SALTON SEA
AIR QUALITY MITIGATION PROGRAM
2019 Stakeholder Overview
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BACKGROUND

As part of the agreement to reduce California's dependency on Colorado River Water, the Imperial Irrigation District (IID) is transferring 300,000 acre-feet of conserved water per year to other agencies. The conservation measures reduce the volume of return flows from agricultural use to the Salton Sea. As a result, the Sea is shrinking and exposed playa is increasing. Playa refers to the exposed, dry lakebed formerly inundated by the Salton Sea. In general, exposed playa surfaces are unprotected and subject to wind erosion. Airborne dust, or emissions, can affect air quality in nearby communities because a significant portion of the emissions is \( \text{PM}_{10} \), or particulate matter with an aerodynamic diameter of 10 micrometers or less. These particles are approximately \( \frac{1}{7} \)th the thickness of a human hair, are small enough to be inhaled, and represent a potential human health risk.
AIR QUALITY MITIGATION OVERVIEW

The Salton Sea Air Quality Mitigation Program was developed by IID to provide a comprehensive, science-based, adaptive approach to address air quality mitigation requirements associated with the water transfer agreement. Each component of the program is used to identify, prioritize, and guide implementation of dust control measures on exposed Salton Sea playa. The main components include 1) an annual Emissions Monitoring Program to estimate emissions and to identify areas of exposed playa for proactive dust control, 2) an annual Proactive Dust Control Plan with recommendations and design for site-specific dust control measures, and 3) implementation of dust control measures to prevent PM$_{10}$ dust source areas from becoming significant sources of dust emissions, and also scaling and adapting dust control measures to efficiently achieve control at a larger scale. The annual Emissions Monitoring Program is designed to work hand-in-hand with the development of the annual Proactive Dust Control Plan and subsequent implementation of dust control measures. This approach allows effective use of resources to help protect the public health of communities near and around the Salton Sea.
THE SALTON SEA AIR BASIN

An air basin is a geographic boundary for air quality standards based primarily on common air flow. The Salton Sea Air Basin includes Imperial County and a portion of Riverside County. The top three sources of \( \text{PM}_{10} \) in the air basin are the open desert areas surrounding the sea, unpaved roads, and agricultural operations. High \( \text{PM}_{10} \) concentrations transported from Mexicali, Mexico, are also considered a primary source of \( \text{PM}_{10} \) in Imperial County. The adjacent desert area is important because it is upwind of the playa and provides an unlimited supply of sediments that blow toward the Salton Sea and fragile playa surfaces, thus increasing the emissions potential of exposed playa.

Salton Sea playa emissions make up less than 1% of the total emissions in the Salton Sea Air Basin.

AIR QUALITY MITIGATION PROGRAM INFOGRAPHIC

This infographic provides information about each program component, including activity and progress at each step. This is a cyclical process that repeats each year, providing a growing amount of knowledge to address air quality mitigation at the Salton Sea.
The Salton Sea Air Quality Monitoring Network includes multiple air quality, meteorological, and camera stations for the purpose of monitoring and characterizing windblown dust in the Imperial Valley. The network includes 6 permanent and 5 portable stations around the Salton Sea, and 3 portable stations in the desert. The network was developed and is maintained by IID, in collaboration with the California Air Resources Board and the Environmental Protection Agency.
AIR QUALITY MONITORING STATIONS

The six permanent monitoring stations located around the Salton Sea are near existing communities, known emission sources, or sensitive receptor areas. These permanent stations monitor hourly average mass concentrations of particulate matter and associated meteorological parameters on a continuous basis. At each permanent station, a TEOM instrument continuously measures particulate matter concentrations. At two of the permanent stations, a Partisol instrument collects filter samples to provide elemental information on the chemical composition of the particles.

METEOROLOGICAL TOWERS

Meteorological towers are also installed near each permanent station. The meteorological towers are about 30 feet tall and measure wind direction, wind speed, relative humidity, solar radiation, and temperature. The portable monitoring stations monitor wind speed and direction at various locations and heights.

360-DEGREE CAMERAS

Two Roundshot cameras provide a 360-degree panoramic image every 10 minutes during the daylight hours. The Roundshot cameras provide live views of conditions at the south end of the Salton Sea and near Anza-Borrego in the Ocotillo Wells State Vehicular Recreation Area. An additional five still-frame cameras are distributed around the Sea. The Roundshot camera images can be viewed at www.iid.com/airquality.
EMISSIONS ESTIMATE

The annual Emissions Monitoring Program estimates emissions and identifies areas of exposed playa for proactive dust control. It also identifies the location and magnitude of emissions potential in desert areas adjacent to the Sea. The emissions estimate includes four key steps: map exposure, characterize surfaces, model wind conditions, and estimate emissions.

MAP EXPOSURE

Playa exposure is analyzed at the end of each year, when the Sea is at the lowest point of the hydrological cycle. Analysis includes use of satellite imagery, United States Geological Survey (USGS) water-surface elevation data, and high-resolution bathymetric data. The end-of-year 2002 shoreline (prior to the start of the conserved water transfer) serves as the baseline from which subsequent years are compared. Therefore, exposed playa for 2018 is defined as the total area of exposed land between the former Salton Sea shoreline at the end of 2002 and the shoreline at the end of 2018. Exposed playa is currently about 20,910 acres (32 square miles), including approximately 15,930 acres of bare playa, 4,290 acres of vegetation, and 690 acres of open water. The elevation of the Sea is expected to stabilize around 2047. At that time, the Salton Sea will be approximately two-thirds of its current size and there will be an estimated 130 square miles of exposed playa.

The timing and location of playa exposure is a function of the Salton Sea floor elevation and the Sea’s response to inflows, salt loads, and evaporation rates. Models originally developed to simulate the effects of the water transfer on Salton Sea elevation and salinity have since been refined to help estimate projected playa exposure. Projected playa exposure using the “median” model run is very close to actual playa exposure. Projected versus actual playa exposure will continue to be monitored as part of the Air Quality Mitigation Program.

THE EMISSIONS ESTIMATE INCLUDES FOUR KEY STEPS

1. MAP EXPOSURE

Current exposed playa is about 32 square miles. Around 2047, exposed playa is anticipated to peak at approximately 130 square miles.

2. CHARACTERIZE SURFACES

Analysis of over 1,125 surface surveys and PI-SWERL samples since 2016 provides an understanding of the type, location, and extent of surfaces vulnerable to erosion.

3. MODEL WIND CONDITIONS

The Weather Research and Forecasting model is used to simulate wind speed and wind direction based on data from almost 70 weather stations throughout the region.
4. ESTIMATE EMISSIONS

Emissions estimates are calculated based on the best available datasets and scientific methodology.

* 2017-2018 RESULTS

- NORTH - 0%
- EAST - 11%
- WEST - 63%
- SOUTH - 25%

Percentage of Total
Salton Sea Playa Emissions
Salton Sea Air Quality Mitigation Program

CHARACTERIZE SURFACES

Playa and desert surfaces are characterized annually to provide a better understanding of the type, location, and extent of surfaces vulnerable to erosion. Surface characteristics are directly related to the spatial and temporal nature of PM$_{10}$ emissions. The primary playa surface types are no-crust, smooth, weak botryoidal, botryoidal, and barnacles (image below). Playa surface characteristics are mapped using remotely-sensed data resources and ground-based surface evaluations. Each surface is sampled with a PI-SWERL, or Portable In-Situ Wind ERosion Laboratory, which simulates various wind speeds to measure the potential for surface and soil erosion (and associated dust emissions) of different surface types. PI-SWERL results are then used to identify the primary drivers of emissions.

Emissions potential is highly variable, but is driven by surface type, surface moisture, and the presence of loose surface sand. Overall, playa surfaces dominated by coarser-textured (sandy) soils have more predictable emissions because emissions are largely a factor of saltating sand (image page 11). In contrast, emissions from playa surfaces with finer-textured, clay soils have less predictable emissions because of sensitivity to environmental influences. For example, precipitation events, diurnal temperature changes, and relative humidity can cause playa surface characteristics to change and increase (or decrease) the potential for erosion.
In the desert, surface types range from relatively stable surfaces, like cobble and bedrock, to more emissive surfaces, like dry washes, sand sheets, and sand dunes. Sand intrusion from these areas will increase the emissions potential of exposed playa due to the associated surface disturbance and erosion.

The primary source of PM$_{10}$ emissions from exposed Salton Sea playa will likely be from saltation of sand and sand-sized soil particles. Saltation is the bouncing or leaping of sand and soil particles across the playa surface (image above). As particles saltate, they abrade surfaces and dislodge smaller particles, generating dust. Windblown erosion can also expose underlying, sometimes more erodible soil layers. Dust control measures are designed to reduce PM$_{10}$ emissions by reducing the availability and/or kinetic energy of saltating particles.

Weather variables, like wind speed and wind direction, play a pivotal role in emissions potential. Although there are numerous point weather observation stations in the study area, the station data only represent the point of collection and adjacent areas, and thus are not suitable to support estimation of dust emissions throughout the entire study area. Accordingly, the Weather Research and Forecasting model is used to estimate wind speed and wind direction based on almost 70 weather stations. Results are used to inform the emissions estimates and to identify and relate high wind speed events to observed emissions from the playa.
As described previously, the emissions estimates for the playa and the desert are based on the extent of various surface types, the surface characteristics and associated emissions potential, and simulated wind conditions. It is important to remember there are other non-negligible factors that impact PM$_{10}$ emissions potential. Nevertheless, these emissions estimates are comprehensive and calculated based on the best available datasets and scientific methodology.

The annual Emissions Monitoring Program is designed to work in tandem with proactive dust control planning and implementation to proactively mitigate windblown dust emissions at the Salton Sea. For example, existing and planned dust control pilot projects, as well as projects planned by other stakeholders, will cover over 7,750 acres. These areas account for over 51% of the total yearly playa emissions. More specifically, assuming 95% design control efficiency per project, the playa emissions estimate is 0.63 tons/day, compared to a playa emissions estimate of 1.23 tons/day with no dust control projects.
The annual Proactive Dust Control Plan describes recommendations for site-specific dust control measures based on rigorous evaluation of the surface characteristics and emissions potential. This evaluation considers soil suitability, the availability of water resources, other planned stakeholder projects, and more.

The overall goal of the Air Quality Mitigation Program is to keep playa emissions at low levels, even as playa exposure accelerates, through implementation of targeted, proactive dust control measures on priority playa areas. This approach provides flexibility for implementing effective dust control measures in the most cost-efficient manner and for facilitating dust control actions at the Salton Sea.

The success of the proactive dust control strategy requires the development and testing of a range of dust control measures that can be quickly implemented, adequately maintain a stabilized surface, and prevent the spread of emissive source areas as playa is exposed. Each year, a Proactive Dust Control Plan recommends site-specific dust control measures based on rigorous evaluation of the emissions potential, soil suitability, the availability of water resources, other planned stakeholder projects, and more.

The primary dust control measures recommended are surface roughening and vegetation. Surface roughening is recognized around the world as an effective dust control measure on exposed surfaces. It provides quick, waterless, and effective control. Vegetation is also widely recognized as an effective dust control measure, but requires irrigation for establishment. A series of plot and field studies inform how to tailor these dust control measures to Salton Sea soils and climate.
Planning for implementation of dust control measures requires soil information, particularly texture and salinity. Due to the expansive area of exposed playa, a high-throughput method was developed to characterize soil conditions. Methods include an electromagnetic survey (EMI) to select soil coring locations, soil coring, and documentation and analysis of the soil cores. To date, soil conditions on over 7,500 acres of exposed playa have been characterized.

A high-resolution photo is taken using a custom-built photogrammetry workbench, including an automated camera station to take pictures every two inches. Individual photos are then stitched together to create a continuous, high-resolution soil core photo.

Spectroradiometer readings are collected at two-inch intervals along the core to inform soil texture, including percentage of sand and clay. Sub-samples of the cores are also taken at intervals that represented a single textural class and a single spectroradiometric measurement.
WATER AVAILABILITY

Water availability is another main driver of dust control measure suitability because vegetation requires irrigation for establishment. Surface water sources exist at the northern and southern areas of the Salton Sea, including agricultural drains, the Whitewater River (north), and the New and Alamo Rivers (south). Water supply from these agricultural drains and rivers supports stands of naturally-established vegetation. In the eastern and western areas of the Salton Sea, surface water flow occurs only with highly variable precipitation and is not a reliable source for vegetation establishment.

VEGETATION ESTABLISHMENT

Vegetation establishment is challenging due to high salinity in playa soils, limited water availability for irrigation, and the desert climate. Results from a series of plot-based studies provide key insights into effective vegetation establishment at the Salton Sea. The following page describes vegetation establishment strategies developed for the Salton Sea Air Quality Mitigation Program.
Vegetation Establishment Strategies

1. Species Selection

Iodine bush is the primary species used due to its high salinity tolerance. Other species, notably saltbush species and greasewood, may play a future role in more upslope plantings due to their greater rooting depth relative to iodine bush.

2. Cultivation Strategies

Cultivation strategies increase the chances of successful plant establishment. Key strategies include proper siting relative to depth to groundwater, seed treatments to increase germination, irrigation to reduce soil salinity and support establishment, soil amendments to increase plant growth rate, and prevention of sand burial. Sand burial prevention and irrigation are critical to successful vegetation establishment.

3. Irrigation

The use of flooded furrows with seed spread onto the surface is effective for rapid vegetation establishment and works for most species, including iodine bush. However, the resulting hedgerow may contain some gaps and require infill plantings to enhance dust control. Scheduling seeding to occur after the high-wind months of March through May can reduce the amount of seed dispersion and reduce sand burial.
IMPLEMENTATION

The annual Proactive Dust Control Plan describes recommendations for site-specific dust control measures based on rigorous evaluation of the surface characteristics and emissions potential. This evaluation considers soil suitability, the availability of water resources, other planned stakeholder projects, and more.

Constructed, designed, and recently identified field studies will cover over 5,300 acres of high-priority playa. Surface roughening continues to be recommended for all field study areas with suitable playa and soil conditions. This dust control measure is effective, waterless, and can be quickly implemented. However, it is unsuitable for areas with predominantly coarse-grained soils due to the rapid degradation of ridges in sandy soils. For these areas, vegetation is recommended. For most field studies, a combination of surface roughening and vegetation is recommended based on site-specific suitability.

Field study areas account for nearly 43% of the total yearly emissions (192 of the 447 tons/year of PM$_{10}$) identified in the 2017/2018 Emissions Estimate. When considered together with projects planned by other stakeholders, the acreage increases to approximately 7,750 acres of dust control and habitat projects. These areas account for over 51% of the total yearly playa emissions (228 of the 447 tons of PM$_{10}$).
This map shows the locations of existing and recommended field study areas. Implementation of the field studies is subject to funding authorized by the Quantification Settlement Agreement Joint Powers Authority.

IMPLEMENTATION OF MULTI-PURPOSE FIELD STUDIES ACCOMPLISHES THE FOLLOWING:

- Provides cost-effective dust control for the majority of priority playa areas that are not currently incorporated into existing IID field studies, projects by stakeholders, or the Salton Sea Management Plan.

- Facilitates continued evaluation of dust control effectiveness and implementability using a combination of dust control techniques at a larger scale.

- Continues refinement of dust control performance monitoring techniques and identifies appropriate criteria for triggering management, augmentation, or replacement of dust control measures.

- Adaptively refines the proactive dust control planning and design process based on findings from implementation of the field studies.
Select Field Studies

- **The Alamo North Field Study** includes approximately 205 acres of surface roughening and vegetation. As shown in the 2016 to 2019 comparison, a single large pulse of water through a hand-seeded furrow was adequate to establish a nearly continuous vegetation hedgerow.

- **The Alamo South Field Study** includes approximately 220 acres of surface roughening and vegetation. Similar to the Alamo North Field Study, a single large pulse of water was used to establish vegetation at designated spacings throughout the field study area. Gap-filling of some hedgerows is planned for 2019/2020.

- **The Poe Road Field Study** includes approximately 330 acres of surface roughening and vegetation based on site-specific suitability. Gap-filling of some hedgerows is planned for 2019/2020.
Development of dust control performance monitoring techniques and appropriate maintenance criteria are another main focus of the Air Quality Mitigation Program. These are essential for ensuring adequate surface stabilization over time.

Two approaches for monitoring dust control performance include ground-based environmental sensors and remote sensing. Performance monitoring data are most informative when they can be readily compared to the original design criteria developed for the site. These design criteria originate from the Single-event Wind Erosion Evaluation Program (SWEEP). SWEEP is a physically-based model used to design site-specific dust control measures based on soils, vegetation, surface roughness, and local 24-hour high wind event attributes. While environmental sensors provide more direct measures of windblown sand flux, they are limited in spatial extent and are subject to bias introduced in the sampling design. On the other hand, remote sensing provides a spatially comprehensive measurement, thus removing sampling bias, and when coupled with a physically-based model (e.g., SWEEP), sand flux can be accurately estimated.

GROUND-BASED SENSORS

Ground-based sensors, including Cox Sand Catchers, Sensits, and BGI PQ200 ambient air particulate samplers, are used to measure real-time horizontal sand fluxes. These sensors can be placed upwind of dust control areas to provide a baseline of particle movement, mid-area to quantify reduction of the baseline, and downwind to assess the full impact of the treatment. Collected data are useful to validate SWEEP modeling, assess the performance of dust control measures, and guide planning and future implementation of proactive dust control.

Image Left:
The Cox Sand Catcher is a positionally-fixed vertical tube that physically traps saltating particles at six inches above the soil surface (small orange tube on the left). Sensits use a piezoelectric crystal to measure saltating particles that strike the sensor surface. Like the CSC, the Sensit is positionally fixed, but it has the advantage of providing highly-resolved data at specified logging intervals. A data logger with a solar panel collects data from the site.
Uncontrolled playa emissions vs. implemented field study at Alamo South captured from HD video monitoring

REMOTELY-SENSED PERFORMANCE MONITORING

After dust control measure implementation, vegetation and surface roughness can be quantified using remote-sensing-based methods (e.g., Light Detection And Ranging [LiDAR]), evaluated within SWEEP, and used to understand dust control performance relative to the design criteria.

This approach is:

- accurate and repeatable
- spatially comprehensive
- scalable effectively and efficiently to large areas
- cost-efficient

In 2018, a remote-sensing-based monitoring technique was developed using ultra-dense LiDAR point clouds. A series of algorithms were developed to translate the LiDAR data into surface roughness attributes used in the SWEEP model. This includes ridge height, ridge spacing, surface roughness length, and random roughness. Surface roughness conditions can now be assessed using LiDAR each quarter following dust control measure installation and compared to the design criteria. This allows dust control maintenance activities to occur, such as retilling, and for the restoration of roughness that has eroded over time. As an example, results from the Alamo South field study area are shown in the image above.
The Salton Sea has and continues to be an important stop-over for millions of migratory birds moving along the Pacific Flyway. As the transfer of conserved water ramps up, increased salinity is and will continue to accelerate changes to the food web, significantly reducing the quality and availability of habitat for these migratory birds. IID and other stakeholders are targeting critical habitat creation and enhancement projects to minimize impacts to migratory birds and other important waterfowl, and to provide air quality benefits by protecting the playa surface. For example, the State of California’s Salton Sea Management Plan, Phase 1 (10-Year Plan), was developed to expedite implementation of habitat and dust mitigation projects. The 10-Year Plan defines acreage goals for habitat and dust mitigation projects annually between 2019 and 2029.

Currently planned stakeholder projects include the California Natural Resources Agency’s Species Conservation Habitat Project, the US Fish and Wildlife Service’s Red Hill Bay Project, and the Torres Martinez Wetland Project. In addition, the National Audubon Society is working to quickly develop projects that provide immediate habitat benefits while balancing the goals of both habitat creation and proactive dust control. These targeted projects are needed to “bridge the gap” while large-scale habitat is designed and constructed by the State of California (implementation planned in 2023 at the earliest). Prior to large-scale implementation in 2023, playa exposure and salinity are projected to increase to over 48,000 acres and 90,000 milligrams per liter, respectively.
CHALLENGES AT THE SALTON SEA

There are several challenges associated with air quality mitigation at the Salton Sea. In particular, the western side of the Salton Sea is responsible for the majority (63%) of playa emissions and will be the most challenging to control.

01 SAND INTRUSION FROM UPWIND DESERT

There is no buffer to slow high westerly winds before they reach the playa. The adjacent desert area provides an unlimited supply of sediments that blow onto the playa during high-velocity winds. In many locations, sand dunes and sand sheets are advancing eastward toward exposed playa. For example, aeolian sand from dunes and sand sheets adjacent to the Naval Test Base continue to migrate onto the playa, increasing estimated playa emissions by approximately five times compared to adjacent playa areas without evidence of sand migration. In addition, fluvial deposition and migration of sand down dry washes and alluvial fans continue to occur and increase emissions.

02 SOIL SUITABILITY AND LIMITED WATER RESOURCES

Second, there is limited suitability for surface roughening and limited water resources for vegetation establishment on the western side. Soils here were deposited primarily from alluvial flow, and soil core data indicate much of this area has coarse-textured soils. Although there are many small watersheds, surface flow varies significantly based on precipitation and is not reliable for vegetation establishment. Groundwater and use of mobile reservoirs are currently being evaluated as an alternative irrigation source.
Questions?

For more information on IID’s Salton Sea Air Quality Mitigation Program, please visit www.iid.com/airquality.

Send questions to airquality@iid.com.