PACIFIC INSTITUTE

# Hazard's Toll

## The Costs of Inaction at the Salton Sea

September 2014

# HAZARD'S TOLL

## The Costs of Inaction at the Salton Sea

**September 2014**

by Michael J. Cohen

The full report is available online at
http://pacinst.org/publication/hazards–toll


ISBN: 1893790576
ISBN 13: 978–1–893790–57–5

Pacific Institute
654 13th Street, Preservation Park
Oakland, California 94612
www.pacinst.org
Phone: 510.251.1600
info@pacinst.org

Cover photograph courtesy of Andrew Morang,
worldofdecay.blogspot.com

Layout and design by Nikki Ward
www.morrisonalleydesign.com

Funding for this report generously provided by the Bureau of Reclamation

# About the **Pacific Institute**

The Pacific Institute is one of the world's leading nonprofit research and policy organizations working to create a healthier planet and sustainable communities. Based in Oakland, California, we conduct interdisciplinary research and partner with stakeholders to produce solutions that advance environmental protection, economic development, and social equity – in California, nationally, and internationally. We work to change policy and find real-world solutions to problems like water shortages, habitat destruction, global warming, and environmental injustice. Since our founding in 1987, the Pacific Institute has become a locus for independent, innovative thinking that cuts across traditional areas of study, helping us make connections and bring opposing groups together. The result is effective, actionable solutions addressing issues in the fields of freshwater resources, climate change, environmental justice, and globalization. More information about the Institute and our staff, directors, funders, and programs can be found at www.pacinst.org.

# About the **Project Team**

## Michael Cohen

Michael Cohen is a senior research associate at the Pacific Institute and is based in Boulder, Colorado. He is the lead author of two previous Pacific Institute reports on the Salton Sea: *Haven or Hazard*: *The Ecology and Future of the Salton Sea* (1999), and *Hazard: The Future of the Salton Sea With No Restoration Project* (2006), as well as several articles and opinion pieces about the Salton Sea. He served on California's Salton Sea Advisory Committee. Mr. Cohen has a Master's degree in Geography, with a concentration in Resources and Environmental Quality, from San Diego State University, and a B.A. in Government from Cornell University.

## Jason Sauer

Jason Sauer provided invaluable research assistance for this project, tracking down relevant articles, experts, and data. He recently graduated with a Bachelor's of Science in environmental geosciences and policy from the University of Colorado at Boulder, and is currently pursuing a master's degree in water resources at the University of Connecticut. Mr. Sauer is chiefly concerned with meeting the water needs of humans and ecosystems, in light of changes in land usage and climate.

# Acknowledgements

The Bureau of Reclamation generously provided funding and support for this study (contract R13PX30407). The views and opinions contained within this report are those of the author and are not necessarily the views or opinions of the Bureau of Reclamation.

This report could not have been completed without the assistance and support of many people.

Valuable comments, recommendations, and suggestions through the long process of preparing this report were provided by Becky Blasius, Todd Bricker, Eric Connally, Heather Cooley, John Gerstle, Bob Hargreaves, Andy Horne, Josué Medellín-Azuara, Jennifer Pitt, Phil Rosentrater, Kurt Schwabe, Val Simon, Mark Thayer, and Bruce Wilcox. I gratefully acknowledge their insights and their time. New and remaining errors are solely my own.

I also thank the following people for their advice, assistance, information, maps, and photos: Lola Aguilar, Liz Bailey, Khaled Bali, Doug Barnum, Bill Brownlie, Phyllis Cason, Dan Denham, Joaquin Esquivel, Terry Fulp, Rafael Garcia, Taylor Hawes, Karen Henderson, Chris Holdren, Al Kalin, Tom Kirk, Emily Lee, Jessica Lovecchio, Paula Luu, Andrew Morang, Stephen Munday, Phayvanh Nanthavongdouangsy, Amelia Nuding, Brad Poiriez, Jenny Ross, Nancy Ross, Brian Schmid, Chris Schoneman, Rachel Sleeter, Richard Snyder, Robert Taylor, Bill Travis, Earl Withycombe, and Steve Zelinka.

GIS and cartography by Brian Cohen, The Nature Conservancy.

# Executive Summary

The Salton Sea, a 350 square mile saltwater lake in southeastern California, faces disaster. In the next fifteen years:

- The amount of water flowing into the lake will decrease by about 40%;
- Its surface will drop by twenty feet and its volume will decrease by more than 60%;
- Salinity will triple; and
- The shrinking lake will expose 100 square miles of dust-generating lake bottom to the region's blowing winds, worsening the already poor air quality in the region.

To date, neither the state legislature nor any other agency has taken any action to fund any Salton Sea revitalization plan. In 2003, California accepted responsibility for funding air quality management projects at the Salton Sea, but the legislature has yet to take any action to fund such projects. A local agency is developing plans for air quality management on a portion of the exposed Salton Sea lakebed, but it lacks the funding necessary to implement these plans. With the exception of three relatively modest habitat projects scheduled for construction next year, no projects are currently funded or expected to be constructed at the Salton Sea in the near future. As a result, the lake's habitat value for hundreds of species of resident and migratory birds will rapidly decline, affecting hundreds of thousands of birds and diminishing the lake's appeal.

If current trends continue, by 2045:

- As much as 150 square miles of lakebed will be exposed;
- Exposed lakebed will add as much as 100 tons of fine dust into the air *per day*;
- The total population of the air basin (currently about 650,000) will nearly double;
- The lake will be filled with algae, bacteria, and viruses, providing no value to birds or people.

The deteriorating conditions at the Salton Sea will have adverse impacts on public health, property values, agricultural production, recreational revenue, and the region's habitat value for birds and wildlife generally. These impacts impose costs on people in the area and, to a lesser extent, on Californians generally.

Many people assume that deferring Salton Sea-related decisions and actions will not result in any additional costs, implicitly assigning these impacts a value of zero. Decision-makers have weighed the high costs of Salton Sea revitalization and the lower but still significant costs of mitigation against this assumed zero cost of not taking action, and have yet to approve or fund any major projects at the Salton Sea. This inaction and delay imposes real costs.

## Objective

The objective of this report is to estimate the costs of inaction – defined as the absence of any large-scale revitalization or air quality management project – at the Salton Sea, to provide decision-makers and the general public with information for deciding on a path forward. Specifically, this report estimates the impacts of the deteriorating Salton Sea on:

- health care costs, due to the adverse impact that increased dust emissions have on human health;
- regional property values, due to real and perceived health threats and declining aesthetic value;
- agricultural productivity, due to dust emissions and loss of the Sea's buffering impacts on temperature and humidity in nearby farmland;
- recreational revenues; and
- ecological values, including impacts to threatened and endangered species.

## The Costs of Action

The California Natural Resources Agency estimated the capital cost for its 2007 preferred Salton Sea revitalization alternative at about $10 billion (all costs adjusted to 2013 dollars), plus annual operations & maintenance costs of $150 million once fully constructed, yielding a total present value of $9.6 billion at a 4% discount rate, through the year 2047. These projected revitalization costs are separate and distinct from the costs projected for mitigating (off-setting the impacts of) the Imperial Valley-San Diego water transfer. The present value of the state's conceptual mitigation plan is about $1.7 billion through 2047. These values represent the costs of 'action' at the Salton Sea.

## Inaction Costs – Public Health

Many scientific and medical studies document the link between blowing dust and a broad range of public health impacts, including childhood and adult asthma, cardiac disease, lung cancer, and increased mortality rates. Two previous studies suggest methods to estimate the magnitude of these costs at the Salton Sea: based on the estimated per capita cost of exceeding federal air quality standards, or based on a cost per unit of exposed dust. Using the first method, the public health costs of continuing not to meet federal air quality standards – exacerbated by expected Salton Sea dust emissions and a rapidly growing population – generate a present value as high as $21 billion. Using the second method, under a worst case scenario, with high projected dust emissions and very limited air quality management, the present value cost of uncontrolled dust emissions on public health could be $37 billion through 2047. Assuming a much lower rate of emissions and implementation of dust control measures on portions of the exposed Salton Sea lakebed reduces the estimate of public health costs to about $3 billion. Annual public health costs increase as the Salton Sea shrinks, exposing more dust-emitting lakebed; but even in the near term, they could still exceed hundreds of millions of dollars per year.

## Inaction Costs – Property Value

Studies on the economic impacts of environmental hazards in other areas, such as landfills, confined animal feeding operations, and refineries, offer methods for estimating potential impacts to property values at the Salton Sea. Regional or state polling data on public perceptions of the Salton Sea would be informative, but no such polls have been conducted in at least a decade. Blowing dust and the stigma associated with a deteriorating lake pose a risk to property values within several miles of the lake, suggesting that property devaluation in the immediate area associated with the deteriorating Salton Sea is likely to be at least $400 million. Dust and noxious odors could also depress property values and revenues in the Coachella Valley more broadly, which includes 124 golf courses as well as numerous resorts and vacation homes, so the total impact on property values could be as much as $7 billion.

## Inaction Costs – Agricultural Productivity

Insufficient information exists to estimate the potential costs associated with either the impacts of blowing dust and salt on crop productivity near the Salton Sea or the diminished micro-climate benefits that will occur as the lake shrinks. Both of these impacts will be felt within a few miles of the Salton Sea, so their overall cost may be small relative to the magnitude of Imperial and Coachella valley agriculture generally, but these impacts could be significant at the scale of the individual farm.

## Inaction Costs – Recreational Revenues

The future Salton Sea will continue to experience declines in visitation to the lake and in direct recreation-related expenditures. Recent declines have caused a loss of $6 million per year in direct spending at the Salton Sea State Recreation Area relative to estimated historic rates, suggesting the loss of $110 – $150 million in present value through 2047. Given the absence of records or surveys of current and historic expenditures for Salton Sea recreation as a whole, this rough estimate should be considered very conservative.

## Inaction Costs – Ecological Values

The Salton Sea currently provides tens of thousands of acres of shoreline and near-shore habitats to hundreds of thousands of birds. More than 400 species of birds use the Salton Sea, including a large number of special status species. As the lake deteriorates, the size and quality of its habitats will diminish, reducing its value to the resident and migratory birds that depend upon it. Through contingent valuation surveys and other methods, people have expressed a willingness to pay to preserve similar values at other locations. Previous studies have indicated that Californians as a whole have valued wetland habitats at about $60,000 per acre, suggesting that the Salton Sea provided some $2.6 billion annually in shoreline habitat value as recently as the year 2000. Transferring the benefits Californians have reported for Mono Lake suggests a potential non-use valuation of the Salton Sea on the order of $1.9 billion annually. Depending on the discount rate, these annual values translate into present values ranging from $10 billion to $26 billion through 2047.

## Conclusion

The high costs of the California Natural Resources Agency's proposed 'preferred alternative' have inhibited deliberation and deterred any meaningful investment in the revitalization of the Salton Sea. The assumption seems to be that delaying action at the Salton Sea will result in business as usual, with no additional costs. This is clearly not the case. Because the Salton Sea has changed over the past decade and will soon enter a period of very rapid deterioration, the costs of inaction are escalating rapidly. *When* a project is implemented dramatically affects the inaction costs estimated above. Postponing decisions and actions for the Salton Sea imposes significant costs on the people and property owners in the region, and lesser costs on Californians generally.

Figure ES-1 compares the project costs of the state's proposed revitalization alternative and of its conceptual mitigation plan with the estimated inaction costs for public health and non-use benefits, and with the one-time estimated devaluation of property in the region, through the year 2047. In the figure, the higher estimated inaction costs appear in red, while the lower estimates appear in orange. These estimated costs provide an initial basis for comparison with the estimated project costs of revitalization or mitigation, shown in black, to demonstrate that the costs of inaction are not zero. Even at the low estimate, the long-term social and economic costs of a deteriorating Salton Sea could approach $29 billion, well in excess of the project cost of the state's revitalization plan. A more robust

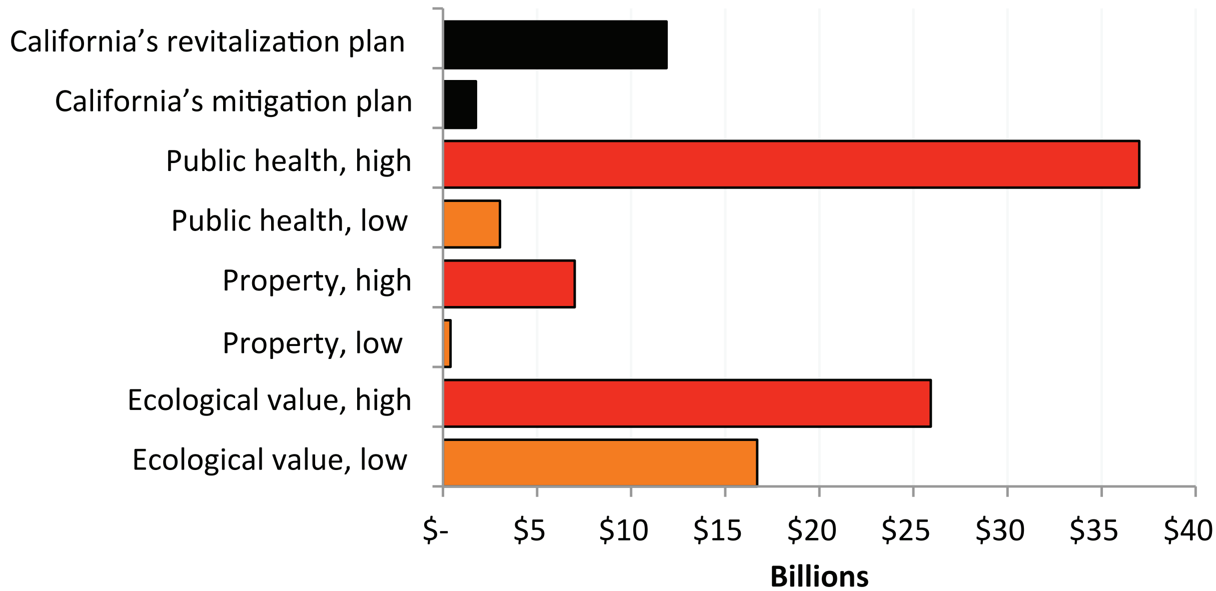



**Figure ES-1. Present values of estimated costs of Salton Sea action and inaction, through 2047.**

comparison would require additional information about the total economic costs and benefits of the revitalization and mitigation projects.

Figure ES-1 indicates that the costs of inaction greatly exceed the costs of action at the Salton Sea, strongly suggesting that action at the Salton Sea should be funded and implemented quickly. However, not all 'actions' would avoid the 'inaction' costs: a mitigation plan designed only to control dust emissions would not improve recreation in the region, nor would it improve property values or promote economic development; such a plan would do little to improve declining ecological values. A project that both controls dust and creates habitat could limit or avoid public health costs, reduce or eliminate impacts to property values, and maintain or even enhance ecological values. A more comprehensive revitalization plan should also be evaluated within this broader context of created benefits and avoided costs. In all cases, delaying action imposes real costs.

The consequences of continued inaction at the Salton Sea will be felt most directly by the 650,000 people who live in harm's way of the Salton Sea's dust, as well as by the birds and other life that depend on the lake. These consequences generate real costs. These considerable costs, estimated for the first time by this report, demonstrate the urgent need for action at the Salton Sea.

# Table of **Contents**

# Tables and Figures

# Abbreviations

| | |
|---|---|
| AF | Acre-feet (one acre-foot = 325,851 gallons) |
| CARB | California Air Resources Board |
| CNRA | California Natural Resources Agency (formerly, California Resources Agency) |
| CVWD | Coachella Valley Water District |
| DFW | California Department of Fish & Wildlife (formerly, Department of Fish & Game) |
| DWR | California Department of Water Resources |
| g/L TDS | grams per liter, total dissolved solids |
| ICAPCD | Imperial County Air Pollution Control District |
| IID | Imperial Irrigation District |
| JPA | Joint Powers Authority |
| $\mu g/m^3$ | micrograms per cubic meter |
| NGVD | "National Geodetic Vertical Datum" – a vertical reference standard used by USGS |
| O&M | operations and maintenance |
| PEIR | Salton Sea Ecosystem Restoration Program Programmatic Environmental Impact Report |
| $PM_{10}$ | particulate matter less than 10 microns in diameter |
| QSA | Quantification Settlement Agreement |
| Reclamation | Bureau of Reclamation, U.S. Department of the Interior |
| SDCWA | San Diego County Water Authority |
| South Coast | South Coast Air Quality Management District |
| SS SRA | Salton Sea State Recreational Area |
| SSA | Salton Sea Authority |
| US FWS | U.S. Fish & Wildlife Service |
| USGS | U.S. Geological Survey |

# 1. Introduction

The Salton Sea, located in remote, southeastern California, stretches nearly 35 miles between the lower Coachella Valley in Riverside County and the Imperial Valley in Imperial County (Figure 1), in a region that has experienced rapid population growth. California's largest lake, with a current surface area of about 350 square miles, the Salton Sea is also very shallow. As the Salton Sea shrinks due to declining inflows, it exposes large expanses of lakebed, some of which will emit dust. This dust will contribute to poor air quality in a basin that already fails to meet state and federal air quality standards. The lake, reliant on agricultural runoff, lies more than 230 feet below sea level in one of the hottest deserts in the country. Lacking any outlet except evaporation and suffering from declining inflows, the Salton Sea grows ever saltier and less hospitable. Its increasingly salty, oxygen-starved waters – previously home to one of the most productive fisheries in the world – have lost all but the hardiest, most resilient fish. Declining numbers of fish and invertebrates mean a smaller food base for the hundreds of thousands of resident and migratory birds that depend on the lake.

The lake has a rich and storied history, replete with glamorous celebrities and international speedboat races. But the Salton Sea has fallen on hard times in the past several decades, its waters rising in the early 1970s to flood marinas and hotels, then receding in the past decade to strand shoreline properties. The hundreds of thousands of visitors who once flocked to its shores have moved on. The hotels and marinas and stores that once prospered along the Sea's shoreline have long since shut their doors.


**Figure 1. California's Salton Sea.**
Source: California Department of Water Resources.

The Salton Sea's future looks even more grim. The lake faces catastrophic change, driven most immediately by a massive water transfer between Imperial Valley and San Diego County and a subsequent reduction in flows to the Salton

Sea, as well as by declining inflows from Mexico, increasing urbanization, changing agricultural practices, and a hotter and drier climate (CNRA 2006). In the next fifteen years, the volume of water flowing into the lake will decrease by about 40%, the Salton Sea's surface will drop by twenty feet and its volume will decrease by more than 60%. Salinity will triple. One hundred square miles of lakebed will be exposed to the region's blowing winds, increasing dust emissions (Cohen and Hyun 2006).

The magnitude of these changes has been known for many years. There have been scores of studies and plans and proposals and suggestions for revitalizing the Salton Sea, many meetings and millions of dollars spent in pursuit of solutions. In 2007, the California Natural Resources Agency submitted a preferred Salton Sea Restoration Plan (CNRA 2007) to the state legislature that carried a $10 billion cost estimate (adjusted to 2013$[1]), plus annual operation and maintenance costs of about $150 million once fully constructed. Other proposals, such as pumping in millions of acre-feet of ocean water from the Gulf of California, have also been suggested, but they would be even more expensive, take longer to construct, and would require the negotiation of a new international treaty. The massive scale of the Salton Sea means that a bare-bones mitigation effort, simply to offset the direct impacts of the Imperial Valley-San Diego water transfer, could cost almost a billion dollars in capital expenditures alone, plus $56 million annually for operations and maintenance. The magnitude of these costs and the scale of the problem, as well as the absence of a consensus solution, have discouraged state and federal legislators from funding Salton Sea revitalization efforts and have become a ready excuse for postponing meaningful action at the Salton Sea.

Figure 2 show the costs estimated for the state's preferred alternative (CNRA 2006); the default basis of comparison for these costs has been zero, or the presumed cost of not taking any action at the Salton Sea. To date, the California legislature has not taken any action on the Resources Agency's 2007 preferred alternative, so the planning and construction underlying the cost projections shown below would be shifted by at least seven years. That is, costs projected for 2008-13 would be incurred in 2015-20 or later.

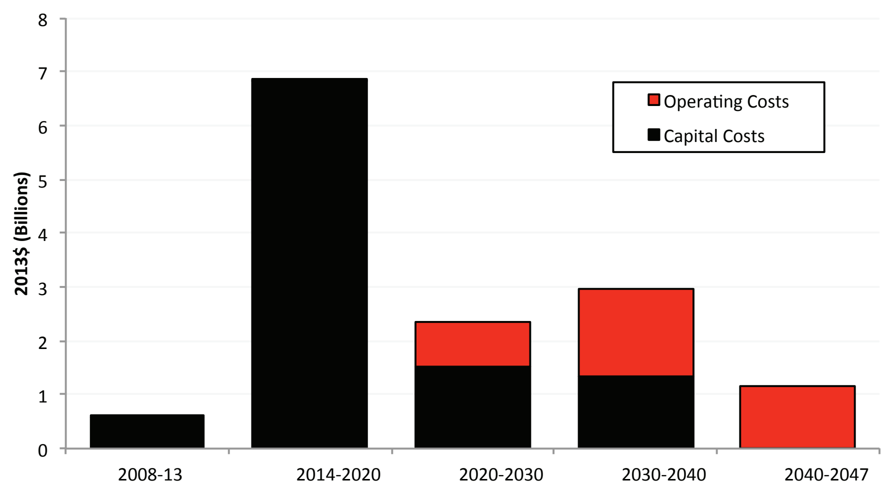



**Figure 2. Projected costs of state's preferred alternative, 2008-2047.**

Source: CNRA 2007.

Although future Salton Sea conditions have been projected (Cohen and Hyun 2006, CNRA 2006), the economic costs associated with increased dust emissions due to additional lakebed exposure and diminished property values due to real and perceived problems at the lake previously had not been estimated. To date, decision-makers have had to decide between the very high costs of Salton Sea restoration, the lower but still significant costs of mitigation, and the perception that deferring Salton Sea-related decisions and actions will not result in any measurable, additional costs. This report offers the first

[1] Unless otherwise indicated, all dollar values referenced in this report have been adjusted to 2013$, using the Consumer Price Index, calculated at http://www.measuringworth.com/.

estimates of the many local and regional costs associated with deferring meaningful action at the Salton Sea.

This discrepancy between the stated costs of action at the Salton Sea and the unstated and frequently ignored costs of inaction underscores one of the greatest hurdles confronting the Sea: its future condition will be dramatically worse than its current condition, significantly increasing the costs of inaction. The discontinuity between recent conditions and fundamentally different future conditions challenges efforts to plan accordingly (Tversky and Kahneman 1974, Milly et al. 2008). Although we lack certainty about the exact timing and specific, quantified impacts arising from a future Salton Sea, it is clear that the deteriorating Salton Sea will adversely affect the region, causing real, measurable adverse impacts to public and ecological health (IID 2002, Cohen and Hyun 2006, CNRA 2006). Despite the many warnings about the impending Salton Sea catastrophe, little has been done. Unfortunately, this reflects a broader trend: while society often responds quickly to existing disasters, we frequently fail to act to avert predicted future events. California's inaction with respect to the Salton Sea represents another example of failure to avoid a known threat.

The future costs of inaction – such as damages to public health and to property values – at the Salton Sea have been largely unquantified, implicitly assigning them a value of zero (Schwabe et al. 2008). This implicit zero value fosters the belief that failing to take action at the Salton Sea will not impose any new or additional costs. This report suggests preliminary estimates for these future costs of inaction, to address this obvious oversight and to offer a basis for comparing the costs of an action at the Salton Sea with the benefits of that action (in this case, both the avoided costs of inaction and the direct benefits generated by the project itself). The question should be: does the broader societal value generated by building a restoration project at the Salton Sea justify the direct cost of that project? Justifying this cost requires not only an estimate of the benefits generated by the restoration project, but also an estimate of the additional damages that could arise in the absence of the project.[2]

Yet, to date, there has not been an effort to compare the costs of restoring or rehabilitating the Salton Sea with the costs of not taking action. Because conditions at and around the Salton Sea will deteriorate in coming years (Cohen and Hyun 2006, CNRA 2006), the economic and ecologic costs of inaction could be quite significant. These costs include:

- Rising health care costs, due to the adverse impact increased dust emissions have on human health;
- Falling regional property values, due to real and perceived health threats and declining aesthetic value;
- Diminished agricultural productivity, due to dust emissions and to the loss of the Sea's buffering impacts on temperature and humidity in nearby farmland;
- Declining recreational revenues; and
- Diminished ecosystem services, including impacts to listed species and related non-market values.

## Objective

The objective of this report is to estimate the costs of "inaction" at the Salton Sea, to provide decision-makers and the general public with information for deciding on a path forward for the Salton Sea.

---

[2] The opportunity costs of Salton Sea projects can be construed as avoided damages, or the opposite of a conventional foregone benefit of an action. In the case of the Salton Sea, not acting imposes additional costs.

This report is a companion volume to *Hazard: The Future of the Salton Sea With No Restoration Project*[3] (Cohen and Hyun 2006). The previous volume contains information on the formation, ecological processes, and hydrology of the Salton Sea, as well as an assessment of the potential ecological impacts of the Sea's current decline.

## Scope

The scope of this economic assessment includes:

1. Changes in health care costs, given the projected increase in dust emissions and the link to respiratory problems, in areas downwind from the Salton Sea;
2. Changes in property values in the immediate vicinity, and in the Coachella and Imperial valleys more broadly;
3. Costs associated with impacts on local agriculture, from dust and from the loss of the Sea's microclimate;
4. Changes in recreational revenues; and
5. Changes in non-use values.

The boundaries of the Salton Sea Air Basin, including the Coachella Valley in Riverside County and all of Imperial County, constitute the geographic scope of this study (see Figure 3). This study evaluates potential economic impacts associated with a declining Salton Sea to the year 2047, coinciding with the term of the current Imperial Valley-San Diego water transfer agreement.[4]


**Figure 3. Study area boundaries.**
Source: California Air Resources Board.

The remainder of this introduction describes the assumptions, basic methods, and limitations for this study. The next chapter briefly describes the changing physical conditions at the Salton Sea and the institutional context framing current and future actions. Chapters 3 through 7 describe the methods used and the initial estimates of the costs of inaction on public health, property values, agriculture, recreation, and non-use values such as existence and preservation values. Chapter 8 summarizes these results, while Chapter 9 offers conclusions and recommendations.

## Assumptions

This report describes the costs of "no action" at the Salton Sea. Estimating these future costs requires a number of assumptions about both the changing physical conditions at and around the Salton Sea and local, state, and federal responses to these changes. There have been, and will continue to be, some projects implemented at the Salton Sea. In this report, "no action" and "inaction" mean the absence of a large-scale Salton Sea revitalization effort. As described in the following, "no action" and "inaction" also refer to the potential delays in implementing

[3] *Hazard* is available online at http://pacinst.org/publication/restoration-project-critical-to-salton-seas-future/.

[4] Many of the public health costs associated with increased dust emissions will occur after this study period, so the suggested estimates are lower than they would be if they reflected the lifetime impacts of exposure to unhealthy concentrations of $PM_{10}$.

an air quality management project of a scale sufficient to address the expected dust emissions arising from the exposed lakebed.

The estimates made in this report assume the following, described in greater detail in Chapter 2, *The Changing Salton Sea*:

1. Changing physical conditions at the Salton Sea, including the rate of exposure of lakebed and changes in salinity, occur at the rates projected by Cohen and Hyun (2006) and by the California Natural Resources Agency (CNRA 2006);
2. Currently scheduled habitat projects at the Salton Sea, including California's Species Conservation Habitat (640 acres), the Red Hill Bay project (650 acres), and the Torres–Martinez wetlands (105 acres), are completed by or before 2017;
3. The state will not assume responsibility for funding air quality mitigation at the Salton Sea until 2025 (California State Auditor 2013), and possibly as late as 2048, based on interpretations of the factors triggering state liability (see following discussion);
4. The Quantification Settlement Agreement (QSA) Joint Powers Authority (JPA), responsible for implementing mitigation projects, may experience budget shortfalls prior to 2025 because expenditures in some years may exceed revenues under the QSA payment schedule, potentially delaying the implementation of mitigation projects; and
5. The QSA JPA, and subsequently the State of California, will be directly responsible for air quality management of about 58% of the Salton Sea playa[5] exposed in 2047; the remainder will be the responsibility of individual land owners. Determining responsibility for managing specific parcels of land may lead to litigation and further delay management efforts, increasing dust emissions in the interim.

## Methods

This study estimates the potential economic costs of a declining Salton Sea based on published projections of future conditions, including water quality, elevation, amount of exposed lakebed, and the potential volume and frequency of dust emissions. The methods used to estimate these economic costs include both evaluations of the costs that would accrue from the five topics listed in the above scope and estimates of the costs required to avoid or mitigate these impacts, including but not limited to those developed by the State of California's 2007 Salton Sea Ecosystem Restoration Program PEIR, the QSA JPA, and the state's Species Conservation Habitat. The following chapters include detailed discussion of the methods used to estimate costs for each topic.

Unless otherwise noted, all costs are reported in 2013 dollars, adjusted using the Consumer Price Index as calculated by www.MeasuringWorth.com. Future costs are escalated at 2% per year to reflect expected increases in the consumer price index. That is, if the cost of building an air quality management project is estimated to cost $100 million in 2014, this study projects that it would cost $102 million in 2015. The present value of future costs (including capital and O&M costs) through 2047 is calculated assuming this cost escalation, and then discounted using 4% and 6% rates.

[5] "Playa" refers to exposed or dry lakebed, typically very level land lacking vegetation in arid, interior basins.

## Limitations

Several factors limit the accuracy and precision of the estimates in this report, including:

1. Absence of an inventory of dust-emitting Salton Sea playa;
2. Absence of an accepted projection of future emissivity;
3. No published relationship between dust loadings (in tons/day or equivalent) from Salton Sea playa and $PM_{10}$ concentrations (in µg/m3) in the region;
4. No published studies on $PM_{10}$ concentrations in the Salton Sea air basin and impacts on public health or costs related to these impacts;
5. No published studies on the impacts of dust or airborne toxic materials on crop production or quality in the Coachella or Imperial Valleys;
6. Absence of recent regional or state polling data on public perceptions of the Salton Sea;
7. Incomplete information on the number and origins of Salton Sea visitors and their local expenditures;
8. Lack of survey data on homebuyers'/sellers' expectations about the future Salton Sea;
9. No published studies on the lake's reported micro-climate benefits for local crops; and
10. Absence of survey data on local, regional, state, and national willingness-to-pay to protect and preserve the Salton Sea's non-use ecosystem benefits.

# 2. The Changing Salton Sea

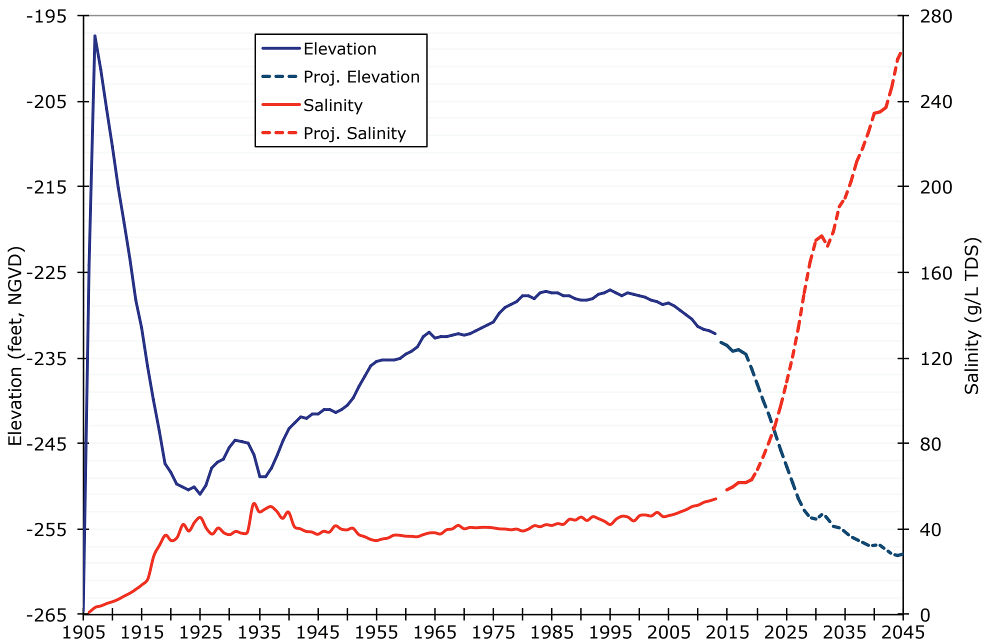



**Figure 4. Annual average and projected Salton Sea elevation and salinity, 1905-2045.**

Sources: USGS, Reclamation, CH2M-Hill.

The Salton Sea has changed throughout its history. The Colorado River broke through an unprotected diversion structure to form the current incarnation of the lake in 1905, refilling an ancient lakebed that had filled and dried many times over the past several millennia. The lake quickly shrank after losing the river's inflows in 1907, but began to grow again with the expansion of irrigated agriculture and the designation of the lake as a depository for agricultural drainage in the 1920s. Figure 4 shows that the elevation and salinity of the Salton Sea have changed considerably over the past 110 years. After the initial flooding, the Sea reached its maximum size and elevation in the mid-1990s, as a result of several factors including increased agricultural acreage and more intensive irrigation practices in the watershed. Water in the Salton Sea lacks any outlet aside from evaporation, meaning that salts and other constituents washed into the lake tend to concentrate over time, as shown in the figure by salinity's rising trend since 1955.

The Salton Sea will change more rapidly in the future, as shown in Figure 4. Within five to seven years, the lake will no longer sustain fish; those currently living in the lake will die off, stressed by rapidly increasing salinity, decreasing concentrations of dissolved oxygen, and increased incidence of parasites and disease. The lake's habitat value for resident and migratory birds will rapidly decline, affecting hundreds of thousands of birds (Cohen and Hyun 2006). Over the next fifteen years, the volume of water flowing into the lake will decrease by about 40%, its surface will drop by twenty feet, and its volume will decrease by more than 60%. Salinity will triple. By 2030, the surface area of the lake will shrink by about 100 square miles, exposing a similar amount of lakebed. By 2045, as much as 150 square miles of lakebed will be exposed to the region's blowing winds, increasing dust emissions in an area already suffering from poor air quality. In some areas, especially along the southern shoreline, the lake will recede as much as five miles from the shoreline established in the year 2000. (Cohen and Hyun 2006).

Several factors drive these expected changes. Key among these is the water conservation and transfer agreement signed in October, 2003, between the Imperial Irrigation District (IID) and the San Diego County Water Authority (SDCWA). Part of the 2003 QSA, the IID-SDCWA water transfer reduces the amount of water flowing into the Imperial Valley. Through the end of 2017, IID offsets the impacts of the transfer on the Salton Sea by delivering "mitigation water" directly to the lake, according to the schedule shown in Appendix A. After 2017, the mitigation water deliveries will no longer be legally required and the lake will enter a 10-12 year period of rapid decline, as shown by the dotted line in Figure 4. Other factors also affect the Salton Sea, including changing cropping patterns within the Salton Sea watershed, hotter and drier conditions that increase evaporation from the lake's surface and from agricultural fields, reductions in the volume of water flowing in the New River from Mexico, and changing land uses.[1]

In 2002, the environmental compliance report documenting the projected environmental impacts of the water transfer identified several significant but unavoidable impacts, including the degradation of air quality due to the reduction of inflows to the Salton Sea and subsequent exposure of potentially dust-emitting playa (IID 2002). That same year, California's State Water Resources Control Board (SWRCB) required the implementation of a four-step air quality monitoring and mitigation plan, to address potential air quality concerns.[2]

The Quantification Settlement Agreement (QSA) and related enabling legislation established a Joint Powers Authority (JPA) comprised of the California Department of Fish and Wildlife (DFW), the Coachella Valley Water District (CVWD), IID, and SDCWA. The QSA JPA "administers the funding of environmental mitigation requirements related to QSA water transfers" and is currently developing an air quality management plan for Salton Sea playa exposed due to the QSA itself. This plan, still in the early draft stages, is developing cost estimates for dust emission control measures and related expenditures.

California's initial estimate of the costs for dust emission control measures and other mitigation expenditures was about $920 million in capital costs, for construction of a large conveyance canal and related infrastructure as well as the unit costs for different treatment methods, and an additional $56 million per year for O&M costs, at full build-out (CNRA 2006). Assuming a 10-year construction schedule starting in 2015, with increasing O&M costs and a 2% annual cost escalation to reflect expected inflation, suggests that the present value of the state's conceptual mitigation plan would be about $1.4 billion through 2047, with a 6% discount rate. The QSA JPA air quality management plan and the state's mitigation plan are both distinct from any full-scale restoration plan. These mitigation

[1] See Chapter 5 of the Resources Agency's draft environmental impact report (CNRA 2006) for a detailed description of the hydrologic changes expected to affect the Salton Sea over the next several decades.

[2] See SWRCB WRO 2002-0013, available at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/orders/2002/wro2002-13revised.pdf, and WRO 2002-0016, available at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/orders/2002/wro2002-16.pdf.

plans seek to offset the water transfer's impacts on air quality and on listed species such as the endangered desert pupfish. Neither would address the full extent of air quality degradation due to the shrinking Salton Sea because both assume that individual landowners will be responsible for managing dust emissions outside of the elevations -233.5' to -247.5', identified as the elevations exposed by the water transfer itself (CNRA 2006).

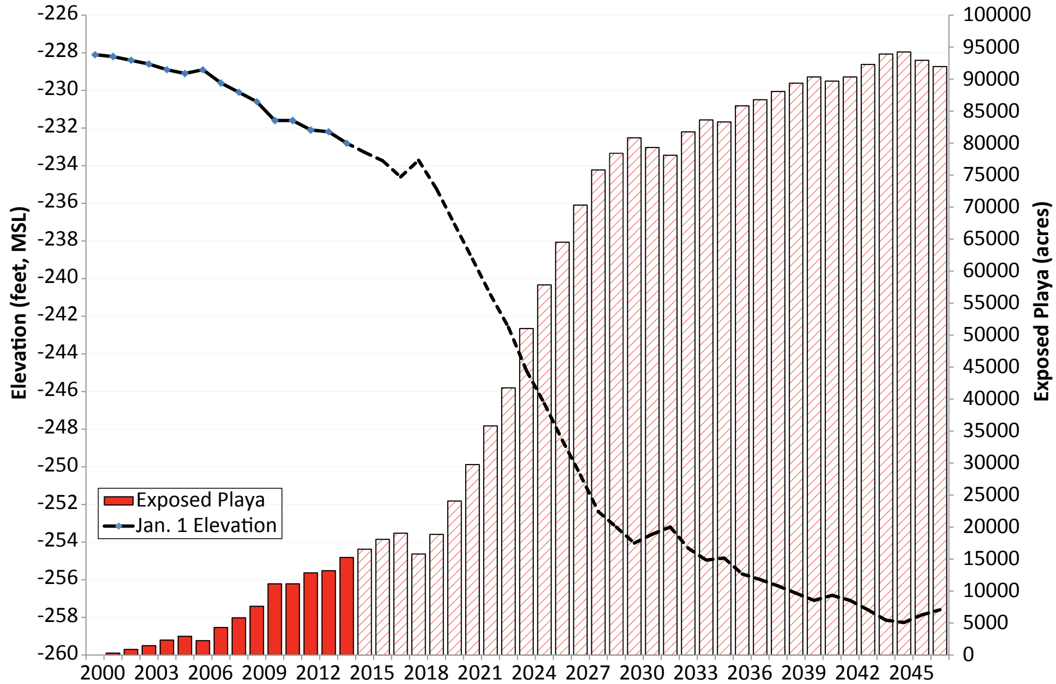



**Figure 5. Historic and projected Salton Sea January 1 elevations and exposed playa relative to January 1, 2000, assuming no action.**
Sources[4]: USGS, Reclamation, CH2M-Hill.

The increasing amount of exposed playa and the declining ability of the lake to sustain its current abundance and diversity of species are the major factors contributing to the costs of inaction. Figure 5 shows actual January 1 elevations (on the left axis) of the Salton Sea as a solid line, with projected January 1 elevations indicated by a dashed line. The figure also shows the amount of lakebed (on the right axis) that has been exposed (known as "playa") relative to the January 1, 2000, elevation[3], in solid bars, and projected exposures in stippled bars. Figure 5 shows that some 15,000 acres of Salton Sea playa have already been exposed since January 1, 2000. It is not known how quickly Salton Sea air quality management projects can be funded or constructed: the figure shows exposure based on an assumption that no action will be taken, though it does reflect the construction and land use of the state's Species Conservation Habitat, the Red Hill Bay project, and the Torres-Martinez wetlands, covering a total of 1,395 acres.

Figure 5 shows a slight increase in elevation in 2018 relative to the previous year and decrease in exposed playa, due to the mitigation water delivery requirements (see Appendix A). The slight increase in elevation projected for the years 2046 and 2047 reflects a relative stabilization of inflows and a decreasing rate of evaporation due to rising salinity. Projected elevations and acres of exposure come from CH2M-Hill's Salton Sea Planning Model and do not reflect the range of uncertainty inherent in these long-term forecasts.

[3] The January 1, 2000 elevation is within 0.01 foot of the average January minimum elevation for the period 1988-2000.

[4] Historic elevations reported by USGS gage 10254005 "Salton Sea Nr Westmorland CA." Elevation-Surface Area conversions from Reclamation spreadsheet on file with author. Projected elevations from CH2M-Hill model, converted to NGVD standard.

## Expected Changes

Three Salton Sea habitat projects, shown in Figure 6, are scheduled for completion in the near future. California's Species Conservation Habitat (640 acres), the joint U.S. Fish & Wildlife Service/IID Red Hill Bay project (650 acres), and the Torres-Martinez wetlands (105 acres) comprise the extent of habitat or air quality management projects currently scheduled for construction around the Salton Sea by 2017. Each of these habitat projects has plans for subsequent expansion, but to date none has secured the funding necessary to grow beyond the listed acreages, so this study assumes they will cover the planned 1,395 acres. In addition to the direct habitat benefits generated by each project, they reduce the amount of exposed playa and will offer limited amenity values.[5]

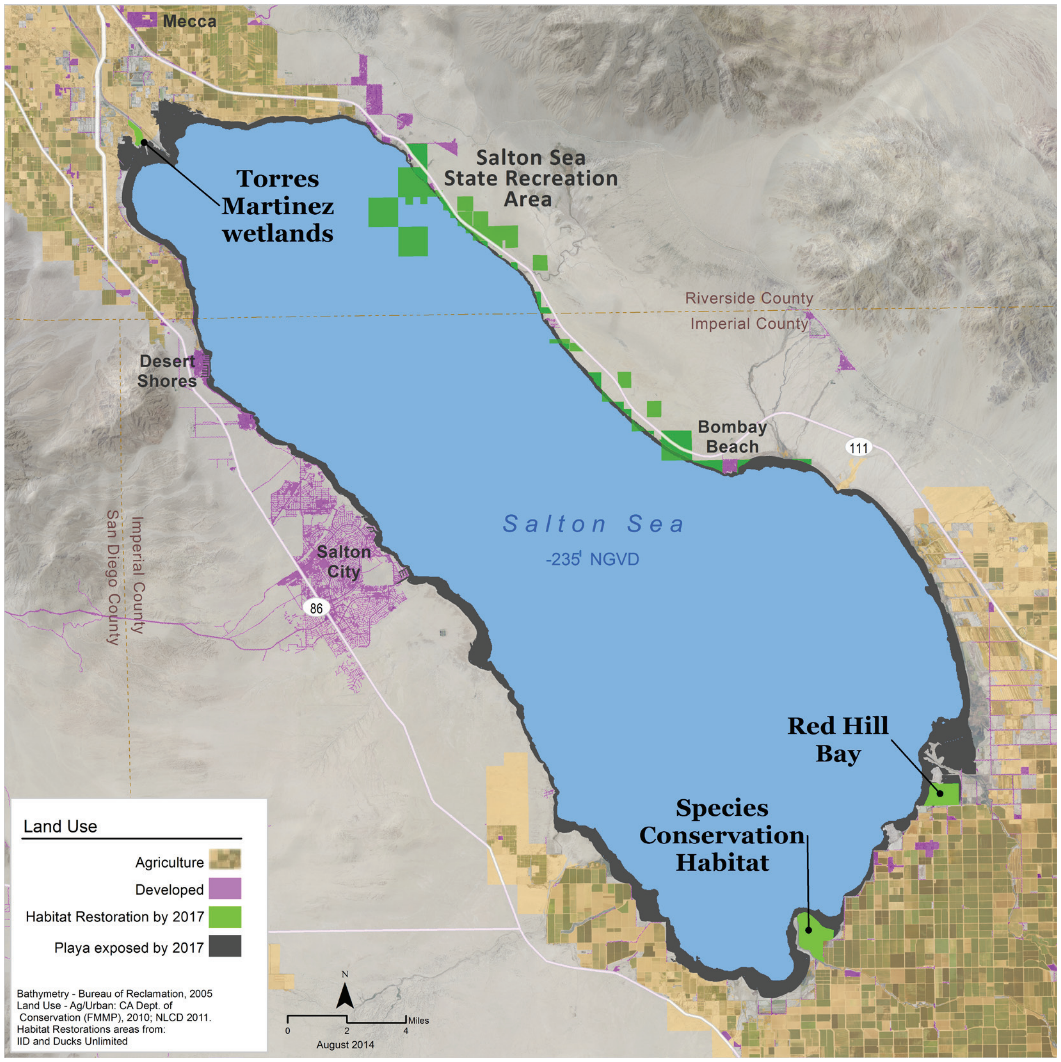



**Figure 6. Salton Sea habitat projects in 2017.**

Under various agreements, IID, CVWD, and SDCWA assume responsibility for the first $133 million (2003$) in environmental mitigation costs associated with the QSA. Such costs include, but are not limited to, mitigation for air quality impacts. The *QSA JPA Creation and Funding Agreement*[6] states that "The State is solely responsible for the payment of the costs of and liability for Environmental Mitigation Requirements in excess of the" $133 million from the water agencies. The California State Auditor Report (2013, p. 23) notes that "Joint powers authority (JPA) officials roughly estimate that the local water agencies could exhaust most of their environmental mitigation contributions

[5] "Amenity values means those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes." Source: http://www.rmaguide.org.nz/rma/introduction/glossary.cfm.

[6] See QSA Joint Powers Authority Creation and Funding Agreement, at http://www.sdcwa.org/sites/default/files/files/QSA_jpa-funding.pdf.

under the QSA as early as 2025." However, the payment schedule for the local water agencies' environmental mitigation contributions could result in revenue shortfalls, when the actual costs of environmental mitigation requirements could exceed, on an annual basis, the agencies' annual payments. The QSA JPA funding agreement does not specify *when* state funding responsibility is triggered. In the worst case, this ambiguity about the start date of state funding responsibility and the QSA JPA payment schedule could delay implementation of air quality management projects at the Salton Sea.

There are at least three distinct conditions that could trigger state payments: 1) an annual QSA JPA budget shortfall, in which the costs of projects in that fiscal year exceed agency contributions to date; 2) when cumulative QSA JPA environmental mitigation requirements are projected to exceed an inflation-adjusted $133 million, projected by the California State Auditor (2013) to be as early as 2025; or 3) after the agencies have contributed their full $133 million in inflation-adjusted environmental mitigation contributions, currently scheduled to end in the year 2047. To date, California has not stated when it expects to begin payments, nor has the state legislature considered legislation authorizing or appropriating such payments. This uncertainty regarding the timing of the state's payments, as well as the absence of legislative activity on the subject, suggests that full funding of an air quality management plan for the Salton Sea may be delayed until 2025 or even as late as 2047, with actual construction of such projects occurring even later.

To date, the local air pollution control districts have not finalized regulations regarding the control of dust emissions from exposed Salton Sea playa. More than 40% of the exposed playa will be the responsibility of the individual landowners rather than of the QSA JPA, so these new regulations will directly affect the volume of future dust emissions. The effectiveness and timing of landowner control measures will not be known for some time. To date, landowners have implemented few if any dust control measures on the roughly 15,000 acres of playa that have already been exposed since the year 2000.

## Changes in the Built Environment

The Salton Sea is situated within the Salton Sea Air Basin (see figure 3, above) that includes more than 500,000 acres of irrigated land and several cities, including Calexico, Coachella, El Centro, Indio, La Quinta, Palm Springs, and Rancho Mirage. The total population of the air basin is currently about 650,000, and includes some of the fastest growing cities in the state. According to county-level projections, the population potentially affected by worsening air quality in the basin will almost double in the next thirty years (Table 1). People living near the Salton Sea itself are disproportionately Hispanic and poor, raising environmental justice concerns. An analysis of the census tracts immediately adjacent to the Salton Sea indicates that about 39,500 people lived within several miles of the lake in 2010. About a third of this population lived at or below the poverty line, and some 70% lived within 200% of the poverty line. More than 80% of this population was Hispanic.

**Table 1. Current and projected populations in the Salton Sea Air Basin.**[7]

| | 2013 | 2015 | 2020 | 2035 | 2045 | Source |
|---|---|---|---|---|---|---|
| Coachella Valley | 469,248 | 488,300 | 576,161 | 842,960 | 931,150 | Riverside County Projections |
| Imperial County | 179,527 | 192,707 | 222,920 | 277,418 | 311,360 | California Dept. of Finance |
| **Total** | **648,775** | **681,012** | **799,081** | **1,120,378** | **1,242,512** | |

[7] Coachella Valley populations beyond 2035 County projection estimated at 1% annual growth rate.

# 3. Air Quality and Public Health Impacts

The Salton Sea Air Basin includes all of Imperial County, subject to the jurisdiction of the Imperial County Air Pollution Control District (ICAPCD), and Coachella Valley, subject to the jurisdiction of the South Coast Air Quality Management District (South Coast). Air quality in the Salton Sea Air Basin does not meet state or federal standards for particulate matter less than 10 microns in diameter (roughly one-seventh the thickness of an average human hair), known as $PM_{10}$. Elevated $PM_{10}$ concentrations are associated with many adverse health impacts (CNRA 2011).

Many scientific and medical studies document the link between $PM_{10}$ emissions and a broad range of public health impacts. Elevated $PM_{10}$ concentrations are associated with a decrease in the growth and development of lung function in school-aged children (Gauderman et al. 2000) and are also associated with an increase in the risk of cardiac disease, heart attacks, and mortality in adults (Peters et al. 2001). Atkinson et al. (2013) report consistent associations of elevated $PM_{10}$ concentrations and heart failure, with a stronger association in more affluent areas. Norris et al. (1999) report that elevated $PM_{10}$ concentrations are associated with increased asthma-related emergency room visits by children. Anderson et al. (2005) reviewed 95 papers for publication bias, finding that even with bias correction, a strong positive association exists between increasing concentrations of $PM_{10}$ and incidences of daily mortality and with the number of hospital admissions for asthma-related symptoms. The International Agency for Research on Cancer has reported that elevated $PM_{10}$ concentrations have been associated with an increased incidence of lung cancer (Straif et al. 2013).

Dominici et al. (2002) found a slightly less than 1% increase in mortality rate in the City of Riverside associated with a 10 unit increase in the previous day's $PM_{10}$ concentrations, slightly higher than the average increase of about 0.5% found in their study of 88 cities nationwide. In a study in Utah, Pope et al. (1992) report that a 100 $\mu g/m^3$ increase in the five-day rolling average $PM_{10}$ concentration was associated with a 16% increase in the daily death rate. The maximum daily $PM_{10}$ concentration during their study period was 365 $\mu g/m^3$, less than 40% of the maximum concentration reported in the Salton Sea air basin in 2013. Zanobetti and Schwartz (2005) found that a 10 $\mu g/m^3$ increase in $PM_{10}$ concentrations was associated with a 0.65% increase in the risk of hospitalization for heart attacks among elderly populations. These dose-response studies, in the context of the Salton Sea Air Basin's periodic instances of elevated $PM_{10}$ concentrations, suggest that increased dust emissions from Salton Sea playa would increase the incidence of acute and chronic adverse health impacts.

$PM_{10}$ poses a threat to public health based on the size of the particles themselves, rather than due to any specific toxins within the particles. Recent studies suggest that Salton Sea sediments contain some constituents of concern, potentially posing additional risks. For example, Sapozhnikova et al. (2004) found PCB and DDE concentrations at levels of concern, while King et al. (2011) identified elements such as antimony, arsenic, cadmium, chromium, lead, and selenium in Salton Sea sediments. The additional public health impacts associated with toxic constituents in dust emitted from Salton Sea playa merit investigation, but insufficient information currently exists to estimate any additional public health costs due to the presence of these toxins.

The lake also creates other air quality problems. The Salton Sea's periodic hydrogen sulfide emissions exacerbate the public's negative perception of the Sea and present a nuisance, and potentially a hazard to human health (Lovett 2012). Periodic dust storms, exacerbated by exposed Salton Sea playa, can also impair visibility. Although hydrogen sulfide and impaired visibility create a nuisance and may impose measurable costs on those directly affected, this study only estimates the costs associated with increased dust emissions.

The Salton Sea air basin currently does not meet state or federal $PM_{10}$ standards. Figure 7 shows the estimated number of days in which the basin exceeded California's 24-hour $PM_{10}$ standard (defined as emissions greater than 50 micrograms per cubic meter (µg/m³)) and the federal 24-hour $PM_{10}$ standard (emissions greater than 150 µg/m³), per year for the years 1989–2012. The figure also shows annual maximum 24-hour concentrations, along the right axis. The maximum 24-hour value reported during this period was 840 µg/m³, in 2003. The dotted black line in the figure shows the trend in the number of days exceeding the state standard. The figure clearly shows that air quality in the Salton Sea region fails to meet state standards in more than half of the years shown below.

Figure 8 shows the locations of the six air quality monitoring stations sited around the Salton Sea, along with windrose diagrams depicting prevailing wind direction and speed on May 22, 2013. The table in the upper right corner of the figure lists wind speed and recorded $PM_{10}$ concentrations at these stations.[1] The maximum average hourly $PM_{10}$ concentrations at each station exceeded the state threshold for $PM_{10}$ concentrations; the four stations that reported wind speeds in excess of 10 mph that day all exceeded the federal threshold as well.

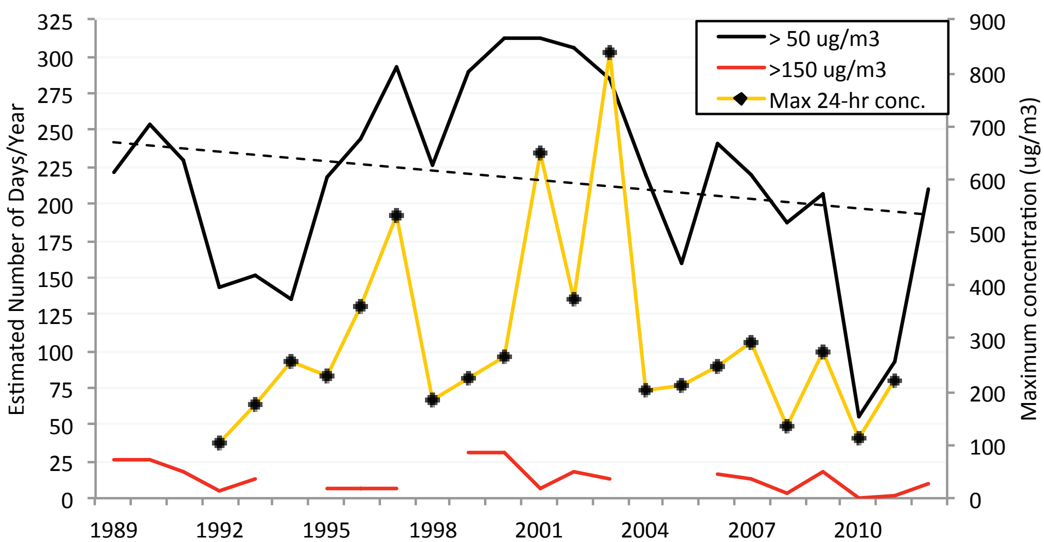
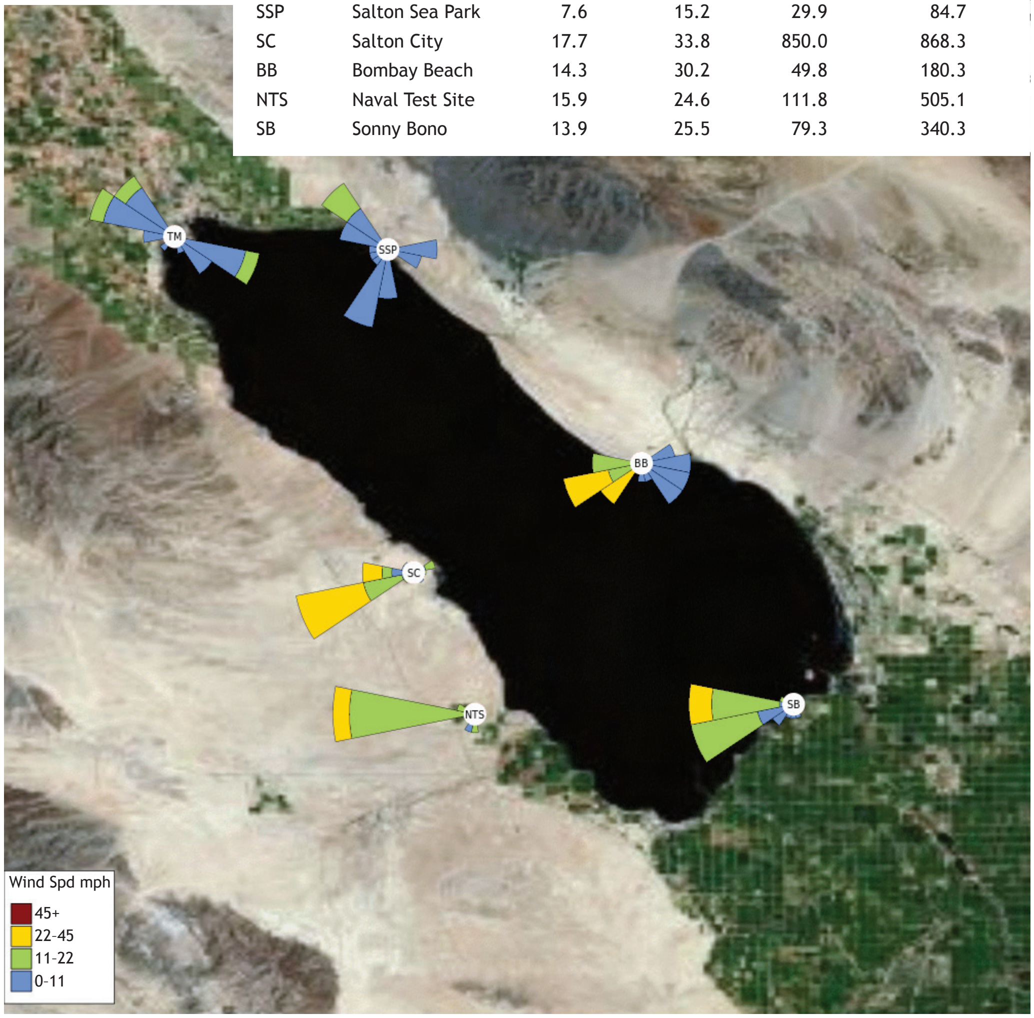



**Figure 7. Number of days of exceedance of daily $PM_{10}$ state and federal standards in the Salton Sea Air Basin.**

Source: California Air Resources Board, Annual $PM_{10}$ Trends Summary.

[1] CARB's quality assurance program flagged the maximum value reported for Salton City as unreliable; the value shown is the maximum value CARB reports as valid.




| Abbrev. | Site | Avg. WS (mph) | Max. WS (mph) | Avg. PM10 (ug/m3) | Max. PM10 (ug/m3) |
|---|---|---|---|---|---|
| TM | Torres-Martinez | 6.9 | 14.3 | 30.1 | 116.9 |
| SSP | Salton Sea Park | 7.6 | 15.2 | 29.9 | 84.7 |
| SC | Salton City | 17.7 | 33.8 | 850.0 | 868.3 |
| BB | Bombay Beach | 14.3 | 30.2 | 49.8 | 180.3 |
| NTS | Naval Test Site | 15.9 | 24.6 | 111.8 | 505.1 |
| SB | Sonny Bono | 13.9 | 25.5 | 79.3 | 340.3 |

**Figure 8. Salton Sea air quality monitoring stations and May 22, 2013 data.** Image courtesy of IID; data from CARB AQMIS2 and IID.

Almost 70% of the $PM_{10}$ emissions reported for the Salton Sea air basin arise from fugitive dust,[2] as shown in Figure 9. Information about the maximum $PM_{10}$ emissions shown in Figures 7 & 8 come from monitoring data, while the values shown in Figure 9 are estimated by CARB, based on existing inventories of emissive areas and calculated emission rates. The declining trend in the number of days exceeding daily $PM_{10}$ state standards shown in Figure 7 is consistent with the general decline in the estimated number of tons per day of $PM_{10}$ emissions shown in Figure 9. To date, the local air pollution control districts have not finalized or published an inventory of emissive areas or emission rates for Salton Sea playa, or from undeveloped areas in the basin generally. As the Salton Sea continues to shrink, dust emitted from exposed playa could reverse the recent trend of declining emissions. This additional dust may prevent the two local air districts from attaining state and federal air quality standards, which could lead to additional dust control requirements. Such dust control measures could inhibit other economic activity, such as construction and agriculture, with broader impacts on the regional economy.

## Future Air Quality in the Salton Sea Air Basin

Estimating future air quality in the Salton Sea Air Basin requires a detailed inventory of potentially emissive sites, projected emission rates for these different areas, and control measures available

[2] CARB defines 'fugitive dust' as "Dust particles that are introduced into the air through certain activities such as soil cultivation, or vehicles operating on open fields or dirt roadways. This is a subset of fugitive emissions," defined as "Emissions not caught by a capture system; which are often due to equipment leaks, evaporative processes and windblown disturbances." Source: http://www.arb.ca.gov/html/gloss.htm#F.

to manage potential dust emissions. Determining the contribution of these additional dust loadings to measurable $PM_{10}$ concentrations in the air requires sophisticated models accounting for wind speed and direction, ambient conditions, and other factors. Determining the public health impacts of these projected increases in $PM_{10}$ concentrations then requires an assessment of exposure rates and duration and the numbers of potentially affected people. Unfortunately, as discussed in the following, key information about each of these relationships is insufficient or absent.

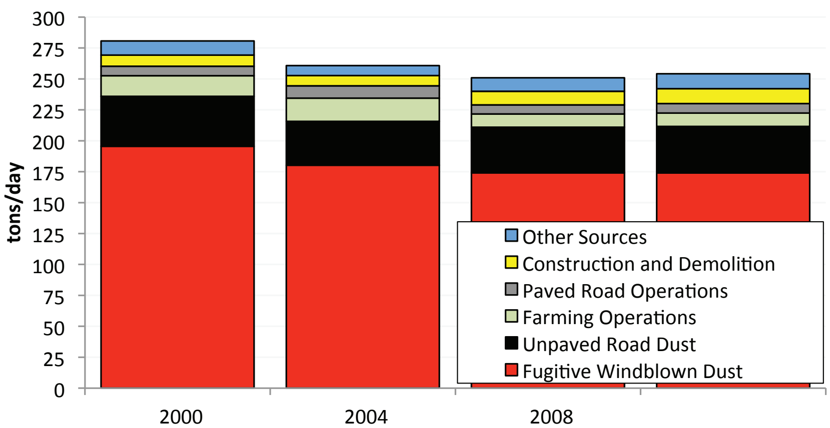



**Figure 9. Total tons of $PM_{10}$ emissions per day in the Salton Sea Air Basin, by emissions source.**
Source: CARB.

The amount of dust that will be emitted from Salton Sea playa in coming years is not known, but is a "potentially significant, unavoidable impact" of the water transfer (IID 2002). The PEIR (CNRA 2006) states:

> Defining the future air quality in the Salton Sea Air Basin under the No Action Alternative is an inherently challenging task. There are several major variables at play, each with varying degrees of uncertainty. These variables include future population growth in the region, the extent of various emissions sources, emissivity of each source, and the success of the local jurisdictions and others in implementing effective air emissions control measures over the coming decades. Pollutant transport from Mexico also influences air quality compliance in the region.

The local air pollution control district is expected to publish an inventory of dust emissions from exposed playa within the coming year, but to date such an inventory is not available. Projected emissions come from two previous studies. Calculations detailed in Attachment E3 of the Draft PEIR (CNRA 2006) project that No Action conditions at the Salton Sea would result in 0.071 tons of $PM_{10}$ emissions per acre from exposed playa each year on average, or less than a half a pound of fugitive dust per acre per day. King et al. (2011), using on-site wind tests at controlled speeds intended to mimic existing wind velocities, report a considerable range of measured emission rates, dependent on soil type, humidity and temperature, and strongly correlated with the shear velocity of the heavier particles (such as sand) that dislodge $PM_{10}$ particles. Their results show that a shear velocity of 0.7 meters/second, equivalent to that produced by short-term (10 minute) sustained winds in the region, could generate on the order of 30 pounds of dust per acre per hour. Extrapolating from these limited, controlled measurements suggests that Salton Sea playa could emit about 800 pounds of dust per acre per year, on average. This estimate is almost six times greater than the annual average projected by the 2006 PEIR.

A related question is how much of the exposed playa will actually be emissive, and for how long. King et al. (2011, p. 78) conclude that "The Salton Sea salt-based crusts near the shoreline appeared to be significant but temporary sources of dust, limited to cool, wet months, whereas silt/clay crusted sites and dry washes (not only limited to playa-like environments) appeared to be significant sources of dust throughout the year." On-going monitoring efforts around the

Salton Sea will improve our understanding of the timing and magnitude of dust storms. Initial estimates (Cohen and Hyun 2006) assumed that 40% of exposed playa would be emissive. The state's PEIR (CNRA 2006) assumed that all exposed lakebed, including those lands not exposed due to the QSA, would have air quality control measures but that such measures would be slightly less than 100% effective, leading to very limited dust emissions. Newer planning efforts, such as the QSA JPA's on-going development of an air quality management plan and the Imperial County Air Pollution Control District's forthcoming $PM_{10}$ state implementation plan, reportedly assume that 90–100% of exposed lakebed will be emissive and will require control measures.

**Figure 10. Dust blowing from Red Hill Bay playa past Garst Road, January 13, 2010.**
Photograph courtesy of FWS/Chris Schoneman.

Despite the well-documented associations of $PM_{10}$ with adverse health impacts, only two studies that estimate the economic impact of $PM_{10}$ emissions were found in an extensive literature search and a brief survey of air quality experts. Brajer et al. (1991) estimated the annual benefits of meeting ozone and $PM_{10}$ air quality standards in the South Coast Air Basin (including the greater Los Angeles metropolitan area inland to parts of Riverside and San Bernardino counties) ranged from about $8.9 to $38.7 billion, primarily in the form of averted mortality associated with lower $PM_{10}$ concentrations. More recently, Mohamed and El Bassouni (2007) estimated the total health-related costs associated with $PM_{10}$ emissions at about $61/kg, equivalent to about $55,000/ton, based on the chronic (85%) and acute (15%) effects of direct exposure to $PM_{10}$ on life expectancy. These two studies approached the impacts of $PM_{10}$ on public health differently. The earlier study estimated the public health costs when daily $PM_{10}$ concentration exceed the federal threshold in a specific populated region, while the later study assigned an estimated average cost per unit of $PM_{10}$, without respect to the density of affected populations, increases in $PM_{10}$ concentrations, or local health-care costs. The Mohamed and El Bassouni (2007) study embedded several key steps in estimating the relationship between dust emissions and public health costs, and should be taken as suggestive at best. Given the absence of clear emissions data and the lack of a clear relationship between emissions and $PM_{10}$ concentrations, and the need for some general estimates of the potential public health costs associated with a shrinking Salton Sea, Brajer et al. (1991) and Mohamed and El Bassouni (2007) offered some general guidance on estimating future costs associated with $PM_{10}$ emissions from Salton Sea playa.

In the study period of 1984–86, Brajer et al. (1991) estimated that $PM_{10}$ concentrations in excess of federal standards increased the risk of death of the average South Coast air basin resident by about 1 in 10,000, almost double the risk of dying in a car accident in any given year. The authors noted that the small, increased risk of premature death applied to the large population in the air basin and actuarial estimates of the value ascribed to these premature deaths generated a best estimate of $6.4 billion (1990$) for a total population of about 13 million, with a reported ten million exposures. This suggests that the value of attaining federal $PM_{10}$ standards is equivalent to about $880/person/year, in 2013$. Assuming approximately 650,000 people in the Salton Sea air basin (not including Mexico) and using the same value per death estimate as in Brajer et al., suggests that meeting federal $PM_{10}$ standards in the region would currently be worth about $570 million per year, solely accounting for avoided premature death. Brajer et al. (1991) report that the cost of premature death represented a disproportionate percentage of the total economic costs associated with elevated $PM_{10}$ concentrations. This estimate is a direct function of population; projected population growth in the basin would increase these costs proportionately. As shown in Table 1, the total U.S. population in the air basin is expected to increase by 90% by the year 2045.

Several caveats apply to the suggestion that estimated annual cost of $570 million is an appropriate value to apply to the air quality costs associated with a no-action Salton Sea. The first is that Brajer et al. (1991) report their estimate as a threshold value; since the Salton Sea air basin is already not in attainment of federal $PM_{10}$ standards, it is not clear to what extent the additional emissions from Salton Sea playa can be captured by this threshold value. Second, the estimate itself is based on research from more than twenty years ago and may no longer reflect current actuarial estimates. Nonetheless, the study suggests that even limited exposure to $PM_{10}$ can impose substantial costs when spread over a large population. Third, the baseline health of the South Coast air basin may be greater than that of the Salton Sea air basin, meaning that the people affected by poor air quality in South Coast may have greater resilience, while those in the Salton Sea air basin may suffer from greater vulnerability, increasing marginal damages. On the other hand, average income is greater in South Coast, so income-related impacts would be lower in the Salton Sea Air Basin (Schwabe, pers. comm.)

As noted above, estimates vary on the amount of dust that may be emitted by exposed Salton Sea lakebed. Assuming the maximum value of about 800 pounds of dust per acre per year, and additionally assuming that 100% of the maximum exposure of about 96,000 acres of playa is emissive, suggests that the lakebed could emit as much as 100 tons of dust per day. This amount is about half of the total fugitive dust emissions reported for the basin as a whole in the year 2000 (see Figure 9). Maximum daily emissions, governed by ambient conditions and windspeed, could be significantly greater. On the other hand, the state's PEIR (CNRA 2006), using different methods, estimated that average emissions without management controls would be about 14 tons day. These coarse annual estimates do not lend themselves to specific projections about maximum potential concentrations or peak emission rates, but they do offer an initial basis for suggesting the magnitude of the economic impacts of dust emissions on public health. Figure 11 depicts the estimated amount of dust emitted per year, based on these two per-acre estimates and the amount of playa exposed relative to January 1, 2000.

Based on Mohamed and El Bassouni's (2007) inflation-adjusted estimate of about $55,000 of total health care costs per ton of $PM_{10}$ and the high dust emission estimate suggests that the total public health-related costs associated with dust emissions from Salton Sea playa could rise from about $360 million in 2014 to $1,400 million in 2025, to about $2,000 million per year after 2035, assuming no revitalization or air quality mitigation plan is in place. Completion of a functional air quality management plan would reduce the amount of fugitive dust emitted from Salton Sea playa and would dramatically reduce associated health care costs.[3] With the

[3] The scale, timing, and effectiveness of any air quality management plan for the Salton Sea are not known. The QSA JPA is currently developing such a plan, elements of which may be operational as soon as 2017, at a limited

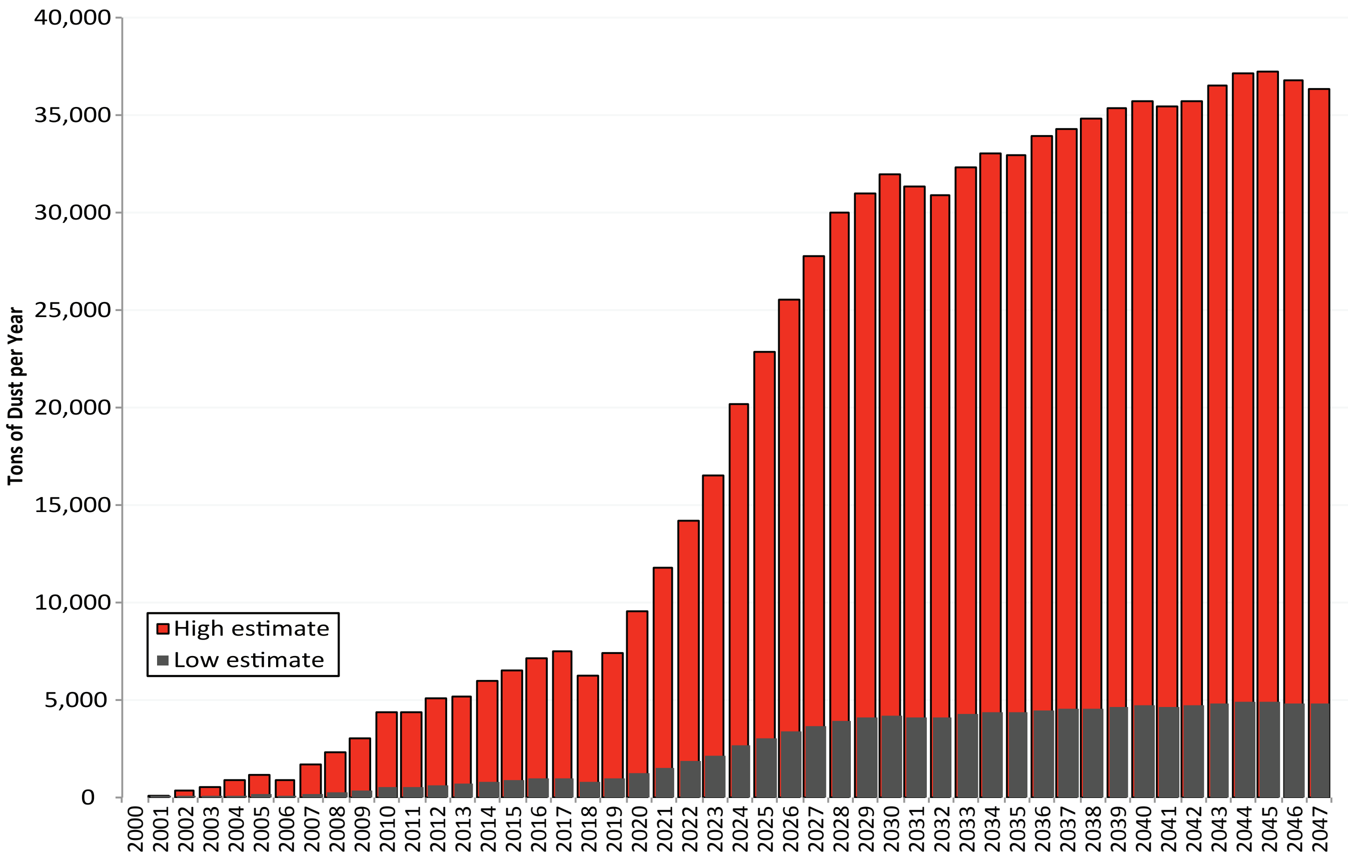



**Figure 11. Estimated tons of dust emitted per year from Salton Sea playa, 2000-2047.**
Based on data from King et al. (2011) and CNRA (2006).

scale. However, several factors may delay implementation of the QSA JPA air quality management plan, including a mismatch between the QSA parties' scheduled payments and the expenditures required for plan implementation. The state's conceptual mitigation plan (CNRA 2006) required the construction of extensive water delivery infrastructure, to convey drainage water to playa around the lake's perimeter. Construction of this infrastructure would be very expensive, and well beyond the QSA JPA's current budget. If required, this infrastructure component could significantly delay construction of the project and the control of dust from exposed playa. As noted previously, the State of California has yet to announce when it assumes responsibility for these payments. This could be as early as 2025, or as late as 2047. Further complicating these estimates is that the QSA JPA is not responsible for playa exposed due to factors aside from the QSA; by 2047, more than 40% of the land exposed will not be the QSA JPA's responsibility. It is not clear when these additional lands will be controlled, or how. In the worst case, only very limited amounts of land will have dust control by 2047.

low dust emission estimate, public health costs would rise from about $47 million in 2014 to $190 million in 2025, to about $260 million per year after 2035. Note that these values do not reflect costs associated with pain and suffering, often quantified as a willingness to pay to avoid these impacts, so total public health costs could be higher (Schwabe, pers. comm.).

The timing and scope of a planned JPA QSA air quality management plan directly affect the estimates of the present value of public health costs associated with dust emissions from Salton Sea playa. In the best case scenario, dust control measures will be in place on all Salton Sea playa by 2016, so that there would be essentially no new public health impacts. In the worst case scenario, the state does not accept responsibility for QSA mitigation costs until after 2047, the QSA JPA is only able to construct minimal dust control measures due to limited funding and insufficient infrastructure, and playa exposed due to non-QSA factors is not controlled. Assuming 2000 acres of QSA JPA dust control measures, plus the roughly 1400 acres of habitat projects, means that as much as 94,000 acres of playa may still be emissive. With the low emissions estimate (140 pounds of $PM_{10}$/acre/year) suggested by the PEIR and a 6% discount rate, this yields a present value of more than $3.5 billion through 2047. With the higher emissions estimate (800 lbs/acre/year) and a 4% discount rate, the present value of inaction through 2047 rises to more than $37 billion. Assuming that the QSA JPA constructs dust control measures quickly, without construction or funding constraints, but still assuming that playa exposed due to non-QSA factors is not controlled, yields present values ranging from about $2.2 billion on the low end to almost $23 billion on the high end, using the estimates noted above.

Based on Brajer et al.'s (1991) estimated public health cost of $PM_{10}$ non-compliance of $880 per person per year and conservatively assuming a 2% annual increase in such costs, as well as the population growth projections shown in Table 1, suggests that the present value of the total public health costs of continued $PM_{10}$ non-compliance in the Salton Sea Air Basin through the year 2047 would be about $21 billion at a 4% discount rate, or more than $15 billion at a 6% discount rate. The extent to which uncontrolled emissions from exposed Salton Sea playa will contribute to or exacerbate existing non-compliance with state and federal $PM_{10}$ standards is not known and was not estimated as part of this study.

For context, gross hospital revenue in Imperial County in 2012 was about a billion dollars, and about $12.6 billion in Riverside County as a whole. Recall the Mohamed and El Bassouni (2007) estimate that about 85% of projected health costs would be for chronic rather than acute conditions, indicating that most of the projected public health costs would not be captured by direct hospital revenues.

# 4. Property Values

Proximity to water typically increases the value of property, especially residential property. People tend to characterize water features such as lakes, rivers, and the ocean as amenities, desirable features contributing aesthetic value to the property and adding to the quality of life. Higher property values for waterfront property or proximity to water reflect this premium. For example, Mahan et al. (2000) found that a 1,000 foot reduction in a home's distance to open water increased the median property value in the Portland, Oregon area by more than 1%.

Proximity to the Salton Sea appears to be an exception to this general rule. An informal review of property values in the area shows little correlation with distance to the Sea. Figure 12, a screenshot of a Google Earth image of Salton Sea Beach, is typical of many of the communities around the Salton Sea: houses are not located preferentially along the shoreline, and in fact many of the lots closest to the shoreline are vacant. Housing values in shoreline communities are also lower than in more distant communities: the median housing prices of currently listed


**Figure 12. Salton Sea Beach, showing home location relative to the shoreline.**

Source: Google maps.

homes in Salton City is about $55,000, compared to about $250,000 for currently listed homes in Holtville, a small town about 26 miles southeast of the Sea, in Imperial County. Similarly, the median housing prices of currently listed homes in Mecca, about 3½ miles north of the Salton Sea, is about $50,000, compared to about $187,000 for currently listed homes in Coachella, ten miles farther away from the Sea along Highway 111. In Indian Wells, about 19 miles northwest of the Salton Sea, the median housing price of listed homes is about $750,000.

The low housing values of communities directly adjacent to the Salton Sea and the relative distance of such homes from the shoreline itself reflect the lake's shift from a recreational amenity in the 1960s to its current status as a disamenity. More than fifteen years ago, Bazdarich (1998, p. 12) wrote that "the Sea currently is suffering depressed economic conditions, due in large part to the afflictions of salinity and pollution in its waters and the negative reputation this has engendered among vacationers and tourists." Several years later, RSG (2003) wrote, "the perception that the Sea is dying has significantly depressed surrounding property values." The loss of the Salton Sea as a tourist attraction devastated the tourism-based economy in the immediate area, closing hotels and restaurants and stores and reducing the number of jobs in the area. But the disamenity value may be even greater adjacent to the Salton Sea than in other more remote areas in the desert, because of the general perception that current conditions are relatively worse than they used to be, even if on an absolute basis they may still be objectively better than in other, more remote areas that have not experienced any environmental degradation (cf. Davis 1959).

These depressed economic conditions have continued around the Salton Sea and offer an indication of future economic conditions under continued no action. Regional or state polling data on public perceptions of the Salton Sea would be informative, but no such polls have been conducted in at least a decade. Anecdotally, this negative reputation helps explain the depressed economic condition of the area adjacent to the Salton Sea. If no action is taken at the lake, physical and ecological conditions will continue to degrade, leading to increased dust emissions and widespread fish and bird die-offs, further diminishing the lake's amenity value. Dust emissions and the lake's diminishing reputation could have an adverse economic impact beyond adjacent areas to other downwind communities. Determining the geographic scope of these impacts would require new public surveys, but two recent data points suggest the potential extent of the Salton Sea's influence. On September 9th and 10th, 2012, strong winds transported hydrogen sulfide more than 150 miles northwest to Los Angeles, prompting hundreds of complaints (Lovett 2012). Dust emitted from Owens Lake has been detected more than 60 miles away.

Studies on the economic impacts of environmental hazards or disamenities in other areas suggest methods for estimating potential impacts to property values at the Salton Sea. Many studies have attempted to quantify the impacts of disamenities such as landfills (Brasington and Hite 2005), confined animal feeding operations (Isakson and Ecker 2008), damaged nuclear power plants (Nelson 1981), refineries (Farber 1998), superfund sites (Messer et al. 2006), and, at a finer scale, diseased trees (Kovacs et al. 2011) on the value of nearby properties.

Boyle and Kiel (2001) reviewed 38 previous studies, several of which suggest methods for estimating the potential decline in property values around the Salton Sea based on analogous disamenities. Nelson et al. (1992) found that homes located on the boundary of a landfill suffered a 12% decline in value, while those within one mile of the landfill suffered a 6% decline. Reichert al. (1992) found that homes within about a mile of a landfill suffered a 5.5% decline in value. Smolen et al. (1992) found that there was no impact on prices beyond 5.7 miles from a hazardous waste landfill, while for houses within 2.6 miles, each additional mile from the landfill increased home values by $9,000–14,000. Kiel (1995) found that nominal housing sale prices increased by nearly $1,900 per mile from a proposed superfund site, in the late 1970s. Messer et al. (2006) argue that delayed cleanup of Superfund sites are associated with long-term declines in property values, in one case by an average of almost 40% within an 8.5 km radius of the site, due to persistent stigma associated with the location. Carroll et al. (1996) report that an explosion at a rocket fuel plant in 1988 caused prices to fall by 17.6% in Henderson, Nevada, reflecting the impacts of a catastrophic event rather than an on-going nuisance.

Clark and Nieve (1994) report that petrochemical refineries and nuclear plants diminish representative household value by about $750 and $400 respectively, per facility in a 1000 square mile area. Nelson (1981), writing in the aftermath of the Three Mile Island nuclear accident, found no significant impact in property values in the months after the accident. Folland and Hough (2000), using different methods, found significant negative impacts associated with proximity to older nuclear plants, an effect that reversed with newer plants that apparently were perceived as being safer. They found that the older plants impacted land values within a sixty mile radius, centering at about 10% of land values.

Currie et al. (2013) assess the impacts of 1,600 openings and closings of industrial plants that emit toxic particulates, finding that these industrial plants affect property values by about 1.5% within a one mile radius, and by 2–3% within a half mile radius. At a finer scale, Kovacs et al. (2011) estimate that diseased oaks on a property decrease property values by three to 6%, while a broader neighborhood distribution of diseased and dying oaks can decrease property values by eight to 15% for homes located within a quarter mile of infected trees.

Isakson and Ecker (2008) find that, for homes within three miles of a confined animal feeding operation (CAFO), location relative to prevailing wind direction is the most significant factor affecting property value (relative to other CAFO variables), while for homes beyond three miles, the size of the CAFO is the most significant factor. They report that homes within two miles of a CAFO at an average of 34° from the prevailing wind direction suffer a loss in property value of almost 17%. An additional mile from the CAFO at the same wind angle reduces the loss in property value to 3.7%; small reductions in property value were found as much as six miles downwind of a CAFO.[1]

The studies noted above offer a range of potential depreciation rates to apply to property values in the Salton Sea area. Determining which depreciation rate is most applicable requires an assessment of the magnitude of the perceived risk posed by a deteriorating Salton Sea and the degree to which that risk may affect market values. The magnitude of that risk includes the geographic scope of the impacts (such as the dispersion of fugitive dust and hydrogen sulfide), the frequency of adverse events, and the severity of these events. The reputational risk of the Salton Sea may be comparable to that of a nuclear plant in terms of familiarity with the source of the threat, but the lake's risk is

[1] The Colorado River Regional Water Quality Control Board reports that there are 27 large CAFOs in the Imperial Valley: 2 dairies and 25 feedlots. While there are no CAFOs in the Coachella Valley, as many as 26 illegal toxic dumps operated in the lower portion of the valley within the past decade, many of them on tribal lands. At least one of these was declared a Superfund site. In 2011, the EPA closed another landfill, citing complaints from nearby schools about noxious odors and health problems. There is also a 47 megawatt biomass cogeneration facility in Mecca fueled primarily by wood waste products. These and a variety of other disamenities contribute to the lower Coachella Valley's overall social and environmental vulnerability (London et al. 2013).

far lower in terms of the severity of an adverse event. The Salton Sea, like nuclear plants, suffers from a very poor reputation, but the Sea does not pose the threat of a catastrophic, life-threatening event. However, noxious events at the lake, such as dust storms and hydrogen sulfide emissions, will be common, generating a relatively high-frequency, low-to-moderate level of impact. This suggests that a better surrogate for the Salton Sea's adverse impacts on property values may be petrochemical plants or CAFOs, which represent more regular, lower-level nuisances, though the dispersion of dust suggests that the geographic extent of nuclear plants' estimated impacts on property values may be appropriate.[2]

The significant uncertainty clouding the magnitude of the future risk posed by a no-action Salton Sea precludes robust modeling efforts, suggesting instead that qualitative, order-of-magnitude level estimates are more appropriate. Additionally, developing a robust hedonic model would require conducting a survey of home buyers'/sellers' expectation about future Salton Sea conditions and a formal statistical analysis, both beyond the scope of this study. Ultimately, home buyers' expectations and perceptions about the Salton Sea and its future will determine the extent to which the lake impacts property values. As the lake continues to degrade under a no action scenario, it is likely that its disamenity value will increase and the geographic scope of this impact will similarly increase.

The depressed property values adjacent to the Salton Sea demonstrate the lake's current lack of amenity value. Bazdarich (1998) reported that the value of non-federal, state, or tribal property within one-half mile of the current Salton Sea shoreline (then at about -228.0'[3]) was $154.8 million in 1997 ($225 million in 2013$). TetraTech (2005) reported the assessed value of land within a broader study area (as much as four miles from the shoreline) as $327 million in fiscal year 2002/2003 ($414 million in 2013$). This represents about 0.6% of the total assessed property value in Imperial County and the Coachella Valley.[4]

The incremental impacts of additional Salton Sea degradation, such as increased dust emissions and decreased recreational and aesthetic amenity values, on existing near-shore properties is likely diminished because of the decades of cumulative impacts generated by a declining Sea, as well as the impacts arising from the high foreclosure rate in the area. The lower Coachella Valley and parts of the Imperial Valley include many locally undesirable land uses, such as CAFOs and toxic waste dumps, that presumably depress nearby property values. A deteriorating, no-action Salton Sea will exist within this broader context of depressed property values and environmental vulnerabilities, exacerbating already poor conditions but presumably not depressing property values as much as it would if these other disamenities did not exist. The previous section notes that the area affected by future dust storms will extend beyond the lower Coachella Valley and Imperial County, potentially affecting areas thirty or more miles downwind via increased dust emissions and the perception of additional adverse impacts. Figure 13 shows the distance of various communities from the Salton Sea, as well as the locations of existing CAFOs and other locally undesirable land uses, as context for the following discussion.

---

[2] Dust transport studies from Owens Lake indicate that playa emissions from that area can lead to air quality violations 50 miles downwind.

[3] USGS reports elevations for the gaging station USGS 10254005 SALTON SEA NR WESTMORLAND CA as "Lake or reservoir water surface elevation above NGVD 1929, feet." NGVD is the "National Geodetic Vertical Datum," which USGS defines as: "As corrected in 1929, a vertical control measure used as a reference for establishing varying elevations."

[4] Although some economists prefer to use actual transaction values rather than assessed property values, the latter are publicly available and also form the basis for tax revenues for a variety of taxing jurisdictions, so assessed property values are used in this report.

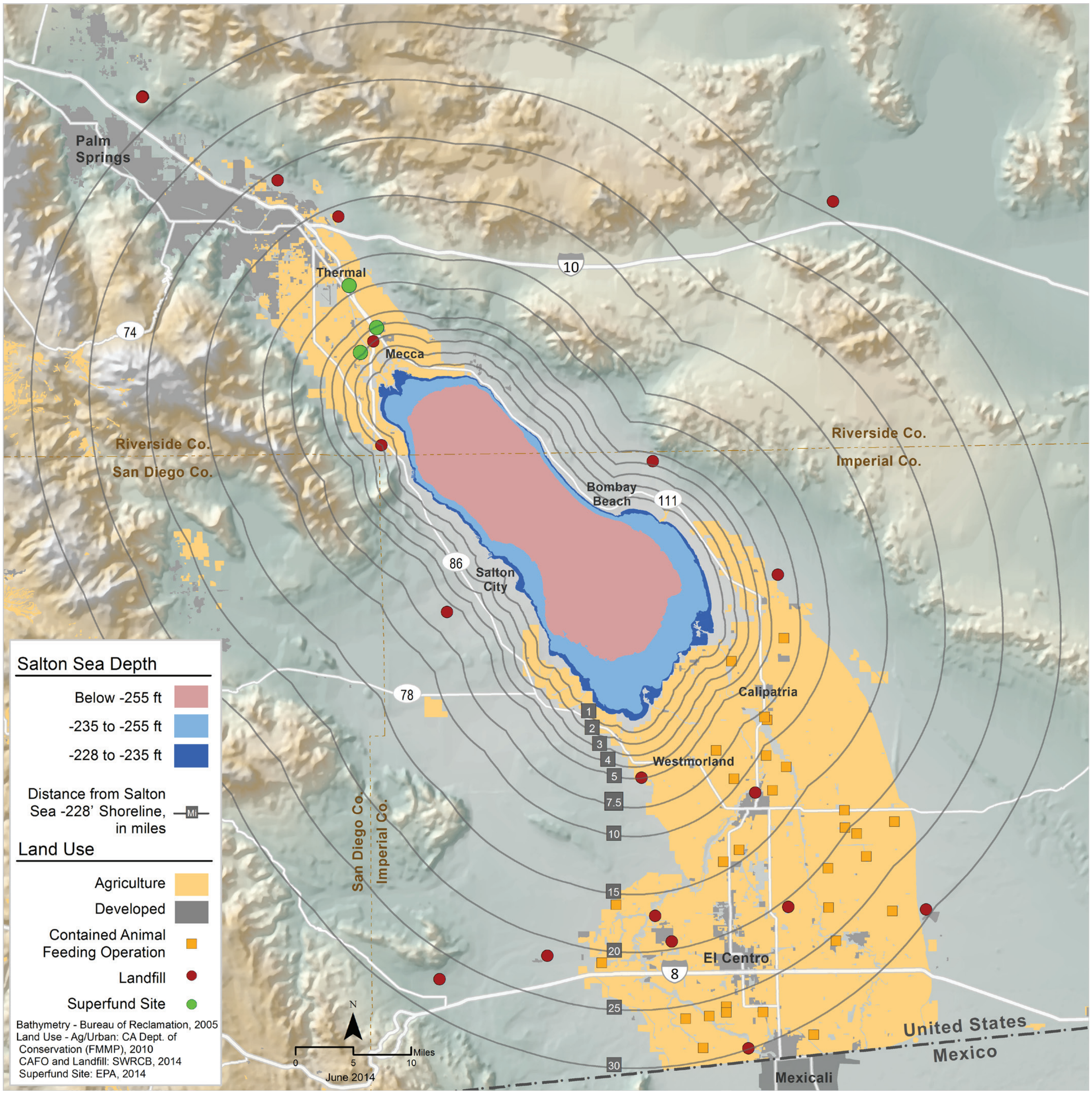



**Figure 13. Distances from the Salton Sea -228' shoreline, with locations of existing disamenities.**

Figure 14 shows the assessed value of property in Imperial County as a whole and of property within the Coachella Valley, in constant 2013$. Imperial County total assessed property value declined from a maximum of $11.7 billion in FY 2007/08 to $10.1 billion in the past two years, while Coachella Valley assessed property values fell from a high of about $79 billion in FY 2008/09 to about $63 billion in the most recent fiscal year, a decline of more than 20%. These changing values reflect the impacts of the recent recession and macroeconomic factors in the national and regional real estate economies; they are not intended to suggest that the deterioration of the Salton Sea caused the post-2008 decline in Coachella Valley property values.

A no-action Salton Sea could exacerbate two factors reducing local property values: 1) dust emissions and the threat to public health, and 2) the stigma (Roddewig 1996, Messer et al. 2006) associated with a 'dying' lake.[5] In the absence of public survey data, anecdotal reports of the Salton Sea's stigma suggest that concerns about the lake's smell and recurrent fish and bird die-offs could depress local property values. As described in the previous section, the magnitude and duration of dust emissions arising directly from exposed playa are not well defined and are further clouded by uncertainties about the timing and investment of the State of California and other responsible parties in mitigation efforts. The geographic scope of the potentially affected area is also not well defined, but can be estimated based on studies of other regions. Dust transport studies from Owens Lake indicate that playa emissions from that area can lead to air quality violations 50 miles downwind.[6] If we assume this bounds a worst-case scenario for the Salton Sea, dust from Salton Sea playa could affect all of the Coachella Valley (470,000 people), all of the Imperial Valley (175,000 people), and the city of Mexicali (about one million people) in Mexico.

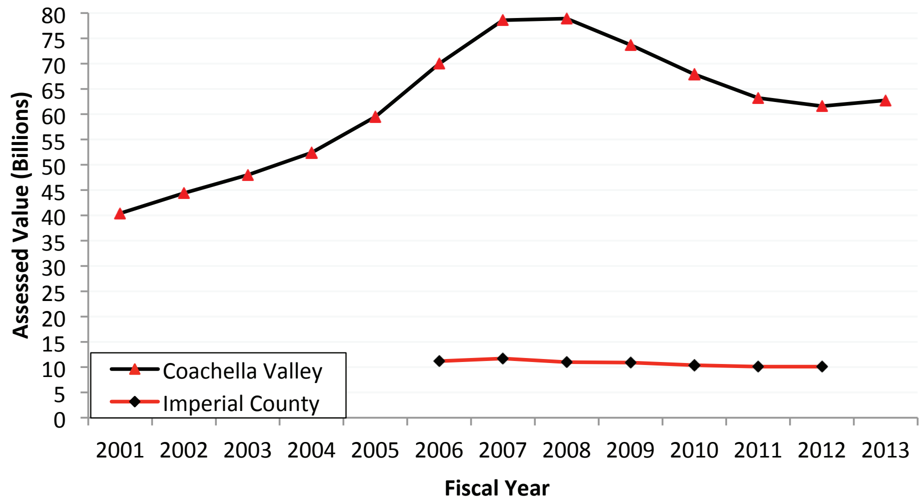



**Figure 14. Assessed property values in the Coachella Valley and Imperial County by fiscal year.**

Sources: CVAG, Imperial County.

As is the case for many existing environmental disamenities, the environmental baseline is already compromised, suggesting that the incremental damage to property values from new dust storms is less than it would be in pristine conditions. This suggests that the magnitude of dust-related impacts should be discounted by some value. Table 2 summarizes disamenities' impacts on property values described previously, to provide a basis for suggesting potential property value decreases due to deteriorating Salton Sea conditions under a no action scenario.

Table 2 suggests two general analogs for estimating potential property devaluations due to continued inaction at the Salton Sea. The first is that the lake may be akin to a landfill or CAFO, emitting noxious odors on a regular basis that adversely affect those living within two to three miles of the shoreline, devaluing those properties by as much as 17%. The second analog is that the future Salton Sea may suffer from a broader stigma value akin to a refinery or an older nuclear plant, devaluing property over a much broader region. Verifying this approach would require surveying homebuyers' and sellers' expectations about the future Salton Sea and the

[5] Messer et al. (2006) describe several properties of stigma relevant to the Salton Sea: 1) contagion, associated with physical contact, such as with dust or hydrogen sulfide; 2) permanence, where the stigma does not decrease over time; 3) insensitive to dose: even non-hazardous concentrations of hydrogen sulfide could trigger the stigma response; 4) the specific source of concern may be unknown; and 5) fear of bodily harm, as is often expressed by people unwilling to bathe in the Salton Sea.

[6] People more than 100 miles away complained about the smell of the Salton Sea's September 10, 2012 hydrogen sulfide eruption, but that one-time event was likely insufficient to affect local property values.

**Table 2. Reported impacts on property values, by type of disamenity.**

| Disamenity | Extent | Property Value Impact | Source |
|---|---|---|---|
| Landfill | 0-1 mile | -12% to -6% | Nelson et al. (1992) |
| Landfill | 2.6 miles | -5.5% | Reichert al. (1992) |
| Landfill | >5.7 miles | 0 | Smolen et al. (1992) |
| Landfill | <2.6 miles | +$9-14,000 per mile | Smolen et al. (1992) |
| Superfund site | | +$1,854 per mile | Kiel (1995) |
| Superfund site | <5.5 miles | -14% to -39.5% | Messer et al. (2005) |
| refinery | 1000 sq miles | -$750/house per facility | Clark and Nieve (1994) |
| nuclear plants | 1000 sq miles | -$400/house per facility | Clark and Nieve (1994) |
| older nuclear plants | 60 mile radius | average 10% decrease | Folland and Hough (2000) |
| toxics-emitting industrial plants | 0.5 mile radius; 1 mile radius | -2% to -3%; -1.5% | Currie et al. (2013) |
| diseased oak trees | 0.25 mile | -8% to -15% | Kovacs et al. (2011) |
| CAFO | <2 miles | -17% | Isakson and Ecker (2008) |
| CAFO | 2-3 miles | 3.7% | Isakson and Ecker (2008) |

extent to which it would affect purchasing and selling decisions.

For the first approach, assuming that dust-related impacts from the Salton Sea are roughly comparable to property devaluations associated with CAFOs. At these rates, and assuming total adjacent property value as reported by Bazdarich (1998) and TetraTech (2005) suggests that total devaluation could amount to as much as $44 million. However, it is likely that existing Salton Sea property values already reflect this impact, so the actual impact on existing properties may be closer to zero. Expected catastrophic decline of the Salton Sea, manifested as recurrent fish and bird die-offs (see Cohen et al. 1999) and noxious odors, could increase the existing devaluation, though these impacts may be more directly associated with an increased stigma associated with the lake, as estimated in the following.

Using the second approach, assuming that an environmentally degraded Salton Sea would create a stigma that could adversely affect property values at a lower rate but across a much broader region, suggests that the impact could be much greater. The actual percent decrease for property values associated with a continued deterioration of the Salton Sea would require surveys regarding expected Salton Sea conditions, as noted above. Assuming a 10% decrease in property values, consistent with the rate reported by Folland and Hough (2000) for properties within a 60 mile radius of an older nuclear facility, could be considered a maximum estimate, and very likely overstates the potential impact of a declining Salton Sea because the lake does not pose a threat of catastrophic failure. 10% of the total assessed property value in the Coachella Valley and Imperial County in 2012 would be more than $7 billion. Several golf courses and private country clubs in La Quinta lie less thirteen miles from the shoreline, suggesting that blowing dust and noxious odors could affect some high-value properties. Conservatively assuming that the real and perceived impacts of blowing dust, noxious odors, and the general stigma of a deteriorating Salton Sea have limited affect beyond the immediate area suggests a different calculation. Assuming a 5% decline in property value at 2 miles from the shoreline and a geometric decrease in the rate of decline suggests that total property devaluation due to a potential negative stigma associated with the deteriorating Salton Sea could be on the order of $400 million.

However, if the lake's stigma and dust emissions become prevalent, they could negatively impact the Coachella Valley's prominent golf industry, depressing the property value and revenues of some or many of the 124 golf courses and associated resorts in the valley. Although the economic value of this industry has not been estimated, California's golf industry generates more than $11 billion annually. Some 16% of the state's golf courses are in the Coachella Valley, suggesting that they may generate on the order of $1.8 billion annually. These courses could suffer disproportionate declines in value as the Salton Sea deteriorates, dust storms and noxious odors increase, and the attractiveness of Coachella Valley golf courses and resorts diminish as a result.

Unlike the public health costs estimated in the previous chapter, this property value devaluation represents a one-time cost, rather than an annual cost. Messer et al. (2006) suggest that the impacts associated with environmental disamenities could persist for many years, affecting property tax revenues for the local authorities, but these estimated devaluations do not reflect annual costs.

An important caveat is that these estimates arise from existing property value assessments. The projected 90% population growth by 2045 – much of which is expected to occur in unincorporated areas closer to the Salton Sea – would increase the number of housing units in the area. Although the value of this new housing is speculative, it does represent an additional baseline against which future property devaluations could occur. Alternatively, a deteriorating 'no action' Salton Sea could simply reduce the rate at which housing prices increase or, more dramatically, the actual and perceived public health threats and stigma associated with a no action Salton Sea could decrease the rate of population growth in the region, imposing additional costs. In this case, the no action Salton Sea could cause losses in housing development and decreased economic growth. These potential impacts to housing and economic growth are not estimated here, though they may be significant.

Note that these property devaluations are not solely dependent on the implementation of air quality mitigation projects. Instead, they are also contingent on the implementation of large-scale revitalization projects, which could minimize disamenities or even generate outright amenities. As described in the literature review at the start of this chapter, these impacts on property values could arise from a variety of factors, including direct impacts associated with increased dust emissions (separate and distinct from direct impacts on public health costs) and the broader loss or reduction of local amenity values due to periodic odors from the lake, as well as from a general stigma associated with the lake.

# 5. Impacts on Agriculture

The Salton Sea lies in the midst of an agricultural region that grows a significant percentage of the nation's winter vegetables, as well as large amounts of fruits, wheat, and forage crops. Enjoying an abundance of sunshine, senior water rights, and mild winter temperatures, the Imperial and Coachella valleys harvest an average of about 500,000 acres and 63,000 acres of crops each year, respectively. In 2010, Imperial Valley agricultural revenues, including cattle production, totaled roughly $1,600 million, while Coachella Valley agricultural revenues that year totaled about $620 million. The Imperial Valley accounts for almost 90% of total harvested acreage in Imperial County, while the Coachella Valley accounts for about 30% of total harvested acreage in Riverside County. Agriculture provides almost a third of all jobs in Imperial County, but less than 2% of all jobs in Riverside County.

Agriculture is the fundamental driver affecting Salton Sea conditions. In 1928, President Coolidge designated the Salton Sea as an agricultural sump, affording irrigators in the watershed the benefit of a gravity-fed drainage reservoir. Though naturally a part of the Colorado River delta (demonstrated by previous incarnations of Lake Cahuilla – see Cohen et al. (1999), the current Salton Sea would not exist without agricultural drainage. In return, the Sea provides two additional benefits to agriculture:

(1) *dust mitigation* – the Sea covers playa that, when exposed, will likely emit dust that may reduce crop productivity. The Sea itself also traps blowing dust and sand, entraining or capturing some of the particles that blow across its surface and reducing total particulate concentrations in the region; and

(2) *micro-climate* – the Sea reportedly buffers temperature and humidity changes in nearby fields, enabling farmers to harvest earlier and potentially reap a price advantage over more distant fields.

Neither of these current benefits has been adequately investigated or documented, so the values of these benefits cannot be clearly estimated. Nonetheless, it is useful to discuss these values, both to prompt further investigation and to draw attention to the potential costs associated with the loss of these benefits. Like other externalities arising from the decline of the Salton Sea, the loss of these current benefits, and the additional impacts caused by the decline of the Sea, would have real costs that should not be ignored simply because they have not been quantified.

As noted previously, no inaction conditions at the Sea would dramatically increase the amount of exposed playa (see Figure 5) and dust emissions (Figure 11) in the region, simultaneously reducing the Sea's ability to capture blowing dust and sand. A smaller Salton Sea would also have less ability to buffer local temperature and humidity, a loss that would affect a small percentage of total agricultural land in the region. These two changes are discussed in the following sections.

## Dust on Crops

Although there have been a number of published studies evaluating the impacts of cement dust on crops (Singh and Rao 1981, Chaurasia et al. 2013), the number of articles describing the impacts of fugitive dust on crop productivity is smaller than expected. Armbrust (1986) concluded that dust would not pose a major problem to cotton production "under normal growing conditions," though this assumed brief episodes of low deposition rates (3 days at 1.5 $\mu g/m^2$), after which wind and rain were assumed to remove >90% of the accumulated dust. However, Armbrust found that higher deposition rates (>28.6 $\mu g/m^2$) altered crop physiology and reduced plant weight by blocking plant stomata and increasing leaf temperature. Farmer (1993), in a review article of dust impacts on vegetation, summarizes impacts observed in other studies: increased water loss, decreased growth, blocked stomata, reduced transpiration, reduced seed set, and reduced photosynthesis, noting that the results varied depending on the particulate size and the specific chemistry of the dust itself. Farmer also notes that dust may exacerbate other types of stress affecting the plant. However, most of the studies that Farmer reviews evaluated dust from cement kilns and factories, rather than the soil and salt-based sources found at the Salton Sea. Although the direct physical impacts of similarly-sized particles at the Salton Sea could be comparable to those summarized by Farmer, the chemical impacts will likely differ.

A local farmer has reported that salt dust from Salton Sea playa has damaged sweet corn leaves in parcels near the Sea, and that salt dust could damage other crops such as lettuce and spinach, rendering them unfit for sale (Blake 2007). These claims have not been rigorously investigated or confirmed, but they offer a basis for estimating the magnitude of potential impacts around the Salton Sea. Lettuce has been planted extensively in the Imperial Valley, suggesting that it could be vulnerable to dust impacts and financial losses. In 2010, the Imperial Valley harvested more than 27,000 acres of lettuce, with an adjusted gross value of about $250 million (2013$). Fewer acres of lettuce were planted in 2012 and prices fell by more than 15%, so adjusted gross value declined to about $150 million that year. These declines presumably reflect broader market conditions rather than concerns about potential problems from blowing dust.

Actual locations of crops potentially affected by salt dust, such as leafy greens, vary year to year and in many cases are considered proprietary information, challenging efforts to predict how much acreage could be affected in any given year. Conservatively assuming that salt dust blown off of exposed Salton Sea playa and deposited on fields downwind were to damage 1% of the total harvested lettuce crop sufficiently to render it unfit for sale suggests that total lettuce-crop related damages could range from $1.5–$2.5 million annually. However, market prices and total planted acreage will have much greater impact on total crop-related revenues than will occur due to dust-related damage. Presumably, growers would shift to other, more marketable crops if dust problems became chronic near the Sea, so the long-term impacts of salt dust deposited on crops may be limited over time. In summary, salt-laden dust blowing from exposed Salton Sea playa may have significant impacts on a limited number of crops grown near the Salton Sea, but insufficient information exists to make credible estimates of these impacts.

## Micro–Climate Impacts

The Salton Sea's large thermal mass and evaporative surface tend to buffer temperature and humidity changes in nearby fields, generating a local micro-climate benefitting local farmers, according to anecdotal reports. The Sea's thermal mass warms the surrounding air during the cooler winter months, accelerating plant growth in nearby fields and allowing farmers to harvest earlier, potentially reaping a price advantage over more distant fields. In addition to these seasonal benefits, air temperatures immediately above the Sea's surface experience less extreme highs and lows than do air temperatures above land: air blowing over the Sea at night will warm adjacent fields relative to those more distant from the Sea. Anecdotal reports suggest that crops such as cantaloupes and sweet corn planted in fields near the Salton Sea are ready for market as much as two weeks earlier than those commodities grown 25 miles away from the Sea (Kalin, pers. comm.). During the summer, warmer land temperatures relative to the Sea create localized near-shore breezes, pulling cooler air from above the Sea to reduce temperatures in adjacent fields, reducing plant wilt and stress (CNRA 2011). Humidity from the Sea combines with the Sea's ability to buffer summer temperature extremes to enable farmers downwind of the Sea to bale hay, while farmers upwind of the Sea may find their hay crop too dry and brittle to bale (Kalin, pers. comm.), providing an additional benefit to those farmers downwind from the Sea.

As the Sea shrinks it will lose more than 60% of its thermal mass, diminishing its ability to warm adjacent air in the winter. Additionally, the shrinking Sea will recede from adjacent cropland, by as much as five miles from some areas along the southern shoreline, further diminishing the impact of this buffering effect. Although no research has been done to date on the geographic extent of the Sea's micro-climate benefits, presumably these benefits will be greatly diminished or eliminated entirely under no action conditions. The absence of published measurements or specific estimates of these micro-climate benefits frustrates efforts to monetize them.

In summary, insufficient information exists to estimate the potential costs associated with either the impacts of blowing dust and salt on crop productivity near the Salton Sea nor the diminished micro-climate benefits that will occur as the lake shrinks. Both of these impacts will be felt within a few miles of the Salton Sea, so their overall cost may be small relative to the magnitude of Imperial and Coachella valley agriculture generally, but these impacts could be significant at the scale of the individual farm. Estimating these impacts requires new research.

# 6. Recreational Revenues

The Salton Sea was a very popular tourist destination in the 1950s and 1960s, when people visited the Sea for boating, fishing, and other recreation. The number of visitor-days at California's Salton Sea State Recreation Area (SS SRA), in the northeast portion of the lake, was almost 600,000 in fiscal year 1961–62, but then steadily declined to about 180,000 visitor-days in the early 1970s. These declines reflect the diminishing popularity of the lake as a whole, due to its increasing salinity and changing popular tastes. As shown in Figure 15, total visitation to the state recreation area rebounded in the early 1980s, declining again in the early 1990s to fewer than 100,000. Visitation records are not available for the mid- to late-1990s. The most recent three years for which records are available, through fiscal year 2011–12, show a 70% decline in visitation relative to the long-term average. This recent decline may reflect the impacts of the recession and decreased discretionary spending, though it also coincides with the accelerating decline of the Salton Sea itself and the loss of access to the lake from boat ramps. Given previous declines in reported visitation, it also may reflect diminishing interest in the Salton Sea as a desired destination due to real and perceived reductions in amenities.

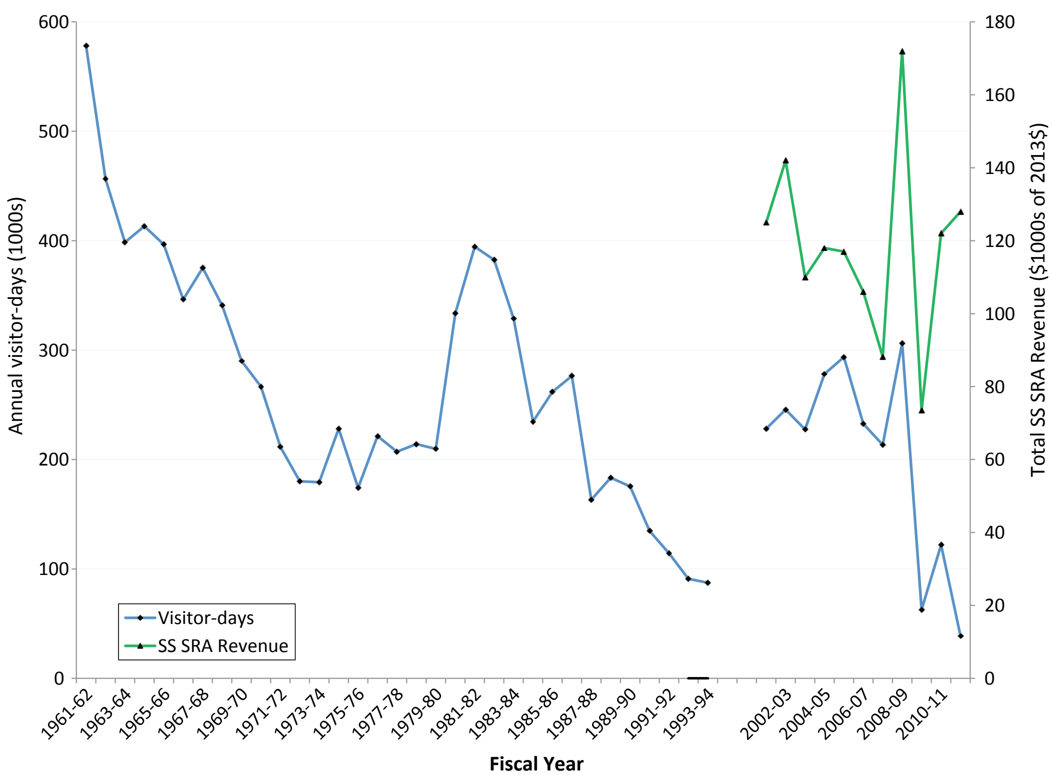



**Figure 15. Number of annual visitor-days and annual park revenue at the Salton Sea State Recreation Area (SS SRA), FY 1962–2012.**

Sources: California State Parks Archives; California State Parks Annual Statistics reports; SSA 1995.

Figure 15 also shows total direct annual revenues reported by the SS SRA for the fiscal years 2001–02 to 2011–12. The recreation area's direct average annual revenue over this period (in constant 2013$) was about $118,000, or an average of less than one dollar per visitor-day. These values only reflect revenue reported by the SS SRA itself and do not reflect total visitor spending. Despite the dramatic reduction in the number of visitor-days in the most recent three-year period, reported revenue in the past two years has remained above the average for the period as a whole. The reason revenues remained relatively high despite declining visitation was not determined. The cause of the spike in visitor-days and revenues in 2008/09 is not known.

An economic profile study prepared for the Salton Sea Authority (1995) notes that the federal wildlife refuge at the southern end of the Salton Sea attracted about 31,000 visitors per year for the years 1984–1993, while the Imperial Wildlife Area Wister Unit attracted about 15,000 visitors annually over that same period. It is not known how many people may have visited more than one of these sites: the number of visitor-days at the various sites should not simply be added together.

The Sonny Bono Salton Sea National Wildlife Refuge Complex estimates its current visitation rate at about 27,000 people per year over the past decade, slightly lower than the 1984–1993 average, and about 25,000 in 2013. These data suggest a slight downward trend in the number of visitors to the refuge over the past several decades, but much more consistent visitation numbers than reported by the state recreation area.

The state's PEIR (CNRA 2006) asserts that "On average, visitors to the Salton Sea State Recreational Area (SS SRA) spent $92.50 per visitor per day," (about $117/day in 2013$) though this appears to be based on a report estimating that same expenditure rate for visitors to Riverside County generally. SSA (1995) cite a 1995 report estimating that bird-watchers at the wildlife refuge spent $19 per person per day (about $30/day in 2013$). Given that full hook-up sites currently cost $30/night at the SS SRA headquarters campground, and primitive campgrounds at the SS SRA currently cost $10/night, as well as the direct revenues reported by the SS SRA itself, actual daily expenditures by Salton Sea visitors are likely closer to $30/person than to the $92.50/person reported by the PEIR.

Inaction conditions at the Salton Sea would adversely affect some but not all Salton Sea-related recreational uses. Hunters and birdwatchers visiting California's Imperial Wildlife Area will likely continue to visit at historic rates, since the wildlife area enjoys a dedicated water supply and will not be directly affected by declining Salton Sea elevations. Some camping and day-use will likely continue at the SS SRA despite the decline in Salton Sea conditions, though the recession of the shoreline by half a mile or more will strand existing facilities and diminish the appeal of the site. Most of the land owned by the National Wildlife Refuge is currently under the Salton Sea; much of this land will be exposed as the Sea recedes, allowing the refuge to expand its operations and potentially increasing visitation rates to managed areas. However, to date no plans to develop these exposed lands have been published. This area may also suffer from large dust storms due to the amount of playa exposed in the area, diminishing visitation rates. In the absence of specific projections, this study assumes that visitation rates to the refuge will continue to fall at recent rates.

Assuming about $30 in expenditures per person per day suggests that visitors to the SS SRA spent an average of about $8 million annually (in 2013$) during the period from 1961 to 2009, decreasing to about $2 million annually in the subsequent three years. Assuming that inaction conditions at the Salton Sea further diminish the average number of visitor-days at the SS SRA by half, to about 37,000 per year – roughly the same number reported for the most recent fiscal year – suggests that the loss of direct recreational revenues would be slightly above $6 million annually relative to historic levels, not accounting for the loss of revenues due to declining number of visitor-days at other locations around the Salton Sea. This $6 million per year difference suggests an order-of-magnitude level estimate of the total decline in total direct recreation-related expenditures due to real and perceived losses of Salton Sea recreational amenities. The total present value of this reduced recreational revenue through the year 2047, assuming an annual cost escalation of 2%, would be about $150 million with a 4% discount rate and $110 million with a 6% discount rate. These values are quite small relative to the potential costs associated with public health impacts. This coarse estimate does not account for income transfers, which would require surveys to determine the percentage of visitors coming from outside the region, versus intra-regional income transfers from local visitors spending money at the lake.

The number of people recreating at the Salton Sea has generally declined over the past fifty years, for a variety of reasons. The projected inaction conditions at the Sea will further this decline in visitation and in direct recreation-related expenditures, resulting in the loss of roughly $6 million per year in direct spending in the area relative to estimated historic rates. In the absence of robust surveys of current and historic expenditures, these $110 million – $150 million present value costs should be taken as general, order of magnitude estimates.

# 7. Non–Use Values

The Salton Sea provides a host of benefits, at a variety of scales, including dust prevention and interception, recreational and amenity values, and micro-climate benefits to nearby farms. As described above, many of these benefits can be quantified based on market transactions, as suggested by the values estimated previously. Many other benefits, however, do not readily lend themselves to market-based valuations. Examples of non-use benefits include the value of a species or of a particular habitat. Economists describe four general types of non-use values: option values (for goods and services that may be used in the future); altruistic values (that may be used by others in the current generation); bequest value (that may be used by future generations); and existence value (Schwabe et al. 2008).


**Figure 16. Brown pelicans and terns at the Salton Sea.**
Photograph © Jenny E. Ross / www.jennyross.com.

The Salton Sea's ecological importance suggests that its non-use values, particularly its bequest and existence values, may be considerable. This ecological importance has been well documented. The Salton Sea and the surrounding region support a tremendous diversity and abundance of birds (Figure 16), including many listed species. The Sea is an important stopover on the migratory corridor known as the Pacific Flyway, providing feeding, roosting, and loafing habitat for hundreds of species of birds often numbering in the hundreds of thousands of individuals, and also provides breeding habitat for several species. Cooper (2004, p. 202) states that the Salton Sea "is arguably the most important body of water for birds in the interior of California." Jehl and McKernan (2002) estimated that more than three million eared grebes were at the Salton Sea on one day in 1988. Roughly the entire western population of American white pelicans was observed at the Sea on one day in 1998 (Anderson 1999). Table 3, copied from the PEIR (CNRA 2006), lists many of the important bird species found at the Salton Sea, based on abundance or legal status.

As the Salton Sea's water quality and surface area decline over time due to no action, the value of the Sea to migratory and resident birds will diminish. The loss of the Sea's fish and many of its macro-invertebrates in the next five to seven years will enable certain salt-tolerant macro-invertebrates such as brine shrimp and brine flies to thrive, offering an abundant food source to many bird species, including grebes and gulls, but will largely eliminate the value of the Sea for many of the species and individual birds that currently depend on it. Some of these birds may be able to use other habitats, but the loss of more than 90% of the wetland habitats in California means that many or most of these birds will face increased morbidity and mortality (Cohen and Hyun 2006, CNRA 2006).

## Estimated Benefits

Many studies estimate the non-use values various local and regional ecosystems provide. Economists have applied various tools to estimate the economic magnitude these non-market benefits, often relying on surveys to determine

**Table 3. Focal bird species and criteria.**

| SPECIES | CRITERIA |
|---|---|
| Aechmophorous spp. (Includes Clark's and Western Grebes) | Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |
| American Avocet | Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |
| American White Pelican | DFG Bird Species of Special Concern Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |
| Black Skimmer | DFG Bird Species of Special Concern; Service Birds of Conservation Concern - BCR 33 National Waterbird Conservation Plan (species considered Highly Imperiled or of High Concern) |
| Black Tern | DFG Bird Species of Special Concern |
| Black-necked Stilt | Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |
| Brown Pelican | Federally endangered species State endangered species |
| California Gull | Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |
| Cattle Egret | Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |

| SPECIES | CRITERIA |
|---|---|
| Double-crested Cormorant | DFG Bird Species of Special Concern; Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |
| Dowitcher spp (Includes Long-billed and Short-billed Dowitchers) | Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |
| Dunlin | U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score) |
| Eared Grebe | Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |
| Gull-billed Tern | DFG Bird Species of Special Concern; National Waterbird Conservation Plan (species considered Highly Imperiled or of High Concern) Service Birds of Conservation Concern - BCR 33 |
| Least Bittern | DFG Bird Species of Special Concern |
| Long-billed Curlew | DFG Bird Species of Special Concern; U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score) |
| Marbled Godwit | U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score) Service Birds of Conservation Concern - BCR 33 |
| Ring-billed Gull | Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |
| Ruddy Duck | Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |
| Snowy Egret | National Waterbird Conservation Plan (species considered Highly Imperiled or of High Concern) |
| Snowy Plover | DFG Bird Species of Special Concern; U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score); Service Birds of Conservation Concern - BCR 33 |
| Western Sandpiper | Greater than 10,000 birds counted on single survey (Shuford et al., 2002); U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score) |
| Whimbrel | U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score); Service Birds of Conservation Concern - BCR 33 |
| White-faced Ibis | DFG Bird Species of Special Concern; Greater than 10,000 birds counted on single survey (Shuford et al., 2002) |

Notes: DFG = Department of Fish and Game [now known as Department of Fish and Wildlife]; Service = U.S. Department of the Interior, Fish and Wildlife Service. Source: CNRA 2006 (App. C, Table C-1).

respondents' willingness to pay for benefits such as the preservation of habitat or protection of a species, or the general 'existence value' of the resource as a whole. Kroeger and Manalo (2007), for example, reported that California households not visiting the Mojave desert in 2003 claimed existence and stewardship values for that area at about $170 million (2013$) that year alone. It was well beyond the scope and means of this study to conduct a new local, regional, or national survey, though such a survey would offer a stronger basis for estimating such non-market values.

Instead, this study relies upon the only previous effort that sought to estimate the Salton Sea's non-use benefits. Also lacking the resources to conduct primary research, K2 Economics (2007) estimated the non-market benefits generated by the Salton Sea based on a review of 23 previous studies on species preservation or habitat values. They ultimately focused on two prior studies, which used willingness-to-pay surveys to estimate similar benefits provided by Mono Lake and by wetlands in California's San Joaquin Valley. K2 Economics reports the average annual value of the San Joaquin Valley wetlands at about $60 million (2013$) per 1000 acres. The recent USGS/CDWR *Salton Sea Ecosystem Monitoring and Assessment Plan* reports about 44,000 acres of Salton Sea shoreline habitat at lake elevation -228',[1] not including another roughly 200,000 acres of open-water habitat (Case et al. 2013). Based on this shoreline habitat acreage and further assuming that the non-market benefits provided by the Sea are comparable to those in the San Joaquin Valley suggests that these Salton Sea habitats generate roughly $2.6 billion per year in non-market benefits, not including the value of open-water and other habitats at the lake. K2 Economics cautions that "different population & site characteristics" may limit the transferability of the estimated San Joaquin Valley wetlands benefits to the Salton Sea.

K2 Economics also summarizes several contingent valuation studies estimating the value of maintaining the surface of Mono Lake at various elevations. The most conservative of these reported an annual value of $151 per California household (in 2013$), or a total of about $1.9 billion per year. While there are several similarities between the non-market values of protecting Mono Lake and protecting the Salton Sea, including the preservation of valuable migratory bird saline wetland habitats in remote parts of the state, Californians' familiarity with and support for Mono Lake exceeds that of the Salton Sea. However, the Salton Sea's surface area is roughly five times larger than Mono Lake's, and the Sea currently supports much greater species diversity, so arguably the Sea's non-use value is comparable to Mono Lake's. Additionally, San Diego's diversion of water that would otherwise flow into the Salton Sea could be characterized as similar to Los Angeles' diversion of water that would otherwise flow into Mono Lake, so San Diego residents may feel a connection to the Salton Sea.[2]

The K2 Economics study (2007) strongly cautions that the values it reports are merely suggestive and should be documented by primary valuation studies. In the absence of such studies, and more broadly in the absence of general valuation studies of the Salton Sea, we are left with the general range of $1.9 – $2.6 billion in annual non-use values generated by the Salton Sea. Presumably, these values would diminish over time as the quantity and quality of habitats decline. Arbitrarily assuming that the existing

[1] Calculated as the one-kilometer band of water closest to the shoreline plus the 25-meter band of land surface closest to the shoreline. This shoreline stratum has the greatest use by birds and fish (Case et al. 2013).

[2] In a reversal of previous opinion, the *San Diego Union Tribune* stated "The Salton Sea … is worth saving." *San Diego Union Tribune* editorial board, "Saving the Salton Sea," June 21, 2014, available at http://www.utsandiego.com/news/2014/jun/21/salton-sea-imperial-restoration-geothermal/.

habitat values decrease by 15% per year starting in 2018 suggests a potential rate of decay for these non-use values. Table 4 shows the present value of these low and high estimates through 2047, based on an assumed 2% annual cost escalation and 4% and 6% discount rates applied to these values over time. For comparison, the present value of the "Existence and stewardship values of CA households not visiting the Mojave" Desert reported by Kroeger and Manalo (2007) ranges from $3.2-$4.2 billion.

**Table 4. Present value of non-use Salton Sea benefits.**

| $billions<br>Estimate basis | discount rate<br>4% | <br>6% |
|---|---|---|
| San Joaquin wetlands | $26 | $17 |
| Mono Lake | $17 | $10 |

# 8. Summary

Southern California's Salton Sea faces significant, perhaps catastrophic changes in the next ten to fifteen years, with dramatic changes starting in less than five years. These changes, driven primarily by the effects of the IID-San Diego water transfer as well as by declining inflows from Mexico, increasing urbanization, changing agricultural practices, and a hotter and drier climate, will adversely affect human and ecological health in the region. In the next fifteen years, the volume of water flowing into the lake will decrease by about 40%, the Salton Sea's surface will drop by twenty feet and its volume will decrease by more than 60%. Salinity will triple. One hundred square miles of lakebed will be exposed to the region's blowing winds, increasing dust emissions in an area already suffering from poor air quality (Cohen and Hyun 2006). By 2045, as much as one hundred and fifty square miles of lakebed will be exposed to the region's blowing winds, increasing dust emissions in an area already suffering from poor air quality. The lake's habitat value for resident and migratory birds will rapidly decline, affecting hundreds of thousands of birds (Cohen and Hyun 2006) and further diminishing the lake's appeal.

Although these changes have been anticipated for more than a decade and many plans and projects have been discussed in the interim, to date no major Salton Sea revitalization project has been authorized or implemented. The availability of state funding for required mitigation activities is also unclear, so much of the dust emitted from exposed Salton Sea playa might not be controlled for many years. With the exception of three relatively small habitat projects scheduled for construction next year, no habitat projects are currently funded or expected to exist at the Salton Sea in the near future. This inaction at the Salton Sea, combined with the adverse public health and ecological impacts associated with the lake's rapid changes, will have significant economic costs.

The California Natural Resources Agency's estimated capital cost for the 2007 preferred restoration alternative was about $10 billion (adjusted to 2013$), plus annual operation and maintenance costs of $150 million once fully constructed. Based on the proposed construction schedule and assuming a 2% annual cost escalation through 2047, this yields a total present value of $9.6 billion at a 4% discount rate, or $7.4 billion at a 6% discount rate. The capital cost of the state's concept-level mitigation plan was almost a billion dollars, plus $56 million annually for operations and maintenance. Assuming a ten-year construction schedule (siting projects as the lake recedes) starting in 2015 and escalating O&M costs based on expanding project area, yields a total present value of about $1.7 billion at a 4% discount rate, or $1.4 billion at a 6% discount rate. These values represent the costs of 'action' at the Salton Sea, as described to date. To date, the state legislature has taken no action on either the preferred alternative or funding authorization for any large-scale mitigation effort. Given this lack of attention and the number of years required to permit and construct any project at the scale of the Salton Sea, continued inaction appears certain for at least several more years.

This continued inaction imposes costs on the people living in the region and on the ecosystem itself. Although future Salton Sea conditions have been projected (Cohen and Hyun 2006, CNRA 2006), the economic costs associated with increased dust emissions due to additional lakebed exposure, and the diminished amenity and use values due to real and perceived problems at the lake, have not previously been estimated. Instead, these no action costs have implicitly been assigned a value of zero. To date, decision-makers have had to decide between the very high costs of Salton Sea restoration, the lower but still significant costs of mitigation, and the perception that deferring Salton Sea-related decisions and actions will not result in any measurable costs. This report offers the first estimates of the costs associated with deferring meaningful action at the Salton Sea.

The deteriorating Salton Sea will impose the following costs:

1. Increased dust emissions, from exposed lakebed, will impair public health;
2. Real and perceived threats posed by the deteriorating condition of the Salton Sea could diminish property values in the area;
3. Blowing dust and the loss of the lake's climate-buffering function could decrease agricultural productivity and revenue;
4. The decreasing amenity value of the Salton Sea will reduce recreational revenues; and
5. The changing Salton Sea will provide fewer ecosystem services, reducing non-market benefits.

Estimating the costs of inaction requires a number of assumptions, many of them based on limited information or on the basis of impacts and assessments reported for other locations. In some cases, such as the impacts of the changing Salton Sea on agricultural productivity, sufficient information does not exist to estimate potential economic costs, though we presume that these costs are greater than zero. An additional complicating factor is the growing number of people subject to degraded air quality and vulnerable to impaired health. As the population in the Salton Sea air basin is projected to almost double by 2047, many more people – and more property – will be vulnerable to the changes outlined above, increasing total costs. The Salton Sea and the region generally are dynamic, increasing the uncertainty about specific impacts.

Extrapolating from existing studies and estimates suggests that Salton Sea playa could emit as much as 800 pounds of dust per acre per year, on average. At a maximum exposure of more than 96,000 acres, exposed playa could emit more than 100 tons of dust per day, on average. Converting this projected increase into a public health impact requires information on the relationship between emission rates and concentrations in the air itself. This information is not available for the region (Zelinka, pers. comm.), meaning that it is not possible to model the relationships between estimated dust emissions, subsequent air quality concentrations, individuals' exposure and dosing, and subsequent health costs. Instead, two previous studies suggest a means of approximating an estimate: based on the estimated per capita cost of exceeding state and federal air quality standards, or based on a cost per unit of exposed dust. With a worst case scenario with the emissions rate noted above and very limited air quality management, the latter method yields a present value cost of as much as $37 billion through 2047. The threshold costs of continuing not to meet state and federal air quality standards – exacerbated by expected Salton Sea dust emissions and a rapidly growing population – generate a present value estimate as high as $21 billion.

The potential impacts of a deteriorating Salton Sea on property values exists within the context of the lake's existing disamenity value: property values generally increase with distance from the Sea, unlike typical water features that add value. Determining how a deteriorating lake will affect future property values requires an assessment of homebuyers' and sellers' expectations about the future lake. In the absence of resources to conduct such a survey, this study relies on previous research on the impacts of disamenities on property values. The existing depressed property values near the lake suggest that a deteriorating Salton Sea will likely not have any additional impact on valuation. But the stigma associated with a deteriorating lake could pose a risk to properties further removed from the lake, suggesting that total property devaluation due to the stigma associated with the deteriorating Salton Sea could be on the order of $400 million. Dust and noxious odors could also depress property values and revenues of the 124 golf courses and resorts in the Coachella Valley, so the total impact on property values could rise to $7 billion.

Insufficient information exists to estimate the potential costs associated with either the impacts of blowing dust and salt on crop productivity near the Salton Sea or the diminished micro-climate benefits that will occur as the lake shrinks. Both of these impacts will be felt within a few miles of the Salton Sea, so their overall cost may be small relative to the magnitude of Imperial and Coachella valley agriculture generally, but these impacts could be significant at the scale of the individual farm.

The projected inaction conditions at the Salton Sea are expected to continue the recent decline in visitation to the lake and in direct recreation-related expenditures, resulting in the loss of roughly $6 million per year in direct spending at the Salton Sea State Recreation Area relative to estimated historic rates. In the absence of records or surveys of current and historic expenditures for Salton Sea recreation as a whole, this rough estimate can be considered very conservative. Assuming a 2% annual escalation rate and 4% and 6% discount rates, this conservative estimate suggests $110 – $150 million in foregone recreational expenditures through 2047.

The Salton Sea currently provides tens of thousands of acres of shoreline and near-shore habitats to hundreds of thousands of birds. More than 400 species of birds use the Salton Sea,

**Figure 17. Birds at shallow Salton Sea habitat.**
Photograph courtesy of Doug Barnum, US Geological Survey.

including a large number of special status species (see Table 3). As the lake deteriorates in coming years, the size and quality of its habitats will diminish, reducing its value to the resident and migratory birds that depend upon it. Through contingent valuation surveys and other methods, people have expressed a willingness to pay to preserve similar values at other locations. Previous studies have indicated that Californians as a whole have valued wetland habitats at about $60,000 per acre, suggesting that the recent Salton Sea provided some $2.6 billion annually in shoreline habitat value. Transferring the benefits Californians have reported for Mono Lake suggests a potential non-use valuation of the Salton Sea on the order of $1.9 billion annually.

Table 5 summarizes the high and low estimates of the costs of inaction. For public health impacts due to dust emissions, the year in which an air quality management plan becomes operational greatly affects the estimated cost, as does the estimated amount of emissions. A state audit suggests that California may assume funding responsibilities for the air quality management plan in 2025. Under the worst case scenario, such a management plan would not be operational before 2048 and individual landowners, controlling about 40% of the land that will be exposed, do not manage dust emitted from their lands. The non-attainment costs shown in Table 5 simply reflect estimated threshold values for failing to meet state and federal air quality standards, providing context for the previous two estimates. The property value estimates arise from the potential negative stigma that may be associated with a future Salton Sea; they range from $400 million to as high as $7 billion, though these values are speculative.

**Table 5. Estimated present value of inaction at the Salton Sea through 2047, by impact area.**

| Impact | Scenario | Emissions | Discount | ($millions)<br>Cost Estimate |
|---|---|---|---|---|
| Public health | Best case | any | n/a | $0 |
| Public health | QSA mitigation | low | 6% | $2,200 |
| Public health | Worst case | High | 4% | $37,000 |
| Public health | non-attainment | | 6% | $15,000 |
| Public health | non-attainment | | 4% | $21,000 |
| Property values | high | | | $7,000 |
| Property values | low | | | $400 |
| Dust on crops | | | | >0 |
| Loss of micro-climate | | | | >0 |
| Recreational revenues | | | 6% | $110 |
| Recreational revenues | | | 4% | $150 |
| Habitat values | San Joaquin | | 4% | $26,000 |
| Preservation/existence values | Mono Lake | | 6% | $10,000 |
| | | | High Estimate | $70,000 |
| | | | Low Estimate | $11,000 |

Insufficient information exists to estimate the potential costs of dust on crops or the loss of the Salton Sea's climate-buffering benefits for nearby farms, though anecdotal reports suggest that these costs are greater than zero. The present values of declining recreational revenues are very conservative figures, based solely on recent trends at the Salton Sea State Recreation Area; general information on visitation to the Salton Sea as a whole is not available. The broad range of the estimated present value of lost non-use benefits reflects the uncertainty regarding the value of the Salton Sea to the broader public.

A number of factors affect these suggested costs, including the degradation of the Salton Sea itself and assumptions about public perceptions regarding these changes, but also broader regional factors such as population growth, affecting the total number of potentially vulnerable individuals as well as the total amount of affected property. As shown in Table 5, estimated public health costs are the highest market-based cost associated with a declining Salton Sea, while the loss of ecosystem services and related bequest and existence values suggest that non-use costs could be very significant as well.

## Limitations

As noted previously, the lack of information on a number of important factors limits the confidence of these cost estimates. Basic information, such as the amount of dust emitted from Salton Sea playa and the impacts of dust on Imperial Valley crops, simply does not exist. We lack important survey data on public perceptions of the Salton Sea and expectations about its future, data that would inform projections of future property values in the region and would identify key concerns. Information on total visitation rates to the Salton Sea area and its value as an economic engine for the region do not exist. These factors, combined with general uncertainty about population growth rates, climate change, and changing hydrologic conditions, suggest that the above estimates should be considered indicative of a general magnitude of potential future costs, rather than precise projections.

# 9. Conclusion

To date, the high costs of the California Resources Agency's proposed 'preferred alternative' (CNRA 2007) have inhibited deliberation and deterred any meaningful investment in the revitalization of the Salton Sea. The underlying assumption has been that the value generated by building a revitalization project at the Salton Sea would not justify the cost of that project. The assumption also seems to have been that deferring and delaying action at the Salton Sea would result in business as usual, with no additional costs. This is clearly not the case. Because the Salton Sea has changed over the past decade, and will soon enter a period of very rapid deterioration, the costs of inaction are escalating rapidly. *When* a project is implemented dramatically affects the total inaction costs estimated above. Time, then, is money in the Salton Sea air basin. Deferring decisions about project implementation and delaying action impose real costs on the people and property owners in the region, and lesser costs on Californians generally.

In the absence of a detailed air quality mitigation plan, the state's conceptual plan (CNRA 2006) suggests a total cost for mitigation: about $1.4 to $1.7 billion, depending on the discount rate, assuming implementation starts

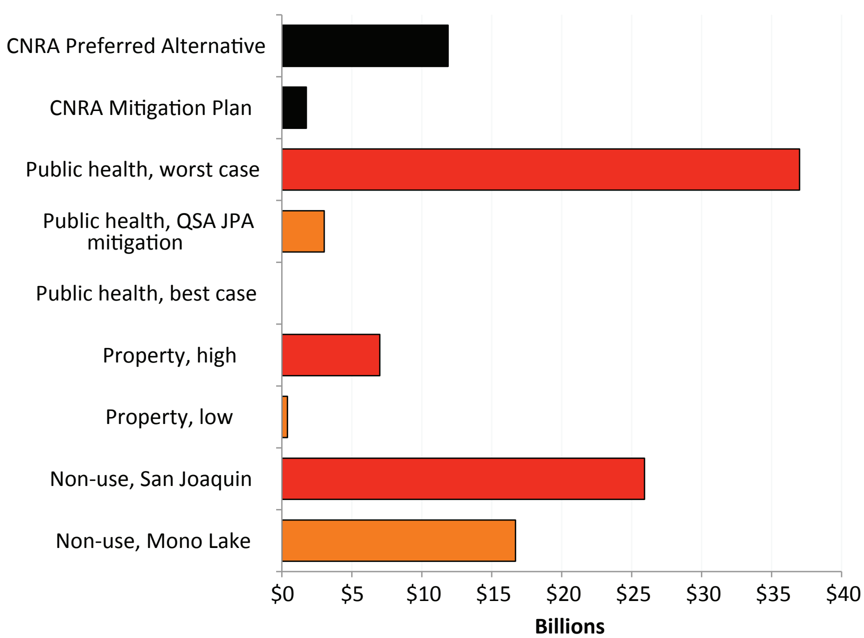



**Figure 18. Present values of estimated costs of Salton Sea action and inaction.**

next year. Delaying implementation another decade could defer the state's expenditures by shunting those costs onto the local population, whose health costs could rise $1.2 billion or more in the interim. Long-term failure to implement an effective air quality mitigation project at the Salton Sea could generate tens of billions of dollars of health care costs.

**Figure 19. Caspian tern at the Salton Sea.**
Photograph © Jenny E. Ross / www.jennyross.com.

Figure 18 compares the projected project costs of the state's proposed preferred alternative and its conceptual mitigation plan (CNRA 2006, CNRA 2007) with the estimated social and economic costs of inaction for public health and non-use benefits, and with the one-time estimated devaluation of property in the region. With the exception of the property value estimates, these costs all reflect a 2% annual escalation and a 4% discount rate, to facilitate comparison. These inaction costs, all shown in red and orange, provide an initial basis for comparison with the estimated project costs of restoration or mitigation, shown in black. A more robust comparison would require additional information about the total economic costs and benefits of the revitalization and mitigation projects. Capturing the non-use values espoused by survey respondents would require some method to monetize and collect these estimated values.

Figure 18 indicates that the costs of inaction greatly exceed the costs of action at the Salton Sea, strongly suggesting that action at the Salton Sea should be funded and implemented quickly. However, not all 'actions' would avoid the 'inaction' costs: a mitigation plan designed only to control dust emissions would not improve recreation in the region, nor would it improve property values or promote economic development; such a plan would do little to improve declining ecological values. A project that both controls dust and creates habitat could limit or avoid public health costs, reduce or eliminate impacts to property values, and maintain or even enhance ecological values. A more comprehensive revitalization plan should also be evaluated within this broader context of created benefits and avoided costs. In all cases, delaying action imposes real costs.

This report also highlights a large number of important data gaps that should be addressed in the near future. Despite many decades of study and the impending decline of the Salton Sea, we still lack information on many factors affecting life and the economy in the region.

Bill deBuys (1999, p.23) writes in *Salt Dreams*, "In low places consequences collect." The consequences of continued inaction at the Salton Sea will be felt most directly by the 650,000 people that live in the air basin, as well as by the birds and other life that depend on the lake. These consequences generate real costs. These considerable costs, estimated for the first time by this report, demonstrate the urgent need for action at the Salton Sea.

# References

## Personal Communications

Kalin, Al. Imperial Valley Farm Bureau. Email correspondence, February 27, 2014.

Schwabe, Kurt. UC Riverside. Email correspondence, July 26, 2014.

Thayer, Mark. San Diego State University. Email correspondence, June 13, 2014.

Zelinka, Steve. California Air Resources Board. Email correspondence. March 10, 2014.

## Publications

Anderson, D. 1999. "A regional perspective for migratory bird resources of the Salton Sea area," presented at *Science for Salton Sea Ecosystem Management*. Sponsored by the Salton Sea Science Subcommittee, USGS, and the University of California, Riverside. Riverside. January 5.

Anderson, HR, RW Atkinson, JL Peacock, MJ Sweeting, and L Marston. 2005. Ambient Particulate Matter and Health Effects: Publication Bias in Studies of Short-Term Associations. *Epidemiology* 16:155-163

Armbrust, DV. 1986. Effect of particulates (dust) on cotton growth, photosynthesis, and respiration. *Agronomy Journal* 78: 1078-1081.

Atkinson, RW, IM Carey, AJ Kent, TP van Staa, HR Anderson, and DG Cook. 2013. Long-Term Exposure to Outdoor Air Pollution and Incidence of Cardiovascular Diseases. *Epidemiology* 24: 44-53.

Bazdarich, M. 1998. "An Economic Analysis of the Benefits of Rehabilitating the Salton Sea". Inland Empire Economic Databank and Forecasting Center. The A. Gary Anderson Graduate School of Management. University of California, Riverside.

Blake, C. 2007. Farmers question impact of Salton Sea Restoration Alternative Plan on California agriculture. *Western Farm Press*, July 11. Available at http://westernfarmpress.com/farmers-question-impact-salton-sea-restoration-alternative-plan-california-agriculture-0.

Boyle, MA, and KA Kiel. 2001 A Survey of House Price Hedonic Studies of the Impact of Environmental Externalities. *Journal of Real Estate Literature* 9: 117-144.

Brajer, V, JV Hall, and R Rowe. 1991. The Value of Cleaner Air: An Integrated Approach. *Contemporary Policy Issues* 9: 81-91.

Brasington, DM, and D Hite. 2005. Demand for Environmental Quality: A Spatial Hedonic Analysis. *Regional Science and Urban Economics* 35: 57-82.

California Natural Resources Agency (CNRA) (formerly, the California Resources Agency). 2006. *Salton Sea Ecosystem Restoration Program Draft Programmatic Environmental Impact Report*. Prepared by the California Department of Water Resources (DWR) and California Department of Fish and Game (DFG). Available at http://www.water.ca.gov/saltonsea/documents/draft_eir.cfm.

California Natural Resources Agency (CNRA) (formerly, the California Resources Agency). 2007. *Salton Sea Ecosystem Restoration Program Final Programmatic Environmental Impact Report*. Prepared by the California Department of Water Resources (DWR) and California Department of Fish and Game (DFG). Available at http://www.water.ca.gov/saltonsea/documents/final_eir.cfm.

California Natural Resources Agency (CNRA). 2011. *Salton Sea Species Conservation Habitat Project: Draft Environmental Impact Statement/Environmental Impact Report*. State Clearinghouse No. 2010061062. August. Available at http://www.water.ca.gov/saltonsea/habitat/eir2011.cfm.

California State Auditor. 2013. *Salton Sea Restoration Fund: The State Has Not Fully Funded a Restoration Plan and the State's Future Mitigation Costs Are Uncertain*. Report 2013-101. Sacramento, California. Available at http://www.auditor.ca.gov./pdfs/reports/2013-101.pdf.

Carroll, TM, TM Clauretie, J Jensen, and M Waddoups. 1996. The Economic Impact of a Transient Hazard on Property Values: The 1988 PEPCON Explosion in Henderson, Nevada. *Journal of Real Estate Finance and Economics* 13: 143-167.

Case III, HL, J Boles, A Delgado, T Nguyen, D Osugi, DA Barnum, D Decker, S Steinberg, S Steinberg, C Keene, K White, T Lupo, S Gen, and KA Baerenklau. 2013. *Salton Sea ecosystem monitoring and assessment plan*. U.S. Geological Survey Open-File Report 2013-1133, 220 p.

Chaurasia, S, A Karwariya, and AD Gupta. 2013. Effect of cement industry pollution on chlorophyll content of some crops at Kodinar, Gujarat, India. *Proceedings of the International Academy of Ecology & Environmental Sciences* 3: 288-295.

Clark, DE, and LA Nieves. 1994. An Interregional Hedonic Analysis of Noxious Facility Impacts on Local Wages and Property Values. *Journal of Environmental Economics and Management* 27: 235-253.

Cohen, MJ, JI Morrison, EP Glenn. 1999. *Haven or Hazard:  The ecology and future of the Salton Sea*. Oakland, CA: Pacific Institute. 63 pp. Available at http://pacinst.org/wp-content/uploads/2013/02/haven_or_hazard3.pdf.

Cohen, MJ, and KH Hyun. 2006. *Hazard: The Future of the Salton Sea With No Restoration Project*. Oakland, CA: Pacific Institute. 48 pp. Available at http://pacinst.org/publication/restoration-project-critical-to-salton-seas-future/.

Cooper, DS. 2004. *Important Bird Areas of California*. Pasadena, California: Audubon California, 286 pp.

Currie, J, L Davis, M Greenstone, and R Walker. 2013. Do housing prices reflect environmental health risks? Evidence from more than 1600 toxic plant openings and closings. National Bureau of Economic Research. 40 pp. Available at http://www.nber.org/papers/w18700.

Davis, JA. 1959. A formal interpretation of the theory of relative deprivation. *Sociometry* 22: 280-296.

deBuys, WE. 1999. *Salt Dreams: land and water in low-down California*. Albuquerque: UNM Press, 407 pp.

Dominici, F, M Daniels, SL Zeger, and JM Samet. 2002. Air pollution and mortality: estimating regional and national dose-response relationships. *Journal of the American Statistical Association* 97: 100-111.

Farber, S. 1998. Undesirable Facilities and Property Values: A Summary of Empirical Studies. *Ecological Economics* 24: 1-14.

Farmer, AM. 1993. The effects of dust on vegetation - a review. *Environmental Pollution* 79: 63-75.

Folland, S, and R Hough. 2000. Externalities of nuclear power plants: further evidence. *Journal of Regional Science* 40: 735-753.

Gauderman, WJ, R McConnell, F Gilliland, S London, D Thomas, E Avol, H Vora, K Berhane, EB Rappaport, F Lurmann, HG Margolis, and J Peters. 2000. Association between air pollution and lung function growth in southern California children. *American Journal of Respiratory and Critical Care Medicine* 162: 1383-90.

Imperial Irrigation District (IID). 2002. Imperial Irrigation District Water Conservation and Transfer Project, Final Environmental Impact Report/Environmental Impact Statement (State Clearinghouse No. 99091142). June. Available at http://www.iid.com/index.aspx?page=220.

Isakson, HR, and MD Ecker. 2008. An analysis of the impact of swine CAFOs on the value of nearby houses. *Agricultural Economics* 39: 365-372.

Jehl, JR, and RL McKernan. 2002. Biology and migration of eared grebes at the Salton Sea. *Hydrobiologia* 473: 245-253.

K2 Economics. 2007. A Preliminary Investigation of the Potential Non-Market Benefits Provided by the Salton Sea. Final report to the Salton Sea Authority. January. Riverside, CA. 37 pp.

Kiel, KA. 1995. Measuring the Impact of the Discovery and Cleaning of Identified Hazardous Waste Sites on House Values. *Land Economics* 71: 428-435.

King, J, V Etyemezian, M Sweeney, BJ Buck, and G Nikolich. 2011. Dust Emission Variability at the Salton Sea, California USA. *Aeolian Research* 3: 67-79.

Kovacs, K, TP Holmes, JE Englin, and J Alexander. 2011. The Dynamic Response of Housing Values to a Forest Invasive Disease: Evidence from a Sudden Oak Death Infestation. *Environmental and Resource Economics* 49: 445-471.

Kroeger, T, and P Manalo. 2007. *Economic Benefits Provided by Natural Lands: Case Study of California's Mojave Desert*. Defenders of Wildlife. 109 pp. Available online at http://www.defenders.org/sites/default/files/publications/economic_benefits_of_the_mojave_desert.pdf.

London, J, T Greenfield, and T Zagofsky. 2013. Revealing the Invisible Coachella Valley: Putting Cumulative Environmental Vulnerabilities on the Map. Davis, CA: UC Davis Center for Regional Change. 12 pp. Available at http://regionalchange.ucdavis.edu/ourwork/CRC/ourwork/publications/copy_of_publications-1.

Lovett, I. 2012. Lake Is Blamed for Stench Blown Across Southern California. *New York Times*. September 12.

Mahan, BL, S Polasky, and RM Adams. 2000. Valuing urban wetlands: a property price approach. *Land Economics* 76: 100-113.

Messer, KD, WD Schulze, KF Hackett, TA Cameron, and GH McClelland. 2006. Can stigma explain large property value losses? The psychology and economics of Superfund. *Environmental and Resource Economics* 33: 299-324.

Milly, PCD, J Betancourt, M Falkenmark, RM Hirsch, ZW Kundzewicz, DP Lettenmaier, and RJ Stouffer. 2008. Stationarity is Dead: Whither Water Management? *Science* 319: 573-574.

Mohamed, AMO, and KM El-Bassouni. 2007. Externalities of fugitive dust. *Environmental Monitoring and Assessment* 130: 83-98.

Nelson, JP. 1981. Three Mile Island and Residential Property Values: Empirical Analysis and Policy Implications. *Land Economics* 57: 363-372.

Nelson, AC, J Genereux, and M Genereux. 1992. Price Effects of Landfills on House Values. *Land Economics* 68: 359-365.

Norris, G, SN Young Pong, JQ Koenig, TV Larson, L Sheppard, and JW Stout. 1999. An association between fine particles and asthma emergency department visits for children in Seattle. *Environmental Health Perspectives* 107: 489-493.

Peters, A, DW Dockery, JE Muller, and MA Mittleman. 2001. Increased particulate air pollution and the triggering of myocardial infarction. *Circulation* 103: 2810-2815.

Pope III, CA, J Schwartz, and MR Ransom. 1992. Daily mortality and PM10 pollution in Utah Valley. *Archives of Environmental Health: An International Journal* 47: 211-217.

Reichert, AK, M Small, and S Mohanty. 1992. The Impact of Landfills on Residential Property Values. *Journal of Real Estate Research* 7: 297–314.

Roddewig, R. 1996. Stigma, environmental risk and property value: 10 critical inquiries. *The Appraisal Journal* 64: 375–387.

Rosenow Spevacek Group, Inc. (RSG) 2003. The Salton Sea: Tax Increment Financing Feasibility Study. Prepared for the Salton Sea Authority.

Salton Sea Authority (SSA). 1995. *Salton Sea Management Project Economic Profile Study and a Discussion of Methodology for Economic Impact Analysis*. Prepared by Onaka Planning & Economics, Source Point, and Ogden Environmental and Energy Services Company, Inc. September. Project No. 313561000. 54 pp.

Sapozhnikova, Y, O Bawardi, and D Schlenk. 2004. Pesticides and PCBs in sediments and fish from the Salton Sea, California, USA. *Chemosphere* 55: 797–809.

Schwabe, KA, PW Schuhmann, KA Baerenklau, and N Nergis. 2008. Fundamentals of estimating the net benefits of ecosystem preservation: the case of the Salton Sea. *Hydrobiologia* 604: 181–195.

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

Singh, SN, and DN Rao. 1981. Certain responses of wheat plants to cement dust pollution. *Environmental Pollution Series A, Ecological and Biological* 24: 75–81.

Smolen, GE, G Moore, and LV Conway. 1992. Economic Effects of Hazardous Chemical and Proposed Radioactive Waste Landfills on Surrounding Real Estate Values. *Journal of Real Estate Research* 7: 283–295.

Straif, K, A Cohen, and J Samet (eds.). 2013. *Air pollution and cancer*. International Agency for Research on Cancer Scientific Publications 161. Distributed by WHO Press, Switzerland. 228 pp.

Tetra Tech. 2005. *Recreation And Economic Opportunities Assessment For The Salton Sea, California*. Draft report, dated August 12, 2005. Submitted by: The Salton Sea Authority. Prepared for: The State of California Department of Water Resources. Available at http://saltonsea.ca.gov/pdfs/Salton%20Sea%20Rec%20and%20Econ%2008122005.pdf.

Tversky, A, and D Kahneman. 1974. Judgment under Uncertainty: Heuristics and Biases. *Science* 185: 1124–1131.

Zanobetti, A, and J Schwartz. 2005. The effect of particulate air pollution on emergency admissions for myocardial infarction: a multicity case-crossover analysis. *Environmental health perspectives* 113: 978–982.

# Appendix A

## Quantification Settlement Agreement Delivery Schedule By Conservation Method

| QSA Year | Calendar Year | IID and SDCWA | IID and CVWD[a], | IID and MWD | Total Delivery | Total Efficiency | Fallowing for Delivery | Mitigation Fallowing | Total Fallowing |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2003 | 10 | 0 | 0 | 10 | 0 | 10 | 5 | 15 |
| 2 | 2004 | 20 | 0 | 0 | 20 | 0 | 20 | 10 | 30 |
| 3 | 2005 | 30 | 0 | 0 | 30 | 0 | 30 | 15 | 45 |
| 4 | 2006b | 40 | 0 | 0 | 40 | 0 | 40 | 20 | 60 |
| 5 | 2007 | 50 | 0 | 0 | 50 | 0 | 50 | 25 | 75 |
| 6 | 2008 | 50 | 4 | 0 | 54 | 4 | 50 | 25 | 75 |
| 7 | 2009b | 60 | 8 | 0 | 68 | 8 | 60 | 30 | 90 |
| 8 | 2010 | 70 | 12 | 0 | 82 | 12 | 70 | 35 | 105 |
| 9 | 2011 | 80 | 16 | 0 | 96 | 16 | 80 | 40 | 120 |
| 10 | 2012b | 90 | 21 | 0 | 111 | 21 | 90 | 45 | 135 |
| 11 | 2013 | 100 | 26 | 0 | 126 | 46 | 80 | 70 | 150 |
| 12 | 2014 | 100 | 31 | 0 | 131 | 71 | 60 | 90 | 150 |
| 13 | 2015 | 100 | 36 | 0 | 136 | 96 | 40 | 110 | 150 |
| 14 | 2016 | 100 | 41 | 0 | 141 | 121 | 20 | 130 | 150 |
| 15 | 2017 | 100 | 45 | 0 | 145 | 145 | 0 | 150 | 150 |
| 16 | 2018 | 130 | 63 | 0 | 193 | 193 | 0 | 0 | 0 |
| 17 | 2019 | 160 | 68 | 0 | 228 | 228 | 0 | 0 | 0 |
| 18 | 2020 | 192.5 | 73 | 2.5 | 268 | 268 | 0 | 0 | 0 |
| 19 | 2021 | 205 | 78 | 5 | 288 | 288 | 0 | 0 | 0 |
| 20 | 2022 | 202.5 | 83 | 2.5 | 288 | 288 | 0 | 0 | 0 |
| 21 | 2023 | 200 | 88 | 0 | 288 | 288 | 0 | 0 | 0 |
| 22 | 2024 | 200 | 93 | 0 | 293 | 293 | 0 | 0 | 0 |
| 23 | 2025 | 200 | 98 | 0 | 298 | 298 | 0 | 0 | 0 |
| 24 | 2026 | 200 | 103 | 0 | 303 | 303 | 0 | 0 | 0 |
| 25 | 2027 | 200 | 103 | 0 | 303 | 303 | 0 | 0 | 0 |
| 26 | 2028 | 200 | 103 | 0 | 303 | 303 | 0 | 0 | 0 |
| 27 to 45 | 2029 to 2047 | 200 | 103 | 0 | 303 | 303 | 0 | 0 | 0 |
| 46 to 75c | 2048 to 2077 | 200 | 50 | 0 | 250 | 250 | 0 | 0 | 0 |

All values in thousands of acre-feet

**a** If CVWD declines to acquire these amounts, MWD has an option to acquire them, but acquisition by MWD of conserved water in lieu of CVWD during the first 15 years is subject to satisfaction by MWD of certain conditions, including subsequent environmental assessment.

**b** In addition to the conserved amounts shown on this Table, additional amounts of up to 25,000 acre-feet in 2006, 50,000 acre-feet in 2009 and 70,000 acre-feet in 2012 could be conserved to meet the Interim Surplus Guidelines (ISG) benchmarks. IID has the discretion to select the method of conservation used to make the ISG backfill water. If fallowing is selected to conserve water to meet the ISG benchmarks, the total acres of fallowing would be within the amount originally evaluated in the EIR/EIS.

**c** This assumes that the parties have approved the extension of the 45-year initial term of the IID Water Conservation and Transfer Project. Source: Imperial Irrigation District (IID), "Water Conservation and Transfer Project Draft EIR/EIS and Draft Habitat Conservation Plan," 2002.