W A T E R   B R I E F   2

Past and Future of the Salton Sea

Michael J. Cohen

Off in the hinterlands of remote southeastern California, the Salton Sea – an oddity created by the vagaries of human behavior and nature – shrinks slowly, perhaps irreversibly, a hazard in the making. The Salton Sea is a creeping environmental problem (Glantz 1999) that may not attract the attention and investment needed to avoid catastrophic impacts to public health and to the millions of birds the Sea supports. Rapid municipal growth and rising demand for water in urban Southern California, coupled with projected declines in future water supply, impose great pressure on the imperiled Sea. Located predominantly in one of the poorest counties in California, the Sea suffers from the indifference and outright hostility of distant communities and water users. Protecting and rehabilitating the Sea will require years of determined effort and billions of dollars, yet neither is assured.

The Salton Sea lies more than 70 m below sea level, a vast, incongruous salty lake amidst the harsh Colorado Desert. The Sea is a terminal lake – water flowing into the lake has no escape except through evaporation. Maximum temperatures in the basin exceed 40° C 136 days per year, and exceed 45° C more than 10 days per year. Fewer than 7 centimeters (cm) of precipitation fall annually in the basin, generating an annual net evaporation of about 1.8 m. The Salton Sea watershed covers 21,700 km^2, yet more than 85% of its inflows come from surface and subsurface agricultural runoff from the ~2,500 km^2 of irrigated fields of the Imperial, Mexicali, and Coachella valleys (Cohen et al. 1999). See Figure WB2.1.

Designated as an 'agricultural sump' by President Coolidge in 1924, the Sea is often dismissed as unnatural or worse, seen by some as an aberration in the desert that should be allowed to disappear (Nijhuis 2000). Yet the nutrient-rich agricultural drainage fuels a remarkably productive ecosystem, sustaining a great abundance and diversity of micro-organisms and more than 270 species of migratory and resident birds. Shuford et al. (2002) note "the Salton Sea is of regional or national importance to various species groups – pelicans and cormorants, wading birds, waterfowl, shorebirds, gulls and terns," as well as to a large number of individual species. In the winter of 1999, extensive surveys recorded 24,974 white pelicans and 18,504 double-crested cormorants at the Sea (Shuford et al. 2000). Jehl and McKernan (2002) estimated that 3.5 million eared grebes were at the Sea on March 5, 1988. The loss of 90–95% of California's predevelopment wetlands and a similar percentage of the former Colorado River delta (Cohen 2002) has left migrating birds with few other stopovers along the Pacific Flyway. See Figure WB2.2.

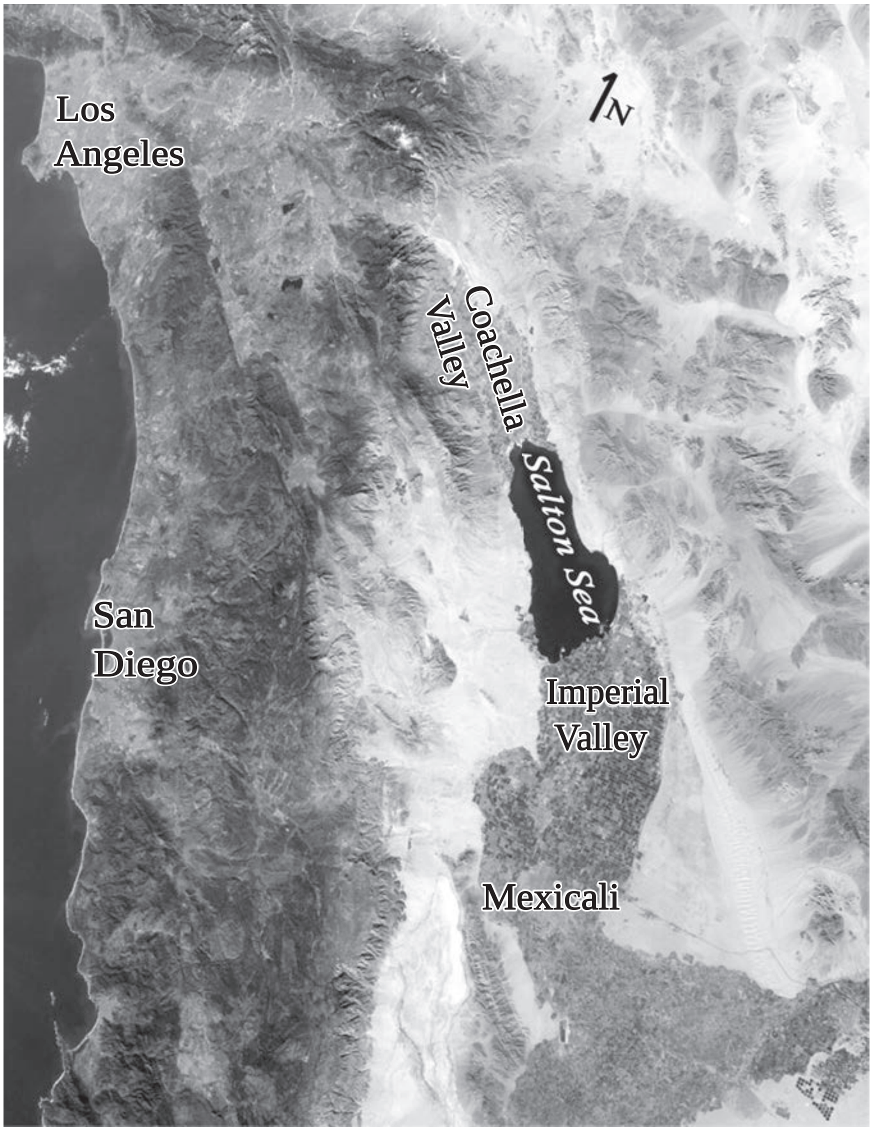

FIGURE WB 2.1 SALTON SEA LIES IN REMOTE SOUTH-EASTERN CALIFORNIA.
Source: Image ISS004-E-6119.JPG taken January 10, 2002, courtesy of Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center, available at http://eol.jsc.nasa.gov.

The Salton Sea defies expectations. California's largest lake, it extends 56 km by about 24 km at its widest, with a total surface area of roughly 950 km^2. Yet it is relatively shallow, less than 15 m at its deepest, with an average depth of only 9 m. The lake currently holds some 8.56 km^3 of hypersaline water, almost half of the mean annual flow of the Colorado River. But the Salton Sea, with a current salinity of about 48 g/L, is already 37% saltier than the Pacific Ocean and 67 *times* saltier than the Colorado River at Imperial Dam (the initial source of most of the Sea's inflows). With evaporation the only exit for incoming waters, the Sea inexorably concentrates incoming salts, nutrients, and contaminants in its waters and sediments. For more than 40 years, prognosticators have predicted the Sea would die within a decade (Pomeroy and Cruse 1965), certain that rising salinity signaled the impending demise of its fishery. Others dismiss the ecological value of a hypereutrophic[1] lake fed by agricultural drainage, especially one limited to a

1. Characterized by high levels of primary productivity, low concentrations of dissolved oxygen, and low visibility.

single species of fish – a hybrid freshwater species originally from Africa. Yet year after year, millions of birds visit the Sea, feeding on its abundance, nesting and roosting on its shores and islands, or just passing through (Shuford et al. 2000, 2002, 2004), indifferent to how natural the Sea might be, or how tenuous its future.

Background

Prior to the early years of the 20th century and the dams of the Age of Reclamation (Reisner 1993), the Colorado River meandered about its delta (see Fig. W.B2.2), periodically discharging north into the Salton Basin before shifting once again to flow south into the Upper Gulf of California (Sykes 1937). Previous incarnations of the Salton Sea, known as Lake Cahuilla, grew to several times the size of the present lake before being abandoned by the river and left to evaporate under the relentless desert sun. In early 1905, unexpected Colorado River floods tore through an unprotected headgate cut by Imperial Valley irrigators in the river's right bank, diverting the entire flow of the river into the bed of the old Lake Cahuilla for more than 18 months. After the Colorado was forced back into its original bed, this new lake, dubbed the "Salton Sea," would have evaporated if not for the agricultural drainage that continues to feed it. The taming of the Colorado River, by means of massive dams, incised and armored channels, and carefully released flows, now insulates the Salton Sea from these previous cycles of filling and drying.

These dams and associated water rights and delivery agreements mean that more than 23% of the total average annual yield of the Colorado River currently flows into the Salton Sea basin each year, regardless of the river's actual discharge. Although irrigators' senior water rights and return flows into the Sea have protected it from drying completely, inter-annual and seasonal variability, reflecting seasonal evaporation rates and farmers' irrigation and cropping patterns, still cause the Sea's surface elevation to vary about 0.3 m annually. Figure WB2.3 shows calculated inflows to the Salton Sea from1967–2006. Prior to the 2003 signing of a large agricultural-to-urban water transfer agreement, total annual inflows to the Sea averaged about 1.6 km^3. This has since declined to about 1.5 km^3, and is projected to decline further, to about 0.88 km^3/yr within 25 years (DEIR 2006). A variety of factors account for these reductions, including reduced flows from Mexico, changes in cropping patterns, and, after 2017, the water transfer itself. Climate change impacts on evaporation from the Sea's surface, and on evapotranspiration from the irrigated fields in its watershed, are also expected to have a marked effect on the Sea's size and water quality (Cohen and Hyun 2006).

California Water Transfers

In the mid-1990s, the federal government and the other six U.S. states that share the Colorado River began to exert increasing pressure on California to reduce its consumption of Colorado River water. This pressure drove California state and local water agencies' discussions and negotiations over the "Quantification Settlement Agreement (QSA)."[2] Central among these discussions were the terms of an Imperial Valley-San Diego

2. The QSA and related agreements quantified the water rights of some California Colorado River contractors, enabled acquisition and transfer of conserved water, and obligated environmental impact mitigation. For texts of selected QSA documents, see: http://www.crss.water.ca.gov/crqsa/index.cfm

FIGURE WB 2.2 COLORADO RIVER AND ITS FORMER DELTA.
Modified from Sykes, G. 1937. *The Colorado Delta.* Publication no. 460. Washington, DC: Carnegie Institution.

water transfer. San Diego sought to invest in Imperial Valley water-efficiency improvements (such as lining canals), in exchange for receiving the conserved water over time. In 2001 and 2002, these discussions foundered over costs, liability, potential impacts to state and federal threatened and endangered species at the Salton Sea, and the costs of conveyance. In early 2003, the Bureau of Reclamation initiated proceedings to unilaterally decrease deliveries to the Imperial Irrigation District (IID), citing unreasonable water use.[3] To facilitate the water transfer and the signing of the QSA and to avoid unilateral reductions, California state negotiators agreed, among other things, to cap the water agencies' liability for QSA-related impacts to the Sea at $133 million; the

3. See Colorado River, Notice of Opportunity for Input Regarding Recommendations and Determinations Authorized by 43 CFR Part 417, Imperial Irrigation District, 68 Fed Reg 22738 (April 29, 2003).

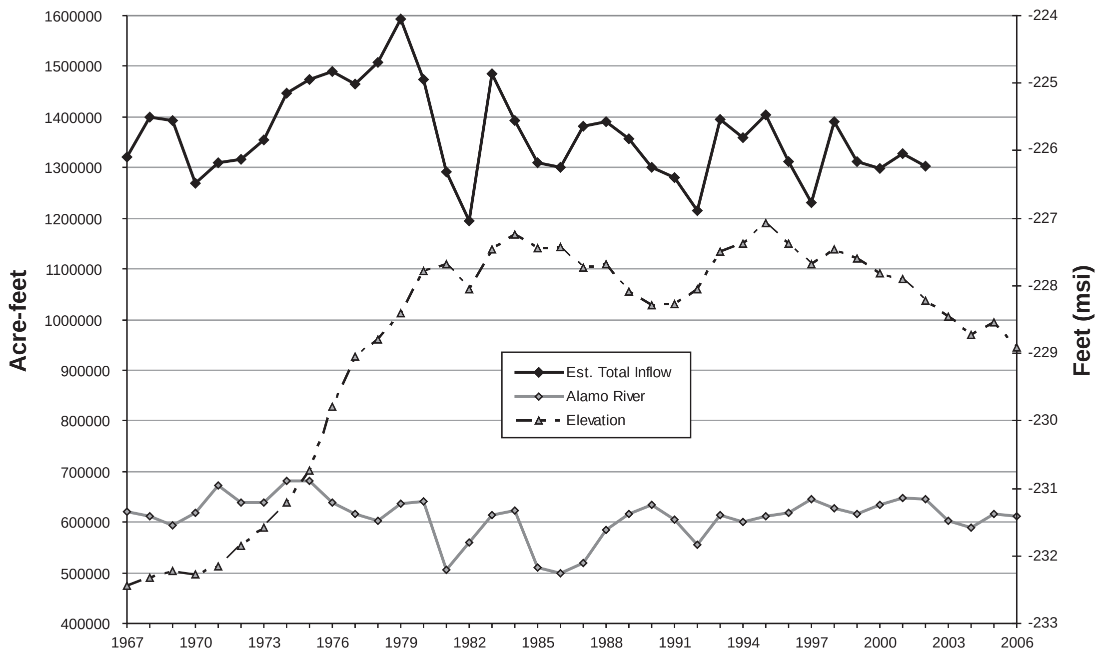

Figure WB 2.3 Salton Sea Inflows and Average Annual Elevation., 1967–2006.
Source: Estimated total inflows from U.S. Bureau of Reclamation, Elevation and Alamo River data from U.S. Geological Survey gages.

state entered into contracts and adopted legislation to assume liability for costs in excess of this amount. In 2007, the state estimated capital costs for simply managing air quality and endangered species at the Salton Sea at more than $800 million (PEIR 2007).

The QSA also requires IID to offset the impacts of declining inflows due to the water transfers by delivering "mitigation" water directly to the Sea, through 2017, providing a brief window in which restoration can be designed and implemented. Without a restoration project, starting in 2018, the size and water quality of the Salton Sea will begin a period of vary rapid decline, with a roughly 60% loss of volume, a tripling of salinity, and exposure of nearly 300 km^2 of lakebed within a dozen years (Cohen and Hyun 2006).

Restoration

The Salton Sea will change dramatically in the near future, whether or not state and federal officials take action on its behalf. For the Salton Sea, successful restoration will not mean a healthier lake of similar size. Instead, it will mean a completely unrecognizable combination of various infrastructure-heavy project elements, possibly including massive dams, multiple pumps, sedimentation basins, and hundreds of miles of berms and canals. Unlike more typical, science-based restoration projects, Salton Sea restoration requires a policy-level or political determination of a preferred set of conditions that bear no resemblance to any pre-disturbance state of the lake. These challenges underscore the differences between Salton Sea restoration and more typical projects focusing on restoring or promoting the recovery of damaged or degraded ecosystems (SER 2004).

Salton Sea restoration has been proposed for more than 40 years. Yet the goals of restoration have changed over time, and continue to differ based on the location and objectives of restoration advocates. Four general types of actions could be taken: 1) full-Sea restoration; 2) partial-Sea restoration; 3) shallow-habitat construction; and 4) the legal minimum of air quality and desert pupfish management. Additionally, the state could fail to meet its legal obligations, due to legislative inaction or the staggering costs of meeting such obligations, and not fund any significant action at the lake. The estimated $800+ million price tag for meeting these obligations (DEIR 2006) and the general lack of political will to protect the Salton Sea (San Diego Union Tribune 2006) suggest that legislative action might be deferred and delayed for many years, until litigation and court orders require it.

Full-Sea Restoration Alternative

Historically, when inflows to the lake were thought to be relatively secure, restoration proponents envisioned a full Sea, preserving the Sea's shoreline at roughly its elevation of the time, and stabilizing its salinity at marine levels (~33–35 g/L TDS). Now, with the decrease in inflows to the Sea, the only way to maintain a full Sea would be to import sufficient volumes of water to offset projected declines. Increasing demand for the over-allocated Colorado River and federal legislation prohibiting diversions of additional Colorado River flows into the lake rule out new sources of fresh water. The only other nearby water source with sufficient volume is the ocean. To maintain current elevation and a salinity of 44 g/L would require pumping some 4.2 km^3 of water up roughly 20 m and a distance of 286 to 350 km (depending on the route) from the Upper Gulf of California through Mexico to the lake. The size of the Sea could be readily managed just by importing additional water, but the ocean water would carry a huge salt load, quickly spiking the Sea's salinity beyond acceptable ranges. Stabilizing the Sea's salinity would require removing an additional 3.3 km^3 of highly saline Salton Sea water up 90 m and 286 to 350 km back to the ocean, each year, to create a flow-through system necessary to avoid the accumulation of additional salts. The required infrastructure and energy requirements of such a project would be exorbitant – costs could exceed $70 billion – and such a project would require the approval of the Mexican government (DEIR 2006). Additionally, the time required for designing, permitting, acquiring rights-of-way, and constructing such a project would delay benefits to the Sea for decades, during which the Sea would degrade at a rapid rate. Despite these problems, many people living near the Sea continue to advocate such a binational pipeline, because it is the only way to maintain the Sea as people now know it.

Partial-Sea Restoration Alternative

The exorbitant costs and institutional obstacles associated with full-Sea restoration make it, at best, a theoretical option only. Most serious observers and analysts no longer consider it a realistic possibility. Partial-Sea restoration proposals appear more feasible. Generally, these proposals seek to preserve some extent of existing shoreline, create a smaller lake with approximately marine salinity, include air-quality control measures to limit emissions of dust from an exposed lakebed, and would construct large shallow ponds to create habitat for many of the species of birds that use the Sea.

California legislation adopted in 2003 required the California Resources Agency to craft and submit to the state legislature a Salton Sea ecosystem restoration plan, in consultation with a broad range of stakeholders. This legislation (California Fish and Game Code § 2931(c)) directs the Resources Agency to submit a preferred alternative that provides the maximum feasible attainment of the following objectives:

- Restoration of long-term stable aquatic and shoreline habitat for the historic levels and diversity of fish and wildlife that depend on the Salton Sea.
- Elimination of air quality impacts from the restoration projects.
- Protection of water quality.

During consultation, the state reviewed several partial-Sea proposals that include various permutations of impoundments on the north or south side of the existing lake (see DEIR 2006), ultimately developing a preferred alternative that drew from the general concepts driving these partial-Sea proposals. The Resources Agency's preferred alternative, submitted to the legislature in 2007 and shown in Figure WB2.4, calls for the creation of: 251 km^2 of shallow saline habitats, primarily at the south end of the Sea; a 182 km^2 horseshoe-shaped marine lake impounded by an 84 km-long dam; 304 km^2 managed for air quality and 429 km^2 of total exposed lakebed; and associated canals, pumps, sedimentation ponds, and related infrastructure. The plan as designed would cost an estimated $8.9 billion, with an additional $142 million each year in operations and maintenance, at build-out (PEIR 2007). The plan would require the importation and placement of an estimated 145 million cubic meters of rock and gravel, for the dam and other barriers, and the dredging or excavation of 81 million cubic meters of lakebed. To give an idea of the scale of this construction, the PEIR estimates that 3,000 truck trips would be required each day for several years, just to transport the needed rock and gravel. However, existing air-quality restrictions limit diesel emissions, suggesting that 3,000 daily truck trips may not be feasible, potentially lengthening the time of construction and the time required to complete the project well beyond the state's projected dam closure in 2022. See Figure WB2.4.

To complicate matters, some local agencies dispute the state's estimates of the size of future inflows to the Salton Sea. The Imperial Irrigation District, source of the agricultural water being transferred, has adopted resolutions stating it will not enter into future water-transfer agreements. Pointing to these resolutions, these agency directors claim that the state underestimates future inflows. These inflow estimates determine the scope and scale of proposed restoration projects: if inflows are different than estimated, infrastructure such as dams and canals will be under- or over-built and might not function as designed. Other project elements, such as air-quality control measures or shallow habitat areas, may not receive sufficient water if flows are too low, stranding them. Insufficient flows could also render proposed marine lakes too salty. On the other hand, if inflows are larger than projected, local officials have expressed concern that this will encourage urban water agencies to demand additional water transfers, threatening the local economy. Further challenging these estimates is the historic variability in flows (see Fig. WB2.3): scaling the restoration project to estimated median annual inflows would mean that roughly 50% of the time, the project would have insufficient water to function as designed. Even designing the project to function at 20th percentile inflows would mean that the project would fail to perform as designed one year in five. This suggests that the restoration project should be sufficiently flexible to adapt to variable inflows, perhaps by varying the elevation of the lake or by creating or desiccating shallow habitat ponds based on water availability.

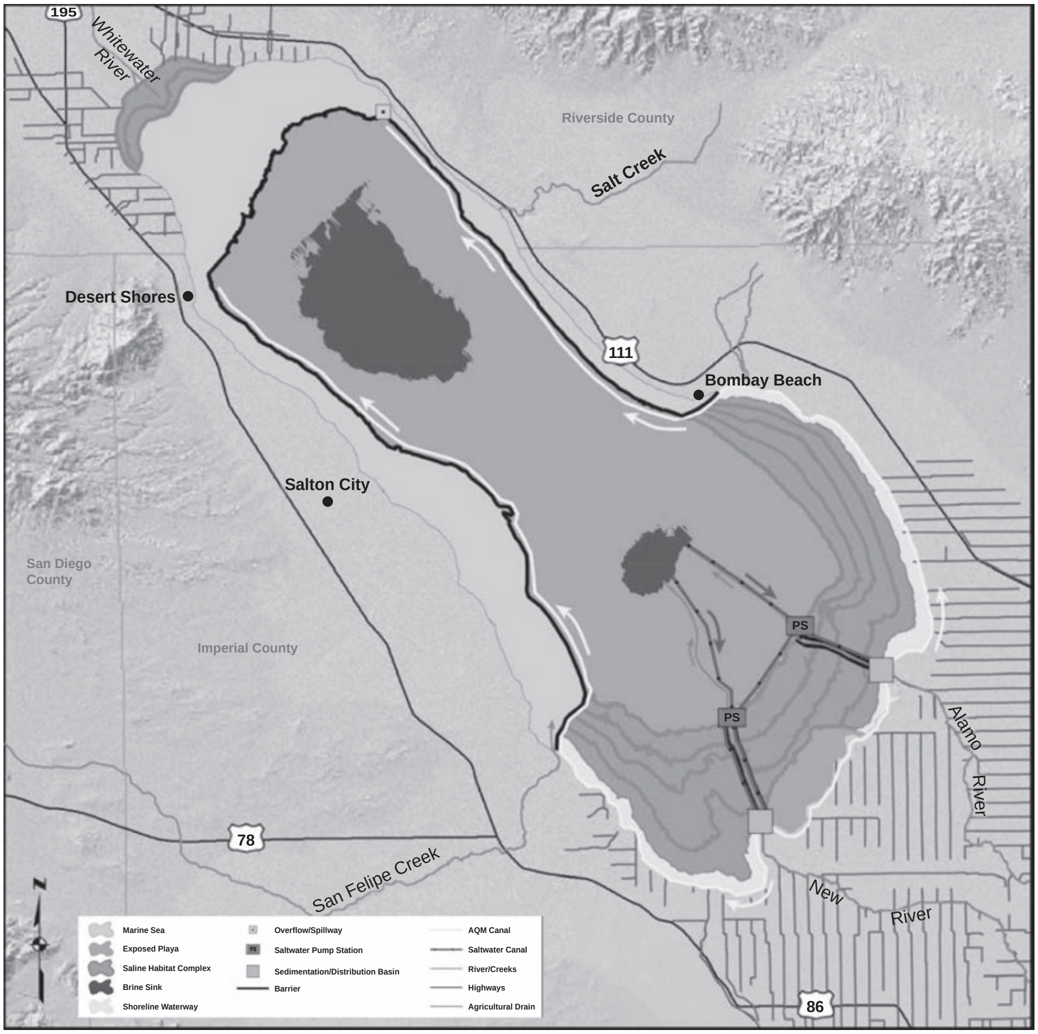

FIGURE WB 2.4 RESOURCES AGENCY'S PREFERRED SALTON SEA RESTORATION PROGRAM ALTERNATIVE.

The Salton Sea Authority (SSA), a joint powers authority comprised of representatives of the two counties, two water agencies, and one tribe bordering the lake, proposed a less ambitious plan that assumes average annual inflows will be about 12% greater than the state's estimates.[4] The SSA Plan does not account for climate change-driven increases to evaporation from the >500 km^2 of open water. Their plan seeks to maximize economic development and recreational use of the lake. It includes a large dam across the width of the Sea, plus various conveyances, pumping more than two million cubic meters of saltwater per day, and two, 1.1+ million cubic meter/day water treatment plants intended to improve water quality in the impounded north lake. The plan also designates shallow saline habitat areas for wildlife, and would attempt to manage exposed lakebed by impounding hypersaline water to create salt crusts. The state estimated the cost of its version of this plan at ~$5.2 billion, with an additional $82 million in annual operations and maintenance costs.

Despite their differences, the state and SSA plans share several significant logistical challenges. Among these is the seismic activity in the region, one of the most tectoni-

4. The SSA Plan is available at http://www.saltonsea.ca.gov/ and was reviewed in slightly modified form in the DEIR (2006).

cally active in North America (Monroe 2007).[5] The Sea itself lies atop the seismically active zone between the Pacific and North American plates; the former moves away from the latter at a rate of about 4 cm/year (Monroe 2007, Elders et al. 1972). The San Andreas and San Jacinto faults both run near or beneath the Sea. The San Andreas fault historically experiences a major earthquake in this area roughly every 200 years, though the most recent occurred 335 year ago (Monroe 2007). This seismic activity requires that proposed structures be designed accordingly, dramatically increasing costs (Reclamation 2007). Other logistical challenges include the harsh summer climate, occasional days of large waves that will limit water-based construction, staging difficulties as the shrinking lake requires frequent dredging or relocation of harbors, the restrictions on diesel emissions noted above, the absence of a proximate quarry with sufficient rock in the size and quantity needed, and the limited number of construction firms capable of handling a project of this scale.

Multi-billion dollar restoration proposals also face the harsh fiscal realities of California's projected multi-billion dollar budget deficit, and limited prospects for any federal or local funding. Although the project timeline extends through 2077, the reality is that the bulk of financing would be required during construction, in the first 10–15 years of the project. Adding to the projected high capital costs are the equally daunting annual operations and maintenance expenses; for the state's Preferred Alternative, these expenses would be equivalent to more than 35% of the California Department of Fish and Game's total FY 08–09 budget.

Shallow Habitat Alternative

In 1998, Congress adopted P.L. 105–372, directing the Bureau of Reclamation to conduct a feasibility study for maintaining the Sea as an agricultural sump; stabilizing its salinity and elevation; reclaiming fish and wildlife and their habitats; and enhancing the potential for recreation and economic development. In 2004, Congress further directed Reclamation to complete a feasibility study on a preferred Salton Sea restoration alternative (P.L. 108–361). In January, 2008, the Bureau of Reclamation released an appraisal-level report on Salton Sea restoration that declined to recommend any of the five action alternatives it reviewed, due to their extreme costs and their significant risks and uncertainties (Reclamation 2007). Reclamation estimated costs for alternatives similar to those evaluated by the state: these costs ranged from \$3.5 to \$14 billion, with an additional \$119 to \$235 million in estimated annual costs. The report also noted "substantial uncertainties and risks associated with engineering, physical, and biological elements of the alternatives."

Instead, the report recommends a "Progressive Habitat Development Alternative." This concept-level alternative would develop and study the performance of 809 ha of shallow saline habitat complexes, constructed over a period of 7–10 years. Such complexes would impound water with salinities of 20 g/L and higher, to depths of up to 2 m, in a variety of configurations designed to increase habitat variability (see Fig. WB2.5.) California's Preferred Alternative contains a very similar component, known as "Early Start Habitat," though the state's plan calls for the 809 ha acres of shallow saline habitat to be constructed by 2011, fully 7 years earlier than the federal proposal. The state's plan also includes early start habitat as an interim measure, to provide habitat value for birds while the larger preferred alternative is developed and constructed.

5. For a map of recent earthquakes in the region, see http://www.data.scec.org/index.html

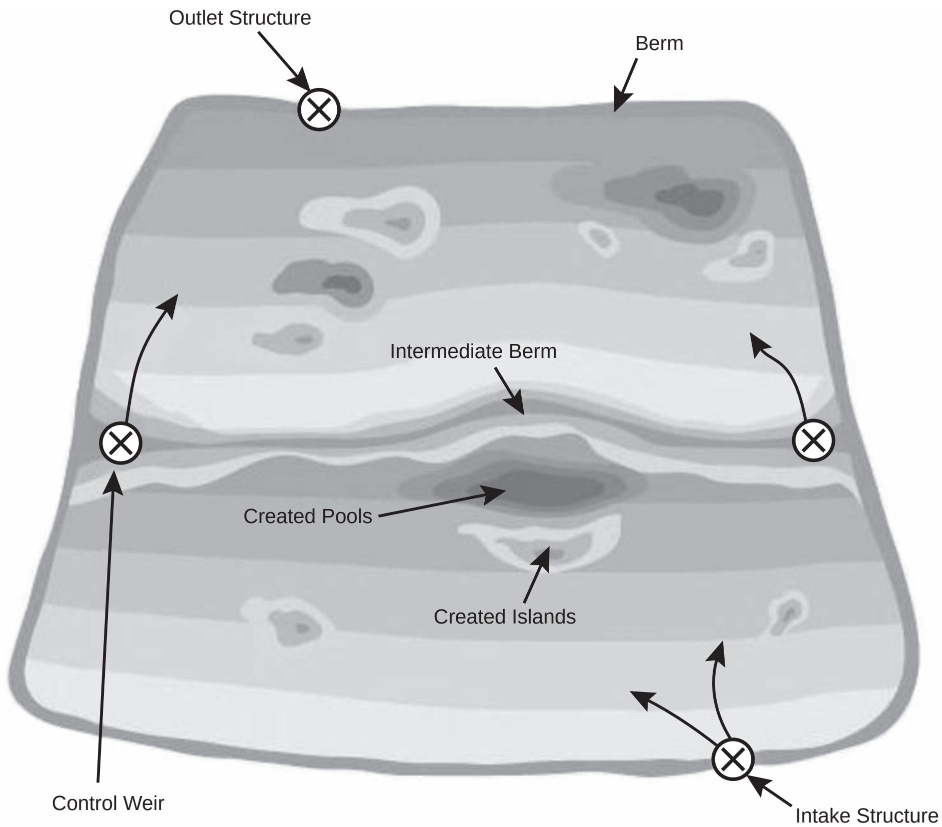

FIGURE WB 2.5 CONCEPTUAL DESIGN FOR SALTON SEA SHALLOW SALINE HABITATS.
Source: U.S. Bureau of Reclamation.

Reclamation's report, on the other hand, suggests that federal restoration would not include any major infrastructure elements.

The benefit of the federal approach is that it could be phased in over time, and would be far less expensive. Additionally, such shallow habitat ponds could be constructed relatively quickly, creating interim habitat in the near future, and could be relatively resilient in the face of earthquakes – some of the ponds would likely survive even if others were lost. The most significant drawback is that even tens of thousands of hectares of shallow saline habitat would almost certainly fail to replicate the existing habitat and recreational values of the Sea's deep open water. Such a project would bear no resemblance to the existing Sea, and will not enjoy local support.

Legal Requirements

Whether a restoration project is implemented, California is required to undertake two actions at the Salton Sea: 1) monitor land exposed as the lake recedes and control such dust-emitting soils as may be exposed due to the 2003 water transfer, and 2) promote the recovery of the endangered desert pupfish, by ensuring that pupfish populations in the various drains and rivers do not become isolated (DEIR 2006). The latter task could simply involve connecting drainage canals and rivers around portions of the Sea. Air-quality monitoring and management, however, could be very expensive, given the magnitude of lands exposed. As the surface elevation of the Sea falls to a new elevation based on declining inflows over the next 20–30 years, some 350 km^2 of lakebed will be exposed. It is not known how much of this exposed lakebed will actually emit dust. California is currently in the process of developing a monitoring network to measure such emissions. A variety of methods could be used to control dust emissions, including the use of sand fences, shallow flooding, planting and irrigating salt-tolerant vegetation, and creating salt crusts. Most of these methods require water. This water would come from the remnant Sea itself, or by diverting some of the lake's inflows. Either way, the Sea would shrink further, exposing additional lakebed.

In 2003, California assumed responsibility for air-quality monitoring and mitigation for impacts due to the water transfer (the transfer parties are responsible for the first $133 million in environmental mitigation costs; the state assumed liability for all costs exceeding this threshold). However, the transfer itself represents just over half of the state's estimated reduction in flows to the Sea. Landowners will be responsible for lakebed exposed due to factors other than the transfer, such as declines in flows from Mexico or changes in cropping patterns, or due to increases in evaporation. Determining what factors actually lead to land exposure will be very contentious, given the responsibility to control emissions from such lands. This uncertainty could lead to extensive litigation between landowners and the state (Cohen and Hyun 2006).

No Action Alternative

As of mid-2008, California was suffering from a $14.4 billion budget deficit and the legislature had demonstrated little interest in funding Salton Sea restoration. The federal government has invested millions of dollars in Salton Sea studies (Cohen et al. 1999), and has funded the construction of 40 ha of shallow ponds near the southeastern edge of the Sea, but has yet to authorize the hundreds of millions of dollars that will be required for restoration. The extremely high costs estimated for Salton Sea restoration, the high degree of uncertainty regarding future conditions, the lack of consensus on a restoration plan, the other environmental problems clamoring for state and federal intervention (such as the San Francisco/Sacramento Bay-Delta, eroding delta levees, and the Klamath) and the Salton Sea basin's limited political leverage relative to the Bay-Delta region and to urban Southern California, combine to suggest that any large-scale action at the Salton Sea may be deferred for many years, if it is ever implemented at all. These challenges make the "no-action alternative"—intentional or not – a real possibility.

Conclusion

For the next decade, change at the Salton Sea will continue to be gradual. Salinity will slowly rise to about 60 g/L, the surface of the Sea will drop another meter, more dust will blow, and fish and invertebrate populations will be stressed by worsening water quality. But the Sea will look much the same as it does now. Starting in 2018, however, the rate of change will increase dramatically as inflows drop precipitously. After 2018, the shrinking Sea will quickly become an environmental catastrophe, threatening public health with massive dust storms and potentially threatening the survival of the large populations of many species of birds that currently depend on the Sea (Cohen and Hyun 2006). The greatest challenge facing restoration advocates is convincing decision-makers that action needs to be taken now, to avert the catastrophe.

Fortunately, there have been some positive developments. The U.S. Geological Survey's Salton Sea Science Office is currently operating and monitoring a 40-ha pilot project of shallow habitat on the southeast end of the Sea, while the Torres-Martinez Desert Cahuilla Indian tribe has constructed a 34-ha wetland on their land at the northwest end of the lake (Kelly 2008). These two projects have both attracted large numbers of birds, with more than 135 different species recorded at the sites. Building upon these successes could demonstrate the benefits of state and federal commitment to the Sea, generating momentum while providing real benefits on the ground.

REFERENCES

Cohen, M.J. 2002. Managing across boundaries: the case of the Colorado River delta. In Gleick, P.H, editor. *The World's Water 2002–2003*. Washington D.C.: Island Press, pp. 133–147.

Cohen, M.J., and Hyun, K.H. 2006. *Hazard: The Future of the Salton Sea with No Restoration Project*. Oakland, CA: Pacific Institute.

Cohen, M.J., Morrison, J.I., and Glenn, E.P. 1999. *Haven or Hazard: The Ecology and Future of the Salton Sea*. Oakland, CA: Pacific Institute.

Draft Environmental Impact Report (DEIR). 2006. *Salton Sea Ecosystem Restoration Program Draft Programmatic Environmental Impact Report*. Prepared for State of California, The Resources Agency, by California Department of Water Resources and California Department of Fish and Game. State Clearinghouse #2004021120. Available at http://www.saltonsea.water.ca.gov/PEIR/draft/.

Elders, W.A., Rex, R.W, Meidou, T., Robinson, P.T., and Biehler, S. 1972. Crustal spreading in southern California. *Science* 178:15–24.

Glantz, M.H. 1999. Sustainable development and creeping environmental problems in the Aral Sea region. In Glantz, M.H., editor. *Creeping Environmental Problems and Sustainable development and in the Aral Sea Basin*. Cambridge: Cambridge University Press. pp. 1–25.

Jehl, J.R., and McKernan, R.L. 2002. Biology and migration of eared grebes at the Salton Sea. *Hydrobiologia* 473: 245–253.

Kelly, D. 2008. Part of Salton Sea's desolate shore made into a lush oasis. *Los Angeles Times*, February 24. Available at http://www.latimes.com/news/printedition/california/la-me-wetlands24feb24,0,5237505.story

Monroe, R. 2007. The shaky future of the Salton Sea. *Explorations* 14(9). Available at http://explorations.ucsd.edu/Features/Salton_Sea/

Nijhuis, M. 2000. Accidental refuge: Should we save the Salton Sea? *High Country News*, June 19. Available at http://www.hcn.org/servlets/hcn.Article?article_id=5865

PEIR. 2007. *Salton Sea Ecosystem Restoration Program Final Programmatic Environmental Impact Report*. Prepared for State of California, The Resources Agency, by California Department of Water Resources and California Department of Fish and Game. Available at http://www.saltonsea.water.ca.gov/PEIR/.

Pomeroy, R.D., and Cruse, H. 1965. *A Reconnaissance Study and Preliminary Report on a Water Quality Control Plan for Salton Sea*. Prepared for the California State Water Quality Control Board. Available at http://projects.ch2m.com/webuploads/ssRestoration/182_1965_Recon_Study_and_Prelim_WQC_Plan_1_of_5.pdf

Reclamation U.S. Department of the Interior, Bureau of Reclamation. 2007. *Restoration of the Salton Sea: Summary Report*. Available at http://www.usbr.gov/lc/region/programs/saltonsea.html.

Reisner, M. 1993. *Cadillac Desert: The American West and its Disappearing Water*. NY: Penguin Books. 2nd ed.

San Diego Union-Tribune. 2006. On Salton Pond; Man can't save this desert lake. *San Diego Union-Tribune*, October 23.

Society for Ecological Restoration (SER). 2004. International Science & Policy Working Group. *The SER International Primer on Ecological Restoration*. Tucson: Society for Ecological Restoration International. 15 pp. Available at www.ser.org

Shuford, W. D., Warnock, N., Molina, K.C., Mulrooney, B. and Black, A.E.. 2000. *Avifauna of the Salton Sea: Abundance, distribution, and annual phenology*. LaQuinta, CA: Contribution No. 931 of Point Reyes Bird Observatory. Final report for EPA Contract No. R826552-01-0 to the Salton Sea Authority, 78401 Highway 111, Suite T, La Quinta, CA 92253.

Shuford, W. D., Warnock, N., Molina, K.C., and Sturm K. 2002. The Salton Sea as critical habitat to migratory and resident waterbirds. *Hydrobiologia* 473:255–274.

Shuford, W.D., Warnock, N., and McKernan, R.L., 2004. Patterns of shorebird use of the Salton Sea and adjacent Imperial Valley, California. *Studies in Avian Biology* 27:61–77.

Sykes, G. 1937. *The Colorado Delta*. American Geographical Society. Baltimore, Maryland: Lord Baltimore Press, 19:193.