN (see text)

[1] No access per agency with jurisdiction (U.S. Navy)

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
LOWER SANTA ANA RIVER BASIN																						
Santa Ana River																						
Reach 1 - Tidal Prism to 17th Street in Santa Ana	+							X[2]	X		I				I						801.11	
Reach 2 - 17th Street in Santa Ana to Prado Dam	+	X			X			X	X		X				X	X					801.11	801.12
Aliso Creek	X				X			X	X		X				X	X					845.63	
Carbon Canyon Creek	X				X			X	X		X				X	X					845.63	
Santiago Creek Drainage																						
Santiago Creek																						
Reach 1 - below Irvine Lake	X				X			X[2]	X		X				X						801.12	801.11
Reach 2 - Irvine Lake (see Lakes, pg. 3-23)																						
Reach 3 - Irvine Lake to Modjeska Canyon	I				I			I	I		I				I						801.12	
Reach 4 - in Modjeska Canyon	X				X			X	X		X				X						801.12	
Silverado Creek	X				X			X	X		X				X						801.12	
Black Star Creek	I				I			I	I		I				I						801.12	
Ladd Creek	I				I			I	I		I				I	I					801.12	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

[2] Access prohibited in all or part by Orange County Environmental Managmeent Agency (OCEMA)

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
San Diego Creek Drainage																						
San Diego Creek																						
Reach 1 - below Jeffrey Road	+							X[2]	X		X				X						801.11	
Reach 2 - above Jeffrey Road to Headwaters	+				I			I	I		I				I						801.11	
Other Tributaries: Bonita Creek, Serrano Creek, Peters Canyon Wash, Hicks Canyon Wash, Bee Canyon Wash, Borrego Canyon Wash, Agua Chinon Wash, Laguna Canyon Wash, Rattlesnake Canyon Wash, Sand Canyon Wash,* and other Tributaries to these Creeks	+				I			I	I		I				I						801.11	
San Gabriel River Drainage																						
Coyote Ck. (within Santa Ana Regional boundary)	X							X	X		X				X							

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
+ Excepted from **MUN** (see text)

* Sand Canyon Wash also has **RARE** Beneficial Use
2 Access prohibited in all or part by Orange County Environmental Managmeent Agency (OCEMA)

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
UPPER SANTA ANA RIVER BASIN																						
Santa Ana River																						
Reach 3 - Prado Dam to Mission Blvd. in Riverside	+	X			X			X	X		X				X	X					801.21	801.27, 801.25
Reach 4 - Mission Blvd. in Riverside to San Jacinto Fault in San Bernardino	+				X			X[3]	X		X				X						801.27	801.44
Reach 5 - San Jacinto Fault in San Bernardino to Seven Oaks Dam†	X*	X			X			X[3]	X		X				X	X					801.52	801.57
Reach 6 - Seven Oaks Dam to Headwaters (see also Individual Tributary Streams)	X	X			X		X	X	X				X		X		X				801.72	
San Bernardino Mountain Streams																						
Mill Creek Drainage:																						
Mill Creek																						
Reach 1 - Confluence with Santa Ana River to Bridge Crossing Route 38 at Upper Powerhouse	I	I			I			I	I				I		I	I					801.58	
Reach 2 - Bridge Crossing Route 38 at Upper Powerhouse to Headwaters	X	X			X		X	X	X				X		X						801.58	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

* **MUN** applies upstream of Orange Avenue (Redlands); downstream, water is excepted from **MUN**
† Reach 5 uses are intermittent upstream of Waterman Avenue
3 Access prohibited in some portions by San Bernardino County Flood Control

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Mountain Home Creek	X				X		X	X	X				X		X						801.58	
Mountain Home Creek, East Fork	X				X		X	X	X				X		X		X				801.70	
Monkey Face Creek	X				X			X	X				X		X						801.70	
Alger Creek	X				X			X	X				X		X						801.70	
Falls Creek	X				X		X	X	X				X		X		X				801.70	
Vivian Creek	X				X			X	X				X		X						801.70	
High Creek	X				X			X	X				X		X						801.70	
Other Tributaries: Lost, Oak Cove, Green, Skinner, Momyer, Glen Martin, Camp, Hatchery, Rattlesnake, Slide, Snow, Bridal Veil, and Oak Creeks and other Tributaries to these Creeks	I				I			I	I				I		I						801.70	
Bear Creek Drainage:																						
Bear Creek	X	X			X		X	X	X				X		X		X				801.71	
Siberia Creek	X				X			X	X				X		X		X				801.71	
Slide Creek	I				I			I	I				I		I						801.71	
All other Tributaries to these Creeks	I				I			I	I				I		I						801.71	
Big Bear Lake (see Lakes, pg. 3-23)																						

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Big Bear Lake Tributaries:																						
North Creek	X				X			X	X				X		X		X				801.71	
Metcalf Creek	X				X			X	X				X		X		X				801.71	
Grout Creek	X				X			X	X				X		X		X				801.71	
Rathbone (Rathbun) Creek	X				X			X	X				X		X						801.71	
Meadow Creek	X				X			X	X				X		X						801.71	
Summit Creek	I				I			I	I				I		I						801.71	
Other Tributaries to Big Bear Lake: Knickerbocker, Johnson, Minnelusa, Polique, and Red Ant Creeks and other Tributaries to these Creeks	I				I			I	I				I		I						801.71	
Baldwin Lake (see Lakes, pg. 3-23)																						
Baldwin Lake Drainage:																						
Shay Creek	X				X			X	X				X		X	X					801.73	
Other Tributaries to Baldwin Lake: Sawmill, Green, and Caribou Canyons and other Tributaries to these Creeks	I				I			I	I				I		I						801.73	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Other Streams Draining to Santa Ana River (Mountain Reaches‡)																						
Cajon Creek	X				X			X	X				X		X	X					801.52	801.51
City Creek	X	X			X			X	X				X		X	X	X				801.57	
Devil Canyon Creek	X				X			X	X				X		X						801.57	
East Twin and Strawberry Creeks	X	X			X			X	X				X		X		X				801.57	
Waterman Canyon Creek	X				X			X	X				X		X						801.57	
Fish Creek	X				X			X	X				X		X		X				801.57	
Forsee Creek	X				X			X	X				X		X		X				801.72	
Plunge Creek	X	X			X			X	X				X		X	X					801.72	
Barton Creek	X	X			X			X	X				X		X						801.72	
Bailey Canyon Creek	I				I			I	I				I		I						801.72	
Kimbark Canyon, East Fork Kimbark Canyon, Ames Canyon, and West Fork Cable Canyon Creeks	X				X			X	X		X		X		X						801.52	
Valley Reaches‡ of Above Streams	I				I			I	I		I				I						801.52	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

‡ The division between Mountain and Valley reaches occurs at the base of the foothills of the San Bernardino or San Gabriel Mountains

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Other Tributaries (Mountain Reaches‡): Alder, Badger Canyon, Bledsoe Gulch, Borea Canyon, Breakneck, Cable Canyon, Cienega Seca, Cold, Converse, Coon, Crystal, Deer, Elder, Fredalba, Frog, Government, Hamilton, Heart Bar, Hemlock, Keller, Kilpecker, Little Mill, Little Sand Canyon, Lost, Meyer Canyon, Mile, Monroe Canyon, Oak, Rattlesnake, Round Cienega, Sand, Schneider, Staircase, Warm Springs Canyon, and Wild Horse Creeks and other Tributaries to these Creeks	I				I			I	I				I		I						801.72	801.71, 801.57
San Gabriel Mountain Streams (Mountain Reaches‡)																						
San Antonio Creek	X	X	X	X	X		X	X	X				X		X						801.23	
Lytle Creek (South, Middle, and North Forks) and Coldwater Canyon Creek	X	X	X	X	X		X	X	X				X		X	X					801.41	801.42, 801.52, 801.59
Day Creek	X			X	X			X	X				X		X						801.21	
East Etiwanda Creek	X			X	X			X	X				X		X	X					801.21	
Valley Reaches‡ of Above Streams	I				I			I	I		I				I						801.21	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

‡ The division between Mountain and Valley reaches occurs at the base of the foothills of the San Bernardino or San Gabriel Mountains

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Cucamonga Creek																						
Reach 1 - Confluence with Mill Creek to 23rd St. in Upland	+				X			X[3]	X			X			X						801.21	
Reach 2 (Mountain Reach‡) -23rd St. in Upland to headwaters	X		X	X	X		X	X	X				X		X		X				801.24	
Mill Creek (Prado Area)	+							X	X		X				X	X					801.25	
Other Tributaries (Mountain Reaches‡): Cajon Canyon, San Sevaine, Deer, Duncan Canyon, Henderson Canyon, Bull, Fan, Demens, Thorpe, Angalls, Telegraph Canyon, Stoddard Canyon, Icehouse Canyon, Cascade Canyon, Cedar, Falling Rock, Kerkhoff, and Cherry Creeks and other Tributaries to these Creeks	I				I			I	I				I		I						801.21	801.23
San Timoteo Area Streams																						
San Timoteo Creek																						
Reach 1 - Santa Ana River Confluence to Gage at San Timoteo Canyon Road	+	I			I			I[3]	I		I				I						801.52	801.53

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

‡ The division between Mountain and Valley reaches occurs at the base of the foothills of the San Bernardino or San Gabriel Mountains
3 Access prohibited in some portions by San Bernardino County Flood Control

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Reach 2 - Gage at San Timoteo Canyon Road to Confluence with Yucaipa Creek	+				X			X	X		X				X						801.61	801.62
Reach 3 - Confluence with Yucaipa Creek to Bunker Hill II Groundwater Subbasin Boundary (T2S/R3W-24)	+				X			X	X		X				X						801.62	
Reach 4 - Bunker Hill II Groundwater Subbasin Boundary (T2S/R3W-24) to Confluence with Little San Gorgonio and Noble Creeks (Headwaters of San Timoteo Creek)	+				X			X	X		X				X						801.62	
Oak Glen, Potato Canyon, and Birch Creeks	X				X			X	X		X				X						801.67	
Little San Gorgonio Creek	X				X			X	X				X		X						801.69	801.62, 801.63
Yucaipa Creek	I				I			I	I		I				I						801.67	801.61, 801.62, 801.64
Other Tributaries to these Creeks - Valley Reaches‡	I				I			I	I		I				I						801.62	801.52, 801.53
Other Tributaries to these Creeks - Mountain Reaches‡	I				I			I	I				I		I						801.69	801.67
Anza Park Drain	X							X	X		X				X		X				801.27	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

‡ The division between Mountain and Valley reaches occurs at the base of the foothills of the San Bernardino or San Gabriel Mountains

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Sunnyslope Channel	X							X	X		X				X		X				801.27	
Tequesquite Arroyo (Sycamore Creek)	+				X			X	X		X				X		X				801.27	
Prado Area Streams																						
Chino Creek																						
Reach 1 - Santa Ana River confluence to beginning of concrete-lined channel south of Los Serranos Rd.	+							X	X		X				X	X					801.21	
Reach 2 - Beginning of concrete-lined channel south of Los Serranos Rd. to confluence with San Antonio Creek	+							X[3]	X			X			X						801.21	
Temescal Creek																						
Reach 1A - Santa Ana River Confluence to Lincoln Ave.	+	X	X		X			X[4]	X		X				X	X	X				801.25	
Reach 1B - Lincoln Ave. to Riverside Canal	+							X[4]	X			X			X						801.25	
Reach 2 - Riverside Canal to Lee Lake	+	I	I		I			I	I		I				I						801.32	801.25
Reach 3 - Lee Lake (see Lakes, pg. 3-23)																						

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

[3] Access prohibited in some portions by San Bernardino County Flood Control
[4] Access prohibited in some portions by Riverside County Flood Control

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Reach 4 - Lee Lake to Mid-section line of Section 17 (downstream end of freeway cut)	+	I			I			I	I		I				I	X					801.34	
Reach 5 - Mid-section line of Section 17 (downstream end of freeway cut) to Elsinore Groundwater Subbasin Boundary	+	X			X			X	X		X				X	X					801.35	
Reach 6 - Elsinore Groundwater Subbasin Boundary to Lake Elsinore Outlet	+				I			I	I		I				I						801.35	
Coldwater Canyon Creek	X	X			X			X	X		X				X						801.32	
Bedford Canyon Creek	+				I			I	I		I				I						801.32	
Dawson Canyon Creek	I				I			I	I		I				I						801.32	
Other Tributaries to these Creeks	I				I			I	I		I				I						801.32	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
SAN JACINTO RIVER BASIN																						
San Jacinto River																						
Reach 1 - Lake Elsinore to Canyon Lake	I	I			I			I	I		I				I						802.32	802.31
Reach 2 - Canyon Lake (see Lakes, pg. 3-24)																						
Reach 3 - Canyon Lake to Nuevo Road	+	I			I			I	I		I				I						802.11	
Reach 4 - Nuevo Road to North-South Mid-Section Line, T4S/R1W-S8	+	I			I			I	I		I				I						802.14	802.21
Reach 5 - North-South Mid-Section Line, T4S/R1W-S8, to Confluence with Poppet Creek	+	I			I			I	I		I				I						802.21	
Reach 6 - Poppet Creek to Cranston Bridge	I	I			I			I	I		I				I						802.21	
Reach 7 - Cranston Bridge to Lake Hemet	X	X			X			X	X				X		X						802.21	
Bautista Creek - Headwaters to Debris Dam	X	X			X			X	X				X		X						802.21	802.23
Strawberry Creek and San Jacinto River, North Fork	X	X			X			X	X				X		X						802.21	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Fuller Mill Creek	X	X			X			X	X				X		X						802.22	
Stone Creek	X	X			X			X	X				X		X						802.21	
Salt Creek	+							I	I		I				I						802.12	
Other Tributaries: Logan, Black Mountain, Juaro Canyon, Indian, Hurkey, Poppet, and Protrero Creeks and other Tributaries to these Creeks	I	I			I			I	I		I				I						802.21	802.22

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

Table 3-1 BENEFICIAL USES - Continued

LAKES AND RESERVOIRS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
UPPER SANTA ANA RIVER BASIN																						
Baldwin Lake	+							I	I		I		I	I	I	I					801.73	
Big Bear Lake	X	X			X			X	X		X		X		X	X					801.71	
Erwin Lake	X							X	X				X	X	X	X					801.73	
Evans, Lake	+							X	X		X		X		X						801.27	
Jenks Lake	X	X			X			X	X				X		X						801.72	
Lee Lake	+	X	X		X			X	X		X				X						801.34	
Mathews, Lake	X	X	X	X	X			X[5]	X		X				X	X					801.33	
Mockingbird Reservoir	+	X						X[6]	X		X				X						801.26	
Norconian, Lake	+							X	X		X				X						801.25	
LOWER SANTA ANA RIVER BASIN																						
Anaheim Lake	+				X			X	X		X				X						801.11	
Irvine Lake (Santiago Reservoir)	X	X						X	X		X		X		X						801.12	
Laguna, Lambert, Peters Canyon, Rattlesnake, Sand Canyon, and Siphon Reservoirs	+	X						X[7]	X		X				X						801.11	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

[5] Access prohibited by the Metropolitan Water District
[6] Access prohibited by the Gage Canal Company (owner-operator)
[7] Access prohibited by Irvine Ranch Company

Table 3-1 BENEFICIAL USES - Continued

LAKES AND RESERVOIRS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
SAN JACINTO RIVER BASIN																						
Canyon Lake (Railroad Canyon Reservoir)	X	X			X			X	X		X				X						802.11	802.12
Elsinore, Lake	+							X	X		X				X						802.31	
Fulmor, Lake	X	X						X	X		X		X		X						802.21	
Hemet, Lake	X	X			X		X	X	X		X		X		X		X				802.22	
Perris, Lake	X	X	X	X	X			X	X		X		X		X						802.11	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
+ Excepted from **MUN** (see text)

Table 3-1 BENEFICIAL USES - Continued

WETLANDS (INLAND)	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
San Joaquin Freshwater Marsh**	+							X	X		X			X	X	X					801.11	
Shay Meadows	I							I	I				I		I						801.73	
Stanfield Marsh**	X							X	X				X		X	X					801.71	
Prado Flood Control Basin**	+							X	X		X				X	X					801.25	
San Jacinto Wildlife Preserve**	+							X	X		X			X	X	X					802.15	
Glen Helen	X							X	X		X				X						801.59	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

** This is a created wetland as defined in the wetlands discussion.

Table 3-1 BENEFICIAL USES - Continued

GROUNDWATER SUBBASINS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
UPPER SANTA ANA RIVER BASIN																						
Big Bear Valley	X			X																	801.71	801.73
Cucamonga	X	X	X	X																	801.24	801.21
Chino I	X	X	X	X																	801.21	481.23, 481.22, 801.27
Chino II	X	X	X	X																	801.21	481.21, 801.23
Chino III	X	X	X	X																	801.21	481.21, 801.27, 801.26
San Timoteo	X	X	X	X																	801.60	801.63, 801.64, 801.66, 801.68
Bunker Hill I	X	X	X	X																	801.51	
Bunker Hill II	X	X	X	X																	801.52	
Bunker Hill Pressure	X	X	X	X																	801.52	
Lytle Creek	X	X	X	X																	801.41	801.42
Rialto	X	X	X	X																	801.43	801.44
Colton	X	X	X	X																	801.44	801.45, 801.27
Riverside I	X	X	X	X																	801.27	
Riverside II	X	X	X	X																	801.27	
Riverside III	X	X	X	X																	801.27	
Arlington	X	X	X	X																	801.26	801.25

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
+ Excepted from **MUN** (see text)

Table 3-1 BENEFICIAL USES - Continued

GROUNDWATER SUBBASINS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Bedford (Upper Temescal I)	X	X	X	X																	801.32	
Lee Lake (Upper Temescal II)	X	X	X	X																	801.34	
Coldwater (Upper Temescal III)	X	X	X	X																	801.31	
Temescal	X	X	X	X																	801.25	
SAN JACINTO RIVER BASIN																						
Garner Valley	X	X																			802.22	
Idyllwild Area	X		X																		802.22	802.21
San Jacinto - Canyon	X	X	X	X																	802.21	
San Jacinto - Lower Pressure	X	X	X																		802.21	
San Jacinto - Intake	X	X	X	X																	802.21	
San Jacinto - Upper Pressure	X	X	X	X																	802.21	
Hemet	X	X	X	X																	802.15	802.21
Lakeview	X	X	X	X																	802.14	
Perris North	X	X	X	X																	802.11	
Perris South I	X	X																			802.11	
Perris South II	X	X																			802.11	
Perris South III	X	X																			802.11	
Winchester	X	X																			802.13	
Menifee I	X	X		X																	802.12	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
+ Excepted from **MUN** (see text)

Table 3-1 BENEFICIAL USES - Continued

GROUNDWATER SUBBASINS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Menifee II	X	X		X																	802.12	
Elsinore	X	X		X																	802.31	802.32
LOWER SANTA ANA RIVER BASIN																						
La Habra	X	X																			845.62	
Santiago	X	X	X																		801.12	
Santa Ana Forebay	X	X	X	X																	801.11	801.13, 845.61
Santa Ana Pressure	X	X	X	X																	801.11	845.61
Irvine Forebay I	X	X	X	X																	801.11	
Irvine Forebay II	X	X	X	X																	801.11	
Irvine Pressure	X	X	X	X																	801.11	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from **MUN** (see text)

Appendix E
Regional Water Quality Control Board
Water Quality Objectives

Appendix E-1
California State Water Resources Control Board
California Ocean Plan

TABLE B
WATER QUALITY OBJECTIVES

	Units of Measurement	Limiting Concentrations 6-Month Median	Daily Maximum	Instantaneous Maximum
OBJECTIVES FOR PROTECTION OF MARINE AQUATIC LIFE				
Arsenic	ug/l	8.	32.	80.
Cadmium	ug/l	1.	4.	10.
Chromium (Hexavalent) (see below, a)	ug/l	2.	8.	20.
Copper	ug/l	3.	12.	30.
Lead	ug/l	2.	8.	20.
Mercury	ug/l	0.04	0.16	0.4
Nickel	ug/l	5.	20.	50.
Selenium	ug/l	15.	60.	150.
Silver	ug/l	0.7	2.8	7.
Zinc	ug/l	20.	80.	200.
Cyanide (see below, b)	ug/l	1.	4.	10.
Total Chlorine Residual (For intermittent chlorine sources see below, c)	ug/l	2.	8.	60.
Ammonia (expressed as nitrogen)	ug/l	600.	2400.	6000.
Acute* Toxicity	TUa	N/A	0.3	N/A
Chronic* Toxicity	TUc	N/A	1.	N/A
Phenolic Compounds (non-chlorinated)	ug/l	30.	120.	300.
Chlorinated Phenolics	ug/l	1.	4.	10.
Endosulfan	ug/l	0.009	0.018	0.027
Endrin	ug/l	0.002	0.004	0.006
HCH*	ug/l	0.004	0.008	0.012
Radioactivity	Not to exceed limits specified in Title 17, Division 1, Chapter 5, Subchapter 4, Group 3, Article 3, Section 30253 of the California Code of Regulations. Reference to Section 30253 is prospective, including future changes to any incorporated provisions of federal law, as the changes take effect.			

* See Appendix I for definition of terms.

Table B Continued

Chemical	30-day Average (ug/l) Decimal Notation	Scientific Notation
OBJECTIVES FOR PROTECTION OF HUMAN HEALTH – NONCARCINOGENS		
acrolein	220.	2.2×10^{2}
antimony	1,200.	1.2×10^{3}
bis(2-chloroethoxy) methane	4.4	4.4×10^{0}
bis(2-chloroisopropyl) ether	1,200.	1.2×10^{3}
chlorobenzene	570.	5.7×10^{2}
chromium (III)	190,000.	1.9×10^{5}
di-n-butyl phthalate	3,500.	3.5×10^{3}
dichlorobenzenes*	5,100.	5.1×10^{3}
diethyl phthalate	33,000.	3.3×10^{4}
dimethyl phthalate	820,000.	8.2×10^{5}
4,6-dinitro-2-methylphenol	220.	2.2×10^{2}
2,4-dinitrophenol	4.0	4.0×10^{0}
ethylbenzene	4,100.	4.1×10^{3}
fluoranthene	15.	1.5×10^{1}
hexachlorocyclopentadiene	58.	5.8×10^{1}
nitrobenzene	4.9	4.9×10^{0}
thallium	2.	$2. \times 10^{0}$
toluene	85,000.	8.5×10^{4}
tributyltin	0.0014	1.4×10^{-3}
1,1,1-trichloroethane	540,000.	5.4×10^{5}
OBJECTIVES FOR PROTECTION OF HUMAN HEALTH – CARCINOGENS		
acrylonitrile	0.10	1.0×10^{-1}
aldrin	0.000022	2.2×10^{-5}
benzene	5.9	5.9×10^{0}
benzidine	0.000069	6.9×10^{-5}
beryllium	0.033	3.3×10^{-2}
bis(2-chloroethyl) ether	0.045	4.5×10^{-2}
bis(2-ethylhexyl) phthalate	3.5	3.5×10^{0}
carbon tetrachloride	0.90	9.0×10^{-1}
chlordane*	0.000023	2.3×10^{-5}
chlorodibromomethane	8.6	8.6×10^{0}

* See Appendix I for definition of terms.

Table B Continued

Chemical	30-day Average (ug/l) Decimal Notation	Scientific Notation
OBJECTIVES FOR PROTECTION OF HUMAN HEALTH – CARCINOGENS		
chloroform	130.	1.3×10^{2}
DDT*	0.00017	1.7×10^{-4}
1,4-dichlorobenzene	18.	1.8×10^{1}
3,3'-dichlorobenzidine	0.0081	8.1×10^{-3}
1,2-dichloroethane	28.	2.8×10^{1}
1,1-dichloroethylene	0.9	9×10^{-1}
dichlorobromomethane	6.2	6.2×10^{0}
dichloromethane	450.	4.5×10^{2}
1,3-dichloropropene	8.9	8.9×10^{0}
dieldrin	0.00004	4.0×10^{-5}
2,4-dinitrotoluene	2.6	2.6×10^{0}
1,2-diphenylhydrazine	0.16	1.6×10^{-1}
halomethanes*	130.	1.3×10^{2}
heptachlor	0.00005	5×10^{-5}
heptachlor epoxide	0.00002	2×10^{-5}
hexachlorobenzene	0.00021	2.1×10^{-4}
hexachlorobutadiene	14.	1.4×10^{1}
hexachloroethane	2.5	2.5×10^{0}
isophorone	730.	7.3×10^{2}
N-nitrosodimethylamine	7.3	7.3×10^{0}
N-nitrosodi-N-propylamine	0.38	3.8×10^{-1}
N-nitrosodiphenylamine	2.5	2.5×10^{0}
PAHs*	0.0088	8.8×10^{-3}
PCBs*	0.000019	1.9×10^{-5}
TCDD equivalents*	0.0000000039	3.9×10^{-9}
1,1,2,2-tetrachloroethane	2.3	2.3×10^{0}
tetrachloroethylene	2.0	2.0×10^{0}
toxaphene	0.00021	2.1×10^{-4}
trichloroethylene	27.	2.7×10^{1}
1,1,2-trichloroethane	9.4	9.4×10^{0}
2,4,6-trichlorophenol	0.29	2.9×10^{-1}
vinyl chloride	36.	3.6×10^{1}

* See Appendix I for definition of terms.

Appendix E-2
Los Angeles Regional Water Quality Control Board Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties

Inland Surface Water

Table 3-8. Water Quality Objectives for Selected Constituents in Inland Surface Waters[a].

Reaches are in upstream to downstream order.

WATERSHED/STREAM REACH[b]	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Boron[c] (mg/L)	Nitrogen[d] (mg/L)	SAR[e] (mg/L)
Miscellaneous Ventura Coastal Streams	*no waterbody specific objectives [f]*					
Ventura River Watershed:						
Above Camino Cielo Road	700	300	50	1.0	5	5
Between Camino Cielo Road and Casitas Vista Road	800	300	60	1.0	5	5
Between Casitas Vista Road and confluence with Weldon Canyon	1000	300	60	1.0	5	5
Between confluence with Weldon Canyon and Main Street	1500	500	300	1.5	10	5
Between Main St. and Ventura River Estuary	*no waterbody specific objectives [f]*					
Santa Clara River Watershed:						
Above Lang gaging station	500	100	50	0.5	5	5
Between Lang gaging station and Bouquet Canyon Road Bridge	800	150	100	1.0	5	5
Between Bouquet Canyon Road Bridge and West Pier Highway 99	1000	300	100	1.5	10	5
Between West Pier Highway 99 and Blue Cut gaging station	1000	400	100	1.5	5	10
Between Blue Cut gaging station and A Street, Fillmore	1300	600	100	1.5	5	5
Between A Street, Fillmore and Freeman Diversion "Dam" near Saticoy	1300	650	80	1.5	5	5
Between Freeman Diversion "Dam" near Saticoy and Highway 101 Bridge	1200	600	150	1.5	-	-
Between Highway 101 Bridge and Santa Clara River Estuary	*no waterbody specific objectives [f]*					
Santa Paula Creek above Santa Paula Water Works Diversion Dam	600	250	45	1.0	5	5
Sespe Creek above gaging station, 500' downstream from Little Sespe Creek	800	320	60	1.5	5	5
Piru Creek above gaging station below Santa Felicia Dam	800	400	60	1.0	5	5
Calleguas Creek Watershed:						
Above Potrero Road	850	250	150	1.0	10	f
Below Potrero Road	*no waterbody specific objectives [f]*					

Table 3-8. Water Quality Objectives for Selected Constituents in Inland Surface Waters[a] (cont.)

Reaches are in upstream to downstream order.

WATERSHED/STREAM REACH[b]	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Boron[c] (mg/L)	Nitrogen[d] (mg/L)	SAR[e] (mg/L)
Miscellaneous Los Angeles County Coastal Streams	*no waterbody specific objectives* [f]					
Malibu Creek Watershed	*2000*	*500*	*500*	*2.0*	*10*	-
Ballona Creek Watershed	*no waterbody specific objectives* [f]					
Dominguez Channel Watershed	*no waterbody specific objectives* [f]					
Los Angeles River Watershed:						
Above Figueroa Street	950	300	150	g	8	g
Between Figueroa Street and Los Angeles River Estuary (Willow Street). Includes Rio Hondo below Santa Ana Freeway	1500	350	150	g	8	g
Rio Hondo above Santa Ana Freeway [h]	750	300	150	g	8	g
Santa Anita Creek above Santa Anita spreading grounds	250	30	10	g	f	g
Eaton Canyon Creek above Eaton Dam	250	30	10	g	f	g
Arroyo Seco above spreading grounds	300	40	15	g	f	g
Big Tujunga Creek above Hansen Dam	350	50	20	g	f	g
Pacoima Wash above Pacoima spreading grounds	250	30	10	g	f	g
San Gabriel River Watershed:						
Above Morris Dam	250	30	10	0.6	2	2
Between Morris Dam and Ramona Blvd.	*450*	*100*	*100*	*0.5*	8	g
Between Ramona Blvd. and Firestone Blvd.	750	300	150	*1.0*	8	g
Between Firestone Blvd. and San Gabriel River Estuary (downstream from Willow Street) including Coyote Creek	*no waterbody specific objectives* [f]					
All other minor San Gabriel Mountain streams tributary to San Gabriel Valley [i]	300	40	15	g	f	g
Island Watercourses:						
Anacapa Island	*no waterbody specific objectives* [f]					
San Nicolas Island	*no waterbody specific objectives* [f]					
Santa Barbara island	*no waterbody specific objectives* [f]					
Santa Catalina Island	*no waterbody specific objectives* [f]					
San Clemente Island	*no waterbody specific objectives* [f]					

Table 3-8. Water Quality Objectives for Selected Constituents in Inland Surface Waters[a] (cont.)

Reaches are in upstream to downstream order.

WATERSHED/STREAM REACH[b]	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Boron[c] (mg/L)	Nitrogen[d] (mg/L)	SAR[e] (mg/L)
Other Watercourses:						
San Antonio Creek[j]	225	25	6	–	–	–
Chino Creek[j]	–	–	–	–	–	–

a. As part of the State's continuing planning process, data will continue to be collected to support the development of numerical water quality objectives for waterbodies and constituents where sufficient information is presently unavailable. Any new recommendations for water quality objectives will be brought before the Regional Board in the future.

b. All references to watersheds, streams and reaches include all tributaries. Water quality objectives are applied to all waters tributary to those specifically listed in the table. See Figures 2-1 to 2-10 for locations.

c. Where naturally occurring boron results in concentrations higher than the stated objective, a site-specific objective may be determined on a case-by-case basis.

d. Nitrate-nitrogen plus nitrite-nitrogen (NO3-N + NO2-N). The lack of adequate nitrogen data for all streams precluded the establishment of numerical objectives for all streams.

e. Sodium adsorption ratio (SAR) predicts the degree to which irrigation water tends to enter into cation-exchange reactions in soil.

SAR = Na+/((Ca++ + Mg++)/2)1/2

f. Site-specific objectives have not been determined for these reaches at this time. These areas are often impaired (by high levels of minerals) and there is not sufficient historic data to designate objectives based on natural background conditions. The following table illustrates the mineral or nutrient quality necessary to protect different categories of beneficial uses and will be used as a guideline for establishing effluent limits in these cases. Protection of the most sensitive beneficial use(s) would be the determining criteria for the selection of effluent limits.

Recommended objective (mg/L)	Beneficial Use Categories				
	MUN (Drinking Water Standards) [1]	PROC	AGR	AQ LIFE*(Frshwtr)	GWR
TDS	500 (USEPA secondary MCL)	50-1500 [2,7,9]	450-2000 [2,3,6]		Limits based on appropriate groundwater basin objectives and/or beneficial uses
Chloride	250 (USEPA secondary MCL)	20-1000 [2,9]	100-355 [2,3,8]	230 (4 day ave. continuous conc) [4]	
Sulfate	400-500 (USEPA proposed MCL)	20-300 [2,9]	350-600 [2,8]		
Boron			0.5-4.0 [2,6,8]		
Nitrogen	10 (USEPA MCL)				

References: 1) USEPA CFR § 141 et seq., 2) McKee and Wolf, 1963, 3) Ayers and Westcot, 1985, 4) USEPA, 1988, 5) Water Pollution Control Federation, 1989, 6) USEPA, 1973, 7) USEPA 1980, 8) Ayers, 1977.
* Aquatic life includes a variety of Beneficial Uses including WARM, COLD, SPWN, MIGR and RARE.

g. Agricultural supply is not a beneficial use of the surface water in the specified reach.

h. Rio Hondo spreading grounds are located above the Santa Ana Freeway

i. The stated objectives apply to all other surface streams originating within the San Gabriel Mountains and extend from their headwaters to the canyon mouth.

j. These watercourses are primarily located in the Santa Ana Region. The water quality objectives for these streams have been established by Santa Ana Region. Dashed lines indicate that numerical objectives have not been established, however, narrative objectives shall apply. Refer to the Santa Ana Region Basin Plan for more details.

Groundwater

Table 3-10. Water Quality Objectives for Selected Constituents in Regional Ground Waters[a].

DWR Basin No.[b]	BASIN	OBJECTIVES (mg/L)			
		TDS	Sulfate	Chloride	Boron
	Pitas Point Area [c]	None specified			
	Ojai Valley				
4-1	Upper Ojai Valley				
	West of Sulfur Mountain Road	1,000	300	200	1.0
	Central area	700	50	100	1.0
	Sisar area	700	250	100	0.5
4-2	Lower Ojai Valley				0.5
	West of San Antonio--Senior Canyon Creeks	1,000	300	200	0.5
	East of San Antonio--Senior Canyon Creeks	700	200	50	
4-3	**Ventura River Valley**				
	Upper Ventura	800	300	100	0.5
	San Antonio Creek area	1,000	300	100	1.0
	Lower Ventura	1,500	500	300	1.5
	Ventura Central [d]				
4-4	Santa Clara--Piru Creek area				
	Upper area (above Lake Piru)	1,100	400	200	2.0
	Lower area east of Piru Creek	2,500	1,200	200	1.5
	Lower area west of Piru Creek	1,200	600	100	1.5
	Santa Clara--Sespe Creek area				
	Topa Topa (upper Sespe) area	900	350	30	2.0
	Fillmore area				
	Pole Creek Fan area	2,000	800	100	1.0
	South side of Santa Clara River	1,500	800	100	1.1
	Remaining Fillmore area	1,000	400	50	0.7
	Santa Clara--Santa Paula area				
	East of Peck Road	1,200	600	100	1.0
	West of Peck Road	2,000	800	110	1.0
	Oxnard Plain				
	Oxnard Forebay	1,200	600	150	1.0
	Confined aquifers	1,200	600	150	1.0
	Unconfined and perched aquifers	3,000	1,000	500	--
4-6	Pleasant Valley				
	Confined aquifers	700	300	150	1.0
	Unconfined and perched aquifers	--	--	--	--
4-7	Arroyo Santa Rosa	900	300	150	1.0
4-8	Las Posas Valley				
	South Las Posas area				
	NW of Grimes Cyn Rd & LA Ave & Somis Rd	700	300	100	0.5
	E of Grimes Cyn Rd and Hitch Blvd	2,500	1,200	400	3.0
	S of LA Ave between Somis Rd & Hitch Blvd	1,500	700	250	1.0
	Grimes Canyon Rd & Broadway area	250	30	30	0.2
	North Las Posas area	500	250	150	1.0
4-5	**Upper Santa Clara**				
	Acton Valley	550	150	100	1.0
	Sierra Pelona Valley (Agua Dulce)	600	100	100	0.5
	Upper Mint Canyon	700	150	100	0.5
	Upper Bouquet Canyon	400	50	30	0.5
	Green Valley	400	50	25	--
	Lake Elizabeth--Lake Hughes area	500	100	50	0.5

Table 3-10. Water Quality Objectives for Selected Constituents in Regional Ground Waters[a] (cont.)

DWR Basin No.[b]	BASIN	OBJECTIVES (mg/L)			
		TDS	Sulfate	Chloride	Boron
4-4.07	**Eastern Santa Clara**				
	Santa Clara--Mint Canyon	800	150	150	1.0
	South Fork	700	200	100	0.5
	Placerita Canyon	700	150	100	0.5
	Santa Clara--Bouquet & San Francisquito Canyons	700	250	100	1.0
	Castaic Valley	1,000	350	150	1.0
	Saugus Aquifer	--	--	--	--
4-9	**Simi Valley**				
	Simi Valley Basin				
	Confined aquifers	1,200	600	150	1.0
	Unconfined aquifers	--	--	--	--
	Gillibrand Basin	900	350	50	1.0
4-10	**Conejo Valley**	800	250	150	1.0
4-11	**Los Angeles Coastal Plain**				
	Central Basin	700	250	150	1.0
	West Coast Basin	800	250	250	1.5
	Hollywood Basin	750	100	100	1.0
	Santa Monica Basin	1,000	250	200	0.5
4-12	**San Fernando Valley**				
	Sylmar Basin	600	150	100	0.5
	Verdugo Basin	600	150	100	0.5
	San Fernando Basin				
	West of Highway 405	800	300	100	1.5
	East of Highway 405 (overall)	700	300	100	1.5
	Sunland-Tugunga area [e]	400	50	50	0.5
	Foothill area [e]	400	100	50	1.0
	Area encompassing RT-Tujunga-Erwin-N. Hollywood-Whithall-LA/Verdugo-Crystal Springs-Headworks-Glendale/Burbank Well Fields	600	250	100	1.5
	Narrows area (below confluence of Verdugo Wash with the LA River)	900	300	150	1.5
	Eagle Rock Basin	800	150	100	0.5
4-13	**San Gabriel Valley**				
	Raymond Basin				
	Monk Hill sub-basin	450	100	100	0.5
	Santa Anita area	450	100	100	0.5
	Pasadena area	450	100	100	0.5
	Main San Gabriel Basin				
	Western area [f]	450	100	100	0.5
	Eastern area [f]	600	100	100	0.5
	Puente Basin	1,000	300	150	1.0
4-14 8-2 [g]	**Upper Santa Ana Valley**				
	Live Oak area	450	150	100	0.5
	Claremont Heights area	450	100	50	--
	Pomona area	300	100	50	0.5
	Chino area	450	20	15	--
	Spadra area	550	200	120	1.0
4-15	**Tierra Rejada**	700	250	100	0.5
4-16	**Hidden Valley**	1,000	250	250	1.0
4-17	**Lockwood Valley**	1,000	300	20	2.0
4-18	**Hungry Valley and Peace Valley**	500	150	50	1.0

Table 3-10. Water Quality Objectives for Selected Constituents in Regional Ground Waters[a] (cont.)

DWR Basin No.[b]	BASIN	OBJECTIVES (mg/L)			
		TDS	Sulfate	Chloride	Boron
4-19	Thousand Oaks area	1,400	700	150	1.0
4-20	Russell Valley				
	Russell Valley	1,500	500	250	1.0
	Triunfo Canyon area	2,000	500	500	2.0
	Lindero Canyon area	2,000	500	500	2.0
	Las Virgenes Canyon area	2,000	500	500	2.0
4-21	Conejo-Tierra Rejada Volcanic area [h]	--	--	--	--
	Santa Monica Mountains--southern slopes [i]				
	Camarillo area	1,000	250	250	1.0
	Point Dume area	1,000	250	250	1.0
4-22	Malibu Valley	2,000	500	500	2.0
	Topanga Canyon area	2,000	500	500	2.0
	San Pedro Channel Islands [j]				
	Anacapa Island	--	--	--	--
	San Nicolas Island	1,100	150	350	--
	Santa Catalina Island	1,000	100	250	1.0
	San Clemente Island	--	--	--	--
	Santa Barbara Island	--	--	--	--

a. Objectives for ground waters outside of the major basins listed on this table and outlined in Figure 1-9 have not been specifically listed. However, ground waters outside of the major basins are, in many cases, significant sources of water. Furthermore, ground waters outside of the major basins are either potential or existing sources of water for downgradient basins and, as such, objectives in the downgradient basins shall apply to these areas.

b. Basins are numbered according to Bulletin 118-80 (Department of Water Resources, 1980).

c. Ground waters in the Pitas Point area (between the lower Ventura River and Rincon Point) are not considered to comprise a major basin, and accordingly have not been designated a basin number by the California Department of Water Resources (DWR) or outlined on Figure 1-9.

d. The Santa Clara River Valley (4-4), Pleasant Valley (4-6), Arroyo Santa Rosa Valley (4-7) and Las Posas Valley (4-8) Ground Water Basins have been combined and designated as the Ventura Central Basin (DWR, 1980).

e. The category for the Foothill Wells area in previous Basin Plan incorrectly groups ground water in the Foothill area with ground water in the Sunland-Tujunga area. Accordingly, the new categories, Foothill area and Sunland-Tujunga area, replace the old Foothill Wells area.

f. All of the ground water in the Main San Gabriel Basin is covered by the objectives listed under Main San Gabriel Basin – Eastern area and Western area. Walnut Creek, Big Dalton Wash, and Little Dalton Wash separate the Eastern area from the Western area (see dashed line on Figure 2-17). Any ground water upgradient of these areas is subject to downgradient beneficial uses and objectives, as explained in Footnote a.

g. The border between Regions 4 and 8 crosses the Upper Santa Ana Valley Ground Water Basin.

h. Ground water in the Conejo-Tierra Rejada Volcanic Area occurs primarily in fractured volcanic rocks in the western Santa Monica Mountains and Conejo Mountain areas. These areas have not been delineated on Figure 1-9.

i. With the exception of ground water in Malibu Valley (DWR Basin No. 4-22), ground waters along the southern slopes of the Santa Monica Mountains are not considered to comprise a major basin and accordingly have not been designated a basin number by the California Department of Water Resources (DWR) or outlined on Figure 1-9.

j. DWR has not designated basins for ground waters on the San Pedro Channel Islands.

Appendix E-3
San Diego Regional Water Quality Control Board
Water Quality Control Plan for the San Diego Basin

Inland Surface Water

Table 3-2. WATER QUALITY OBJECTIVES

Concentrations not to be exceeded more than 10% of the time during any one one year period.

Inland Surface Waters			Hydrologic Unit Basin Number	Constitiuent (mg/L or as noted)												
				TDS	Cl	SO_4	%Na	N&P	Fe	Mn	MBAS	B	ODOR	Turb NTU	Color Units	F
SAN JUAN HYDROLOGIC UNIT			**901.00**													
Laguna	HA		1.10	1000	400	500	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Mission Viejo	HA		1.20	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
San Clemente	HA		1.30	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
San Mateo Canyon	HA		1.40	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
San Onofre	HA		1.50	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
SANTA MARGARITA HYDROLOGIC UNIT			**902.00**													
Ysidora	HA		2.10	750	300	300	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Deluz	HA		2.20	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Deluz Creek	HSA	b	2.21	750	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Gavilan	HSA	b	2.22	750	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Murrieta	HA		2.30	750	300	300	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Auld	HA		2.40	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Pechanga	HA		2.50	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Wolf	HSA	b	2.52	750	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Wilson	HA		2.60	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Cave Rocks	HA		2.70	750	300	300	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Aguanga	HA		2.80	750	300	300	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Oakgrove	HA		2.90	750	300	300	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0

HA - Hydrologic Area
HSA - Hydrologic Sub Area (Lower case letters indicate endnotes following the table.)

Table 3-2. WATER QUALITY OBJECTIVES

Concentrations not to be exceeded more than 10% of the time during any one one year period.

Inland Surface Waters		Hydrologic Unit Basin Number	Constitiuent (mg/L or as noted)												
			TDS	Cl	SO_4	%Na	N&P	Fe	Mn	MBAS	B	ODOR	Turb NTU	Color Units	F
SAN LUIS REY HYDROLOGIC UNIT		**903.00**													
Lower San Luis	HA	3.10	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Monserat	HA	3.20	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Warner Valley	HA	3.30	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
CARLSBAD HYDROLOGIC UNIT		**904.00**													
Loma Alta	HA	4.10	-	-	-	-	-	-	-	-	-	none	20	20	1.0
Buena Vista Creek	HA	4.20	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Agua Hedionda	HA	4.30	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Encinas	HA	4.40	-	-	-	-	-	-	-	-	-	none	20	20	1.0
San Marcos	HA	4.50	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Escondido Creek	HA	4.60	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
SAN DIEGUITO HYDROLOGIC UNIT		**905.00**													
Solana Beach	HA	5.10	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Hodges	HA	5.20	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
San Pasqual	HA	5.30	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Santa Maria Valley	HA	5.40	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Santa Ysabel	HA	5.50	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
PENASQUITOS HYDROLOGIC UNIT		**906.00**													
Miramar Reservoir	HA	6.10	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Poway	HA	6.20	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0

HA - Hydrologic Area
HSA - Hydrologic Sub Area (Lower case letters indicate endnotes following the table.)

Table 3-2. WATER QUALITY OBJECTIVES

Concentrations not to be exceeded more than 10% of the time during any one one year period.

Inland Surface Waters		Hydrologic Unit Basin Number	Constitiuent (mg/L or as noted)												
			TDS	Cl	SO_4	%Na	N&P	Fe	Mn	MBAS	B	ODOR	Turb NTU	Color Units	F
Scripps	HA	6.30	-	-	-	-	a	-	-	-	-	none	20	20	-
Miramar	HA	6.40	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Tecolote	HA	6.50	-	-	-	-	a	-	-	-	-	none	20	20	-
SAN DIEGO HYDROLOGIC UNIT		**907.00**													
Lower San Diego	HA	7.10	1000	400	500	60	a	0.3	0.05	0.5	1.0	none	20	20	-
Mission San Diego	HSA	7.11	1500	400	500	60	a	1.0	1.00	0.5	1.0	none	20	20	-
Santee	HSA [c]	7.12	1000	400	500	60	a	1.0	1.00	0.5	1.0	none	20	20	-
Santee	HSA [d]	7.12	1500	400	500	60	a	1.0	1.00	0.5	1.0	none	20	20	-
San Vicente	HA	7.20	300	50	65	60	a	0.3	0.05	0.5	1.0	none	20	20	1.0
El Capitan	HA	7.30	300	50	65	60	a	0.3	0.05	0.5	1.0	none	20	20	1.0
Boulder Creek	HA	7.40	300	50	65	60	a	0.3	0.05	0.5	1.0	none	20	20	1.0
PUEBLO SAN DIEGO HYDROLOGIC UNIT		**908.00**													
Point Loma	HA	8.10	-	-	-	-	-	-	-	-	-	none	20	20	-
San Diego Mesa	HA	8.20	-	-	-	-	-	-	-	-	-	none	20	20	-
National City	HA	8.30	-	-	-	-	-	-	-	-	-	none	20	20	-
SWEETWATER HYDROLOGIC UNIT		**909.00**													
Lower Sweetwater	HA	9.10	1500	500	500	60	a	0.3	0.05	0.5	0.75	none	20	20	-
Middle Sweetwater	HA	9.20	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Upper Sweetwater	HA	9.30	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0

HA - Hydrologic Area
HSA - Hydrologic Sub Area (Lower case letters indicate endnotes following the table.)

Table 3-2. WATER QUALITY OBJECTIVES

Concentrations not to be exceeded more than 10% of the time during any one one year period.

Inland Surface Waters		Hydrologic Unit Basin Number	Constitiuent (mg/L or as noted)												
			TDS	Cl	SO_4	%Na	N&P	Fe	Mn	MBAS	B	ODOR	Turb NTU	Color Units	F
OTAY HYDROLOGIC UNIT		**910.00**													
Coronado	HA	10.10	-	-	-	-	-	-	-	-	-	-	-	-	-
Otay Valley	HA	10.20	1000	400	500	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
Dulzura	HA	10.30	500	250	250	60	a	0.3	0.05	0.5	0.75	none	20	20	1.0
TIJUANA HYDROLOGIC UNIT		**911.00**													
Tijuana Valley	HA	11.10	-	-	-	-	-	-	-	-	-	-	-	-	-
San Ysidro	HSA	11.11	2100	-	-	-	a	-	-	-	-	none	20	20	-
Potrero	HA	11.20	500	250	250	60	a	0.3	0.05	0.5	1.0	none	20	20	1.0
Barrett Lake	HA	11.30	500	250	250	60	a	0.3	0.05	0.5	1.0	none	20	20	1.0
Monument	HA	11.40	500	250	250	60	a	0.3	0.05	0.5	1.0	none	20	20	1.0
Morena	HA	11.50	500	250	250	60	a	0.3	0.05	0.5	1.0	none	20	20	1.0
Cottonwood	HA	11.60	500	250	250	60	a	0.3	0.05	0.5	1.0	none	20	20	1.0
Cameron	HA	11.70	500	250	250	60	a	0.3	0.05	0.5	1.0	none	20	20	1.0
Campo	HA	11.80	500	250	250	60	a	0.3	0.05	0.5	1.0	none	20	20	1.0

HA - Hydrologic Area
HSA - Hydrologic Sub Area (Lower case letters indicate endnotes following the table.)

ENDNOTES FOR TABLE 3-2

a Concentrations of nitrogen and phosphorus, by themselves or in combination with other nutrients, shall be maintained at levels below those which stimulate algae and emergent plant growth. Threshold total Phosphorus (P) concentrations shall not exceed 0.05 mg/l in any stream at the point where it enters any standing body of water, nor 0.025 mg/l in any standing body of water. A desired goal in order to prevent plant nuisances in streams and other flowing waters appears to be 0.1 mg/l total P. These values are not to be exceeded more than 10% of the time unless studies of the specific body in question clearly show that water quality objective changes are permissible and changes are approved by the Regional Board. Analogous threshold values have not been set for nitrogen compounds; however, natural ratios of nitrogen to phosphorus are to be determined by surveillance and monitoring and upheld. If data are lacking, a ratio of N:P =10:1 shall be used. Note - Certain exceptions to the above water quality objectives are described in Chapter 4 in the sections titled Discharges to Coastal Lagoons from Pilot Water Reclamation Projects and Discharges to Surface Waters.

b These objectives apply to the lower portion of Murrieta Creek in the Wolf HSA (2.52) and the Santa Margarita River from it's beginning at the confluence of Murrieta and Temecula Creeks, through the Gavilan HSA (2.22) and DeLuz HSA (2.21), to where it enters the Upper Ysidora HSA (2.13).

c Sycamore Canyon Subarea, a portion of the Santee Hydrologic Subarea, includes the watersheds of the following north-south trending canyons: Oak Creek, Spring Canyon, Little Sycamore Canyon, Quail Canyon, and Sycamore Canyon. The Sycamore Canyon subarea extends eastward from the Mission San Diego HSA to the confluence of the San Diego River and Forester Creek, immediately south of the Santee Lakes.

d These objectives apply to the Lower Sycamore Canyon portion of the Santee Hydrologic Subarea described as all of the Sycamore Canyon watershed except that part which drains north of the boundary between sections 28 and 33, Township South, Range 1 West.

Groundwater

Table 3-3. WATER QUALITY OBJECTIVES

Concentrations not to be exceeded more than 10% of the time during any one year period.

Ground Water			Hydrologic Basin Unit Number	Constituent (mg/L or as noted)												
				TDS	Cl	SO_4	%Na	NO_3	Fe	Mn	MBAS	B	ODOR	Turb NTU	Color Units	F
SAN JUAN HYDROLOGIC UNIT			**901.00**													
Laguna	HA		1.10													
San Joaquin Hills	HSA		1.11	1200	400	500	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Laguna Beach	HSA		1.12	1200	400	500	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
Aliso	HSA		1.13	1200	400	500	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
Dana Point	HSA		1.14	1200	400	500	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
Mission Viejo	HA		1.20													
Oso	HSA		1.21	1200	400	500	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
Upper Trabuco	HSA		1.22	500	250	250	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
Middle Trabuco	HSA		1.23	750	375	375	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
Gobernadora	HSA		1.24	1200	400	500	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
Upper San Juan	HSA		1.25	500	250	250	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
Middle San Juan	HSA		1.26	750	375	375	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
Lower San Juan	HSA		1.27	1200	400	500	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
Ortega	HSA		1.28	1100	375	450	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
San Clemente	HA		1.30													
Prima Deshecha	HSA		1.31	1200	400	500	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Segunda Deshecha	HSA		1.32	1200	400	500	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
San Mateo Canyon	HA	a	1.40	500 [b]	250	250 [b]	60	45 [b]	0.3 [b]	0.05 [b]	0.5	0.75 [b]	none	5	15	1.0
San Onofre	HA	a	1.50	500 [b]	250	250 [b]	60	45 [b]	0.3 [b]	0.05 [b]	0.5	0.75 [b]	none	5	15	1.0
SANTA MARGARITA HYDROLOGIC UNIT			**902.00**													
Ysidora	HA	a	2.10	750 [c]	300 c	300 [c]	60	10 [c]	0.3 [c]	0.05 [c]	0.5	0.75 [c]	none	5	15	1.0
Deluz	HA		2.20	500	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0

HA - Hydrologic Area
HSA - Hydrologic Sub Area (Lower case letters indicate endnotes following the table.)

Table 3-3. WATER QUALITY OBJECTIVES

Concentrations not to be exceeded more than 10% of the time during any one year period.

Ground Water		Hydrologic Basin Unit Number	Constituent (mg/L or as noted)												
			TDS	Cl	SO_4	%Na	NO_3	Fe	Mn	MBAS	B	ODOR	Turb NTU	Color Units	F
Deluz Creek	HSA [m]	2.21	750	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Gavilan	HSA [m]	2.22	750	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Murrieta	HA	2.30	750 [c]	300 [c]	300 [c]	60	10 [c]	0.3 [c]	0.05 [c]	0.5	0.75 [c]	none	5	15	1.0
Domenigoni	HSA	2.35	2000	-	-	-	-	-	-	-	-	-	-	-	-
Auld	HA	2.40	500	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Pechanga	HA	2.50	500	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Pauba	HSA [o]	2.51	750	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Wolf	HSA [p]	2.52	750	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Wilson	HA	2.60	500	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Cave Rocks	HA	2.70	500	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Aguanga	HA	2.80	500	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Oakgrove	HA	2.90	500	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
SAN LUIS REY HYDROLOGIC UNIT		**903.00**													
Lower San Luis	HA	3.10	800	300	400	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Mission	HSA [a]	3.11	1500 [cd]	500 [cd]	500 [cd]	60	45 [cd]	0.85 [cd]	0.15 [cd]	0.5 [d]	0.75 [cd]	none	5	15 [d]	1.0 [d]
Bonsall	HSA	3.12	1500 [cd]	500 [cd]	500 [cd]	60	45 [cd]	0.85 [cd]	0.15 [cd]	0.5 [d]	0.75 [cd]	none	5	15 [d]	1.0 [d]
Monserate	HA	3.20													
Pala	HSA	3.21	900 [c]	300 [c]	500 [c]	60	15 [c]	0.3 [c]	0.05 [c]	0.5	0.75	none	5	15	1.0
Pauma	HSA	3.22	800 [c]	300 [c]	400 [c]	60	10 [c]	0.3 [c]	0.05 [c]	0.5	0.75	none	5	15	1.0
La Jolla Amago	HSA	3.23	500	250	250	60	5	0.3	0.05	0.5	0.75	none	5	15	1.0
Warner Valley	HA	3.30	500	250	250	60	5	0.3	0.05	0.5	0.75	none	5	15	1.0
CARLSBAD HYDROLOGIC UNIT		**904.00**													
Loma Alta	HA	4.10	-	-	-	-	-	-	-	-	-	-	-	-	-

HA - Hydrologic Area
HSA - Hydrologic Sub Area (Lower case letters indicate endnotes following the table.)

Table 3-3. WATER QUALITY OBJECTIVES

Concentrations not to be exceeded more than 10% of the time during any one year period.

Ground Water			Hydrologic Basin Unit Number	Constituent (mg/L or as noted)												
				TDS	Cl	SO_4	%Na	NO_3	Fe	Mn	MBAS	B	ODOR	Turb NTU	Color Units	F
Buena Vista Creek	HA		4.20													
El Salto	HSA	a	4.21	3500	800	500	60	45	0.3	0.05	0.5	2.0	none	5	15	1.0
Vista	HSA	a	4.22	1000 b	400 b	500 b	60	10 b	0.3 b	0.05 b	0.5	0.75 b	none	5	15	1.0
Agua Hedionda	HA	a	4.30	1200	500	500	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Los Monos	HSA	aj	4.31	3500	800	500	60	45	0.3	0.05	0.5	2.0	none	5	15	1.0
Encinas	HA	a	4.40	3500 b	800 b	500 b	60	45 b	0.3 b	0.05 b	0.5	2.0 b	none	5	15	1.0
San Marcos	HA	ae	4.50	1000	400	500	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Batiquitos	HSA	aek	4.51	3500	800	500	60	45	0.3	0.05	0.5	2.0	none	5	15	1.0
Escondido Creek	HA	a	4.60	750	300	300	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
San Elijo	HSA	a	4.61	2800	700	600	60	45	0.3	0.05	0.5	1.0	none	5	15	1.0
Escondido	HSA		4.62	1000	300	400	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
SAN DIEGUITO HYDROLOGIC UNIT			**905.00**													
Solana Beach	HA	a	5.10	1500 b	500 b	500 b	60	45 b	0.85 b	0.15 b	0.5	0.75 b	none	5	15	1.0
Hodges	HA		5.20	1000 b	400 b	500 b	60	10 b	0.3 b	0.05 b	0.5	0.75 b	none	5	15	1.0
San Pasqual	HA		5.30	1000 b	400 b	500 b	60	10 b	0.3 b	0.05 b	0.5	0.75 b	none	5	15	1.0
Santa Maria Valley	HA		5.40	1000	400	500	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Santa Ysabel	HA		5.50	500	250	250	60	5	0.3	0.05	0.5	0.75	none	5	15	1.0
PENASQUITOS HYDROLOGIC UNIT			**906.00**													
Miramar Reservoir	HA	af	6.10	1200	500	500	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Poway	HA		6.20	750 q	300	300	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Scripps	HA		6.30	-	-	-	-	-	-	-	-	-	-	-	-	-
Miramar	HA	g	6.40	750	300	300	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Tecolote	HA		6.50	-	-	-	-	-	-	-	-	-	-	-	-	-

HA - Hydrologic Area

HSA - Hydrologic Sub Area (Lower case letters indicate endnotes following the table.)

Table 3-3. WATER QUALITY OBJECTIVES

Concentrations not to be exceeded more than 10% of the time during any one year period.

Ground Water			Hydrologic Basin Unit Number	Constituent (mg/L or as noted)												
				TDS	Cl	SO_4	%Na	NO_3	Fe	Mn	MBAS	B	ODOR	Turb NTU	Color Units	F
SAN DIEGO HYDROLOGIC UNIT			**907.00**													
Lower San Diego	HA		7.10													
Mission San Diego	HSA	a	7.11	3000 [b]	800 [b]	600 [b]	60	45 [b]	0.3 [b]	0.05 [b]	0.5	2.0 [b]	none	5	15	1.0
Santee	HSA		7.12	1000 [b]	400 [b]	500 [b]	60	45 [b]	0.3 [b]	0.05 [b]	0.5	0.75 [b]	none	5	15	1.0
Santee (alluvial aquifer for lower Sycamore Canyon)	HSA	n	7.12	2000 b	800 b	600 b	60	45 b	0.3 b	0.05 b	0.5	2.0 b	none	5	15	1.0
El Cajon	HSA		7.13	1200 [b]	250 [b]	500 [b]	60	45 [b]	0.3 [b]	0.05 [b]	0.5	0.75 [b]	none	5	15	1.0
Coches	HSA		7.14	600 [b]	250 [b]	250 [b]	60	5 [b]	0.3 [b]	0.05 [b]	0.5	0.75 [b]	none	5	15	1.0
El Monte	HSA		7.15	600 [b]	250 [b]	250 [b]	60	5 [b]	0.3 [b]	0.05 [b]	0.5	0.75 [b]	none	5	15	1.0
San Vicente	HA		7.20	600	250	250	60	5	0.3	0.05	0.5	0.75	none	5	15	1.0
El Capitan	HA		7.30	1000	400	500	60	45	0.3	0.05	0.5	0.75	none	5	15	1.0
Conejos Creek	HSA		7.31	350	60	60	60	5	0.3	0.05	0.5	0.75	none	5	15	1.0
Boulder Creek	HA		7.40	350	60	60	60	5	0.3	0.05	0.5	0.75	none	5	15	1.0
PUEBLO SAN DIEGO HYDROLOGIC UNIT			**908.00**													
Point Loma	HA	i	8.10	-	-	-	-	-	-	-	-	-	-	-	-	-
San Diego Mesa	HA	i	8.20	-	-	-	-	-	-	-	-	-	-	-	-	-
National City	HA	i	8.30	750	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
SWEETWATER HYDROLOGIC UNIT			**909.00**													
Lower Sweetwater	HA		9.10													
Telegraph	HSA		9.11	3000 [b]	750 [b]	500 [b]	60	45 [b]	0.3 [b]	0.05 [b]	0.5	2.0 [b]	none	5	15	1.0
La Nacion	HSA		9.12	1500 [b]	500 [b]	500 [b]	60	45 [b]	0.3 [b]	0.15 [b]	0.5	0.75 [b]	none	5	15	1.0
Middle Sweetwater	HA		9.20	1000	400	500	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
Upper Sweetwater	HA		9.30	500	250	250	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0

HA - Hydrologic Area
HSA - Hydrologic Sub Area (Lower case letters indicate endnotes following the table.)

Table 3-3. WATER QUALITY OBJECTIVES

Concentrations not to be exceeded more than 10% of the time during any one year period.

Ground Water		Hydrologic Basin Unit Number	Constituent (mg/L or as noted)												
			TDS	Cl	SO_4	%Na	NO_3	Fe	Mn	MBAS	B	ODOR	Turb NTU	Color Units	F
OTAY HYDROLOGIC UNIT		**910.00**													
Coronado	HA	10.10	-	-	-	-	-	-	-	-	-	-	-	-	-
Otay Valley	HA	10.20	1500 [b]	500 [b]	500 [b]	60	10 [b]	0.3 [b]	0.05 [b]	0.5	0.75 [b]	none	5	15	1.0
Otay Valley	HA [l]	10.20	-	-	-	-	-	-	-	-	-	none	-	-	-
Dulzura	HA	10.30	1000	400	500	60	10	0.3	0.05	0.5	0.75	none	5	15	1.0
TIJUANA HYDROLOGIC UNIT		**911.00**													
Tijuana Valley	HA [h]	11.10	2500 [b]	550 [b]	900 [b]	70	-	-	-	-	2.0 [b]	none	-	-	-
Potrero	HA	11.20	500	250	250	60	45	0.3	0.05	0.5	1.0	none	5	15	1.0
Barrett Lake	HA	11.30	500	250	250	60	45	0.3	0.05	0.5	1.0	none	5	15	1.0
Monument	HA	11.40	500	250	250	60	45	0.3	0.05	0.5	1.0	none	5	15	1.0
Morena	HA	11.50	500	250	250	60	45	0.3	0.05	0.5	1.0	none	5	15	1.0
Cottonwood	HA	11.60	500	250	250	60	45	0.3	0.05	0.5	1.0	none	5	15	1.0
Cameron	HA	11.70	500	250	250	60	45	0.3	0.05	0.5	1.0	none	5	15	1.0
Campo	HA	11.80	500	250	250	60	45	0.3	0.05	0.5	1.0	none	5	15	1.0

HA - Hydrologic Area
HSA - Hydrologic Sub Area (Lower case letters indicate endnotes following the table.)

ENDNOTES FOR TABLE 3-3

a The water quality objectives do not apply westerly of the easterly boundary of Interstate Highway 5. The objectives for the remainder of the Hydrologic Area (Subarea) are as shown.

b Detailed salt balance studies are recommended for this area to determine limiting mineral concentration levels for discharge. On the basis on existing data, the tabulated objectives would probably be maintained in most areas. Upon completion of the salt balance studies, significant water quality objective revisions may be necessary. In the interim period of time, projects of ground water recharge with water quality inferior to the tabulated numerical values may be permitted following individual review and approval by the Regional Board if such projects do not degrade existing ground water quality to the aquifers affected by the recharge.

c The recommended plan would allow for measurable degradation of ground water in this basin to permit continued agricultural land use. Point sources, however, would be controlled to achieve effluent quality corresponding to the tabulated numerical values. In future years demineralization may be used to treat ground water to the desired quality prior to use.

d A portion of the Upper Mission Basin is being considered as an underground potable water storage reservoir for treated imported water. The area is located north of Highway 76 an the boundary of hydrologic subareas 3.11 and 3.12. If this program is adopted, local objectives approaching the quality of the imported water would be set and rigorously pursued.

e The water quality objectives do not apply to hydrologic subareas 4.51 and 4.52 between Highway 78 and El Camino Real and to all lands which drain to Moonlight Creek and Encinitas Creek. The objectives for the remainder of the Hydrologic Area are as shown.

f The water quality objectives do not apply to all lands which drain to Los Penasquitos Canyon from 1.5 miles west of Interstate Highway 15. The objectives for the remainder of the Hydrologic Area are as shown.

g The water quality objectives do not apply west of Interstate Highway 15. The objectives for the remainder of the Hydrologic Area are as shown.

h The water quality objectives do not apply west of Hollister Street. The objectives for the remainder of the Hydrologic Area are as shown.

i No significant amount of ground water in this unit.

ENDNOTES FOR TABLE 3-3 (continued)

j The water quality objectives apply to the portion of Subarea 4.31 bounded on the west by the easterly boundary of the Interstate 5 right-of-way and on the east by the easterly boundary of El Camino Real.

k The water quality objectives apply to the portion of Subarea 4.51 bounded on the south by the north shore of Batiquitos Lagoon, on the west by the easterly boundary of the Interstate 5 right-of-way and on the east by the easterly boundary of El Camino Real.

l The water quality objectives apply to the portion of the Otay HA 10.20 limited to lands within and tributary to Salt Creek on the east and Poggi Canyon on the west and including the several smaller drainage courses between these tributaries of the Otay River.

m These objectives apply to the alluvial ground water beneath the Santa Margarita River from the confluence of Murrieta and Temecula Creeks through the Gavilan and DeLuz HSAs to a depth of 100 feet and a lateral distance equal to the area of the floodplain covered by a 10 year flood event. These objectives do not apply to ground water in any of the basins beneath DeLuz, Sandia, and Rainbow Creeks and other unnamed creeks, which are tributaries of the Santa Margarita River.

n These objectives apply for only the alluvial aquifer in the Lower Sycamore Canyon portion of the Santee Hydrologic Subarea described as all of the Sycamore Canyon watershed except that part which drains north of the boundary between sections 28 and 33, Township 14 South, Range 1 West.

o These objectives apply to ground waters within 250 feet of the surface for the most downstream 4,200 acres of the Pauba HSA (2.51) which drain directly to the most downstream 2.7 mile segment of Temecula Creek. Excluded from this area are all lands upgradient from a point 0.5 miles east of the intersection of Butterfield Stage Road and Highway 79.

p These objectives apply to ground waters within 250 feet of the surface for the most downstream 2,800 acres of the Wolf HSA (2.52) including those portions of the HSA which drain directly to the most downstream 1.5 mile segment of Pechanga Creek. Excluded from this area are all lands of HSA 2.52 which are upgradient of the intersection of Pala Road and Via Eduardo.

q These objectives apply to ground waters of the Poway HSA (6.2) that lie east of the San Diego County Water Authority's (SDCWA) First Aqueduct. Ground water quality objectives west of the SDCWA First Aqueduct are 1000 mg/l.

r These objectives apply to the Lower San Luis Rey Hydrologic Area (903.10). The objective for the alluvial aquifer in the Moosa Hydrologic Subarea (903.13) is 1200 mg/l. The objective for the alluvial aquifer in the Valley Center Hydrologic Subarea (903.14) is 1100 mg/l.

Appendix E-4
Santa Ana Regional Water Quality Control Board
Water Quality Control Plan for the Santa Ana River Basin

Inland Surface Water

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
LOWER SANTA ANA RIVER BASIN									
Santa Ana River									
Reach 1 - Tidal Prism to 17th Street in Santa Ana[+]	(Flood Flows Only)							801.11	
Reach 2 - 17th Street in Santa Ana to Prado Dam	650[1]	---	---	---	---	---	---	801.11	801.12
Aliso Creek[+]	---	---	---	---	---	---	---	845.63	
Carbon Canyon Creek[+]	---	---	---	---	---	---	---	845.63	
Santiago Creek Drainage									
Santiago Creek									
Reach 1 - below Irvine Lake	600	---	---	---	---	---	---	801.12	801.11
Reach 2 - Irvine Lake (see Lakes, pg. 4-36)									
Reach 3 - Irvine Lake to Modjeska Canyon	350	260	20	12	2	80	---	801.12	
Reach 4 - in Modjeska Canyon	350	260	20	12	2	80	---	801.12	
Silverado Creek	650	450	30	20	1	275	---	801.12	
Black Star Creek[+]	---	---	---	---	---	---	---	801.12	
Ladd Creek[+]	---	---	---	---	---	---	---	801.12	

[1] Five-year moving average
[+] Numeric objectives have not been established; narrative objectives apply.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
San Diego Creek Drainage									
San Diego Creek									
Reach 1 - below Jeffrey Road	1500	---	---	---	13	---	90	801.11	
Reach 2 - above Jeffrey Road to Headwaters	720	---	---	---	5	---	---	801.11	
Other Tributaries: Bonita Creek, Serrano Creek, Peters Canyon Wash, Hicks Canyon Wash, Bee Canyon Wash, Borrego Canyon Wash, Agua Chinon Wash, Laguna Canyon Wash, Rattlesnake Canyon Wash, Sand Canyon Wash and other Tributaries to these Creeks[+]	---	---	---	---	---	---	---	801.11	
San Gabriel River Drainage									
Coyote Ck. (within Santa Ana Regional Boundary)[+]	---	---	---	---	---	---	---		

[1] Five-year moving average

[+] Numeric objectives have not been established; narrative objectives apply.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
UPPER SANTA ANA RIVER BASIN									
Santa Ana River									
Reach 3 - Prado Dam to Mission Blvd. in Riverside - Base Flow[2]	700	350	110	140	10[3]	150	30	801.21	801.27, 801.25
Reach 4 - Mission Blvd. in Riverside to San Jacinto Fault in San Bernardino	550	---	---	---	10	---	30	801.27	801.44
Reach 5 - San Jacinto Fault in San Bernardino to Seven Oaks Dam	300	190	30	20	5	60	25	801.52	801.57
Reach 6 - Seven Oaks Dam to Headwaters (see also Individual Tributary Streams)	200	100	30	10	1	20	5	801.72	
San Bernardino Mountain Streams									
Mill Creek Drainage:									
Mill Creek									
Reach 1 - Confluence with Santa Ana River to Bridge Crossing Route 38 at Upper Powerhouse	200	100	30	10	1	20	5	801.58	
Reach 2 - Bridge Crossing Route 38 at Upper Powerhouse to Headwaters	110	100	25	5	1	15	5	801.58	

[2] Additional Objectives: Boron: 0.75 mg/L
[3] Total nitrogen, filtered sample

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
Mountain Home Creek	200	100	30	10	1	20	5	801.58	
Mountain Home Creek, East Fork	200	---	---	---	---	---	---	801.70	
Monkey Face Creek	200	100	30	10	1	20	5	801.70	
Alger Creek	200	---	---	---	---	---	---	801.70	
Falls Creek	200	100	30	10	1	20	5	801.70	
Vivian Creek	200	---	---	---	---	---	---	801.70	
High Creek	200	---	---	---	---	---	---	801.70	
Other Tributaries: Lost, Oak Cove, Green, Skinner, Momyer, Glen Martin, Camp, Hatchery, Rattlesnake, Slide, Snow, Bridal Veil, and Oak Creeks, and other Tributaries to these Creeks	200	---	---	---	---	---	---	801.70	
Bear Creek Drainage:									
Bear Creek	175	115	10	10	1	4	5	801.71	
Siberia Creek	200	---	---	---	---	---	---	801.71	
Slide Creek	175	---	---	---	---	---	---	801.71	
All other Tributaries to these Creeks[+]	---	---	---	---	---	---	---	801.71	
Big Bear Lake (see Lakes, pg. 4-36)									

[+] Numeric objectives have not been established; narrative objectives apply.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
Big Bear Lake Tributaries:									
North Creek	175	---	---	---	---	---	---	801.71	
Metcalf Creek	175	---	---	---	---	---	---	801.71	
Grout Creek	150	---	---	---	---	---	---	801.71	
Rathbone (Rathbun) Creek	300	---	---	---	---	---	---	801.71	
Meadow Creek+	---	---	---	---	---	---	---	801.71	
Summit Creek+	---	---	---	---	---	---	---	801.71	
Other Tributaries to Big Bear Lake: Knickerbocker, Johnson, Minnelusa, Polique, and Red Ant Creeks, and other Tributaries to these Creeks	175	---	---	---	---	---	---	801.71	
Baldwin Lake (see Lakes, pg. 4-36)									
Baldwin Lake Drainage:									
Shay Creek+	---	---	---	---	---	---	---	801.73	
Other Tributaries to Baldwin Lake: Sawmill, Green, and Caribou Canyons and other Tributaries to these Creeks+	---	---	---	---	---	---	---	801.73	

+ Numeric objectives have not been established; narrative objectives apply.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
Other Streams Draining to Santa Ana River (Mountain Reaches‡)									
Cajon Creek	200	100	30	10	1	20	5	801.51	
City Creek	200	115	30	10	1	20	5	801.57	
Devil Canyon Creek	275	125	35	20	1	25	5	801.57	
East Twin and Strawberry Creeks	475	---	---	---	---	---	---	801.57	
Waterman Canyon Creek	250	---	---	---	---	---	---	801.57	
Fish Creek	200	100	30	10	1	20	5	801.57	
Forsee Creek	200	100	30	10	1	20	5	801.72	
Plunge Creek	200	100	30	10	1	20	5	801.72	
Barton Creek	200	100	30	10	1	20	5	801.72	
Bailey Canyon Creek	200	---	---	---	---	---	---	801.72	
Kimbark Canyon, East Fork Kimbark Canyon, Ames Canyon and West Fork Cable Canyon Creeks	325	---	---	---	---	---	---	801.52	
Valley Reaches‡ of Above Streams	(Water Quality Objectives Correspond to Underlying GW Basin Objectives)							801.52	

‡ The division between Mountain and Valley reaches occurs at the base of the foothills of the San Bernardino or San Gabriel Mountains.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
Other Tributaries (Mountain Reaches‡): Alder, Badger Canyon, Bledsoe Gulch, Borea Canyon, Breakneck, Cable Canyon, Cienega Seca, Cold, Converse, Coon, Crystal, Deer, Elder, Fredalba, Frog, Government, Hamilton, Heart Bar, Hemlock, Keller, Kilpecker, Little Mill, Little Sand Canyon, Lost, Meyer Canyon, Mile, Monroe Canyon, Oak, Rattlesnake, Round Cienega, Sand, Schneider, Staircase, Warm Springs Canyon and Wild Horse Creeks, and other Tributaries to these Creeks	200	100	30	10	1	20	5	801.72	801.71, 801.57
San Gabriel Mountain Streams (Mountain Reaches‡)									
San Antonio Creek	225	150	20	6	4	25	5	801.23	
Lytle Creek (South, Middle and North Forks) and Coldwater Canyon Creek	200	100	15	4	4	25	5	801.41	801.42, 801.52, 801.59
Day Creek	200	100	15	4	4	25	5	801.21	
East Etiwanda Creek	200	100	15	4	4	25	5	801.21	
Valley Reaches‡ of Above Streams	(Water Quality Objectives Correspond to Underlying GW Basin Objectives)							801.21	

‡ The division between Mountain and Valley reaches occurs at the base of the foothills of the San Bernardino or San Gabriel Mountains.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
Cucamonga Creek									
Reach 1 - Confluence with Mill Creek to 23rd St. in Upland[+]	---	---	---	---	---	---	---	801.21	
Reach 2 (Mountain Reach[‡]) - 23rd St. in Upland to headwaters	200	100	15	4	4	25	5	801.24	
Mill Creek[+]	---	---	---	---	---	---	---	801.25	
Other Tributaries (Mountain Reaches[‡]): Cajon Canyon, San Sevaine, Deer, Duncan Canyon, Henderson Canyon, Bull, Fan, Demens, Thorpe, Angalls, Telegraph Canyon, Stoddard Canyon, Icehouse Canyon, Cascade Canyon, Cedar, Falling Rock, Kerkhoff and Cherry Creeks, and other Tributaries to these Creeks	200	---	---	---	---	---	---	801.21	801.23
San Timoteo Area Streams									
San Timoteo Creek									
Reach 1 - Santa Ana River Confluence to Gage at San Timoteo Canyon Road	290	175	60	60	6	45	15	801.52	801.53

[+] Numeric objectives have not been established; narrative objectives apply.
[‡] The division between Mountain and Valley reaches occurs at the base of the foothills of the San Bernardino or San Gabriel Mountains.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
Reach 2 - Gage at San Timoteo Canyon Road to Confluence with Yucaipa Creek	290	175	60	60	6	45	15	801.61	801.62
Reach 3 - Confluence with Yucaipa Creek to Bunker Hill II Groundwater Subbasin Boundary (T2S/R3W-24)	290	175	60	60	6	45	15	801.62	
Reach 4 - Bunker Hill II Groundwater Subbasin Boundary (T2S/R3W-24) to Confluence with Little San Gorgonio and Noble Creeks (Headwaters of San Timoteo Creek)	290	175	60	60	6	45	15	801.62	
Oak Glen, Potato Canyon and Birch Creeks	230	125	50	40	3	45	5	801.67	
Little San Gorgonio Creek	230	125	50	40	3	45	5	801.69	801.62, 801.63
Yucaipa Creek	290	175	60	60	6	45	15	801.67	801.61, 801.62, 801.64
Other Tributaries to these Creeks - Valley Reaches[+‡]	---	---	---	---	---	---	---	801.62	801.52, 801.53
Other Tributaries to these Creeks - Mountain Reaches[‡]	290	---	---	---	---	---	---	801.69	801.67
Anza Park Drain[+]	---	---	---	---	---	---	---	801.27	

[+] Numeric objectives have not been established; narrative objectives apply.
[‡] The division between Mountain and Valley reaches occurs at the base of the foothills of the San Bernardino or San Gabriel Mountains.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
Sunnyslope Channel[+]	---	---	---	---	---	---	---	801.27	
Tequesquite Arroyo (Sycamore Creek)[+]	---	---	---	---	---	---	---	801.27	
Prado Area Streams									
Chino Creek									
Reach 1 - Santa Ana River confluence to beginning of concrete-lined channel south of Los Serranos Rd.	550	240	75	75	8	60	15	801.21	
Reach 2 - Beginning of concrete-lined channel south of Los Serranos Rd. to confluence with San Antonio Creek[+]	---	---	---	---	---	---	---	801.21	
Temescal Creek									
Reach 1A - Santa Ana River Confluence to Lincoln Ave.	800	400	100	200	6	70	---	801.25	
Reach 1B - LIncoln Ave. to Riverside Canal[+]	---	---	---	---	---	---	---	801.25	
Reach 2 - Riverside Canal to Lee Lake[+]	---	---	---	---	---	---	---	801.32	801.25
Reach 3 - Lee Lake (see Lakes, pg. 4-36)									

[+] Numeric objectives have not been established; narrative objectives apply.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
Reach 4 - Lee Lake to Mid-section line of Section 17 (downstream end of freeway cut)+	---	---	---	---	---	---	---	801.34	
Reach 5 - Mid-section line of Section 17 (downstream end of freeway cut) to Elsinore Groundwater Subbasin Boundary+	---	---	---	---	---	---	---	801.35	
Reach 6 - Elsinore Groundwater Subbasin Boundary to Lake Elsinore Outlet+	---	---	---	---	---	---	---	801.35	
Coldwater Canyon Creek	250	---	---	---	---	---	---	801.32	
Bedford Canyon Creek+	---	---	---	---	---	---	---	801.32	
Dawson Canyon Creek+	---	---	---	---	---	---	---	801.32	
Other Tributaries to these Creeks	250	---	---	---	---	---	---	801.32	

+ Numeric objectives have not been established; narrative objectives apply.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
SAN JACINTO RIVER BASIN									
San Jacinto River									
Reach 1 - Lake Elsinore to Canyon Lake	450	260	50	65	3	60	15	802.32	802.31
Reach 2 - Canyon Lake (see Lakes, pg. 4-37)									
Reach 3 - Canyon Lake to Nuevo Road	820	400	---	250	6	---	15	802.11	
Reach 4 - Nuevo Road to North-South Mid-Section Line, T4S/R1W-S8*	500	220	75	125	5	65	---	802.14	802.21
Reach 5 - North-South Mid-Section Line, T4S/R1W-S8, to Confluence with Poppet Creek	300	140	30	25	3	40	12	802.21	
Reach 6 - Poppet Creek to Cranston Bridge	250	130	25	20	1	30	12	802.21	
Reach 7 - Cranston Bridge to Lake Hemet	150	100	10	15	1	20	5	802.21	
Bautista Creek - Headwaters to Debris Dam	250	130	25	20	1	30	5	802.21	802.23
Strawberry Creek and San Jacinto River, North Fork	150	100	10	15	1	20	5	802.21	

+ Numeric objectives have not been established; narrative objectives apply.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
Fuller Mill Creek	150	100	10	15	1	20	5	802.22	
Stone Creek	150	100	10	15	1	20	5	802.21	
Salt Creek[+]	---	---	---	---	---	---	---	802.12	
Other Tributaries: Logan, Black Mountain, Juaro Canyon, Indian, Hurkey, Poppet and Protrero Creeks, and other Tributaries to these Creeks	150	70	10	12	1	15	5	802.21	802.22

[*] Note the quality objective for Reach 4 is not intended to preclude transport of water supplies or delivery to Canyon Lake

Table 4-1 WATER QUALITY OBJECTIVES - Continued

LAKES AND RESERVOIRS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
UPPER SANTA ANA RIVER BASIN									
Baldwin Lake*+	---	---	---	---	---	---	---	801.73	
Big Bear Lake**	175	125	20	10	0.15	10	---	801.71	
Erwin Lake+	---	---	---	---	---	---	---	801.73	
Evans, Lake	490	---	---	---	---	---	---	801.27	
Jenks Lake	200	100	30	10	1	20	---	801.72	
Lee Lake+	---	---	---	---	---	---	---	801.34	
Mathews, Lake	700	325	100	90	---	290	---	801.33	
Mockingbird Reservoir	650	---	---	---	---	---	---	801.26	
Norconian, Lake	1050	---	---	---	---	---	---	801.25	
LOWER SANTA ANA RIVER BASIN									
Anaheim Lake	600	---	---	---	---	---	---	801.11	
Irvine Lake (Santiago Reservoir)	730	360	110	130	6	310	---	801.12	
Laguna, Lambert, Peters Canyon, Rattlesnake, Sand Canyon, and Siphon Reservoirs	720	---	---	---	---	---	---	801.11	

* Fills occasionally with storm flows; may evaporate completely
** Additional Objective: 0.15 mg/L Phosphorus
+ Numeric objectives have not been established; narrative objectives apply.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

LAKES AND RESERVOIRS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
SAN JACINTO RIVER BASIN									
Canyon Lake (Railroad Canyon Reservoir)***	700	325	100	90	8	290	---	802.11	802.12
Elsinore, Lake****	2000	---	---	---	1.5	---	---	802.31	
Fulmor, Lake	150	70	10	12	1	15	---	802.21	
Hemet, Lake	135	---	25	20	1	10	---	802.22	
Perris, Lake	220	110	50	55	1	45	---	802.11	

*** Note : The quality objectives for Canyon Lake is not intended to proclude transport of water supplies or delvery to the Lake.
**** Lake volume and quality highly variable.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

WETLANDS (INLAND)	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
San Joaquin Freshwater Marsh**	2000	---	---	---	13	---	90	801.11	
Shay Meadows+	---	---	---	---	---	---	---	801.73	
Stanfield Marsh+**	---	---	---	---	---	---	---	801.71	
Prado Flood Control Basin+**	---	---	---	---	---	---	---	801.25	
San Jacinto Wildlife Preserve+**	---	---	---	---	---	---	---	802.15	
Glen Helen+	---	---	---	---	---	---	---	801.59	

\+ Numeric objectives have not been established; narrative objectives apply.

** This is a created wetland as defined in the wetlands discussion (see Chapter 3).

Groundwater

Table 4-1 WATER QUALITY OBJECTIVES - Continued

GROUNDWATER SUBBASINS	WATER QUALITY OBJECTIVES (mg/L)						Hydrologic Unit	
	TDS	Hard.	Na	Cl	NO_3-N	SO_4	Primary	Secondary
UPPER SANTA ANA RIVER BASIN								
Big Bear Valley	300	225	20	10	5	20	801.71	801.73
Cucamonga	220	170	15	15	5	20	801.24	801.21
Chino I	220	170	15	15	5	20	801.21	481.23, 418.22, 801.27
Chino II	330	185	18	18	6	20	801.21	418.21, 801.23
Chino III	740	425	100	50	11	110	801.21	481.21, 801.27, 801.26
San Timoteo	240	170	45	25	6	35	801.60	801.63, 801.64, 801.66, 801.68
Bunker Hill I	260	190	15	10	1	45	801.51	
Bunker Hill II	290	190	30	20	5	62	801.52	
Bunker Hill Pressure	300	160	30	20	1	62	801.52	
Lytle Creek	225	175	15	10	1	30	801.41	801.42
Rialto	200	95	35	35	2	40	801.43	801.44
Colton	400	240	35	35	3	64	801.44	801.45, 801.27
Riverside I	490	270	50	50	4	85	801.27	
Riverside II	650	360	70	85	10	100	801.27	
Riverside III	990	500	125	170	20	135	801.27	
Arlington	1050	500	125	180	20	160	801.26	801.25

Table 4-1 WATER QUALITY OBJECTIVES - Continued

GROUNDWATER SUBBASINS	WATER QUALITY OBJECTIVES (mg/L)						Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**NO_3-N**	**SO_4**	Primary	Secondary
Bedford (Upper Temescal I)	840	440	80	100	9	200	801.32	
Lee Lake (Upper Temescal II)	600	300	100	100	6	140	801.34	
Coldwater (Upper Temescal III)	350	175	45	25	2	125	801.31	
Temescal	840	440	120	180	9	160	801.25	
SAN JACINTO RIVER BASIN								
Garner Valley	300	100	65	30	2	40	802.22	
Idyllwild Area+	---	---	---	---	---	---	802.22	802.21
San Jacinto - Canyon	250	130	25	20	1	30	802.21	
San Jacinto - Lower Pressure	800	380	120	100	3	330	802.21	
San Jacinto - Intake	350	145	50	35	5	40	802.21	
San Jacinto - Upper Pressure	350	145	50	35	5	40	802.21	
Hemet	600	300	80	80	4	215	802.15	802.21
Lakeview	500	190	80	160	2	25	802.14	
Perris North	300	100	70	90	3	15	802.11	
Perris South I	1000	---	---	---	---	---	802.11	
Perris South II	2000	---	---	---	---	---	802.11	
Perris South III	1500	---	---	---	---	---	802.11	
Winchester	1200	---	---	---	---	---	802.13	
Menifee I	2000	---	---	---	---	---	802.12	

+ Numeric objectives have not been established; narratve objectives apply.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

GROUNDWATER SUBBASINS	WATER QUALITY OBJECTIVES (mg/L)						Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**NO_3-N**	**SO_4**	Primary	Secondary
Menifee II	1500	---	---	---	---	---	802.12	
Elsinore	450	260	50	60	4	60	802.31	802.32
LOWER SANTA ANA RIVER BASIN								
La Habra[+**]	1000	---	---	250	---	250	845.62	
Santiago[+]	---	---	---	---	---	---	801.12	
Santa Ana Forebay	600	290	60	65	3	120	801.11	801.13, 845.61
Santa Ana Pressure	500	240	45	55	3	100	801.11	845.61
Irvine Forebay I	1000	450	180	180	8	340	801.11	
Irvine Forebay II	720	380	100	150	6	240	801.11	
Irvine Pressure	720	380	100	150	6	240	801.11	

[+] Numeric objectives have not been established; narratve objectives apply.

[**] Water quality objectives apply to upper unconfined La Habra subbasin. Additional objective, Boron; 1.0 mg/L. Lower confined La Habra subbasin objectives are consistent with the Santa Ana Pressure water quality objectives.

Ocean Water

Table 4-1 WATER QUALITY OBJECTIVES

OCEAN WATERS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	**Hard.**	**Na**	**Cl**	**TIN**	**SO_4**	**COD**	Primary	Secondary
NEARSHORE ZONE*									
San Gabriel River to Poppy Street in Corona del Mar+	---	---	---	---	---	---	---	801.11	
Poppy Street to Southeast Regional Boundary+	---	---	---	---	---	---	---	801.11	
OFFSHORE ZONE									
Waters Between Nearshore Zone and Limit of State Waters+	---	---	---	---	---	---	---		

* Defined by Ocean Plan Chapter II A.1.: "Within a zone bounded by shoreline and a distance of 1000 feet from shoreline or the 30-foot depth contour, whichever is further from shoreline..."
+ Numeric ojectives have not been established; narrative objectives apply.

Table 4-1 WATER QUALITY OBJECTIVES - Continued

BAYS, ESTUARIES, AND TIDAL PRISMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	TDS	Hard.	Na	Cl	TIN	SO_4	COD	Primary	Secondary
Anaheim Bay - Outer Bay+	---	---	---	---	---	---	---	801.11	
Anaheim Bay - Seal Beach National Wildlife Refuge+	---	---	---	---	---	---	---	801.11	
Sunset Bay - Huntington Harbour+	---	---	---	---	---	---	---	801.11	
Bolsa Bay+	---	---	---	---	---	---	---	801.11	
Bolsa Chica Ecological Reserve+	---	---	---	---	---	---	---	801.11	
Lower Newport Bay+	---	---	---	---	---	---	---	801.11	
Upper Newport Bay+	---	---	---	---	---	---	---	801.11	
Santa Ana River Salt Marsh+	---	---	---	---	---	---	---	801.11	
Tidal Prism of Santa Ana River (to within 1000' of Victoria Street) and Newport Slough+	---	---	---	---	---	---	---	801.11	
Tidal Prism of San Gabriel River - River Mouth to Marina Drive+	---	---	---	---	---	---	---	845.61	
Tidal Prisms of Flood Control Channels Discharging to Coastal or Bay Waters+	---	---	---	---	---	---	---	801.11	

+ Numeric objectives have not been established; narrative objectives apply.

Appendix F
California State Water Resources Control Board Areas of Significant Biological Significance

APPENDIX V

AREAS* OF SPECIAL BIOLOGICAL SIGNIFICANCE

TABLE V-1
AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE
(DESIGNATED OR APPROVED BY THE STATE WATER RESOURCES CONTROL BOARD)

No.	ASBS Name	Date Designated	SWRCB Resolution No.	Region No.
1.	Pygmy Forest Ecological Staircase	March 21, 1974,	74-28	1
2.	Del Mar Landing Ecological Reserve	March 21, 1974,	74-28	1
3.	Gerstle Cove	March 21, 1974,	74-28	1
4.	Bodega Marine Life Refuge	March 21, 1974,	74-28	1
5.	Kelp Beds at Saunders Reef	March 21, 1974,	74-28	1
6.	Kelp Beds at Trinidad Head	March 21, 1974,	74-28	1
7.	Kings Range National Conservation Area	March 21, 1974,	74-28	1
8.	Redwoods National Park	March 21, 1974,	74-28	1
9.	James V. Fitzgerald Marine Reserve	March 21, 1974,	74-28	2
10.	Farallon Island	March 21, 1974,	74-28	2
11.	Duxbury Reef Reserve and Extension	March 21, 1974,	74-28	2
12.	Point Reyes Headland Reserve and Extension	March 21, 1974,	74-28	2
13.	Double Point	March 21, 1974,	74-28	2
14.	Bird Rock	March 21, 1974,	74-28	2
15.	Ano Nuevo Point and Island	March 21, 1974,	74-28	3
16.	Point Lobos Ecological Reserve	March 21, 1974,	74-28	3
17.	San Miguel, Santa Rosa, and Santa Cruz Islands	March 21, 1974,	74-28	4
18.	Julia Pfeiffer Burns Underwater Park	March 21, 1974,	74-28	3
19.	Pacific Grove Marine Gardens Fish Refuge and Hopkins Marine Life Refuge	March 21, 1974,	74-28	3
20.	Ocean Area Surrounding the Mouth of Salmon Creek	March 21, 1974,	74-28	3
21.	San Nicolas Island and Begg Rock	March 21, 1974,	74-28	4
22.	Santa Barbara Island, Santa Barbara County and Anacapa Island	March 21, 1974,	74-28	4
23.	San Clemente Island	March 21, 1974,	74-28	4

Table V-1 Continued on next page…

Table V-1 (Continued)

Areas of Special Biological Significance (Designated or Approved by the State Water Resources Control Board)

No.	ASBS Name	Date Designated	SWRCB Resolution No.	Region No.
24.	Mugu Lagoon to Latigo Point	March 21, 1974,	74-28	4
25.	Santa Catalina Island – Subarea One, Isthmus Cove to Catalina Head	March 21, 1974,	74-28	4
26.	Santa Catalina Island - Subarea Two, North End of Little Harbor to Ben Weston Point	March 21, 1974,	74-28	4
27.	Santa Catalina Island - Subarea Three, Farnsworth Bank Ecological Reserve	March 21, 1974,	74-28	4
28.	Santa Catalina Island - Subarea Four, Binnacle Rock to Jewfish Point	March 21, 1974,	74-28	4
29.	San Diego-La Jolla Ecological Reserve	March 21, 1974,	74-28	9
30.	Heisler Park Ecological Reserve	March 21, 1974,	74-28	9
31.	San Diego Marine Life Refuge	March 21, 1974,	74-28	9
32.	Newport Beach Marine Life Refuge	April 18, 1974	74-32	8
33.	Irvine Coast Marine Life Refuge	April 18, 1974	74-32	8
34.	Carmel Bay	June 19, 1975	75-61	3