CRISIS AT THE SALTON SEA

The Vital Role of Science

A special report prepared for policymakers and stakeholders by the

UNIVERSITY OF CALIFORNIA RIVERSIDE
SALTON SEA TASK FORCE

JUNE 2021

Sponsored by the **EDGE Institute** and the **Center for Science to Policy** at UC RIVERSIDE

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ACKNOWLEDGEMENTS

The Salton Sea Task Force received support from the University of California, Riverside, and the EDGE Institute. We benefited from discussion with Doug Brown and William Ota from the Center for Science 2 Policy. Assemblymember Eduardo Garcia and consultant Keith Ciolino met with the Task Force and provided helpful advice on direction. We thank our reviewers:

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SHOREBIRDS FORAGING near North Shore Yacht Club. Jonathan Nye

EXECUTIVE SUMMARY

The Vital Role of Science in a Successful Salton Sea Policy

The Salton Sea, a hypersaline lake in southern California, is in crisis. A combination of mismanagement and competition among federal, state and local agencies has stalled efforts to address declining lake levels and unstable water chemistry. This delay has heightened the public health threat to regional communities as retreating shorelines expose dry lakebed—a source of potentially toxic dust—while aquatic ecosystems face collapse due to rising salinity and oxygen loss. Although state agencies are making efforts to mitigate the problems, the scientific assumptions informing current management practices are outdated or lacking entirely, making outcomes unpredictable at best.

THE ABSENCE OF AN ADAPTIVE, SCIENCE-BASED approach to addressing the environmental and human health challenges at the Salton Sea prompted UC Riverside's Environmental Dynamics and GeoEcology (EDGE) Institute and Science to Policy Center to launch an independent Salton Sea Task Force to identify critical scientific research necessary to guide policymakers in making decisions about the region's future. As an interdisciplinary group of scientists, engineers medical experts, and economists, we considered three potential, realistic scenarios facing the Salton Sea over the coming decade: (1) business as usual, where lake levels continue to decline without intervention, (2) stabilization, where enough water is directed to the Sea to slow the decline and potentially stabilize lake levels at a level lower than it is today, and (3) recovery, where enough water is brought in from the ocean or local freshwater sources to stabilize, and possibly increase, lake levels.

Based on our array of first-hand research experience at the Salton Sea, we identified substantial challenges and opportunities in seven interconnected areas: water policy, watershed hydrology, water chemistry, air quality,

AIR QUALITY monitoring equipment: dust that sticks to marbles can be analyzed later in the lab. Emma Aronson

ecology, human health, and geothermal resources. This report devotes a chapter to each of these areas of concern and provides specific suggestions for research tasks that would provide the necessary clarity to evaluate outcomes of current Salton Sea management policies and help make necessary adjustments moving forward.

Urgency

PRAGMATIC URGENCY drives the research directions outlined in this report. We are keenly aware of the limited funding currently allocated for mitigation efforts at the Salton Sea, and we duly focused our scientific curiosity about this dynamic region through the lens of the two primary goals the state of California identifies in its current Salton Sea management plan: (1) improve air quality and (2) provide critical environmental habitat for birds along the Pacific Flyway. Furthermore, we evaluated these goals using four economic criteria used commonly to determine the success or failure of a policy: *effectiveness*, *efficiency*, *equity*, and *sustainability*.

Effectiveness

FIRST CONSIDER EFFECTIVENESS, which measures how successfully a plan achieves its desired results. We can set a lower bound for the effectiveness of current Salton Sea policies by asking two simple questions: Will air quality improve? Will there be critical habitat for birds?

The Salton Sea Management Program, led by a consortium of state agencies, aims to achieve its desired outcomes by constructing 30,000 acres of bird habitat and dust suppression projects by 2028. Progress has been slow, however, with only 755 acres completed by the end of 2020 (SSMP, 2021). Potential outcomes of these efforts are highly uncertain. Plans to limit air pollution rely largely on limiting acreage of exposed lakebed, or playa. Yet the acreage of exposed playa will depend on the Sea's volume, which in turn depends on regional water policy (Chapter 1) and complex interactions between surface water and groundwater, a factor that has been overlooked until recently (Chapter 2). Air quality, too, is a function not only of water availability but also of the chemistry and biology of the lake itself, which is changing rapidly as water volume diminishes (Chapters 3, 4, 5).

The degree to which restoration efforts will produce viable bird habitats is similarly uncertain (Chapter 5). The characteristics of restored wetland habitat will depend on the intersection of water quantity, water quality, and other inputs, such as food sources for birds. Yet, as this report demonstrates, we are proceeding with a lack of understanding of the Sea's water quantity (Chapters 1 and 2) and water quality (Chapter 3) dynamics. In short, whether planned wetland projects will provide the minimum range of ecosystem functions required to support specific bird species depends on variety of factors that require further scientific research (Chapter 5).

Efficiency

CURRENT STATE POLICIES are even more concerning from an efficiency perspective. Within the economic lexicon, efficiency is an outcome for which net benefits—total benefits less total costs—are maximized. The lack of understanding of the outcomes associated with current mitigation efforts to reduce air pollution or restore critical habitat coupled with uncertainty surrounding the drivers of pulmonary illness associated with changing Salton Sea characteristics (Chapter 6) make any quantifiable measure of the benefits indeterminate. Reasonable discussions about efficiency are premature until we garner a better understanding of the science. Indeed, expecting efficiency from Salton Sea management policies may be unrealistic. A less demanding criterion would be to seek a solution that is merely cost-effective, defined as the minimum cost to achieving a particular outcome.

Even a less demanding cost-effective criterion will be difficult to achieve without an understanding of the science and issues identified in this report. Because of the uncertainty surrounding the drivers of pulmonary illness associated with changing Salton Sea characteristics (Chapter 6) and the likely outcomes associated with current mitigation efforts to restore critical habitat or reduce air pollution (Chapters 3, 4, 5), any quantifiable measure of benefits is indeterminate. Without a firmer grasp on probable outcomes for proposed mitigation strategies assessments of the cost-effectiveness of current policies are also premature. Put another way, the rate of return on current investments in mitigation as measured by current management targets are highly uncertain and not guaranteed to be positive over time, due largely to the issues identified in this report.

Furthermore, as economics is about trade-offs, the consequences of a receding Sea on the state's intended outcomes of reducing air pollution and improving critical habitat should be considered alongside economic opportunities—namely, what can be gained from further development and investment in the Sea's geothermal and lithium resources (Chapter 7).

Equity

RECENTLY CALIFORNIA has increased its efforts to incorporate local community concerns and insight into its Salton Sea management plan. Considering input from local stakeholders is a commendable pivot relative to the state's earlier efforts, which were focused more on trying to identify cost-effective solutions than on how different communities would bear those distributions of costs and benefits. Despite this progress, equity issues are still largely unresolved because of the uncertain outcomes associated with air pollution (Chapter 4), how that pollution impacts local communities surrounding the Salton Sea (Chapter 6), and what rents associated with geothermal and lithium development can be funneled back into the local communities in terms of employment and income opportunities (Chapter 7).

It is critical to note that significant health disparities in this region are likely to amplify the impacts of expected environmental hazards (Chapter 6). The communities surrounding the Salton Sea are characterized relative to state averages by low income, poor health, and low access to health care. As such, knowing how the benefits and costs of different management plans will affect these communities is paramount to understanding the degree to which such plans are equitable; because of the uncertainty surrounding the effectiveness of the management plans—and until an understanding of the issues raised in this report is achieved—the degree to which such plans are equitable is unclear.

Sustainability

FINALLY, THIS REPORT clarifies the need for more scientific research to understand how the Salton Sea system will evolve over time. Getting a better handle on the Sea's future volume, chemistry and probable generation and

LAUNCHING WATERCRAFT for field work is difficult. Shorelines have receded far from existing boat ramps. Charlie Diamond

transport of dust and other air pollutants is critical to the restoration and sustainability of critical habitat for birds and clean air for local communities. Both a better understanding of the science and continual monitoring and assessment of the consequences of mitigation will be required to gauge the effectiveness and return on the state's efforts. The same kinds of science are crucial for recognizing when ongoing investments in a particular strategy need to be reimagined and reconfigured.

Action

A COMMON REFRAIN in discussions about how to manage the Salton Sea crisis is 'enough science has been done—what we need now is action.' This report makes clear that we need both science and action. Without significant consideration of the issues presented in this report, the ability of the Salton Sea Management Program to achieve the desired outcomes of its mitigation efforts will be difficult, if not impossible. We therefore recommend that the Salton Sea Management Program set aside a portion of the funding allocated to mitigation efforts for a competitive research program open to researchers from universities, non-profits, and other state agencies so that action may be informed by ongoing and complementary scientific inquiry. Moreover, we recommend that the federal government, which owns roughly 40% of lands at the Salton Sea, partner with California to invest in economic and mitigation efforts in the region, also setting aside a portion of funding for the necessary scientific research to make effective investments.

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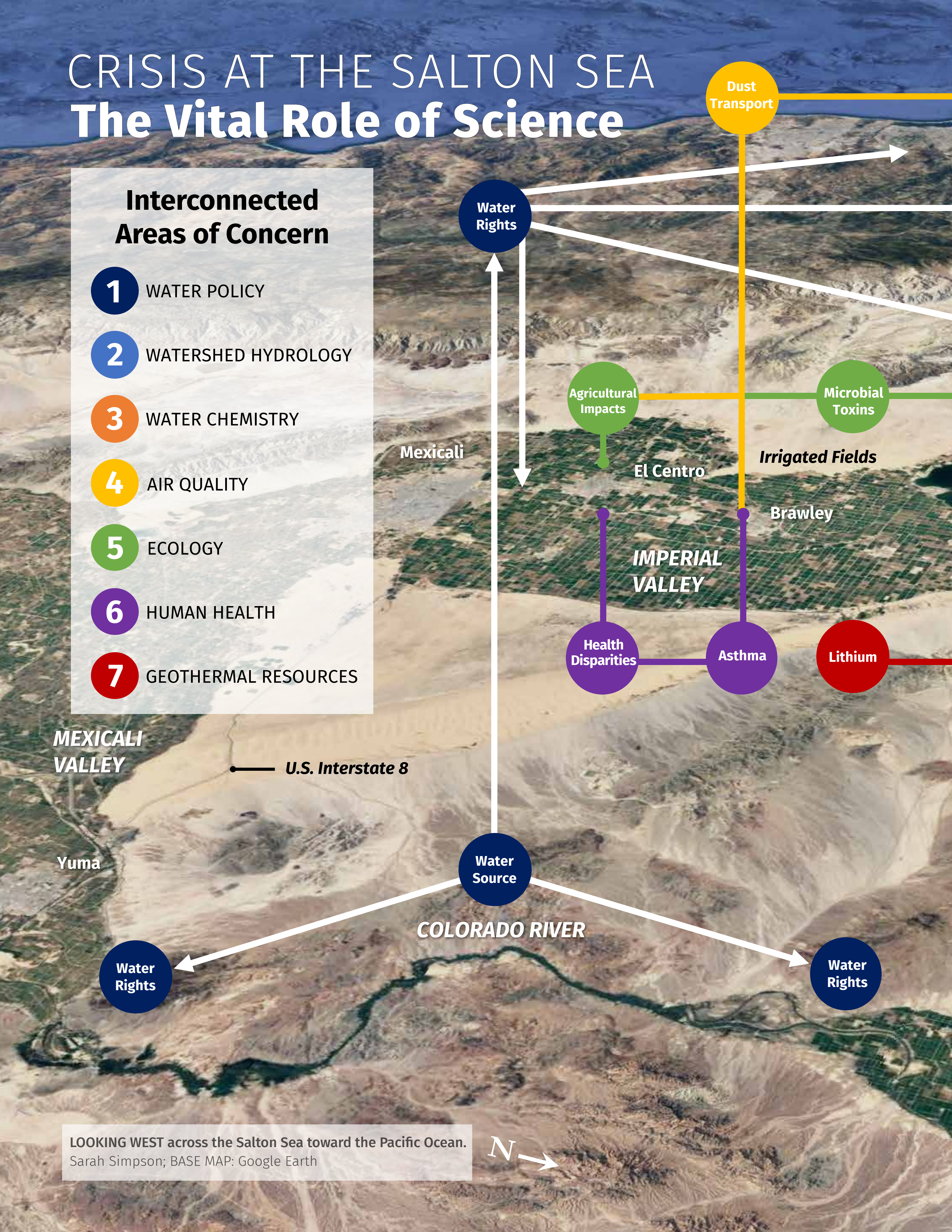
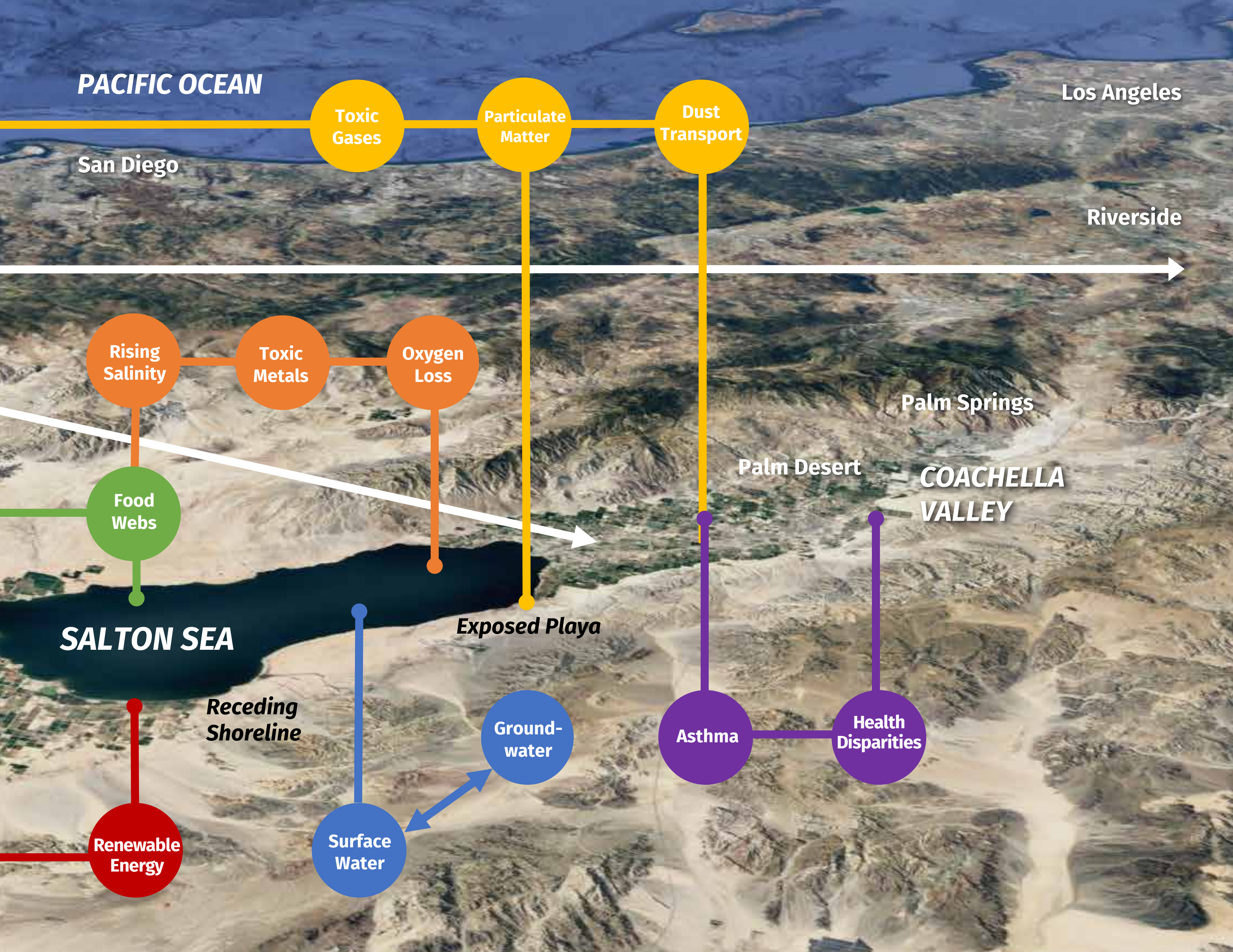


LOOKING WEST across the Salton Sea toward the Pacific Ocean.
Sarah Simpson; BASE MAP: Google Earth



Water Policy 1

A key science need is to determine the optimal lake water level to reduce lakebed dust while maintaining wildlife habitat and agricultural production in the basin.

The problems facing the Salton Sea are multi-faceted and complex, spanning from ecological and medical concerns to health disparities and economic opportunities. Continued shrinking of the sea exposes dry lakebed that exacerbates windblown dust as aquatic ecosystems crash or disappear. Managing lake levels is challenging in large part because urban water districts in San Diego and Los Angeles compete with agricultural irrigation and natural ecosystems for the same inflows from the Colorado River, which are projected to decline. As the construction of wetland restoration and dust mitigation projects ramps up on the northern and southern shores of the lake in the coming years, it will become increasingly imperative that scientific research guides and informs these efforts.

2 Watershed Hydrology

A comprehensive assessment of lake-groundwater interactions is needed to explain the underlying causes of significant reductions in Salton Sea volume since 1995.

The Salton Sea watershed is one of the most productive agricultural regions in the United States. With an area of 8417.4 square miles, this watershed's hydrology is tightly coupled to water imported from the Colorado River, which provided about 1.1 x 10^6 acre feet per year of water to the lake via irrigated agricultural runoff and subsurface drainage from 1980 to 2018. Despite no substantial decrease in agricultural inflows, lake levels declined significantly decline from -227.06 ft in 1995 to -234.8 ft in 2016. One possible explanation for this unexpected decline is poorly understood connections between the lake and local groundwater aquifers and subsurface water flow, which has never been evaluated adequately.

The volume of the Salton Sea is a straightforward difference between inflows and outflows. The Sea's only surface outflow is via well-understood rates of evaporation, and surface inflow is estimated from measured flow rates at various rivers and drains. The unknown factor is the dynamics of subsurface water. The model that the Salton Sea Management Program has used to predict lake levels for current management plans assumes constant net groundwater flows into the lake, but the possibility of lake discharge to groundwater is not considered. Accurate predictions of future lake level require new research to properly quantify lake-groundwater interactions.

AGRICULTURAL DRAINS (left) entering the Alamo River near its terminus at the Salton Sea. Jonathan Nye

Water Chemistry 3

Shrinking of the Salton Sea will exacerbate water quality issues as dead zone episodes last longer and the receding shoreline exposes mud that is more highly concentrated in toxic metals and pesticides.

GREEN TIDE from precipitation of gypsum in the warm waters of the Salton Sea in August 2020. Caroline Hung

Changing water chemistry at the Salton Sea is already causing serious perturbations to fish stocks and waterfowl feeding habits. It also makes windblown dust from the dry lakebed increasingly toxic as the Sea recedes. Each summer the deeper waters lose oxygen and accumulate hydrogen sulfide through the activities of algae and bacteria. These dead zone waters mix with the surface layers on windy days, resulting in fish kills and airborne accumulation of foul-smelling hydrogen sulfide. It is likely that these conditions will become longer-lived and more frequent as lake volume decreases. Concentrated in the central portions of the basin, these waters also tend to enrich the underlying sediment in metals far beyond concentrations observed on the lake margin. Molybdenum and selenium, for example, are beneficial at low levels but become health hazards when elevated. Along with pesticides, these metals will likely remobilize to surface waters as the sea recedes and be transported into ambient air as dust from the dried lakebed. Detailed research must monitor the biogeochemistry of the lake water and focus on patterns of oxygen loss and toxic metal remobilization under different water management strategies.

4 Air Quality

Airborne dust fluxes at sites close to the Salton Sea are already in the high range of values observed at Owens Lake , Calif., before mitigation began; dust control there has already cost more than $2 billion.

Despite uncertainties in quantifying the impacts of a shrinking Salton Sea on local air pollution, measurement and modeling studies suggest that ongoing reductions in inflows will very likely contribute to worsening air quality for residents throughout the basin and beyond. A large fraction of the large particulate matter captured as dust at sites closest to the shore of the Salton Sea is associated with emissions from the lakebed and sea spray. Pungent and reactive gases are also regularly produced in the Sea and emitted to the atmosphere, contributing to noxious odors and formation of fine particulate matter. A drop in air quality will likely add additional burdens on communities already dealing with disproportionately high levels of ambient particulate matter and related respiratory issues. More work is necessary to fully understand the transport, composition, and health impacts of pollutants originating from the Salton Sea and its increasingly exposed lakebed, and to inform and guide mitigation efforts aimed at improving the health and well-being of local communities.

GYPSUM-LADEN SALT CRUST on the exposed lakebed near Desert Shores. Caroline Hung

Ecology 5

Without significant freshwater introduction to the Salton Sea, the ecosystem faces collapse due to excessive nutrients, rising salinity, and declining water levels.

WETLANDS in Unit 2 of the Sonny Bono Salton Sea National Wildlife Refuge. Jonathan Nye

The dynamic and unstable Salton Sea historically has supported abundant wildlife, ranging from a diverse array of microorganisms to endangered species of fish and birds. Terrestrial desert ecosystems give way to agricultural fields, riparian zones, natural and managed wetlands, and the aquatic ecosystems of the lake itself, which are supported by water and nutrients derived largely from agricultural inputs. Excessive nutrient flows into the Salton Sea result in harmful algal blooms, threatening wildlife and humans. Declining water levels disrupt migration patterns for fish-eating birds and isolate populations of endangered desert pupfish inhabiting the Sea's margins, putting them at increased risk of extinction. The salinity of the Sea—at 74 parts per thousand already more than double that of the Pacific Ocean—will continue to rise as the sea shrinks, leading to a catastrophic collapse of the aquatic food web if the current trend is not halted.

Planned construction of wetland habitats may benefit certain species of birds; however, none of these plans address the core problems that limit ecosystem functioning.

6 Human Health

Respiratory illness and other consequences of the environmental hazards in and around the Salton Sea will likely amplify the region's significant social and economic disparities.

The ongoing crisis at the Salton Sea presents multiple consequences for the region's human residents. In communities already subject to disparities in social and economic status, the environmental hazards of life in the region—particularly increases in windblown dust that are expected as the shrinking sea exposes more dry lakebed—are evident from the epidemiology of diseases, especially pulmonary diseases such as asthma. Comorbid factors including the high incidence of obesity, poverty, poor access to health care, and chemical exposures from agriculture work further degrade the quality of life, driving additional impacts on mental health in the community. Continued environmental degradation at the Salton Sea accompanied by increased production of dust and other air pollutants has already impaired the economic and social fabric of the region. Health disparities and costs to the community will likely increase unless steps are taken to address the issues raised here.

NORTH SHORE YACHT CLUB, originally built along the shoreline, is now high and dry. Jonathan Nye

Geothermal Resources 7

Economic opportunities for developing non-traditional mineral and energy resources at the Salton Sea could help offset expected environmental and human health costs.

GEOTHERMAL POWER PLANT on the southeastern shore operating in the early morning. Jonathan Nye

The existing electrical generation industry at the Salton Sea Geothermal Field has tremendous potential to become a world-class producer of lithium and other critical metals, which can be extracted from geothermal brines. The industry could also generate nontraditional geothermal energy via production of electricity from pumped storage and by producing hydrogen via electrolysis, thereby boosting California's ability to meet legal mandates to produce more renewable energy while lowering greenhouse gas emissions. Development of these nontraditional resources together could make expanded geothermal power production at the Salton Sea more competitive with solar and wind power.

These efforts would lead to substantial local job creation and increased tax revenues. Multiple benefits would be maximized by coordinating the expansion of geothermal resources with reclamation plans for the Sea, as the receding shoreline opens up new land suitable for construction of both artificial wetlands and new geothermal infrastructure.