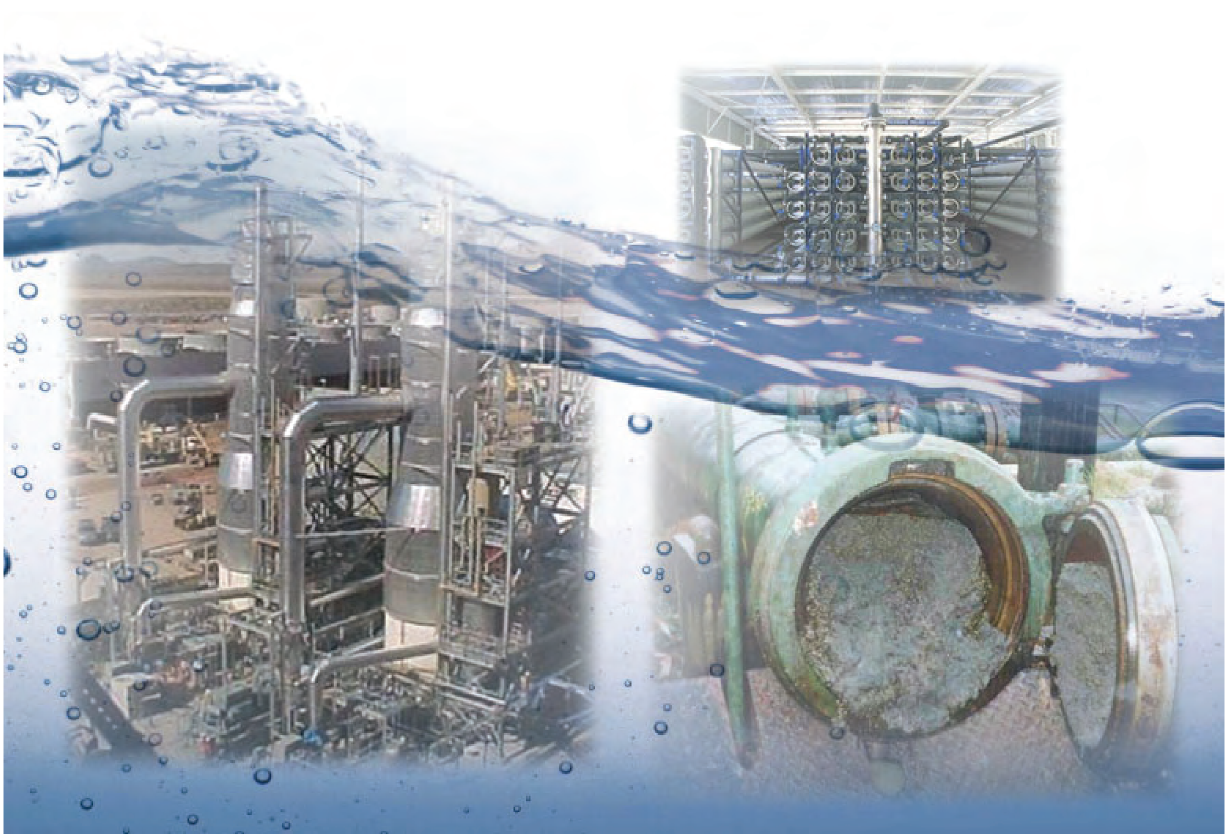
RECLAMATION
Managing Water in the West

Executive Summary

Southern California Regional Brine-Concentrate Management Study – Phase I
Lower Colorado Region



U.S. Department of the Interior
Bureau of Reclamation

October 2009

Acknowledgements

The Southern California Regional Brine-Concentrate Management Study is a collaboration between the United States Department of the Interior Bureau of Reclamation and 14 local and state agency partners as shown below. The project is funded on a 50/50 cost-sharing basis between the United States Department of the Interior Bureau of Reclamation and the cost-sharing partners, who together form the Brine Executive Management Team. It was under their direction that this work was completed by CH2M HILL.

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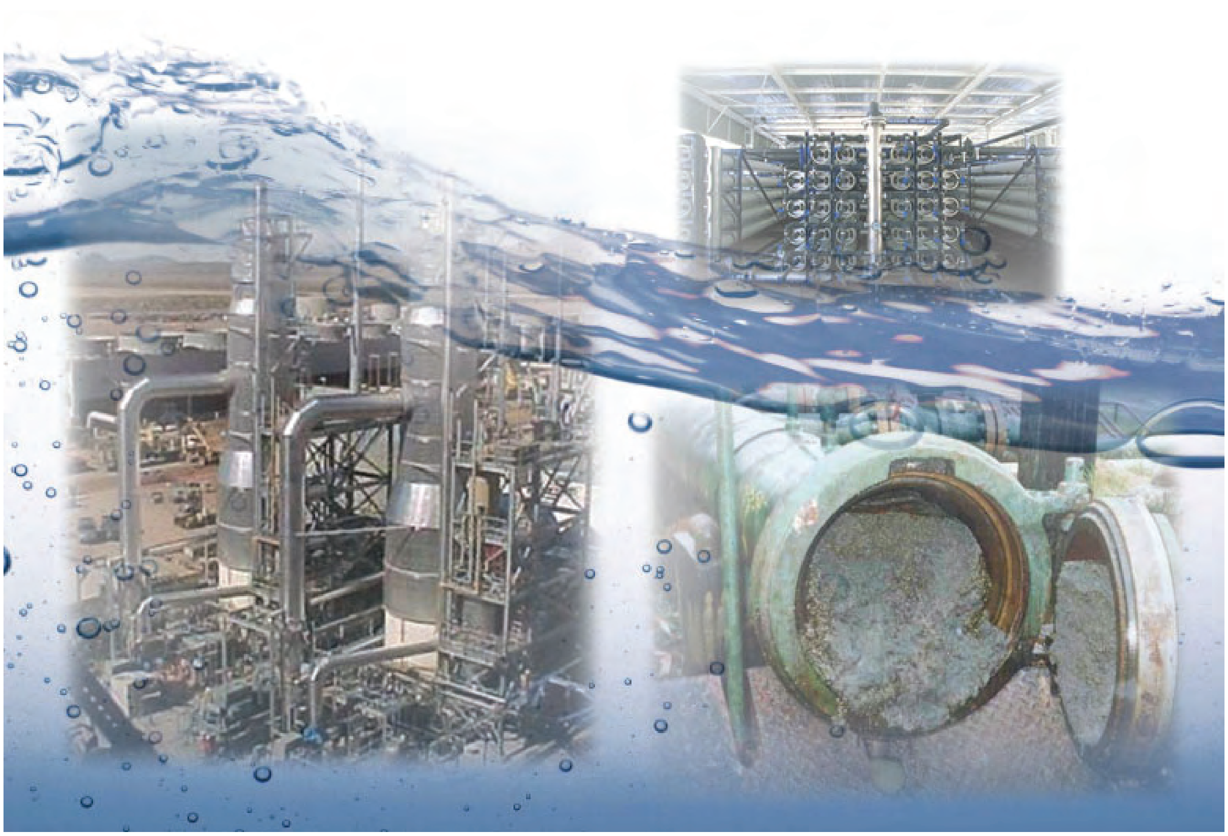

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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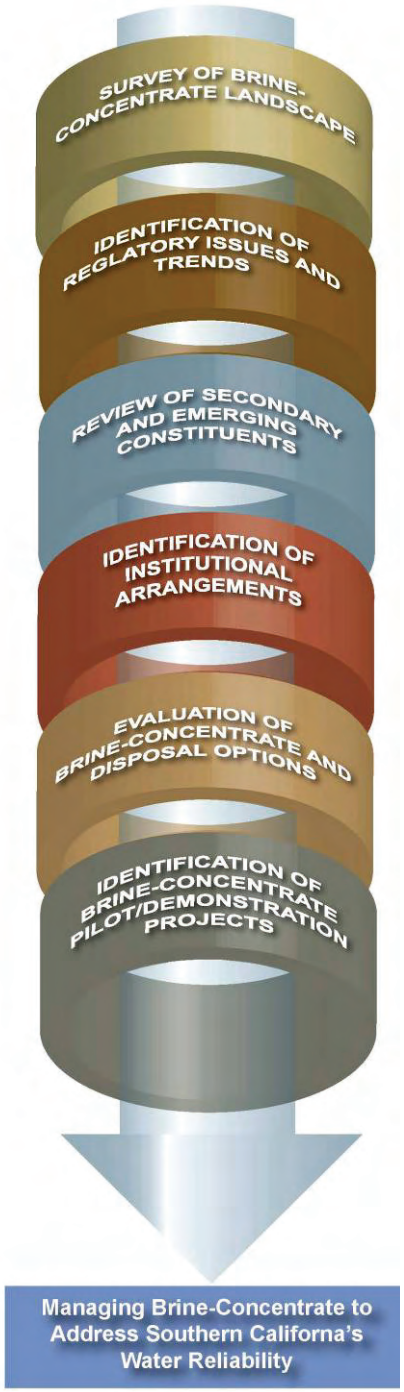
Introduction



Reclamation, along with the study partners, identified the management of brine-concentrate as significant in addressing southern California's water supply reliability. Management of brine-concentrate faces economic, environmental, and regulatory hurdles to developing ocean and brackish groundwater supplies and recycling water. Developing these new water supply sources is important for water and wastewater agencies in southern California due to limitations in availability of existing imported water and good quality groundwater supplies. As these existing supplies continue to be strained, lower quality and more expensive water sources will be developed or recovered for use.

Development of these lower quality waters often requires the use of membrane or other treatment technologies that produce brine or concentrate waste streams. This waste is classified by the United States Environmental Protection Agency as an industrial waste and can face regulatory limitations on disposal. Currently, the most common practice for disposal is the use of brinelines and ocean outfalls. However, as the amount of brine-concentrate waste increases, a two-fold concern emerges.

First, reductions in wastewater flows due to water conservation efforts and increases in water recycling result in changes to the blending and dilution of brine-concentrate inflows to wastewater treatment plants (WWTPs) and ocean outfalls. Such increased concentrations levels could result in potential impacts to benthic organisms and the physical environment. Secondly, capacity limitations in existing facilities may reduce the amount of water that can be developed or recovered due to discharge constraints. In inland or other areas where no access to a brineline or ocean outfall exists, concerns arise from developing brine-concentrate management options that are cost-effective, environmentally acceptable, and institutionally supported. These implementation, regulatory, and institutional issues often present complex challenges to agencies.

From the issues facing management of brine-concentrate, it is clear that there are a number of different elements that together formulate the regional landscape for management of this waste stream. These elements are the amount of brine-concentrate produced, regulatory issues driving brine-concentrate management needs (including emerging constituents of concern), institutional arrangements, available brine-concentrate management or disposal options, and planned agency brine-concentrate management projects including pilot/demonstration projects. Each one of these is a key element in formulating a comprehensive view of the southern California brine-concentrate management landscape. For this reason, complete reports were developed for each of these elements as part of this study. This executive summary was developed as an overview of these reports and provides highlights as well as summarizes the key findings from each of the six reports.

Survey of Brine-Concentrate Landscape

As part of the brine-concentrate management survey conducted under this study, 119 wastewater facilities, 53 groundwater desalters, and 19 outfall systems were identified as either existing or planned in southern California. Figures 1 and 2 show the facilities identified as part of the survey. These facilities will generate approximately 47.4 million gallons per day (mgd) of brine-concentrate in 2010 (Figure 3). Currently a majority of the brine-concentrate generated is disposed using ocean outfalls.

Existing brine-concentrate generators include 10 WWTPs/WRPs and 22 groundwater desalters. The largest generator of brine-concentrate in the study area is the OCWD's Groundwater Replenishment System project. Brine-concentrate generation is projected to increase to over 135 mgd by buildout (beyond 2035) as shown in Table 1 and Figure 3. At buildout there are 22 WWTPs/WRPs and 53 groundwater desalters that generate brine-concentrate. These facilities will enable local agencies to produce or recover almost 204 mgd of water supply from

TABLE 1
SUMMARY OF BRINE-CONCENTRATE GENERATED IN SOUTHERN CALIFORNIA

Region	Average Daily Brine-Concentrate Generated (mgd)		
	Groundwater Desalters	WWTP	Total
EXISTING (2008)			
Inland Empire	7.83	0.00	7.83
Los Angeles County	1.43	5.28	6.71
North Orange County	0.49	10.68	11.17
South Orange County	1.70	0.00	1.70
San Diego County	1.40	0.81	2.21
Ventura County	2.68	0.00	2.68
Total	15.53	16.77	32.30
FUTURE (ULTIMATE BUILDOUT – POST 2035)			
Inland Empire	23.46	0.14	23.60
Los Angeles County	7.42	19.65	27.07
North Orange County	3.99	23.00	26.99
South Orange County[a]	18.70	0.15	18.85
San Diego County	13.35	9.37	22.72
Ventura County	9.05	6.79	15.84
Total	75.97	59.10	135.07

Notes:
[a] Groundwater values for the South Orange County region include brine flows from the proposed South Orange Coastal Ocean Desalination Project which will discharge brine via SOCWA's San Juan Creek Ocean Outfall

membrane treated recycled and brackish ground water sources in 2010 and nearly 407 mgd by 2030 as shown in Figure 4. This will increase to just over 500 mgd by buildout of these facilities (i.e., post 2035), a threefold increase in water supply. Groundwater supplies generated from reverse osmosis (RO) membrane treatment processes increase from approximately 72.8 mgd (2008) to 251.9 mgd at buildout. These projections include the South Orange Coastal Ocean Desalination Project, which is projecting a 15-mgd supply and will discharge brine via the South Orange County Wastewater Authority (SOCWA) San Juan Creek Ocean Outfall.

Figure 4 shows that the use of RO to recover water from WWTPs/WRPs results in an increase of water supply from approximately 93.0 mgd in 2010 to 249.5 mgd by 2030. By comparison, in the southern California urban area, which is nearly all served by the Metropolitan Water District of Southern California and the San Bernardino Valley MWD, projected water demands are expected to be

4.78 million acre feet per year (afy) by 2010 and 5.42 million afy by 2030. Thus, these recycled and brackish ground water membrane treated supply sources represent over 4.7 percent of the total water demand in the southern California urban area in 2010 and over 8 percent by 230. The projection of brine-concentreate flows could be exacerbated if regulatory requirements result in the increased usage of RO membranes or other brine-concentrate generating processes. Figure 5 shows how different regulatory requirements could impact the amount of brine-concentrate produced. For example, if all recycled water is required to undergo advanced treatment prior to reuse (Scenario 2) then the production of brine-concentrate in southern California would increase from 57 mgd in 2008 to 150 mgd in 2015 and to 218 mgd by build out conditions. Brine-concentrate generation could increase to over 400 mgd (Scenario 4) if all wastewater and recycled water facilities are required to implement RO. Table 2 has a description of the Scenarios used in Figure 5.

As seen in Figure 5, changes in regulations can drastically increase not only the need for RO processes but also the generation of brine-concentrate. If RO processes are utilized to meet increased regulation of constituents, existing brine-concentrate management measures in southern California will not be adequate to manage the brine-concentrate generated. Therefore, additional volume reduction, treatment, or disposal mechanisms for brine-concentrate will be needed.

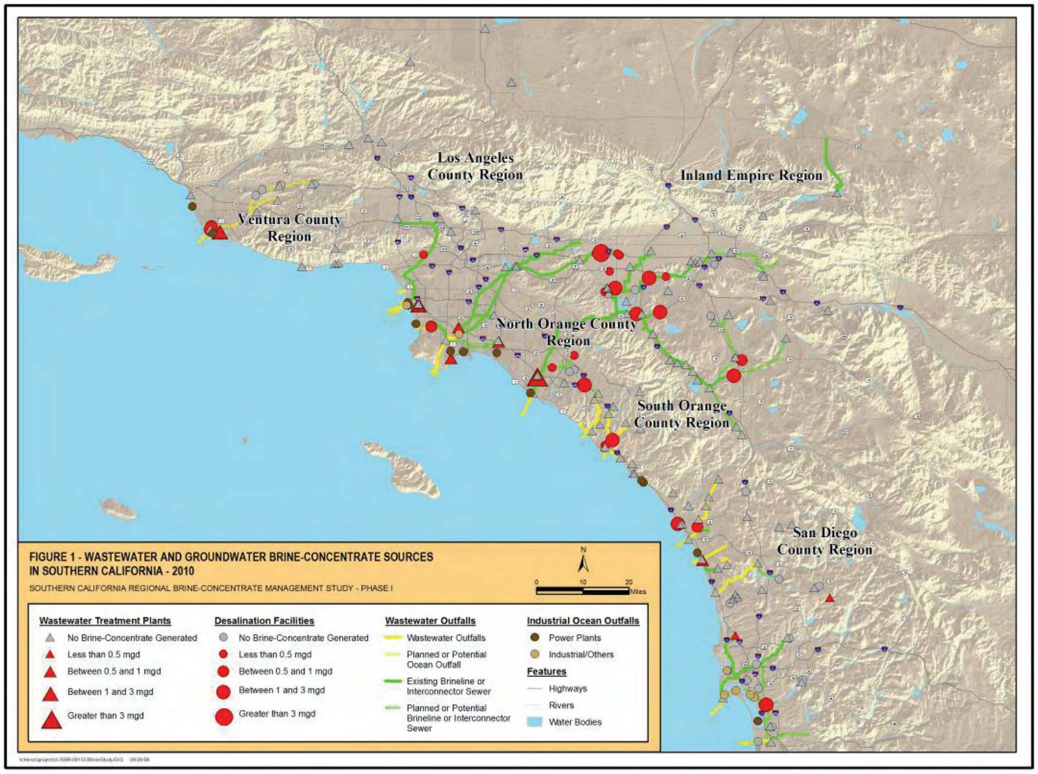


FIGURE 1 - WASTEWATER AND GROUNDWATER BRINE-CONCENTRATE SOURCES IN SOUTHERN CALIFORNIA - 2010
SOUTHERN CALIFORNIA REGIONAL BRINE-CONCENTRATE MANAGEMENT STUDY - PHASE I

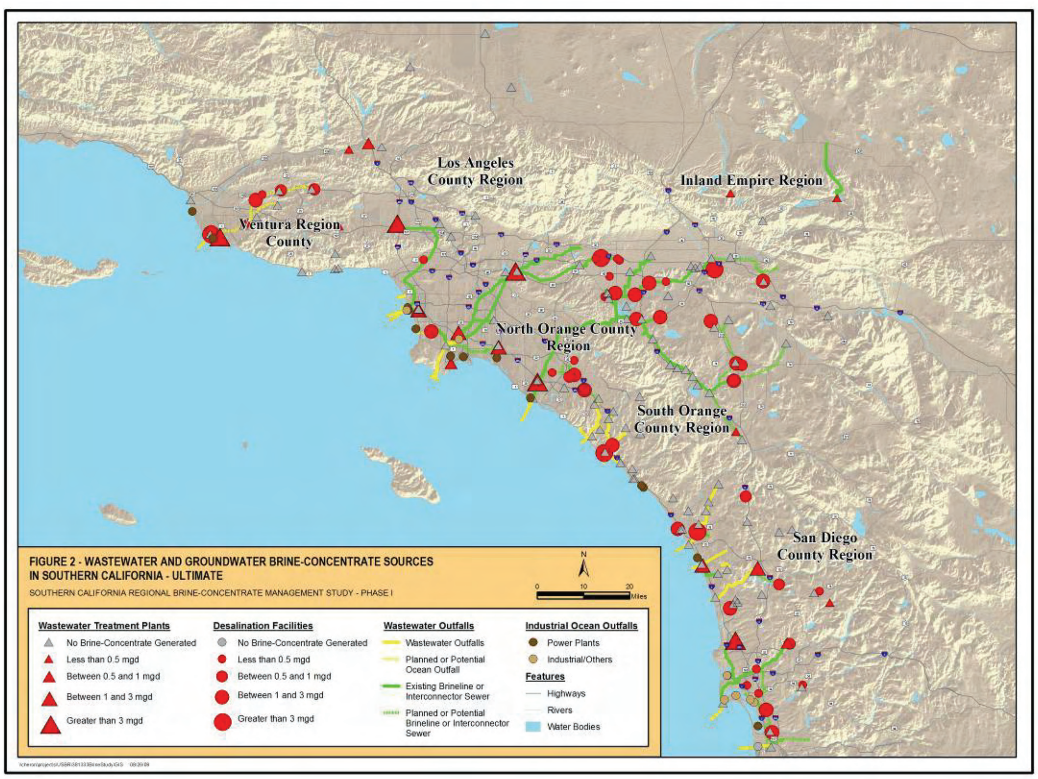
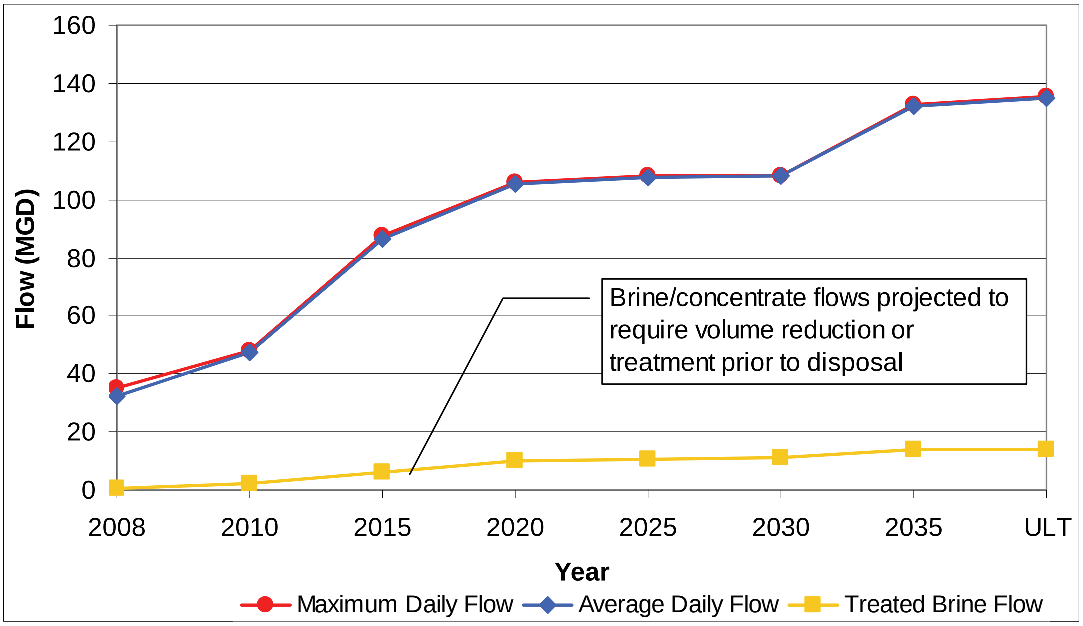


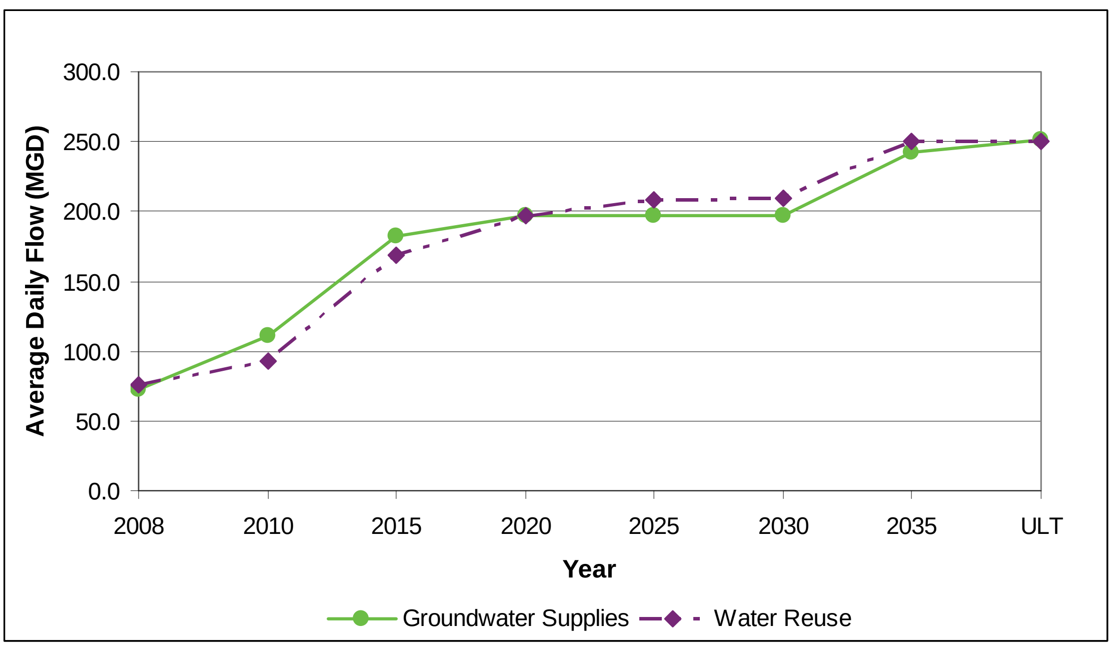
FIGURE 2 - WASTEWATER AND GROUNDWATER BRINE-CONCENTRATE SOURCES IN SOUTHERN CALIFORNIA - ULTIMATE
SOUTHERN CALIFORNIA REGIONAL BRINE-CONCENTRATE MANAGEMENT STUDY - PHASE I

FIGURE 3 BRINE-CONCENTRATE FLOW SUMMARY FOR SOUTHERN CALIFORNIA



Note: Brine generation is from wastewater treatment and groundwater desalting. These projections also include the South Orange Coastal Ocean Desalination Project.

FIGURE 4 WATER SUPPLIES THAT RESULT IN THE GENERATION OF BRINE-CONCENTRATE IN SOUTHERN CALIFORNIA



Note: Figure includes WWTP/WRPs, groundwater recharge, seawater intrusion barrier, brackish groundwater, and 15 mgd from the South Orange Coastal Ocean Desalination Project.

FIGURE 5 BRINE-CONCENTRATE FLOW SUMMARY AND SCENARIOS FOR SOUTHERN CALIFORNIA

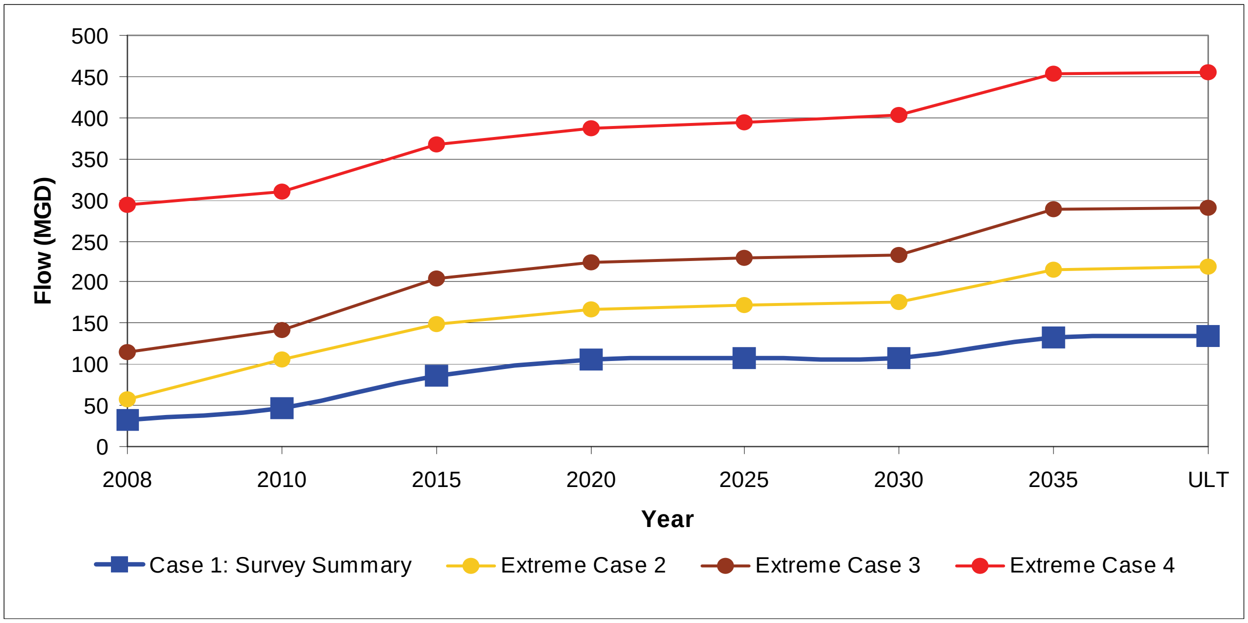


TABLE 2
SCENARIO DEFINITIONS

Scenario Name	Description	Conditions Included in Scenario that Produce Brine/Concentrate:				
		Advanced Treatment Where Required for Indirect Potable Reuse, BPOs, TDS, etc.	Advanced Treatment of All Recycled Water	Advanced Treatment of All Inland Wastewater Discharges	Advanced Treatment of All Wastewater Discharges	Groundwater Desalting Facilities
Case 1	Survey summary: includes all projected advanced treatment projects for reuse and GW desalting	✓				✓
Extreme Case 2	Advanced treatment implemented on all recycled water produced	✓	✓			✓
Extreme Case 3	Advanced treatment implemented on all inland wastewater discharges and water recycled	✓	✓	✓		✓
Extreme Case 4	Advanced treatment implemented on all wastewater discharges and recycled water	✓	✓		✓	✓

Identification of Regulatory Issues and Trends

Managing Brine-Concentrate to Address Southern Californa's Water Reliability

Currently, there are no regulations that specifically apply to the production or disposal of brine-concentrate; however, there are a number of regulations that impact brine-concentrate management projects. The most significant regulatory concern facing brine-concentrate management is disposal of a concentrated waste product that often has high levels of salts and is classified as an industrial waste. The regulation of disposal of these waste products is typically focused on setting limits or requirements to satisfy standards for air, water, or environmental quality. A complete list of the laws and regulations that may apply to brine-concentrate management projects are shown in Table 3.

Most of these regulations deal with the actual development of a project and its potential impact on the physical environment of the receiving water body. Brine-concentrate management projects are most impacted by regulatory control via discharge requirements or National Pollution Discharge Elimination System permits. These requirements both control the constituents and the amount that can be discharged. An example of this type of regulation is the use of Total Maximum Daily Loads (TMDLs), which regulate the maximum amount of a pollutant that a body of water can receive and still safely meet water quality standards, to limit discharge concentrations. This type of regulation can create the need to implement brine-concentrate management technologies or can be used to limit how much brine-concentrate can be discharged. At the Valencia WRP, the Sanitation Districts of Los Angeles County must reduce the amount of chloride discharged to the Santa Clarita basin to meet a chloride TMDL. Due to this requirement, advanced treatment will be implemented as well as a brine-concentrate reducing technology or other brine-concentrate management strategy.

Salts are another constituent that are driving the need for membrane treatment. Salt management is an increasing concern as more total dissolved solids (TDS) are introduced by imported water and recovered from brackish groundwater basins. Disposal of these salts could escalate the need for increased brine-concentrate management in southern California. With increased production of brine-concentrate, as well as a better understanding of certain constituents' impact on human and environmental health, it is likely that regulation will continue to become more stringent. This is particularly important for constituents of emerging concern.

TABLE 3
SUMMARY OF APPLICABLE FEDERAL AND STATE LAWS AND REGULATIONS

Law/Regulation	Description
Federal Water Pollution Control Act (Clean Water Act, 1972)	Establishes structure for regulating pollutant discharges to waters of the U.S.
National Pollution Elimination System (NPDES)	Regulates point sources that discharge pollutants into waters of the U.S. to control water pollution
Section 404	Regulates discharge of dredged or fill material to waters of the U.S.
Section 401	Ensures that pollution prevention and control occurs on projects regulated by the federal government
Section 303(d) and TMDLs	Requires states, territories, and authorized tribes to develop a list of impaired bodies of water and establish limits for the maximum amount of pollutant a body of water can receive
Antidegradation Policy	Protects bodies of water with high water quality for beneficial uses and from any adverse impacts to water quality
California Toxics Rule	Lists 126 priority toxic pollutants, establishes numeric aquatic-life criteria for 57 compounds, and describes how these criteria are to be applied
California Ocean Plan	Establishes water quality standards for coastal waters including estuaries and prohibits discharge to ASBS
Federal Safe Drinking Water Act	Protects public health by regulating the public drinking water supply and its sources
Maximum Contaminant Levels	Enforceable standards that define the maximum levels of constituents that can be present in drinking water
Calderon-Sher Safe Drinking Water Act and Public Health Goals	Requires monitoring and limits for contaminants in drinking water. A PHG is a level of contaminant in drinking water that does not pose a significant risk to health.
Action Levels	Describes nonregulatory advisory levels for the level of constituent in drinking water that does not pose a significant health risk
Underground Injection Control Program	Protects the USDW by classifying and then setting standards and permit requirements for different classes of wells

TABLE 3
SUMMARY OF APPLICABLE FEDERAL AND STATE LAWS AND REGULATIONS

Law/Regulation	Description
Coastal Zone Management Act	Encourages the preservation, protection, development, and (where possible) the restoration and enhancement of natural coastal resources and wildlife habitat
California Coastal Act	Defines the "coastal zone" and establishes land use control for the zone
California Water Code	Regulates all aspects of water policy in California from quantity and quality to water agency formation
Porter Cologne Water Quality Control Act	Establishes the State and Regional Water Quality Control Boards, the requirement for Basin Plans and Waste Discharge requirements, and the regulation of groundwater, surface water, and recycled water quality
Waste Discharge Requirements (WDR)	Establishes process and permit requirements for any waste discharged in California
Recycled Water Policy	Establishes policy and requirements to regulate and encourage the use of recycled water in California
CCR Title 22	Establishes water quality criteria and guidelines applicable to recycled water projects
Clean Air Act	Establishes NAAQ criteria and requires the development of SIPs to comply with those criteria
California Environmental Quality Act	Requires a project proponent to conduct an environmental review of the project in addition to a Negative Declaration or EIR
National Environmental Policy Act	Requires federal agencies to integrate environmental values into a decision-making process by considering the environmental impacts of proposed actions and reasonable alternatives to action in an EIS
Endangered Species Act	Establishes a broad federal interest in identifying, protecting, and providing for the recovery of threatened or endangered species
Title 27 Environmental Protection, Division 2: Solid Waste and U.S. Subtitle D	Governs the construction and operation of landfills including types of waste that can be accepted

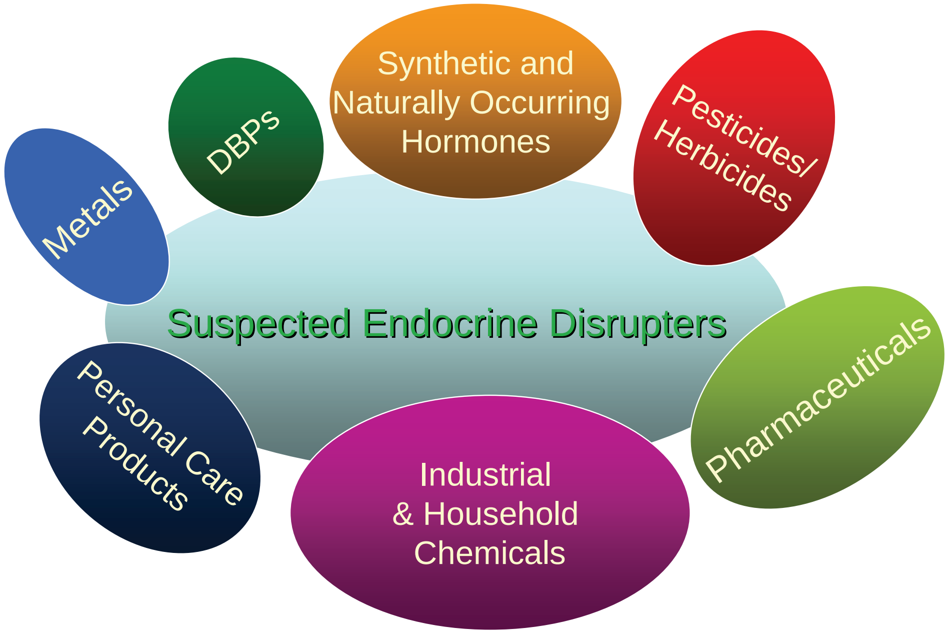
Review of Secondary and Emerging Constituents

Contaminants of Emerging Concern (CECs) refer to a relatively large group of synthetic and naturally occurring chemicals which have become a concern as scientists discover that new toxicity concerns, build-up in the environment, or detection in humans or other living organisms resulting from these constituents. In addition, there is a potential for these constituents to cause adverse effects on public health and the environment. The USEPA has not recommended 304(a) water quality criteria, the State Water Resources Control Board or Regional Water Quality Control Boards have not enacted numeric water quality objectives or a numeric translators for relevant narrative objectives, and the California Department of Public Health (CDPH) has not adopted a Maximum Contaminant Levels (MCL). Examples of CECs include bis-phenol-A, phthalates, arsenic, perchlorate, nonylphenols, synthetic musks and other personal care product ingredients, nitrosodimethylamine, brominated flame retardants. These constituents are found in industrial and household chemicals as shown in Figure 6. These compounds are emerging as a regulatory concern for wastewater and brine-concentrate dischargers. Further regulation of these constituents could drive the need for implementation of additional brine-concentrate treatment technologies.

Common examples of CECs include Dichlorodiphenyltrichloroethane (DDT), Polychlorinated biphenyls (PCBs), Polycyclic aromatic hydrocarbons (PAHs), and Halogenated aromatic hydrocarbons (HAHs). Because some of these compounds can cause developmental and reproductive changes in fish and amphibians, and concerns exist that mammals may be sensitive to extremely low concentrations of these CECs, there is a growing concern about these compounds.

Although CECs have been known to occur in U.S. waters for over 30 years, it is only in the past decade that health and environmental concerns have been linked to these chemicals and have been brought to the forefront of the regulatory, scientific, and environmental communities. Increased attention to emerging constituents has been driven primarily by the increased ability to detect the chemicals in water supplies and wastewater at very low concentrations. These compounds are also receiving attention because a number of them have been reported to interfere with animal and human hormone systems at subnanogram levels of exposure. Because some of these chemicals have been detected in trace amounts in wastewater effluent and drinking water sources, RO concentrate streams may contain these chemicals as well. CECs are not currently regulated; however with several studies to monitor CECs underway in California, Pennsylvania, and other states, the development of regulations are expected to be developed in the future.

FIGURE 6 COMPOUNDS OF EMERGING CONCERN AND SUSPECTED ENDOCRINE DISRUPTERS



Some CECs exhibit adverse ecological effects that have caused concern among utility communities, regulators, and the public regarding the fate of these compounds during water and wastewater treatment. Determining the fate and removal efficiencies of these compounds during treatment processes is a fairly complex task. This is a result of CECs including a broad range of compounds with very diverse structures and physical-chemical (p-chem) characteristics. In addition, some CECs occur at trace levels (e.g. parts per trillion) and some CECs are more polar (i.e., have more charge density) than currently regulated aromatic compounds. Wastewater treatment facilities are designed to meet effluent quality parameters, such as total suspended solids, biochemical oxygen demand, and chemical oxygen demand and not necessarily specific compounds. Studies have shown that most conventional drinking water treatment processes have a limited success in removal of CECs; however, advanced water treatment processes are effective in removing CECs. With growing public concern and historical regulatory trends, whether supported by or despite scientific studies, it is expected that there will be increased need for advanced treatment as well as subsequent management of brine-concentrate produced.

CECs are diverse compounds whose characteristics can be different even within the same subcategory (that is, PhACs and PCPs). Because of this diversity, no single technology, including RO, can treat all CECs effectively. A multiple barrier treatment approach is the most effective method. Technologies that can remove CECs to a moderate extent (that is, a 50 to 70 percent removal rate) include activated carbon adsorption, UV irradiation (at greater than 580 mJ/cm^2), conventional activated sludge (CAS) systems, and membrane bioreactors (MBRs). These technologies are documented to remove more than 67 percent of the compounds reviewed in the Secondary/Emerging Constituents Report. Technologies that have a high removal efficiency for CECs (that is, at least an 85 percent removal rate) include RO, ozone, ozone/AOP, UV/AOP, and biologically active carbon (BAC). Table 4 provides a summary of the treatment technologies and their CEC removal efficiencies. The green and yellow highlighted cells in Table 4 indicate that the selected technology exhibits high and moderate removal efficiency, respectively. Where CEC removal efficiency is unknown for a selected technology, the cell is labeled as N/A (not available) designation. Pink highlighted areas indicate that the selected technology exhibits unsatisfactory removal (less than 50 percent removal) of the specified CECs.

TABLE 4
TREATMENT TECHNOLOGIES AND CEC EFFICIENCY REMOVAL LEVELS

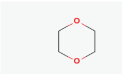
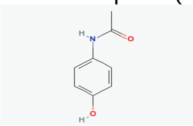
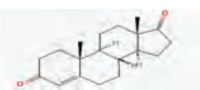
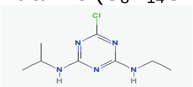
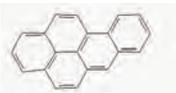
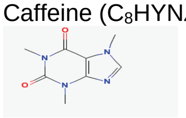
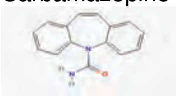
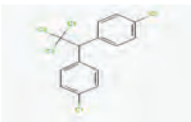
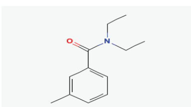
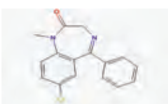
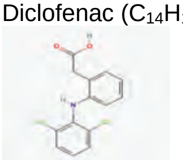
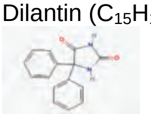
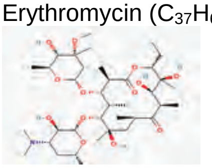
Compound	Subcategory	Percentage Removal (%)									
		Activated Carbon Adsorption	Ozone	UV AOP	UV Irradiation	CAS	MBR	NF	RO	Biologically Active Sand	Biologically Active Carbon
1,4-Dioxane ($C_4H_8O_2$) [a] 	Industrial	<20	<35	>95	<20	<20	<20	20-40	20-50	<20	<20
Acetaminophen ($C_8H_9NO_2$) 	Analgesics	78	>95	>97	73	N/A [b]	>99	25-50	>90	79	95
Androstenedione ($C_{19}H_{26}O_2$) 	Steroids	70	>80	96	89	N/A	>98	50-80	>61	96	97
Atrazine ($C_8H_{14}ClN_5$) 	Pesticides	63	20-50	80	92	N/A	N/A	50-80	N/A	54	83
Benzon(a)pyrene ($C_{20}H_{12}$) 	PAH	72	N/A	N/A	N/A	>85	N/A	>80	>90	N/A	89
Caffeine ($C_8HYN_4O_2$) 	Stimulant	59	>80	89	44	>97	>85	50-80	>99	77	93
Carbamazepine ($C_{15}H_{12}N_2O$) 	Analgesics, stimulant	72	>95	>88	60	N/A	20	50-80	>99	54	90

TABLE 4
TREATMENT TECHNOLOGIES AND CEC EFFICIENCY REMOVAL LEVELS

Compound	Subcategory	Percentage Removal (%)									
		Activated Carbon Adsorption	Ozone	UV AOP	UV Irradiation	CAS	MBR	NF	RO	Biologically Active Sand	Biologically Active Carbon
DDT ($C_{14}H_9Cl_5$) 	Pesticides	70	N/A	N/A	N/A	N/A	N/A	>80	N/A	N/A	85
DEET ($C_{12}H_{17}NO$) 	Pesticides	54	50-80	89	52	N/A	20	50-80	>95	37	80
Diazepam (Valium) ($C_{16}H_{13}ClN_2O$) 	Anticonvulsant	67	50-80	93	52	<20	N/A	50-80	N/A	82	84
Diclofenac ($C_{14}H_{11}Cl_2NO_2$) 	Analgesics	49	>95	>98	>98	N/A	>50	50-80	>97	67	75
Dilantin ($C_{15}H_{12}N_2O_2$) 	Anticonvulsant	56	50-80	97	96	N/A	4	50-80	>99	77	80
Erythromycin ($C_{37}H_{67}NO_{13}$) 	Antimicrobials	52	>95	50-80	39	N/A	96	>80	>98	79	78

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TREATMENT TECHNOLOGIES AND CEC EFFICIENCY REMOVAL LEVELS

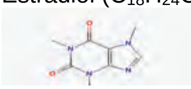
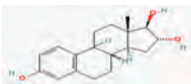
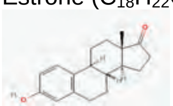
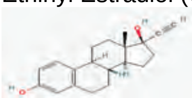
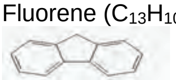
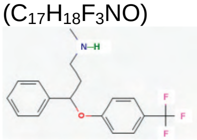
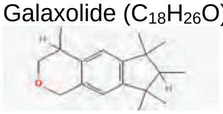
Compound	Subcategory	Percentage Removal (%)									
		Activated Carbon Adsorption	Ozone	UV AOP	UV Irradiation	CAS	MBR	NF	RO	Biologically Active Sand	Biologically Active Carbon
Estradiol ($C_{18}H_{24}O_2$) 	Steroids	55	>95	>98	93	60-80	N/A	50-80	N/A	85	94
Estriol ($C_{18}H_{24}O_3$) 	Steroids	58	>95	>99	90	>85	>98	50-80	N/A	81	92
Estrone ($C_{18}H_{22}O_2$) 	Steroids	77	>95	>99	94	80	82	50-80	>95	62	95
Ethinyl Estradiol ($C_{20}H_{24}O_2$) 	Steroids	70	>95	>98	93	N/A	N/A	50-80	N/A	73	91
Fluorene ($C_{13}H_{10}$) 	PAH	94	N/A	N/A	N/A	N/A	N/A	>80	N/A	N/A	>94
Fluoxetine (Prozac) ($C_{17}H_{18}F_3NO$) 	Antidepressant	91	>95	>98	>98	N/A	40	>80	>96	98	>99
Galaxolide ($C_{18}H_{26}O$) 	Fragrance	59	50-80	N/A	N/A	<20	N/A	50-80	>98	N/A	74

TABLE 4
TREATMENT TECHNOLOGIES AND CEC EFFICIENCY REMOVAL LEVELS

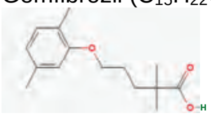
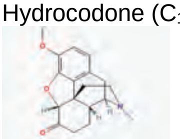
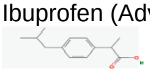
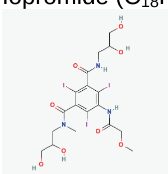
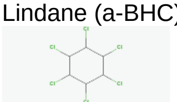
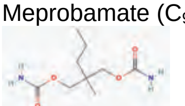
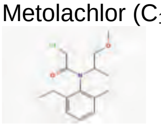
Compound	Subcategory	Percentage Removal (%)									
		Activated Carbon Adsorption	Ozone	UV AOP	UV Irradiation	CAS	MBR	NF	RO	Biologically Active Sand	Biologically Active Carbon
Gemfibrozil ($C_{15}H_{22}O_3$) 	Heart Medication	38	>95	95	57	N/A	>86	50-80	>99	54	74
Hydrocodone ($C_{18}H_{21}NO_3$) 	Analgesics	72	>95	>98	64	N/A	>94	50-80	>98	47	92
Ibuprofen (Advil) ($C_{13}H_{18}O_2$) 	Analgesics	26	50-80	94	70	>80	95	50-80	>99	66	83
Iopromide ($C_{18}H_{24}I_3N_3O_8$) 	X-Ray Contrast Media	31	20-50	91	99	N/A	20	>80	>99	28	42
Lindane (a-BHC) ($C_6H_6Cl_6$) 	Pesticides	70	N/A	N/A	N/A	N/A	N/A	50-80	N/A	N/A	91
Meprobamate ($C_9H_{18}N_2O_4$) 	Anticonvulsant	36	20-50	75	29	N/A	<1	50-80	>99	36	71
Metolachlor ($C_{15}H_{22}ClNO_2$) 	Pesticides	50	N/A	N/A	N/A	N/A	N/A	50-80	N/A	N/A	79

TABLE 4
TREATMENT TECHNOLOGIES AND CEC EFFICIENCY REMOVAL LEVELS

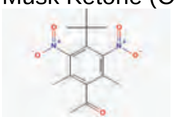
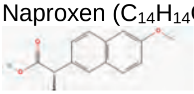
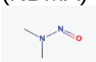
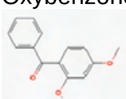
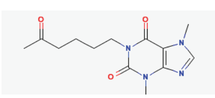
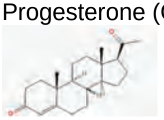
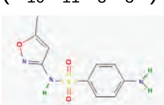
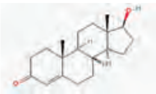
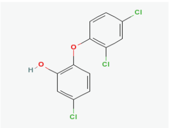
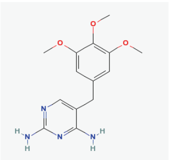
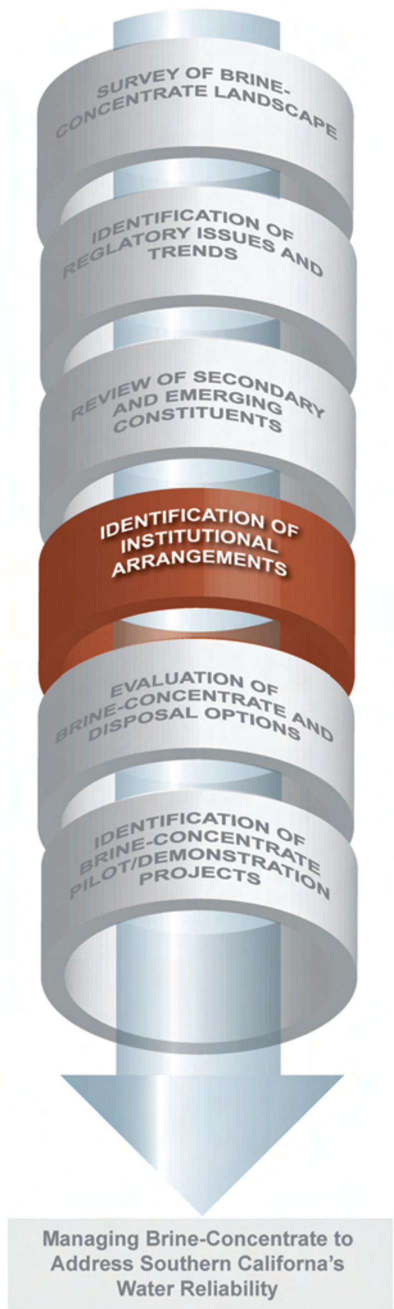
Compound	Subcategory	Percentage Removal (%)									
		Activated Carbon Adsorption	Ozone	UV AOP	UV Irradiation	CAS	MBR	NF	RO	Biologically Active Sand	Biologically Active Carbon
Musk Ketone ($C_{14}H_{18}N_2O_5$) 	Fragrance	69	N/A	N/A	N/A	<20	N/A	>80	N/A	N/A	83
Naproxen ($C_{14}H_{14}O_3$) 	Anti-Inflammatory Agent, Analgesics	60	>95	>99	99	N/A	>86	20-50	>99	80	82
N-Nitrosodimethylamine (NDMA) ($C_2H_6N_2O$) [a] 	DBPs	<20	40-70	>95	<20	<20	<20	20-50	30-70	<20	<20
Oxybenzone ($C_{14}H_{12}O_3$) 	Sun Screen	92	>95	50-80	50	>85	95	>80	>93	83	98
Pentoxifylline ($C_{13}H_{18}N_4O_3$) 	Heart Medication	71	>80	90	50	N/A	85	50-80	>96	91	90
Progesterone ($C_{21}H_{30}O_2$) 	Steroids	84	>80	98	92	N/A	95	50-80	N/A	N/A	99
Sulfamethoxazole ($C_{10}H_{11}N_3O_3S$) 	Antimicrobials	43	>95	>99	>99	N/A	20	50-80	>99	77	63

TABLE 4
TREATMENT TECHNOLOGIES AND CEC EFFICIENCY REMOVAL LEVELS

Compound	Subcategory	Percentage Removal (%)									
		Activated Carbon Adsorption	Ozone	UV AOP	UV Irradiation	CAS	MBR	NF	RO	Biologically Active Sand	Biologically Active Carbon
TCEP ($C_9H_{15}O_6P$) 	Flame Retardant	60	<20	16	10	<20	20	50-80	>91	53	80
Testosterone ($C_{19}H_{28}O_2$) 	Androgenic Steroids	71	>80	97	91	N/A	96	50-80	N/A	92	96
Triclosan ($C_{12}H_7Cl_3O_2$) 	Antimicrobials	90	>95	>97	>97	70	70	>80	>97	97	97
Trimethoprim ($C_{14}H_{18}N_4O_3$) 	Antimicrobials	69	>95	94	<5	N/A	>76	50-80	>99	24	94

Note:
[a] Notification levels for NDMA and 1,4 Dioxane are 10 and 3000 ng/L respectively
[b] N/A = Information Not Available

Identification of Institutional Issues



There are a number of potential organizational structures that could be implemented to plan, design, construct, and operate and maintain regional brine-concentrate management systems. Organizational structures can often be used to foster collaborative relationships between agencies implementing brine-concentrate management projects. The type of organizational structure that is put into place will depend on funding availability, needs of the individual agencies/users, existing facilities, and timing of project implementation. Other internal and external agency political and historical working relationships also could affect the type of organization structure.

There are four types of organizational structures that have been used successfully on southern California regional brine-concentrate systems.

- Multiple Owners – A multiple-owner organizational structure is one in which multiple agencies are partial owners of a system. Under this structure, the agencies jointly fund and operate the system, with each one building a portion(s) of the facility that will be required to serve the specific agency's needs. No single agency is responsible for the overall system. Individual agency's responsibilities are summarized in a detailed agreement, which is developed and approved by the participating agencies.

- Joint Powers Authority (JPA) – A JPA is a public agency where two or more government agencies can establish a new public entity authorized to exercise commonly held powers (in other words, any power held by any member agency can be exercised). JPAs are established by entering into an agreement for joint exercise of power, a JPA agreement, which establishes operational constraints, the composition of the governing board, funding arrangements, staffing, and duration of the authority.
- Single-Owner Multiple Contracts – A single-owner multiple contracts is an arrangement where a single-owner funds the system as a regional asset and enters into contracts with other public or private entities to use the asset. The single-owner owns and operates the system after it is completed, with contributions from the users of the system.
- Single-Owner Special District – The single-owner special district structure is a district that is developed to perform a single function (for instance, providing water services) and managed like a business in that services are paid for via user fees. This arrangement has an independently elected or appointed Board of Directors.

Multiple concerns are considered as part of the evaluation of an institutional structure for implementation of any facility or system. The type of arrangement selected for a specific project is dependent on:

- Project/System Development
- Environmental and Permit Compliance
- Permit Violation Management and Enforcement
- Clear Accountability
- Asset Management and Protection of Investments
- User Commitments
- Involvement in Decision to Add Users
- Project Funding
- Capital Reserves and Bonding
- Dispute Resolution

Table 5 provides a summary of the different organizational arrangements as well as the advantages and disadvantages of each.

If project timing is critical, then a multiple-agency arrangement might be the optimal solution because most participating agencies can move ahead with building system components while a detailed agreement is negotiated for operations and maintenance (O&M) and regulatory compliance. A single owner with contracts also could be effective if the owning agency can fund the project prior to having user agreements in place.

If project financing is the critical factor affecting a project, then implementing a JPA or single-owner special district could be the optimal organizational structure. Both JPAs and special districts are able to use pooled funding capabilities to secure bonds based on multiple assessments or user fees paid to member agencies. The advantage of having multiple member agencies pool financing is that it enables each agency to take on less risk and can result in reduced interest rates.

If regulatory or permitting compliance or enforcement is the driving issue for a project, then having a single entity responsible for a project is vital. Implementing a JPA, a single owner with contracts, or a single-owner special district would provide a sole responsible party for regulatory and permit compliance and enforcement.

If a JPA or single-owner special district organizational structure is selected, then each member agency has a voice in decision making through the governing board. In a single owner with contracts, the owning agency is responsible, and it would control all decisions of compliance with permits and regulations.

Agencies in southern California have used each of the organization structures to implement brine-concentrate and wastewater disposal projects. The organizational structure selected depends on financial viability, project timing, and the number of partners or users connected to a system.

TABLE 5
TYPES OF ORGANIZATIONAL STRUCTURES MATRIX

Type of Partnership	Advantages	Disadvantages	Examples
Multiple Owners	✓ Each agency builds and owns its piece of the facility ✓ Each agency funds a portion of the system ✓ No agency is responsible for entire system	✗ Requires high level of cooperation and detailed agreement regarding O&M cost-sharing, and regulatory compliance ✗ Downstream portions of system have to be designed to convey upstream flows and may be responsible for permitting or regulatory compliance even with no control of upstream users discharges ✗ No single agency responsible for system but one agency may have permitting/regulatory compliance responsibility ✗ No single agency responsible for funding entire system	✪ City of Los Angeles/West Basin MWD Reuse/Brine Agreements
Joint Powers Authority	✓ Provides a broad array of financial options for member agencies ✓ Costs are shared between agencies ✓ Allows for inclusion of new agency partners ✓ Can ease financing and lower finance costs ✓ Proven and effective mechanism ✓ Allows member agencies benefit of exercising powers of another agency	✗ Takes time and effort to develop ✗ Higher administrative costs	✪ SEJPA/EWA ✪ SOCWA ✪ SAWPA/SARI ✪ IRWD SIBL

TABLE 5
TYPES OF ORGANIZATIONAL STRUCTURES MATRIX

Type of Partnership	Advantages	Disadvantages	Examples
Single Owner with Contracts	✓ Owner controls the construction and operation of the facility ✓ Cost shared through contracts with other agencies ✓ Allows different user types (such as public and private)	✗ Costs for construction funded by single agency ✗ Owning agency responsible for water quality or discharge ✗ Users have limited decision making in system O&M and regulatory compliance ✗ Owner controls access or use of system	✪ City of San Diego MWWD ✪ OCSD Outfall ✪ Oceanside Ocean Outfall ✪ IRWD Wastewater/Brine Disposal System
Single-Owner Special District	✓ Ease and speed of implementation ✓ One owner controls the construction and operation of the facility ✓ Regulatory enforcement and compliance are responsibility of owning agency ✓ Can ease risks and/or lower financing costs	✗ Requires membership in special district ✗ Limits flexibility for different user types ✗ Owner controls access to system	✪ Calleguas MWD ✪ MWDSC

Evaluation of Brine-Concentrate and Disposal Options

There are a number of technologies that can be used for brine-concentrate management. The technology selected will be based on location, need, and cost. These concentrate disposal technologies can be categorized into three broad groups—volume reducing, zero liquid discharge, and final disposal technologies.

Volume Reduction Technologies

Volume reduction technologies are designed to reduce the size and cost of the ultimate concentrate facilities or final disposal flow. Because the technologies produce a liquid residual stream, they are often called liquid-residual-producing processes. Depending upon the water quality and technology used, volume reduction technologies can reduce concentrate volumes by up to 90 percent. After the concentrate is reduced using one of these technologies, an additional process is required to completely dispose of the concentrate either by solidifying the concentrate product or discharging the liquid concentrate. The volume reduction technologies that are available include:

- Electrodialysis/Electrodialysis Reversal
- Vibratory Shear-Enhanced Processing
- Precipitative Softening and Reverse Osmosis
- Enhanced Membrane System
- Brine Concentrator
- Natural Treatment Systems

Technologies that are not available in US market or are under development include:

- Two Pass Nanofiltration
- Forward Osmosis
- Membrane Distillation
- Slurry Precipitation and Reverse Osmosis
- Advanced Reject Recovery of Water
- Capacitive Deionization

Zero Liquid Discharge

Zero Liquid Discharge (ZLD) refers to processes that fully removes water from the concentrate stream (in other words, no liquid is left in the discharge). The end product of a ZLD system is a solid residue of precipitate salts that needs to be transferred to an appropriate solid waste disposal facility, such as a landfill. Toxicity tests and other applicable tests will determine the type of the landfill (municipal solids waste landfill versus hazardous waste landfill). ZLD systems range from less complex/technological (that is, natural treatment systems) to highly complex/technological (that is, complex mechanical processes) solutions. ZLD systems include:

- Combination Thermal Process with ZLD
- Mechanical and Thermal Evaporation ZLD
- Enhanced Membrane and Thermal ZLD
- Evaporation Ponds
- Wind-Aided Intensified Evaporation (WAIV)
- Dewvaporation
- Salt Solidification and Sequestration

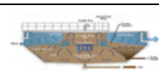
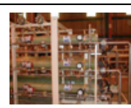
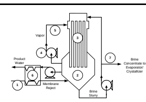
Final Disposal Options

Final disposal options are concentrate management options that require no additional treatment or management. Final disposal options result in the concentrate being discharged into the ocean, injected underground, or disposed in a landfill. These options are: ocean discharge (existing and new), deep well injection, downstream discharge to wastewater treatment plant or disposal station, and disposal to landfills. Each of these concentrate management technologies requires regulatory approval prior to discharge.

Summary of Technologies

Table 6 presents a summary of the brine-concentrate treatment technologies and disposal options. An assessment of the applicability to wastewater and groundwater sources for each technology is also provided. The relative performance of the treatment and disposal options is rated based on the performance, amount of water recovered, water quality produced, design flexibility and implementability, technology footprint, amount of waste minimization, hazardous wastes/environmental concerns, chemical usage/handling and safety, proven technology, regulatory complexity, maintenance and labor requirements, aesthetics and public acceptance, and ease of use. These criteria were used to summarize the advantages and disadvantages of each technology.

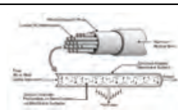
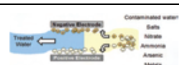
TABLE 6 SUMMARY OF BRINE-CONCENTRATE TECHNOLOGY APPLICABILITY AND EVALUATION CRITERIA

Technology	Illustration	Applicability		Evaluation Criteria												
		Groundwater	Recycled Water	Performance	Amount of Water Recovered	Water Quality Produced	Design Flexibility and Implementability	Technology Footprint	Amount of Waste Minimization	Hazardous Wastes/ Environmental Concerns	Chemical Usage/ Handling and Safety	Proven Technology	Regulatory Complexity	Maintenance and Labor Requirements	Aesthetics and Public Acceptance	Ease of Use
VOLUME REDUCTION TECHNOLOGIES																
Electrodialysis (ED) / Electrodialysis Reversal (EDR)		Good	Good	Good	Average	Poor	Good	Good	Average	Good	Average	Good	Good	Average	Good	Average
Vibratory Shear-Enhanced Processing (VSEP)		Good	Average	Good	Average	Average	Average	Good	Average	Average	Average	Poor	Average	Poor	Average	Average
Precipitative Softening and Reverse Osmosis (PS/RO)		Good	Average	Good	Good	Good	Average	Average	Average	Average	Poor	Good	Good	Average	Average	Poor
Enhanced Membrane Systems (EMS)		Good	Average	Good	Good	Good	Good	Average	Average	Average	Average	Good	Good	Average	Average	Poor
Mechanical and Thermal Evaporation (MTE)		Good	Good	Good	Good	Good	Average	Average	Average	Average	Average	Good	Good	Poor	Poor	Poor
Constructed Wetlands (CW)		Good	Average	Average	Poor	Poor	Poor	Poor	Good	Average	Good	Average	Average	Good	Good	Good
Two-Pass Nanofiltration		Good	Average	Average	Average	Average	Average	Good	Average	Average	Average	Poor	Good	Average	Good	Poor

LEGEND

Good Average Poor NA - Not Applicable Unk. - Unknown

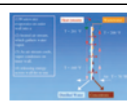
TABLE 6 SUMMARY OF BRINE-CONCENTRATE TECHNOLOGY APPLICABILITY AND EVALUATION CRITERIA

Technology	Illustration	Applicability		Evaluation Criteria												
		Groundwater	Recycled Water	Performance	Amount of Water Recovered	Water Quality Produced	Design Flexibility and Implementability	Technology Footprint	Amount of Waste Minimization	Hazardous Wastes/ Environmental Concerns	Chemical Usage/ Handling and Safety	Proven Technology	Regulatory Complexity	Maintenance and Labor Requirements	Aesthetics and Public Acceptance	Ease of Use
VOLUME REDUCTION TECHNOLOGIES																
Forward Osmosis (FO)		Unk.	Unk.	Unk.	Unk.	Unk.	Unk.	Unk.	Unk.	Unk.	Unk.	Unk.	Unk.	Unk.	Unk.	Unk.
Membrane Distillation (MD)		Good	Average	Average	Average	Average	Average	Average	Average	Average	Average	Poor	Good	Average	Good	Poor
Natural Treatment Systems (NTS)		Good	Average	Average	Poor	Poor	Poor	Poor	Good	Average	Good	Average	Average	Good	Good	Good
Slurry Precipitation and Reverse Osmosis (SPARRO)		Good	Average	Average	Good	Average	Average	Average	Average	Average	Average	Poor	Average	Average	Good	Poor
Advanced Reject Recovery of Water (ARROW)		Good	Average	Good	Good	Good	Average	Average	Average	Average	Poor	Poor	Average	Average	Average	Poor
Capacitive Deionization (CDI)		Good	Average	Average	Average	Poor	Average	Average	Good	Good	Average	Average	Average	Average	Good	Average

LEGEND

Good Average Poor NA - Not Applicable Unk. - Unknown

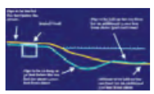
TABLE 6 SUMMARY OF BRINE-CONCENTRATE TECHNOLOGY APPLICABILITY AND EVALUATION CRITERIA

Technology	Illustration	Applicability		Evaluation Criteria												
		Groundwater	Recycled Water	Performance	Amount of Water Recovered	Water Quality Produced	Design Flexibility and Implementability	Technology Footprint	Amount of Waste Minimization	Hazardous Wastes/ Environmental Concerns	Chemical Usage/ Handling and Safety	Proven Technology	Regulatory Complexity	Maintenance and Labor Requirements	Aesthetics and Public Acceptance	Ease of Use
ZERO LIQUID DISCHARGE																
Combination Thermal Process with Zero Liquid Discharge (ZLD)		Good	Good	Good	Good	Good	Average	Average	Average	Average	Average	Good	Good	Poor	Poor	Poor
Enhanced Membrane and Thermal System ZLD		Good	Good	Good	Good	Good	Average	Average	Average	Average	Average	Good	Good	Poor	Poor	Poor
Evaporation Ponds (EP)		Good	Good	Good	Poor	Poor	Average	Poor	Average	Average	Good	Good	Good	Good	Poor	Good
Wind-Aided Intensified Evaporation (WAIV)		Good	Average	Average	Poor	Poor	Good	Good	Good	Average	Average	Poor	Average	Average	Poor	Good
Dewvaporation		Good	Good	Average	Good	Good	Average	Good	Good	Good	Good	Poor	Average	Average	Average	Average

LEGEND

Good Average Poor NA - Not Applicable Unk. - Unknown

TABLE 6 SUMMARY OF BRINE-CONCENTRATE TECHNOLOGY APPLICABILITY AND EVALUATION CRITERIA

Technology	Illustration	Applicability		Evaluation Criteria												
		Groundwater	Recycled Water	Performance	Amount of Water Recovered	Water Quality Produced	Design Flexibility and Implementability	Technology Footprint	Amount of Waste Minimization	Hazardous Wastes/ Environmental Concerns	Chemical Usage/ Handling and Safety	Proven Technology	Regulatory Complexity	Maintenance and Labor Requirements	Aesthetics and Public Acceptance	Ease of Use
FINAL DISPOSAL OPTIONS																
Deep Well Injection (DWI)		Good	Good	Good	NA	NA	Average	Good	Good	Good	Good	Good	Average	Good	Good	Good
WWTP Effluent Blending		Good	Good	NA	NA	NA	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Ocean Outfall		Good	Good	NA	NA	NA	Poor	Average	Poor	Poor	Good	Good	Poor	Good	Poor	Good
Landfill		Good	Good	Good	NA	NA	Poor	Poor	Good	Good	Good	Good	Good	Average	Average	Average

LEGEND

Good Average Poor NA - Not Applicable Unk. - Unknown

Identification of Brine-Concentrate Pilot/Demonstrative Projects

The final element in formulating a comprehensive view of the southern California brine-concentrate management landscape is to identify potential pilot/demonstration projects. Specifically, the objective of this element of the study is to identify up to 10 pilot/demonstration projects for potential further evaluation in Phase II of this Project. These projects were identified during the evaluation and analysis of data from the survey of brine-concentrate generators. Table 7 contains a brief description of each of the 34 projects identified.

Once the projects were identified, a multicriteria analysis was used to evaluate the projects.

TABLE 7
PILOT/DEMONSTRATION PROJECT SUMMARY TABLE

Project/ Lead Agency	Proposed Technology	Description
Ventura County Region		
Calleguas Salinity Management Pipeline System **Lead Agency:** Calleguas MWD	Brine-concentrate volume reduction	The Calleguas SMP will be constructed in nine phases and will ultimately connect the West Simi Valley Desalter with the Hueneme Outfall. The SMP will eventually connect at least six desalters, five WWTPs/WRPs, and a number of industrial dischargers. The capacity of the SMP is 20 mgd, which should be sufficient to convey projected brine-concentrate flows to the ocean. However, if future flows exceed the SMP capacity, then some level of brine-concentrate volume reduction may be necessary.
Oxnard AWPF Brine-Concentrate Treatment Wetlands **Lead Agency:** City of Oxnard	Brine-concentrate volume reduction or ZLD	The Advance Water Purification Facility (AWPF) is a part of the City of Oxnard's Groundwater Recovery Enhancement and Treatment (GREAT) program. The AWPF will use microfiltration (MF), RO, and advanced oxidation to treat the secondary effluent. The use of RO will result in generation of brine-concentrate. A portion of the brackish concentrate that the RO system will generate will be treated by an innovative wetlands system intended to reduce nutrients, heavy metals, and other toxic compounds while demonstrating the ability to use the concentrate as a beneficial resource.
Los Angeles County Region		
Hyperion WWTP Water Quality Concerns **Lead Agency:** City of Los Angeles	None	If inflows to the Hyperion WWTP drop because of upstream water reuse or increased water conservation, then the brine-concentrate would impact the influent water quality to the Hyperion WWTP. This would increase the influent TDS to West Basin MWD's WRP. Such an increase would impact their RO operations at West Basin's Edward C. Little WRF and would increase the TDS of WBMWD's Title 22 recycled water.
West Basin MWD Water Quality Requirements **Lead Agency:** West Basin MWD	None	Water quality fluctuations at the Weymouth WTP are the result of different mixes of State Project Water and Colorado River water, both of which serve as water supply sources for the Weymouth WTP. West Basin MWD has not considered a project to address these concerns. However, if their users continue to be impacted by water quality changes, then the West Basin MWD may have to address these concerns.

TABLE 7
PILOT/DEMONSTRATION PROJECT SUMMARY TABLE

Project/ Lead Agency	Proposed Technology	Description
The Groundwater Reliability Improvement Program **Lead Agency:** Water Replenishment District	NF followed by RO	The Water Replenishment District of Southern California (WRD) and the Upper San Gabriel Valley MWD (USGVMWD) are investigating the feasibility of implementing an indirect potable reuse project that would treat up to 54.5 mgd of effluent from the County Sanitation Districts of Los Angeles County's San Jose Creek WRP. The product water (up to 46,000 afy) would be used to recharge the Central and Main San Gabriel Groundwater Basins. The membrane pilot study will evaluate the performance of a primary NF/secondary RO treatment system to increase the overall recovery to 93 percent.
C. Marvin Brewer Desalter Outfall **Lead Agency:** West Basin MWD	None	The C. Marvin Brewer Desalter uses RO to treat water from a saline groundwater plume prior to supplying the water to users in the West Basin MWD service area. TDS in the groundwater plume is approximately 3,600 mg/L. Currently, brine from the desalter is conveyed to the Joint Outfall System (JOS) for ocean discharge. West Basin MWD is investigating the potential use of another outfall at the AES Redondo Generating Station.
Leo J. Vander Lans Plant Expansion **Lead Agency:** Water Replenishment District	Enhance the recovery of RO from 85 percent to approximately 91 percent with an additional stage of RO membrane	WRD is planning an expansion at the Leo J Vander Lans Plant to produce another 3,000 to 5,000 afy of water. This expansion would allow imported water used to recharge the Alamitos Barrier Project to be replaced with highly treated recycled water. The plant uses MF, RO and UV disinfection to treat recycled water for groundwater recharge. Approximately 0.53 mgd of brine-concentrate is currently generated by the RO process and discharged into the sewer. Using the same processes, this project would double the brine-concentrate flow, which would exceed the available sewer capacity. A volume reducing technology is needed to reduce flows so that the brine can be discharged to the sewer.
Sanitation Districts' Clearwater Program **Lead Agency:** Sanitation Districts of Los Angeles County	None	The Sanitation Districts of Los Angeles County is investigating alternatives to take the existing JOS offline either for a short period to assess the condition of the system or for a longer period to repair or rehabilitate the system if necessary. Advanced treatment may be necessary to satisfy water quality requirements if the flow from the JOS is discharged to the Los Angeles Harbor or reused for groundwater recharge for example. Use of advanced treatment would result in the need to implement concentrate management.

TABLE 7
PILOT/DEMONSTRATION PROJECT SUMMARY TABLE

Project/ Lead Agency	Proposed Technology	Description
Terminal Island Renewal Energy Project (TIRE) **Lead Agency:** City of Los Angeles	Carbon sequestration, fuel cells powered by methane, state-of-the-art monitoring system	This project has been injecting brine-concentrate along with Terminal Island WWTP biosolids for the past 13 months via a 6,000-foot-deep well. However, the amount of brine-concentrate that can be injected is limited due to the capacity of the well used for the TIRE project. Currently, all of the biosolids from the Terminal Island WWTP are being injected. To expand injection of brine-concentrate, another well(s) would need to be developed.
Santa Clarita River: Chloride TMDL **Lead Agency:** Sanitation Districts of Los Angeles County	Deep well injection, brine/concentrate volume reduction technology	The Sanitation Districts of Los Angeles County has submitted a plan to treat 3.2 mgd of flow from the Valencia WRP using advanced treatment processes (RO) prior to discharge. This advanced treatment will result in concentrate generation of approximately 0.57 mgd in an inland area where there is distant access to brinelines. Therefore, the Sanitation Districts of Los Angeles County is investigating the use of DWI for concentrate disposal.
Newhall Ranch WRP Deep Well Injection **Lead Agency:** Sanitation Districts of Los Angeles County	Deep well injection, ZLD	The Newhall Ranch Wastewater Reclamation Plant (NRWRP) is planned to be constructed by 2015. The plant would produce Title 22 recycled water. In addition, a portion of the municipal wastewater will receive further treatment to remove chlorides so that the facility can meet TMDLs set for the receiving surface water, the Santa Clara River. To comply with these requirements, RO treatment will be provided, and DWI will be used to dispose of the brine-concentrate waste stream.
Antelope Valley Power Generation **Lead Agency:** Sanitation Districts of Los Angeles County	Evaporation Ponds, ZLD	In the Antelope Valley, proposed solar power generators will create brine-concentrate as a waste product. This brine-concentrate is generated from the advanced treatment of recycled water for process water at the solar facilities. Currently, the brine-concentrate generated from these pilot solar projects is conveyed to the Sanitation Districts of Los Angeles County WRPs in Lancaster and Palmdale for disposal. The Sanitation Districts of Los Angeles County does not want to be responsible for disposal of the brine-concentrate over the long term. The solar power generators most likely would implement evaporation ponds to dispose of brine-concentrate from the full-scale power generating facilities. However, ZLD might have to be used if the RWQCB will not permit evaporation ponds.

TABLE 7
PILOT/DEMONSTRATION PROJECT SUMMARY TABLE

Project/ Lead Agency	Proposed Technology	Description
San Joaquin Valley Agricultural Water Recovery Demonstration Project **Lead Agency:** Metropolitan Water Districts of Southern California	Evaporation Ponds	This project would recover excess agricultural flows in the San Joaquin Valley from perched groundwater basins and tile drain systems located south of the Delta. This water will be treated using pressure filters and chemical treatment for pretreatment, followed by RO to remove salts. The RO system is proposed to produce 9.4 mgd of permeate, which will be blended with a split stream to produce a total of 10 mgd of product water. The brine-concentrate from this system will be handled using an enhanced evaporation system consisting of spray evaporators and evaporation ponds.
Inland Empire and Mountain Regions		
Santa Ana Regional Interceptor Capacity and Scaling Issues **Lead Agency:** Santa Ana Watershed Project Authority	None	Current projections by the Santa Ana Watershed Project Authority (SAWPA) indicate that future groundwater desalter and MF-RO reuse projects will produce brine-concentrate flows that will exceed the SARI system capacities in several reaches. As such, SAWPA has initiated studies to address these capacity limitations as well as potential scaling concerns.
Arlington and Chino Desalters Pellet Softening **Lead Agency:** Chino Basin Desalter Authority	Pellet Softening	The Chino Basin Desalter Authority (CBDA) has worked with Western MWD to pilot test pellet softening at the Arlington Desalter. The purpose of the pilot test was to evaluate if pellet softening reduces a scale-forming mineral and thereby reduces scale formation in the SARI line. The CBDA is considering implementing this technology at the Arlington and Chino desalting facilities.
Santa Rosa WRF Brine-Concentrate Management **Lead Agency:** Rancho California Water District	None	The Rancho California Water District (RCWD) is planning to implement an advanced wastewater treatment project to reduce TDS levels so that recycled water can be served to its agricultural customers by 2015. One project proposed as part of this effort is to build a demineralization/desalination plant to reduce TDS levels to less than 500 mg/L in recycled water from EMWD's Temecula Valley WRP. In addition, RCWD is considering implementing a brine-concentrate volume-reduction technology to reduce brine-concentrate disposal flows to the TVRI/SARI system.

TABLE 7
PILOT/DEMONSTRATION PROJECT SUMMARY TABLE

Project/ Lead Agency	Proposed Technology	Description
EMWD Brine-Concentrate Volume Reduction **Lead Agency:** Eastern MWD	Electrodialysis reversal (EDR), brine concentrators, evaporation ponds, crystallizers, and precipitative softening (PS)/RO	The Eastern Municipal Water District (EMWD) investigated expanding the EMWD brine management system that connects to the TVRI/SARI system by constructing up to four new pipelines that would convey high salinity effluent. In addition to expanding the brine management system, EMWD has been investigating a number of different brine-concentrate volume reduction and ZLD technologies.
City of Corona Temescal Desalter **Lead Agency:** City of Corona	Pellet Softening	The City of Corona may need to reduce the amount of brine-concentrate discharged to the SARI system. A likely volume-reduction technology to be used is PS as a pretreatment for RO, which would be similar in nature to the pellet softening being tested at the Arlington Desalter and would need to be pilot tested prior to implementation.
San Bernardino Clean Water Factory **Lead Agency:** City of San Bernardino	EDR, mechanical and thermal evaporation, conventional ZLD processes, evaporation ponds, and deep well injection	The City of San Bernardino is considering implementing advanced treatment at the San Bernardino WRP for treatment of recycled water for groundwater recharge in the Bunker Hill basin. Up to 23 mgd of advanced treatment capacity might be added to the San Bernardino WRP. If this project is implemented, a brine-concentrate management technology could be implemented to increase the water supply yield and to reduce the amount of brine-concentrate disposed of via the SARI system, in which San Bernardino currently owns only 2.5 mgd of capacity.
Big Bear Groundwater Recharge Project **Lead Agency:** Big Bear Area Regional Wastewater Agency	None	The Big Bear Area Regional Wastewater Agency (BBARWA) has proposed the implementation of advanced treatment to produce recycled water for groundwater recharge. The advanced treatment proposed at the BBARWA Facility consists of MF and RO, followed by ultraviolet disinfection (UV) with advanced oxidation. The BBARWA Advanced Treatment Facility (ATF) will be a 1.17-mgd plant that will produce approximately 160,000 gallons per day (gpd) of concentrate (reject) stream. This reject stream would either be further reduced or disposed of using a brine-concentrate management technology.

TABLE 7
PILOT/DEMONSTRATION PROJECT SUMMARY TABLE

Project/ Lead Agency	Proposed Technology	Description
Lake Arrowhead Groundwater Recharge Project **Lead Agency:** Lake Arrowhead Community Services District	Brine concentrator, evaporation ponds, ZLD	Lake Arrowheads Indirect Potable Reuse project would provide advanced treatment at the Grass Valley WWTP for up to 1.5 mgd. The process would produce approximately 1.1 mgd (approximately 1,200 afy) of product water and approximately 0.4 mgd of concentrate. The quantity of concentrate would be further reduced using a brine concentrator and then conveyed via the existing wastewater disposal outfall pipeline to evaporation ponds at the existing wastewater disposal site in Hesperia.
Orange County Region		
Moulton Niguel Water District: Golf Course Recycled Water Projects **Lead Agency:** Moulton Niguel Water District:	Wind aided technologies or misters. Wetlands pre-treatment, brine-concentrate volume reduction or ZLD	The Moulton Niguel Water District (MNWD) is currently working with three golf courses to potentially serve recycled water to their greens. Advanced treatment may be required for water serving the greens, which would create a brine-concentrate waste stream. The golf courses are currently investigating potential onsite brine-concentrate disposal mechanisms, including using the existing ponds on the course as evaporation ponds.
OCSD Outfall Water Quality Limitations **Lead Agency:** Orange County Sanitation District	Brine-concentrate volume reduction or ZLD	The Orange County Sanitation District (OCSD) may not be able to continue to meet Waste Discharge Requirements (WDR) if brine-concentrate levels do not have adequate blending with wastewater. OCSD has stringent WDR limits for ammonia and hardness, which restricts the amount of brine-concentrate that can be blended and discharged. This could become a significant issue if the use of recycled water for groundwater recharge increases in Orange County and the Inland Empire while the amount of domestic wastewater is decreased in the SARI system and in the OCSD's service area. If a brine-concentrate management technology is required, the efficacy of the technology can be tested at the OCWD membrane test laboratory.
Newport Back Bay Nitrogen-Selenium Program **Lead Agency:** Newport Back Bay Nitrogen-Selenium Program	None	This is a 5-year program addressing nitrogen and selenium in the Newport Bay Watershed as part of an NPDES permit compliance requirement. A pilot project was completed in 2006 that identified RO as a potential best management practice for the treatment and removal of nitrogen and selenium. The brine-concentrate from the pilot test was disposed of via OCSD sewers. If RO is implemented across the watershed to reduce nitrogen and selenium levels, a second process, such as a brine concentrator, might be added to obtain higher water recovery rates. The addition of brine-concentrate management technologies would enable Orange County to maximize water supply from the groundwater treatment.

TABLE 7
PILOT/DEMONSTRATION PROJECT SUMMARY TABLE

Project/ Lead Agency	Proposed Technology	Description
South Coast Water District Groundwater Recovery Project **Lead Agency:** South Coast Water District	Brine-concentrate volume reduction or ZLD	The South Coast Water District (SCWD) uses greensand filtration and RO to recover groundwater with high concentrations of TDS, iron, and manganese. Currently, the project is having difficulty complying with discharge limitations due to the high concentrations of iron and manganese in the backwash water. SCWD is considering implementing new technologies to treat brine-concentrate prior to discharge to the ocean that would comply with permit limits.
South Orange Coastal Ocean Desalination Project **Lead Agency:** Municipal Water District of Orange County/ Future Joint Powers Authority	None	The proposed 30-mgd capacity (15-mgd production) seawater desalination facility will obtain seawater from slant wells drilled under the ocean floor. Brine concentrate from the proposed desalination facility will be co-disposed through SOCWA's San Juan Creek Ocean Outfall. Constituents of concern in the desalination brine-concentrate will affect the quality of the water that is discharged from the outfall.
San Diego County Region		
North San Diego Farming Brine/Concentrate Project(s) **Lead Agency:** San Diego Region Irrigated Lands Group Educational Corporation	Brine-concentrate volume reduction or ZLD	The RWQCB is developing a conditional waiver (No. 4) for discharges from agricultural and nursery operations. This waiver will require monitoring and installation of management measures (MMs) or BMPs for discharges from agricultural and nursery operations if discharges contain pollutants that can percolate to groundwater or infiltrate to surface waters via runoff. Currently, agricultural and nursery operations are required to install MMs and BMPs. Farmers have organized the San Diego Region Irrigated Lands Group Educational Corporation to help them satisfy the requirements of the waiver.

TABLE 7
PILOT/DEMONSTRATION PROJECT SUMMARY TABLE

Project/ Lead Agency	Proposed Technology	Description
Camp Pendleton Wastewater and Groundwater Treatment **Lead Agency:** U.S. Marine Corps Base Camp Pendleton	Brine-concentrate volume reduction or ZLD	Currently, the Marine Corps Base at Camp Pendleton has five WWTPs located in the southern portion of the base. The Corps plans to consolidate WWTPs No. 1, No. 2, No. 3, and No. 13, construct a new regional WWTP, and maximize the use of tertiary-treated effluent on the base. This new treatment plant would treat 2.71 mgd of average day influent and have a maximum capacity of 5 mgd. Excess flow from the new WWTP would be discharged using the existing Oceanside Ocean Outfall. In the northern portion of the base, construction of an Advanced Water Treatment Facility and a new ocean outfall are planned. The AWTF would include granulated activated carbon and RO processes to reduce the concentrations of TDS, total organic carbon (TOC), and corrosivity in the groundwater. This plant would require construction a new ocean outfall near to or connecting to the existing outfall at the San Onofre Nuclear Generating Station (SONGS).
Ramona MWD San Vicente Evaporation Pond **Lead Agency:** Ramona MWD	Evaporation Ponds	The Ramona MWD is implementing RO to address TDS and nutrient loading concerns in the basin. The RWQCB established a TDS limit of 550 mg/L on the WDR for the San Vicente and Santa Maria WWTPs. The limit required the installation of RO to comply with discharge limits and to use recycled water in the area. Currently, the brine-concentrate from the RO unit is being disposed of at a landfill, but the Ramona MWD is constructing evaporation ponds as a long-term disposal mechanism.
City of Escondido Advanced Tertiary Treatment Project **Lead Agency:** City of Escondido	Brine-concentrate volume reduction or ZLD	The City of Escondido is investigating potential projects to reuse 6 to 18 mgd of advanced treated water from the Hale Avenue Resource Recovery Facility. Tertiary treated effluent would be treated via MF/RO and then reused. Reuse options include indirect potable reuse, direct potable reuse, wetlands, live stream discharge, groundwater replenishment, saltwater barrier and industrial use. Brine-concentrate reject flows from the RO process would be disposed of via the existing San Elijo outfall. A study is needed to determine if the outfall capacity is adequate, and if not, to determine the best brine-concentrate volume reduction technology to utilize.

TABLE 7
PILOT/DEMONSTRATION PROJECT SUMMARY TABLE

Project/ Lead Agency	Proposed Technology	Description
San Pasqual Groundwater Desalter Brineline **Lead Agency:** City of San Diego	Brine minimization, precipitative softening, or ZLD	The City of San Diego is investigating the recovery of degraded groundwater from the San Pasqual basin. The proposed 5-mgd San Pasqual desalter would be located at the site of the existing San Pasqual Water Reclamation Plant, which was recently been shut down by the City. The facility would produce about 1-mgd of brine-concentrate. Potential disposal options evaluated include: sewer disposal through Escondido's HARRF and subsequent San Elijo Outfall; a 7-mile brineline directly to the San Elijo Outfall; and ZLD. The City is conducting a brine minimization study to maximize the overall RO recovery and minimize the amount of brine requiring disposal.
Mission Valley Groundwater Desalination Project **Lead Agency:** City of San Diego	Brine-concentrate volume reduction or ZLD	The City of San Diego is considering desalination of brackish groundwater in the Mission Valley area. The project would result in the generation of 2,000 afy of potable water. The desalination process would generate 0.4 mgd of brine-concentrate by 2015. The brine-concentrate would be disposed of in the East Mission Gorge Interceptor System or in the proposed San Diego County Regional Brineline System.
San Diego County Regional Brineline System **Lead Agency:** San Diego County Water Authority	Brine-concentrate volume reduction or ZLD	The San Diego County Water Authority (SDCWA), in association with the City of San Diego, City of Chula Vista, Otay Water District, and the Sweetwater Authority, evaluated the feasibility of establishing an environmentally sound and cost-effective method to manage the disposal of brine/concentrate flows generated within south San Diego County. The San Diego County Regional Brineline System would generally follow a north/south alignment along the coast of San Diego Bay between Sweetwater River and the SBOO. The Regional Brineline would collect brine-concentrate flows from wastewater treatment plants, groundwater desalters, and industrial dischargers in southern San Diego County.

TABLE 7
PILOT/DEMONSTRATION PROJECT SUMMARY TABLE

Project/ Lead Agency	Proposed Technology	Description
City of San Diego Indirect Potable Reuse Project **Lead Agency:** City of San Diego	Brine-concentrate volume reduction or ZLD	The City of San Diego is actively investigating alternative methods that can increase local water supplies and also reduce wastewater flows to the Point Loma WWTP. San Diego is currently preparing to construct a 1-mgd Indirect Potable Reuse (IPR) demonstration project at the North City WRP. This demonstration project would be operated for at least one year to demonstrate to the City the viability of using this RO treated water to augment the raw water supplies in the City's San Vicente Reservoir. In addition, this demonstration project would provide the necessary data and information to comply with the California DPH IPR regulations under Title 22. The City is also conducting a study to identify opportunities to increase recycling and beneficial reuse within the service area of the San Diego and Metro Participating Agencies.

The projects were evaluated based upon the following criteria.

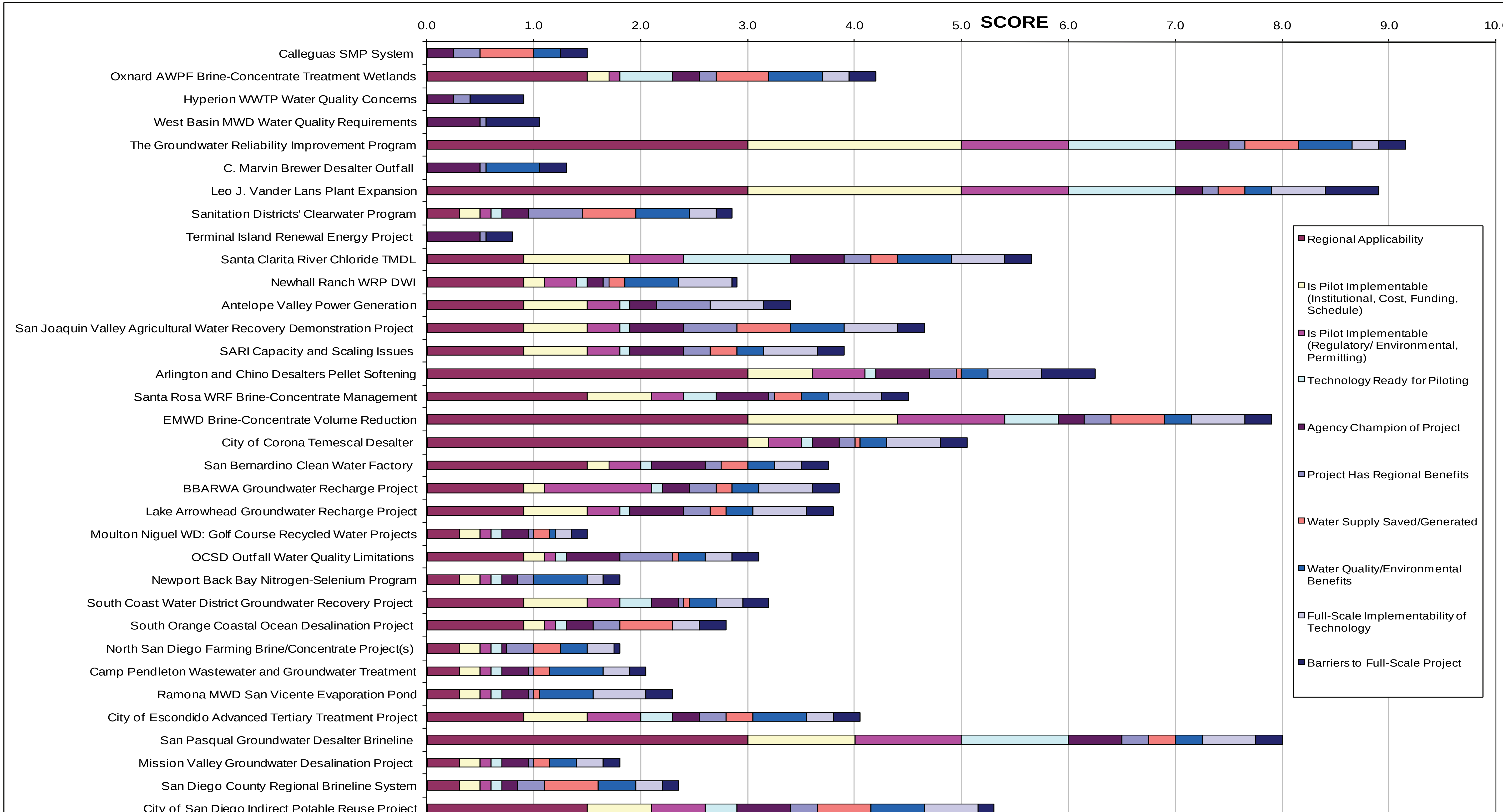
- Does the technology/pilot have regional applicability?
- Is the pilot implementable from an institutional, funding, and schedule perspective?
- Is the pilot implementable from a regulatory/environmental perspective?
- Is the technology ready to be pilot tested?
- Is there a Brine Executive Management Team (BEMT) local agency partner or other local agency ready to champion the project?
- Does the project have regional benefits?
- How much water supply is saved/generated by the project?
- Does the project improve water quality or provide environmental benefits?
- Can the technology be implemented for a full-scale project?
- Are there barriers (i.e., regulatory, environmental, or funding) to full-scale project implementation?

The results of this analysis are shown in Figure 7. The projects that showed the highest multicriteria analysis (MCA) benefit score were:

- Groundwater Reliability Improvement Program (Los Angeles County)
- Leo J. Vander Lans Plant Expansion (Los Angeles County)
- San Pasqual Groundwater Desalter Brineline (San Diego County)
- EMWD Brine-Concentrate Volume Reduction (Inland Empire)
- Arlington and Chino Desalters Pellet Softening (Inland Empire)
- Santa Clarita River Chloride TMDL (Los Angeles County)
- City of Corona Temescal Desalter (Inland Empire)
- City of San Diego Indirect Potable Reuse Project (San Diego County)
- San Joaquin Valley Agricultural Water Recovery Demonstration Project (Other)
- Santa Rosa WRF Brine-Concentrate Management (Inland Empire)

These Projects ranked highest in the preliminary analysis, but the final pilot project(s) to be selected for Phase II will be selected by the Phase II BEMT. These projects cover all parts of the study area and represent a mix of inland and coastal projects.

Figure 7 MCA Criteria and Pilot Project Evaluation



Moving forward to pilot testing will require interagency collaboration to determine how pilot project costs will be shared. This collaboration and the selection of the specific project(s) to be piloted will be the focus of Phase II of this project.

In addition to pilot testing, there are other concerns which could be addressed via additional studies. These recommendations are based on information and analyses developed as part of this study and relate to brine/concentrate management. These regional issues that could be investigated include:

- Prepare an inventory of NPDES and WDRs permits for wastewater and brine outfalls to identify consistencies/inconsistencies in permitting requirements by locality and RWQCB.
- Develop a framework for capacity credits for agencies that implement brine/concentrate management technologies. The capacity credits would be for an agency that concentrates or reduces its flow contribution to an existing brine line and/or ocean outfall.
- Study the marine impacts of brine/concentrate disposal via ocean outfalls by identifying the constituent(s) that adversely affect the marine environment, specifically in the mixing zone, and include impacts due to changes in temperature, turbidity, toxicity, and dissolved oxygen concentrations. The incorporation of seawater desalting facilities should be considered in this assessment because the addition of five major facilities in southern California could change the impact on marine ecology.
- Evaluate the waste classification of brine/concentrate with the view for potential reclassification as a nonhazardous waste.
- Conduct an appraisal-level study on potential methods to pretreat water for removal of toxic constituents.
- Conduct an appraisal-level study of using existing or abandoned oil and gas pipelines for brine pipelines. This effort could include an inventory of potential pipeline locations in southern California or the western U.S., regulatory constraints, water quality issues, and pipeline-integrity considerations.
- Conduct an appraisal-level study of the issues and impacts associated with decommissioning a brine/concentrate evaporation pond.
- Develop a guidance document for IPR projects based on OCWD’s GWR project experience to assist other agencies with regulatory issues and requirements.

- Work with regulators to develop consistence policies and regulations on requirements or restrictions related to the use of different water sources for recycled water.

These proposed studies could be submitted for funding under Reclamation's Science and Technology grant program. Proposals under this program are typically due in June for funding in the following federal fiscal year.