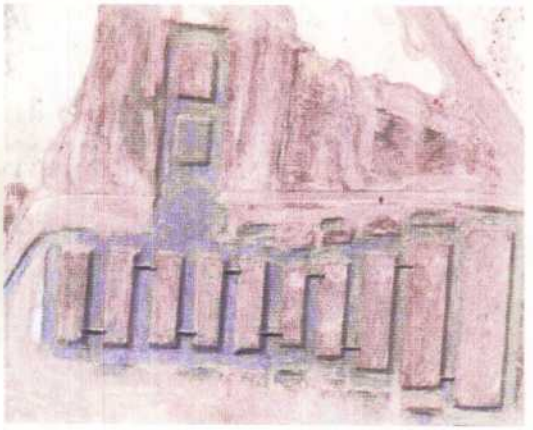


The Salton Sea Symposium

"Bridging the Crossroads"

January 9-10, 2002

SALTON SEA AUTHORITY

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

AGENDA

DAY ONE – Wednesday

8:00-9:00 **REGISTRATION -** *Tuscany Foyer*

CONTINENTAL BREAKFAST – *Tuscany Room*

9:00-9:25 **INTRODUCTION –** *Florentine Room*

Supervisor Roy Wilson, Salton Sea Authority Board President
Secretary Mary Nichols, Resource Agency

9:25-10:45 **RESTORATION PROJECT REPORT –** *Florentine Room*

Dr. Milt Friend, Salton Sea Science Office
Mike Walker, U.S. Bureau of Reclamation
Tom Kirk, Salton Sea Authority

10:45-11:00 **BREAK –** *Florentine Foyer*

11:00-12:00 **VISIONS OF NO ACTION –** *Florentine Room*

Moderator – Director Andy Horne, Imperial Irrigation District
Tim Krantz, University of Redlands
Chris Holdren, U.S. Bureau of Reclamation
Nils Warnock, Point Reyes Bird Observatory

12:15-1:45 **LUNCH –** *Tuscany Room*

Water Education Foundation Film Preview, Rita Sudman
Keynote Speaker – Congresswoman Mary Bono

2:00-3:15 **REALITY CHECKS** – *Florentine Room*

Moderator – Rita Schmidt-Sudman, Water Education Foundation
Maureen Stapleton, San Diego County Water Authority
Supervisor Gary Wyatt, County of Imperial
Dan Taylor, Audubon Society
George Ray, Imperial County Farm Bureau

3:15-3:30 **BREAK** – *Florentine Foyer*

3:30-5:00 **CAN OR SHOULD WE PULL IT ALL OFF?** – *Florentine Room*

Moderator – Mike Spear, Resource Agency
Bob Johnson, U.S. Bureau of Reclamation
Mike Cohen, Pacific Institute
Mayor Larry Grogan, City of El Centro
Don Cox, Farmer

5:30 **RECEPTION (No-Host)** – *Tuscany Foyer*

6:30 **DINNER** – *Tuscany Room*

Stewardship Awards-Director Peter Nelson, Coachella Valley Water District
Keynote Speaker, Congressman Ken Calvert

DAY TWO - Thursday

8:00 **REGISTRATION** - *Tuscany Foyer*

CONTINENTAL BREAKFAST – *Tuscany Room*

8:15 **INTRODUCTION** – *Florentine Room*

Congressman Bob Filner

8:30-9:30 **WHAT WE'RE LEARNING FROM DOING** – *Florentine Room*

Moderator – Supervisor Wally Leimgruber, County of Imperial
Paul Weghorst, U.S. Bureau of Reclamation
Carla Scheidlinger, Agrarian Research
Charlie Pelizza, U.S. Fish & Wildlife Service
Marie Barrett, New River Wetlands Project

9:30-10:30 KEY ISSUES – *Florentine Room*

Moderator – Dr. Milt Friend, Salton Sea Science Office
Jim Setmire, U.S. Bureau of Reclamation & U.S. Geological Survey
Tonie Rocke, National Wildlife Health Center
Glenn Black, CA Department of Fish & Game
Chris Amrhein, University of CA, Riverside

10:30-10:45 BREAK – *Florentine Foyer*

10:45-11:45 An Open Forum: Questions and Comments – *Florentine Room*

Moderator – Director Stella Mendoza, Imperial Irrigation District
Paul Weghorst, U.S. Bureau of Reclamation
Eugenia McNaughten, U.S. Environmental Protection Agency
Bill Brownlie, Tetra Tech
Carol Roberts, U.S. Fish & Wildlife Service

11:45-noon Wrap Up – *Florentine Room*

Tom Kirk, Salton Sea Authority

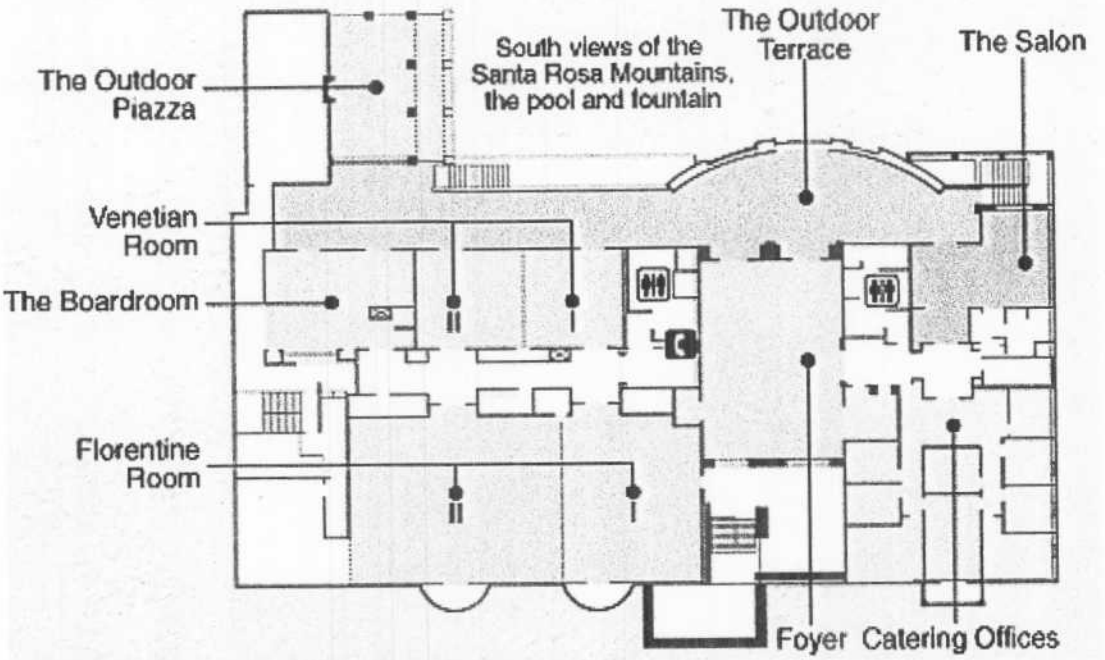
12:00-5:00 LUNCH & TOUR – Pilot Projects, Niland Solar Ponds & Salton Sea Test Base

Pick up lunches in Florentine Foyer.
For pilot project tour, proceed to hotel entrance to load buses.

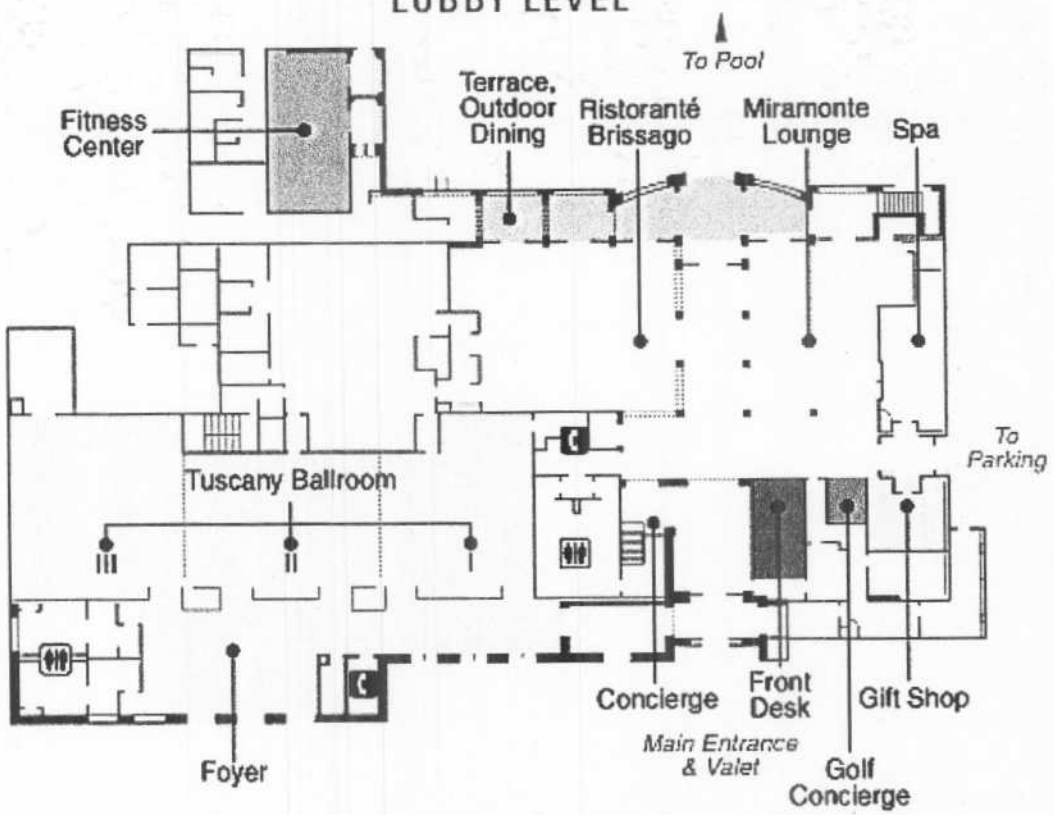
MiraMonte RESORT

HOTEL MAP

UPPER LEVEL



LOBBY LEVEL



SALTON SEA AUTHORITY
BOARD OF DIRECTORS

Roy Wilson, Board President

Supervisor, Riverside County

Roy was first elected to represent the 4th District in 1994 and was re-elected in June 1998. The fourth district is the largest geographic region in the County, Stretching from the North Palm Springs area south to the Salton Sea and east to the Colorado River and the California/Arizona border.

The district covers more than 5,000 of the County's 7,300 square miles.

Prior to becoming a County Supervisor, Roy spent more than 33 years in higher education as an administrator and professor at California State University, Stanislaus (6 years) and College of the Desert (27 years).

During more than 20 of those years at College of the Desert, Roy served in municipal government as a Planning Commissioner (3 years) and a City Council member (17 years) for the City of Palm Desert. He served four terms as Mayor of the city.

His civic duties also include 11 years as a governing board member for the South Coast Air Quality Management District, 20 years on the Riverside County Transportation Commission, and 4 years on the Mojave Desert Air Quality Management District

In addition to civic duties, Roy has been active in professional journalism organizations, his teaching specialty.

He has served as President of the California/Arizona Journalism Association of Community Colleges and President of the national Community College Journalism Association.

In 1995, Roy was inducted into the Community College Journalism Association's Hall of Fame in Washington, D.C. He is the author of a textbook used throughout the United States and in Canada, which is now in its fourth edition.

Mass Media/Mass Culture, is published by McGraw-Hill, the largest publisher of textbooks in the world. Because of time constraints imposed by his duties on the Board of Supervisors, Roy was joined for the development of the fourth edition by a co-author, his brother, a professor of mass communication and journalism at California State University, Fresno.

Roy holds bachelor and master's degrees from California State Universities and a doctorate in higher education from the University of Southern California.

Although Roy doesn't find much spare time, when he does, he enjoys visiting with his family, which includes five children and ten grandchildren. He also enjoys reading, traveling and hiking around his mountain cabin in Idyllwild.

Andy Horne

Board Member
Imperial Irrigation District

Imperial Irrigation District Director Andy Home was elected in November 1998. He represents Division I of IID, which includes the El Centro area.

Horne is a real estate agent. He graduated from Central Union High School in El Centro and holds a Bachelor of Arts in history from the University of California, Riverside.

As an IID director, Horne serves on a number of study groups, including those focusing on: the budget, groundwater, public affairs, the Salton Sea and the conservation and transfer agreement between IID and the San Diego County Water Authority.

He is a past president of the El Centro Rotary Club, the El Centro Chamber of Commerce and Visitors Bureau and the Imperial Valley Board of Realtors. He also is a former trustee of the McCabe Union School District in rural El Centro and immediate past president of the IID Board.

Horne and his wife, Alexa live in rural El Centro. They have three children, Betsy, Stafford and Matthew.

Patricia A. Larson

Board Member
Coachella Valley Water District

Patricia A. Larson received a Bachelor of Science degree from UCLA in 1949, a Juris Doctorate from Citrus Belt Law School in Riverside in 1990, and was admitted to the California Bar in the same year.

She is currently Executive Director of the Coachella Valley Association of Governments (CVAG).

She has been active in community work including serving two terms on the Palm Springs Board of Education, working as President of the Riverside County School Board Association and as Director of State School Boards Association.

She is a founder of both the California Women for Agriculture and American Agriwomen. She also served as Supervisor, 4th District, Riverside County Board of Supervisors, being elected to office in 1982 then re-elected for a second term in 1986 and a third term in 1990.
Patricia has also been an active member in the Local Agency Formation Commission (LAFCO), the Riverside County Housing Authority, Sunline Transit Agency Board of Directors, Riverside County Transportation Commission (RCTC), Coachella Valley Mountains Conservancy Board of Directors, the Bureau of Land Management's California Desert District Advisory Council, and the Salton Sea Authority.

Wally Leimgruber

Board Member
Supervisor, Imperial County

Wally Leimgruber was elected to the Imperial County Board of Supervisors in 1998 to represent District No. 5.

Wally and his wife Marjie also own and operate a successful farming business in Holtville.

Born in Calexico, Leimgruber was raised on the family farm. Graduating from Holtville High School in 1971, he continued on with his farming roots, starting his own farming business in 1972. Leimgruber has been happily married to the former Marjie Dahm for 25 years and they have two children, Amy and Matthew, both currently attending California universities.

Wally and Marjie have been heavily involved in the community from coaching athletics to being members of the Pioneers Museum, Imperial Valley Swiss Club and the Navy League.
The Leimgruber family has also been active participants in 4-H, FFA and the American Field Service.

Stella A. Mendoza

Board Member
Imperial Irrigation District

Stella A. Mendoza is the Imperial Irrigation District Director representing Division 4. Her election in November 2000 General Election marks the first time a woman won a seat on the IID Board of Directors.

Born in Brawley, Mrs. Mendoza received an AA degree from Imperial Valley College. She is a real estate agent with ERA in Brawley.

She is a past Brawley City Councilwoman and mayor.
She is president of the Women's Community Club of Brawley and a member of the Brawley Lion's Club and the Soroptimists Club of Brawley. She also serves as vice-chairwoman of the Calipatria State Prison Citizen's Advisory Committee.

Peter G. Nelson

Board Member
Coachella Valley Water District

Peter G. Nelson was sworn in as a member of the Coachella Valley Water District board of directors in June 2000 when he was appointed to serve out the unexpired term of Dorothy Nichols who resigned after having served 13 years as a board member.

Nelson, who has resided in the Coachella Valley since 1987, is general manager of agricultural operations for J&P Properties whose interests in the Thermal area produce citrus, dates and table grapes.

He has been in that position since 1989. Prior to that Nelson was associated with the Superior Farming Company for five years. A graduate of California State University, Fresno, with a degree in agricultural economics, Nelson, his wife and three children reside in Thermal.

He is active in youth sports programs and serves as a director of St. Andrew's Presbyterian Church in Indio.

Jim Venable

Board Member
Supervisor, Riverside County

Jim Venable was born on a ranch in Hemet, California, right in the heart of Riverside County. He spent his entire life in the Third District, graduating from Hemet High School in 1954.

He has seen this county grow and is committed to assuring that our children enjoy the quality of life with parks, schools and neighborhoods that he enjoyed as a child. Jim and his wife, Mary, raised eight children and have 20 grandchildren.

Venable has always been an innovator in both the aviation and racing fields. He learned to fly at the age of 14 and started crop dusting at the age of 16, amassing over 20,000 hours of flying time. His father started an aircraft business in 1947, and Jim took over that business in 1960.

Hemet Valley Flying Service was the pioneer company in fighting fires from the air and became the largest aerial firefighting company in the United States, with offices operating worldwide.

He retired from this business in 1996.

After these accomplishments in the private sector, Venable decided to put his energies into public life and to work toward improving his community. He was elected to the Hemet City Council in 1993 and again in 1994. He was sworn into office as the Third District Supervisor for Riverside County in January 1997.

Since taking office as Third District Supervisor, Venable's mission statement has been: "To honestly, fairly, and promptly serve his constituents; to foster unity among all business, community and governmental entities within the District; and to work together with the other members of the Board of Supervisors to build a strong economic base throughout Riverside County."

Gary Wyatt

Board Member
Supervisor, Imperial County

Gary Wyatt graduated from Brawley Union High School and furthered his educational career, attending Imperial Valley College and Southern California College. He received a Management Degree from Berean College.

Gary has been married to Dorothy Elaine Wyatt for 27 years and they have two children, Kari Danise and Jeremy Adam.

Prior to his election, Gary served the Imperial County for 10 years, working in the Sheriff's Department as supervisor of the Crime Prevention Unit and Volunteer Services. His duties included community services and liaison, public relations, special projects coordinator, and media contact.

He was recipient of an Employee of the Year Award and a member of the unit that received the Crime Prevention Unit of the Year Award from the State of California.

Gary has demonstrated public and community involvement, serving on the Brawley Union High School Board of Trustees, being a member of the Navy League, the Imperial Valley Football Officials, the Imperial Valley Basketball Officials, and serving as a chairman of the Sheriff's Reserves Youth & Athletic Committee.

He also served on the California Rural Crime Prevention Task Force, the Red Ribbon Coalition and the California Crime Prevention Officers Association.

Gary is now serving the Imperial County as Imperial County Supervisor, District 4. As Supervisor of District 4, Gary represents the north end of the Imperial Valley.

Congressional Salton Sea Task Force and other key members of Congress

Congresswoman Mary Bono

44th Congressional District
Chair, Salton Sea Congressional Task Force

Congresswoman Mary Bono represents California's 44th Congressional District. Bono was first elected in a special election on April 7, 1998, to fill the seat previously held by her late husband, the Honorable Sonny Bono, M.C.

In November of 2000, the Congresswoman was reelected by an overwhelming majority to serve a second full term in Congress.

The Congresswoman has been assigned to the Energy and Commerce Committee. As a member of the Energy and Commerce Committee, Bono serves on the Commerce, Trade and Consumer Protection Subcommittee, the Energy and Air Quality Subcommittee and the Environment and Hazardous Materials Subcommittee. In addition, Bono serves as chair of the Congressional Salton Sea Task Force and as co-chair of the Entertainment Task Force, and Travel and Tourism Task Force.

In 2000, Congresswoman Bono succeeded in passing legislation establishing the Santa Rosa and San Jacinto National Monument in the Palm Springs region with support from diverse interests including environmentalists and developers.

In addition, she received several awards for her distinguished work in Congress. In 2001, the Congresswoman was honored by the National Organization on Fetal Alcohol Syndrome for her efforts in preventing birth defects caused by alcohol use during pregnancy. In 2000, Congresswoman Bono received the Guardian of Small Business Award from the National Federation of Independent Business for her work on key issues such as tax relief, pension reform and other small business issues.

In 1999 and 2000, Americans for Tax Reform presented Bono with the Hero of the Taxpayer Award for her work in helping to reduce the tax burden on working families and eliminating wasteful government spending.

Bono was born October 24, 1961, in Cleveland, Ohio. As a youth, Mary pursued her first love, gymnastics. With her family's support, Mary became an accomplished gymnast while training with the team Gymnastics Olympica. Her dedication to fitness continues to this day. Mary is a certified personal fitness instructor who has studied martial arts (Karate, Tae Kwan Do) for over five years.

A 1984 graduate of the University of Southern California, with a Bachelor of Fine Arts in Art History Degree, Mary worked her way through college, sometimes working two jobs at once. While celebrating her graduation from USC, Mary was dining with a friend at BONO restaurant when she met the restaurant's owner and her future husband, Sonny Bono. Their relationship blossomed, and in February of 1986, Mary Whitaker married Sonny Bono in Palm Springs, California.

On November 24, 2001, Congresswoman Bono married businessman Glenn Baxley. Mary has two children, Chesare Elan, 12, and Chianna Maria, 9. She served as first lady of the City of Palm Springs, and has been active in a wide range of community charities and service organizations.

Mary was named Woman of the Year in 1993 by the San Gorgonio Chapter of the Girl Scouts of America for her assistance to victims of a tragic Girl Scout bus crash in Palm Springs. In addition, Mary served on the board of the Palm Springs International Film Festival, and played a leadership role in support of the D.A.R.E. program, Olive Crest Home for Abused Children, Tiempos de Los Ninos and many other worthwhile causes. In addition to time spent with her family, Mary's interests range from outdoor activities to a passion for computer technology.

In 1999, Bono was selected by GEORGE Magazine as one of the 20 most fascinating women in politics. In addition, the Congresswoman was named as one of the most Fascinating Women of 1998 by Ladies Home Journal magazine in conjunction with CBS Television. The Congresswoman has been the subject of numerous profile feature articles for a wide array of publications, domestically and abroad, including: GEORGE, The New York Times Magazine, Good Housekeeping, Esquire, ELLE Magazine, PEOPLE, Capital Style, HELLO Magazine, The Washington Post, and USA Today.

Congressman Ken Calvert

43rd Congressional District
Chairman of the Water and Power Subcommittee
House Resources Committee
Salton Sea Congressional Task Force

Ken Calvert, a lifelong resident of Riverside County and 17-year small business owner in the restaurant and real estate industries, represents the 43rd Congressional District of southern California.

Calvert was born on June 8, 1953 and attended neighborhood public schools, graduating from Corona High School in 1971. He proceeded then to attend two years at Chaffey College, in Alta Loma, and then enrolled at San Diego State University, where he graduated in 1975 with a Bachelor of Arts degree in Economics.

The 43rd District is one of the most diverse, encompassing western Riverside County including all of Riverside, Corona, Norco, Lake Elsinore, Canyon Lake, Murrieta and portions of Temecula.

Calvert was first elected to serve the 43rd District in 1992. During his freshman term, Calvert served as an active Member of the Resources Committee and Science Committee. The next two years in office Calvert's ability to work in a bipartisan fashion was rewarded with the Chairmanship of the Energy and Mineral Subcommittee on the Resources Committee. While unusual for a sophomore Member to be given a Chairmanship after only one term in Congress, Calvert served on two other Committees: maintaining his seat on the Science Committee and gaining a seat on the Agriculture Committee. Calvert maintained these Committee slots over six years enabling him to address issues critical to Riverside County, California and the nation. Issues such as the Endangered Species Act, agriculture, energy, water and much more.

In the 107th Congress (2001-2002), Calvert serves on the Armed Services Committee, Resources Committee and Science Committee following his return to the U.S. House of Representatives for his fifth term.

On the Resources Committee, Calvert is Chairman of the Water and Power Subcommittee overseeing federal water rights in the west, including hydro-power generated from federal water projects.

Calvert has worked during his past 4 terms to secure federal funds for critical projects in Riverside County including: March Air Reserve Base; research into the grapevine killing Pierce's Disease scourging California's wine industry; expansion of the Janet Goeske Center for Senior and Disabled Citizens; cutting edge clean air technology

at the University of California at Riverside; and, various environmental restoration and flood control efforts critical to Orange, Riverside and San Bernardino Counties.

Calvert has played an instrumental role in advancing legislation passed into law that protects against identity theft by prohibiting the appearance of Social Security account numbers on or through unopened mailings of checks issued by the Treasury Department, providing additional educational dollars to states through a simplified collection process of oil and gas royalties, increasing the penalties for desecrating our national cemeteries, establishing the Medal of Honor Memorial at the Riverside National Cemetery as a "national" memorial, and reducing or eliminating the use of animals to test product and chemical safety by establishing alternative test methods throughout a coalition of federal agencies.

Additionally, his legislative work has received top ratings from the Americans for Tax Reform, Christian Coalition, League of Private Property Voters, National Federation of Independent Businesses, 60 Plus Association, U.S. Chamber of Commerce, Small Business Survival Committee and Citizens for a Sound Economy.

In the 107th Congress, Calvert's legislative plan includes: working for long term solutions to California's energy and water problems; working towards the implementation and funding of Riverside County's Integrated Plan (RCIP), especially new transportation corridors vital to Riverside's future; continuing oversight and fixes to the Fish & Wildlife Office's enforcement of the Endangered Species Act; and, much more.

Congressman Bob Filner

50th Congressional District

Bob Filner brings experience as a local official, educator, community leader, and neighborhood activist to Washington as the U.S. Representative from California's 50th Congressional District.

Congressman Filner was born in Pittsburgh, Pennsylvania on September 4, 1942 and raised in New York City. He is married to Jane Merrill and has two children – daughter Erin, a high school teacher in New York, and son Adam, a waiter in San Diego.

Bob earned a Bachelor's Degree in Chemistry from Cornell University (1963), a Master's Degree in History from the University of Delaware (1969) and a Doctorate in the History of Science from Cornell University (1973). He is one of only a handful of Members of Congress with a scientific degree and one of only 18 Members in the House of Representatives holding a Ph.D.

While in college, Bob became active in the struggle for civil rights. In 1961, he joined the first Freedom Rides and was arrested and imprisoned for several months in Mississippi.

A History Professor at San Diego State University for more than 20 years, Bob was active in several community issues, including housing, job development, education, environmental protection and civil rights.

In 1975-76, he was selected as a Congressional fellow by the American Political Science Association and served as a Legislative Assistant to Senator Hubert Humphrey and Congressman Don Fraser.

Bob's first elected office was as a San Diego School Board Member (1979-1983). His colleagues elected him Board President in 1982.

Bob served on the San Diego City Council from 1987-1992. He won re-election in 1991, and, that same year, he served as Deputy Mayor of the City of San Diego.

Bob created the city's first Economic Conversion Committee and wrote the city's Economic Conversion Plan. He also found creative ways to fight neighborhood crime--including the introduction of Police Walking Patrols and a Citizen Graffiti Patrol.

Bob was elected to the United States House of Representatives in 1992. He was immediately named to the House Committee on Transportation and Infrastructure and the Committee on Veterans' Affairs. He was re-elected in 1994 and 1996. In 1998, Bob was unopposed in his re-election bid. And in 2000, he was re-elected by a 42-point margin.

During his first term in the House of Representatives (1993-94), Bob sponsored a successful bill that amended the Clean Water Act to allow San Diego to save billions of dollars while meeting environmental standards. With this accomplishment, he became one of only a handful of freshmen to have legislation passed. He also successfully inserted language in the Transportation Appropriations bill that terminated the study of an unwanted international airport in his district.

Bob was also successful in meeting several of his objectives for the 50th District, including passing legislation that restored funds to continue the construction of an international sewage treatment plant to treat raw sewage flowing into the United States from Mexico, and securing funding for State Route 905.

During his second term (1995-96), Bob played a major role in thwarting the new Congressional majority's attempts to slash federal funding for Medicare, crime control, education, the environment and veterans. He introduced legislation that would allocate savings from defense downsizing to job retraining and economic conversion in impacted communities. He also led the fight to close a $2 billion corporate tax loophole that has allowed mutual life insurance companies to avoid paying their fair share of taxes.

As a member of the House Committee on Veterans' Affairs, Bob led the successful opposition to cuts in veterans programs. In addition, he was named Democratic leader of the Veterans' Affairs Subcommittee on Benefits.

During his third term (1997-98), Bob continued the fight for his constituents. In addition to garnering increased support for the above legislative proposals, Filner reintroduced bills encouraging private sector funding for the San Diego & Arizona Eastern Railroad (the "Jobs Train"). With his Identity Theft legislation, Bob led the charge to change the IRS practice of printing taxpayers Social Security Numbers on the mailing labels of tax booklets. He also fought to prohibit insurance companies from dropping their policies with churches and other houses of worship due to fear of arson, and availing more mobile home owners of federal housing assistance.

Through his committee work, Bob introduced legislation seeking to restore promised benefits to Filipino Veterans of World War II, which were rescinded by the 1946 Congress.

In his fourth term (1998-2000), Bob fought to protect the environment and Southern California's water supply by working to pass two important bills. The first, his Bajagua bill – allows for the construction of a sewage treatment plant to treat Mexican sewage in Mexico to stop the flow of contaminated water into the Tijuana River Valley and ultimately, San Diego's beaches and bays. He also fought for passage of legislation to clean up and move a huge uranium tailings pile in Moab, Utah, that was polluting the Colorado River – San Diego County's main water source.

As a member of the Veterans' Affairs Committee, Bob continued his fight for veterans. He secured additional compensation and access to VA hospitals for Filipino veterans of World War II. He also was successful in getting better pay for VA dentists and increasing small business opportunities for veterans. Bob was honored for his dedication to veterans by the Jewish War Veterans, Gold Star Wives, National Coalition of Homeless Veterans and the Task Force for Veterans' Entrepreneurship.

Now in his fifth term, Bob's top priorities are solving California's electricity crisis, working more closely with the new government of Mexico to solve mutual problems on both sides of the border, and continuing his fight for the Jobs Train – a commercial rail line between San Diego and the East Coast.

Already in the 107th Congress, Bob has introduced electricity legislation to set cost-based wholesale electricity rates throughout the West. If passed, the bill would require the Federal Energy Regulatory Commission to establish cost-based wholesale energy rates – the cost to produce the electricity, plus a reasonable profit. His bill – companion legislation to Senator Barbara Boxer's bill – also would order the wholesalers to pay refunds to Californians who have paid above that cost-based rate since June, 2000.

Congressman Duncan Hunter

52nd Congressional District
House Armed Services Committee
Salton Sea Congressional Task Force

Congressman Duncan Hunter represents California's 52nd Congressional District, consisting of eastern San Diego County and Imperial County. He is a Vietnam veteran, who served in the 173rd Airborne and 75th Army Rangers. In 1973, Hunter attended Western State University Law School in San Diego on the G.I. Bill, while also working at farming and construction. Opening a law office in Barrio Logan San Diego, Hunter assisted many in the Hispanic community free of charge and without government compensation. In 1980, he was asked to run against Congressman Lionel Van Deerlin, an 18-year incumbent, where, in a 2-to-1 Democrat district, Hunter won the Congressional seat.

Hunter's first assignment in Congress was to the House Armed Services Committee, where he continues to serve today. As Chairman of the House Military Research & Development Subcommittee, he is responsible for overseeing the development and testing of key military systems, weapons programs, and technologies that fulfill military needs. Hunter also served as Chairman of the House Armed Services Subcommittee on Military Procurement from 1995-2000 where he presided over $60 billion for the acquisition of military weapon systems and components. Hunter focuses his national security efforts on improving military readiness, implementing a ballistic missile defense system, revitalizing equipment and resources, such as U.S. strategic bomber forces and the next generation of nuclear attack submarines, and upgrading benefits for military personnel and their families.

Because his district encompasses nearly all of the California-Mexico border, Hunter has made border enforcement a major priority. In 1988, Hunter authored legislation making the military the lead agency in illegal drug interdiction and was successful in obtaining military units for building roads and fencing along the U.S. border with Mexico. Over 40 miles of fencing and border infrastructure have been constructed to date. Additionally, Hunter passed legislation in 1995 to authorize an additional 5,000 Border Patrol agents in response to the Clinton Administration's budget which attempted to cut agency resources. Hunter remains committed to sealing the U.S. border to illegal alien and drug trafficking, making the region safe for communities on both sides of the international boundary.

Hunter's other legislative priorities include fulfilling promises to our nation's veterans, providing tax relief to America's working families, and continuing cleanup efforts at the New River and Salton Sea in Imperial County.

Congressman Hunter and his wife, Lynne, live in Alpine, California. They have two sons, Duncan Duane and Sam, and one grandson, Duncan Lee II.

Congressman Jerry Lewis

40th Congressional District
House Appropriations Committee
Salton Sea Congressional Task Force

Jerry Lewis, a lifelong resident of San Bernardino County and 30-year owner of a life insurance business, represents the 40th Congressional District of Southern California, including most of San Bernardino and Inyo Counties.

A member of Congress since 1978, Congressman Lewis is one of the most senior members of the House Appropriations Committee, which is responsible for funding all federal programs. He is chairman of the Defense Appropriations Subcommittee, the

panel with jurisdiction over all national security matters including the entire Pentagon budget – nearly half of all funds appropriated by Congress. In this capacity, he is a forceful advocate of critical defense and aerospace jobs in California. Lewis also serves on the Foreign Operations Appropriations Subcommittee and the Legislative Branch Appropriations Subcommittee.

Before taking his current position, Lewis was the chairman of the VA-HUD and Independent Agencies Subcommittee, the panel responsible for funding federal housing, veterans affairs, NASA, the Environmental Protection Agency, the Federal Emergency Management Agency, the National Science Foundation, and other federal agencies.

From 1996-2001, Lewis served as Chairman of the House GOP California delegation, leading California Republicans on legislative issues of importance to the Golden State. Lewis also served as Co-Chair of the entire delegation and worked successfully to unify California Republicans and Democrats to marshal the considerable clout of the 52-member delegation, the largest in the House of Representatives. Under his leadership, the bi-partisan delegation supported dozens of unified efforts on issues ranging from police funding to aid for the state's agricultural industry.

Lewis has personally secured federal funds for critical projects in Southern California including highway improvements along I-15 and I-40 in the high desert; a revolutionary cancer treatment center and NASA research at Loma Linda University; access road and terminal expansion at Ontario International Airport; and the construction of the Santa Ana flood control project critical to Orange, Riverside, and San Bernardino Counties. Lewis has played an instrumental role in pursuing tough federal clean air standards, fashioning effective crime and drug legislation, and securing emergency funding for earthquake, flood, fire, and drought relief for California. An innovative housing program he created with San Bernardino County has provided more than 500 low-income families to buy renovated public housing. And he was the driving force in converting the former George and Norton Air Force Bases into successful local employment centers..

Prior to his election to Congress, Lewis served in the California State Legislature. He was the lead author on legislation establishing the South Coast Air Quality Management District in Southern California, recognized as the leading regional air quality board in the United States. Lewis is also the author of the Child Development Act of 1972, which has since become a national model for innovative childcare. Additionally, he sponsored legislation placing the "Newsman's Shield Law" in the California State Constitution.

Jerry Lewis graduated from UCLA in 1956 with a Bachelor of Arts degree in Government. He continued his education with a fellowship in public affairs with the Coro Foundation in San Francisco. He and Arlene reside in Redlands and have seven children.

Barbara Boxer

United States Senator

A forceful advocate for families, children, consumers, the environment and her State of California, Barbara Boxer became a United States Senator in January 1993, after 10 years of service in the House of Representatives, and was elected to a second, six-year term in 1998.

In the House, she made her mark as a champion of human rights, environmental protection, military procurement reform and a woman's right to choose. Boxer disclosed the famous $7,600 Pentagon coffee pot and successfully passed over a dozen procurement reforms, one of which, alone, has saved taxpayers over $2.6 billion.

Boxer has won numerous awards for her efforts to create a cleaner, healthier environment. As a Senator, she successfully amended the Safe Drinking Water Act to ensure that drinking water standards are set to protect the most vulnerable Americans, including children, pregnant women, and the elderly. She has introduced legislation to remove the threat of offshore drilling along our coasts, and has authored the Children's Environmental Protection Act, which would require environmental standards be set at levels that protect children. Parts of the bill have become law.

A champion of maintaining and improving our public schools, her after-school legislation has been a landmark achievement, while her "Computers in Classrooms" law encourages the donation of computers and software to schools and helps give students the tools they need to get a top quality education.

Committed to eliminating violence in America, Senator Boxer joined colleagues to pass the 1994 Crime Bill, which led to the lowest crime rate in 25 years. Her legislation to prevent the criminal use of personal information obtained through motor vehicle records was signed into law and upheld by the U.S. Supreme Court. She also authored the Violence Against Women Act while serving in the House and helped steer it successfully through the Senate; it also is now law.

A strong advocate of medical research, Senator Boxer is a leader in the drive to double funding for the National Institutes of Health. An early leader in the fight against AIDS in this country, Boxer, more recently, authored bipartisan legislation to accelerate America's leadership in the international fight against HIV/AIDs and tuberculosis. These bills are now law, and have been fully funded. One of the first in Congress to recognize HMO abuses, she authored a Patient's Bill of Rights in 1997 and continues to fight for these much needed protections.

The Senate's leading advocate of a woman's right to choose, Senator Boxer authored the Family Planning and Choice Protection Act and helped lead the floor fight for passage of the Freedom of Access to Clinic Entrances Act. She is now leading the Senate effort to overturn the Bush international gag rule and other anti-choice efforts.

A champion of senior citizens, Senator Boxer has worked to preserve the safety net for older Americans. She introduced pension protection legislation, including the

"401(k) Pension Protection Act of 1997," which was signed into law as part of the 1998 budget agreement. This law protects worker's retirement nest eggs by making it illegal for companies to invest more than 10 percent of a worker's 401(k) pension fund in company stock or other risky investments.

A member of the Senate Environment and Public Works Committee, Senator Boxer chairs the Superfund, Toxics, Risk, and Waste Management Subcommittee. She also serves on the Commerce Committee and the Foreign Relations Committee, where she chairs the Subcommittee on International Operations and Terrorism. A member of the Senate Democratic Leadership, Boxer serves as Chief Deputy for Strategic Outreach, as well as Western Regional Democratic Whip and is a member of the Senate's Hispanic Caucus.

Dianne Feinstein

United States Senator

Reelected on November 7, 2000 to her second full six-year term, Senator Feinstein has served for eight years in the United States Senate. She was first elected in 1992 to fill the remaining two years of then-Senator Pete Wilson's term when he resigned to become California's governor. In 1994, she was elected to her first full six-year term in the Senate.

Senator Feinstein is the first woman to serve on the Senate Judiciary Committee, where she is the chair of the Technology and Terrorism Subcommittee. In this role, Senator Feinstein is working with her colleagues to draft counter terrorism legislation in wake of the September 11th attacks.

Senator Feinstein also serves on the Senate Appropriations Committee as chair of the Subcommittee for Military Construction and the Rules and Administration Committee. This year, Senator Feinstein became a member of the Select Committee on Intelligence and the Energy and Natural Resources Committee, where she has been working on measures to solve California's electricity crisis.

A leader in the battle against cancer, she co-chairs the Senate Cancer Coalition and is Vice-Chair of the National Dialogue on Cancer, with former President George Bush and his wife Barbara. This is a coalition of more than 130 cancer organizations seeking to improve research, care, and treatment, and to find a cure for cancer.

In 1994, Senator Feinstein won one of the toughest battles of her career with passage of the Assault Weapons Ban, prohibiting the manufacture and sale of 19 types of military-style assault weapons.

Senator Feinstein is a native of San Francisco, and was appointed by California Governor Pat Brown to the women's parole board in 1960 at age 27. In 1969, she was elected to the San Francisco County Board of Supervisors, where she became the first woman President of the Board.

She became Mayor of San Francisco in November1978 following the assassination of Mayor George Moscone and Supervisor Harvey Milk and demonstrated a steadiness and command that calmed the city during that turbulent time.

The following year she was elected to the first of two four-year terms. As the City's first woman Mayor, Dianne Feinstein managed the City's finances with a firm hand, balancing nine budgets in a row. In 1987, City and State Magazine named her the nation's "Most Effective Mayor."

Dianne Feinstein received a B.A. in History from Stanford University in 1955 where she served as Student Body Vice-President. She was born on June 22,1933, the daughter of a respected surgeon and professor of the University of California at San Francisco Medical School. She is married to Richard C. Blum, has one daughter, Katherine, three stepdaughters, Annette, Heidi and Eileen and two granddaughters, Eileen and Lea, and one grandson, Mitchell.

The Salton Sea Symposium
"Bridging the Crossroads"
January 9-10, 2002

Alphabetical List of Panelists and Speakers

Christopher Amrhein

Associate Professor, Department of Environmental Sciences
University of California, Riverside

Dr. Amrhein holds a B.S. with High Honors in Soil and Water Science and an M.S. in Water Science from the University of California, Davis. He received his Ph.D. in Soil Chemistry in 1984 from Utah State University.

We was a post-doctoral researcher at the U.S. Salinity Laboratory, USDA, from 1984 to 1988 and Assistant Professor, University of California, Riverside, Dept. of Soil and Environmental Sciences from 1988-1994.

He became Associate Professor of Soil Chemistry, University of California, Riverside in 1994.

His research interests include trace element chemistry in soils, sediments, water, and brines; Oxidation/reduction chemistry in wetlands and metal surfaces; Dissolution and precipitation kinetics of carbonate and silicate minerals; Cation and anion adsorption reactions on phyllosilicate clays, metal oxides, and soils and reclamation of salt-affected soils and the maintenance of soil structure.

Dr. Amrhein is author of a number of recent publications and is one of the principal investigators in a study entitled Nutrient Cycling in the Salton Sea.

He is a member of the Soil Science Society of America, Geochemical Society, American Chemical Society, American Geophysical Union, American Society of Agronomy and the Professional Soil Scientists Association of California.

Marie Barrett

New River Wetlands Project Coordinator

As New River Wetlands Project Coordinator, Ms. Barrett is working to expand knowledge of the New River Wetlands and wetlands in general through educational outreach to Imperial Valley students and promoting benefits to the general public.

She holds a Bachelor of Science in Agricultural Biology, specializing in Economic Entomology.

Marie is a Licensed California Pest Control Advisor and Pest Control Applicator as well as a Certified Hazardous Waste Operations and Emergency Response (Hazwoper) trainer.

As a biologist, she specialized in the study of the Flat tailed Horn Lizard.

As an educator, Marie helped establish an Associate of Science degree in Environmental Technology at Imperial Valley College and promoted work place safety through hazardous materials training.

As a volunteer, she promoted agriculture as Chairperson of the Sweet Onion Festival, President of California Women for Agriculture and chairperson of the Agriculture Gallery at Imperial County Pioneers Museum.

Glenn Black

Senior Environmental Scientist
Department of Fish and Game

Glenn holds a bachelor's degree in Zoology from the California State Polytechnic College, Pomona, Ca.

He began work for the Department of Fish and Game as a Seasonal Aide at Chino Fisheries Base, the Imperial Wildlife Area and the Marine Resources (Long Beach) from 1971-74.

He was appointed Junior Marine Biologist in April of 1974 for Marine Resources (Long Beach) and worked in the Big Game Fish Research Project.

Glenn transferred to Region 5, Chino Fisheries Base in November of 1977 as Fisheries Biologist, working on desert pupfish and Salton Sea sport fishery issues. He became Associate Fishery Biologist in mid-1980's, primarily working on Salton Sea sport fishery.

He was promoted to Fisheries Management Supervisor in Region 5 (Long Beach and Chino) in March of 1990 and was responsible for fisheries management programs in all 10 Southern California counties.

Glenn transferred to the newly formed Natural Heritage Program in Region 5 in April of 1991 and worked on early development of Natural Community Conservation Program in southern California and numerous other multi-species habitat conservation planning efforts.

Since December of 1999, he has been the Senior Environmental Scientist, responsible for the Department of Fish and Game's Habitat Conservation Program in the Colorado Desert. This encompasses the Salton Sea and the Coachella and Imperial Valleys. His office is presently in Chino Hills and the Department is working on leasing office space in the Coachella Valley for this program.

William R. Brownlie, PE, PhD

Tetra Tech Senior Vice President
And Senior Project Manager
Salton Sea Authority

Dr. Brownlie is a civil and environmental engineer with 25 years of experience. He received his PhD in Civil Engineering and Water Resources from the California Institute of Technology in 1981. He is a professional Civil Engineer registered in eight states, including California.

Dr. Brownlie has been employed at Tetra Tech, Inc. for the past 20 years, where he is currently a Senior Vice President and Senior Project Manager. He has extensive experience in project engineering and program management in environmental science and engineering, particularly on large water resources projects.

For the past three years, Dr. Brownlie has served as Program Manager for an environmental and engineering support contract with the Salton Sea Authority, to assist the Authority and the US Bureau of Reclamation in the preparation of environmental engineering studies and documents related to restoration of the Salton Sea.

These projects have included alternative screening, a draft environmental impact statement/report, an assessment of appropriate salinity and elevation goals for the Sea, and a number of other supporting studies. In the past Dr. Brownlie has provided similar

environmental services for the CALFED Bay/Delta Program and the Metropolitan Water District Eastside Reservoir (now Diamond Valley Reservoir) Project.

Michael Cohen

Senior Research Associate
Pacific Institute

Mike Cohen is a Senior Research Associate at the Pacific Institute for Studies in Development, Environment, and Security.

He is the lead author of the Institute's 1999 report entitled: Haven or Hazard: The Ecology and Future of the Salton Sea, and the recently published Missing Water: The Uses and Flows of Water in the Colorado River Delta Region.

Mr. Cohen wrote the Institute's Proposal to Preserve and Enhance Habitat at the Salton Sea (the "diking proposal"), as well as the Institute's comments on the Salton Sea Restoration Project draft EIS/EIR.

He is also the co-author of several journal articles on water and the environment in the border region.

He has a master's degree in geography, with a concentration in resources and environmental quality, from San Diego State University.

Don Cox

Imperial Valley Farmer

Don Cox received a B.S. in Agricultural Economics from the University of California at Berkeley.
He has been a farmer in the Imperial Valley for 50 years.

Don has served on a number of boards including 12 years on the Imperial Irrigation District Board of Directors, 10 years on the Regional Water Quality Control Board, 10 years on the Salton Sea Board of Directors and 6 years on the Colorado River Board.

Dr. Milton Friend

Chief Scientist
Salton Sea Science Office

Dr. Milton Friend, who served as Executive Director of the Salton Sea Science Subcommittee from 1998 until it was disbanded in 2000, is currently Chief Scientist of the Salton Sea's Science Office.

Prior to accepting the Salton Sea assignment in 1998, he was the founding director of the U.S. Geological Survey's National Wildlife Health Center in Madison, Wisconsin. He established the center in 1975, developing it from concept to institutional reality and served as its director for first 23 years of its existence.

He is also an adjunct professor in the Department of Animal Health and Biomedical Sciences at the University of Wisconsin—Madison and has taught at the University since 1976. He also has been a guest lecturer and visiting professor at numerous colleges and universities, including long-term involvement with a wildlife disease instructional program in England.

Dr. Friend has authored more than 100 scientific articles as well as an award winning field guide to wildlife diseases that has recently been reissued as an expanded and fully revised publication.

He has conducted field investigations and consulted on wildlife health issues throughout the world. His international experience includes involvement with wildlife

health issues in a number of countries, including onsite work in England, Demark, India, Australia, New Zealand, Canada, Mexico and France.

His professional specialties are wildlife disease, epidemiology, disease ecology, wildlife ecology and wildlife management. He is a past president of the Wildlife Disease Association and the recipient of numerous awards including that organizations Distinguished Service Award and the Department of the Interiors Meritorious and Distinguished Service Awards.

Although he has maintained an office at USGS facilities in Wisconsin, Dr. Friend has been spending much of his time these past four years in Southern California, providing scientific evaluations and coordinating the extensive scientific studies of the Salton Sea.

Dr. Milton Friend received his Doctorate in Veterinary Science and in Wildlife Ecology with a minor in Epidemiology from the University of Wisconsin-Madison.

Larry Grogan

Mayor, City of El Centro

After serving from 1960 to 1964 in the U.S. Marine Corps, Larry worked for nine years as a manager in the field of consumer finance.

In 1973, he joined San Diego Gas and Electric Co. where he worked for eight years in a number of capacities. He served SDG&E as a representative in the development of community plans as well as redevelopment projects such as Horton Plaza. He also was chairman of the Dells Industrial Redevelopment Project.

Assigned to SDG&E's energy subsidiary, he helped develop Imperial County's Geothermal Element to it's general plan.

For the next 12 years, he worked in the oil industry in various capacities including general development activities involving leasing, permitting, and project management with Phillips Petroleum, Kenecott, Standard Oil of Ohio, and B&P. Most of those years were spent in the Salton Sea Geothermal Field.

His participation included numerous environmental and water studies in that area.

From 1991 to the present he has been a geothermal consultant to SDG&E, BHP, Geothermic Inc. and Cal Energy.

The last ten years he also has owned and operated several small businesses and has been involved in retail associations in El Centro.

He is currently the Mayor of El Centro.

Phil Gruenberg

Executive Officer
Regional Water Quality Control Board

Phil Gruenberg has been Executive Officer of the Regional Water Quality Control Board since 1989. He began work for the regional board as a student assistant in 1972.

The Regional Water Quality Control Board is responsible for water pollution control within California's Colorado River/Salton Sea watershed. The Regional Board has an extensive history of involvement in studying the New River pollution problem and the Salton Sea water quality problems.

Gruenberg, who lived in the Imperial Valley from 1953 through 1967, graduated from California State University at Long Beach in 1975. He holds a Bachelor of Science Degree in Marine Biology.

Chris Holdren

Manager, Ecological Research and Investigations Group
U.S. Bureau of Reclamation

Dr. Chris Holdren is the Manager of the Ecological Research and Investigations Group at the U.S. Bureau of Reclamation in Denver, CO. His responsibilities include a variety of water projects throughout the western United States. Dr. Holdren has over 25 years of experience in lake and watershed management and is widely recognized for his lake and watershed management expertise.

He was lead editor for the document, "Managing Lakes and Reservoirs," which was recently published by the North American Lake Management Society.

Robert W. Johnson

Regional Director
Lower Colorado Region
U.S. Bureau of Reclamation

Robert W. (Bob) Johnson is the Regional Director of the Bureau of Reclamation's Lower Colorado Region. Headquartered in Boulder City, Nevada, the Region encompasses southern Nevada, southern California, most of Arizona, and small portions of Utah and New Mexico.

The Region's programs include management of the last 700 miles of the Colorado River, extending from Lee's Ferry in northern Arizona to the Mexican border. The Region serves as Water Master of the Lower Colorado River on behalf of the Secretary of the Interior. In addition, the Region provides states, Indian Tribes, and local water resources entities assistance with the planning and development of programs and projects to help meet local water needs.

Johnson is responsible for directing all of Reclamation's programs and activities in Southern Nevada, Southern California, and Arizona. He supervises and works with Area Office managers in these states to develop and manage Region wide policies and guidance for all Regional programs.

A Reclamation employee since 1975, Johnson has held several managerial positions, including Deputy Regional Director and Chief of the Water, Land and Power Operations Division in the Lower Colorado Region. He also served in a management position in the Office of the Commissioner in Washington D.C. He began his Reclamation career at Reclamation's Mid-Pacific Regional Office in Sacramento, California.

Johnson has received numerous awards during his career, including the Department of the Interior's Meritorious Service Award, the second highest Departmental award for career employees. Johnson received the award for his expertise and accomplishments in formulating policies related to economic and financial management issues on several of Reclamation's largest projects. Johnson is a graduate of the University of Nevada-Reno, with a Master of Science degree in agriculture and resource economics.

Johnson, a native Nevadan, is married and has two children.

Tom Kirk

Executive Director
Salton Sea Authority

Tom Kirk is the executive director of the Salton Sea Authority. Kirk's professional background includes land, environmental and infrastructure planning as a consultant and as the supervising director of the Coachella Valley Association of Governments. Kirk was

a fellow at the University of California Transportation Center and graduated #1 in his class with a master's degree in regional planning from the University of California, Berkeley.

He also graduated *magna cum laude* from the University of California, Los Angeles and is a public affairs graduate of the Coro Foundation. He has received numerous local, national and academic awards for his work.

Dr. Timothy Krantz

Director of the Salton Sea Database Program
University of Redlands

Dr. Krantz brings over twenty years of professional experience in environmental assessment and land use planning to the project, combining experience in both the private and public sector, academia and environmental engineering.

His primary academic training is in the field of botany and vegetation analysis, and he is a noted authority on the flora of the California deserts. Dr. Krantz has extensive experience with environmental impact assessments prepared in accordance with both the California Environmental Quality Act and National Environmental Policy Act. He has particular expertise with the regulatory requirements of the Clean Water Act and Section 400 permit regulations, jurisdictional wetlands delineations, State Regional Water Quality Control Board regulations and procedures, and State and Federal Endangered Species Act requirements.

Dr. Krantz is trained in GIS applications and has had a broad exposure to applications of this technology to land use and resource management projects. He has specific training in remote sensing and computer image analysis techniques. Dr. Krantz also is skilled at photographic image analysis and computer cartography.

At the University of Redlands, Dr. Krantz is a professor of Environmental Studies, teaching courses in Remote Sensing and Image Analysis, Environmental Impact Assessment, Physical Geography and Plant Taxonomy, among others.

He is Director of the Institute for Environmental Management, and Program Manager for the Salton Sea Database Program. He has traveled and worked extensively in Mexico and has developed many contacts in the government and private sector regarding environmental regulation and natural resource management, particularly dealing with bi-national resource issues concerning the Lower Colorado River and water management in the desert Southwest.

Eugenia McNaughton

Environmental Scientist
Environmental Protection Agency

Eugenia McNaughton, who holds a Ph.D. in biology, works for the U.S. EPA region 9 Water Division's Border Team. Her work includes projects related to water quality throughout the Imperial/Mexicali Valley and the Lower Colorado River Watershed. Her expertise is in aquatic toxicology.

Mary Nichols

Secretary for Resources
California Resources Agency

Governor Gray Davis named Mary D. Nichols California's eighth Secretary for Resources on December 16, 1998.

As head of the Resources Agency, Secretary Nichols sets policy for 27 departments, commissions, boards and conservancies, including the Departments of Conservation, Fish and Game, Forestry and Fire Protection, Parks and Recreation, Water Resources, and the California Coastal Commission.

The Agency is also responsible for interpreting the California Environmental Quality Act.

Secretary Nichols brings to the Davis administration a 30-year legacy of public service that has been instrumental in helping forge the nation's approach to environmental issues.

As a member of the Governor Davis' cabinet, Secretary Nichols serves as his chief advisor on issues related to the State's natural resources. Secretary Nichols played a central role in the acquisition of the Headwaters Forest, the nation's largest privately owned reserve of old-growth coastal redwood forest.

She now oversees the implementation of Propositions 12 and 13, the largest bond measures ever passed that together provide $4 billion in funding for parks, open space, habitat and river parkways.

Secretary Nichols represented the State in developing CALFED, the joint federal-State program that charts a new course for California's water resources and the Bay-Delta ecosystem. She now oversees CALFED's implementation phase, setting in motion the world's largest environmental restoration project.

A resident of Los Angeles, Secretary Nichols has a special interest in urban parks. She is currently overseeing the development of the Joint Rivers and Mountains Conservancy, and the Baldwin Hills Conservancy - the first State conservancies established entirely within wholly urban settings.

Prior to her present State appointment, Nichols served as the Executive Director of Environment Now, a private foundation dedicated to the protection of the California environment. She served in the Clinton administration as the U.S. Environmental Protection Agency's Assistant Administrator for Air and Radiation, and was a senior staff attorney and director of the Los Angeles office of the Natural Resources Defense Council from 1989 to 1993.

During her two terms on the California Air Resources Board in Governor Edmund G. (Jerry) Brown's administration, California established itself as the world leader in air quality regulation ushering in an era of innovative control technologies, cleaner motor vehicles and fuels. As a result of these efforts at the State and federal level, California's air has dramatically improved even while the State's population and economy have led the nation. She also served as Governor Brown's Secretary for Environmental Affairs, the cabinet-level post that later became Secretary of Cal/EPA.

Ms. Nichols was born in Minneapolis, Minnesota and attended school in Ithaca, New York. She received her BA from Cornell University and JD from Yale Law School.

Charles Pelizza

Senior Wildlife Biologist
Sonny Bono Salton Sea National Wildlife Refuge

Charles has been an employee of the US Fish and Wildlife Service since 1980. He has worked primarily on National Wildlife Refuges throughout the Northeast, Midwest and Western portions of the country. Most recently he has held positions as a zone wildlife biologist for National Wildlife Refuges in New York, Pennsylvania, New Jersey and South Dakota.

Currently, he is employed as the Senior Wildlife Biologist at the Sonny Bono Salton Sea National Wildlife Refuge. The responsibilities of this position provide oversight for the wildlife disease response program on the Salton Sea; all land management, research and monitoring activities on the Refuge; and participation on regional, national and international committees.

He received his undergraduate degree at Elmira College, Elmira, NY and his Masters degree at the University of South Dakota, Vermillion, SD. His research and management interests include: winter ecology of swamps, wetland habitat management and wildlife response, and most recently wildlife disease response efforts.

His wife, Sylvia, is also a Refuge employee; they have two children, ages seven and two years. His personal and recreational interests include raising a family, travel, windsurfing, and other consumptive and non-consumptive outdoor activities.

George Ray

Past President
Imperial County Farm Bureau

George was born and raised on a wheat and cattle farm in Oklahoma and received his Masters of Science degree in geology from the University of Oklahoma.

From 1969 to present, George has been a partner and the general manager of Fish Partners, an integrated aquaculture company specializing in the breeding and production of catfish.

George is the president of Fish Producers, Inc., the company handling the marketing and distribution of the fish produced by Fish Partners.

Earlier in his career, George taught high school mathematics and science and was a seismologist and exploration geologist.

He is actively involved in the California Aquaculture Association, serving as their president. He is a past president of the West Coast Aquaculture Development Foundation and a member of the Aquaculture Industry Development Commission, an advisory group to the Department of Fish and Game.

George is immediate past president of the Imperial County Farm Bureau, a past director of both the California Farm Bureau Federation and the Poultrymen's Cooperative Association.

Carol Roberts

Branch Chief
U.S. Fish and Wildlife Service

Carol graduated from the University of Cincinnati with a B.S. in Biological Sciences (1984) and an M.S. in Biological Sciences (1987) from the University of California, Irvine.

After working in a variety of jobs, including biological consulting, Carol joined the Fish and Wildlife Service in 1992. She was in the Environmental Contaminants program from 1992-2000, including two years as Branch Chief.

Carol has worked on a number of studies at the Salton Sea including the Yuma Clapper Rail study and the Drain Selenium study conducted in cooperation with the USGS. In 2000, Carol assumed the position of Salton Sea coordinator and has been focused on the Restoration Project, the water transfer, and canal lining projects.

Dr. Tonie Rocke

Past President
Wildlife Disease Association

Tonie received a Masters of Science in Veterinary Science in 1982 and a doctorate in Veterinary Science and Wildlife Ecology in 1985. Tonie has been an Epizootiologist at National Wildlife Health Center, Madison, Wisconsin since 1985.

Carla Scheidlinger

Project Manager
Agrarian Research and Management Company

Carla Scheidlinger is a project manager for Agrarian Research and Management Company, which has designed, built, and is operating the pilot ponds for solar evaporation under contract to the Salton Sea Authority.

She is a graduate of Swarthmore College and Harvard University, and earned a master's degree from San Diego State University.

She has worked in the field of environmental remediation for over 8 years. Her current work with Agrarian involves the development of control measures for fugitive dust at the Owens Lake, as well as pioneering highly effective bioremediation techniques for removing selenium from agricultural drain water.

She is also the project manager for the solar evaporation pilot ponds that are investigating salinity control strategies for the Salton Sea.

Jim Setmire

Area Hydrologist
U.S. Bureau of Reclamation

Jim has 30 years experience as a hydrologist with the U.S. Geological Survey. He currently is on detail to the U.S. Bureau of Reclamation. The focus of Jim's work is on surface water quality, including sediment and biota.

Prior to his current assignment, Jim was the chief of the Western Lake Michigan Drainages study unit of the National Water Quality Assessment Program, located in Madison, Wisconsin.

Jim worked in the southern California office of the USGS for over 20 years. He was project chief of several studies in the Salton Sea area as part of the National Irrigation Water Quality Program. He headed a multi-agency team investigating the effects of agricultural drainage on water, sediment, and biota in the Salton Sea area.

Jim has a Bachelor of Science degree from the University of Southern California with a major in bacteriology and a minor in chemistry.

His current assignment with the Bureau of Reclamation involves reclamation activities in the Salton Sea area. The primary focus of this work is on selenium removal from drain water. He is also involved in projects concerning the eutrophication of the Salton Sea. Jim was the editor of the report "Eutrophic Conditions at the Salton Sea" which presented the results of the Eutrophication Workshop convened at the University of California at Riverside, September 7-8, 2000.

Michael J. Spear

Deputy Secretary for Land Conservation and Stewardship
California Resources Agency

Mike Spear has worked on conservation issues for more than 30 years. He began his career with the U.S. Fish and Wildlife Service in Washington D.C.

Mr. Spear has worked as a Regional Director in Albuquerque, New Mexico, and Portland, Oregon. He served as the Assistant Director for Ecological Services in Washington, D.C., and was the Manager of the California/Nevada Operations Office here in Sacramento for three and a half years.

As Manager of the CNO, Mr. Spear provided hands-on leadership to regional conservation planning efforts in California, building a strong partnership with the State. In July, Mr. Spear joined the California Resources Agency as the Deputy Secretary for Land Conservation and Stewardship.

Maureen A. Stapleton

General Manager,
San Diego County Water Authority

Maureen A. Stapleton is the General Manager of the San Diego County Water Authority, the public agency responsible for providing more than 2.8 million people living in the San Diego region with a safe, reliable supply of imported water.

Stapleton is the Authority's ninth general manager since it began operations in 1945. She assumed her duties in January 1996.

During her tenure, Maureen has played a leadership role in securing reliable water supplies, improving the regional water delivery and storage system, increasing local water supplies, and implementing a more stable mix of funding sources.

The Authority has acted to diversify San Diego County's water supply by securing new water sources. In April 1998, the Authority signed an historic water conservation and transfer agreement with the Imperial Irrigation District that eventually will provide approximately one-quarter of the county's water supply. And in November 1998, the Authority signed an Exchange Agreement with Metropolitan Water District of Southern California that will satisfy the transportation arrangements for the water transfer agreement.

In addition to the effort to secure a diversified water supply, the Authority is investing more than $1.5 billion in a long-term capital improvement plan to expand and enhance the regional water delivery and storage system. Included in this plan are construction of a new dam and reservoir, and the raising of an existing dam within the San Diego region. These investments will not only improve the reliability of the system, but will add almost 100,000 acre-feet of additional storage within San Diego County.

The Authority also is working with its 23 member agencies to expand the region's dependable supply of local water resources through conservation, recycling and groundwater development projects, some of which have received state and national recognition. It is anticipated that these efforts will increase local supplies from approximately 50,000 to over 100,000 acre-feet by the year 2015.

Before joining the Authority, Stapleton worked for the City of San Diego for nine years and served as Assistant City Manager from 1991 to 1996. Prior to that, she was Assistant City Manager for the City of Claremont.

Stapleton earned her bachelor's degree with honors from California Polytechnic University in Pomona and her master's degree in public administration from California State University Consortium at Long Beach. She lives in San Diego with her husband, Frank.

Rita Schmidt-Sudman

Water Education Foundation

Rita specializes in planning and management of small and large-scale education programs, television and radio production, editing written publications, public policy presentations, project management, design and implementation of public involvement campaigns.

She served as Executive Director for the Water Education Foundation from 1980 – 2000, developing the Foundation's annual budget from $30,000 to $1.5 million.

She also was responsible for coordinating the Foundation's activities with its 25-member Board of Directors, which represents a broad cross section of West's water, business, education, public service and environmental communities.

The Foundation's 9 member staff and numerous contract writers, artists, and volunteers.

She currently is Editor of Western Water magazine, a bi-monthly publication with a circulation of 20,000 and Represents the Foundation on state, national and

international organizations and forums. Her current board affiliations include Water For People, University of California Water Resources Center and Archives.

Rita is also responsible for creation and coordination of public involvement and outreach programs and Supervises web site development for the Foundation.

She has served as technical advisor and fund development manager on major public and commercial television documentaries: Water Colors: Restoring the Klamath River Basin with Larry Hagman (2000), Setting a Course: The California Bay Delta with Tim Busfield; Safe and Sound (1998) and Flood Warning (1997)- flood documentaries; Healing the Water: The Truckee River and Pyramid Lake with Robert Conrad (1997) and To Quench A Thirst: The California Water Story with Roger Mudd.

She was Technical advisor and developed scripts for a series of short educational videos on Groundwater Quality, Conjunctive Use (1999) and Water Recycling in California and Nevada (2000).

Daniel Taylor

Executive Director
Audubon California

Dan Taylor serves as Executive Director for Audubon California, the official state program of the National Audubon Society, a position he has held since 1996.

He leads the Audubon conservation efforts in California that includes 51 local chapters and 67,000 members and a professional staff of 40.

Before assuming the post as State Director, Mr. Taylor served as western regional representative of the National Audubon Society for 17 years. His duties included leading National Audubon's work on protecting Mono Lake, endangered species protection, and forest conservation.

A California native, he received an AB degree in zoology from University of California, Davis, and an MA in Biology with emphasis in plant ecology from California State University, Fullerton.

Mr. Taylor has served on numerous state boards and task forces including the Central Valley Habitat Joint Venture, the California Riparian Habitat Joint Venture, the California Timberlands Task Force, and the Upper Sacramento River Fisheries and Riparian Habitat Advisory Council.

A resident of Sacramento, he is married and the father of a seventeen year old son.

The mission of Audubon California is to conserve and restore California's natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefit of humanity and the earth's biological diversity.

Mike Walker

Salton Sea Program Manager
U.S. Bureau of Reclamation

Mike graduated from Arizona State University with a B.S. in Wildlife Ecology (1976) and an M.S. in Zoology (1978), specializing in large mammal ecology.

After graduate school, he spent several years conducting various wildlife research projects involving black bears, desert bighorn sheep, feral burros, mule deer, peregrine falcons and bobcats for various entities including the Navajo Tribe and the State of Arizona.

He has worked with the Bureau of reclamation for 25 years. His primary responsibilities during this period were fulfilling requirements of various environmental laws, specializing in NEPA, ESA, and the Fish and Wildlife Coordination Act.

He has been a member of Reclamation's NEPA Implementation Team (NIT) and has assisted in revising Reclamation's NEPA Handbook. Since 1992, Mike has held various managerial positions and has overseen several large projects and programs such as the preparation of the Biological Assessment for Interim lower Colorado River Biological Opinion for the lower Colorado River Operation and Maintenance Activities, implementation of the RPA provisions for the Interim Biological Opinion for the lower Colorado River Operation and Maintenance (1996-2000); he was also a member of the lower Colorado MSCP regional Team, and has held the positions of Regional Environmental Compliance Branch Chief and Regional Group Manager for Biological Resources.

He has, for the past year, fulfilled the responsibilities of the Salton Sea Program Manager while working out of the Regional and Yuma Area Offices.
Mike presently lives in Yuma, Arizona with his 8-year-old son, Bryant.

Nils Warnock

Point Reyes Bird Observatory

Nils Warnock co-directs the Wetlands Program at the Point Reyes Bird Observatory. Nils received his Ph.D. in Ecology from the University of California, Davis and San Diego State University.

Much of his current research focuses on the conservation and management of water birds. He is also actively engaged in Endangered species research.

In 1999, Nils was the principal investigator of the EPA and Salton Sea Authority funded project: Avifauna of the Salton Sea: Annual phenology, Numbers and Distribution.

Recently, he has been collaborating with the USGS and other organizations in trying to better understand the relationship between bird populations and salt pond habitat in San Francisco Bay, as well as conducting research on how radio-marked shorebirds migrate along the Pacific Flyway.

Paul Weghorst

Hydrologist and engineer
Bureau of Reclamation

Paul Weghorst is a principal hydraulic engineer for the Bureau of Reclamation in Denver, Colorado.

He is a register professional and received a civil engineering degree at the University of Colorado in 1982. He is a recognized expert in the fields of water resource management, hydrology, and arid advanced hydrologic modeling applications.

He has spent the majority of his career in public service as a consultant to Reclamation offices throughout the Western United States. Currently Paul is assigned to the Salton Sea Restoration Project as both a hydrologist and engineer.

SALTON SEA AUTHORITY

The Salton Sea Authority

is a joint powers agency formed in 1993 by

- the Coachella Valley Water District
- the Imperial Irrigation District
- Riverside County
- Imperial County

The Authority's Board of Directors is comprised of elected officials from each of these member agencies.

The Torres Martinez Desert Cahuilla Indian Tribe and Federal, State and regional agencies are also represented within the Authority.

The Authority was formed to bring together the many stakeholders interested in understanding and addressing the Sea's challenges and making the most of the Sea's opportunities. The Authority believes restoration of the Sea is a unique opportunity to improve the environment and enjoy economic benefits in doing so.

The Salton Sea Authority is committed to maintaining the Sea as an agricultural drainage reservoir protecting and enhancing the Sea as a critical link along the Pacific Flyway, stimulating recreational use and providing an environment for economic development. Before 1997, the Authority relied on funds provided by the member agencies and a small grant to carry out its mission. Since then, the Authority has received, or will receive, over nineteen million dollars from Federal and State appropriations and a State bond measure to further its mission.

The Authority has entered into a joint agreement with our Federal partner, the U.S. Department of Interior's Bureau of Reclamation. Together, our agencies are providing the engineering and environmental analysis to provide a restoration report to Congress to meet the terms of the 1998 Salton Sea Reclamation Act. Additionally, the Salton Sea Authority has provided, through a federal appropriation, all of the funding supporting the work of the Salton Sea Science Subcommittee. Their efforts led to the greatest degree of ecological understanding of the Sea ever compiled. The Authority is now supporting a series of pilot projects. The first underway is a wildlife disease program in concert with the U.S. Fish & Wildlife Service, Department of Fish and Game and National Wildlife Health Center. Other pilot projects will address desalinization, harvesting fish and cleaning up the shoreline.

While the Authority's budget and activities have expanded, its commitment to action, entrepreneurialism, and partnerships has not waned. Over 90% of the Authority's budget goes to contractors to provide environmental planning, scientific, engineering, construction and operation services. The Authority's ability to maximize its use of funds is furthered by inherent and fostered relationships with federal, state, tribal, environmental and other agencies and organizations.

BOARD OF DIRECTORS

Roy Wilson
Supervisor, District 4
County of Riverside

Andy Horne
Imperial Irrigation District

James Venable
Supervisor, District 3
County of Riverside

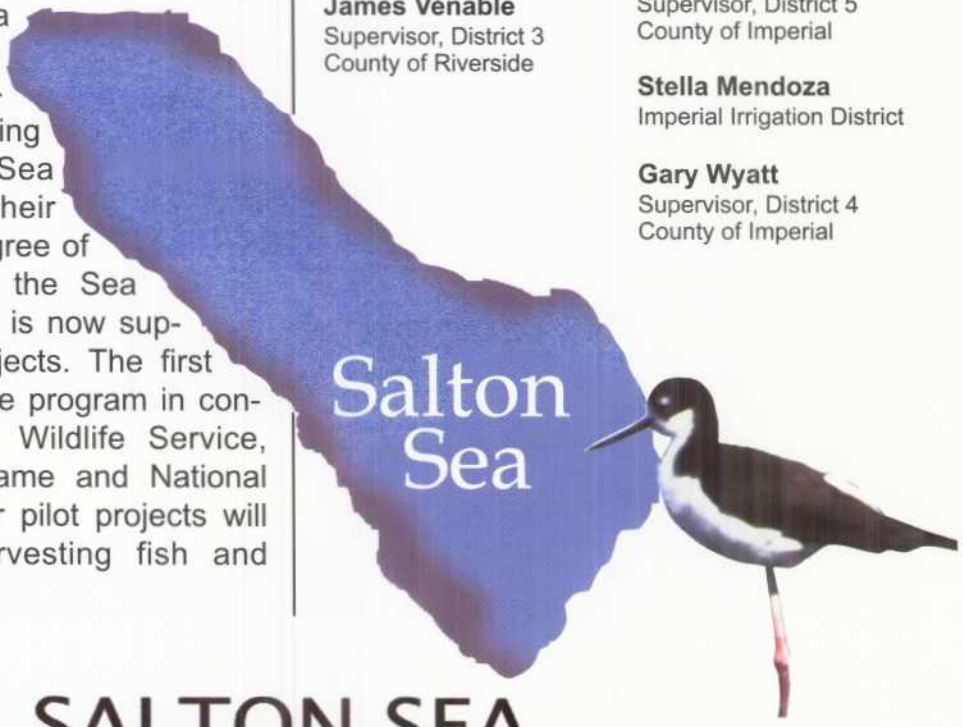
Peter Nelson
Coachella Valley Water District

Corky Larson
Coachella Valley Water District

Wally Leimgruber
Supervisor, District 5
County of Imperial

Stella Mendoza
Imperial Irrigation District

Gary Wyatt
Supervisor, District 4
County of Imperial



Tom Kirk
Executive Director
Linda Quesnell
Executive Secretary

SALTON SEA AUTHORITY

78-401 Highway 111
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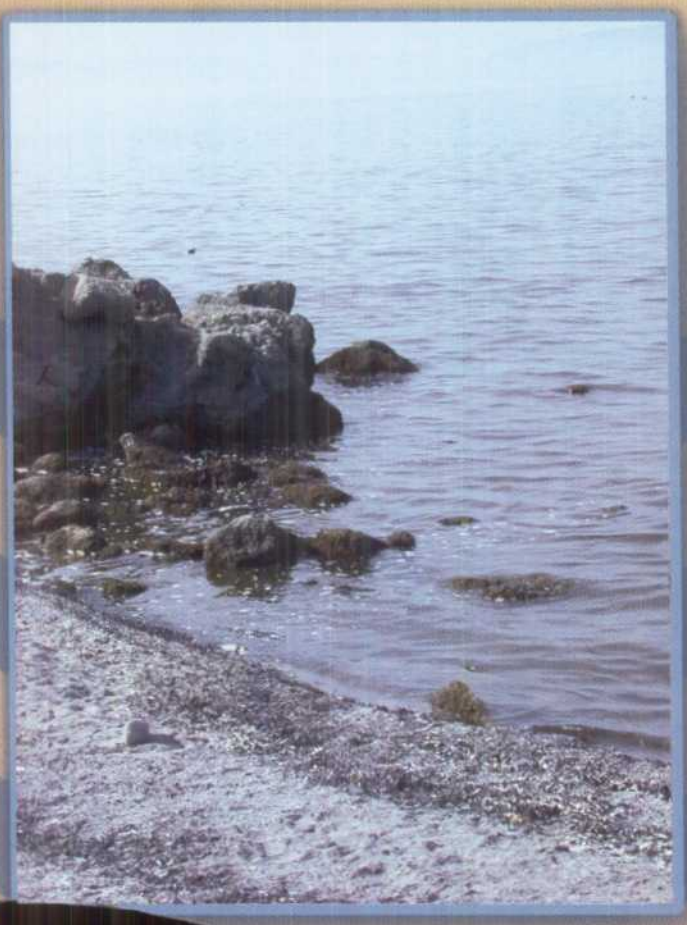
La Quinta, CA 92253

www.saltonsea.ca.gov
(760) 564-4888

Debunking the Myths

Restoration of the Salton Sea is a unique opportunity to improve the environment and enjoy economic benefits of a major natural resource. The Salton Sea Authority stands committed to maintaining the Sea as a critical link along the Pacific Flyway, stimulating recreational use and providing an environment for economic development, and maintaining the Sea as an agricultural drainage reservoir.

As we begin to realize these goals, everyone involved in this effort can also assist by helping to dispel the numerous myths about the Sea that have spread throughout the country. These myths have made it more difficult to define the Sea's problems, explore and understand the Sea's possibilities and take the steps necessary to travel from understanding the problems to creating the possibilities.



Myths and Realities

Myth No. 1

"Given its man-made origin, the Sea should simply dry up and revert to its dusty and dry natural beginnings. Dust to Dust."

The Facts

This myth begins with the factual history of the Sea. Massive flooding in 1905 caused the Colorado River to break through an irrigation canal head works and flow freely into the Salton Basin for a year and a half. Man's "intervention" may have been to stop, in 1907, what had been a natural process for thousands of years.

Myth No.1 assumes that a static, dry, "natural" state exists in the basin. It does not. There have been numerous occurrences of flooding of the Salton Trough by the Colorado River since the mid-1800's. There have been at least 4 previous Salton Seas of greater magnitude during historic times. The last Lake Cahuilla disappeared around 300-500 years ago.

Indians made use of a massive Sea's bounty during the 1500's, leaving behind artifacts recording their practices. Each time and countless times before, the Colorado River has meandered west and filled the Salton Basin with fresh water.

Drainage from 500,000 acres of farms in the two Valleys now sustains the Sea. The Sea is a designated Federal repository of agricultural run-off and agriculture is a billion dollar mainstay of the Valleys' economies. Agricultural use will continue into the future.

Myth No. 2

"The Salton Sea is a Marginal Ecological Resource"

The Facts

The Sea is increasingly important to the Pacific Flyway because over 92% of the wetlands that provided habitat value to birds along the Pacific Flyway in California have disappeared.

Several million birds migrate and inhabit the area every year. The Sea provides wintering habitat for over 450,000 ducks and up to 30,000 Snow and Ross geese. In fact, over 400 species of birds have been spotted at and around the Sea, more than any other place in the U.S. other than the Gulf Coast of Texas. Endangered species also make the Sea their home, including the Brown Pelican and Yuma Clapper Rail.

The U.S. Fish and Wildlife Service was prepared to de-list the Brown Pelican until 1400 died at the Salton Sea in 1996, decimating approximately 1/3 of the California population. This and other bird die-offs is a significant issue but must be put into perspective with the safe, healthy refuge the Sea provides to millions of other birds every year.

Myth No. 3

"The Salton Sea is a Marginal Economic Resource."

The Facts

Before 1985, the Sea's State Park had more visitor days per year than did Yosemite National Park and press reports from the 1960's highlight the popularity of the Sea as a recreational destination. Complaints about overcrowding and conflict between boats and swimmers on the 350+ square-mile lake were common.

A 1985 California Fish and Game study found that the Sea was more productive (fish caught per angler hour) than any California marine fishery and equal to the most productive freshwater fisheries. A study now underway indicates that the fishery may be the most productive in the world.

Business and academic interests have suggested that a restored Sea could drive the regional economy for years to come.

Myth No. 4

"Mexicali Pollution is causing all of the problems at Salton Sea."

The Facts

While much publicized, water carried by the New River from Mexico is not a major contributor to the Sea's problems. In fact, only about 12% of the Sea's inflow originates in Mexico.

By the time water containing human and industrial wastes crosses the border and traverses the 60 miles to its delta at the Sea, the New River's water quality is nearly equivalent to that of the nearby Alamo River's. Waste from Mexico undergoes natural treatment in the River and is diluted by agricultural drainwater from the Imperial Valley. Additionally a wastewater treatment plant is being constructed in Mexicali to improve water quality in the New River.

Myth #5

"The Sea is a Toxic Dump Created by Agriculture"

The Facts

Pesticides are not found at any significant level in the Sea. Pesticide levels are periodically found to be high at some drains, but the Sea's shear volume and most pesticides' ability to biodegrade seems to limit their impact pact.

This was further validated with two independent studies conducted by the Salton Sea Science Subcommittee. This research indicated there were no pesticides detected in the sediment and water quality of the Salton Sea. A third study found extremely low levels of contaminants in the Sea's barnacles, a finding which surprised the researchers because the levels were much lower than found in the waters of San Diego.

Selenium is another concern. Selenium is a naturally occurring element in Colorado River water, the source of the vast majority of the Sea's water, not in the soils of the Imperial and Coachella Valleys. The infamous culprit at Kesterson reservoir in central California is found at about 1 microgram per liter in the Sea water, with some localized areas with higher concentrations. For comparison, the federal standard is 5 micrograms per liter and at Kesterson the level was about 80 micrograms per liter.

Then what are the Sea's actual problems?

The Facts

One is its immensity and complexity. It is California's largest inland body of water and supports an ecosystem of introduced and endemic biota. Another is its location. Far from urban centers and the usually vigilant eye of environmental interest, the Sea has been largely ignored. With the recent massive bird die-offs, the environmental community is waking to the Sea's problems and possibilities (the Audubon Society has made the Sea a #1 priority).

We do not know all that there is to know about the Sea. But we do know its problems include bird disease outbreaks, fluctuating surface levels, nutrient-rich water, algal blooms and fish kills. We are also certain of at least one factor that has and continues to contribute to the Sea's downward spiral of ecological and economic health: salinity. The Sea's salinity has steadily increased over the years. Now at 44 parts per thousand, or 25 o/o greater than the ocean, the hyper-saline environment is jeopardizing the survival of fish and will ultimately jeopardize the survival of much of the Sea's biological bounty.

And that is why we must act while there is still time to develop short term and ultimately long term solutions to restoring the Sea. We must not cave in to the myths that have contributed to public confusion for so many years now. The Sea's immensity, complexity and remoteness may in the past have combined to create the Sea's greatest threat: uncertainty leading to unease resulting in inaction.

However, the knowledge developed from the extensive research on the real problems, coupled with the political will to take responsible action have made it a new day.

SALTON SEA AUTHORITY

www.saltonsea.ca.gov

The History and Culture of the Sea

SALTON SEA Restoration Project

SEA FACTS

The history of the Salton Sea area has been scrutinized in the last decade more closely, perhaps, than ever before, especially as the culture and history of the region's land and people are studied for environmental impacts. Although there may have been no historical events of global significance associated with the Sea, the creation of the Sea itself and the rise of the region's agricultural industry are two very important chapters in local and California history.

From an anthropological standpoint, the Salton Basin is rich in Native American history. Nine different Native American groups have occupied the area around the Salton Sea Basin, including the Cahuilla people, from whom the members of the present-day Torres Martinez Desert Cahuilla Indians are descended. When the Spanish made contact with the Cahuilla people in 1774, there were about 6,000 members of the tribe. In 1876, the US government established the 24,800-acre Torres Martinez Desert Cahuilla Indian Reservation; thirty years later, nearly half of the reservation was submerged when the basin flooded with Colorado River water to form the Salton Sea.

The University of California's Bancroft Library maintains a collection of Imperial County photographs from the turn of the 20th century. Many of the photographers were amateurs, who nonetheless often captured images of daily life of the Native American and early nonnative residents. At right is a photo of Antonio Martinez, a full-blooded Cahuilla man from Indio. A typical Desert Cahuilla Indian dwelling (below) was made of brush secured to a frame of branches.

Photos courtesy of Bancroft Library, University of California

Although Native Americans had occupied the Salton Basin for at least 12,000 years, it wasn't until 1771 that the first Europeans laid eyes on the Imperial Valley. As early as 1853, the valley was recognized as a potential garden spot in the desert, if only it could be adequately irrigated. This dream became reality with the building of the Imperial Canal in 1901. This event led to an agricultural boom in the Imperial Valley, and land speculators moved in, spawning such new towns as Calexico, Heber, Imperial, and Brawley. But in only three years, the canal could no longer supply the valley with water—its flow had become blocked with silt. The temporary diversion of the Colorado River that was constructed to replace the water from the blocked canal was breached

The History and Culture of the Sea (continued)

in 1905 during a flood, which proved to be the most significant natural event since Lake Cahuilla dried up: by the time the breach had been repaired, the overflow had created the Salton Sea.

Repairing the breach was an impressive engineering feat in itself. A railroad trestle, destroyed by the flood waters, was replaced by two trestles built across the breach to allow railcars to bring in fill material. Carloads of boulders, gravel, and sand were brought in 24 hours a day to build a dike, which, sixteen months later, would cut off the flow of Colorado River water to the Sea.

In 1911, the Imperial Irrigation District was established and began promoting a new canal to supply water to the valley. Congress authorized building the All-American Canal in 1928, and by 1942 the canal was supplying the Imperial Valley with water; the Coachella branch of the canal began carrying water in 1948. Today, the agricultural industry uses approximately 98 percent of the region's water supply.

As early as 1907, one of the first recreational pastimes that was promoted for the Salton Sea was sport fishing. When it began to catch on, the California Department of Fish and Game started stocking the Sea with game fish. By the 1950s, all manner of recreational pursuits had been promoted, including hunting, swimming, boating, water-skiing, birding, and hiking. With the recreational enthusiasts came other kinds of tourists, and with the tourists came hotels, resorts, restaurants, marinas, and a state park.

Today it's up to the Salton Sea Authority and the US Bureau of Reclamation, along with the many stakeholders and residents of the Salton Sea area, to find ways to make sure that the Sea has a future.

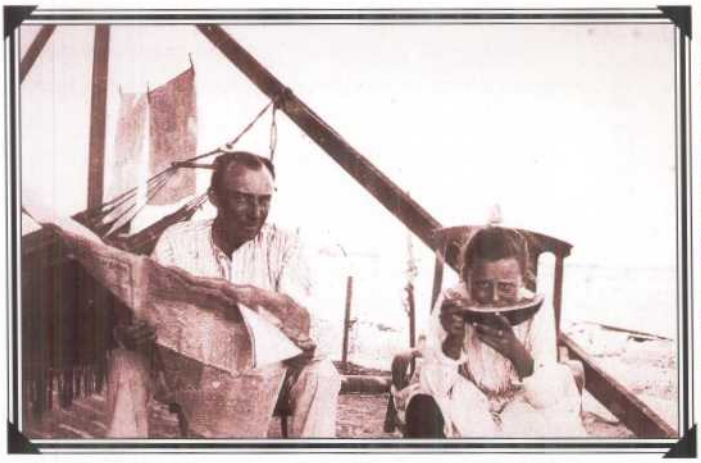
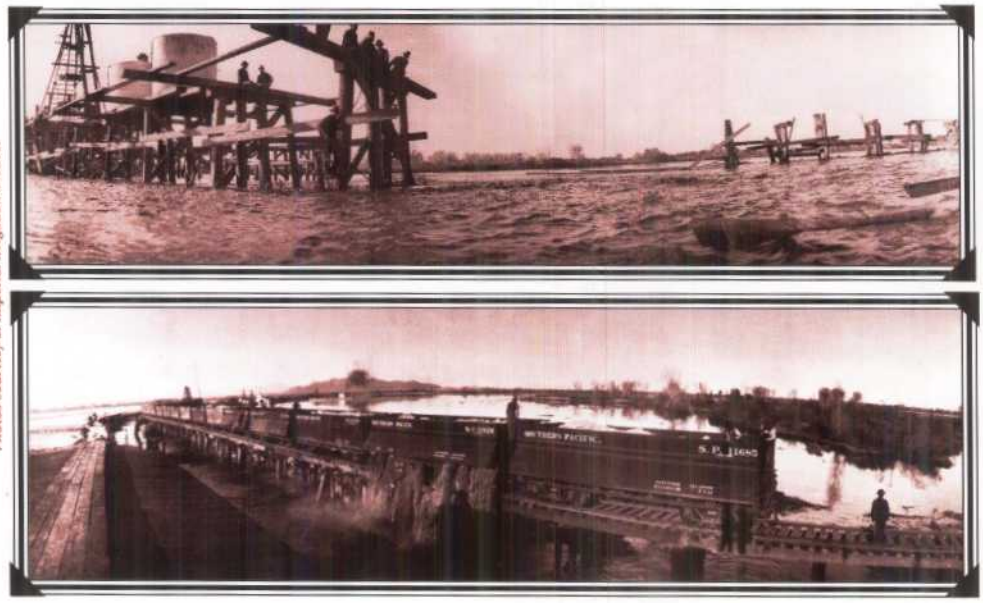


Photo courtesy of Bancroft Library, University of California

Mr. F. S. Miller reads while his daughter enjoys a slice of watermelon. Mr. Miller built Brawley's first hotel, The Bungalow, and the first school building, which doubled as a church on Sundays. Before moving to a new home, the Miller family lived in a tent "until the scare about the Colorado River overflowing and the danger of it flooding the Imperial Valley. Then the fun was all over and fear filled our souls."



Photos courtesy of Imperial Irrigation District

When the Colorado River breached, the force of the water all but destroyed the railway trestle that ran across one of its banks (top left). To mend the breach, two trestles were built; then carloads of boulders, gravel, and sand were brought in 24 hours a day to contain the outflow (below left).

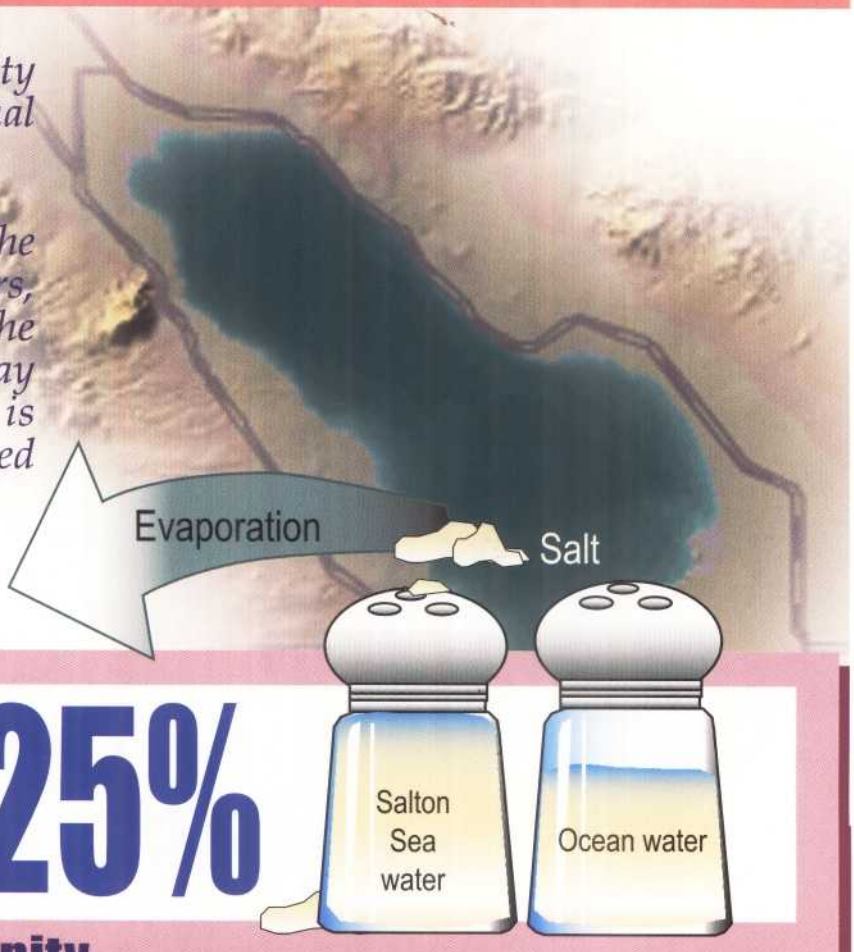
SALT PROBLEMS

SALTON SEA Restoration Project

SEA FACTS

The Salton Sea has a salinity problem because it is a "terminal lake," meaning it has no outlets.

Water flows into the lake from the Whitewater, Alamo and New rivers, bringing with it salt from the Colorado River. The only way Salton Sea water can leave is through evaporation. The imported salt is left behind.



SALTS

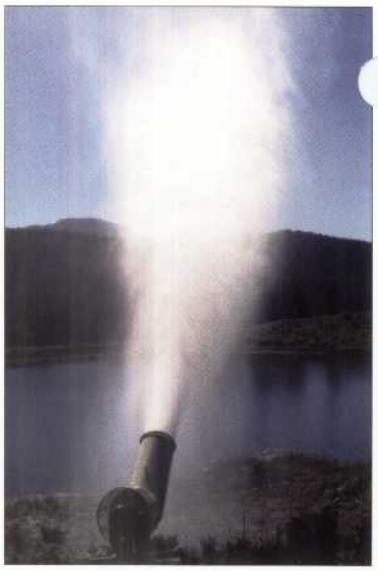
pose a serious problem because of the level of salinity in the lake. The Salton Sea is currently 25 percent saltier than the ocean and getting saltier every day. There are an estimated 500 million tons of salt in the Salton Sea.

25%

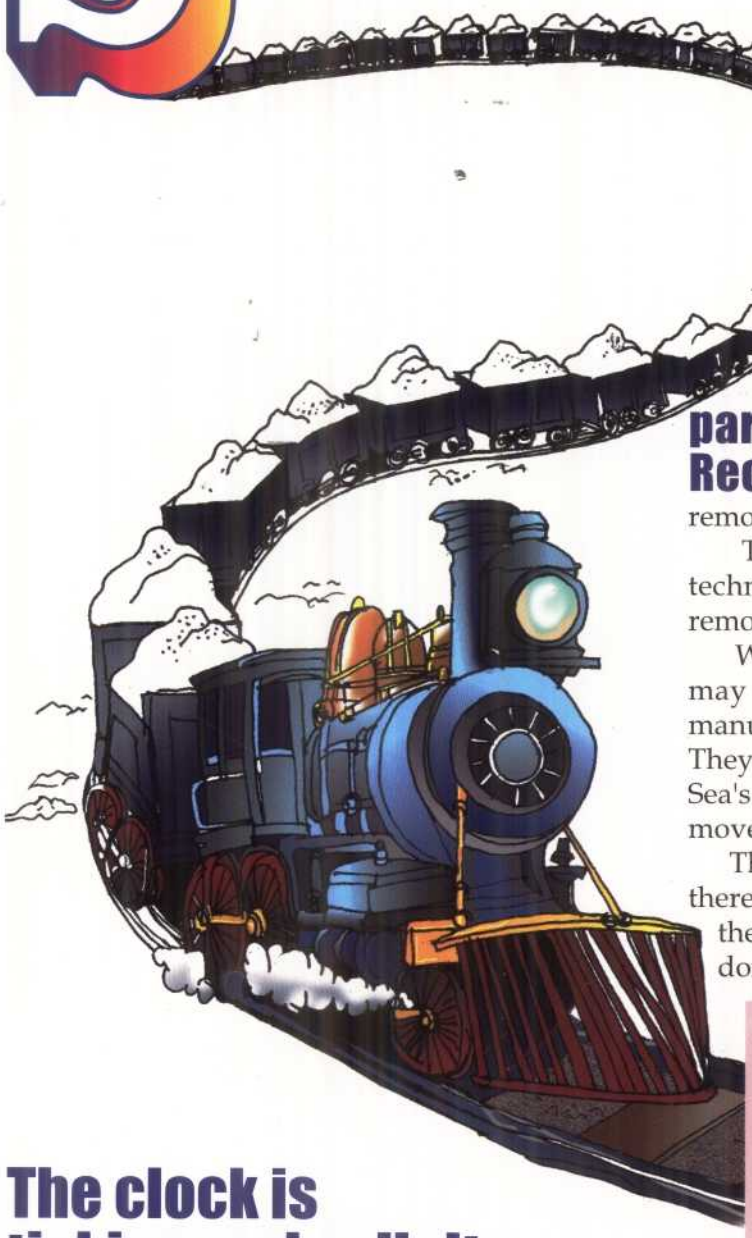
Salinity has been called Salton Sea's "time bomb." Scientists are concerned that even a small increase could be enough to affect fish reproduction and ultimately survival, affecting not only fish but the birds that feed on them. The economic development of the area also could be adversely affected if salinity is not controlled.

Several million tons

of salt are added to the lake every year - an estimated train load every day. Even if that "train" were to be stopped, salinity would not be reduced because of continuing evaporation.



The use of enhanced evaporation systems is one of the methods being tested for removing salt from the Salton Sea.



The Salton Sea Authority, in partnership with the Bureau of Reclamation, is testing several methods for removing salt from the Salton Sea.

There is a dilemna, though, with any salt reduction technique: what should be done with the salt that is removed from the lake?

While the material may be of sufficient quality that it may be attractive to commercial markets, salt manufacturers are doubtful that it would be profitable. They say that high transportation costs from the Salton Sea's remote location to market centers may make such a move financially impractical.

The disposal problem, then, remains an issue. Perhaps there could be uses for some of the salts that come out of the water. However, much more work needs to be done.

The Challenges

- To remove salt at a scale never before attempted.
- To dispose of the salt removed.

The clock is ticking and salinity reduction is a priority.

The ultimate solution lies in a cost-effective, efficient method that stabilizes salinity levels so that we don't lose the fishery. The Salton Sea will never be a clear freshwater lake. But then again, our responsibility is to insure it does not become a dead sea.

SALTON SEA RESTORATION PROJECT
(760) 564-4888 or (702) 293-8129
www.saltonsea.ca.gov

SALINITY REDUCTION: WHAT WON'T WORK

SALTON SEA Restoration Project

SEA FACTS

The Salton Sea is a unique environment and needs to be preserved as a highly productive link in the Pacific Flyway. For the first time, there is hard science to guide decisions and improve the chance of success.

But, as we actually begin work to restore California's largest lake after more than 50 years of studies, one thing has become evident: there is no silver bullet to reduce salinity.

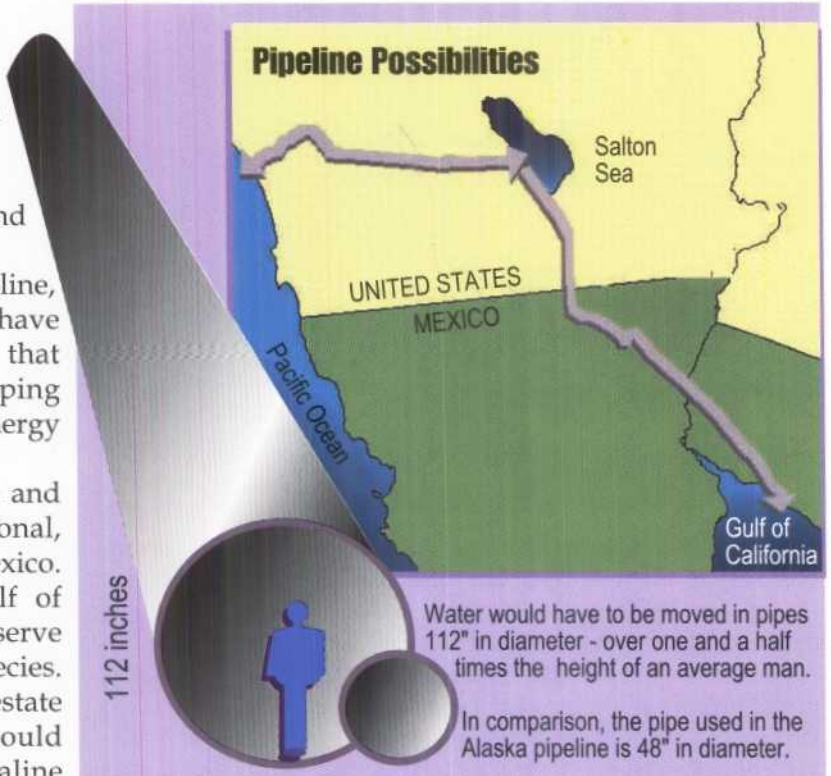
So, why don't we just transport the lake's water to the ocean through pipes to create an outlet for the Salton Sea and bring ocean water back? It sounds appealing.

PIPELINES could pump Salton Sea water out to the Gulf of California or the Pacific Ocean and pump ocean water back in. The problem, though, is much more complex. In fact, the practicality of this idea evaporates when costs and environmental issues are closely examined.

The cost, both to build and to operate a pipeline, is estimated at $3 billion. Each pipeline would have to be huge to handle the volume of water that would need to be moved. Multiple pumping stations would be required and the annual energy demand would be large.

Permits and rights of way for construction and operation would be needed from local, regional, state and federal governments, including Mexico. Parts of the Colorado River Delta and Gulf of California are in an international biosphere reserve with both land- and sea-based endangered species. The California coast contains expensive real estate with influential owners. Neither area would welcome massive pipelines disposing of saline water, and court challenges and appeals would be inevitable.

Scientists and environmentalists are concerned about the inability to control any "little critters" that might be transferred from the ocean to the Salton Sea or vice-versa. Transferring unwanted new species, bacteria and disease, or pollution could be an unwanted outcome and is also prohibited under federal regulations.



Even if all the above issues could be resolved, the pipelines would be unlikely to make a dent in reducing salinity. Ocean water is just about as saline as Salton Sea water. As a result, the salt coming in would greatly increase the demand on systems to remove salt and would greatly lengthen the time it would take to reduce salinity.

Okay. Can a shipping canal work better?

Again, it sounds great. After all, it could be used by boats and be a boost to economic development in the region. But getting the necessary agreements in place to exchange ocean and Salton Sea water would take too long to help the wildlife that is dependent on the lake. And, shipping canals are less effective than the pipelines in moving water.

What about desalinization?

The Salton Sea Authority, in partnership with the Bureau of Reclamation, is presently evaluating the potential of reducing salinity with a combination of passive and active desalinization techniques. Other options that have been proposed include reverse osmosis, bioremediation and collecting and recycling the water as it evaporates from the salt. None of these options have proven technology at the scale required for the Salton Sea. Desalinization would require both a very expensive desalting facility and an expensive disposal system for the brine in a process that would extract relatively small amounts of salt. While some of these methods may be a cost-effective alternative or adjunct in the future, the Salton Sea's need is virtually immediate and cannot wait.

We can't afford to be sidetracked.

Whatever actions are undertaken will take time and one single act will not cure all of the problems. There is no silver bullet. However, we have a window of opportunity now. Interest in restoring this vital resource is very high among governmental and non-governmental leaders at local, state and federal levels. We have enough information to get started now. There are cost-effective options available and we must pursue them.

The Salton Sea is too important to ignore.

SALTON SEA RESTORATION PROJECT
(760) 564-4888 or (702) 293-8129
www.saltonsea.ca.gov

Eutrophic Conditions at the Salton Sea

A topical paper from the Eutrophication Workshop convened at the University of California at Riverside, September 7-8, 2000

Edited
by

Jim Setmire[1]

Contributions from:

Chris Holdren[2]
Dale Robertson[3]
Chris Amrhein[4]
John Elder[3]
Roy Schroeder[5]
Geoff Schladow[6]
Hank McKellar[7]
Rick Gersberg[8]

Workshop sponsored by the Salton Sea Authority, the Salton Sea Science Office, and the U.S. Bureau of Reclamation

1. Jim Setmire – Hydrologist, U.S. Geological Survey on detail to the U.S. Bureau of Reclamation, Temecula, CA.
2. Chris Holdren – Limnologist, U.S. Bureau of Reclamation, Denver, CO.
3. Dale Robertson – Research Hydrologist, U.S. Geological Survey, Middleton, WI.
3. John Elder - Research Hydrologist, U.S. Geological Survey, Middleton, WI.
4. Chris Amrhein - Professor, University of California, Riverside
5. Roy Schroeder - Research Hydrologist, U.S. Geological Survey, San Diego, CA.
6. Geoff Schladow - Associate Professor of Water Resources and Environmental Engineering, University of California, Davis
7. Hank McKellar - Associate Professor, Dept. Environmental Health, Sciences, University of South Carolina
8. Rick Gersberg - Professor, San Diego State University, San Diego, CA

EUTROPHIC CONDITIONS AT THE SALTON SEA

BACKGROUND:

LOCATION AND HISTORY OF SALTON SEA

The Salton Sea is located in the southeastern desert of California. It occupies the northern part of the Salton Trough that includes the Coachella and Imperial Valleys of California and the Mexicali Valley of Mexico. The current Salton Sea was formed during the 17 months from October 1905 to February 1907 following summer flooding and the failure of a temporary diversion of the Colorado River. During the 17 months, most of discharge of the Colorado River flowed into the Salton Trough. At the closure of the break, the Salton Sea's elevation was
-195 ft Mean Sea Level (MSL) and the surface area was 520 square miles. Evaporation and lack of significant tributary inflow caused the Sea's elevation to gradually recede to a low of -250 ft MSL by 1925. From 1925 to the mid 1980's, the elevation of the Salton Sea gradually increased to its current level at about
-227 ft MSL as a result of increased agricultural discharge. The current Sea occupies about 365 mi^2.

Climate is an important factor controlling many of the physical, chemical and biological processes affecting the Salton Sea. The Imperial Valley, one of the most arid areas in the United States, has an average annual rainfall of 3 in. The maximum temperature exceeds 100 ^{0}F more than 110 days per year. The average annual temperature is 74 ^{0}F. Evaporation in the Salton Sea is estimated at 5.78 ft/yr (Hely and others, 1966). At its current elevation, about 1.34 million acre-ft of water annually is lost from the Salton Sea by evaporation. This loss is balanced by tributary inflow.

Agriculture in the Coachella and Imperial Valleys is sustained by Colorado River water diverted at the Imperial Dam and delivered via the All-American and the Coachella Canals. There are 481,000 acres (1995) of irrigated farmland in the Imperial Valley where agriculture and livestock grossed one billion dollars in 1995. The New and Alamo Rivers carry agricultural discharge from the Imperial Valley to the Salton Sea. The New River also carries agricultural discharge and municipal and industrial effluent from Mexicali, Mexico. The Whitewater River carries agricultural discharges, municipal and industrial effluent, and stormwater runoff from the Coachella Valley. Agricultural discharges from the Imperial, Coachella, and Mexicali Valleys along with municipal and industrial effluent maintain the elevation of the Salton Sea.

SALTON SEA HISTORY

Visitor use at the Salton Sea was at its peak levels during the 1950's and 1960's when the number of visitor days at the Salton Sea exceeded visitor use at Yosemite National Park. The boom period at the Sea saw development of marinas, a golf course, major recreational use, and the beginnings of home construction with the paving and naming of roads. Fishing and boating were at their peak, with record numbers of corvina caught. However, as a result of the continual loading of agricultural and municipal discharges, the very high evaporation rates, and no outlet for the Sea, the salinity continued to increase and the elevation to rise. The rising water level inundated many of the new structures and the salinity threatened the fishery. As the 1960's ended, the next decade seemed to bring forebodings of the demise of the Sea. Visitor use began to taper off, the stability of the Sea's elevation was uncertain, and the effects of eutrophication became more pronounced. Each succeeding decade seemed to heighten the previous decades problems, especially as the tilapia found their way into the Sea. The 1990's brought major bird die-offs, fish kills in the millions and concern for the health of the Sea's ecosystem. With no control over the increasing salinity, the uncertainty of the elevation, massive fish and bird kills, odor problems, shores lined with the skeletons of dead fish, and incredible algal blooms, the economic future of the area was bleak and the ability of the ecosystem to support a healthy fishery for the many fish-eating birds questionable.

SALTON SEA RESTORATION

The Salton Sea Restoration Project authorized under the Salton Sea Reclamation act of 1998 (Public Law 105-372) directs the Secretary of the Interior to: "complete all studies, including, but not limited to environmental and other reviews, of the feasibility and cost-benefit of various options that permit the continued use of the Salton Sea as a reservoir for irrigation drainage and: (i) reduce and stabilize the overall salinity of the Salton Sea, (ii) stabilize the surface elevation of the Salton Sea, (iii) reclaim, in the long term, healthy fish and wildlife resources and their habitats, and (iv) enhance the potential for recreational uses and economic development of the Salton Sea."

The current project builds upon decades of previous efforts to develop a means to address the increasing salinity of the Salton Sea and stabilization of its elevation. This focus has been driven by the impacts of these factors on recreational use of the Sea and on shoreline development. Other factors such as eutrophication, which impact the current Restoration Project, have not benefited from previous focused attention. As a result there has been no foundation to build upon. Solutions to the eutrophication of the Salton Sea have been comparatively intractable and/or costly. However, to meet the goals of the restoration project, a means to decrease the eutrophic character of the Salton Sea is needed. To these ends a workshop was convened as an initial evaluation of whether or not eutrophication was a problem meriting action, and if so, could it be addressed.

MEETING

On September 7-8, 2000, a panel of ten scientists, convened at the University of California at Riverside, concluded that eutrophication adversely affects the beneficial uses of the Salton Sea. Panel members were from both academic and federal institutions, some involved in past or active research in the Salton Sea, while the remainder had backgrounds in limnology and research experience in other eutrophic systems. The first day of the meeting was an open discussion session attended by about 50 individuals with varied interests in the Salton Sea. A brief introduction to the concepts of eutrophication was followed by presentations of case studies of eutrophic systems and nutrient cycling studies at the Salton Sea. The second day was a closed session at which panel members discussed the extent of eutrophication of the Sea and examined possible solutions to improve the problem. **This paper presents the results of the discussions, and as such, is not a complete analysis of nutrient cycling in the Salton Sea. It is intended to provide a glimpse of the complex dynamics of the Sea and possible actions to reduce its eutrophication.**

EUTROPHICATION – GENERAL CONCEPTS

Eutrophication is defined as "the loading of inorganic and organic dissolved and particulate matter to lakes and reservoirs at rates sufficient to increase the potential for high biological production and to lead to a decrease in basin volume" (Cooke and others, 1993). Eutrophication is a natural process that leads to the evolution of a lake through succession of different stages, from oligotrophic (least productive) to mesotrophic (intermediate state) to eutrophic (most productive). Usually this process takes thousands of years, but in recent decades, it has been rapidly accelerated in a number of systems around the world through the effects of human activities. This accelerated eutrophication process is often termed "cultural eutrophication."

Oligotrophic
Oligotrophic lakes generally are clear with low inputs of nutrients. The aquatic community of oligotrophic lakes is characterized by low biomass and low productivity. Because of the low productivity in the system, only small population densities of rooted vegetation (macrophytes), zooplankton, benthic invertebrates, and fish are supported.

Mesotrophic
Mesotrophic lakes show increased biological productivity, supported by higher inflows of nutrients. Although occasional algal blooms can occur, losses of dissolved oxygen in the deeper water are generally not severe or of an extended duration. Fisheries in many of these systems are excellent, with relatively high abundance of several desirable species. Moderate populations of rooted macrophytes, zooplankton, and benthic invertebrates are supported.

Eutrophic
Eutrophic systems, like the Salton Sea, typically are highly turbid. Productivity and biomass are very high which can become a problem if the biomass exceeds the capacity of the system to support it. One of the most common manifestations of this excess is the development of extensive oxygen depletion (anoxic conditions), caused by decay of accumulated senescent biological material. These conditions stress the aquatic life and may cause extensive fish kills, leading to even further oxygen depletion along with unpleasant odors.

Because of the high biological and chemical oxygen demand, anoxia can develop at almost any time in the hypolimnion. The lack of oxygen is not only a major biological stressor; it also has the important chemical effect of creating reducing conditions. The reducing environment leads to many chemical changes, including the transformation of sulfates to sulfides (including hydrogen sulfide gas that has a strong odor of rotten eggs) and reduction of nitrate to ammonia, which, at high concentrations, can be toxic to fish and other biota.

Algal communities in eutrophic systems commonly include populations of blue-green algae, some species of which are likely to produce extensive nuisance blooms. Fish species are generally limited to those with a tolerance for low dissolved oxygen, and other stresses; those species may indeed thrive under these conditions, finding plenty of food to support rapid metabolism and growth. Although they are subject to population crashes when the conditions become too stressful, they usually are able to recover quickly. Systems with very high turbidity that experience frequent algal blooms and fish kills are considered hypereutrophic.

Eutrophication is principally a function of nutrient inflow, but is often associated with sediment inflow; sediments flowing into a lake carry nutrients with them and, once they become part of the bottom material, they act as a nutrient reservoir in the lake, from which nutrients can be released to the water column.

A common misconception about eutrophication is that it correlates to toxicological problems in the same water body. In fact, eutrophication is *not necessarily* associated with toxic substances in the system. In some watersheds, where the nutrient sources are also toxicant sources, increases in nutrients and toxic substances might happen simultaneously, but in others, there is no relationship whatsoever. Eutrophic systems may or may not have elevated concentrations of toxic substances, and toxic-contaminated systems may or may not be eutrophic.

Limiting nutrients

Nitrogen and phosphorus are nearly always the chemical elements that act as the primary nutrients capable of stimulating primary productivity in aquatic systems. The ratio of their concentrations (the "N:P ratio") provides an indication of when a system changes from a potential imitation by one nutrient to a potential limitation by the other. This threshold ratio is determined by the needs of the primary producers, the algae and the macrophytes. Their needs are a function of the N:P ratio within their tissues. The "Redfield ratio" (Redfield et al. 1963) – often cited as a reference value by which to judge nutrient limitation – gives a ratio of 7.2:1 as the relative abundance of nitrogen and phosphorus (by weight) in marine phytoplankton. For freshwater systems, and for other organisms, this number can fluctuate considerably, but a reasonable estimate for most systems is 10:1. If the N:P ratio in the water is much higher than 20:1, P is nearly always the potential limiting nutrient; if it is lower than 10:1, N would likely be the limiting nutrient. Between these values, either nitrogen or phosphorus can become deficient, either in fresh water or salt water (Guildford and Hecky 2000). Light also could be locally limiting, especially during periods of intense algal blooms.

SALTON SEA AND EUTROPHICATION

CHARACTERISTICS

The Salton Sea is a eutrophic to hypereutrophic water body characterized by high nutrient concentrations, high algal biomass as demonstrated by high chlorophyll *a* concentrations, high fish productivity, low clarity, frequent very low dissolved oxygen concentrations, massive fish kills, and noxious odors. Water quality of the Salton Sea is summarized in the following tables, which were constructed from data collected from July 1968 to May 1969 (U.S. Department of the Interior Federal Water Quality Administration, 1970) and during 1999 from the Salton Sea Restoration Project (C. Holdren, USBR, 2000, written communication).

Salton Sea – Nutrient concentrations at the center of the Salton Sea

* Average mean concentration of three sites (4 depths sampled during summer)

Depth	Season	Ortho-P mg/L	Total P mg/L	NH3-N mg/L	NO3/NO2-N mg/L	TKN mg/L	Total N mg/L	N:P Ratio
				1968-69				
Surface	Summer	0.04	0.06	0.22	0.11	3.0	3.1	52:1
	Fall	0.02	0.05	0.36	0.22	3.3	3.5	70:1
	Winter	0.03	0.07	0.25	0.16	1.5	1.6	23:1
	Spring	0.06	0.20	0.27	0.49	4.5	5.0	25:1
				1999				
Surface	Annual mean*	0.024	0.087	1.3	0.1	3.6	5.0	104:1
	Summer	0.013	0.067	1.6	0.1	4.1	5.8	192:1
	Fall	0.032	0.043	1.2	0.1	4.2	5.5	137:1
	Winter	0.040	0.120	1.5	0.2	2.5	4.2	24:1
	Spring	0.012	0.116	0.9	0.2	3.7	4.8	64:1
Bottom	Annual mean	0.016	0.061	1.6	0.1	3.7	5.4	213:1
	Summer	0.003	0.056	2.5	0.1	5.3	7.9	430:1
	Fall	0.015	0.027	1.4	0	4.0	5.4	288:1
	Winter	0.037	0.079	1.5	0.1	1.8	3.4	25:1
	Spring	0.011	0.083	0.9	0.1	3.7	4.7	108:1

In 1968-9, average seasonal total phosphorus concentrations near the surface in the Sea range between about 0.04 and 0.12 mg/L. For samples collected during 1999 from three sites in the Salton Sea, total phosphorus concentrations in water ranged from a low of <0.005 mg/L to a high of 0.222 mg/L with a median of 0.071 mg/L in the surface waters and a median of 0.059 mg/L in the bottom water. Concentrations are generally highest in the winter and spring and lowest in the summer and fall. Ortho phosphorus is quite variable representing 10 percent (spring) to 75 percent (fall) of the total phosphorus. Phosphorus concentrations slightly decrease with increasing depth in the Sea, indicating little net release of phosphorus from the sediments (discussed later). Phosphorus concentrations in water, although high, appear to be unchanged from the 1969 to 1999.

Total nitrogen concentrations in the Salton Sea range from about 4 to 6 mg/L (see table). Concentrations are slightly higher during the summer and fall than in the winter and spring. Organic nitrogen is the main form (about 75 percent) of nitrogen in the water column possibly reflecting the algal population and algal breakdown. Ammonia (NH_3) generally represents about 25 percent of the total nitrogen; very little nitrate was measured. By comparison, nitrate is by far the dominant form of nitrogen in the tributaries, followed by organic nitrogen. Although ammonia is present in the tributaries, especially in the New River, ammonia is the dominant redox-indicating form of nitrogen

in the Sea. In the 1960's, ammonia concentrations, averaging 0.2-0.3 mg/L, were significantly lower than in 1999. This increase in ammonia (greater than one order of magnitude) is one of the most obvious changes in nutrient concentrations that have occurred in the Salton Sea. Ammonia concentrations in 1999 are higher in the bottom water, especially in summer months with seasonal averages as high as 2.8 mg/L. The presence of ammonia clearly indicates that reducing conditions are often present in the Salton Sea. It is unclear what effect these levels of ammonia have on the fish. Overall, total nitrogen concentrations appear to have increased by about 50 percent since the 1960's, primarily as a result of increasing ammonia concentrations.

Limiting nutrient

Water samples collected from the surface and bottom of the water column at three sites in the Salton Sea during 1999 had an overall mean N:P mass ratio of 185:1. Data were summarized seasonally. There was significant seasonal variation in the N:P ratio with the highest ratios (from about 200:1 to over 400:1) occurring during summer when total phosphorus was limiting, especially in the bottom water. The overall ratios show that phosphorus is by far the potential limiting nutrient in the Salton Sea. Even though the lowest nitrogen to total phosphorus ratios (23:1 to 28.7:1) during winter approach the threshold above which phosphorus would become limiting (about 25:1), the SRP:TIN ratio of 154:1 still strongly indicates potential phosphorus limitation. Winter has the greatest variability in total phosphorus concentrations, having both the maximum and minimum concentrations. Any efforts to reduce eutrophication in the Salton Sea needs to focus on phosphorus removal, especially the SRP (soluble reactive phosphorus) portion of total phosphorus.

High algal populations result in high chlorophyll *a* concentrations, a parameter often used to estimate phytoplankton biomass (Cooke and others, 1993; Wetzel, 1983). Chlorophyll *a* concentrations in the Sea are usually over 25 µg/L. Water clarity is generally fairly poor as measured by Secchi depths, which were usually less than 5 feet.

Salton Sea nutrient concentrations, chlorophyll a, and transparency

Constituent/year	Summer	Autumn	Winter	Spring
Total N (mg/L)				
1968-9	3.13	3.48	1.61	4.96
1999	4.2	4.2	2.5	3.5
Total P (mg/L)				
1968-9	0.06	0.05	0.07	0.2
1999	0.053	0.026	0.107	0.087
Chlorophyll *a*, µg/L				
1968-9	-	50.4	35.7	48.2
1999		27		
Transparency (ft)				
1968-9	3.6	4.1	3.4	3.5
1999	3.0	2.4	2.9	2.5

One method of classifying the water quality or productivity of water bodies is by computing water-quality indices (Trophic State Indices, or TSI's). These indices, based on near-surface concentrations of total phosphorus, chlorophyll *a*, and on Secchi depths, were developed by Carlson (1977). TSI's place each water-quality characteristic on the same scale. TSI's less than 40 are considered oligotrophic water bodies, between 40 and 50 are mesotrophic systems, and greater than 50 are considered eutrophic systems. Water bodies with TSI's greater than 60 are usually considered hypereutrophic.

All three indices indicate that the Salton Sea is generally eutrophic and often hypereutrophic. Chlorophyll *a* concentrations in 1968-9 give a TSI of between 60 and 70. A single sample collected during 2000 had a chlorophyll *a* concentration of 27 µg/L also would classify the Salton Sea as eutrophic. The Secchi depth in the Salton Sea for both 1968-69 and 1999 translates to a TSI of 60-70). The total phosphorus concentrations in 1968-9 translate to a TSI of between 50 in the autumn to over 80 in the spring placing the Salton Sea in the eutrophic to hypereutrophic category. In 1999, total phosphorus concentrations were variable. Calculated TSI's averaged between 50 and 70.

Nitrogen concentrations also can provide an indication of the trophic state of a water body. If the system is phosphorus limited, however, increases in nitrogen concentration will not be reflected by increases in productivity as indicated by Secchi depth or chlorophyll *a* concentration. Total nitrogen concentrations also place the Salton Sea in the eutrophic category.

Throughout much of the year, dissolved oxygen (DO) in the surface waters (epilimnion) is supersaturated during daylight hours. Dissolved oxygen, however, is nearly absent in the deep water (hypolimnion) when the water is stratified (C. Holdren, USBR, 2000, written communication). Occasionally the DO within certain areas of the Sea is absent from the top of the water column to the bottom. These episodes are usually associated with or follow algal blooms (described by others as green water) and often result in massive fish kills. The presumption is that algae in the bloom die and the subsequent aerobic bacterial breakdown depletes the available DO in the water column.

Much of the Salton Sea is a wind driven system (Cook and others, 1998), and fish kills also occur associated with wind shifts. The prevailing wind direction is from the west-northwest (Cook and others, 1998). Because the Sea is 35 miles long, wind direction and velocity at the southern end are different than those at the north or center (Cook and others, 1998). Major shifts in the direction and velocity in the southern end appear to be associated with fish kills. Strong winds from the south agitate the anaerobic sediments creating an immediate oxygen demand in an area that already has DO depleted water in the lower part of the water column. As this water is turned over and mixed with the upper water column, the entire water column of these shallow water areas is depleted of DO, killing the fish. As prevailing winds reestablish, windrows of dead fish often are found off of the New and Alamo River deltas. Although fish kills

have been common at the Salton Sea for a long time, during the past decade die-offs are more numerous and many of the die-offs number several million fish. Tilapia, the most abundant fish in the Salton Sea, also is the species most often involved in kills. Other fish such as sargo and croakers also have experienced large die-offs, but none of the magnitude of those involving tilapia. The following table presents fish kills during the past year.

Date	Total Dead	Tilapia Dead	Croaker Dead	Corvina Dead
16-Jan-00	50,000	50,000	0	0
21-Jan-00	100,000	100,000	0	0
10-Feb-00	2,600,000	2,600,000	0	0
04-May-00	40,000	40,000	0	0
18-May-00	83,000	83,000	0	0
29-May-00	50,000	0	50,000	0
30-May-00	5,000	0	5,000	0
01-Jun-00	1,000	0	0	1,000
06-Jun-00	120,000	100,000	17,000	1,200
16-Jun-00	5,800	1,200	4,600	0
27-Jun-00	55,000	25,000	30,000	0
30-Jun-00	10,000	10,000	0	0
10-Jul-00	100,000	100,000	0	0
13-Jul-00	55,000	49,500	5,500	0
03-Aug-00	120,000	120,000	0	0
03-Aug-00	25,000	0	25,000	0
15-Aug-00	2,500,000	2,500,000	0	0
18-Aug-00	5,200,000	5,200,000	0	0
25-Aug-00	115,000	25,000	90,000	0
26-Sep-00	3,090,000	3,000,000	90,000	0

Source: Tahni Johnson, Salton Sea Authority; Compiled byJacquie Lesch, Digital Library Administrator, University of Redlands

The eutrophic state of the Salton Sea with its high biomass translates to high fish production, especially for forage fish such as tilapia. If the Salton Sea were less eutrophic, there likely would be fewer tilapia, fewer and different algal blooms, and fewer occasions of fish kills associated with anoxic conditions.

Another problem associated with eutrophication in the Salton Sea is the objectionable odor that is so pervasive. This odor, that directly impacts recreational use, likely results from a unique combination of factors. The massive numbers of dead and decaying fish in the water and on the shores, algal decay, hydrogen sulfide from anoxic areas within the Sea, the Sea being saltier than the ocean, geothermal plants and agriculture all contribute to the smell near the Salton Sea. A significant reduction in the eutrophic state of the Sea likely would cause a reduction in the odor and a change in its character. There would be fewer dead fish, fewer algal blooms and hopefully less anoxic

sediments. The Salton Sea would still have a unique smell, but hopefully not the noxious odor of decay that currently is so unpleasant.

SOURCES OF NUTRIENT LOADING

The eutrophic condition of the Salton Sea is controlled or limited by phosphorus; therefore, we need to examine where the phosphorus in the Sea is coming from. Possible sources of phosphorus to the Sea include external loading from inflowing tributaries, ground water, precipitation, and from internal loading from the sediments.

Tributary loading

The major tributaries to the Salton Sea are the New, Alamo, and Whitewater Rivers. These rivers currently account for about 46, 32, and 6 percent of the inflow to the Salton Sea (J. Agajanian, USGS, 1998, written communication). Imperial Valley drains discharging directly to the Sea account for an 8 percent of the inflow. Tributary loading supplies the majority of nutrients to the Sea. The following table presents average historical and current phosphorus and nitrogen concentrations and loading to the Salton Sea in 1968-69 and 1999. Trends in annual loading and changes in nutrient sources can be evaluated by comparing data from 1968-9 with data from 1999.

Comparison of nutrient concentrations and loads to the Salton Sea

Site	Org.-N	NH3-N	NO2-N	NO3-N	O-P	T-P	T-N	Q, in acre-ft
Alamo River,								
1968-69, in mg/L	1.23	0.58	0.32	6.00	0.20	0.33	8.13	
load, in kgX10^6	0.966	0.454	0.249	4.72	0.176	0.258	6.39	637,700
1999, in mg/L	1.5	1.26	NM	6.42	0.408	0.719	9.2	617,130
load, in kgX10^6	1.14	0.959		4.89	0.310	0.574	7.08	
New River,								
1968-69, in mg/L	0.97	0.47	0.22	4.48	0.29	0.60	6.14	
load, in kgX10^6	0.50	0.240	0.113	2.28	0.15	0.304	3.13	413,000
1999, in mg/L	1.0	3.72	NM	3.55	0.697	1.11	8.2	488,080
load, in kgX10^6	0.482	2.24		2.14	0.50	0.660	4.96	
Whitewater River,								
1968-69, mg/L	0.83	0.16	0.06	6.28	0.26	0.58	7.33	
load, in kgX10^6	0.077	0.014	0.0045	0.59	0.024	0.054	0.686	76,300
1999, in mg/L	1.2	0.729	NM	14.3	0.710	0.865	16.3	52,983
load, in kgX10^6	0.078	0.048		0.935	0.046	0.053	1.03	

1999 loads in this table were based on mean concentrations and total annual discharge from C.Holdren, USBR, 2000 (Written Communication). 1968-69 data were from U.S. Department of the Interior Federal Water Quality Administration, 1970.
org-N = organic nitrogen, NH3-N = ammonia nitrogen, NO2-N = nitrite nitrogen, NO3-N = nitrate nitrogen, O-P = ortho phosphate, T-P= total phosphorus, Q = discharge, and NM = not measured

In the Alamo River, total phosphorus concentrations and loads increased by about 120% from 1968-9 to 1999 and ortho phosphate increased about 85%. In the New

River, total phosphorus loads increased by about 80% and ortho phosphorus loads increased by 230%. The total annual phosphorus load discharged to the Salton Sea in 1968-69 by tributaries was estimated to be 0.660 $X10^6$ kg, one-half of the current load.

In the New River, ortho phosphorus comprised 75% of the total phosphorus load in 1999 compared to 50% in 1968-9. Municipal and industrial waste discharges to the New and Alamo Rivers contributed 0.179 $X10^6$ kg of ortho-phosphate to the Salton Sea in 1964 (Regional Board,1964, written communication). Mexicali's contribution was estimated to be 48 percent of this load. Insufficient data are available for the year 2000 to evaluate changes in total phosphorus and ortho phosphorus loading from municipal and industrial effluent. Advances in sewage treatment technology make comparisons between the 1960's and today less indicative of basin wide changes. Elimination of phosphorus containing detergents also has impacted phosphorus loading from treatment plants. Similar changes were observed in the Whitewater River; however, ortho phosphate has become less important in the Alamo River.

Nitrogen concentrations and loads are presented in the above table for comparison and perspective, but will not be discussed. Because the Salton Sea is phosphorus limited, control of nitrogen, given the tremendous loading, cannot possibly be reduced to a level where eutrophication of the Sea can be reversed.

Agricultural drains

Agricultural drains that discharge directly to the Sea account for about 8 percent of the inflow. If it is assumed that the total phosphorus concentration in these drains is similar to the Alamo River (0.712 mg/L; it is expected that this is a high estimate), direct drains would then supply about 91,000 kg/yr to the Sea.

Ground water and precipitation

Ground water accounts for less than 5 percent of the inflow to the Salton Sea, the majority of which comes from the Coachella Valley. Concentrations of total phosphorus in ground water are usually very low and, therefore, phosphorus loading to the Sea is expected to be insignificant. Only about 4 inches of precipitation falls on the Sea per year. Phosphorus concentrations in precipitation are also usually very low and, therefore, phosphorus loading from precipitation is also thought to be insignificant.

Internal sediment release

Chemical compounds that reach the sediments do not necessarily remain there permanently. In many lake systems, sediments function as a reservoir or temporary resting place for certain elements such as phosphorus, which can be released back into the water column with changing environmental conditions. Depletion of dissolved oxygen in the overlying water of these lakes produces a reducing environment that can result in remobilization of phosphorus from the bottom sediments. This process termed "internal loading" is calculated in $mg/m^2/day$. Estimates of the net internal phosphorus loading from column studies using sediments from the Salton Sea range from –5 $mg/m^2/day$ for deep-water sediments to –10 $mg/m^2/day$ for shallow-water sediment (C.

Amrhein, UCR, 2000, written communication). These internal loading estimates indicate the potential for a tremendous negative flux, or a sink for phosphorus in the sediments at certain times of the year rather than a source of phosphorus. These, however, are instantaneous values from chambers where the input of external phosphorus is stopped and the sediment interface is oxygenated. The continuous high phosphorus loading, diffusive fluxes, and the lack of increased near-bottom phosphorus concentrations indicate that there is a significant phosphorus loss to the sediments.

Total phosphorus loading

Therefore the current total phosphorus loading to the Salton Sea is about 1.385 million kg/yr:

Alamo River*	574,000 kg/yr
New River*	660,000 kg/yr
Whitewater River*	52,000 kg/yr
Direct drains	99,000 kg/yr
Internal sediment release	*A*
Ground water precipitation	insignificant
Total	1,385,000 kg/yr

* Loads computed from monthly sampling (bimonthly during summer) using instantaneous concentrations and discharges, which were then averaged to compute annual loading (C. Holdren, USBR, 2000, written communication)

A No current level available although current research indicates that it likely is a negative number

Apportioning this load over the 365 square mile surface area of the Salton Sea gives an areal loading of 4.02 mg/m^2/day.

Clearly, no matter what trophic index is applied, the Salton Sea is a eutrophic water body. What is interesting is that the eutrophic state of the Salton Sea is virtually unchanged over the past 30 plus years. Although nutrient loading has increased, it has not significantly increased the eutrophic state of the Sea. The algal species composition, salinity, and fish type and abundance all have changed since the 1960's, but the overall eutrophic character is the same as indicated by the above characteristics.

MODELING PHOSPHORUS CONCENTRATIONS IN THE SALTON SEA

To understand the role of phosphorus in the eutrophication of the Salton Sea, it is important to determine if the present phosphorus concentrations (and resulting eutrophic conditions) in the Salton Sea is expected given the loading of phosphorus from the watershed. One way to answer this question is to compare the phosphorus loading rate and measured phosphorus concentrations in the Sea with those predicted

by models developed from similar measurements made in lakes and reservoirs from around the world. Twelve of these empirical models that relate hydrologic and phosphorus loading to in-lake phosphorus concentrations are contained within the Wisconsin Lakes Modeling Suite (WiLMS; J. Panuska, Wisconsin Department of Natural Resources, written communication, 1999). When these models are applied to the current hydrologic and phosphorus loading of the Salton Sea, all but one of these models predict the phosphorus concentrations in the Sea should be much higher than that measured (the other model predicts a concentration of 0.095 mg/L, slightly higher than that measured).

Model	Predicted P (mg/L)
Walker, 1987 Reservoir	0.598
Canfield-Bachmann, 1981 Natural Lake	0.181
Canfield-Bachmann, 1981 Artificial Lake	**0.095**
Rechow, 1979 General	0.120
Rechow, 1977 Anoxic	1.133
Rechow, 1977 water load<50m/year	0.188
Walker, 1977 General	3.491
Vollenweider, 1982 Combined OECD	0.905
Dillon-Rigler-Kirchner	7.323
Vollenweider, 1982 Shallow Lake/Res.	0.950
Larsen-Mercier, 1976	2.365
Nurnberg, 1984 Oxic	5.474

PROCESSES CONTROLLING PHOSPHORUS DYNAMICS

Since modeling results indicate that phosphorus concentrations in the Sea should be higher than observed concentrations, there appears to be processes controlling phosphorus concentrations in the water column of the Salton Sea. Typically following this modeling exercise one can determine what type of loading reduction is required to result in a specified change in P concentrations in a lake (Sea). In this case, it is obvious that the Sea responds much differently than most other systems and has other factors controlling the phosphorus concentrations in the Sea.

Geochemical Precipitation

Initial geochemical modeling (C. Holdren, 2000, U.S. Bureau of Reclamation, written communication) indicates that Salton Sea water is supersaturated with respect to hydroxyapatite when phosphorus concentrations are greater than 0.005 mg/L. While formation of this mineral is kinetically hindered, it often forms on calcite nuclei and is likely to be forming in the Salton Sea. As such, precipitation of hydroxyapatite could also represent one possible sink for phosphorus. To quantify phosphorus cycling from the bottom sediments, water samples were collected from "peepers" placed at multiple depths in bottom sediments (C. Amrhein, UC Riverside, 2000, written communication). The phosphorus concentrations in pore water were about 10 times higher than that in the overlying water; therefore, a concentration gradient exists and phosphorus should diffuse into the water column whenever anoxic conditions are present at the interface. However, monitoring data does not show accumulation of phosphorus in the hypolimnion even during anoxic periods. Bottom sediments from cores collected during the summer of 2000 (C. Amrhein, UCR, 2000, written communication) are high in

organic carbon in the deepest parts of the Salton Sea. In these areas of fine grain sediments, Calcite ($CaCO_3$) is 35% of the material composition, which also includes barnacles and other precipitates. There also are areas of high phosphorus in coarse material in the northern end of the Sea, which may be attributed to the accumulation of $Ca_5(PO_4)_3OH$. The median total phosphorus concentration in sediments is 672 mg/kg, which is typical of calcareous lake sediments.

In 1910, three years after the Salton Sea was formed, the composition of the water was clearly dominated by dissolution of sodium chloride salts in the Salton Trough. The ionic composition was significantly different from the Colorado River water that formed it. The ionic composition of the Salton Sea and its sources of water are shown in the table below (In the table, ion ratios are calculated on an atomic basis rather than a mass ratios because mass ratios are strongly affected by heavier ions such as sulfate and carbonate). The percent of sodium has decreased as magnesium increased, and the percent chloride has decreased as sulfate increased from 1948 to 1989. The solubility and equilibrium chemistry of sulfate, sodium, calcium and magnesium likely have controlled their concentrations as the salinity increased. Based on the solubility of sulfate, gypsum should be found in the bottom sediments (Hely and others, 1966). X-ray diffraction analysis and dissolution studies of bottom sediment samples collected in 2000 indicate the presence of an amorphous precipitate containing Na, Ca, SO_4, and possibly CO_3. The formation of this precipitate in the sediments of the Salton Sea could account for the apparent loss of the compound's constituents from the water column. At this time, it is unknown whether or not there is any phosphate associated with this compound.

Source	Ca	Mg	Na	K	Alk	SO_4	Cl	TDS
Colorado River 1989 [1]								
mg/L	76	31	10	4.1	152	290	100	737
%	17	12	4	1	14	27	25	
Salton Sea 1910 [2]								
mg/L	137	98	1,893	35	64	764	2,809	5,600
%	2	2	46	0.5	0.5	4	44	
Salton Sea 1948 [2]								
mg/L	804	992	11,824	192	192	7,550	16,990	38,550
%	2	4	45	0.4	0.3	7	42	
Salton Sea 1955 [2]								
mg/L	764	951	9,938	224	180	6,806	14,422	33,290
%	2	4	44	0.6	0.3	7	42	
Salton Sea 1988 [1]								
mg/L	950	1,300	11,000	220	185	10,000	17,000	43,700
%	2	5	42	0.4	0.2	9	42	
Salton Sea 1999 *								
mg/L	942	1,400	12,340	259	249	10,520	17,470	43,920
%	2	6	44	0.5	0.2	9	40	
Ocean 1989 [3]								
mg/L	403	1,260	10,500	390	120	2,650	18,900	34,200
%	1	5	42	1	0.1	2.5	49	
Alamo at Outlet [1]								
mg/L	180	100	430	12	212	910	580	2,500
%	8	7	34	0.6	4	17	29	

1999 mg/L*	166	83	389	8.2	259	762	443	2,020
%								
New at Outlet[1]								
mg/L	180	90	600	15	227	800	880	2,850
%	6	5	37	0.5	3	12	35	
1999 mg/L*	177	82.8	566	12.6	300	716	724	2,440
%	10	8.4	24.4	0.5	6.4	19.5	30.6	
Whitewater at Outlet*								
1999 mg/L	122	32	303	9	245	527	235	1,553
%	9	4	41	0.7	7.6	17	20.5	

Schroeder, Rivera, and others, 1993

2 Walker, 1961

3. Scripps Pier, published in Schroeder, Rivera, and others, 1993: Ca = calcium, Mg =magnesium, Na = sodium, K = potassium, Alk = alkalinity as calcium carbonate, SO_4 = sulfate, Cl = chloride, and TDS = total dissolved solids

* C. Holdren, USBR, 2000

Phosphorus Release from the Sediments

In many lakes, phosphorus released from the sediments is transported to the surface water during lake overturn as the anoxic bottom water from a stratified lake is mixed with upper oxygenated water. Bacterial processes in the hypolimnion remove oxygen from bottom water gradually producing anoxic conditions that release phosphorus from the sediments and settling particles. In the Salton Sea, this process is not likely important due to the high sulfide concentrations.

Biological Processes

It appears, however, that algae and tilapia may play a significant role in cycling phosphorus in the Salton Sea. In order to determine the relative importance of algae and tilapia, it is important to compare their potential contributions with the overall content of phosphorus in the water column.

The average mass of phosphorus in the Salton Sea is 6.3×10^5 kg using a weighted average total phosphorus concentration of 68 µg/L and a weighted average volume of 7.48×10^6 acre-ft for 1999 (C. Holdren, USBR, written communication). Overall net phosphorus in the water column remains about the same from year to year although major spikes and drops occur within a year. These changes likely occur following major algal blooms when most of the total phosphorus incorporated in the algae settles to the bottom. As the algae die, bacteria use the available oxygen to breakdown the settling biomass, leaving behind a very low total phosphorus concentration in the water column. This phosphorus is likely stored as organic compounds in the bacteria. Much of this phosphorus may become available as the wind driven system stirs up the sediments and causes additional algal blooms.

The number of tilapia in the Salton Sea, which appears to have increased dramatically since the 1980's, further complicate the cycling of phosphorus. Recent studies show there are about 90 million tilapia present in the Salton Sea (B. Costa-Pierce, Mississippi-Alabama Sea Grant Consortium, written communication). Tilapia tie up a

portion of the phosphorus in their tissues that is eventually released as the tilapia die and decompose. The average tilapia is about 0.5 kg, comprised of about 76 percent water and 2.9 percent phosphorus (Tan, 1971 and Costa-Pierce, 2000). Therefore, the mass of phosphorus tied up in tilapia is

9.0×10^7 tilapia X 0.5 kg/tilapia X 24 % dry weight X 2.9 % P in tilapia = 3.13×10^5 kg,

representing about 25 percent of the annual external phosphorus loading to the Salton Sea. Therefore, harvesting of tilapia may be an option and has been discussed as a means of removing phosphorus from the Sea.

When fish in the Salton Sea die, phosphorus in their bones may be lost from the system and not remineralize because of the high salinity of the water. With a life span in the Salton Sea of approximately two years, about 45 million tilapia die each year. If we assume that 75 percent of the dry weight of tilapia is bone, about 1.2×10^5 kg of phosphorus is deposited in the bones of dead fish each year and removed from the system. This amount is 10 percent of the total phosphorus loading to the Salton Sea. Tilapia, therefore, not only tie-up a significant mass of phosphorus in the Salton Sea, but in their death, may permanently remove a small portion of the external phosphorus load. In addition, the large number of tilapia and their bottom feeding habits coupled with the increasing salinity also could affect the species type and abundance of the plankton population and in turn affect the water clarity of the Sea.

This discussion shows that tilapia appear to play an important role in phosphorus cycling in the Salton Sea. If the salinity of the Salton Sea is allowed to increase to a point where the tilapia no-longer can survive, the effect on the eutrophication of the Sea could be significant.

A similar calculation for the Salton Sea in 1968-9 (elevation –232 ft. MSL) using a maximum total phosphorus concentration in the spring of 0.2 mg/L gives a total phosphorus mass in the Sea of 1.6×10^6 kg. This mass, resulting from an external loading of 6.241×10^5 kg, is about the same as current mass. In other words, at twice the total phosphorus loading today, the total phosphorus in the Sea is about the same as it was in 1968-69. This similarity in total phosphorus mass indicates that a phosphorus removal mechanism in the bottom sediments or incorporation into the fish and other macro organisms has accommodated the additional phosphorus. The implication is that to reduce the eutrophic state of the Salton Sea, a reduction in phosphorus loading of greater than 50 percent is necessary.

REDUCING EUTROPHICATION

Based on the above discussion that phosphorus is the limiting nutrient in the Salton Sea, and external loading is significantly larger than internal loading, it appears that educing the external phosphorus loading may reduce eutrophication problems in the alton Sea. The major limitation is that because some unknown process seems to be ntrolling phosphorus in the Sea, phosphorus concentrations are about the same now

as they were in the 1960's in spite of a doubling of the phosphorus loading. Therefore it is difficult to quantify the exact response of the Sea to various loading reduction scenarios. Because there has been no apparent change in the eutrophic character of the Sea since the 1960's (based on this limited evaluation), it is very likely that a greater than 50 percent reduction in external loading will be necessary to achieve a marked reduction in eutrophication. A reduction of at least 80 percent probably will be required.

POSSIBLE SOLUTIONS

Alum, aluminum sulfate, $Al_2(SO_4)_3$, has been added to lakes and reservoirs since the 1950's to control algal blooms by reducing internal phosphorus loading (Cooke, 1986). When added to water, the aluminum forms aluminum hydroxide which is a colloidal, amorphous flocculent with high phosphorus adsorption properties (Cooke, 1986). Typically, alum is added directly to lakes to adsorb the phosphorus and form a barrier on the sediments, limiting internal phosphorus loading. The sheer size of the Salton Sea makes such alum treatment impractical. However, alum may be able to be added to the tributaries to tie-up phosphorus before the water enters the Salton Sea. A significant amount of phosphorus is associated with fine suspended particles in the tributaries to the Salton Sea. These fine particles likely have a high percent of the phosphorus adsorbed to their surfaces. Various polymers have been added to river water to increase the settling rate of fine particles. Another way to reduce the phosphorus loading to the Sea may be to increase the settling rate of the fine particles by the addition of a specific polymer and increasing the settling rate of the fine particles in the tributaries.

The panel recommends:

1. Alum and/or polymer addition to the New and Alamo Rivers at or near their outlets to the Salton Sea could remove significant loads of phosphorus and decrease the eutrophication of the Salton Sea.
2. Experiments should be initiated to investigate the ratio of aluminum to phosphorus and the possible addition of polymers needed to remove at least 80 percent of incoming phosphorus and to determine the effects of the flocculent when it mixes with the saline water of the Salton Sea. Available information indicates that the high sediment concentrations in the Alamo River (>300 mg/L) interfere with alum removal of phosphorus. Experiments to test multiple upstream injection sites to maximize the effectiveness of sediment and phosphorus removal and minimize the volume of alum and/or polymers need to be performed. A proposal, "Reducing Eutrophic Conditions of the Salton Sea," to test and evaluate the efficiency of sediment and phosphorus removal from tributaries to the Salton Sea has been approved for Proposition 13 funding by the State Water Resources Control Board's Nonpoint Source Pollution Control Program.

OTHER POSSIBLE SOLUTIONS

Other possible solutions may eventually reduce the amount of alum and/or polymers needed to treat the tributaries to the Salton Sea. However, in the absence of direct

phosphorus removal from the tributaries these solutions are not expected to cause major improvements in the eutrophic nature of the Sea. These possible solutions include:

1. Reduction in loading to tributaries

Nutrient loading to tributaries is from three major components: 1) treatment plant effluent; 2) agricultural discharge; and 3) municipal and industrial effluent from Mexicali. Municipal effluent from both the United States and Mexicali will continue to contribute an ever-increasing load of ortho phosphorus as populations in the area continue to grow. Controlling these sources, however, is expensive. Agricultural phosphorus inputs need to be further evaluated to determine: 1) what component of the total phosphorus contributed by tailwater runoff is bio-available after reaching the Salton Sea; and 2) how much of the phosphorus applied in fertilizers washes off during irrigation. To be effective in reducing eutrophication in the Sea, 50 to 75 percent (rough estimate) of the farmers in the Imperial Valley would have to participate in phosphorus reduction efforts.

Total maximum daily loads (TMDL's) currently are being implemented in the Salton Sea area. The sediment TMDL may remove some of the phosphorus associated with the sediment, but whether or not this phosphorus is biologically available is unknown.

2. Wetland treatment

Wetland treatment to remove various contaminants from water is gaining in popularity worldwide. The consensus of the panel was that wetlands constructed along tributaries or in deltas of the rivers would not significantly change the eutrophication of the Salton Sea. Wetlands are effective at removing nitrogen, but not effective at removing phosphorus. Wetlands primarily affect a small portion of the total flow, and if present in substantial acreage, will reduce the water inflow to the Sea because of increased evaporation. The wetlands do promote other benefits such as creating habitat and possibly removing some nitrogen, selenium, and sediment.

3. Fish Harvesting

Fish harvesting has been proposed as a means to remove phosphorus from the Salton Sea. From the previous discussion, it is clear that tilapia may play a significant role in tying up and removing phosphorus. Even if about 50 percent of the fish are harvested each year, it has been calculated that harvesting could remove only 10 percent of the external loading of phosphorus from the Sea. If this were the only solution, it would have minimal impact on eutrophication. However, coupled with other possible solutions, it could prove to be helpful. Fish harvesting also might be feasible for economic reasons, but it is possible that it may increase the productivity of the Sea by reducing grazing by tilapia on phytoplankton.

CONDITIONAL RECOMMENDATIONS

Eutrophication of the Salton Sea has severely impacted its beneficial uses, including recreation and fish and wildlife resources. Some of the effects of eutrophication include high algal biomass, high fish productivity, low clarity, frequent very low dissolved oxygen concentrations, massive fish kills, and noxious odors. Salinity increase also is threatening the survival of corvina, the major sport fish, and eventually the other fish in the Sea. External loading of nutrients, particularly phosphorus, to the Salton Sea from agricultural discharges and from municipal and industrial effluent is responsible for the eutrophication of the Salton Sea. Because internal phosphorus loading in the Salton Sea appears to be very low and external phosphorus loading to the Sea is high, reduction of tributary phosphorus loading to the Salton Sea may reduce eutrophication. The reduction in tributary loading is not expected to have an immediate effect on the state of eutrophication but may have an effect within 5 years.

To reduce phosphorus loading to the Salton Sea, the workshop panel thinks the best solution is to evaluate and test the addition of alum to the tributaries, forming an aluminum-phosphate flocculent. The flocculent should settle as river water mixes with water in the Sea, thereby removing phosphorus from the biological cycle. Also, addition of polymers to the tributaries may increase the settling of fine particles with adsorbed phosphorus.

Other solutions that we think may help to reduce phosphorus loading to the Salton Sea are to:

1. Require tertiary treatment of all municipal effluent in the basin.
2. Initiate Best Management Practices to reduce phosphorus originating from agricultural fields, feed lots, and fish farms.
3. Harvest fish in the Salton Sea to remove their phosphorus

Additional solutions to reduce phosphorus loading to the Salton Sea that we considered, but felt to be minimally promising are to:

1. Control golf course phosphorus applications, septic systems, and lawn fertilizers.
2. Evaporation ponds for salinity control and removal of phosphorus.
3. Wetlands intercepting tributary inflow to remove phosphorus.

Finally, to better understand eutrophication of the Salton Sea and prior to trying to correct the eutrophication process, we suggest that the following information be collected:

1. A detailed phosphorus budget for the Salton Sea needs to be developed which includes the complete physical and biogeochemical cycling of phosphorus.
2. Temporal trends in phosphorus loading to the Salton Sea should be evaluated to better understand its relation to eutrophication in the Sea (chlorophyll *a* concentrations).

3. Temporal trends of phosphorus in the Salton Sea should be evaluated to determine how chlorophyll *a* concentrations are related to the observed changes in eutrophication.
4. Develop a one-dimensional vertical model of the Salton Sea to determine how changes in hydrologic management will affect water levels and stratification of the Salton Sea.
5. Explore the geochemistry of the alum and polymer complexes to determine the fate of the aluminum-phosphate and other complexes as they enter the saline environment of the Sea.
6. Develop a monitoring program to evaluate the success of the eutrophication reduction program to include measurement of Secchi depth, chlorophyll *a*, total phosphorus and C^{14} based primary productivity rates.

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EFFECT OF SALT PRECIPITATION ON HISTORICAL AND PROJECTED SALINITIES OF THE SALTON SEA: SUMMARY COMMENTS FROM WORKSHOP AT UC (RIVERSIDE), JANUARY 30-31. 2001

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Introduction

The Salton Sea Science Office convened a workshop at the University of California in Riverside on January 30-31, 2001, for the purpose of resolving the basic question, "Are dissolved solids precipitating and/or being biologically reduced in the Salton Sea?" The issue of salt precipitation has important economic and environmental implications for the Salton Sea Restoration Project. If salts are precipitating, the lake's rate of increase in salinity will be less rapid and that would provide more time to arrest the increase before salinity levels become toxic to fish. Furthermore, if less salt needs to be removed, the space that must be set aside for restoration (evaporation and disposal of salts) and the engineering cost of remediation are reduced. The issue was addressed through formal presentations from several speakers and by dialogue between the speakers, public, and panel members on the first day of the workshop. The 8 panel members listed at the top of this page then met privately for a day to deliberate on the topic and to produce this "white paper" that contains their conclusions and recommendations. The paper contains 5 sections:

1) a brief discussion of the local hydrologic and geochemical cycles,
2) temporal trends in salinity of the Salton Sea,
3) calculations for the amount of salt precipitating in the Salton Sea,
4) recommendations on future data needs, and
5) the panel's response to questions.

Hydrology and the Salt Cycle

When catastrophic flooding of the Colorado River discharged to the Salton Sink in 1905-07, the fresh water rapidly dissolved salts that had accumulated on the dry

lakebed and led quickly to the formation of a brackish lake. With the continuing discharge of wastewater from agriculture and municipal wastewater from towns in the Salton Basin, salts have continued to accumulated in the terminal lake, which is now about 20% more saline than the ocean. Soluble salts, like sodium chloride, continue to accumulate in the water column; while less soluble salts, like calcite and gypsum, will accumulate in the water column until their concentrations reach saturation, after which the excess precipitates and accumulates within the bottom sediment. The extent to which the precipitation of these minerals is taking place will affect the rate at which the salinity of the Salton Sea is increasing. Just as the first few years of flooding dissolved accumulated salts from the dry lakebed, it seems likely that irrigation initially must have leached some salts from the newly farmed soils. It takes an average of 5 years for irrigation water applied to the area's fields to percolate through the soil until it is discharged by subsurface drains (Michel and Schroeder, 1994). Therefore, over the years the soils have been leached multiple times by the application of about 6 ft of irrigation water annually. As a result, the local geochemical cycle is now sufficiently close to steady state that the salt load carried by the Colorado River diverted at the Imperial Dam yields a fairly accurate estimate for the annual load of salt carried in rivers and surface drains that discharge to the Salton Sea. Average salt concentrations for the waters in the basin are presented in Table 1.

Table 1 shows that although the dissolved salt concentration in subsurface drainwater from the Imperial Valley is increased through evapotranspiration by about an order of magnitude compared to irrigation water, the relative proportion of the most abundant anions, chloride and sulfate, remains virtually unchanged during the waters transit through the soil. Although sulfate reduction occurs at depth in Imperial Valley soils (Schroeder and others, 1991), and even in some shallow depths as evidenced by the presence of H_2S in a few drainwater sumps close to the Salton Sea, the effect on drainwater composition derived from the entire valley is minimal. Based on the cation composition of the drainwater and irrigation water, it appears that there may be a small increase in Na, and a loss of Ca, due to cation exchange processes and calcite precipitation in the soil.

Insofar as Colorado River water is itself oversaturated with respect to calcite (Figure 1), precipitation of calcite ($CaCO_3$) within the soil during the high evaporative concentration that occurs in this arid environment might be anticipated, and is illustrated by the following reaction.

$$Ca^{++} + 2HCO_3^- \rightarrow CaCO_3 + CO_2 + H_2O \qquad \text{Eq. 1}$$

It is possible to estimate the amount of calcite that that is currently precipitating in the soil using the Ca, Cl, and alkalinity (HCO_3) concentrations in the irrigation water and drainwater. Based on these ion ratios, we calculate that approximately two-thirds of the dissolved Ca^{2+} and HCO_3^- precipitate within the soil during the lengthy travel time from soil surface to drain. Although not all of the applied water infiltrates the soil

(possibly as much as 30% goes to tailwater runoff), the precipitation of calcite within the soil constitutes the first major loss of dissolved ions from the water. Based on the data in Table 1, we estimate that approximately 400,000 tons of $CaCO_3$ precipitate in the soils every year, or about 10% of the total salt load to the basin.

The subsurface drainage water is diluted by the addition of tailwater runoff (surface water at the end of the fields) and municipal wastewater. These combined flows contribute to the "River water" (Table 1), which is a time-averaged and flow-weighted composition of the New, Alamo, and Whitewater Rivers. These data suggest that the average river is approximately two-thirds tailwater and one-third drainwater. The municipal flows are similar in chemical composition to the tailwater. The salt load of this average river constitutes the major inflow to the Salton Sea.

Temporal Salinity Trend

Salinity of the Salton Sea has been measured over the years by a number of different laboratories at varying frequencies. It is beyond the scope of this paper to cite or review these data other than to note additional comment on this topic in the section on Future Data Needs. Temporal changes in historical salinity of the Salton Sea are discerned from these individual measurements and long-term annual trends are computed by averaging the change in salinity over a number of years. Annual changes in salinity of the Salton Sea also have been computed from flow and chemical data on the Colorado River water that is diverted for use in the Salton Basin, together with lake volume as monitored by lake level.

Inter-annual changes computed in this manner cannot be confirmed from analyses of the Salton Sea because the uncertainty in the Sea's salinity, obtained either by summing individual ion concentrations or by weighing the residue following evaporation at high temperature (160°C), is subject to a one-sigma precision of no better than 5% (based on historical information from the USGS National Water Quality Laboratory in Denver). This corresponds to an uncertainty of ~2,000 mg/L in measurements of salinity, and is equivalent to about 5 times the salt load delivered annually to the Sea (annual salt load is ~4 million metric tons and total dissolved salt contained in the Salton Sea is ~400 million metric tons). As a result, any concordance between measured salinity change in the Sea and salt discharge on an annual basis is merely fortuitous. However, by carrying the inventory forward over a period of many years, a decrease in the Sea's measured salinity (and the concentration of individual ions as well) from the trend line established by adding the annual salt loads to the volume of water in the Salton Sea can be used to infer removal of salts by precipitation. Panel member Weghorst used an accounting approach similar to this to infer inception of gypsum precipitation in the Salton Sea around the mid-1980's. He also estimated an annual salt precipitation in the Salton Sea of 1.4 million metric tons, which equals about one-third the annual salt discharge to the Sea.

Tostrud (1997) estimated the annual salt precipitation at 1.5 million tons. This calculation was based on long-term trends in the chemical constituents being discharged into the sea and the actual composition of the sea. Differences between salt load to the sea and salt content of the sea were attributed to the precipitation of Ca, HCO_3, and SO_4. Apparent increases in Na, Cl, and Mg were attributed to mineral dissolution from the sea floor.

Salt Precipitation

Thermodynamic potential for minerals (salts) to precipitate from solution is often expressed in terms of a saturation index (SI) defined as

$$SI = \text{Log } (IAP/K_{sp}),$$

where IAP is the measured ion activity product and K_{sp} is the "solubility product" for the same ions in a saturated solution. Positive values of SI indicate a solution that is supersaturated so if the kinetics is favorable, the mineral will precipitate. Negative values indicate that dissolution of the mineral can occur. The Salton Sea, Alamo and New Rivers, and irrigation water are all oversaturated with respect to calcite. Panel members Amrhein and Schroeder report measuring calcium carbonate contents close to one-third (dry weight basis) in bottom sediment from areas near the center of the Salton Sea. Given its saturation in Colorado River water, it is likely that calcium carbonate has been precipitating throughout the history of the Salton Sea.

Surface water sources of discharge to the Salton Sea are clearly undersaturated with respect to gypsum (Figure 1) so it is not surprising that some considerable time had to elapse before calcium and sulfate ions concentrations became high enough for gypsum to possibly precipitate in the Salton Sea. Hely and others (1966) suggested the Sea was saturated with respect to gypsum as early as the 1960s. There is some evidence that gypsum may be precipitating, including geochemical calculations and direct observations of gypsum crystals from the sea sediments. Some of the panel members suggested the gypsum is remnant from earlier periods of drying in the Salton Sink. Laboratory studies by panel member Weghorst, have shown that an additional 20% concentration is needed before gypsum will precipitate from Salton Sea water. Additional work is needed of the lake's sediment to determine where gypsum may be precipitating.

Panel member Parkhurst used the geochemical model PHREEQC to simulate the evolution of water quality in the Salton Sea and calculate the amount of calcite and gypsum that might precipitate. Total volume of the Salton Sea is assumed to be 7.6×10^6 acre-ft and composition used in the simulation is given in Table 1. A volume of water equal to 1.36×10^6 acre-ft with composition given by the "average river water" column in Table 1 was added each year to the Sea and then evaporated to maintain constant volume. Results after 1 year and after 50 years of simulation are given in the

two columns on the left side of Table 2. In the simulation we assumed that the current level of oversaturation was maintained ($SI_{calcite}$ = 1.15 and SI_{gypsum} = 0.18) and the Sea has an average pCO_2 = -3.01. In the first year, 0.35 mmol/L of calcite and 0.69 mmole/L of gypsum precipitate, and 0.39 mmol/L of CO_2 is evolved due to the precipitation of calcite (Eq. 1). This equates to the precipitation of 330,000 metric tons of calcite and 880,000 metric tons of gypsum, and a summed total of 1.2 million metric tons of salt during year 1. If the process is repeated, during the 50th year 360,000 metric tons of calcite and 540,000 metric tons of gypsum precipitate—a gradual decrease in the amount of gypsum precipitating and a total of 0.9 million metric tons in the 50th year.

[The masses of salt reported here are the amounts that would be measured using the standard method of evaporation to dryness at 160°C. Under these conditions gypsum, $CaSO_4 \cdot 2H_2O$, is dehydrated to $CaSO_4$. The mass of "gypsum" reported is given as anhydrous $CaSO_4$. This is also the amount of dissolved ions that will be removed from solution, not the actual mass of gypsum that will potentially accumulate in the bottom of the sea. To convert to the tons of gypsum, as the dihydrate solid, multiply the tons of $CaSO_4$ by 1.26.

The mass of calcite reported is the amount that would potentially precipitate as a solid and the amount that would be measured during an evaporation test. It is not an accurate measure of the mass of dissolved ions removed from the water. The precipitation of calcite occurs via Equation 1, which shows that 2 bicarbonate ions are lost from solution for each Ca ion precipitated. The total mass of ions removed from solution is greater than the tons of calcite precipitated because CO_2 is evolved. To convert the tons of calcite precipitated to tons of calcium and bicarbonate removed from solution, multiply the tons of calcite by 1.62.]

Additional calculations were done using PHREEQC and selecting different values for pH and pCO_2. Biological degradation of organic matter in the sediments would likely lower the pH and raise the CO_2 in the sediment porewater. Dropping the pH to 7.5, and raising the CO_2 about 5 fold to pCO_2 = −2.29 by maintaining the same initial alkalinity as in the previous simulation, yields little change in total accumulation of calcite and gypsum, provided the new steady state (SI = 0.63 for calcite and 0.18 for gypsum) is maintained. Results are given in the two columns on the right side of Table 2.

Panel member Pyles, who has experience with ocean water evaporation and desert dry lake brines, was skeptical that gypsum precipitation was taking place to any great extent in the Salton Sea. Gypsum is found in the sea but there is uncertainty whether the crystals found in the sediments are prehistoric or modern. The crystals found in the Sea are often single, isolated crystals whereas gypsum formed from brine precipitations typically is seen in large agglomerations of fine crystals, according to Pyles. Because gypsum precipitation does not appear to be as extensive as these

calculations indicate, another calculation was done in which precipitation of gypsum was blocked.

Allowing the SI of gypsum to increase so that no precipitation of this mineral occurs has almost no effect on the amount of calcite precipitated. This is because calcite precipitation is limited by insufficient bicarbonate alkalinity. Repeating the first simulation without gypsum precipitation yields 360,000 metric tons of calcite during the 1st year and 370,000 metric tons during the 50th year, while SI for gypsum increases from an initial value 0.18, to 0.52 at the end of 50 years. This increase in SI corresponds to a more than a doubling of the ion activity product at the end of 50 years. This means that if gypsum precipitation is blocked, the Ca concentration in the sea will continue to increase over the whole time period. This is contrary to the evidence that the Ca concentration in the sea is not increasing, and may even be decreasing (Tostrud, 1997). Thus, either there is extensive gypsum precipitation (880,000 tons/year) or there is another source of bicarbonate alkalinity that allows more calcite to precipitate than the model predicts. An important mechanism of alkalinity generation is sulfate reduction. This is discussed below in further detail.

It is well known that the PHREEQC chemical speciation model was not designed for high salinities. The calculations are thought to be reasonable, but to be sure, panel member Holdren repeated these calculations given above using PHRQPITZ, a computer program designed to calculate ion activities and saturation indexes at very high salinities. Holdren's simulation using PHRQPITZ yields a salt deposition of 343,000 metric tons/yr for calcite and 403,000 metric tons/yr for gypsum. The calcite value is close to the PHREEQC estimate (330,000 tons), but the gypsum value is less than half (compare 403,000 with 880,000) suggesting much less precipitation of gypsum.

Holdren also repeated the simulation while blocking the precipitation of gypsum but allowing calcite precipitation. This simulation using PHRQPITZ yielded 356,000 metric tons/yr of calcite and compares very closely with the PHREEQC calculation of 360,000 tons. In both models, the amount of calcite formed appears to be controlled by the alkalinity of the sea. The largest difference between the two models is for gypsum precipitation. In this case, the estimate by PHRQPITZ of 403,000 metric tons/yr for gypsum is thought to be more reliable because the chemical speciation was designed for elevated salinities.

Other Reactions Affecting Mineral Precipitation

The biological activity, which includes carbon fixation by algae and oxidation-reduction reactions by bacteria within the sediments, almost certainly has a major effect on salt precipitation in the Salton Sea. However, the information necessary to quantify this effect is not known.

Because of the high nutrient loading to the sea and high temperatures, algal growth is intense. Dead algal cells fall to the sediments where they are oxidized by bacteria. The idealized reaction showing the oxidation of organic matter (CH_2O) with sulfate at the terminal electron acceptor is as follows:

$$SO_4^{2-} + 2CH_2O \rightarrow 2HCO_3^- + H_2S \qquad \text{Eq. 2}$$

This reaction, which occurs in the absence of oxygen in the sediments of the Salton Sea, generates both bicarbonate alkalinity and hydrogen sulfide gas. The panel members hypothesized that this reaction is occurring, and shifting the relative proportions of calcite and gypsum precipitating. The generation of additional alkalinity allows for more calcite to form than the models are predicting.

Although the odor of hydrogen sulfide is pervasive at the Salton Sea, its net release to the atmosphere is unknown, but is likely quite small compared to the total sulfur (S) inventory. However, there may be enough sulfate reduction to generate sufficient alkalinity to precipitate the year's total input of Ca as calcite. There are currently no measurements of sulfate reduction rates at the Salton Sea, although based on published rates of reduction in estuaries (with much lower sulfate concentrations), panel member Parkhurst calculated that the flux of H_2S out of bottom sediment in the Salton Sea could be comparable to the external sulfur (as sulfate) load delivered by discharge to the Salton Sea. Based on Parkhurst's calculations, there could easily be enough sulfate reduction and alkalinity generation such that only small amounts of gypsum are forming, and calcite is the dominant mineral phase.

Not all of the hydrogen sulfide formed in the sediments will make it to the atmosphere. Oxidation of hydrogen sulfide within the water column will consume alkalinity (generate acidity), as represented by the reaction below.

$$H_2S + 2O_2 \rightarrow SO_4^{=} + 2H^+ \qquad \text{Eq. 3}$$

This could be an important mechanism that decreases the alkalinity of the Sea water. Preliminary data collected by researchers at UC Riverside indicates there is no calcite precipitation within the water column of the sea but extensive precipitation within the pore water of the sediments. Thus, the region of active sulfate reduction also favors rapid calcite precipitation. The fate of hydrogen sulfide released to the water column is probably some out-gassing to the atmosphere and some reoxidation within the aerobic portion of the sea. Clearly, there exists a need for field data to determine sulfate reduction rates in the sediments and hydrogen sulfide evolution rates to the atmosphere to quantify the extent of alkalinity generation within the sea.

The ultimate limit on sulfate reduction in the Salton Sea is the amount of organic matter, or algal biomass, available for oxidation. Because algal production is phosphate limited in the Sea (Setmire and others, 2001), it is possible to estimate the total amount

of biomass produced each year. Assuming all of this biomass decomposes anaerobically via sulfate reduction, alkalinity generation can be estimated. Using only the total mass of P that enters the sea every year (1,339,000 kg/yr; Setmire and others, 2001), panel member Amrhein calculated that sufficient alkalinity is generated to precipitate 98% of the annual Ca load, or 691,000 tons of calcite. This calculation does not take into account internal recycling of P from the sediments. Studies in progress by researchers at UC Riverside (Anderson and others, 2001) have shown that internal loading of P is approximately 10% of the external loading. This additional P will increase the estimate of total biomass produced each year.

There is good evidence that the concentration of Ca in the sea is not increasing, and in fact may be decreasing. If there is sufficient alkalinity generation within the sea via sulfate reduction, the annual Ca load may be precipitating as calcite. If this were true, the total "salt" precipitation as $CaCO_3$ would be 705,000 metric tons.

Reactions other than those involving calcite and gypsum can affect aqueous salinity, but their effect is much less important. Some of the sulfide formed from sulfate reduction is precipitating within the sediments as FeS_2 (pyrite). The source of Fe for this reaction is the dissolution of iron oxides and iron-containing clay minerals in the bottom sediments and suspended solids entering the sea. Based on marine systems, the rate of pyrite formation is probably limited by the rate of dissolution of these iron-containing minerals. The amount of pyrite in the sediments has not been measured, but is needed to estimate the contribution of this process to sulfate loss from the sea.

Magnesium can be removed from solution through substitution for calcium in calcite. An estimate of the importance of this reaction can be computed using the data from Mucci and Morse (1983), who studied the coprecipitation of Mg^{2+} into calcite formed in ocean water. Based on these data and the Mg/Ca molar ratio of the Salton Sea water, the calcite formed in the sea should have a Mg/Ca mole ratio of 0.054. This would give an average formula for the calcite mineral as: $Ca_{0.949}Mg_{0.051}CO_3$.

If the calcite contains 5% Mg, the total mass of calcium/magnesium carbonate would be 735,000 metric tons, compared to 705,000 tons without magnesium.

X-ray diffraction analysis can also be used to determine the extent of Mg substitution into calcite. Magnesium incorporation into calcite causes a collapse of the crystal lattice, which can be accurately measured using X-ray diffraction. Using this method, panel member Amrhein has determined that the calcite in the Salton Sea sediment contains between 3.0% and 3.8% $MgCO_3$. This would increase the total tonnage of calcite from 705,000 metric tons/yr to about 725,000 metric tons/yr.

Additional losses of Mg from the sea can be attributed to the precipitation of magnesium silicate minerals like sepiolite and "protosepiolite" (Levy et al., 1995).

Dissolved silica also might be precipitated as diatom exoskeletons. A reasonable assumption, based on the date in Table 1, is the annual Si load precipitates every year. If all of the Si precipitates as sepiolite ($Mg_4Si_6O_{15}(OH)_2 \cdot 6H_2O$), a total of 39,000 metric tons will form. Overall, the precipitation of Mg and Si will have a small, but not negligible effect on salinity.

Ion exchange between dissolved ions and clay minerals also has the potential to alter the salt balance in the Salton Sea. Suspended solids (soil material) that are washed into the sea will have predominately Ca on the exchange phase. After equilibration with the Sea water, the exchange phase will be dominated by Na, and Ca will be released to the water. This has the potential of increasing the total amount of Ca available for precipitation as calcite or gypsum. An approximation assuming a suspended sediment concentration in discharge to the Salton Sea of 300 mg/L, clay content of one-third in the suspended load, and cation-exchange capacity of 100 meq (milliequivalents) per 100 g clay yields an ion exchange capacity of 0.1 meq/L in the average river water input to the Sea. This is equivalent to 0.15 mg/L based on the equivalent weights of 23 for Na and 20 for Ca, the ions primarily involved in exchange, which translates into less than 0.01% of the dissolved salt load given in Table 1. Panel member Amrhein reached a similar conclusion from direct measurements of cation exchange capacity in bottom sediment from the Salton Sea.

Future Data Needs

Material in the preceding sections illustrates the importance of additional information in two areas: monitoring and historical reconstruction. Confidence in the effect that salt precipitation has on salinity trends in the Salton Sea will be achieved only after there is agreement between model simulations and field data. Accordingly, there exists a need for better, as well as additional kinds of data to constrain the models. Given the importance of monitoring, it would probably be useful to compile all historical water-quality (salinity) records from the Salton Sea, and the associated lake stage (volume), in an electronic spreadsheet. Information on previous lake conditions, especially as they relate to the early history of the Salton Sea, should also be sought from two additional sources: the anecdotal accounts of older residents and their descendents, and the biogeochemical changes that are recorded by the sediment that has accumulated beneath the Salton Sea.

There are three issues with respect to measuring salinity that need to be addressed: analytical precision (and accuracy), sample location and sample handling, and reporting units. The current analytical precision of about 5% in estimates of the Salton Sea's salinity is approximately equivalent to 5 times the annual discharge of dissolved salt to the Sea. Accordingly, the determination of average annual salinity trends and the early detection of major changes in salt precipitation in the Salton Sea now requires the averaging (or cumulative accounting) of measurements over a period of at least a decade—far too insensitive an indicator to be useful. The precision on

salinity (either from gravimetric or from sum of individual constituents) analyses could be greatly improved, but it would require special efforts not generally provided by broad-service laboratories. However, specific conductance can routinely be measured with a precision of ±1% in the field, if accurate temperature measurements and suitable standards are used. The collection and analysis of this surrogate for salinity should be repeated at least every 6 months. The resulting conductance data would itself certainly lead to a marked improvement in the determination of short-term annual salinity trends, and might even provide the sensitivity needed to detect major changes in annual salt deposition within a few years after they occur. Comprehensive chemical analyses also are certainly desirable for determination of trends and are essential for use in geochemical models, but the need for high-precision data becomes less frequent if good conductance information is available.

Profiles shown in Figure 2 illustrate the fact that surface-water quality is very dependent on location in the Salton Sea. The approximately 3% difference in salinity between the center of the north and south sub-basins becomes even greater closer to the south shore, where most of the freshwater discharge occurs. It is likely that nearly all of the published historical salinity data on the Salton Sea are from water samples taken from the lake's surface, near shore. Panel member Schroeder (unpublished data) found a range of only 1% (within the limit of precision) for specific conductance @ 25°C in bottom water from 11 locations scattered throughout the lake. The narrow range occurred in bottom water spanning a depth from 15 to 50 feet, and at a time of maximum thermal stratification in July. A salinity-monitoring program should therefore be based on sampling of the sea at several depths near the center of the Salton Sea, although precise location seems not to be very important.

Salinity (and chemical concentrations) for the Salton Sea has usually been expressed in volumetric units as mass of salt per liter of solution. As such, the values are density dependent (oceanographers use grams of salt per kilogram of solution to eliminate this effect) and the density information is rarely available. Panel member Amrhein has measured the density of Salton sea water and found a range from 1.028 to 1.032 g/mL, with an average of 1.030 g/mL.

Reasonable adjustments to specific conductance measurements if the temperature at which the salinity measurement was made is known. But the temperature must be known to within about ±0.1°C because the thermal dependence for specific conductance is about 2% per degree. Precise values for temperature will become increasingly important as future measurements are made by lowering instruments through the water column to obtain profiles. Therefore, laboratory data for conductance over the range in temperature that occurs in the Salton Sea should be obtained so that anyone can then make the necessary adjustments to convert the conductance data to a temperature of 25°C.

Sample handling in the field and transport to the laboratory are also important. The common practice of refrigerating water samples could cause the immediate precipitation of gypsum. Ideally, samples should be diluted in the field to reduce the level of saturation, and the potential for calcite and gypsum precipitation. For calcium analysis, acidification using HCl or HNO_3 may be effective in stopping precipitation if the pH is <2. Sulfuric acid should never be used because it leads to rapid gypsum precipitation.

Water samples for alkalinity determination should be diluted at least 50% with deionized water, preferably in the field or immediately upon return to the lab. The most reliable and accurate method is to use an electronic balance to add 100 g of dionized water to 100 g of Sea water. Inexpensive, portable electronic balances make it possible to do this dilution in the field.

The simulations reported herein used PHREEQC and PHRQPITZ. Other geochemical models exist and each is likely to yield slightly different results; however, the differences are much less important than is our lack of quantitative information on the biological and chemical processes that govern precipitation and dissolution. Furthermore, these processes must be determined not only in the water column, but also where they are most important—within the bottom sediment itself where they occur. Required information includes rates of oxidation and reduction within the sediment (including any role that iron might play in the reactions); flux (from porewater chemical profiles) for sulfide, as well as for the other nutrients, major ions, and alkalinity; and complete chemical and mineralogical analyses of the bottom sediment.

Response to Questions

The response to several questions posed by members of the audience and the Salton Sea Science Office is given below. Some of the questions and answers repeat topics addressed in more detail above.

Q Are dissolved salts being precipitated and(or) being biologically reduced in the Salton Sea?
A Yes.

Q If so, which salts are they and to what extent is precipitation occurring? What percent of the TDS in inflow waters is precipitating on an annual basis?
A Calcium salts, as carbonate and possibly sulfate, are precipitating. The extent of precipitation is uncertain, partly because quantitative information on the extent of biological reduction is not available. Estimates of salt precipitation in this paper range from 330,000 to 1.5 million metric tons annually, with a range between 0.7 and 1.2 million thought to be the best estimate. At the upper end of the range, salt precipitation represents about one third of the annual salt load.

Q Will salts re-dissolve if salinity is reduced, and what should be the salinity goal for remediation?
A. Dissolution will not occur until dilution is sufficient to reduce the constituent aqueous-ion concentrations below saturation ($SI \leq 0$). Panel member Holdren used PHRQPITZ to conclude gypsum dissolution will not begin until salinity was decreased to 31,000 mg/L. Calcite will never re-dissolve. Hence, reducing salinity to "oceanic" levels would not result in re-dissolving salts. There are no obvious benefits (as regards any salt exchange between the sediment and water) to lowering salinity below current levels. In fact, it could be argued that allowing salinity to remain near the current higher level is beneficial in that it results in the need to dedicate less land for evaporation ponds and in less salt to dispose. (Our assessment does not consider any possible ecological ramifications from a salinity that differs compositionally and is somewhat higher than oceanic levels as the panel does not have expertise on that topic.)

Q Are there other sources of salt to the Salton Sea, such as ground-water seepage?
A Ground-water seepage, geothermal fluxes, and magmatic CO_2 fluxes through the lake bottom are two additional direct sources that were considered. Hely and others (1966) estimated that ground water is 3.6% of total inflow and Schroeder and others (1993, Table 10) measured dissolved-solids concentration of about 14 g/L in regional ground water (below the depth affected by irrigation drainage) at the north end of the Imperial Valley near the south shore of the Salton Sea. This yields a value for salt inflow from ground water that is about 20% of the surface-water load—not large, but not insignificant either. However, most of the ground-water seepage probably occurs along the (east and west) sides and at the north end of the Salton Sea adjacent to the Coachella Valley, areas where the soils are more permeable and the ground water likely is much less saline. Hence, the ground-water contribution to salt loading is likely only a few percent.

Panel member Kharaka postulated an annual magmatic CO_2 flux of 10^6 moles/km^2 to calculate an annual gas flux of 44,000 metric tons for the whole lake. If the CO_2 simply evolves (volatilizes), there would be no effect on salinity. Because the sea is so highly oversaturated with respect to calcium carbonate, elevated levels of CO_2 will decrease the pH of the sea but not result in calcite dissolution. The venting of geothermal water within the sea could contribute an indeterminate amount of salt.

Q Do we need to look at TDS, only at NaCl, or at individual components?
A All of the major ions need to be considered to gain a complete understanding of the processes that affect the salt budget of the Salton Sea.

Q Are organisms generating bicarbonate over what is brought in with inflows?
A Biological generation of alkalinity via sulfate reduction is substantial. Estimates based on potential biomass production indicate an additional 50% of the inflow alkalinity could be generated in the sea. However, there are no quantitative

measurements of processes and the net production is unknown. Any excess alkalinity that is generated will increase the amount of calcite that is precipitating. The amount of calcite that precipitates is currently limited by alkalinity.

Q What if processes are not at "steady state" or at "equilibrium" in the Salton Sea?
A One indication of the magnitude of effects is provided by the range in annual salt precipitation that is computed by simulations with various assumptions. Another is to note that the amount by which gypsum exceeds saturation at SI = 0.18 is equivalent to about a decade of discharge to the Salton Sea. These observations illustrate the necessity of regular and careful monitoring as well as studies to quantify the chemical and biological processes that affect precipitation and dissolution. All of the precipitation reactions are sensitive to temperature. Because the temperature of the sea is constantly changing, there never is a true steady state condition. Equilibrium can never be reached because of the dynamic nature of inflow, evaporation, mixing events, temperature changes, and rising salinity.

Q Will seasonal and spatial variability in the Salton Sea affect processes in such a way that understanding and projecting trends from simple models will not be representative?
A Models, and simulations, could be made more complex to account for variability if sufficient data were available but it not readily apparent that the greater complexity that would result is important for discerning trends and calculating lake-wide salt budgets over periods of several, or even a few, years.

Q If biological reduction, rather than chemical precipitation, is the dominant process affecting precipitation, wouldn't an imbalance in salt inflow and salt inventory show up as a gradual effect, rather than an abrupt change, in the Salton Sea's salinity trend?
A Biological reduction leads to chemical precipitation, so the two are linked. The following equations show how this occurs:

$$SO_4^{2-} + 2CH_2O_{(org.\ matter)} \rightarrow 2HCO_3^- + H_2S(g)$$

$$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3(s) + CO_2 + H_2O$$

Precipitation will always be a gradual process so no abrupt change is likely. The rates of precipitation and biological reduction change with the season, mostly due to temperature changes and photosynthetic activity.
Q Will diurnal (photosynthesis/respiration) cycles have an effect on TDS measurements as $CaCO_3$ precipitates and dissolves in response to changes in CO_2 levels.
A The effect on salinity would be far too small to measure. It does not appear that significant amounts of calcite are precipitating within the water column; ie. There is very little "calcite fallout" due to photosynthetic activity in the surface water. The mechanisms blocking the precipitation of calcite in the surface water are not known, although dissolved organic compounds and phosphate have been implicated in other

lakes. Virtually all of the calcite precipitation appears to be occurring within the pore water of the sediments. The concentration of CO_2 could never change enough to dissolve calcite in the sea. Calcite will not dissolve in the Salton Sea, even with extensive dilution.

Q Did massive fish die-offs since the 1980's cause a change in salinity trends.
A There is no obvious direct effect as the amount of mineral matter, as skeletal material, tied up in fish (assuming 10^8 fish with 0.05 kg bone per fish) is at least 5 orders of magnitude less than the amount of salt that is precipitating annually.

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Table 1. Chemical composition of various waters in the Salton Basin.

Constituent	Irrigation water[1]	Drainwater[1]	River Water[2]	Salton Sea[2]
Temperature (°C)	--	--	22.6	23
Dissolved oxygen (mg O_2/L)	--	--	6.41	5.48
Specific conductance (µS/dm)	1.06	8.29	--	--
Dissolved solids (g/L)	0.69	4.86	2.28	43
pH	8.3	7.2	7.6	8.1
Ammonium (mg N/L)	0.03	0.18	--	--
Nitrate (mg N/L)	0.22	12	--	--
Calcium (mg/L)	76	310	168	944
Magnesium (mg/L)	29	330	80.8	1,400
Sodium (mg/L)	110	1,420	454	12,400
Potassium (mg/L)	4.3	19	9.9	258
Chloride (mg/L)	92	1,200	543	17,240
Sulfate (mg/L)	270	3,000	734	10,500
Alkalinity (as mg $CaCO_3$/L)	145	383	274	247
Silica (mg/L)	10	15.5	14	9.84
Selenium (µg/L)	~2	24	--	--

[1] From Schroeder (1996, Table 1), with a corrected value for drainwater sodium based on charge balance and specific conductance measurements. The original Na was 2,000 mg/L, which as been shown to be in error.
[2] Values used by Parkhurst and Holdren for model simulations reported herein.

Table 2. Projected chemical concentrations in the Salton Sea from model simulations.

Constituent	After 1 year[1]	After 50 years[1]	After 1 year[2]	After 50 years[2]	No ppt 50 yrs[3]
Dissolved Solids (mg/L)	43,830	57,900	43,872	57,950	63,400
pH	8.12	8.16	7.50	7.54	~9.0
Calcium (mg/L)	933	820	933	820	2,450
Magnesium (mg/L)	1,420	2,130	1,420	2,130	2,130
Sodium (mg/L)	12,520	16,510	12,520	16,510	16,510
Potassium (mg/L)	261	347	261	347	347
Chloride (mg/L)	17,410	22,180	17,410	21,280	21,280
Sulfate (mg/L)	11,030	15,620	11,030	15,630	17,100
Alkalinity (as mg $CaCO_3$/L)	246	292	291	342	2,700
Calcite precipitated (mg/L)	35.1	1,890	38.8	1,893	0
Gypsum precipitated (mg/L)	97.3	3,060	93.7	3,052	0

[1]Evolves CO_2 and precipitates calcite and gypsum to maintain pCO_2 = -3.01, $SI_{calcite}$ =1.15, and SI_{gypsum} = 0.18 throughout the simulation.
[2]Based on decreasing pH to 7.5 with same initial alkalinity, then maintaining the resulting pCO_2 = -2.29, $SI_{calcite}$ = 0.63, and SI_{gypsum} = 0.18 throughout the simulation.
[3]Chemical composition of the Salton Sea after 50 years if no precipitation (No ppt) were to occur and the River water composition remains the same as given in Table 1 and the annual inflow is 1.36 MAF.

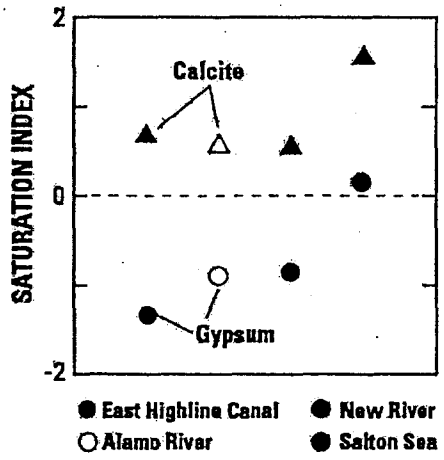


Figure 1. Saturation indices for waters in the Salton Basin.

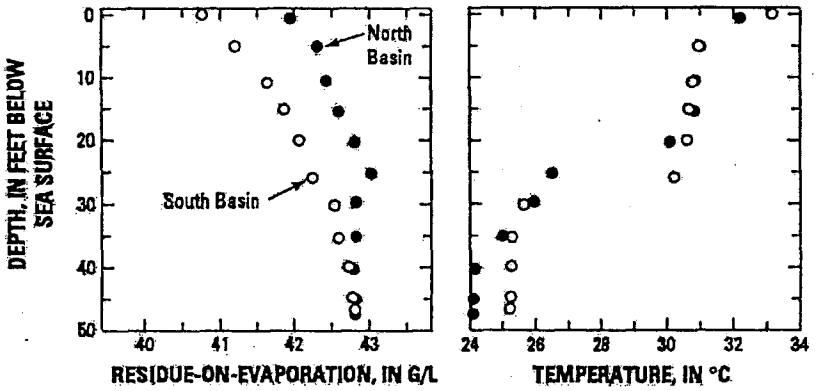


Figure 2. Profiles from the North and South subbasins in the Salton Sea.

SALTON SEA Restoration Project

SEA NOTES

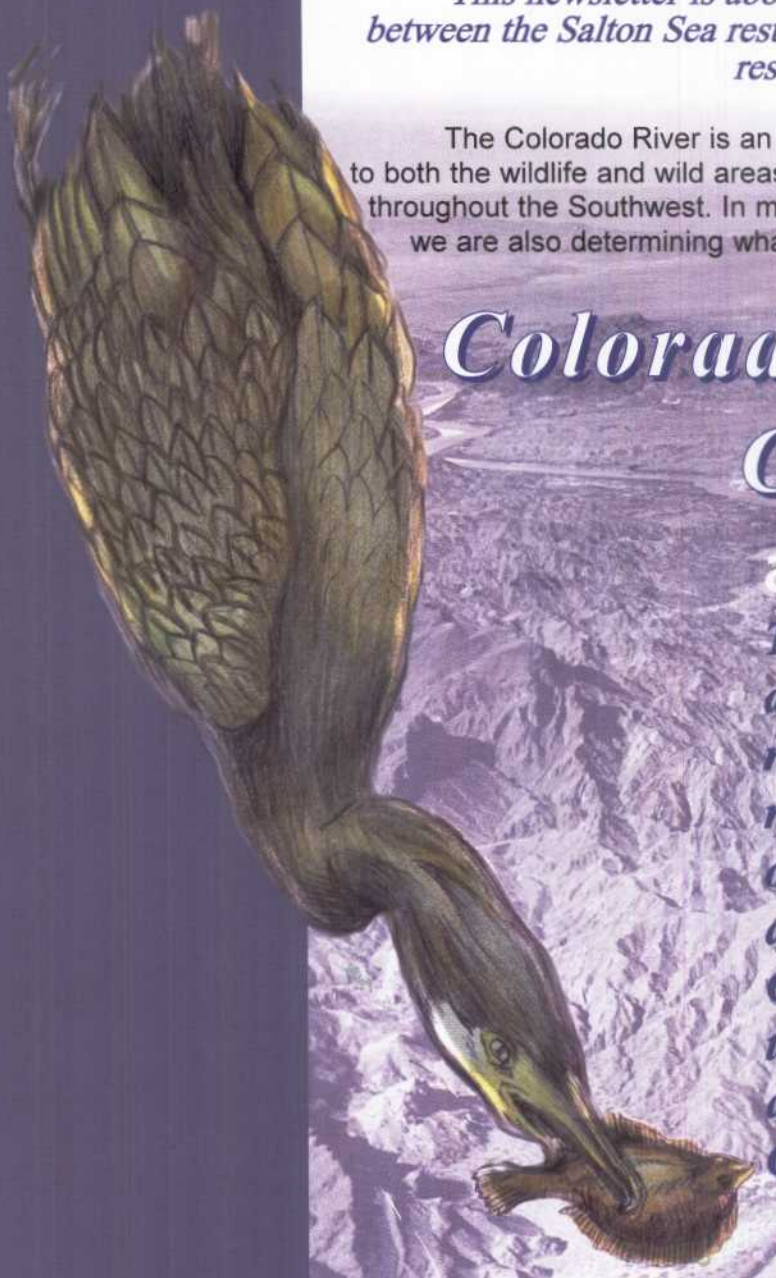
August 2001 *Reprint*

A newsletter of the Salton Sea Restoration Project

Newspapers and news broadcasts in recent months have been filled with stories about decisions regarding water and wildlife in the West. However, listening to the news, it is not always obvious how these decisions are intertwined. Further, many misperceptions exist.

This newsletter is about the connections – and differences – between the Salton Sea restoration and the Colorado River Delta restoration in Mexico.

The Colorado River is an oversubscribed river that is essential to both the wildlife and wild areas as well as the agricultural and urban areas throughout the Southwest. In making the choices of how to use this water, we are also determining what is to survive and what isn't to survive.



Colorado River Delta Connections—

a Brief Water History

The Lower Colorado River has always been a meandering river. It has also been a river that carried large loads of sediment, collected as it drained from the mountains of Colorado and Wyoming through the canyons of Utah and Arizona to the Gulf of California.

Millions of years ago, the Gulf extended through the Salton basin to present day Indio. The river intersected the Gulf near what is now Yuma (Figure 1). As deposits of sediment built up in the former delta, a low 10 -mile wide berm was created which extended 30 miles from Yuma to the Cocopah Mountains on the west side of the valley (Figure 2).

Eventually, the berm divided the north and south sides of the Gulf. The lake left to the north dried up. The Gulf to the south was pushed further and further south as sediments continued to be deposited (Figure 3).

The river itself was fickle in where it flowed. Depending upon its sediment deposits, it would change course, flowing sometimes south around the large berm to the Gulf and sometimes north to the Salton basin (Figures 4 and 5). Today's New and Alamo rivers flow in former Colorado River water courses. For roughly the last three million years, the river has changed course, leaving sediments on both sides of the berm and freshwater lakes behind in the Salton Sink.

In a December 2000 report, entitled "An Inventory and Evaluation of Lake Cahuilla Cultural Resources along Imperial Irrigation District's SA-Line," authors Jerry Schaefer, Ph.D., RPA and Ken Moslak, Associate Archaeologist, note that, "One of the most dynamic and dramatic aspects of the Colorado Desert paleoenvironment to effect human occupa-

Chronology for the Colorado River Delta

Figure 1

The Gulf, millions of years ago...

Figure 2

Splitting of the Gulf...

Figure 3

The lake to the north dries up...

Figure 4

At times, the river flowed north to the Salton Basin...

Figure 5

At times, it flowed south to the Gulf ...

Figure 6

Formation of the Salton Sea, 1905

tion was the flooding of the Salton Trough to form ancient Lake Cahuilla..." (Figure 4)

When the Salton basin filled completely, the lake was approximately six times the size of the current Salton Sea.

"The Imperial and Coachella Valleys filled with water in about 18 years to form the largest fresh water lake in California. It was 110 miles long, 32 miles wide, and over 280 feet deep at the center. The lake filled to an elevation of 40 ft above sea level, the height of the Colorado Delta that acted as a dam," according to the Schaefer report. It adds "Radiocarbon dates from marsh deposits and archaeological sites around the lake indicate from three to four major lacustrine [periods when the lake was filled] phases over the last 2000 years, each lasting for several hundred years."

In fact, while more research is needed, it is possible the river may have flowed north to the Salton basin more often than it did to the Gulf over that time. Schaefer's studies conclude that "for the last 1,300 years, the Colorado River flowed into the Salton Trough 55% of the time while directly emptying into the Gulf 45% of the time. Even so, with the long periods of recession, there was water in the trough more often than not." Other studies concur with these same findings (See table on page 4).

"There were also partial infillings and many fluctuations in lake levels. Recent research has also demonstrated that there was at least a partial infilling as recently as A.D. 1600-1700 (Schaefer 1994, 2000; Laylander 1994, 1995)," Schaefer writes.

A number of smaller lakes existed after 1600, including nine during the 1800s. According to Godfrey Sykes, who wrote several scientific articles on the Colorado River Delta between 1914 and 1937, water from the river entered the Salton Sink five times in the middle of the nineteenth century and one other time in the latter part of that century.

Sykes said the Colorado River entered the sink in 1840 (probably when the New River was formed), 1842, 1852, 1853, 1859, and 1867. In June 1891, the river flowed into the Salton Sink and created a 100,000 acre lake, according to Sykes. Shoreline evidence of travertine deposits, mollusk and fish remains, vegetative evidence, and tribal sites document the history of the lakes.

The 2000 Schaefer report: "Each time the lake filled, Indians from the Colorado River on the east and the Peninsular Range and desert fringes to the west established seasonal settlements along the sandy beaches of the shore line...The lake provided abundant fish, a species of freshwater mollusc, migratory waterfowl, cattail, reeds, and other marsh vegetation...Especially on the western side of the lake, stone fish traps were constructed in the shallow waters to take advantage of natural fish behavior to hide in rocky enclosures when startled or during spawning. Today, parallel lines of these V-shaped stone traps can be seen from aerial photographs in the now dry desert where the prehistoric ancestors of the Cahuilla and Kumeyaay (Kamia) Indians fished and where they built new lines of traps as the lake waters receded."

The Schaefer report notes that "formation of Lake Cahuilla was so important that at least one Cahuilla lineage preserved the oral history of the event, describing how they were forced from the low basin by the rising waters but then returned down to the shoreline to fish, gradually descending to lower elevations as the waters retreated."

See *CONNECTIONS*, Page 5

CITATIONS

Schaefer, Jerry, Ph.D., RPA & Moslak, Ken, December 2000. An Inventory and Evaluation of Lake Cahuilla Cultural Resources along Imperial Irrigation District's SA-Line. San Diego and Imperial Counties, California. ASM Affiliates, Inc. 543 Encinitas Boulevard, Suite 114, Encinitas, California 92024. 760-632-1094.

Walker, Boyd W., (ed) 1961. The Ecology of the Salton Sea, California, in Relation to the Sportfishery. State of California Department of Fish and Game, Fish Bulletin No. 113.

The Whole Colorado River Delta

is bounded loosely at the north by Indio and surrounding areas, to the east by the Colorado River at Yuma, to the south by the mouth of the Gulf of California and to the west by the Laguna Salada (as outlined in white in the figure to the left).

Redlands Database to deal with Whole Historic Delta

The Salton Sea Database Program at the University of Redlands is developing information on the historic and pre-historic flows of the Colorado River.

The Redlands team is working on integrating historical hydrological data, geomorphological evidence, and lacustrine evidence of Lake Cahuilla to tell the story of the greater Colorado River Delta which includes the Salton Trough.

"The purpose of this work is to provide better information to decision-makers, the public and stakeholders about the 'natural' flows of the Colorado River and the resulting distribution of water across the entire Delta," according to Dr. Tim Krantz, Professor of Environmental Studies and Salton Sea Database Program Manager at Redlands.

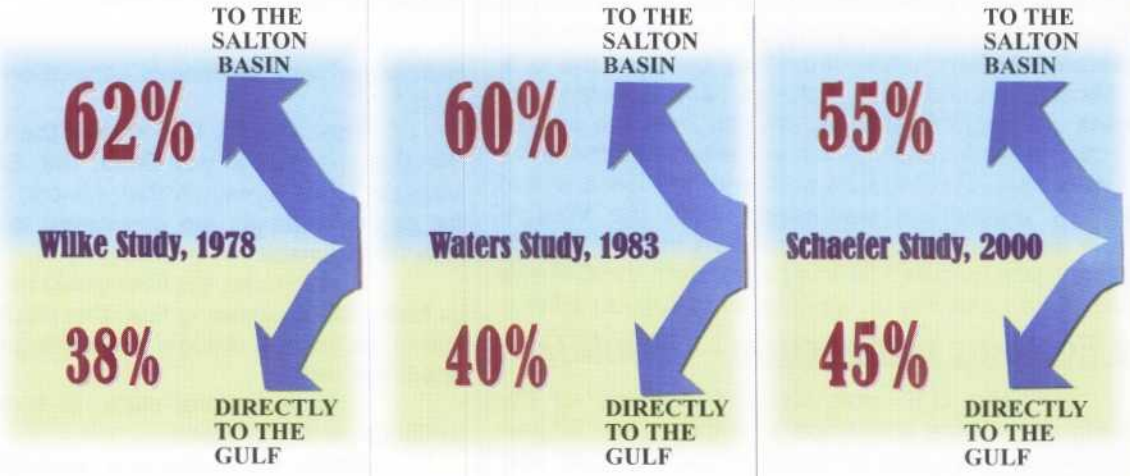
The project is expected to be completed in September.

Aerial view of Salton Sea and surrounding agricultural areas.
(Bureau of Reclamation photo)

Where did the Colorado River "naturally" flow?

Three scientists give surprisingly similar estimates for the past 2000 years.

Adapted from *An Inventory and Evaluation of Lake Cahuilla Cultural Resources along Imperial Irrigation District's SA-Line, San Diego and Imperial Counties, California,* ASM Affiliates, Inc., December, 2000.



In the fifty years *before the well-known "man-made accident" of the Colorado River floods of 1905 into the Salton trough, the Colorado River NATURALLY flowed into the trough several times in the 1800's.*

Connections *(Continued from Page 3)*

When not flowing into the Salton Sink, the Colorado River continued on its path to the Mexican Delta we think of today. As recently as 50 years ago, that region was a very large marshy area with multiple channels, rich wetlands, and abundant wildlife.

Over the last century, the Colorado River has been harnessed for farms and cities along its entire course. The economic value of the river has far exceeded anything even its earliest visionaries ever imagined. But the cost has been changes to the river's natural world.

A river that once carried nutrients and sediments from upper basin mountains and canyons in Utah and Arizona all the way to the Gulf is now a working river. The water is used and reused over its course. It flows through numerous agricultural fields and then is held behind large reservoirs that regulate its flows. Solids are concentrated as water evaporates and sediments drop out behind dams. The water diversions, and the underground aquifers they have created, sustain a vast agriculture industry, some of the largest cities in the West, the U.S. portion of the Delta -- including the Salton Sea -- as well as the Mexican portion of the Delta.

Under the existing flow regimes on the Colorado River, the Salton Sea is in balance - inflows of 1.3 million acre feet match evaporation of 1.3 million acre feet. But salinity is increasing. The Mexican portion of the delta has lost the majority of its inland wetlands, but the combination of guaranteed flows under the treaty between the U.S. and Mexico, groundwater recharge, and supplemental releases on the Colorado into Mexico over the last 20 years provide the potential for sustained restoration of wetland habitat. The Mexican portion of the Delta is also helped by agricultural wastewater from the Welton-Mohawk district in the U.S. that sustains the Cienega de La Santa Clara (pictured on this page). Both the Cienega and the Salton Sea rely on wastewater to support wildlife.

The Ecologic Connection – *Wildlife*

Both the U.S. and Mexican portions of the Colorado River Delta are critical to wildlife. Over 90 percent of inland lakes and wetlands in both the U.S. and Mexican Californias have disappeared due to development.

The Sea is the second most important bird area in the U.S. Over 400 species are found there. But it is especially important to water birds - there are millions at certain times - equaling the San Francisco Bay and Great Salt Lake in importance. The combination of fish in the Sea, deep and shallow feeding areas, and nearby agricultural fields provides what is needed for both local and migratory species.

While the bird populations at the Salton Sea and in the Mexican portion of the delta differ in many ways, the river's lower delta in Mexico provides critical habitat for migrating shorebirds, neotropicals, and local endangered species such as the Yuma Clapper Rail.

Fisheries, too, are important in both areas. The Salton Sea, while having no native fish other than the endangered pupfish, is considered one of the most productive fisheries in the world - a positive result of the nutrients flowing into the Sea from farm fields. The lower delta, especially in intertidal areas and the estuaries where the Colorado flows into the Gulf of California, has supported very rich fisheries. Today, with river flows unlikely to reach the Gulf, those fisheries are declining, and species like the Vaquita porpoise and totoaba have become endangered.

Riparian corridors along the Colorado, New, and Alamo rivers and desert corridors through the Cocopah and Coyote Mountains allow birds and other animals to travel throughout the greater Delta.

What does this mean?

Some dismiss the importance of restoring the Sea because of their erroneous conclusion that it is an "accident."

The reality is that neither the Colorado River nor the U.S. portion of the Delta, the Salton Sea nor the Mexican Delta remain in their historic "natural" states. As far as the wetlands are concerned in both regions, that may be fortunate.

If, somehow, the river would be allowed to resume its historical meandering flow, that would mean a resumption of decades of drought, alternating between the upper and lower deltas.

Such a "natural state" is something our fragile wetlands could not stand.

Rather than judging an ecological resource by its natural "purity" or trying to restore it to an earlier condition that is no longer attainable, existing resources have to be assessed for their current and future value to wildlife that must survive in a permanently changed landscape.

A Scientist's Viewpoint

By Milton Friend

The Salton Sea — To Be Or Not To Be — A Matter of Choices.

The Salton Sea is the latest within a series of waterbodies to occupy the Salton Trough over several thousands of years. However, unlike the waterbodies of the past, the Salton Sea is a contemporary water issue, and as such, it is also a contemporary biodiversity issue.

This relationship lies in the fact that the Salton Sea has become an important habitat for migratory birds. That importance is largely due to the loss of more than 90 percent of the interior wetlands within the State of California, wetland losses elsewhere, the dependable food base within the Sea and surrounding agricultural fields and other factors.

At the time of formation of the Salton Sea, water dependent birds had many alternatives to provide the breeding, migratory stopover, wintering and feeding requirements needed to provide for population maintenance and enhancement. That is no longer the case. Also, at the times of earlier "Salton Seas," major fluctuations in wildlife populations were a part of nature, mostly unobserved by humans.

Modern society has chosen to manage wildlife populations both as stewards of those resources for future human generations and to sustain wildlife populations at levels that serve current human values, including economic returns associated with consumptive and non-consumptive uses of those resources.

The environmental quality of the Sea needs to be improved and is the focus for the development of a restoration effort. Nevertheless, millions of birds are annually using the Sea, and the variety of bird species that have been recorded within the geographic area of the Sea and its surrounding exceeds 400 species.

Thus, the Salton Sea has become one of the premier areas for avian biodiversity. The salient points are that the Salton Sea has far greater importance for migratory birds today than that provided by the past waterbodies of the Salton Trough. If the Sea can be sustained at a salinity level close to present conditions, it will likely be of even greater future importance for migratory bird populations as development continues to consume additional areas of habitat.

As always, choices will need to be made to provide sufficient water of suitable quality to sustain bird populations. However, a unique aspect of the Salton Sea is that wastewater provides the foundation for life sustained by the Sea. Wastewater also provides the economic benefits associated with the vibrant fish and avian communities of the Sea.

Wastewater is, by necessity, becoming an increasingly important water source for sustaining free-ranging wildlife populations. The well-being of wetland-dependent wildlife will be greatly affected by our ability, or inability, to obtain and properly manage wastewater for the creation and maintenance of wetlands.

Will we make the choice to do so?

"The Bottom Line"

The Salton Sea has important implications for sustaining global biodiversity. The Sea is a "classroom" where we can learn to address the contemporary issue of water for wildlife vs. water for people. We can have both to a far greater degree than our current course is likely to provide.

This place called the Salton Sea is a "proving ground" that tests our resolve and ingenuity in resolving water management issues both on behalf of society and for the conservation of biological resources. The Salton Sea presents a unique opportunity to apply on a large scale, our ingenuity and technology in a manner that reuses irrigation water from agriculture in a manner to provide an array of major benefits.

We can ill afford not to do so.

Those waters should be considered to be part of global water resources and should be managed accordingly rather than dismissed as waste.

It is time to get on with the task of demonstrating how to do so.

Meetings Schedule

Imperial Irrigation District
81-600 Avenue 58
La Quinta, CA

*August Recess

Technical Advisory Committee:
09/06/01 10:30 a.m.

Board of Directors:
09/13//01 10:00 a.m.

Technical Advisory Committee:
10/04/01 10:30 a.m.

Board of Directors:
10/18/01 10:00 a.m.

SALTON SEA AUTHORITY

Plaza La Quinta
78-401 Highway 111, Suite T
La Quinta, CA 92253
www.saltonsea.ca.gov

SALTON SEA Restoration Project

SEA NOTES

December 2001

A newsletter of the Salton Sea Restoration Project

Stakeholders Convene to Map Out Sea's Future

The fourth biennial symposium on the Salton Sea will be held January 9 and 10, 2002 at the Miramonte Resort, 45-000 Indian Wells Lane, Indian Wells, California.

"This symposium, sponsored by the Salton Sea Authority, presents a unique opportunity for all who care about and are working to restore the Sea to come together and share their knowledge and views," said Authority President Roy Wilson.

The theme for the symposium is "Salton Sea, Bridging the Crossroads."

Wilson added, "Much has happened since the 2000 Symposium and we have come to a point where major decisions will be made soon about the future of the Salton Sea."

The agenda contains a review of the achievements of the

(See SYMPOSIUM on page 5)

Research Continues at Test Base

The old Navy Test Base on the West Shore of the Salton Sea made substantial contributions for nearly a half-century on weapons and parachute recovery systems that contributed both to defense of this country as well as to space exploration.

Salinity Research Facility, Salton Sea Test Base Photo courtesy of Bureau of Reclamation

Although the Navy has decommissioned the facility and it has been taken over by the Department of the Interior, the old base is still the home of very important research — tests that could help the Salton Sea survive.

Enhanced evaporation systems are a technology that has been used to concentrate and remove solids from liquids.

Members of the Congressional Salton Sea Task Force expressed interest in evaluating the effectiveness of these technologies and were successful in securing federal appropriations. This dedicated funding has been used by the Authority and Bureau of Reclamation to use the former base to test Enhanced Evaporation Systems.

The evaporators were run and met expectations for removing salts.

This summer, research at the old base took on a different dimension.

The test ponds that had been installed for the

(See RESEARCH on page 6)

Fallowing benefit: more jobs?

By RUDY YNIGUEZ,
Staff Writer

IMPERIAL — Fallowing agricultural land to provide water for the transfer between the Imperial Irrigation District and the San Diego County Water Authority would result in an increase in the number of local jobs, according to a government report.

The report, generated by a Bureau of Reclamation regional economist for the lower Colorado River basin and presented to the IID's water conservation advisory board, says about 300 net jobs would be created under certain scenarios.

Overall, about 500 jobs would result, including about 100 short-term jobs from the construction of solar evaporation ponds to remove excess salt from the sea.

The report was presented by Tom Kirk, executive director of the Salton Sea Authority.

Kirk said by fallowing flat crop ground to generate water for the pending transfer to San Diego, some of the revenues could be used to more than offset any loss of jobs. To get farmers to participate in the program, there could be incentives paid for each acre of land included as well as a certain amount for each acre-foot of water saved.

For example, farmers could be paid $550 for each participating acre of land, and $137 - from the sale of water to San Diego - for each acre-foot of water conserved.

The water transferred to San Diego is expected to sell for about $250 an acre-foot.

Subtracting $137 for the farmer, that would leave $25 for the IID's loss of revenues from decreased sales of water and power generation. The remaining $88 per acre-foot could be used to the benefit of the community, according to Kirk.

That $88, times 200,000 acre-feet transferred yearly, results in $17.6 million yearly to the community. The money could be used any way the community decides. For example, each of the 366 workers projected to lose their jobs could be compensated with $15,000, and additional funds could be used to retrain them for other business or industry the money could be used to attract to the Imperial Valley.

The study suggests $5.5 million yearly could be used for training, while $6.6 million could be used to attract new business through low-interest loans and reduced power and water rates.

Regarding the impacts of fallowing land, Reclamation regional economist Alan Kleinman - who conducted the study - said: "If you throw enough money at it, you offset the losses."

The loss of jobs was considered under two scenarios: fallowing 50,000 acres on which hays are grown - which is the preferred option, according to the report - and fallowing 50,000 acres of land at random with the full cross-section of crops.

Under the hay scenario, it is estimated 450 workers would lose jobs. Under the full crop scenario, about 1,400 jobs would be lost.

The loss of jobs throug
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are grown would be equal to a
0.8 percent of the total county w
force.

The job loss from the
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section of crops are grown woul
about 2 percent.

The job losses are categorize
direct, third-party and induced. T
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while induced are considered t
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Short of fallowing,
thinks the (Salton Sea) will di
that would harm the local eco
even more. He said a revitaliz
would increase property val
revitalized sea also would not
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happen with the collapse of
environment.

The economic re
mates the recreational val
sea results in benefits to
economy of $8.1 million
the sea were to collapse,
drops to about $2 milli
revitalized sea would br
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Finally, Kirk s
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Imperial Valley comm
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one of its most valu
Should the IID/San
fail, Kirk said a fight
water could result, w
and only attorneys w

Authority aids in bird rehabilitation efforts

The Salton Sea Authority is contributing $45,000 to Sonny Bono Salton Sea National Wildlife Refuge for construction of Pelican Flight pens at cooperating rehabilitation facilities.

The Authority's contribution comes from successful efforts by Senator Jim Battin to secure funding in the State budget for the restoration program.

This contribution is in addition to the $30,000 the Refuge has already received for the pens from the National Fish and Wildlife Foundation as well as many in kind contributions from cooperators.

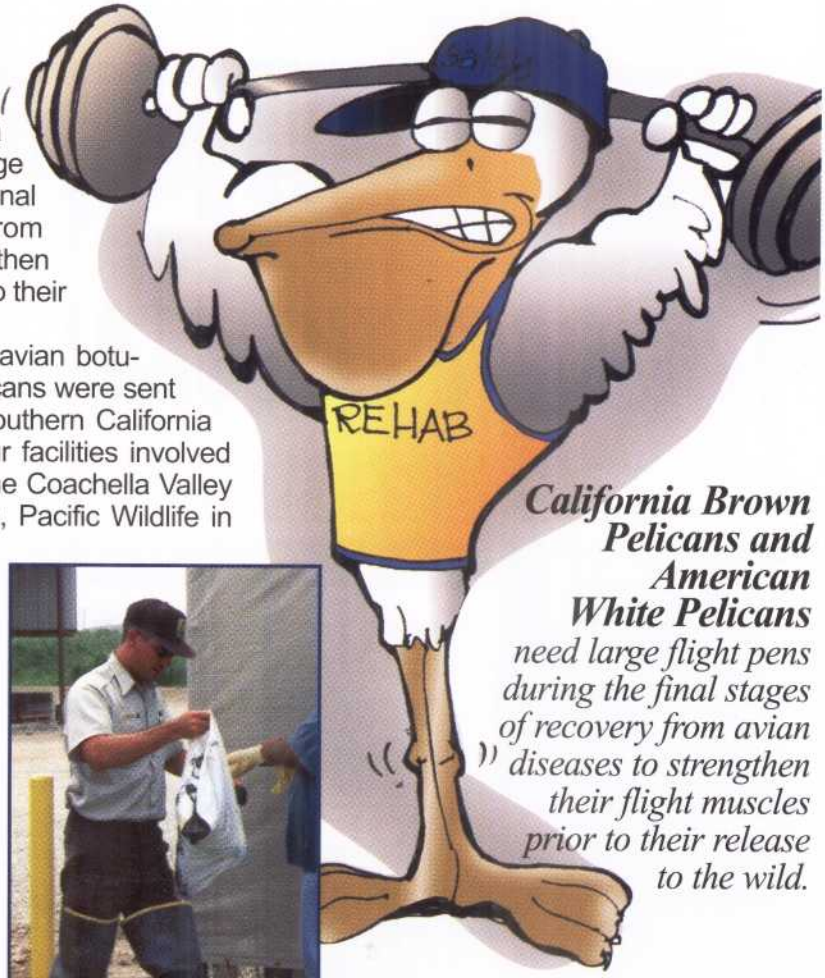
California Brown Pelicans and American White Pelicans need large flight pens during the final stages of recovery from avian diseases to strengthen their flight muscles prior to their release to the wild.

During the 2000 avian botulism outbreak, 1,100 pelicans were sent to facilities throughout Southern California for rehabilitation. The four facilities involved in the rehabilitation are the Coachella Valley Wild Bird Center in Indio, Pacific Wildlife in Irvine, Sea World in San Diego and Wetlands for Wildlife Care Center in Huntington Beach.

The flight pens at the rehabilitation centers are considered a critical element of treatment and will aid in the timely recovery of the pelicans.

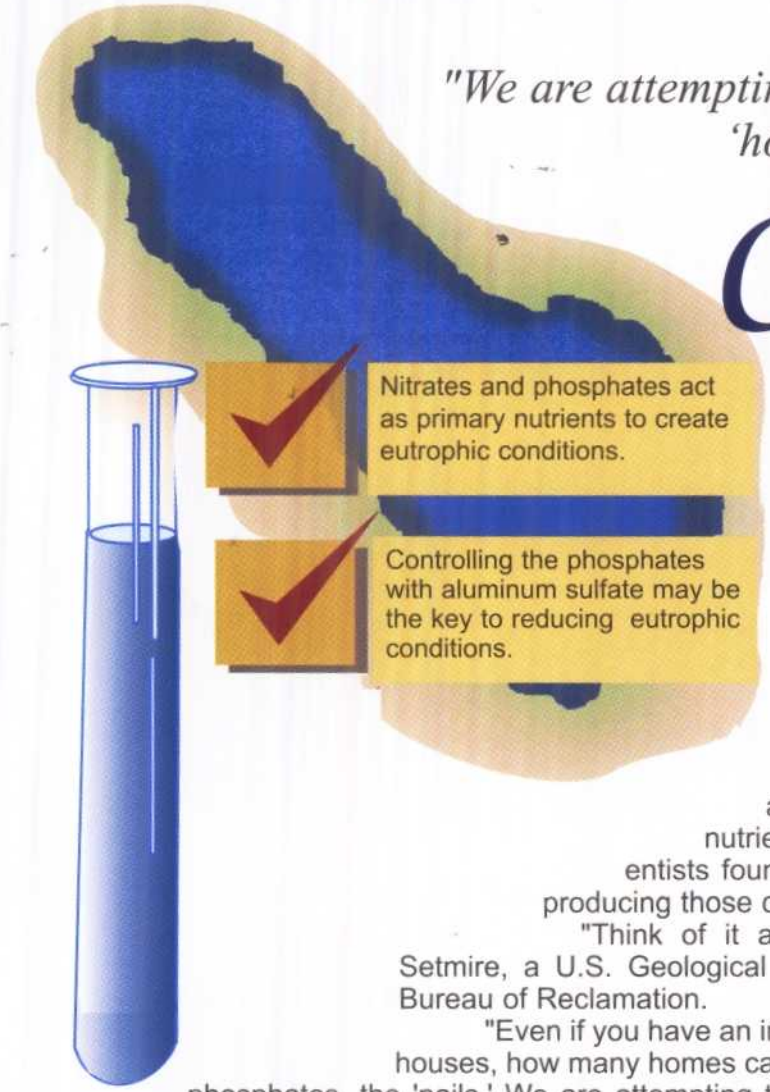
The Authority, the Fish and Wildlife Service and the California Fish and Game Department have a proactive disease response program in place at the Salton Sea that recovers sick birds in the early stages of avian botulism and avian cholera.

"These capture, treatment and release efforts have been very successful with some 60 percent of the pelicans retrieved at the Sea rehabilitated to full health. With flight pens it is expected that the rehabilitation rate will increase to 75 to 90 percent," said Fish and Wildlife Service Refuge Manager Sylvia Pelizza.



California Brown Pelicans and American White Pelicans *need large flight pens during the final stages of recovery from avian diseases to strengthen their flight muscles prior to their release to the wild.*

Scientific Paper Yields Clues to the Sea's Processes



"We are attempting to limit the number of eutrophic 'houses' by taking away the 'nails.'"

Jim Setmire
USGS hydrologist

Control of phosphates may be the key to eventually reducing the Salton Sea's eutrophic conditions, according to a recently published scientific paper.

The paper suggests testing a chemical that has been used for the past 50 years to control algal blooms in other lakes and reservoirs to neutralize the phosphates that flow into the Sea from municipal and agricultural runoff.

Eutrophication is a natural process where a body of water becomes rich in dissolved nutrients. For the Salton Sea, it means high fish populations, massive fish die offs as well as the noxious odors that at times permeate the lake.

While nitrogen and phosphorus are nearly always the chemical elements that act as primary nutrients to create eutrophic conditions in lakes, the scientists found that phosphorus is the main controlling factor in producing those conditions in the Salton Sea.

"Think of it as building houses," said the paper's editor, Jim Setmire, a U.S. Geological Survey hydrologist who is working with the U.S. Bureau of Reclamation.

"Even if you have an infinite amount of wood, but only enough nails for two houses, how many homes can you build? In this case, nitrates are the 'wood' and phosphates, the 'nails.' We are attempting to limit the number of eutrophic "houses" by taking away the 'nails,'" he said.

According to the scientific paper, the addition of aluminum sulfate--also known as alum--to the New and Alamo rivers may help to deal with the phosphates.

While the sheer size of the Salton Sea precludes direct treatment in the lake, the scientists state the alum treatment "may be able to be added to the tributaries to tie up the phosphorus before the water enters the Salton Sea."

The paper is entitled "Eutrophic Conditions at the Salton Sea." It stems from a workshop held last September at the University of California, Riverside.

In addition to Setmire, eight other scientists contributed to the work: Chris Holdren from the Bureau of Reclamation; U.S. Geological Survey scientists Dale Robertson, John Elder, Roy Schroeder; Chris Amrhein, a professor at the University of California, Riverside; Geoff Schladow, an associate professor at the University of California, Davis; Hank McKellar, an associate professor at the University of South Carolina; and Rick Gersberg, a professor at San Diego State University.

"These highly-qualified scientists have given us important insights into the eutrophication processes at the Salton Sea," according to Tom Kirk, Executive Director of the Salton Sea Authority.

The Salton Sea Authority recently received a $570,000 grant from the State Water Resources Control Board to determine the most efficient and cost effective means to reduce phosphorus loading from external sources. This project will investigate alum treatment as well as the control of phosphorus containing sediments.

A complete copy of the paper is posted on the Bureau of Reclamation website. To go directly to the document, which is a pdf file, the address is: http://www.lc.usbr.gov/~saltnsea/pdf_files/scidocs/eutrofin.pdf

SYMPOSIUM *(Continued from Page 1)*

Restoration Project, as well as discussions regarding the relationships between the Sea and the Quantification Settlement Agreement in relation to the Colorado River.

"We plan to air the views of the many Salton Sea stakeholders," Wilson said, "as well as review what we have learned from engineering and scientific perspectives."

As has been the practice in past symposiums, speakers will include policy and decision makers as well as the scientists and engineers who are engaged in the various projects at the Sea.

Tours of the pilot projects and wildlife disease control efforts are being planned as well as a birding tour of the Sea that will take place the day following the symposium at an additional charge.

SALTON SEA SYMPOSIUM REGISTRATION FORM

January 9 and 10, 2002

Please complete the registration form below and mail it with your check or money order to:

Salton Sea Symposium
Salton Sea Authority
78-401 Hwy 111 Suite T
La Quinta, CA 92253

Note: Make checks or money orders out to the Salton Sea Authority. No provisions for credit cards, purchase orders or billing are available and therefore cannot be accepted.

Name: _____

Affiliation: _____

Address: _____

_____

Daytime Phone: _____

Email Address: _____

Make your hotel reservations by calling the Miramonte Resort at 760 / 341 - 2200, or at www.miramonte-resort.com A block of rooms will be held until December 12, 2001.

For more information see the Authority website, www.saltonsea.ca.gov under Current Events, or call 760 / 564-4888.

REGISTRATION OPTIONS
CHECK ONE

Both days with Continental Breakfast (2) .....$35 ☐

Both days with Continental Breakfast (2) and lunch (2) .....$75 ☐

Both days with Continental Breakfast (2), lunch (2) and dinner (1) .....$110 ☐

OPTIONAL (Check all that apply)

Salton Sea Restoration Pilot Projects Tour Afternoon of January 10 (no additional fee)..... ☐

Birding Trip to the Sea — January 11 6-11 a.m. (Additional fees will be assessed; call the SSA for cost)..... ☐

Pre registration deadline is December 21
After December 21 & for walk-in registration, add $20..... ☐

TOTAL ENCLOSED

Research *(Continued from Page 1)*

The objective of the Disposal Research Project is to develop salt deposits that are representative of those expected in a full-scale salt removal effort.

Enhanced Evaporation System were modified to obtain data so a full-scale salt disposal facility can be designed.

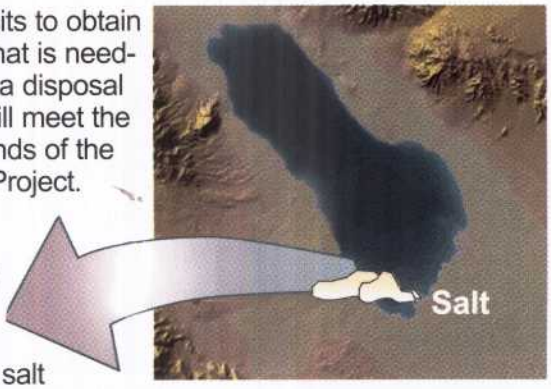
The issue of salt disposal is significant for the Restoration Project, which is currently focusing on the potential of solar evaporation ponds as a means of salt removal. It is expected that tons of salt will be generated each year from the Restoration Project.

"Given the ponds that we constructed, the secluded site and interest in learning more about extracting and storing salt at the Sea, we modified the project this summer to learn more," said the Bureau's Program Manager, Mike Walker.

"We are still running some evaporators, but we are doing it to take a lot of salt out of the Sea so we can determine how we can best deal with it," Walker said.

The objective of the Disposal Research Project is to develop salt deposits that are representative of those expected in a full-scale salt removal effort.

Physical and chemical analysis will be performed on the deposits to obtain information that is needed to design a disposal facility that will meet the heavy demands of the Restoration Project.



In addition, the preferred management technique for the salt deposits will be developed.

"This project is an important start at taking a lot of salt out and it compliments the solar evaporation pond test site on the other side of Sea. We will learn much about salt compounds and disposing of those compounds," Walker said.

Meetings Schedule

Imperial Irrigation District
81-600 Avenue 58
La Quinta, CA

Board of Directors Meeting
12/05/01
2:00 p.m.

Technical Advisory Committee Meeting
12/19/01
10:30 a.m.

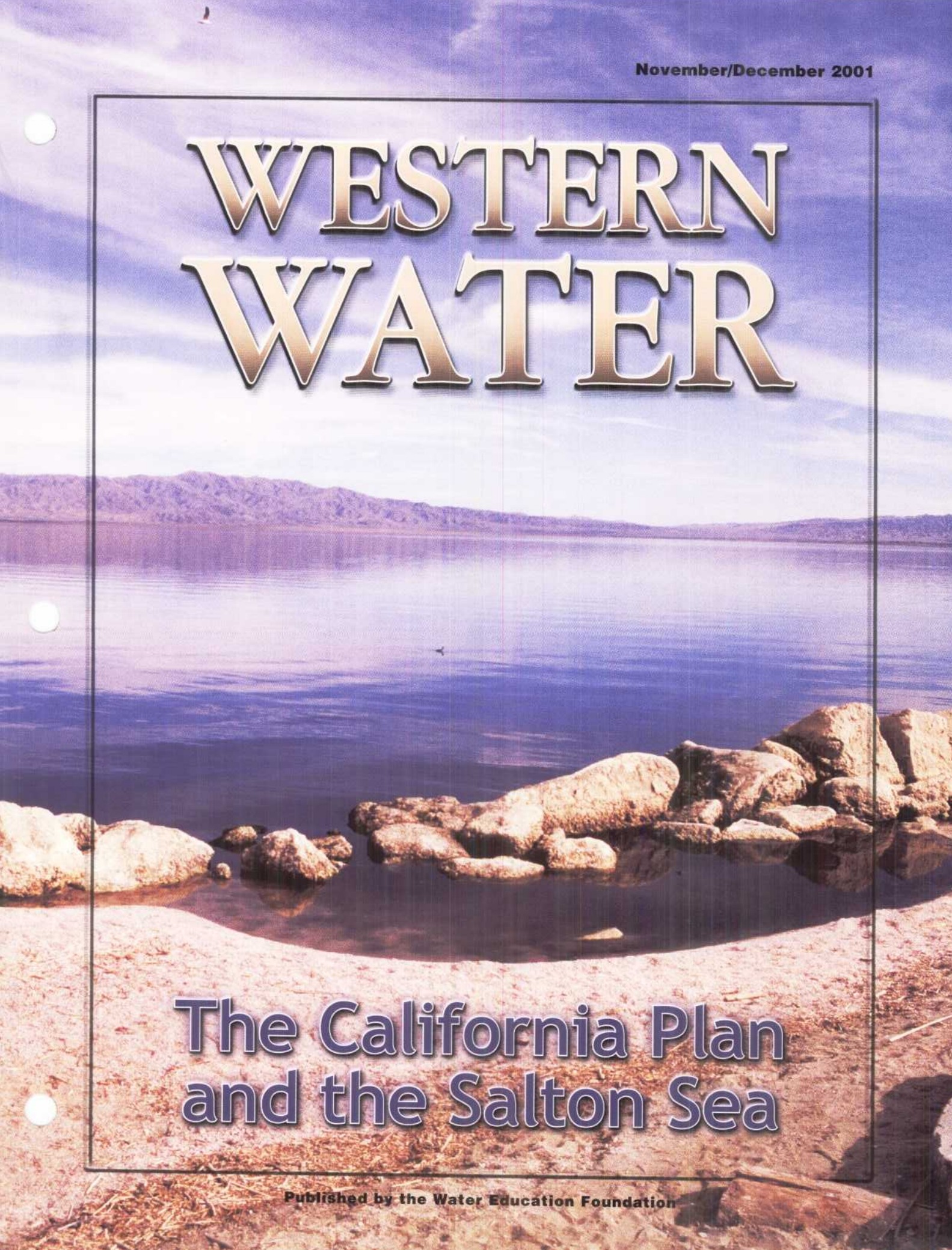
Board of Directors Meeting
1/17/02
10:00 a.m.

SALTON SEA AUTHORITY

Plaza La Quinta
78-401 Highway 111, Suite T
La Quinta, CA 92253
www.saltonsea.ca.gov

November/December 2001

WESTERN WATER



The California Plan and the Salton Sea

Published by the Water Education Foundation

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The Salton Sea
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What Next?
page 13

On the Cover

A view of the Salton Sea.

Cover photo by Sue McClurg

Credits

Editor
Rita Schmidt Sudman

Writer
Sue McClurg

Editorial Assistance
Diana Farmer

Photos
California Department of Water Resources
Interior Department
Sue McClurg

The Water Education Foundation thanks all the sources and experts who reviewed this magazine for balance and accuracy.

The Water Education Foundation is a nonprofit, impartial, tax-exempt organization. Its mission is to create a better understanding of water issues and help resolve water resource problems through educational programs.

Western Water is published by the Water Education Foundation, 717 K Street, Suite 317, Sacramento, CA 95814 (916) 444-6240, fax (916) 448-7699. An annual subscription to this bi-monthly magazine is $35. The balance of the Foundation's information program may be supported by larger amounts, which are tax deductible. Printed on recycled paper with soy-based ink.

E-mail: feedback@watereducation.org
Web page: www.watereducation.org
ISSN: 0735-5424

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Executive Director: Rita Schmidt Sudman

Editor's Desk

It's been said many times by now, but the events of September 11 changed all our lives. Certainly the safety of our drinking water in the United States became a bigger-than-ever concern.

In this issue of *Western Water* we've briefly profiled the events that could affect our water supply in the aftermath of the World Trade Center attack. (See "In the News.") In the January/February issue, Writer Gary Pitzer will look at the long-term effects of dealing with water terrorism on our own soil.

On September 11, like you, I woke up to the terrible news about the attack. I had planned to fly to southern California that day to assist Judy Wheatley Maben with our first Southern California Groundwater Tour. After discussions with speakers and participants, we decided to move forward with the tour and continue our efforts to educate people about this important resource. So instead of driving to Sacramento International Airport, Judy and I drove about 500 miles to southern California to carry on the tour. Although 15 of the 55 participants weren't able to join us because of travel difficulties, we were all glad to be together and concentrate on our work for a few days.

We had never before begun a tour with the Pledge of Allegiance, but now it seemed a meaningful way to begin. For three days we traveled by bus together, keeping in touch with world events, learning about how groundwater is managed in six southern California basins. It's a story of progressive and innovative thinking. We'll be having more tours and conferences analyzing groundwater issues in the West, and I hope many of you will join us for these events in 2002.

On that tour after the September 11 attack, I had a chance to think about how through the years, water issues became the focus of my career. Perhaps many of us are questioning our work. Is water an important issue in a country at war? Some things now seem turned upside down. After some thought, I decided that I want to stay engaged with those working to make a difference for improvement of our environment, cities and farms.

So we'll be following issues like CALFED again soon. In fact recently, while anthrax scares surrounded the capitol, the U.S. Senate debated a bill that would allow federal funds to continue to support the extensive plan for restoring California's Bay-Delta estuary and assuring a reliable water supply for the state. A House version, HR 3208, recently cleared the House Resources Committee. On a somewhat ironic note, the measure, by Reps. Ken Calvert, R-Riverside, and Cal Dooley, D-Fresno, is named the Western Water Security Enhancement Act. But the name is not in response to September 11; rather it dates back to May when Calvert introduced similar legislation.

Water issues do make a difference on how we live now and how our children will live in the future Western U.S. As good citizens we should join in debates on issues we believe matter. And I think water is one of the most important issues. While a few misguided people want to terrorize and tear things down, we can take this opportunity to re-dedicate ourselves to our work to improve our world. ❖

Rita Schmidt Sudman

See page 14 for more on WEF's latest activities, or visit our web site at www.watereducation.org

In the News

Water Officials Enact Safety Measures

The Sept. 11 terrorist attacks on the World Trade Center and the Pentagon prompted federal and state officials to launch a massive reevaluation of the integrity of the nation's water storage and delivery systems, given the possibility of further attacks. Congress is in the midst of considering how much to appropriate for beefed up security measures.

"The terrible attacks on Sept. 11 taught us, as a nation, to imagine unimaginable acts against us and take sound, swift steps to make sure they can't happen," said Rep. James V. Hansen, R-Utah, chair of the House Resources Committee. "At a time like this, we must take actions to facilitate fully-trained, ongoing security at our federal dams and hydroelectric power plants . . .."

Officials took immediate steps to heighten security at water facilities in the wake of the attacks. National Guard troops were deployed to Hoover Dam, a key strategic target in the West. U.S. Highway 93, the main road between Phoenix and Las Vegas that crosses the dam, was closed Sept. 11 but reopened two days later to passenger cars and small pickup trucks. A ban on local trucks, buses, motor homes and boat trailers has been gradually eased. In California, many facilities were immediately closed Sept. 11, including Friant Dam. Kirk C. Rodgers, acting regional director of the U.S. Bureau of Reclamation's mid-Pacific region, asked water contractors in a letter to maintain "a high level of alertness and security at the Reclamation facilities you operate and maintain."

Security also was increased at State Water Project facilities, and at hundreds of other dams, reservoirs and water conveyance systems throughout California. Increased security patrols, aerial surveillance of the California and Colorado aqueducts by the California Highway Patrol and additional testing of water supplies are ongoing.

Gov. Gray Davis, following a tour of a water treatment plant along the American River Oct. 16, said, "While the possibility that our water supply could be contaminated by a biological or chemical threat remains remote, I want the people of California to be assured that we are on full alert and taking every precaution to safeguard our water." Scientists and agency officials emphasize it is unlikely that anyone would poison a water system because of the large volume of contaminants needed to cause an impact.

Agencies have taken steps to upgrade electronic security, particularly the amount and type of information available via the World Wide Web. In the days following the attacks, information that could have been used by terrorists against water systems was removed from web sites. The Association of California Water Agencies made several recommendations to its members, including that they review public information posted on web sites, review printed material that includes information about water facilities and operations and prepare board members and staff to respond to public inquiries about security measures.

Legislative proposals to increase security funding emerged immediately after the attacks and will continue throughout next year. One law allows the Bureau to contract with local, state and federal agencies to provide trained and certified law enforcement security at federal dams. On the funding side, proposals have surfaced for the federal government to spend as much as $105 million to develop vulnerability assessments and emergency response plans for water facilities nationwide. "A substantial investment is needed for water infrastructure security [research and development] to address potential vulnerabilities at our nation's drinking water and wastewater systems," says the Association of Metropolitan Water Agencies. ❖

– Gary Pitzer

WEF 2002 Calendar

January 30 – February 1
WEF Colorado River Stakeholder Symposium
Rita Schmidt Sudman, coordinator
Santa Fe, NM

March 14
WEF 19th Annual Executive Briefing
Rita Schmidt Sudman, coordinator
Sacramento, CA

March 20-22
WEF Lower Colorado River Tour
Judy Wheatley Maben, coordinator
Las Vegas, NV

May 22-24
WEF Central Valley Tour
Judy Wheatley Maben, coordinator
Sacramento, CA

May 30
WEF 25th Anniversary Party
Rita Schmidt Sudman, coordinator
Sacramento, CA

June 19-21
WEF Bay-Delta Tour
Judy Wheatley Maben, coordinator
Sacramento, CA

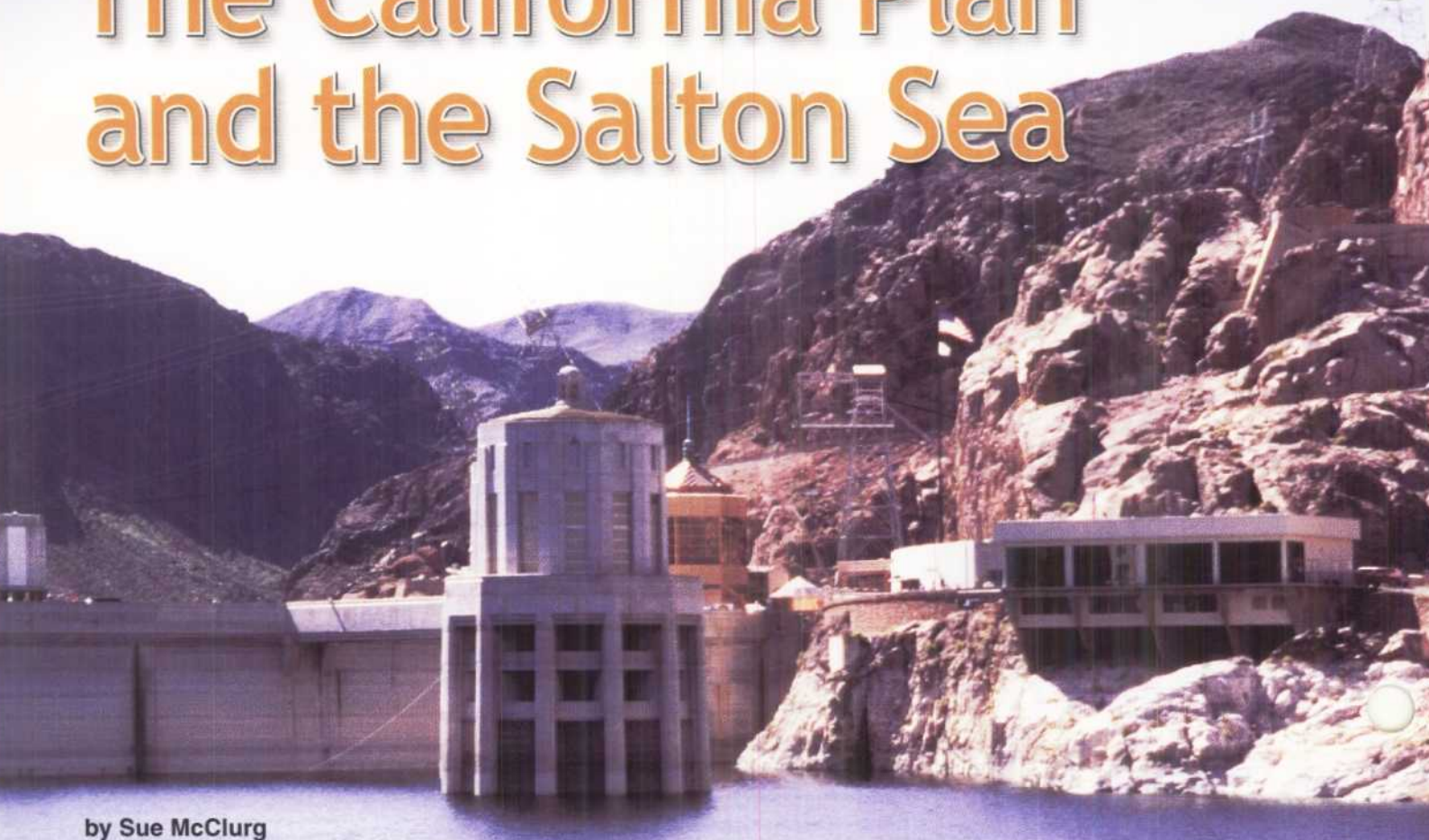
July 18-19
WEF Water Law & Policy Briefing
Rita Schmidt Sudman, coordinator
San Diego, CA

September 11-13
WEF Sierra Watersheds Tour
Judy Wheatley Maben, coordinator
Sacramento, CA

October 2-4
WEF Northern California Tour
Judy Wheatley Maben, coordinator
Sacramento, CA

October 23-25
WEF Southern California Groundwater Tour
Judy Wheatley Maben, coordinator
Ontario, CA

The California Plan and the Salton Sea



by Sue McClurg

Water from the Colorado River transformed the sagebrush and desert sands of the Imperial, Coachella and Palo Verde valleys into lush, green agricultural fields. The growing season is year-round, the water plentiful and the local economies are based almost entirely on farming. As the waters of the Colorado River allowed the deserts to bloom, they allowed southern California cities like Los Angeles and San Diego to boom. Suburbs, jobs and people followed, and the population within the six counties served by Metropolitan Water District of Southern California (MWD) grew from 2.8 million in 1930 to more than 17 million today.

Key to this southern California economy is water from the Colorado River. More water; in fact, than California is entitled to under the various agreements and contracts that form the Law of the River. Water that California is now under obligation to cut back under a deal worked out with the other Colorado River Basin states and the federal government.

To reduce the state's annual draw on the Colorado River from some 5.2 million acre-feet to 4.4 million acre-feet, the state's basic apportionment, the California parties agreed to implement water conservation measures, initiate agricultural to urban transfers and develop comprehensive groundwater banking and conjunctive use programs. It was California's commitment to this Colorado River Water Use Plan (commonly called the 4.4 Plan) that ultimately led to an agreement between California and the other six basin states over the use of surplus water. Adopted in the final days of the Clinton administration, the Interim Surplus Guidelines (Guidelines) are designed to provide California with 15 years of greater certainty of surplus water from Lake Mead as the state gradually cuts its water use.

The linchpin of the 4.4 Plan is the historic water conservation-transfer agreement between Imperial Irrigation District (IID) and the San Diego County Water Authority (SDCWA) in which up to 200,000 acre-feet of water will be transferred from Imperial Valley farms to San Diego via a water exchange arrangement with MWD. (An additional 100,000 acre-feet may be transferred from IID to its agricultural neighbor, the Coachella Valley Water District (CVWD).)

Every drop of water saved and transferred will help California reduce its overall Colorado River use. But

every drop of water saved and transferred is one less drop than would normally flow into the Salton Sea, a vast, saline lake located in the Imperial and Coachella valleys. Formed by the joint forces of man and nature in the early 1900s, agricultural drainage from area farms helps sustain the sea.

The dilemma of how to save the Salton Sea and at the same time implement the transfer has become the overriding issue in the ongoing effort to move the California plan from proposal to reality. Indeed some say the transfer and 4.4 Plan are in danger of collapse, or significant delay – which could mean a loss of surplus water, at least for a time.

"IID is looked at as a source of water for other Colorado River users and to the extent the transfer can be accomplished in a way that is environmentally sound, we would like to proceed," said Board President Andy Horne. "But if we can't proceed, this transfer is in real trouble and so is the 4.4 Plan."

If the transfer deal fails or is delayed, southern California urban water suppliers and users are most at risk because they are last in line when it comes to state's Colorado River water apportionment. "The risk of being cut off is onerous," SDCWA General Manager Maureen Stapleton told the *San Diego Union-Tribune*. "You're talking about being forced to make up a substantial amount."

California officials say they have made substantial progress on finalizing the 42 legal and environmental documents necessary to implement the components of the 4.4 Plan. But the original schedule for completion has slipped and much remains to be done to meet the December 2002 deadline to have a final plan in place.

Noting that the transfer faces numerous challenges, Tom Hannigan, director of the California Department of Water Resources (DWR), stressed that the 4.4 Plan is too important to California's future to allow it to fail. "I remain confident we can work these issues out," he said. "We have to."

The list of issues to be worked out is long and complex. "It was a major undertaking when we started, but it has only gotten bigger in scope as we went along," said Dennis Underwood, vice president of Colorado River issues for MWD. "The complexities have been added by external forces – not because we've been bogged down administratively."

Environmental issues top the list, but underlying the debate over how to resolve these issues is the continuing political controversy within the Imperial Valley over the water conservation-transfer agreement itself.

One of the most volatile issues is how farmers should conserve water. The existing contract prohibits fallowing, instead calling for IID farmers to farm the same amount of acreage, and install on-farm improvements such as tailwater recovery systems (financed by the money provided by SDCWA for the water) to conserve water for transfer to San Diego.

But the water that runs off the land is so important to the Salton Sea, U.S. Bureau of Reclamation (Bureau) and Salton Sea Authority officials developed an alternative proposal in which farmers would be paid to fallow a portion of their acreage to make water available for transfer to San Diego. The reductions of inflows to the Salton Sea would be less under a fallowing program than conventional conservation techniques, reducing the transfer's effect on the sea.

"No fallowing," however, has long been the rallying cry in the Imperial Valley where there is deep concern over the transfer's potential third-party impacts on farm workers, tractor dealers and the local economy in general.

As Imperial Valley interests debate fallowing, MWD and farmers in nearby Palo Verde Valley are finalizing an agreement in which farmers would fallow between 7 and 29 percent of their land in any given year, transferring water not used to MWD at a cost of $153 to $206 per acre-foot. MWD

"IID is looked at as a source of water for other Colorado River users and to the extent the transfer can be accomplished in a way that is environmentally sound, we would like to proceed. But if we can't proceed, this transfer is in real trouble and so is the 4.4 Plan."

– Andy Horne, IID

The Boulder Canyon Project Act of 1928 paved the way for construction of Boulder (Hoover) Dam. The Act was signed by President Coolidge, center.

officials believe if this deal goes forward, it not only will help MWD maintain a full aqueduct, but help California meet its water reduction requirements (see page 11).

The question of how much the IID-SDCWA transfer will affect the Salton Sea, and how to mitigate for those effects, is complicated by the fact that the sea's ecosystem already is deteriorating. Even without the IID transfer, scientists say the sea will eventually become too salty for fish; the transfer will accelerate that process. The issue at hand is how much of the larger Salton Sea restoration effort (see page 8) should be borne by the transfer.

"The Salton Sea will be lost whether transfers occur or not so it's not fair to say transfers have to bear the brunt of the Salton Sea fix," said Robert Johnson, regional director of the Bureau's Lower Colorado Region.

How to pay for these environmental mitigation measures also must be determined. In its agreement with SDCWA, IID placed a $15 million cap on the amount of money it would spend on upfront mitigation (plus an additional $15 million for ongoing mitigation), providing an escape clause from the transfer deal if the costs were greater. There are many indications that the mitigation proposed by the U.S. Fish and Wildlife Service (USFWS) will cost much more, and in order to keep the transfer alive, some of the other California parties and/or the federal government may need to help foot the bill.

Rep. Duncan Hunter, R-El Cajon, has introduced legislation, HR 2764, capping the transfer's share of Salton Sea mitigation at $60 million, and providing federal funds to pay for it. But that $60 million would not be available until 2008, according to environmentalists, who also dislike the bill because it would eliminate public review of a habitat conservation plan (HCP) for certain endangered species.

"It's a terrible bill," said Michael Cohen, senior research associate for the Pacific Institute for Studies in Development, Environment and Security. "It arbitrarily limits the rights of groups to sue, and the time they have to do so, and it relies on an HCP that has been drafted in secret by IID and still has not received any public review."

Although Hunter's bill remains stalled in the House Resources Committee, another bill, HR 3208, by Rep. Ken Calvert, R-Riverside, that includes a $60 million appropriation for activities to address environmental impacts on the Salton Sea associated with implementation of the Quantification Settlement Agreement (QSA) recently cleared the committee 24-18.

Endangered species also are an issue at the state level. The California parties backed legislation to provide the IID-SDCWA water transfer with a waiver from the state's Fully Protected Species Act, which prohibits the "taking" of certain endangered species. Two of California's "no take" species – the brown pelican and desert pupfish – are found in the Salton Sea.

A bill amending this law on a statewide basis failed to pass the state Legislature before it adjourned, but can be reconsidered when the Legislature reconvenes in January. Although

environmentalists oppose the bill, they have indicated a willingness to negotiate on a Salton Sea-only relaxation of the rule, as provided in AB 1561.

The California parties say passage of the state and federal legislation is crucial to the future of the transfer, especially if they are to make the looming deadlines to complete the studies, legal documents and begin transferring water by January 2003.

Even as officials grapple with Salton Sea-related questions, another environmental issue looms on the horizon – supplying water for the Colorado River Delta. Environmentalists tried, but failed, to gain a reliable source of water for this wetlands area south of the border in the Guidelines. They fear implementation of the 4.4 Plan may further reduce what water the Delta does receive through flood control releases because Lake Mead will be maintained at a lower level.

"The lower Lake Mead is, the 'ower the possibility we will have flood flow releases out of Lake Mead to the Delta," said Pam Hyde, executive director of Southwest Rivers. "Are we looking at no water for the Delta?"

This issue of *Western Water* updates progress on the 4.4 Plan, with a special focus on the Salton Sea restoration/water transfer dilemma. More Colorado River information is available in the Foundation's recently updated *Layperson's Guide to the Colorado River*, written proceedings of Colorado River symposia, back issues of *Western Water*, and the biannual *River Report* newsletter, which focuses exclusively on Colorado River issues.

Background

With the signing of the 1922 Colorado River Compact, each basin was granted roughly 7.5 million acre-feet a year. (The Upper Basin states are required to send to the Lower Basin states 75 million acre-feet every 10 years.) Water within the Lower Basin was divided this way: California, 4.4 million acre-feet; Arizona 2.8 million acre-feet and Nevada, 300,000 acre-feet. Yet California has historically used up to 5.2 million acre-feet a year, some 800,000 acre-feet beyond its basic apportionment. For MWD, such water is crucial because its share of the 4.4 million acre-feet, 550,000 acre-feet, is less than half the capacity of its Colorado River Aqueduct.

Until the 1990s, the fact that California consumed more than its share of Colorado River water provoked only minor controversy; after all, the state was simply using water its Lower Basin neighbors did not use. But things changed. Unprecedented growth in southern Nevada brought it close to its full apportionment while Arizona implemented a groundwater storage program under which it diverts nearly its full share.

The first formal surplus under the Annual Operating Plan was declared by the Secretary of the Interior, who serves as watermaster of the Lower Colorado River, in 1996. Favorable hydrologic conditions allowed for subsequent surplus declarations in 1997, 1998, 1999 and 2000.

California's continued reliance on surplus water and the fact that the Lower Basin was near its full apportionment generated unease in the Upper Basin; officials fear such a situation long term could jeopardize the delicate political balance established by the Compact.

With political pressure building from the other Colorado River Basin states and the federal government, California's Colorado River contractors gradually moved from conflict to cooperation (see page 8).

The subsequent Guidelines allow, under certain circumstances, for the greater draw down of Lake Mead, providing California with a greater probability of surplus water. (In 2001, a limited surplus was declared by Interior under existing guidelines.)

For 2002, the Bureau plans to declare a full domestic surplus from Lake Mead as defined in Section 2 of the guidelines as adopted in early 2001, with the amount of surplus water to be released from Lake Mead

"The Salton Sea will be lost whether transfers occur or not so it's not fair to say transfers have to bear the brunt of the Salton Sea fix."

– Robert Johnson, US Bureau of Reclamation

not expected to exceed 640,000 acre-feet. This will provide MWD with a full aqueduct, and some surplus water for domestic users in Nevada and Arizona. (The decision will be reviewed mid-year.)

The IID-SDCWA transfer and the larger Salton Sea restoration proposal each is the focus of its own Environmental Impact Statement and Environmental Impact Report (EIS/EIR). According to SDCWA, the study of the transfer's effects on endangered species has been completed, and SDCWA and IID have made "good progress" on reaching agreements with federal and state fishery officials on what types of projects are needed to offset the impact on the Salton Sea. But they say progress has been slowed because of questions about the Salton Sea that they had expected to be addressed in the larger EIS/EIR, originally scheduled for completion in 2000. If those questions aren't answered, they can't finish their EIS/EIR, which means the transfer won't go forward. But those who are working on the sea's restoration say it is difficult to choose an alternative until they know when the transfer(s) will take place and how much inflow will decline.

"The two EIRs are on parallel tracks," said IID President Horne. "But at some point, the tracks intersect and there is a real chance of a train wreck."

The Salton Sea

Once California's largest fresh water lake, the 375-square-mile Salton Sea today is 25 percent saltier than the Pacific Ocean. Without a natural outlet, water trapped more than 200 feet below sea level in this massive desert sink continually evaporates, increasing the salt content in the remaining water an estimated 1 percent per year. It is a natural process; one embodied in the highly saline Great Salt Lake in Utah and the Dead Sea of the Middle East.

Located in an otherwise harsh desert climate, the Salton Sea is tremendously attractive to birds, especially those in search of a stopover on the Pacific Flyway, the migratory route between South and North America. According to the Salton Sea Authority, millions of birds use the sea each winter day, and some 408 species of birds have been identified at the sea, which is a popular site for birders from around the world. USFWS officials say the disappearance of some 90 percent of California's wetlands makes the sea all that more important.

The Salton Sea originally was inhabited by fresh water fish transported via the Colorado River or intentionally introduced. But the sea gradually became saltier and by the 1930s, many of these fish had died. Wanting to maintain a viable recre-

The California Plan

As outlined in the 1999 Key Terms for Quantification Settlement Agreement, the California parties that share the Colorado River established these broad conditions:

- IID's basic annual apportionment was set at 3.1 million acre-feet of the 3.85 million acre-feet apportioned to the agricultural districts. This is the baseline from which IID will establish a program to conserve water and, ultimately, reduce its use to approximately 2.7 million acre-feet. The water conserved will be transferred to other entities.
- CVWD's basic annual apportionment was set at 330,000 acre-feet. But, CVWD will have the ability to obtain additional water, including 100,000 acre-feet from IID and MWD, for an annual total of 456,000 acre-feet.
- MWD's basic annual apportionment under its fourth priority is to remain at 550,000 acre-feet, but combined with related transactions, could reach as high as an additional 651,000 acre-feet annually. In addition, the Guidelines will allow MWD to receive enough water, in most years, to fill its 1.25 million acre-feet Colorado River Aqueduct.
- Between 130,000 and 200,000 acre-feet of water is to be transferred annually from IID to SDCWA under terms of those agencies' agreement and an exchange agreement between SDCWA and MWD.

The key terms also provided 16,000 acre-feet for facilitating implementation of the San Luis Rey Indian Rights Settlement. This water, as well as an additional of 77,700 acre-feet for MWD, will come from conserved water generated by lining portions of the All-American and Coachella canals.

ational fishery, California fish and game officials planted some 30 species of salt-water fish from the Gulf of California into the Salton Sea. Many thrived, and the sea became one of the most productive fisheries in California. Although some of the fish continue to persist in the current salinity concentration of 44,000 parts per million (the ocean is 35,000 ppm), scientists fear when the sea's salinity reaches 50,000 ppm to 60,000 ppm, the fish will begin to die off. Many of the birds at the sea, in turn, would lose their primary source of food.

Since 1998, the Bureau and the Salton Sea Authority have studied ways to stabilize the sea's salinity through the Salton Sea Restoration Project by annually extracting some 5 million tons of salt, creating, in effect, an artificial outlet. In 2000, officials released a draft EIS/EIR focusing on five potential options: diking off portions of the sea, allowing some areas to grow saltier; accelerating the atural evaporation/salt concentration process by pumping water out of the sea and spraying it into the air; or a combination of these two approaches.

Even as officials look for a way to have water to transfer and to help restore the Salton Sea's ecosystem, some question whether it might be easier and less expensive to replicate the environment of the Salton Sea somewhere else within the Colorado River Basin.

"My understanding is the Salton Sea is going to die if nothing is done, and while the transfer may expedite this process, this is part of the natural process. I question whether it makes sense to hold up a water transfer that is not creating the problem," said Patricia Mulroy, general manager of the Southern Nevada Water Authority (SNWA). "There are a lot of environmental issues on this river that need to be addressed, and I question whether the Salton Sea is the place to put the money."

Others, however, believe the sea offers valuable habitat. The local group Save Our Sea II advocates saving the sea not only because of its benefits to the environment, but to the local economy as well.

In November, federal legislation by Rep. Mary Bono, R-Palm Springs, providing $4.5 million for ongoing restoration was signed into law.

Even without the transfer, if nothing is done to offset the sea's increasing salinity, scientists estimate the sea will reach the 50,000-ppm to 60,000-ppm threshold in 12 to 20 years. The sea now receives about 1.3 million acre-feet in inflow. Agricultural drainage from IID farms provides most of that water, about 1 million acre-feet. If both the IID-SDCWA and the IID-CVWD transfers go through, inflow from IID farms could drop to 700,000 acre-feet.

Because the sea's evaporation rate is now equal to its present inflow, this reduction would accelerate the sea's rising salinity. With the transfers, scientists believe the Salton Sea would reach the 50,000 ppm to 60,000 ppm threshold at least 10 years earlier, maybe even sooner. The sea also would shrink in size, leaving many people who now have lakefront

Since 1998, the Salton Sea Authority and the Bureau have been studying ways to stabilize the sea's salinity by annually extracting some 5 million tons of salt, creating, in effect, an artificial outlet for the sea.

If the transfer deal fails or is delayed, southern California urban water suppliers and users are most at risk because they are last in line when it comes to state's basic Colorado River water apportionment.

property several hundred yards from the shoreline.

According to Mike Walker, who manages the Bureau's Salton Sea Program, the link between the transfer and the sea's decline has left officials with this difficult question to answer: "How do you mitigate for time?"

One controversial approach included in the pending Bureau-Salton Sea Authority revised draft EIS/EIR, to be released early in 2002, would leave some IID farmland unplanted (fallowed) to provide water for the transfers *and* maintain some inflow to the sea. How much land would be fallowed depends on the amount of water that IID transfers. To produce the 200,000 acre-feet IID has committed to transfer to SDCWA would require the idling of some 35,000 acres – a little less than 10 percent of IID's 450,000 irrigated acres.

The proposed QSA, however, calls for the conservation and transfer of 300,000 acre-feet, which would require fallowing at least 50,000 acres. With additional acreage needed for construction of solar evaporation ponds to reduce the sea's salt concentration, officials estimate at least 74,000 acres of land within IID would need to come out of agricultural production.

Although the revised draft EIS/EIR was not released publicly, it was leaked to area newspapers, and quickly generated criticism from Imperial Valley residents and IID directors, who voted at a Nov. 7 meeting to oppose fallowing to save the sea because it would cost the area too many jobs.

Two of the six alternatives would include some "land use conversion" (fallowing), including the least-expensive alternative in the revised draft. Although these dollar figures may change, the six alternatives (based on future inflow of 1 million acre-feet) and their "present value," (which includes capital costs and estimated operation and maintenance costs for the life of the project) are:

- Construction of in-sea solar evaporation ponds, with terraced in-sea salt disposal facilities, using standard dike-construction procedures, $1.6 billion.
- Construction of ground-based enhanced-evaporation systems (turbo-enhanced blower units), $630 million.
- Construction of tower-based enhanced-evaporation systems and on-land terraced salt-disposal facilities, $918 million.
- Construction of in-sea and on-land solar ponds in combination with some "land-use conversion," $450 million.
- Construction of on-land solar evaporation ponds with on-land terraced salt-disposal facilities, $413 million.
- Construction of on-land evaporation ponds and "land-use conversion," $250 million.

Bureau officials say they know how controversial the subject of fallowing is in the Imperial Valley, and that it is ultimately up to the community to determine how to proceed. But they want to make sure the community has all the facts on fallowing vs. on-farm conservation methods – including the economic benefits and trade-offs – when it comes to saving the Salton Sea, and meeting obligations to provide water for transfer.

Although he conceded that fallowing might have the least envi-

ronmental impact on the Salton Sea, Horne said fallowing has long been considered off-limits within the Imperial Valley. "The transfer agreement has a prohibition in it against using fallowing as a way of water conservation," he said.

The legality of discharging water saved by fallowing directly to the Salton Sea is questionable.

In the 2000 draft EIS/EIR, the Bureau and Salton Sea Authority had proposed tapping the Colorado River in flood years to provide periodic transfusions of fresher water into the sea. But such a measure is illegal under the Law of the River, not to mention politically infeasible when California already is under pressure to reduce its use of the river. The agencies are no longer considering this option.

Nor would such a measure gain support from environmentalists who already are fighting to gain access to such flood releases for the Mexican Delta (see page 12).

Even as water officials search for a way to save the sea and implement the transfer, the transfer itself continues to generate opposition from some IID board members and local citizens.

But if the transfer does not go through, it could very well jeopardize the state's ability to tap surplus water over the next 15 years. To ensure that California reduced its draw on the Colorado River, the other Colorado River Basin states linked completion of and adherence to the QSA (including the IID-SDCWA deal) to receiving the benefits of the Guidelines.

The MWD-PVID Proposal

In an effort to fulfill the 4.4 plan, MWD is aggressively pursuing programs in which it would bank and store Colorado River water. In July, MWD officials announced the potential for yet another source of Colorado River water – a landmark partnership with Palo Verde Irrigation District (PVID) in which farmers would be paid to fallow part of their land, transferring this water to MWD.

Under terms of the proposed 35-year agreement, MWD would make a one-time payment of $3,170 per acre to participating PVID farmers, up to a maximum of $84 million. For each acre fallowed, MWD would pay PVID farmers $550, plus a yearly percentage that has yet to be determined.

PVID farmers, in turn, would fallow 7 to 29 percent of their irrigated acreage in any given year of the program, providing MWD with 25,000 to 111,000 acre-feet of water per year – 1.76 million acre-feet to 3.63 million acre-feet over the life of the agreement. Annual acreage participating in the program would range from a minimum of 6,000 acres to a maximum of 26,500 acres. Currently, about 91,400 acres are being farmed in PVID. To address potential third-party impacts to farm workers, equipment dealers and others, MWD has proposed investing $6 million in local community programs.

PVID officials say they are exploring the partnership primarily because of economics. If the transfer deal is implemented, participating farmers would receive a stable income that could help them re-pay debt or finance on-farm improvements.

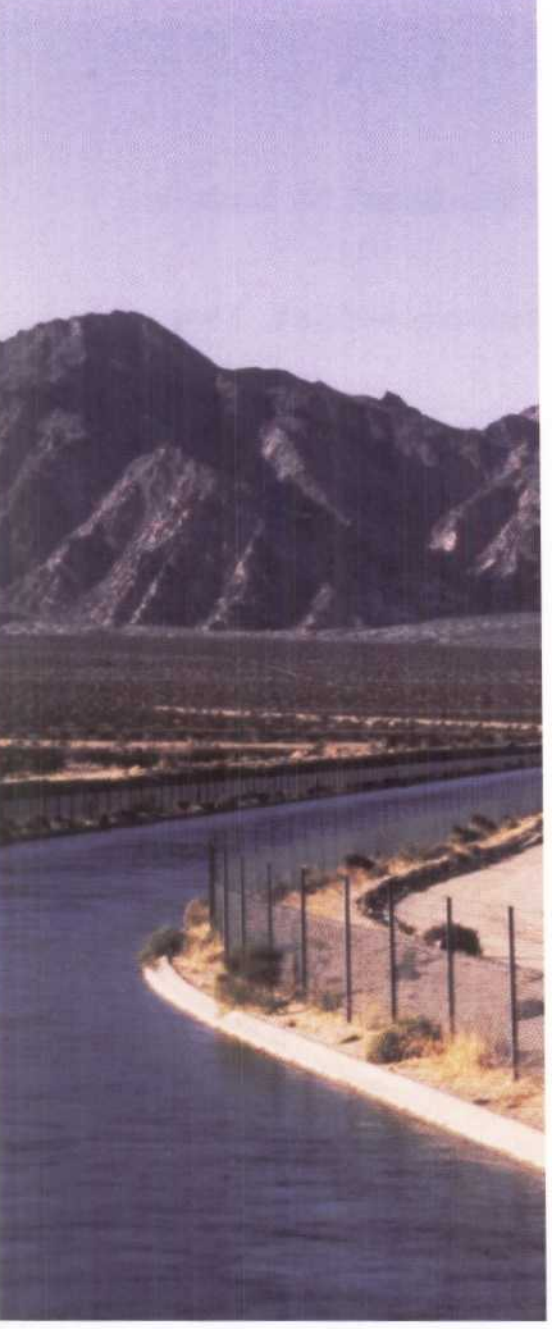
For MWD, the deal would provide even more assurances that it will be able to maintain a full Colorado River Aqueduct beyond the 15-years of surplus water provided by the Guidelines. "We want to have a full aqueduct," Underwood said. "The farther you go out in time, the less likely there will be surplus water, the more problems we would have."

But the program could be in place as early as 2002, leading MWD to suggest that it could help California meet the reduction targets for agricultural water use outlined in the Guidelines.

"The Guidelines are clear," MWD Chief Executive Officer Ronald Gastelum wrote in an Aug. 27 letter to DWR Director Hannigan. "If the Quantification Settlement Agreement is not executed by December 31, 2002 by all the parties, the Guidelines will

"We want to have a full aqueduct. The farther you go out in time, the less likely there will be surplus water, the more problems we would have."

– Dennis Underwood, MWD



The Colorado River Aqueduct.

be suspended unless we can demonstrate a reliable reduction in California's water use of Colorado River water as specified in the Guidelines.

"I am confident," the letter continued, "we can demonstrate compliance with these benchmarks and would welcome an opportunity to explain how Metropolitan has made and is planning to make the necessary investments in programs and projects to reduce Colorado River water use."

According to Underwood, MWD's intent was to point out that even if the IID-SDCWA transfer were delayed because of the Salton Sea dilemma, California could meet the conservation targets established through negotiations with the six other Colorado River Basin states, allowing the Guidelines to proceed as planned.

But the letter stirred up a political firestorm among the other California parties, in part because the QSA's goal was that everyone move forward together. Some of the other agencies also questioned whether MWD correctly interpreted the Guidelines.

The California parties also disliked Gastelum's letter because it indicated legislation might not be necessary to resolve the Salton Sea's environmental issues, legislation the other entities say is crucial to the plan's success.

Gastelum subsequently wrote a second letter to Hannigan. In his Aug. 31 letter, Gastelum noted "the four agencies believe everything possible must be done to facilitate execution of the QSA by December 31, 2002, including state and federal legislation to deal with the Salton Sea issue and the state fully protected species provisions."

As part of its program with PVID, MWD announced in October that it was purchasing 16,344 acres near Blythe from the San Diego Gas & Electric Co. for $42.5 million. Palo Verde farmers are now leasing about 9,704 acres of the property and MWD plans to include this land in the program. As with other PVID lands, however, MWD has pledged to fallow no more than 29 percent of this acreage in any given year.

PVID has one of the oldest and highest priority rights to water from the Colorado River, filing its first appropriative claim in 1877. In contrast to IID, which holds the Colorado River rights in trust for its farmers, water rights in PVID are attached to the land and each landowner controls his or her rights. At this point, it is unclear how many farmers will ultimately sign up for the program, but under a MWD-PVID 1992-1994 test program, 63 agreements with landowners and lessees were signed, saving nearly 93,000 acre-feet of water per year for two years.

The Mexican Delta

In its natural state, the turbulent Colorado River changed course as the force of its waters carved through the region's sandstone. At times, the 1,440-mile river ended at the Gulf of California in Mexico. Other times, th river discharged into the Imperial Valley, forming ancient Lake Cahuilla, twice the size of today's Salton Sea. In fact, millions of years ago, these two bodies of water were linked – until the build up of soft silt carried down the river cut off the sea from the gulf.

The Colorado River Basin's extensive storage has helped even out the annual flows, providing for a more reliable source of water. And since completion of Glen Canyon Dam, water seldom reaches the Gulf of California. (Mexico uses most of its 1.5 million acre-feet annual Colorado River entitlement for irrigation and domestic use in the Mexicali Valley.) Wet conditions and high storage in Lake Mead changed that in the 1980s and 1990s as water flowed down the river below Morelos Dam, reaching the Delta. (Water actually reached the Gulf itself five times.)

Wetlands in the Delta region just below the U.S.-Mexico border benefited from these flows. The flows regenerated vegetation, improving habitat for fish and wildlife, including

endangered species such as the desert pupfish, southwestern willow flycatcher and Yuma clapper rail.

Throughout the process to develop the Guidelines, environmentalists fought to include regular water supplies for the Colorado River Delta, contending that Interior's decision to draw down Lake Mead to provide surplus water will reduce the frequency of flood releases to the Delta region.

Although Interior did not include water for the Delta in the Guidelines, top officials worked with environmentalists and Mexico on an interim step – a conceptual framework to consider U.S. and Mexico studies related to restoration of the Delta.

In September, 400 water users, researchers, stakeholders and government officials from Mexico and the United States – including representatives from the Interior and State departments – met in Mexicali at the Colorado River Delta Stakeholder Symposium. Although it was disrupted by the Sept. 11 terrorist attack, some participating agencies still believe the symposium was beneficial. Others, however, think the symposium should be repeated at a future date because many people had to leave early in response to the attack.

For environmentalists, the symposium was only the latest event illustrating the Colorado River Delta's increased status among the basin states and Interior. "A lot of progress has been made. We have made the Delta into a major environmental issue," said the Southwest River's Hyde, "but we still have not gotten any water."

In March, environmental groups launched a new program in which they call for 1 percent of the river's flow – 150,000 acre-feet – to be delivered annually to the Delta.

"The Delta is an issue that's not going to go away," said SNWA's Mulroy. "I think we'll be forced to deal with it."

What Next?

"Win-win" has become the common catchphrase of today's focus on finding compromise solutions to intractable water problems. It is an admirable goal, yet one difficult to achieve. Consider the 4.4 Plan. California's Colorado River parties have made progress in developing a compromise plan on how to share this valuable resource, yet conflicts and controversies remain.

At the heart of the ongoing effort is the yet-unresolved dilemma of whether it is possible to save the Salton Sea and implement the landmark IID-SDCWA conservation-transfer agreement.

No easy answer exists, which is why the Salton Sea's rising salinity remains unresolved some 35 years after the Bureau and California DWR first conducted a joint appraisal of possible alternatives.

The California parties say passage of the federal and state bills related to the sea's endangered species would be a significant first step toward finding a solution. "I think most people believe some sort of legislation will be needed to address both the federal and state endangered species acts," said Tom Levy, general manager of CVWD.

Yet even if the state and federal environmental issues are resolved by passage of this legislation, the issue of local support for a water transfer that may require fallowing rather than water conservation has heightened questions about whether the IID-SDCWA transfer will truly proceed.

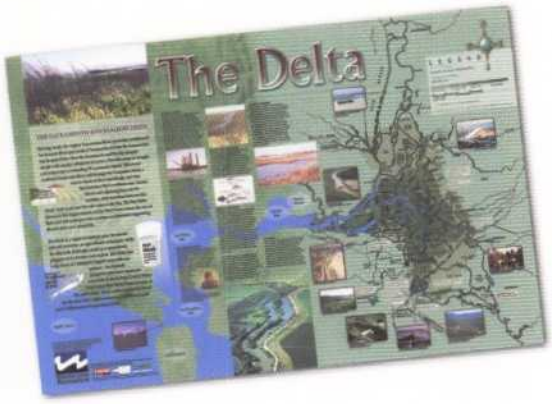
Bureau Regional Director Johnson is convinced the 4.4 Plan's difficulties will be resolved. "I think IID stands to lose more by not implementing the transfers," he said. "In fact, they have a lot to gain by implementing the transfers."

Hyde agreed. "I think that California has gone far enough now that they have a lot of incentives to keep the plan moving forward," she said. "And I think there are a lot of powerful interests who will ensure that these linchpins will go forward. Somebody will find a path around the impasse to make this happen." ❖

"California has gone far enough now that they have a lot of incentives to keep the plan moving forward. Somebody will find a path around the impasse to make this happen."

– Pamela Hyde, Southwest Rivers

What's New



The new Delta Map includes many of CALFED's proposed projects.

New Delta Map – Now Featuring CALFED Proposed Projects

A revised and updated version of our popular **Delta Map** poster is now available from the Foundation.

The base map, adapted from the California Department of Water Resources' *Delta Atlas*, shows waterways, pumping facilities and canals in the Delta. The revised poster also includes Los Vaqueros Reservoir and the location of the proposed Delta Wetlands Project. Text and photos explain Delta issues, and the importance of the Delta to all Californians.

The 2001 version of the map also features many of the proposed projects and studies identified in the CALFED Bay-Delta Program's 2000 Record of Decision, such as fish screens, the dissolved oxygen study, channel enlargements and agricultural drainage improvements. Assisting the Foundation with development of this revised map were CalFed the Bank, the U.S. Geological Survey, and the CALFED Bay-Delta Program.

Suitable for framing and display in any office, copies of this beautiful 36x24" poster are available for $8.50 each, plus appropriate sales tax and shipping charges. To order, visit our web page, www.watereducation.org, or contact Diana Farmer at the Foundation, 916-444-6240.

Lake Tahoe is a stop on the Foundation's Sierra Watersheds Tour.

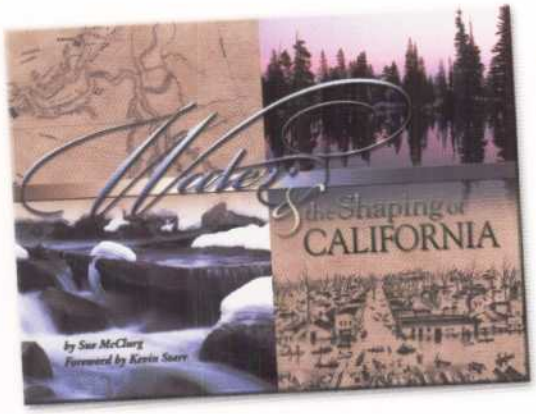
Tour Dates Set, Briefings Scheduled

Mark your calendars – the Foundation has set the dates for its **2002 water tours and briefings**. The tours offer participants a firsthand look at the water facilities, rivers and regions critical in the water debate. Speakers from different viewpoints discuss water supply, water quality, groundwater, environmental restoration, flood management, water marketing and water conservation.

In 2002, the Foundation will offer six tours! Seating is limited – most of these are one-bus tours – so register early!

Tour dates: **Lower Colorado River, March 20-22; Central Valley, May 22-24; Bay-Delta, June 19-21; Sierra Watersheds, September 11-13; Northern California Fisheries and Facilities, October 2-4; Southern California Groundwater, October 23-25**. All tours are three days and two nights.

The Foundation also has scheduled its two annual briefings. The **Executive Briefing will be March 14** in Sacramento. The **Water Law and Policy Briefing will be July 18-19** in San Diego. Watch our web site – www.watereducation.org – for more information, including on-line registration forms, or call the Foundation and request a free tours brochure.



The Foundation's book, *Water & the Shaping of California*, is the ideal gift for clients and colleagues.

The Perfect Holiday Gift

The story of California is the story of water and no book tells that story better than *Water & the Shaping of California*. Released in 2000, **this beautifully designed; oversized "coffee table" book is an ideal gift for colleagues and clients**. Filled with gorgeous photos, a treasury of water literature, and general text written by Foundation Chief Writer Sue McClurg, *Water & the Shaping of California* discusses the engineering feats, political decisions and popular opinion that shaped the nature of the state's most vital resource – water.

"The book is a blend of science and sentiment, poetry and politics, all of it focusing on the real treasure of the Golden State," said a review in the *Los Angeles Times*. Published in conjunction with Heyday Books.

Available in both hardcover and paperback, copies can be ordered through our web site, www.watereducation.org, or by calling the Foundation, 916-444-6240. Discounts are available for orders of five or more books – contact Diana Farmer at the Foundation for more information. ❖

Colorado River Materials

Item No. 4010 November/December 2001 *Western Water*, The California Plan and the Salton Sea, $3.00 each.

Item No. 4000 Yearly subscription to *Western Water*, a bimonthly magazine, $35.00

Item No. 2020 Colorado River Water Map, 32x38 inch poster, suitable for framing, depicts the seven Western states that share the Colorado River. $8.50 each. (100 or more, $7.00 each, Item No. 2020.1)

Item No. 4540 *Layperson's Guide to the Colorado River* 28-page guide updated in 2001, $6.00 each (10 or more, $5.00 each, Item No. 4540.1)

Item No. 4020 Yearly subscription to *River Report*, a bi-annual newsletter devoted to Colorado River issues, $25.00 (Call for information regarding back issues)

Item No. 7090 Colorado River Facts, 4x9 inch slide card that includes information about the Colorado River, $1.00 each (100 or more, $0.85 each, Item No. 7090.01)

Item No. 4675 *Colorado River Symposium Proceedings*, 158-page proceedings of 1999 symposium "Managing the Colorado River: Past, Present and Future." A vital resource for universities, libraries and law schools. $50.00 each.

Item No. 4670 *Colorado River Symposium Compact Proceedings*, 204-page proceedings of 1997 stakeholder symposium marking 75th anniversary of the Colorado River Compact. A vital resource for universities, libraries and law schools. $50.00 each.

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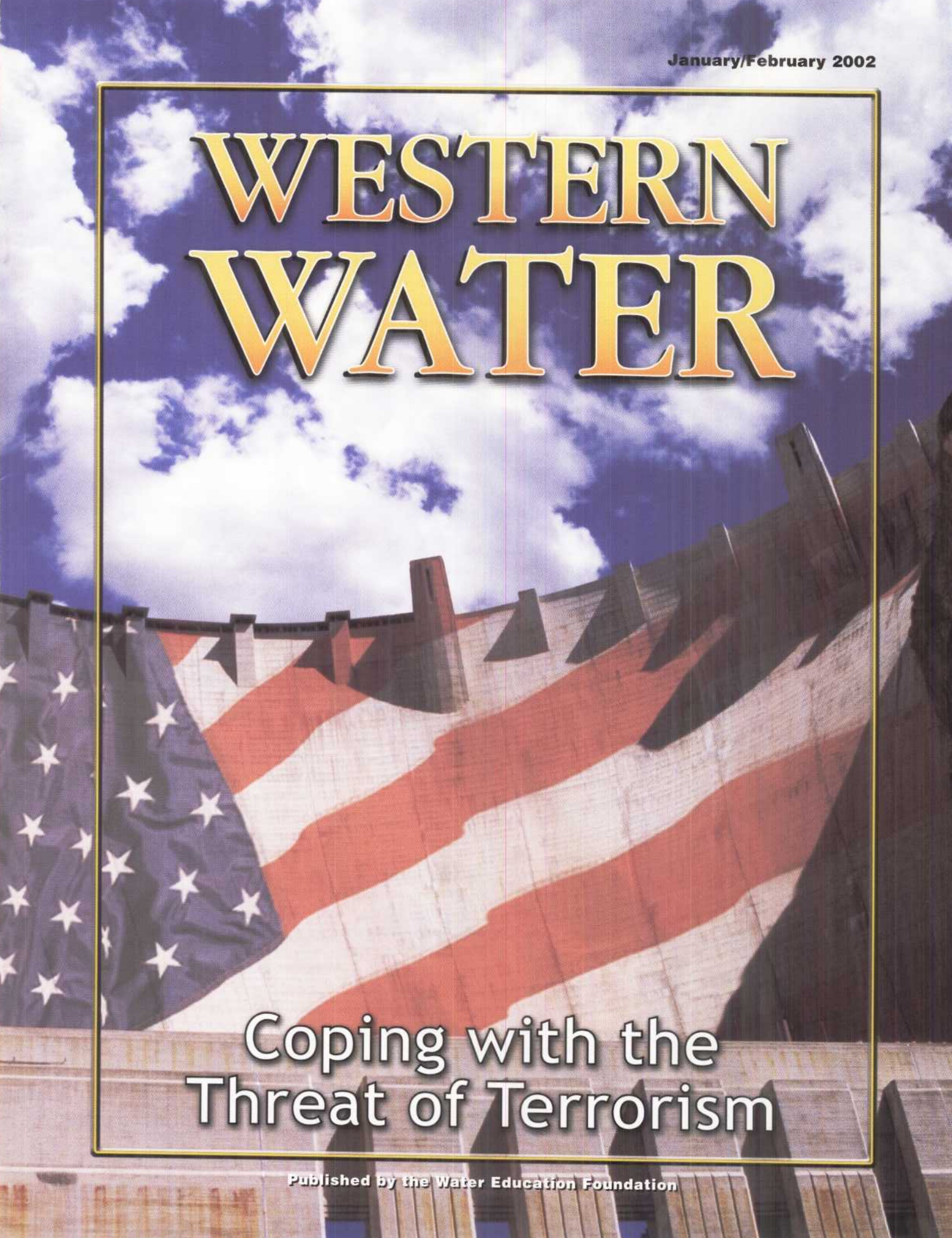

Coping with the Threat of Terrorism

Published by the Water Education Foundation

In this Issue

On the Cover

In the wake of September 11, federal, state and local officials have stepped up security at water facilities, including at Hoover Dam.
Photo illustration by Curt Leipold

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U.S. Bureau of Reclamation

The Water Education Foundation thanks all the sources and experts who reviewed this magazine for balance and accuracy.

The Water Education Foundation is a nonprofit, impartial, tax-exempt organization. Its mission is to create a better understanding of water issues and help resolve water resource problems through educational programs.

Western Water is published by the Water Education Foundation, 717 K Street, Suite 317, Sacramento, CA 95814 (916) 444-6240, fax (916) 448-7699. An annual subscription to this bi-monthly magazine is $35. The balance of the Foundation's information program may be supported by larger amounts, which are tax deductible.

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Web page: www.watereducation.org
ISSN: 0735-5424

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Editor's Desk

Rita with Bob Hagan.

The year 2001 is a year I'm sure we will all remember. The events of September 11 certainly brought a new reality to the water world. Since California was the destination of the four hijacked planes, security was immediately tightened at dams, aqueducts and water treatment plants. Beyond the immediate concerns, we began to wonder about the long-term impacts of this increased security. I have certainly enjoyed the dam tours many of you have been on with us – tours that take us down to see the inner workings of these major water structures. Seeing, for example, the major scale of these facilities at Hoover Dam and noting the small points like the floor inlayed artwork copied from American Indian designs always has been a high point of our annual three-state Colorado River tour. (See details of the 2002 tour on page 14.) After the tragedy, public tours were immediately stopped. Now comes word that limited public tours will begin again, of course, under increased security. This is a small step probably not noticed outside the water world but one that is being taken by the Department of the Interior to give this opportunity back to the American people.

It's in that vein that Writer Gary Pitzer undertook a long-term look at water security in the west. His research gives me a good understanding of what we have – and don't have – to fear in protecting our water supply.

As we look forward to a new and better year, I note that a lot of anniversaries will be marked in 2002. One milestone is the 100th anniversary of the founding of the Bureau of Reclamation with its charge by new President Teddy Roosevelt to bring water to small farmers in the arid West. It's interesting to note that Roosevelt became president in September 1901 after an anarchist assassinated President McKinley. Now we call anarchists by a new name – terrorists. Roosevelt was the father of the conservation movement and dealt with these thorny issues just as we today wrestle with what we term "environmental" issues.

Also in 2002, the Central Valley Project Improvement Act will mark 10 years of existence. As you can see from "In the News," debate continues on the meaning of certain provisions. We'll continue to follow that debate closely.

A happy anniversary will be celebrated on May 30 in Sacramento. A reception and dinner will mark the 25th anniversary of the Water Education Foundation. At that dinner we intend to honor many of the people who helped us build this successful nonpartisan foundation. One of the most outstanding of these people is Dr. Robert Hagan, retired professor from the University of California, Davis. Bob was a founding member of the Foundation. Through the years, he selflessly worked to advance the Foundation's goals of public education on water issues in the West. He was well known at the University for his work in Cooperative Extension – a University outreach of experts in California communities. We were delighted to join other long time affiliations of Bob's, the Association of California Water Agencies and the Yolo County Flood Control and Water Conservation District, in honoring Bob's volunteer service to all three organizations at a recent reception. We're glad that Bob will continue serve as President Emeritus of the Foundation and we wish him well as he starts a second retirement.

See page 14 for more on WEF's latest activities, or visit our web site at www.watereducation.org

Rita Schmidt Sudman

In the News

Legal Ruling Addresses Some CVPIA Issues

Legal issues surrounding a lawsuit involving Central Valley Project (CVP) water contractors, environmentalists and the Department of the Interior (Interior) over the amount of water dedicated to the environment are slowly becoming unwound, following a federal judge's ruling in October. CVP contractors hope the ruling will set the stage for a more thorough accounting of CVP water, while environmentalists are eager to receive a definitive decision on the accounting issue.

Officials say the most significant aspects of the ruling in the case, *San Luis & Delta-Mendota Water Authority (Authority) v. United States*, involve the proper baseline for lower American River flow criteria and the removal of a cap on water used to meet obligations under the Endangered Species and Clean Water acts. "The ruling is relatively significant in terms of the conclusion that all water used to meet endangered species and Delta water quality control plan obligations must be counted to Interior's . . . obligation," said Tom Birmingham, general manager of Westlands Water District.

Environmentalists are not happy with Judge Wanger's decision to lift the cap on water for endangered species and Delta preservation, because it means "little or no additional water for the environment in some years," said David Lewis, executive director of Save The Bay.

As this *Western Water* went to press, an evidentiary hearing was scheduled Jan. 8 in Fresno to address a key issue remaining to be determined – Interior's methodology for accounting for this water.

The origins of the dispute can be traced back a decade to the signing of the CVP Improvement Act. Section 3406(b)(2) requires that Interior "dedicate and manage annually 800,000 acre-feet of CVP yield" (600,000 acre-feet in dry years) for environmental protection. Yield is defined as "the delivery capability of the CVP during the 1928-1934 drought period after fishery, water quality and other flow requirements" have been met. An administrative proposal released by Interior in 1997 did not include a strict interpretation of yield nor a method to account for water used. Instead, the focus was on specific fish actions such as increase in stream flows and decreased pumping at key times of the year. CVP users claimed the proposal would require more than 800,000 acre-feet of yield in some years.

After the proposal's release, the Authority filed suit, arguing that Interior had failed to adequately account for the b2 water. The plaintiffs also alleged that Interior did not include diversions for the Bay-Delta Accord, Endangered Species Act and the Delta water quality control in the calculation for b2 use. Environmentalists also sued, claiming Interior did not properly distinguish between dedicated yield and changes that don't affect water deliveries.

Wanger's memorandum decision and order, issued in October, offered promising tidbits for various interests. Acknowledging the Authority's assertion, he ruled that Interior does not have the discretion whether to annually provide more or less than 800,000 acre-feet of CVP yield for b2 purposes, unless certain findings are made. But contrary to what the Authority wanted, he decided that Interior is not required to use a comparative 1928-1934 period analysis to measure the impact of each b2 action in quantifying annual CVP yield used for b2 purposes. Wanger ruled that the proper baseline for lower American River flow criteria for calculation of CVP yield is Water Rights Decision 893, not the modified flow criteria used in Interior's final decision, an argument consistent with Authority's point of view.

Still unresolved is Interior's methodology for accounting the b2 water – a complicated and contentious process. ❖

Where We Are

January 15
Water Leaders Class Orientation
Jean Auer, class advisor
Sacramento, CA

January 17-21
Water for People Board Meeting
Rita Schmidt Sudman, member
Scottsdale, AZ

January 30 – February 1
WEF Colorado River Stakeholder Symposium
Rita Schmidt Sudman, symposium coordinator
Santa Fe, NM

January 31
California Association of Bilingual Educators Conference
Judy Maben, exhibitor
San Francisco, CA

February 6-7
National Best Education Practices Committee meeting
Judy Maben, participant
Chicago, IL

February 21
WEF Water and Growth Conference
Show Me the Water: Making Sense of New Water and Growth Laws
Rita Schmidt Sudman, coordinator
Sacramento, CA

February 23
National Project WET Coordinators Council Meeting
Judy Maben, California WET coordinator
Indianapolis, IN

February 28
WEF Board of Directors meeting
Henry J. Vaux, Jr., president
Sacramento, CA

March 7
Groundwater education workshop
Judy Maben, coordinator
Monterey, CA

March 14
WEF 19th Annual Executive Briefing
"Milestones and Challenges"
Rita Schmidt Sudman, coordinator
Sacramento, CA

March 20-22
WEF Lower Colorado River Tour
Judy Maben, tour director
Las Vegas, NV

Coping with the Threat of Terrorism

by Gary Pitzer

Americans living in the West awoke to a strange sight as they switched on their television sets the morning of Tuesday, September 11, 2001. Poised to hear the latest news or traffic reports, viewers were instead presented with the surreal image of New York's World Trade Center towers engulfed in thick black smoke. Many immediately thought the buildings had been involved in some kind of horrific accident with an aircraft that had gone astray. But when the cameras suddenly switched to the blazing wreckage at the Pentagon, and later, in western Pennsylvania, the grim reality of the morning became frightfully clear: the United States was under attack.

"I was in a state of shock," said Sonny Fong, security chief for the California Department of Water Resources (DWR). "The response part of me said, 'What can I do?'"

As the day wore on, viewers continued to gaze in disbelief at the footage being televised from New York and Washington. Commentators drew comparisons to Pearl Harbor as images of the incomprehensible devastation appeared but the projected death toll in New York alone left no doubt that what occurred was no less than the worst ever attack on American soil.

Federal and state officials quickly responded to the attacks by securing strategic targets throughout the nation, including key water storage and conveyance facilities in the West. U.S. Bureau of Reclamation (Bureau) sites were immediately closed and public access restricted. National Guard troops were deployed to Hoover Dam, while Highway 93, which links Phoenix to Las Vegas, and traverses Hoover Dam, was closed to all vehicles except passenger cars and small pickup trucks. Vehicle checkpoints were established at dam access points in Arizona and Nevada.

In the aftermath of the attack, public tours of Hoover Dam were immediately canceled. Some three months later, on Dec. 12, Interior Secretary Gale Norton announced that public tours would resume, but only with limited access to the power plant and dam.

In California, the destination of the four hijacked aircraft, the Office of Emergency Services implemented the State Terrorism Plan, which outlines a coordinated response among all levels of government. Security was tightened at dams, aqueducts, reservoirs, pumping stations and water treatment plants. Highway Patrol officers provided air surveillance of possible targets, including the 444-mile California Aqueduct and 242-mile Colorado River Aqueduct, while water treatment plants conducted additional tests of supplies to detect any poisoning attempts. The Metropolitan Water District of Southern California (MWD), the primary supplier of imported water to homes and businesses in southern California, doubled the number of water quality tests normally performed and remained on full-scale alert for days following the attacks.

Other water districts in the state also took quick action to "batten down the hatches" against the threat of terrorism. One Ventura County district did exactly that as crews welded shut hatches and installed new vent systems on water tanks to guard against contamination. Local providers

deployed workers and armed security guards to patrol reservoirs, dams, pump stations and treatment plants.

State and local agencies pledged to re-evaluate their existing disaster and emergency preparedness plans following the attacks. "Terrorism was considered to a limited degree [but] it wasn't something in the forefront," Fong said. "When September 11 came along, it really opened our eyes." Pledging that the safety of Californians "is job number one," Gov. Gray Davis appointed a special advisor on state security on Nov. 1 to advise the governor on anti-terrorism efforts and to facilitate coordination among federal, state and local agencies.

DWR regulates more than 1,200 dams and operates the State Water Project (SWP), which delivers about 500 billion gallons of water a year. It is that immense size that ultimately makes the SWP an unlikely target, given the truckloads of contaminants needed to poison it. Fong said the old adage, "the solution to pollution is dilution," holds true even in a terrorist attack.

The state Department of Health Services (DHS) Division of Drinking Water and Environmental Management, which regulates public water systems, met with key water agencies in northern and southern California to discuss heightened security. Joseph Tait, MWD's chief operating officer, said the district's constant preparation for seismic activity, as well as past events such as the new millennium ("Y2K"), left it in a good position to respond to the threat of terrorism. Beyond beefed up protective measures and increased water quality sampling, MWD leaders have sought to instill a permanent state of vigilance among the 1,800 employees.

"The main point we're trying to make is . . . to eliminate the complacency," he said. "What we've tried to do is say all of you are the best defense."

Congress wasted little time in offering legislative and spending proposals in response to the terrorist threat. Dozens of bills in the House and Senate address a multitude of water-related topics, from bioterrorism to prospective grants to assist local drinking and wastewater facilities in meeting immediate security needs. The Association of Metropolitan Water Agencies (AMWA) recommended that the U.S. Environmental Protection Agency's (EPA) budget for security planning be increased from $2.5 million in 2001 to $155 million in 2002. AMWA also is seeking an additional $5 billion to upgrade water and wastewater treatment facilities, some of which would be used to improve EPA's notification system and some for bioterrorism response plans and identification of security weaknesses.

On Oct. 5, EPA Administrator Christie Whitman announced the formation of a water protection task force charged with ensuring the safety of the nation's water supply. "While EPA already has a strong coordinated partnership program for protecting our drinking water, this task force will have specific duties to expand EPA's service to the community water systems," Whitman said in a press release. She emphasized that the threat of public harm from a terrorist attack on the nation's water supply is small and that the agency's goal is for

"Before the tragic events of September 11, security of water resources and environmental infrastructure was not a very high national priority."

– Rep. John Duncan, R-Tenn.

Security measures were tight at Hoover Dam and Lake Mead.

all drinking water providers to have access to scientific and technical information, as well as be informed about what immediate steps to take and whom to turn to for help.

This issue of *Western Water* examines the issue of water security and the preparedness of federal, state and local agencies to the threat of terrorism. In addition to physical security and bioterrorism, it focuses on the type of long-term security measures being implemented to ensure a safe water supply. While certainly not the last word on the issue, this article will provide a glimpse into a world that was transformed forever September 11.

Physical Security

The sight of the World Trade Center in ruins undoubtedly conjured images of other large, high profile structures similarly struck, including dams. Public opinion polls following the attacks indicated that water supplies were seen by a majority of Americans as likely new targets for terrorist attacks.

"We have to assume that California will be a target of the terrorists," former California Gov. Pete Wilson told the San Francisco Chronicle. As such, political leaders "are compelled to consider all the different possibilities" of future attacks, including water systems.

An executive order by Davis directed the State Strategic Committee on Terrorism to evaluate the potential of a terrorist attack and to review the current state of prevention and responsiveness. Davis also ordered the creation of a subcommittee on the protection of public health to develop recommendations on the preparedness and public response to biological and chemical threats.

The threat to the nation's dams and other water facilities from a terrorist act vaulted quickly to the attention of lawmakers, some of whom have acknowledged they hadn't previously given much thought to the issue.

"Before the tragic events of September 11, security of water resources and environmental infrastructure was not a very high national priority," said Rep. John Duncan, R-Tenn., at a House subcommittee hearing nearly a month after the attacks. "However, on that day, our nation learned that our own equipment and our own structures can be used against us."

Duncan, chair of the House Subcommittee on Water Resources and Environment, said that while not all speculation about the nation's vulnerability to future attacks is valid, "government agencies and the private sector must review the security of all the critical infrastructure they operate, and, where appropriate, take steps that increase security."

The heightened focus on water security resulted in the revelation that EPA is years behind on its timetable for ensuring the safety of the nation's water supply. EPA had been ordered in 1998 to detail its plans for protecting drinking water, but a report published just weeks after the attacks found that many steps, such as identification of vulnerabilities, have just started or are still in the planning stage. An internal audit by EPA declared that while the agency had secured the 16 systems it operates, little had been done about the thousands of local water systems under its jurisdiction.

Agency officials blame the delay, in part, on the fact that complete knowledge of the risks to drinking water remains unclear. Scientists have identified some organisms that can survive in chlorinated water but are still in the process of determining the best means to combat them, according to reports. Experts say it would be counterproductive to disseminate information just to keep on schedule.

Keeping water safe for human consumption hasn't been a problem for the many California water districts that rely exclusively on wells. Water is drawn from the ground through facilities that are locked down from public intrusion. High fences topped with razor wire and steel doors guard against tampering, while enclosed storage tanks are accessible only through locked, enclosed ladders. Public and private agencies have stepped up protection by doubling locks and staggering patrols around the clock in some areas.

Besides its primary focus of protecting the SWP and assisting with the federal Central Valley Project, DWR has been assisting local water agencies through the Water Agency Response Network, a coalition of public and private entities, including DHS, the Association of California Water Agencies (ACWA) and the American Water Works Association (AWWA).

Dams and Aqueducts

Experts agree that dams are a tempting target for terrorists, based on the size and scope of damage that could be wrought through a well-placed attack. "Water resource sites are . . . attractive to environmental terrorists because there is no substitute for water – it is a vitally necessary resource," wrote Elizabeth L. Chalecki, research associate with the Pacific Institute for Studies in Development, Environment and Security, in a September 2001 paper entitled A New Vigilance: Identifying and Reducing the Risks of Environmental Terrorism. "A community of any size that lacks fresh water will suffer greatly. Furthermore, a community does not have to lack water to suffer. Too much water at the wrong time in the form of a flood can cause greater damage, and flooding towns and settlements is a time-tested tactic in warfare."

Security experts say the chances of a hijacked airplane successfully destroying a large dam are remote because of the difficulty in maneuvering through tight river canyons crisscrossed with power lines and because unlike skyscrapers, dams are massive, solid objects. However, terrorist acts on dams would not necessarily have to involve large amounts of explosives, according to Chalecki. Instead, "relatively small" conventional explosives could disrupt dam operations or power generation.

Damaged spillway gates could cause a significant amount of unplanned water release, such as occurred in 1995 when an inoperable gate at Folsom Dam dumped 40,000 cubic feet of water per second into the lower American River. By the time the water level dropped enough to fix the gate, the reservoir had lost 40 percent of its capacity, enough to supply 2 million people with water for one year. The incident did not result in any flood danger, as the river's capacity is 130,000 cubic feet per second. But large, unplanned releases of water

"It's important for the public to know that there's ongoing contingency planning."

– Michael Armstrong, Former FEMA associate director

The California Aqueduct.

"The most important thing is that we've been operational without missing a beat. Every drop of water and every megawatt of power has been delivered."

– Barry Wirth, Bureau of Reclamation

could cause water quality problems as treatment plants are overwhelmed. "Fresh water supply is lost, as is hydroelectric power, commercial fisheries and recreation," according to Chalecki. "Intermediate flood damage is possible if buildings remain in the floodplain. Finally, there is the expense of rebuilding the dam."

Information regarding the safety of the nation's dams is kept in a computer database maintained through the cooperation of states, territories and federal agencies, in coordination with the U.S. Army Corps of Engineers and the Federal Emergency Management Agency (FEMA). Each dam in the database is assigned a downstream hazard potential classification, based on the potential loss of life and damage to property should the dam fail. According to the database, 39 percent of the nation's dams have a high or significant hazard potential. Of those dams with high hazard potential, 39 percent do not have prepared emergency action plans. Forty-four percent of the dams with significant hazard potential lack completed plans.

Dam safety encompasses structural soundness and the preparedness of downstream communities, according to Michael Armstrong, a former FEMA associate director whose domain included the National Dam Safety Program. "It's a game of vulnerability and probability," he said. Attention has shifted to include situations other than natural hazards, but "what hasn't been apparent is making the money available for repair of aging infrastructure." Lawmakers have periodically talked about creating a special fund strictly for repairs, but as it stands, budgeting for maintenance and repair is channeled through the Bureau.

"It's important for the public to know that there's ongoing contingency planning," Armstrong said. "It's highly speculative whether an attack could happen. From my experience, most of the large dams are federally owned and the federal government is well aware of their vulnerability."

A security presence at Hoover Dam has been in place since World War II and "as society evolved, we've added additional precautions," Bureau spokesman Bob Walsh said. Nonetheless, the Bureau's effort to tighten security along the Colorado River system has been criticized by an activist group, which claims that an inordinate amount of attention has been placed at Hoover Dam at the expense of Flaming Gorge and Glen Canyon dams. Living Rivers, a Utah-based organization dedicated to river restoration and water conservation, says that inadequate protective measures at these two dams could cause catastrophic results downstream. "While federal resources are currently focused on protecting 726-foot Hoover Dam . . . from possible terrorist attack, comparatively little is being done at Glen Canyon Dam . . . and at Flaming Gorge Dam upstream on the Green River," Living Rivers states in an Oct. 10, 2001, press release.

The group is concerned that the Bureau has done little to control truck traffic and boat access to the other dams. Trucks cross Flaming Gorge at its crest and through Glen Canyon and a nearby bridge. Living Rivers is especially concerned about the safety of Glen Canyon Dam because of its abutment among "porous, weak" Navajo sandstone. Any type of compromise of the structure would unleash a torrent of water that would scour the Grand Canyon before washing into Lake Mead. "In the best-case scenario, this water would flow over the top of Hoover, creating a downstream flood similar to that were Hoover to fall by itself," according to the press release.

Bureau spokesman Barry Wirth said the claims made by Living Rivers are "pretty contrived" and are designed to serve purposes "other than stated." Contrary to Living Rivers' claim, security at all Bureau dams is "very high," although there are plans and processes that are "non-visible."

The Bureau has "a very proactive security plan that gets reviewed every

day," Wirth said, adding that security measures include the use of human and electronic surveillance. Security has been heightened across all Bureau facilities and the details differ at each site based on varying conditions, he said. "The most important thing is that we've been operational without missing a beat. Every drop of water and every megawatt of power has been delivered."

A U.S. Coast Guard regulation that became effective in November authorizes fines of up to $27,500 per day for the operation or anchoring of vessels within one-half mile of Hoover Dam on Lake Mead or Lake Mohave. The rule is to be enforced by the National Park Service through May 5.

The centerpiece of the SWP, the California Aqueduct, has been under 24-hour surveillance since September 11. The Aqueduct is divided into individual pools that can be isolated from the system, while backup water storage is available. "We have an advantage, because the way it was designed, it can work pretty independently," Fong said. During parts of September and October, security along the SWP was elevated to its highest level, which includes a lockdown of all facilities, restricted access to all dams, cancellation of tours and 24-hour, armed patrols. DWR has halted any vehicle parking on publicly accessible dams such as Oroville and Castaic and implemented a 500-foot restricted zone for public boats. Officials expect to maintain the heightened security level for the immediate future.

Bioterrorism

While the terrorist attacks led some to believe that the nation's water supplies could be paralyzed by incidents of bioterrorism, officials have sought to reassure the public that their drinking water is safe from large-scale contamination by chemical or biological agents. The concept was unheard of prior to September 11, but even amid all the fear and anxiety that continues to linger, experts say that the threat is remote. Some have characterized the chances of widespread health problems caused by contaminated water as nearly impossible.

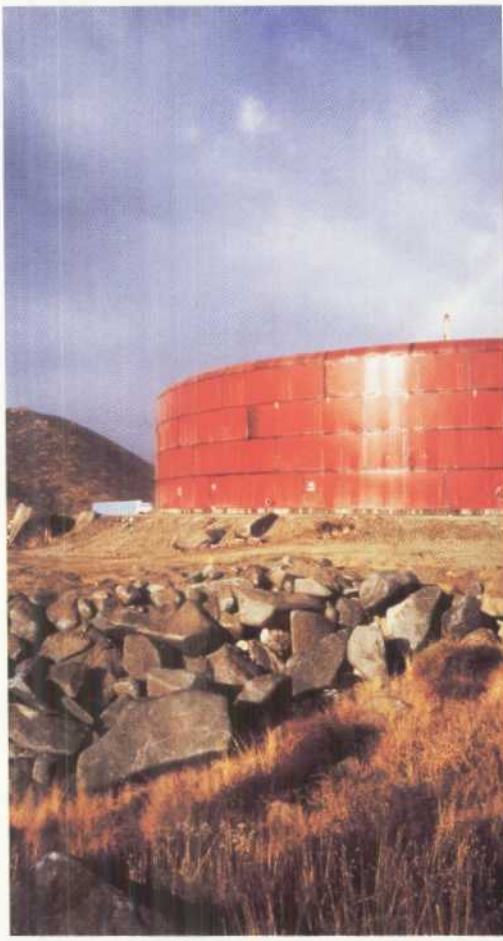
EPA's Whitman took steps to allay fears about the safety of water supplies during a visit to a Silver Springs, MD, treatment facility Oct. 22.

"As someone who drinks water at home from the tap – as does my family – this is a concern I certainly understand," she said. "People are worried that a small amount of some chemical or biological agent – a few drops for instance – could result in significant threats to the health of large numbers of people. I want to assure people – that scenario just can't happen."

The city of San Francisco, for example, receives part of its water supply from Crystal Springs Reservoir south of the city. Poisoning the reservoir with enough hydrogen cyanide to cause death or harm to one person consuming a glass of water would require more than 400,000 tons of the toxin, experts say. Biological agents considered to be weapons of mass destruction pose the most danger in aerosol form, according to EPA. Whitman said EPA is working with other federal agencies to determine the best ways to react to potential contamination incidents.

The Centers for Disease Control is working with EPA, AWWA and the Department of Defense on a study to determine the level of protection afforded by current water treatment technologies against bioterrorism. The study, expected to be complete by early spring, will examine the reaction of three or four organisms to chlorine sensitivity, moist heat inactivation, ozone and ultraviolet radiation. Other contaminants will be added to the list.

Analysis of the nation's vulnerability to drinking water poisoning reveals that it is not beyond the realm of possibility for terrorists to infiltrate smaller water systems or some part of the distribution system. Because of the inherent difficulties in poisoning a large water supply, security experts warn that attacks are more likely to



Security experts warn that attacks are more likely to focus on very small systems or small parts of larger systems. Residual chlorine in storage tanks can neutralize most biological toxins and pathogens, but it is ineffective against chemical toxins and other biological agents. Besides storage tanks, conveyance pipes are also seen as possible targets because of their accessibility.

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Testifying before a joint California legislative committee in October, DHS drinking water chief David Spath said he has been in close contact with water agencies throughout the state to ensure improved security measures are underway.

"We are encouraged by the measures taken by water systems to protect their drinking water sources, treatment and distribution systems," Spath said. "These measures include increasing security personnel, identifying the most vulnerable elements within the water system and placing greater security emphasis on these elements, limiting access to the water system, particularly water sources and treatment facilities and increased monitoring of water quality."

Dan Smith, director of regulatory affairs for ACWA, told lawmakers "for most water agencies, it is not a matter of developing and implementing plans. Rather, it is a matter of updating and expanding existing plans, testing those plans, and of maintaining the sense of awareness caused by the catastrophe."

Scientists in Albuquerque, NM, have developed a soil and groundwater "sniffer" that could be a useful tool in the effort to protect drinking water resources. The device, produced by the U.S. Department of Energy's Sandia National Laboratories, is a unique monitor that can be directly placed in groundwater or soils to detect toxic chemicals at the site without taking samples to a lab. Traditional monitoring methods involve the removal of water, gas or soil from a site for testing elsewhere. The process is expensive, from $100 to $1,000 for each sample analysis, and subject to compromise during collection, transportation and storage. The sniffer "has the capability of detecting in real time undesirable chemicals being pumped into the water supply accidentally or intentionally," said researcher Cliff Ho.

Long-term issues

Beyond the immediate response of federal, state and local agencies to the terrorist attacks lies the far-reaching, permanent changes in security practices that officials hope translate into a safer water supply. Foremost is the physical protection of water supply, storage and conveyance facilities – a process that may not always be apparent to outside observers. The East Bay Municipal Utility District "is bolstering systems against physical intrusion [but] many of these enhancements won't be obvious or visible, and most security enhancements won't be announced," states a recent newsletter.

DWR's Fong said changes are in the offing, based on potential security breaches. DWR and other state

Police Protection

The heightened security throughout the West has, in some cases, stretched available resources to their limit as extra patrols have been added for all types of possible terrorist targets. In California, DWR is working closely with federal law enforcement, and using local and state law enforcement officers, as well as private security guards, to protect its many facilities. The competition with other state agencies for available manpower has had "somewhat of an impact," Fong said. Many DWR staffers have had security monitoring duties added to their regular assignments, such as operations and maintenance or flood control.

Fong said it is the responsibility of local water districts to work with local law enforcement and the community to ensure the safety of water downstream of treatment facilities, in much the same way that the Neighborhood Watch program has helped reduce criminal activity. In addition, it is "very critical" for suppliers to have agreements in place with adjoining agencies to provide water in case of any stoppage in service, regardless if caused by terrorism.

"The best thing for us is to make sure there is tight coordination with our member agencies," said MWD's Tait.

Federal lawmakers have responded by introducing a law that would enable the Bureau to contract for additional security at federal dams and by proposing an expanded role for the National Guard. The latter idea, offered by Sen. Dianne Feinstein, D-Calif., would transform the Guard into "a kind of homeland defense force" that would, among other things, protect dams and aqueducts. Guard officials are said to be in favor of the proposal, as long as it does not impede on the primary mission of providing for the needs of the regular Army and Air Force.

agencies were ahead of the curve September 11 thanks to the preparations that had been taken for Y2K.

Closing Dam Access

The traffic clampdown at Hoover Dam has spurred officials in Nevada and Arizona to press for the expedited completion of a dam bypass bridge. The Federal Highway Administration last year announced it would build a four-lane bridge to bypass the winding, two-lane portion of U.S. Highway 93 across the dam. The project has taken on additional urgency because of the Bureau's decision to reroute large trucks south to Laughlin, NV, for river crossing. The trip adds about 23 miles to the trip between Las Vegas and Phoenix. The bridge, to be built about 1,500 feet downstream of the dam, was to be completed in 2007, but pressure has been building to move that date to 2005, the 70th anniversary of the dam's dedication.

"The new bridge and bypass of the dam will help protect Hoover Dam from future terrorism and the potential impact to millions of people," wrote Nevada Gov. Kenny Guinn and Arizona Gov. Jane Hull in a Sept. 26 letter to U.S. Secretary of Transportation Norm Mineta.

Hoover is not the only dam where a bypass is sought. In northern California, the threat of terrorism could be the impetus for a new bridge spanning the American River below Folsom Dam. As proposed by Rep. John Doolittle, R-Rocklin, the bill would appropriate $85 million to the Bureau for construction costs. The bridge would divert traffic from the dam road, which connects Placer County with the city of Folsom and El Dorado County. In making the announcement last June, Doolittle's office noted that closing public access to the dam "would reduce the threat of terrorist acts that have been identified as a concern with facilities of this nature."

The EPA Water Protection Task Force will provide immediate assistance on improved security to water systems nationwide. The estimated 168,000 public water systems are generally self-contained, unlike other utilities that have interconnections. In case of suspected attack, EPA would dispatch emergency response personnel to the scene immediately, as was done at the World Trade Center and the Pentagon. "These experts are located in all of EPA's 10 regions and they have considerable experience in working with local, state and federal emergency officials and are prepared to help with monitoring, cleanup and expert advice on contaminants," according to an EPA fact sheet.

The task force's goal "is to ensure that water utilities are undertaking the steps to understand vulnerable points and to mitigate the threat from terrorist attacks as quickly as possible."

Cyber Security

Less visible but certainly no less critical to the delivery of safe, reliable water is the network of information technology that controls a myriad of processes, including water treatment. Maintaining the security of vital computer links is one of the duties of the federal government's new Office of Homeland Security, which has designated a special advisory position for that purpose.

"Information technology pervades all aspects of our daily lives . . . from a shipment of goods, to communications, to emergency services, and the delivery of water and electricity to our homes," said Tom Ridge, Homeland Security director, in an October press conference. "We need to prevent disruptions; and when they occur, we need to ensure they are infrequent, short and manageable."

Agencies have taken steps to upgrade electronic security, particularly the amount and type of information available via the World Wide Web. In the days following the attacks, information that could have been used by terrorists against water systems was taken off web sites. A 1999 U.S. Geological Survey document describing the characteristics of large public water supplies in the U.S. was ordered

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– David Spath
DHS Drinking Water Chief

removed from libraries by federal officials. MWD removed specific information about its network of aqueducts, treatment plants and other facilities and has installed a firewall to block the entrance of outsiders into the district's computer network.

Spath said DHS has asked other state agencies, such as the State Water Resources Control Board, to refrain from making public any data that defines the location of drinking water wells and treatment plants. ACWA made several recommendations to its members, including that they review public information posted on web sites, review printed material that includes information about water facilities and operations, and prepare board members and staff to respond to public inquiries about security measures.

Preventing unauthorized persons from "hacking" into computer systems in the public and private sector remains a challenge, particularly since the Internet was designed for accessibility. With the emerging threat of cyber terrorism, efforts are being directed to keep "hackers" from causing serious disruption to all the aspects of everyday life that are dependent on electronic networks.

"It's difficult to build a system that affords the level of reliability you want," said David Wagner, assistant professor of computer science at the University of California, Berkeley.

Reduced exposure methods can be employed, such as backup systems and power generation, but it is incumbent upon utilities to assess the degree to which outsiders could gain entrance and how to isolate that threat. The key, Wagner said, is using countermeasures that are "proportionate."

State officials have known that computer networks are susceptible to security breeches and accounted for that in preparing for Y2K, Fong said. He acknowledged that "some vulnerability" existed regarding the SWP's computer systems, but thanks to a "very aggressive" effort, there have been no problems. "The bottom line is, we did a manual operation of the entire SWP," he said. "We know we can do it and separate it from automatic control. It's something that others should look at."

Based on the recommendations of the special committee on terrorism, Davis ordered several state agencies to take immediate steps to increase their preparedness, including the Department of Information Technology, which is to assess cyber terrorism vulnerabilities.

The Future

The events of September 11 exacted an incalculable emotional toll on Americans. What was once an indomitable belief in the utter immunity of the homeland from foreign attack has been replaced with a new paradigm in which no part of the national infrastructure, commerce or daily routine is free from the specter of terrorism. The impact has been felt at all levels, from the national government to the smallest water utility in the most rural western environment. Increased vigilance comes at a cost, although officials high and low have repeatedly stated that no corners will be cut in the pursuit of upgraded security.

A glimpse of the necessary costs to be incurred came last December, in the preliminary results of a survey done by the National Governors Association (NGA). The group found that at least $11 million is needed to implement the water and sewer plant security measures called for by President Bush. NGA members said the findings justify the need for federal reimbursement of state costs, given the strain on present and future budgets.

In California, millions of dollars have been spent to guard against terrorism, the bulk of which has been for extended air and ground patrols by Highway Patrol officers. The increase in spending, which could reach $200 million over the course of one year, has been against the backdrop of a slowing economy and a projected budget deficit. Despite the anticipated

cuts, political leaders pledge that the increased patrols and water testing will continue. Extra costs for boosted security along the SWP will be passed along to the 29 contractors that purchase the water, according to Fong.

In Congress, lawmakers have taken swift action on a number of bills designed to tighten drinking water security, including the Water Infrastructure Security and Research Development Act, which devotes $60 million over five years on anti-terrorism activities. Specified research areas include cyber security, physical security and monitoring and treatment of suspected contaminants.

The funds for research "will help us find solutions to prevent and, if necessary, respond to the contamination of drinking water and the disruption of water service," said Diane Van De Hei, executive director of the AMWA. Other legislation authorizes $50 million in EPA grants to drinking water agencies for basic security measures. The measure is needed, said Van De Hei, because most agencies don't have the funds on hand to pay for things such as additional fencing, alarm systems and closed circuit television monitoring.

The Bush administration has called for allocating $1.6 billion to the Department of Health and Human Services to counter the threat of chemical and biological terrorism and $30.3 million to protect Bureau water and power projects. The extent to which new laws are necessary to provide better safeguards for water supplies is a work in progress, as officials determine how many changes can be made administratively or whether statutes must be changed. Legislative sources in Sacramento say it is expected that lawmakers will introduce a host of new bills that address the security issue, many of which will likely be tied into the recommendations that emerge from the governor's executive order.

A $3.4 billion water bond targeted for the November ballot includes $50 million for anti-terrorism actions at reservoirs and treatment plants. Sponsors of the measure said security was added because of the concerns raised by water agencies about funding.

Conclusion

Ensuring a safe and reliable supply of water for municipal, agricultural and industrial use has taken on a greater urgency in the months following the September 11 terrorist attacks. While security against intrusion has always existed for federal, state and local agencies, the concentrated efforts to protect water supplies from terrorism have transformed heightened vigilance to a permanent philosophical shift. "We're seeing changes now," Fong said. "In the past, we'd respond to a disaster, do the mitigation and move on. We're in this for the long-term."

Tait said he does not envision water providers returning to pre-September 11 security levels. "I think the comfort level is gone . . . no one here believes the threat is over," he said. "We're focusing on non-complacency now. If we can stay non-complacent, we'll be fine."

In an opinion piece called "Emergency Management in the 21st Century," Jack Harrald and Joseph Barbera, the director and co-director of the Institute for Crisis, Disaster and Risk Management at George Washington University, wrote that while the nation's vulnerability to terrorism was exposed September 11, it must be remembered that the knowledge, tools and technologies exist to reduce that vulnerability.

"The increased number of natural disasters experienced in the 1990s led the emergency management community to begin to focus on how we could reduce, mitigate, and prevent the consequences of disasters, It is time for us to build on this foundation and to incorporate terrorism into a true all-hazards emergency management preparedness and prevention program that will ensure the safety of our citizens and our society for the future." ❖

While the nation's vulnerability to terrorism was exposed September 11, it must be remembered that the knowledge, tools and technologies exist to reduce that vulnerability.

The March 14 Executive Briefing will include a CALFED/Delta panel.

Colorado Tour participants visiting MWD facilities.

What's New

Executive Briefing – Mark Your Calendars

The Foundation's **19th Annual Executive Briefing**, "Milestones and Challenges," will be held **Thursday, March 14** at the Holiday Inn Capitol Plaza in Sacramento. Top state and federal policy-makers and leaders from the various water stakeholder communities will discuss a host of important and timely topics:

- The **California Plan and the Salton Sea** – To reduce the state's draw on the Colorado River, users have agreed to a series of conservation, banking and transfer measures. But this will reduce runoff to the Salton Sea, accelerating its decline. This panel will explore the dilemma of saving the sea, and implementing the 4.4 plan.
- **CALFED** – What's the latest with implementation? With funding? With legislation?
- **Arsenic** – What are the issues regarding problems with arsenic in drinking water? And what will the new federal standard mean for water purveyors?
- **AB 3030 and Groundwater Management** – Ten years ago, a plan for voluntary groundwater management was passed by the state legislature. Where are we today? How many plans have been adopted? Do we need to do more to ensure our groundwater is managed wisely?

Registration for this one-day event is $175 for major contributors to the Foundation, $200 for non-contributors. Proceeds benefit the Foundation's school programs. Watch our web site, www.watereducation.org, for a full agenda or call today to receive your invitation. – Seating is limited. Register today!

Lower Colorado River Tour, March 20-22

Sign-ups are underway for the Foundation's **Lower Colorado River Tour**, which follows the course of the lower Colorado River through portions of Arizona, California and Nevada. This three-day, two-night tour includes a **tour of Hoover Dam**; a boat ride on Lake Mead; and visits to a wildlife refuge and the **Salton Sea**, Central Arizona Project and MWD of Southern California water facilities and agricultural areas.

Issues discussed include the California water use (4.4) plan, the Central Arizona Project, southern Nevada's water needs, restoration of the Salton Sea, tribal water rights and border issues between the U.S. and Mexico. The tour begins in Las Vegas and ends at Ontario International Airport.

This is a one-bus tour, so seating is limited. Contact us today for more information, or visit us on line at **www.watereducation.org, which features a secure, on-line registration form**.

River Report

The **most recent issue of** the Foundation's Colorado River newsletter, ***River Report*, is now available**. The Winter 2001 issue is devoted to the Las Vegas Wash and the effort to combat water quality problems in the wash, which transports storm water runoff and treated wastewater from Las Vegas into Lake Mead. Las Vegas area officials are now working to control erosion in the wash, combat nonpoint source pollution in the wash, and treat perchlorate contamination found in the wash.

Also included in this *River Report* is a short "From the Headlines" piece on water quality in the New River, a tributary to the Salton Sea, a calendar of upcoming events in the Colorado River Basin, and a collection of Upper Basin and Lower Basin news briefs.

Published each June and each December, *River Report* is part of the Foundation's ongoing Colorado River Project. Outtakes from each issue can be found at our web site, www.watereducation.org, under the Colorado River Project icon, and an annual subscription to *River Report* is $25. ❖

Water 101

Item No. 4010 January/February 2002 Western Water, Coping with the Threat of Terrorism, $3.00 each.

Item No. 4000 Yearly subscription to Western Water, a bimonthly magazine, $35.00

Item No. 2000 California Water Map, 24 x 36" poster of natural and developed water resources, $10.00 each. ($7.00 each for 10 or more)

Item No. 2020 Colorado River Water Map, 32 x 38" poster of natural and developed water resources in the seven-state Colorado River Basin, $10.00 each. ($7.00 each for 10 or more)

Item No. 2010 Delta Map, 36 x 24" poster of California's Sacramento-San Joaquin Delta, $10.00 each. ($7.00 each for 10 or more)

Item No. 2030 California Groundwater Map, 24 x 36" poster showing California's groundwater basins, with cutaways of specific examples, $10.00 each. ($7.00 each for 10 or more)

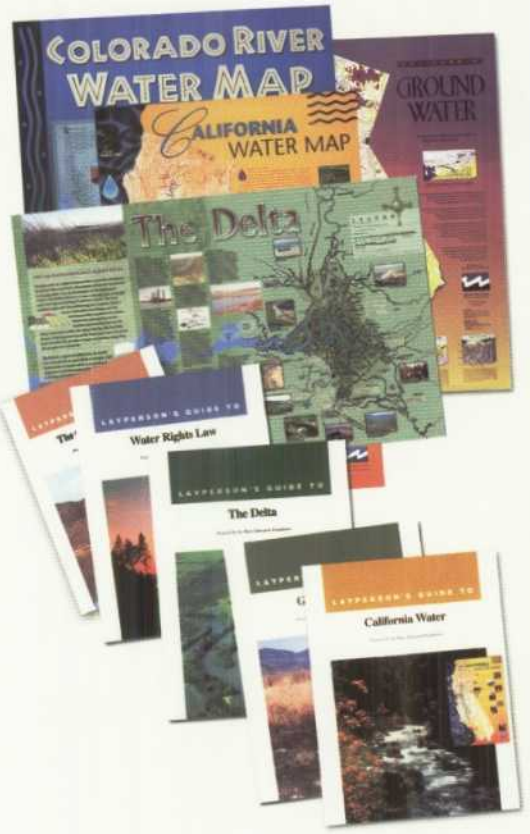
Item No. 4520 Layperson's Guide to California Water, 24-page guide, $7.00 each. ($5.00 each for 10 or more)

Item No. 4540 Layperson's Guide to the Colorado River, 28-page guide, $7.00 each. ($5.00 each for 10 or more)

Item No. 4550 Layperson's Guide to the Delta, 20-page guide, $7.00 each. ($5.00 each for 10 or more)

Item No. 4580 Layperson's Guide to Groundwater, 20-page guide, $7.00 each. ($5.00 each for 10 or more)

Item No. 4640 Layperson's Guide to Water Rights Law, 20-page guide, $7.00 each. ($5.00 each for 10 or more)



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