Oceano Dunes State Vehicular Recreation Area
Draft Particulate Matter Reduction Plan

June 2019

State of California

Department of Parks and Recreation

Off-Highway Motor Vehicle Recreation Division

THIS PAGE INTENTIONALLY LEFT BLANK.

Oceano Dunes SVRA
Draft Particulate Matter Reduction Plan

Table of Contents

List of Tables

List of Figures

PMRP Attachments (Separate Documents)

LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

Acronym / Symbol	Full Phrase or Description
APCO	Air Pollution Control Officer
BSNE	Big Springs Number Eight
CAAQS	California Ambient Air Quality Standards
CARB	California Air Resources Board
CALMET	California Meteorological Model
CCC	California Coastal Commission
CCR	California Code of Regulations
CDP	Coastal Development Permit
CDPR	California Department of Parks and Recreation
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CGS	California Geological Survey
CIMIS	California Irrigation Management Information System
DEM	Digital Elevation Model
DRI	Desert Research Institute
E-BAM	Environmental Beta Attenuation Mass
g/hr	Grams per Hour
h	height
HCP	Habitat Conservation Plan
LSPDM	Lagrangian Stochastic Particle Dispersion Model
m	Meters
m^3	Cubic Meters
m/s	Meters per Second
NAAR	North American Regional Reanalysis
NAAQS	National Ambient Air Quality Standards
NOAA	National Oceanic and Atmospheric Administration
NRP	Nipomo Regional Park
NWS	National Weather Service
OHMVR	Off-Highway Motor Vehicle Recreation
OHV	Off-Highway Vehicle
PI-SWERL®	Portable In-Situ Wind Erosion Laboratory
PM	Particulate Matter
PMRP	Particulate Matter Reduction Plan
$PM_{2.5}$	Fine Particulate Matter
PM_{10}	Coarse Particulate Matter
PRC	Public Resources Code
S	Second

LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

Acronym / Symbol	Full Phrase or Description
SAG	Scientific Advisory Group
SfM	Structure-from-Motion
SIO	Scripps Institution of Oceanography
SLO	San Luis Obispo
SLOAPCD	San Luis Obispo County Air Pollution Control District
SOA	Stipulated Order of Abatement
SODAR	Sonic Detection and Ranging
SVRA	State Vehicular Recreation Area
UAS	Unmanned Aerial System
US	United States
USC	United States Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
µg	Micrograms
µm	Microns / Micrometers
$	U.S. Dollar
%	Percent

EXECUTIVE SUMMARY

The California Department of Parks and Recreation, Off-Highway Motor Vehicle Recreation Division (OHMVR Division) has prepared this Particulate Matter Reduction Plan (PMRP) for Oceano Dunes State Vehicular Recreation Area (Oceano Dunes SVRA) to comply with Condition 2 of the Stipulated Order of Abatement (SOA) approved by the San Luis Obispo Air Pollution Control District (SLOAPCD) Hearing Board in April 2018. The purposes of the PMRP are to:

- Document the efforts needed to comply with the SOA.
- Provide the initial, conceptual plan to control and reduce PM_{10} emissions from Oceano Dunes SVRA over an approximately four-year period from 2019 to 2023.
- Document the modeled baseline conditions against which the OHMVR Division and the SLOAPCD will measure the achievement and success of dust control measures installed at Oceano Dunes SVRA.
- Provide the best current information regarding the ability of the OHMVR to install dust control measures at Oceano Dunes SVRA that achieve federal and state ambient air quality standards.

The measurement and control of dust from an active coastal dune setting on the scale required by the SOA is unprecedented and will require a substantial investment of materials, staff, and economic resources by the State of California, as well as significant coordination with other government agencies. The PMRP is based on the best information currently available to the OHMVR Division, the SLOAPCD, and the Scientific Advisory Group (SAG) intended to evaluate, assess, and provide recommendations on the PMRP and its PM_{10} mitigation strategies; however, the SOA implicitly recognizes the need for the PMRP to be updated over time. The preparation of Annual Reports and Work Plans, as outlined in SOA Condition 4, call for the OHMVR Division, the SAG, and the SLOAPCD to evaluate progress towards achieving SOA objectives in detail, modify planned dust control measures based on empirical data and evidence, improve model formulation, and identify additional actions necessary to fill in gaps in information or resource availability. The OHMVR Division, therefore, will employ an adaptive management approach to dust control at Oceano Dunes SVRA that compares PMRP predictions to real world measurements and refines PMRP assumptions, methodologies and predictions, and dust control strategies as new information becomes available.

The PMRP includes a series of hypothetical dust control modeling scenarios that preliminarily evaluates the approximate size, scale, and level of effort necessary to comply with the SOA's air quality objectives. While it is currently unknown what level of dust control efforts will be needed to comply with the SOA, the results of this analysis indicate that at least 500 total acres of dust control measures (including approximately 132 acres of existing controls), namely vegetation, would reduce PM_{10} emissions from Oceano Dunes SVRA by 36.1% to 51.9%, depending on the modeled scenario, and reduce the amount of PM_{10} measured at SLOAPCD's CDF air quality monitoring station by 31.6% to 50%, depending on the modeled scenario. Although the hypothetical dust control modeling scenarios will inform the OHMVR Division's future Work Plans, it does not constitute the discrete action plan for dust control at Oceano Dunes SVRA. Future proposed dust control efforts will be refined based on additional monitoring and new modeling results. Future dust control projects will also need to be in compliance with applicable statute and permitting requirements, and be evaluated for potential environmental impacts in compliance with CEQA and the California Coastal Act.

In light of the preliminary information presented in this PMRP, the OHMVR Division, the SAG, and the SLOAPCD will need to carefully consider the suitability of the SOA's identified baseline, the use and application of the resources available for controlling dust, and the appropriate increments of progress towards achieving SOA air quality objectives.

1 Introduction

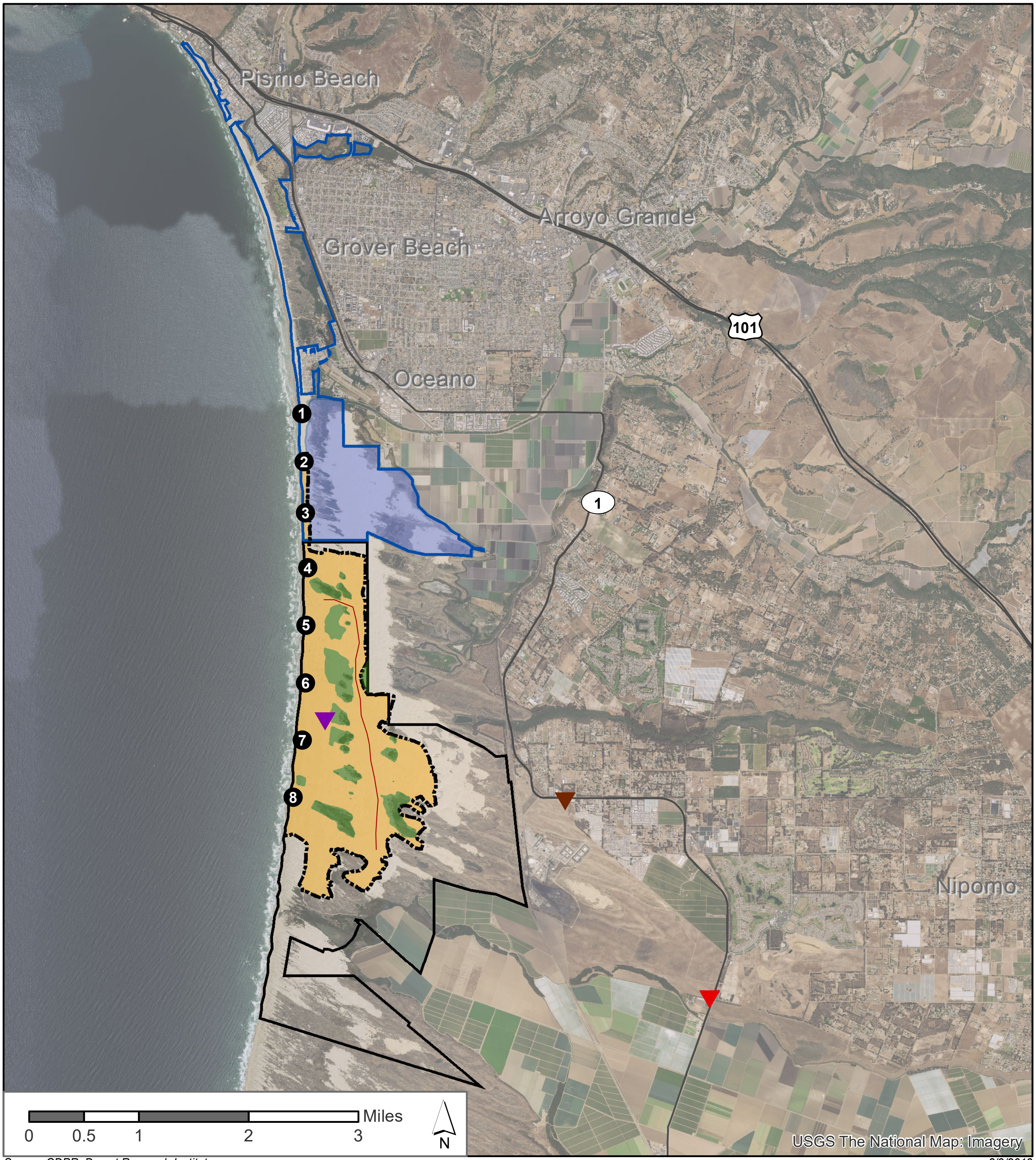
This Particulate Matter Reduction Plan (PMRP) document represents the latest and most comprehensive plan to address dust and particulate matter, or PM, emissions at Oceano Dunes State Vehicular Recreation Area (SVRA), an established, approximately 3,600-acre unit of the California State Parks system that provides motorized and non-motorized recreational opportunities[1]. The SVRA is located on California's Central Coast, in southwestern San Luis Obispo (SLO) County, adjacent to the "Five Cities" area of Arroyo Grande, Grover Beach, Pismo Beach, Oceano, and Shell Beach. The SVRA borders and is contiguous with parts of Pismo State Beach. The Oceano Dunes District manages and oversees operation of both parks, which provide public access to beaches and coastal recreation opportunities, including off-highway vehicle (OHV) recreation in certain designated areas. Figure 1-1 shows the general setting for Oceano Dunes SVRA.

1.1 Background on Dust and PM Emissions at Oceano Dunes SVRA

Oceano Dunes SVRA, as well as adjoining Pismo State Beach and Pismo Dunes Natural Preserve, is located in the Guadalupe-Nipomo Dunes Complex, an approximately 18,000-acre, 18-mile long coastal dune landscape consisting of several distinct dune sheets. Oceano Dunes SVRA is also one of the few coastal areas in California where on- and off-highway vehicles (OHV) may be legally operated on a beach. The SVRA includes approximately 5 ½ miles of beach and 1,400 acres of sand dunes that are seasonally open to OHV use.

According to the California Geological Survey (CGS), Oceano Dunes SVRA is located within the youngest, most active area of the Callender dune sheet complex, where aeolian (wind) transport of sand is ongoing and dunes are actively migrating inland several feet per year (CGS, 2007). The dunes, including the area in which Oceano Dunes SVRA is located, are exposed to

[1] The PMRP uses both the terms "dust" and "particulate matter." While these terms are similar, CARB and SLOAPCD generally define dust as "solid" particles that can become airborne (CARB, 2019 and SLOAPCD, 2013). In contrast, particulate matter is a regulated air pollutant under the federal and California Clean Air Act that includes both solid and liquid particles. For example, Title 17 of the California Code of Regulations, Section 70100, refers to PM_{10} as "atmospheric particles, solid or liquid, except uncombined water . . ."



Source: CDPR, Desert Research Institute

2/3/2019

- Marker post
- Sand Highway, approx.
- Riding area boundary fence
- Fenced vegetation islands (no vehicles allowed)
- Open riding and camping area

Wind monitoring towers

- CDF
- Mesa 2
- S1

Oceano Dunes District

- Oceano Dunes State Vehicular Riding Area
- Pismo State Beach
- Pismo Dunes Natural Preserve

1-1 Oceano Dunes SVRA Overview

Oceano Dunes SVRA 2019 PMRP

strong and frequent prevailing winds from the northwest (i.e., blowing towards the southeast), especially during the springtime (approximately March through June) (SLOAPCD, 2007). These strong prevailing winds exert a force on the surface of the dunes that causes particles to move along the ground surface. This movement can take the form of sand creep, in which sand grains are pushed along the ground surface, or saltation, in which sand grains are lifted by the wind, carried a short distance (generally a few inches to a few feet), and then fall back down to the ground surface. These processes can cause some particles to become suspended in the air and carried away downwind. The saltation process is depicted in Figure 1-2.

Figure 1-2: Saltation and Dust Generation Process

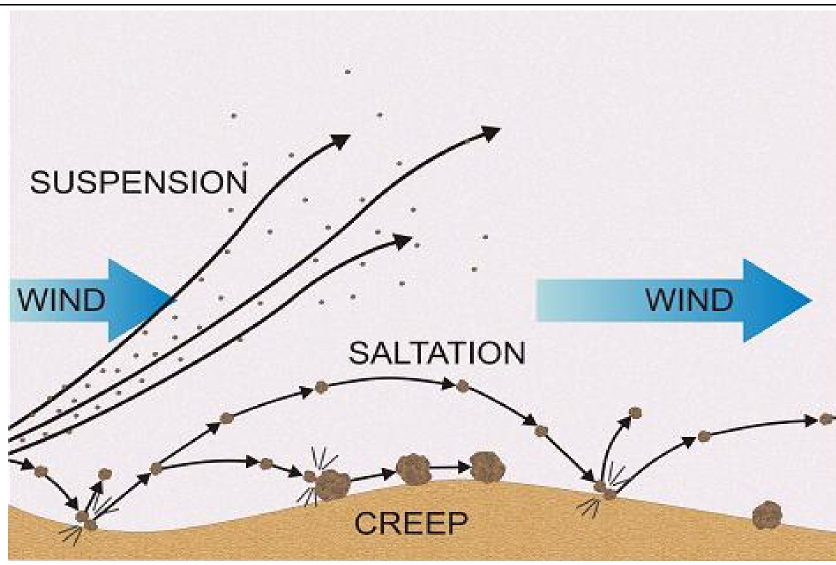


Figure 1-2. Wind results in sand creep or saltation and the suspension of fine particles. Image source: Jaison, 2012.

1.1.1 Measured Exceedances of Air Quality Standards

Generally, when winds exceed approximately 10 miles per hour, the sand grains in the unvegetated dunes that naturally form in the Guadalupe-Nipomo Dunes Complex begin to creep or saltate and generate dust and PM that can affect air quality conditions. The San Luis Obispo County Air Pollution Control District, or SLOAPCD, is the local agency charged with preserving air quality in SLO County. The SLOAPCD maintains and operates three ambient air quality monitoring stations in the South County Region in which Oceano Dunes SVRA is located (see Figure 1-1): CDF, Mesa2, and Nipomo Regional Park (NRP) (SLOAPCD, 2017). These stations are located downwind of Oceano Dunes SVRA, on the Nipomo Mesa. The SLOAPCD's air quality monitoring stations measure ambient concentrations of PM, which is a regulated air pollutant under both the federal and state Clean Air Act. PM is known to cause adverse lung, heart, and other health effects, and is considered a "criteria" air pollutant because the U.S. Environmental Protection Agency (USEPA) and the California Air Resources Board (CARB) regulate PM on the basis of human health and/or environmentally-based criteria (USEPA, 2018a). The federal and state Clean Air Acts regulate two kinds of particulate matter: PM_{10}, also called "inhalable coarse" PM, which consists of particles with an aerodynamic diameter of 10 micrometers or less, and $PM_{2.5}$, also called "fine" particulate matter, which consists of particles with an aerodynamic diameter of 2.5 microns or less. Both types of PM are very small, invisible to the naked eye, and are capable of penetrating deep into the lungs (and potentially bloodstream), resulting in adverse health effects such as asthma, decreased lung function, heart attack, and premature death (USEPA, 2018b). Figure 1-3 provides a graphical depiction of the size of PM_{10} and $PM_{2.5}$ particles.

Figure 1-3: Particulate Matter

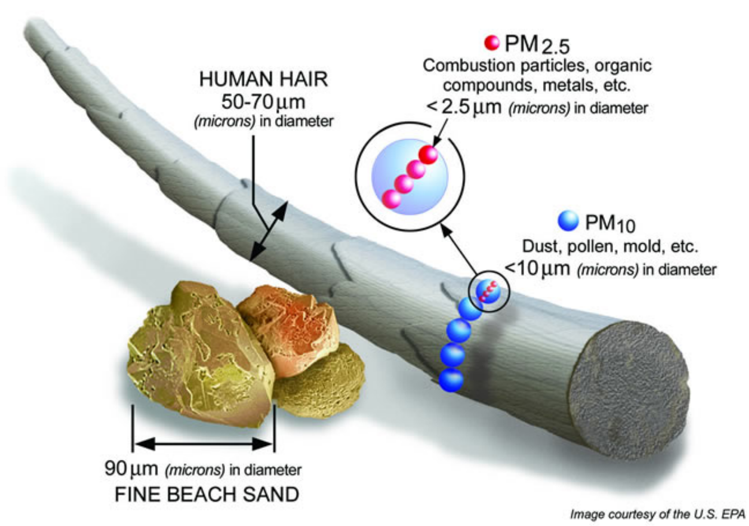


Figure 1-3. PM_{10} particles are approximately five to seven times smaller than the diameter of a human hair. $PM_{2.5}$ particles are approximately 20 to 25 times smaller than the diameter of a human hair. Image source: USEPA, 2018b.

Of the three South County monitoring stations, CDF is the closest to Oceano Dunes SVRA, approximately 0.5 miles southeast of Oceano Dunes SVRA (as measured in the prevailing wind direction, see Figure 1-1). The NRP station is the farthest away from Oceano Dunes SVRA, more than five miles southeast of the SVRA. Mesa2 is of middle proximity, approximately two miles southeast of the SVRA.

According to the SLOAPCD, from May 29, 2012 through October 19, 2017, the SLOAPCD received 133 dust-related complaints from residents downwind of Oceano Dunes SVRA (SOA pg. 5, lines 17-19). Furthermore, the SLOACPD reports that from May 1, 2012 to March 31, 2017 there were 363 different days when the SLOAPCD observed exceedances of the state's 24-hours PM_{10} air quality standard (50 micrograms per cubic meter, or $\mu g/m^3$), including 356 exceedances at the CDF station, 190 exceedances at the Mesa2 station, and 59 exceedances at the NRP station (SOA pg. 5, lines 20-28). The CDF station also exceeded the federal 24-hour PM_{10} standard (150 $\mu g/m^3$) seven times during this time period. After examining the wind speed and wind direction data for this time period, the SLOAPCD has determined the primary source of these exceedances is the Oceano Dunes SVRA OHV use areas located upwind of the Nipomo Mesa (SOA pg. 6 line 1-4). Computer modeling by CARB also supports this SLOACPD determination (SOA pg. 5, line 28, and pg. 6 lines 4-7).

This PMRP focuses on controlling and reducing PM_{10} emissions from Oceano Dunes SVRA. Planning for the control and reduction of PM_{10} emissions will also control and reduce $PM_{2.5}$ emissions; however, the PMRP does not set specific goals related to the reduction of $PM_{2.5}$ emissions.

1.2 Regulatory Basis for the PMRP

The PMRP is needed to comply with a Stipulated Order of Abatement approved by the SLOAPCD Hearing Board in April 2018 to address alleged nuisances pursuant to SLOAPCD Rule 402 and California Health and Safety Code Section 41700. Refer to Attachment 1 for the SOA.

The purposes of the PMRP are to:

1) Document the efforts needed to comply with the SOA.

2) Provide the initial, conceptual plan to control and reduce PM_{10} emissions from Oceano Dunes SVRA over an approximately four-year period from 2019 to 2023.
3) Document the modeled baseline conditions against which the OHMVR Division and the SLOAPCD will measure the achievement and success of dust control measures installed at Oceano Dunes SVRA
4) Provide the best current information regarding the ability of the OHMVR Division to install dust control measures at Oceano Dunes SVRA that achieve federal and state ambient air quality standards.
5) Provide other information relevant to the long-term feasibility, support, and implementation of dust control measures at Oceano Dunes SVRA.

1.3 PMRP Implementation

The California Department of Parks and Recreation, OHMVR Division is the main entity responsible for implementing this PMRP.

The California Department of Parks and Recreation, OHMVR Division may be assisted by other government agencies and consultants as deemed necessary to develop and implement this PMRP. Pursuant to the SOA, the other agencies involved in the development and implementation of dust control measures at Oceano Dunes SVRA will include:

- The Scientific Advisory Group (SAG; see Section 1.4) will evaluate, assess, and provide recommendations on the mitigation of windblown PM_{10} emissions from Oceano Dunes SVRA and on the development of the PMRP and associated documents, such as annual work plans and reports describing dust control measures (see Section 2.3).
- The SLOAPCD will conduct public review processes, review and approve the PMRP and associated documents, enforce schedules and required PMRP actions, evaluate the need for controls on source of PM_{10} external to Oceano Dunes SVRA that may impact PM_{10} levels on the Nipomo Mesa, and conduct all ambient air quality monitoring at CDF, Oso Flaco, and other air quality stations outside Oceano Dunes SVRA.

- The California Coastal Commission will, as needed, review and approve dust control actions for consistency with the California Coastal Act and coastal development permits issued to the OHMVR Division.
- The United States Department of Fish and Wildlife and California Department of Fish and Wildlife may have some permitting and oversight of dust control actions, depending on the types of projects and their potential to impact habitat or individuals listed under the State and Federal Endangered Species Acts.

1.4 Scientific Advisory Group

SOA Condition 3 calls for the creation of a SAG to evaluate, assess, and provide recommendations on the PMRP and its PM_{10} mitigation strategies. The primary responsibilities of the SAG are to:

- Review scientific and technical issues related to the research, development and implementation of windblown PM_{10} controls.
- Prepare technical specifications and analyses of proposed dust control measures.
- Foster communication and understanding of the scientific and technical aspects of PM10 emission control approaches.
- Provide scientific analysis and recommendations to the OHMVR Division for the development of the PMRP.
- Provide critical analyses of the PMRP for use by the SLOAPCD and its Air Pollution Control Officer (APCO).
- Provide critical analyses of the OHMVR Division's annual Reports and Work Plans for use by the SLOAPCD and its APCO.
- Provide a means to increase cooperation and collaboration between the OHMVR Division, SLOAPCD and its APCO, and affected stakeholders.

This PMRP has been prepared by the OHMVR Division, with input from members of the SAG as follows:

- William Nickling, Ph.D., Professor Emeritus, University of Guelph: Dr. Nickling provided preliminary input and recommendations on the PMRP's 2013 baseline modeling (Chapter 4) and updated PI-SWERL measurements (Section 7.1).
- Jack Gillies, Ph.D., Research Professor, Desert Research Institute: Dr. Gillies provided input and recommendations on the PMRP's modeling methodology (Chapter 3), 2013 baseline modeling (Chapter 4), Preliminary Compliance Analysis (Chapter 5), porous fencing and artificial roughness measures (Section 6.2.2), updated PI-SWERL measurements (Section 7.1), and additional air quality monitoring (Section 7.2).
- Carla Scheidlinger, Senior Scientist and Restoration Ecologist, Wood PLC: Carla Scheidlinger provided preliminary input and recommendations on the PMRP's vegetation (Section 6.1) and continuous foredune (Section 6.2.1) control measures.
- Mike Bush, Department of Horticulture and Crop Science, California Polytechnic State University: Mike Bush provided preliminary input and recommendations on PMRP's vegetation (Section 6.1) and continuous foredune (Section 6.2.1) control measures.
- Ian Walker, Ph.D., Professor, School of Geographical Sciences and Urban Planning, Arizona State University: Dr. Walker provided preliminary input and recommendations on the PMRP's foredune control measure (Section 6.2.1), additional air quality monitoring (Section 7.2), SODAR (Section 7.4), and foredune monitoring (Section 7.5).
- Cheryl McKenna Neuman, Ph.D., Professor, School of the Environment, Trent University: Dr. Mckenna-Neuman provided preliminary input and recommendations on the PMRP's additional air quality monitoring (Section 7.2).
- Raleigh Martin, Ph.D., Geosciences Directorate, National Science Foundation: Dr. Martin provided preliminary input and recommendations on the PMRP's modeling methodology (Chapter 3), 2013 baseline modeling (Chapter 4), and additional air quality monitoring (Section 7.2).
- Earl Withycombe, Air Resources Engineer, California Air Resources Board, provided preliminary input and recommendations on PMRP's modeling methodology (Chapter 3).

The SAG members listed above will review and provide additional detailed comments on the PMRP for use by the SLOAPCD and its APCO.

THIS PAGE INTENTIONALLY LEFT BLANK.

2 PMRP Objectives and Implementation

This chapter describes the three fundamental objectives the SOA sets for the PMRP, the OHMVR Division adaptive management and planning approach to implementing the PMRP, and other considerations that affect PMRP implementation, such as compliance with other laws and regulations.

2.1 SOA Objectives

The SOA requires the PMRP cover a four-year time period and satisfy specific air quality standard and emissions reduction objectives. These requirements are described below.

2.1.1 PMRP 4-Year Term (SOA Condition 2.a)

SOA Condition 2.a specifies the term of the PMRP shall be for four (4) years from the date the SLOAPCD APCO approves the PMRP.

While the SOA does not set a specific calendar date by which the OHMVR Division must receive APCO approval for the PMRP, conditions 2.g through 2.j do set forth the process by which the OHMVR Division shall obtain APCO approval of the PMRP. In addition, SOA conditions 5.a through 5.d set forth specific calendar dates for the OHMVR Division to submit Annual Reports and Work Plans to the SAG and the APCO, and the process by which the OHMVR Division shall obtain APCO approval of these reports and plans. Finally, SOA Condition 6.a specifies the SLOAPCD Hearing Board shall retain jurisdiction over the SOA until December 1, 2023, at which point the SOA shall expire (unless the OHMVR Division or the APCO applies to modify the SOA's terms and conditions).

The OHMVR Division anticipates the SOA PMRP approval process will not be complete until mid- to late-Spring 2019. Therefore, the PMRP plans for the implementation of dust control measures over the four-year term shown in Table 2-1. Both the SOA and the PMRP identify the importance and need for vegetation as a means of dust control. While the OHMVR Division grows native vegetation year-round at various nursery facilities (see Section 6.1), dune planting efforts primarily occur during the late fall and winter to take advantage of the rainy season. In addition, although the SOA requires the OHMVR Division to submit its initial Annual Work Plan by August 1, 2019 (SOA Condition 5.a), it may take up to approximately 80 days for the APCO to approve the Work Plan (SOA Conditions 5.b through 5.d). Accordingly, APCO approval and the installation of dust control measures identified in the Annual Work Plan is expected to commence in the fall of one year and, if necessary, conclude in the summer of the following year.

Table 2-1: Preliminary PMRP 4-Year Term and Annual Work Plan and Report Due Dates

PMRP Planning and Implementation	Annual Work Plan Due Date	Annual Report Due Date
Year 1 (Fall 2019 to Summer 2020)	August 1, 2019	August 1, 2020
Year 2 (Fall 2020 to Summer 2021)	August 1, 2020	August 1, 2021
Year 3 (Fall 2021 to Summer 2022)	August 1, 2021	August 1, 2022
Year 4 (Fall 2022 to Summer 2023)	August 1, 2022	August 1, 2023

The PMRP investigates the overall ability of the OHMVR Division to meet SOA air quality objectives, based on the estimated magnitude of dust control measures identified by the PMRP modeling (see Chapter 4 and Chapter 5). As discussed further below, the OHVMR Division would prepare Annual Work Plans and Reports for SAG and SLOAPCD review and approval that would describe and inform the actual dust control measures installed each year at Oceano Dunes SVRA.

2.1.2 Achieve State and Federal Ambient Air Quality Standards (SOA 2.b)

SOA Condition 2.b requires the PMRP be designed to achieve the state and federal ambient air quality standards for PM_{10}. These standards are typically referred to as California Ambient Air Quality Standards, or CAAQS, and National Ambient Air Quality Standards, or NAAQS. The CAAQS and NAAQS for PM_{10} are shown in Table 2-2.

Table 2-2: California and National Ambient Air Quality Standards for PM_{10}		
Averaging Time	**California Standard**	**National Standard**
24-Hour Average	50 $\mu g/m^3$	150 $\mu g/m^3$
Annual Average	20 $\mu g/m^3$	No standard adopted
Source: CARB, 2016.		

According to CARB, ambient air quality standards “define clean air, and are established to protect the health of the most sensitive groups in our communities. An air quality standard defines the maximum amount of a pollutant averaged over a specified period of time that can be present in outdoor air without any harmful effects on people or the environment (CARB, 2019b).”

The CAAQS and NAAQS are mass concentration-based standards that require measurement and analysis of ambient air to determine compliance with the standard. As described in Section 1.1.1, the SLOAPCD maintains a network of air monitoring stations that is designed to collect data for comparison to the CAAQS and NAAQS. Although SOA Condition 2.b does not identify the specific air monitoring station where the PMRP must achieve ambient air quality standards, the CDF station is located closest to Oceano Dunes SVRA. It is also the air monitoring station that, historically, has been used by the SLOAPCD and CARB to characterize air quality impacts associated with PM_{10} emissions from Oceano Dunes SVRA. Finally, the SLOAPCD’s 2018 Annual Ambient Air Monitoring Network Plan identifies the CDF air monitoring station measures “source impacts” from the Oceano Dunes SVRA, records the highest particulate levels in the County, and is strongly influenced by Oceano Dunes SVRA.

For the reasons listed above, the PMRP evaluates compliance with SOA Condition 2.b by evaluating modeled and actual, measured concentrations PM_{10} concentrations at the SLOAPCD’s CDF air monitoring station.

2.1.3 Reduce Maximum 24-Hour PM_{10} Baseline Emissions by 50% (SOA Condition 2.c)

To meet the objective of SOA Condition 2.b (achieve state and federal air quality standards), SOA Condition 2.c requires the PMRP establish an initial target of reducing maximum 24-hour PM_{10} baseline emissions by 50%. The fulfillment of this SOA objective is to be achieved through the use of air quality modeling to define the baseline emissions conditions for the time period May 1, 2013 through August 31, 2013, which was prior to any major dust controls being implemented. In contrast to the CAAQS and NAAQS described in Section 2.1.2, which are mass concentration-based standards, SOA Condition 2.c is a mass-emissions based objective. The OHMVR Division must model and identify the maximum amount of PM_{10} mass (e.g., tons) emitted by Oceano Dunes SVRA over a 24-hour period during the 2013 baseline time period, input dust control measures into the model, and determine the reduction in PM_{10} mass achieved by the dust control measures based on use of the air quality model.

In addition, whereas achieving the CAAQS and NAAQS will be determined through a combination of modeling and ambient air quality measurements that will further inform dust control measures as the PMRP moves forward (see Section 2.2), the mass reduction in emissions required by SOA Condition 2.c is a static objective based on emissions from 2013 and the results of modeling conducted for the PMRP.

SOA Condition 2.c stipulates the modeling shall be carried out by CARB or other modeling groups subject to the review of the SAG. In addition, SOA Condition 2.d sets forth that the 50% reduction in mass emissions set by SOA may be modified based on the results of the PMRP modeling and subject to SAG review.

The modeling methodology employed by the PMRP is described in Chapter 3. As described in Chapter 3, experts from the Desert Research Institute (DRI) conducted the modeling presented in the PMRP.

Chapters 4 and 5 present the results of the PMRP's air quality modeling.

2.2 Adaptive Management Planning Approach

The PMRP is based on the best information currently available to the OHMVR Division, SLOAPCD, and SAG. The PMRP investigates the level of dust control necessary to achieve SOA objectives and provides information on the feasibility and probability of successfully implementing this magnitude of dust control measures.

The SOA implicitly recognizes the need for the PMRP to be updated and improved as new information becomes available through the preparation of Annual Work Plans and Reports. The OHMVR Division, the SLOAPCD, and the SAG will implement the PMRP using the principles of adaptive management. The OHMVR Division's Strategic Plan defines adaptive management as (OHMVR Division, 2009):

> "A type of natural resource management in which decisions are made as part of an ongoing science-based process. Adaptive management involves testing, monitoring, and evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings and the needs of society. Results are used to modify management policy, strategies, and practices."

An adaptive management approach is appropriate for the PMRP because it involves testing modeling predictions, comparing real world measurements to model predictions, and incorporating new information to refine model predictions and dust control strategies. The OHMVR Division, SAG, and SLOAPCD will apply adaptive management principles through the SOA's Annual Work Plan, Annual Reports, and other supporting actions as described below.

2.2.1 PMRP Annual Reports and Work Plans

SOA Condition 4 requires the OHMVR Division to develop, with SAG assistance, an Annual Report and Work Plan for APCO approval each year of the PMRP term. In general, the preparation of these Annual Reports and Work Plans allow the OHMVR Division, SAG, and SLOAPCD to evaluate progress towards achieving SOA objectives in detail, modify planned dust control measures based on empirical data and evidence collected during the prior year's dust control efforts, improve model formulation, and identify additional actions necessary to fill in gaps in information or resource availability. The SOA's specific requirements for the development of Annual Reports and Work Plans are described below.

Annual Reports

The SOA requires Annual Reports to:

- Review dust controls implemented over the previous year (SOA Condition 4.a)

- Compare achievements to the metrics, indicators, and increments of progress contained in the APCO-approved PMRP and any previous Annual Report or Annual Work Plan (SOA Condition 4.a and 4.k)

Work Plans

The SOA requires Annual Work Plans to:

- Propose dust control activities to be undertaken or completed in the coming term year (SOA Condition 4.d)
- Describe increments of progress, using tracking metrics specified in the APCO-approved PMRP, for each proposed dust control measure or supporting action to be implemented in the coming year, such as, but not limited to: foredune development, mitigation of foredune loss due to natural or anthropogenic impacts, quantities of seeds and plants produced on-site and by any contracted entities, the extent of new and replacement vegetation, plant survival rates, new and replacement fencing installed, quantities of other groundcover applied in new and replacement areas and the extent of areas covered (SOA Condition 4.b)
- Analyze expected outcomes, effectiveness, and potential emissions reductions for each proposed dust control measure to be implemented in the coming year (SOA condition 4.d)
- Use air quality modeling to estimate the benefits downwind of Oceano Dunes SVRA and, specifically, predicted reduction in PM_{10} concentrations in populated areas due east of Oceano Dunes SVRA on the Nipomo Mesa (SOA Condition 4.f)
- Contain a SAG evaluation for all proposed dust control measures (SOA Condition 4.e)
- Include a sensitive analysis on emissions rates of increasing the level of effort for each mitigation technique in subsequent years (SOA Condition 4.f)
- Describe the total funding for the coming one-year implementation period, the amount of funding assigned by mitigation type, budget considerations for development and implementation of each proposed dust control measure, funding

sources, and the availability of reserve funds to cover potential cost increases associated with implementing proposed dust control measures (SOA Condition 4.g)

- Include a detailed implementation schedule with deadlines associated with the physical deployment of proposed mitigation measures (e.g., wind fencing set-up, emissions measures of dune surfaces, in-situ mitigation, revegetation, and replacement of temporary mitigation), the duration of each mitigation activity, and the anticipated impact on emissions reduction targets (SOA Condition 4.h and 4.j)

SOA Conditions 4.c and 4.e stipulate the SAG may identify additional metrics to assess mitigation progress and prepare and/or recommended and approve pertinent technical specifications for each proposed dust control measure (e.g., the type, effectiveness, and geographical extent of dust control measures).

2.2.2 PMRP Supporting Actions

Chapter 7 identifies studies and other actions that may produce valuable new information on the dynamics of the Oceano Dunes SVRA PM_{10} emissions system, augment or enhance model inputs and predictions, and improve PMRP results. As new information becomes available, the OHMVR Division, SAG, and SLOAPCD will update PMRP modeling and modify proposed dust control measures as necessary.

2.3 Other PMRP Implementation Considerations

The ability of the OHMVR Division to fully implement the PMRP is partially dependent on factors that are outside the OHMVR Division's control, such as the availability of funding, the need to comply with the California Environmental Quality Act (CEQA) and obtain approvals from other agencies such as the CCC and the U.S. Fish and Wildlife Service (USFWS). In addition, the OHMVR Division, through the California Department of Parks and Recreation, manages Oceano Dunes SVRA pursuant to California's OHMVR Act (PRC Sections 5090.01 – 5090.71).

Issues related to PMRP implementation are briefly discussed below.

2.3.1 Funding Considerations

Funding availability for PMRP dust control measures is an important consideration. In certain cases, specifically capital outlay projects, the State Legislature would be required to first appropriate funds before the OHMVR Division can initiate the process to develop and implement the project. Most projects, however, would be funded through the OHV Program Trust Fund and the Oceano Dunes District's general operating budget, and the OHMVR Division would need to balance funding existing operations programs (e.g., maintenance, law enforcement) with PMRP implementation. Continued funding through the OHV Trust Fund for PMRP implementation is contingent upon the PMRP allowing for the continued operation of a beach camping and OHV recreation area pursuant to the OHMVR Act.

2.3.2 CEQA/Agency Approvals

The SOA recognizes the PMRP will be subject to environmental review under CEQA, and that PMRP dust control measures will require approval by the CCC.

SOA Condition 2.k acknowledges that if the APCO approval of the PMRP precedes the OHMVR Division's completion of the Oceano Dunes SVRA Public Works Plan public review process, the OHMVR Division shall integrate elements of the PMPR into the Public Works Plan public review and comment process to facilitate public input on the non-air quality impacts of the PMRP. Although each project is different, the public review process prescribed under CEQA can take several months to a year or more to complete (depending on the complexity of the project subject to review and the level of public comments received during the review process).

In addition, SOA Condition 4.l identifies the CCC as an agency with a defined role and responsibility in the development and implementation of the OHMVR Division's Annual Work Plans. Specifically, the SOA identifies CCC will review and approve the OHMVR Division's Annual Work Plan prior to the commencement of any proposed dust control measure. This review would occur pursuant to Special Condition 2 of Coastal Development Permit 3-12-050 and may require the CCC to issue new or amended Coastal Development Permits for any work not within the scope of Coastal Development Permit 3-12-050.

2.3.3 Shorebird Conservation

Oceano Dunes SVRA and adjacent Pismo State Beach are home to shorebirds protected by the federal and state Endangered Species Acts, including the western snowy plover (*Charadrius nivosus nivosus*; federal-listed as threatened) and the California least tern (*Sternula antillarum browni;* federal-listed and state-listed as threatened). The management of Oceano Dunes SVRA includes a substantial, ongoing effort to enhance habitat for the western snowy plover and California least tern and to protect these species' nesting sites. Considerable OHV Trust Funds are committed annually to managing and caring for this threatened population of protected shorebirds. PMRP implementation must be compatible with continued shorebird management and serve to conserve and improve shorebird habitat. In 2019, the OHMVR Division will publish a Habitat Conservation Plan (HCP) focused on the conservation of the federally listed species that occur within the Oceano Dunes District. This HCP will also be subject to public review through CEQA and the National Environmental Policy Act. All activities in this PMRP must be consistent with the management program outlined in the HCP, once approved, and all potential activities in this PMRP will need to be evaluated for potential impacts on the species covered by the HCP.

2.3.4 California Department of Parks and Recreation

The Department of Parks and Recreation/OHMVR Division manages all SVRAs pursuant to the OHMVR Act (PRC 5090.01- 5090.71). The OHMVR Act provides guidance on the management and care of SVRA lands. SVRAs are established on lands where there are quality recreational opportunities for OHVs. Oceano Dunes SVRA in particular provides a popular, unique, and low-cost OHV recreational opportunity. This iconic recreational opportunity depends upon sufficient SVRA lands to accommodate its low-cost beach camping and OHV recreation in a natural dune setting. PMRP implementation would need to accommodate the continuation of the Oceano Dunes SVRA management in compliance with the OHMVR Act.

THIS PAGE INTENTIONALLY LEFT BLANK.

3 PMRP Modeling Methodology

The SOA sets forth the use of computer-based air quality modeling, or dispersion modeling, to quantify emissions, emissions reductions, and downwind PM_{10} concentrations under 2013 Baseline (see Chapter 4) and future PMRP dust control scenarios (see Chapter 5). The purpose of the modeling is to provide the OHMVR Division, the SAG, and the SLOAPCD with estimates, or predictions, of key baseline and future performance metrics that can be be tested, evaluated and compared to actual emissions and/or PM_{10} concentration measurements, and adjusted as the PMRP is implemented over time. The modeling also provides the means by which the OHMVR Division, the SAG, and the SLOAPCD will predict the ability of proposed dust control measures to successfully achieve the SOA objectives described in Chapter 2. These predictions would then be compared to direct observations, evaluated for performance, and improved as necessary and feasible.

This chapter provides a basic overview of dispersion modeling, summarizes the methodology, key inputs, and data sources used in the PMRP air quality modeling, and discusses key assumptions associated with any dispersion modeling exercise. Scientific experts from the DRI Division of Atmospheric Sciences, with input from the SAG, CARB, and SLOAPCD, developed the PMRP modeling methodology. Staff from CARB's Air Quality Planning and Science Division, Modeling and Meteorology Branch, as well as staff from the SLOAPCD, have reviewed the DRI modeling documentation. CARB has expressed their support for using the DRI model to: 1) Estimate windblown PM_{10} emissions from the Oceano Dunes SVRA; and 2) Estimate the control effectiveness and downwind benefits of alternative dust control strategies (CARB, 2019c). Full documentation on the DRI model framework and performance is incorporated as Attachment 2 to the PMRP.

3.1 Dispersion Modeling Overview and PMRP Model Selection

Air quality dispersion models are, in general, used to determine the effects of emissions on air quality. The USEPA's Support Center for Regulatory Atmospheric Modeling website describes air quality modeling as follows (USEPA, 2017):

> "Dispersion modeling uses mathematical formulations to characterize the atmospheric processes that disperse a pollutant emitted by a source. Based on emissions and meteorological inputs, a dispersion model can be used to predict concentrations at selected downwind receptor locations."

Dispersion models range from simple screening-level models that are useful for predicting air quality impacts in areas with little to no topography, gradual changes in land use, and uniform meteorological conditions, to refined models capable of computing air quality impacts in areas with complex meteorological conditions and varying topography. Dispersion models are also classified as "steady-state" models, in which emissions rates, meteorological inputs, and other variables are presumed to be constant over time and space, or "non-steady-state", in which emission rates, meteorology, and other variables change over time and space.

Regardless of their complexity, dispersion models generally include three main components:

- **Emissions source(s):** To model air quality impacts, it is necessary to know the amount of pollutants a source will release to the ambient air. Dispersion models incorporate, to varying degrees of complexity, information on the location, elevation, operating times (i.e., when emissions occur), emissions rate (the amount of emissions per unit of time and/or area) for each source being modeled.
- **Meteorological Inputs:** To model air quality impacts, it is necessary to know how emissions released from a source will be transported, or dispersed, by the local meteorological conditions. Dispersion models incorporate data on surface and upper air wind speed, wind direction, temperature, humidity, pressure, etc., as well as other factors that influence overall meteorology and pollutant dispersion, including terrain and land cover.
- **Dispersion equations and algorithms:** To model air quality impacts, it is necessary to know how pollutants are dispersed over time and distance given the source emission rate and meteorological inputs. Dispersion models incorporate equations and algorithms that predict the concentration of pollutants at specified points based on the inputs provided to the model.

According to the USEPA's Guideline on Air Quality Models (40 CFR, Part 51, Appendix W), the extent to which a specific air quality model is suitable for the assessment of source impacts depends upon the following factors:

- The topographic and meteorological complexities of the area.
- The detail and accuracy of the input databases, i.e., emissions inventory, meteorological data, and air quality data.
- The manner in which complexities of atmospheric processes are handled in the model.
- The technical competence of those undertaking such simulation modeling.
- The resources available to apply the model.

Oceano Dunes SVRA is situated in a coastal environment with complex emission, terrain, and meteorological factors. Accordingly, the PMRP relies on a complex, refined, non-steady-state dispersion model developed and run by experts from DRI. The model incorporates and applies historical data collected at Oceano Dunes SVRA to predicted emissions reductions and PM_{10} concentrations downwind of Oceano Dunes SVRA. The model has been reviewed by the SAG and CARB personnel (and has been submitted for external scientific peer-review), is computationally efficient, and is considered the best available model for use in the PMRP at this time.

3.2 PMRP Model Description and Inputs

The model used to characterize the wind-driven dust emission and dispersion system associated with Oceano Dunes SVRA is a very high-resolution, measurement-based dust emission and dispersion model comprised of gridded emissions inputs, local and regional meteorological inputs, and a Lagrangian Stochastic Particle Dispersion Model (LSPDM) to disperse emitted particles. These components are briefly described below. Refer to Attachment 2 for full modeling documentation.

3.2.1 Gridded Emissions Data

PM_{10} emissions from dune surfaces at Oceano Dunes SVRA are dependent on erodibility and emissivity. Erodibility is a measure of the threshold wind speed or shear stress level that defines when surface emissions commence. Emissivity is a measure of how much PM_{10} mass is emitted from a surface once emissions have commenced.

The OHMVR Division, the SLOAPCD, and CARB have, historically, relied on a measurement instrument known as the Portable In-Situ Wind Erosion Lab, or PI-SWERL, to characterize the spatial variation in erodibility and emissivity throughout Oceano Dunes SVRA. The PI-SWERL operates similarly to a wind tunnel. It creates a shear stress under highly controlled conditions on the dune surface that causes the sand to move and release dust particles. The threshold shear stress that defines the initiation for emissions is estimated using signal data from the near-ground optical gate devices within a PI-SWERL that sense particle movement. The measured concentrations of dust particles and flow rate of air through the instrument are used to quantify PM_{10} emission rates (or emissivity).

In 2013, DRI collected 360 PI-SWERL measurements across Oceano Dunes SVRA. These 2013 PI-SWERL measurements form the basis for the gridded emission data used in the air quality model. The locations of the 2013 PI-SWERL measurements are shown in Figure 3-1. The measurements were made along 5 nominally east to west and 5 nominally north to south transect lines. Measurements were made approximately every 330 feet (100 meters) for the east to west transect lines and 985 feet (300 meters) for the north to south transect lines. At each measurement location, the PI-SWERL applied three shear stresses to the surface and measured the emissions (in terms of micrograms per second per square meter, or $\mu g/s\ m^2$) at each shear stress level. From these three measurements a predictive relationship between emissivity and shear stress was developed for each test location.

The 360 PI-SWERL measurements represent a coverage density of approximately one measurement for every four acres of dunes. Therefore, DRI, CARB, and the SLOAPCD developed an interpolation and extrapolation scheme to provide an emission relationship for each of the model domain grid cells where measurements were not made. Interpolation of the grid cells was done by weighting the five nearest measurements of emissivity based on their distance to the cell. The weighting factor used for each datum point was set to $1/r^2$ where r is the distance between the subject location and where the PI-SWERL data was collected. As opposed to using the nearest PI-SWERL measurement data in proximity to a subject site, the interpolation and extrapolation scheme was modified to account for varying site conditions within, and outside of, Oceano Dunes SVRA. The four conditions and the sources used to derive grid cell values are presented below.

- **Cells Entirely in the Riding Area** only utilized data from PI-SWERL measurements taken from within the riding area.
- **Cells Entirely in Non-riding Areas** only utilized data from PI-SWERL measurements taken in non-riding areas.
- **Cells in Non-riding and Privately-owned Areas** utilized data from PI-SWERL measurements taken on private land and measurements from within the dune preserve.
- **Cells in Areas Transitioning from Riding Area to Private Lands** utilized data from the nearest PI-SWERL measurement in the riding area and reduced its interpolated emissivity by 25%. The second closest riding area measurement had its interpolated emissivity reduced by 50% and the third closest had its interpolated emissivity reduced by 75%. Grid cells further than three cell units away from the riding area were treated as cells in non-riding and privately-owned areas.

For additional information regarding the interpolation and extrapolation used to derive grid cell emissivity characteristics, see Attachment 2.

The interpolation and extrapolation scheme yields an emission rate, in terms of grams of PM_{10} per hour (g/hr) at the model-predicted shear velocity in meters per second (m/s) for that hour, for each 4,300 square foot (20 square meter) grid cell (19,500 grid cells in total) . The entire grid cell is assumed to emit at the rate represented by the cell's assigned emission relationship. An example of a gridded emissions map for a specific shear stress (or wind shear velocity) is shown in Figure 3-1.

Figure 3-1: 2013 PI-SWERL Measurement Locations and Interpolated Data Grid

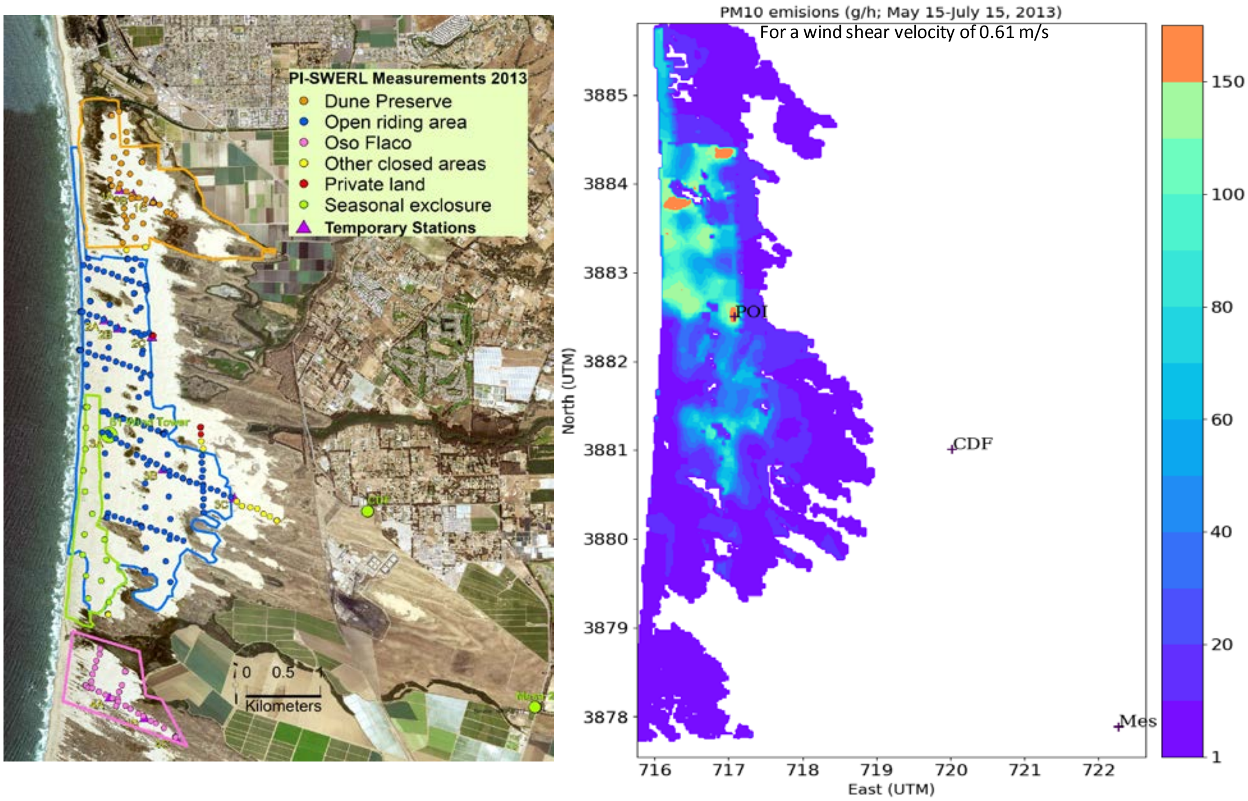


Figure 3-1. Left panel shows the locations of the PI-SWERL tests to measure erodibility and emissivity within the ODSVRA. The purple triangles in the left panel identify the locations of the temporary sites where meteorological measurements were made during the period May 1 to August 31, 2013. Right panel shows an example of the gridded emissions of PM_{10} (g/hr) that result from applying the interpolation/extrapolation scheme for the measured PI-SWERL emission factor relationships for a specific shear velocity (0.61 m/s). This shear velocity corresponds to a wind speed of 35 mph measured at 30 feet above the surface.

Refer to Attachment 2 for details on the development of the gridded emission data and the interpolation/extrapolation scheme used to provide emissions rates throughout Oceano Dunes SVRA.

3.2.2 California Meteorological (CALMET) Model (Version 5.8.5)

The California Meteorological Model, or CALMET (Version 5.8.5), is a USEPA-recommended model used to generate three-dimensional wind fields; it is one of the most common models used by the USEPA and CARB for regulatory and non-regulatory meteorological and air pollution transport studies.

The PMRP modeling implements CALMET using a very fine grid size (4,300 square feet, or 20 square meters) to improve resolution of the detailed wind flow over and around the dune field in addition to the larger scale kinematical and channeling effects of the terrain and slope flows. This level of resolution is necessary for characterizing the local shear stresses acting at the surface of the dunes, which have highly variable topography. The magnitude of the local shear stress acting on the surface controls, to a high degree, the intensity of the dust emissions from that surface.

Meteorological Data Inputs

To inform the model about the state of the atmosphere and for CALMET to subsequently generate the highly-resolved wind field for a given day requires input data of actual measurements within the domain of interest. CALMET was provided with three sources of surface and upper air meteorological input data for the 2013 baseline time period:

- **Surface Meteorological Data:**
  - A temporary network of 13 instrumented towers that was set up within Oceano Dunes SVRA and operated between May and July 2013 provided measurements of hourly mean wind speed and direction across much of the spatial modeling domain. The results of this monitoring temporary meteorological monitoring effort are presented in Attachment 3 to the PRMP.
  - A buoy site approximately 20.5 miles offshore (NOAA-NDBC-46011, Santa Maria; 34.956° North, 121.019° West) was located outside the integration domain but provided offshore and upwind surface wind speed, pressure, air and sea surface temperature data.
- **Upper Air Meteorological Data:**
  - 3-hourly North American Regional Reanalysis (NARR; Mesengir et al., 2006)) soundings over the nearest offshore grid, approximately 11.2 miles away (35.058° N, 120.833° W) and at the Vandenberg National Weather Service (NWS) sounding site approximately 21.8 miles to the south of Ocean Dunes SVRA (34.73° N, 120.58 ° W)

were retrieved to provide upper level airflow data characterizing the atmospheric conditions upwind of the Oceano Dunes SVRA.

The location of the surface and upper air meteorological data stations used to develop the three dimensional CALMET wind field are shown in Figure 3-2. Refer to Attachment 2 for details on the development of the CALMET wind field.

Terrain and Land Use Inputs

In addition to meteorological data parameters, CALMET requires information on the type of surface it is generating winds upon (i.e., the topography and the characteristics of the surface).

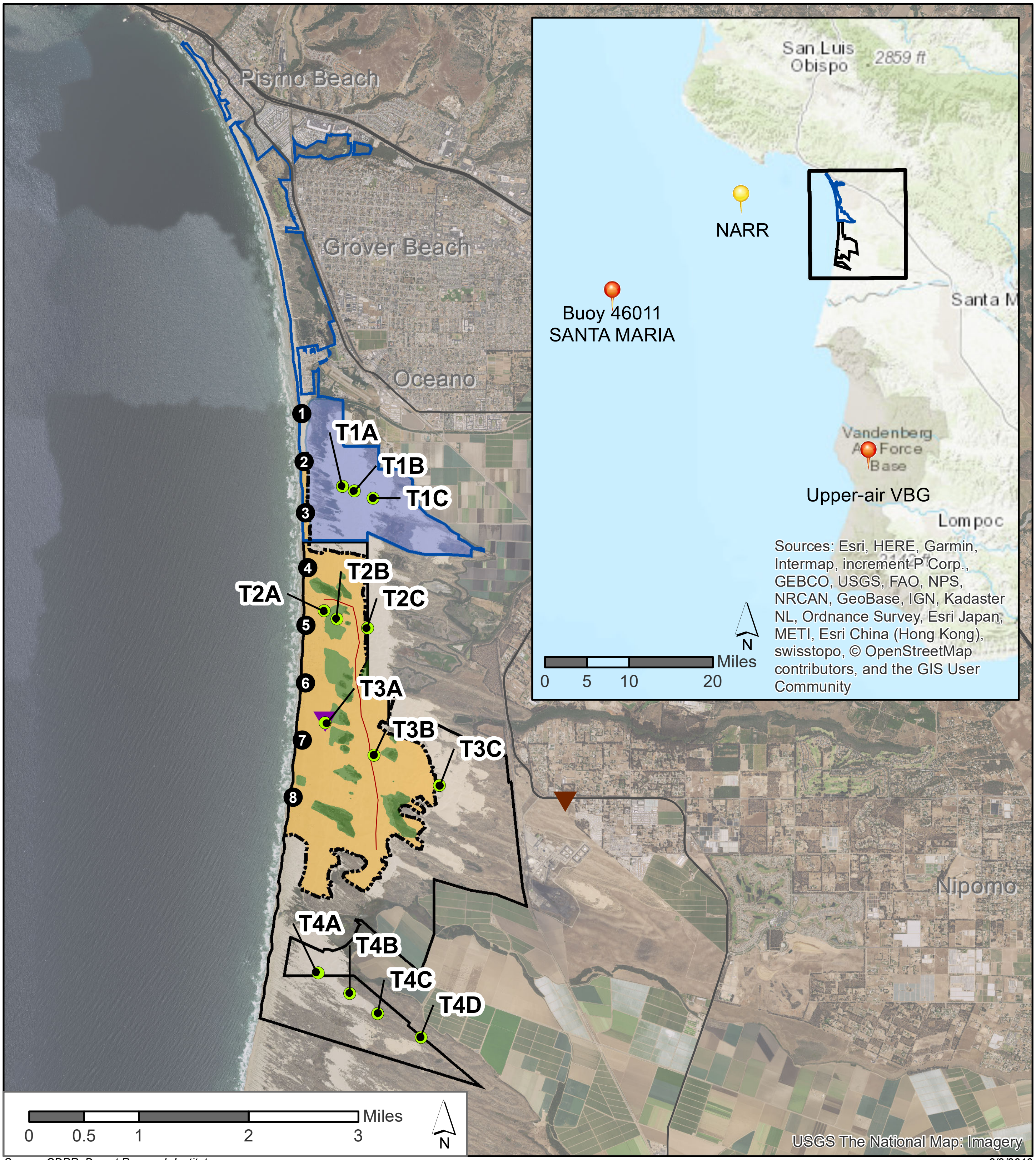
CGS provided 1-meter and 5-meter topographic data for Oceano Dunes SVRA from a compilation of data sources. DRI modified these base topographic layers to produce a 20-meter resolution digital elevation model. The 20-meter resolution DEM used to produce the three-dimensional CALMET wind field is shown in Figure 3-3.

For Oceano Dunes SVRA, the geophysical parameters the model requires (i.e., the albedo, surface roughness length, Bowen ratio, soil heat flux, and vegetation leaf area index) were assigned using default values associated with land use categories contained within CALMET. Three categories were assigned to the grid cells: shrub and rangeland (to the vegetated areas), sandy area (open riding and non-riding sand areas), and water (upwind ocean and lake areas).

3.2.3 Lagrangian Stochastic Particle Dispersion Model (LSPDM)

LSPDMs are used to characterize the transport and dispersion of pollutants in the mixed boundary layer for short and long range distances; they have proved to be very useful to determine and locate source-receptor relationships, while offering the required sensitivity and accuracy necessary for policy relevant decisions.

The DRI-LSPDM model used is a computationally efficient LSPDM that tracks particles in the downwind direction by considering the advection driven by the mean wind field (derived by interpolating hourly time increments from CALMET) and incorporates a secondary effect that takes into account the natural (stochastic) fluctuations in turbulence in the wind (unresolved by CALMET).



Source: CDPR, Desert Research Institute

2/3/2019

- 2013 surface station sites
- Marker post
- Sand Highway, approx.
- Riding area boundary fence
- Fenced vegetation islands (no vehicles allowed)
- Open riding and camping area

Wind monitoring towers

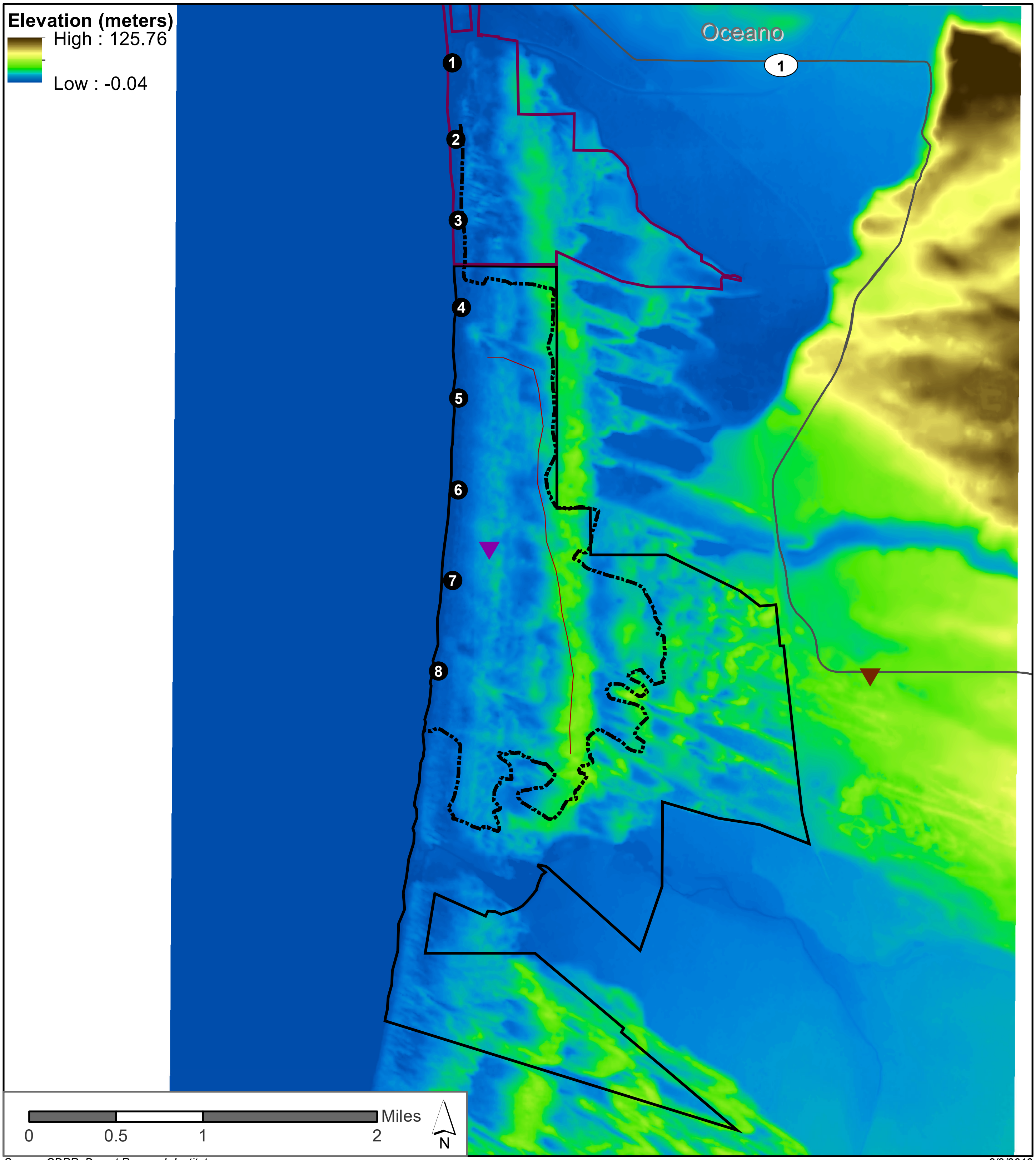
- CDF
- S1

Oceano Dunes District

- Oceano Dunes State Vehicular Riding Area
- Pismo State Beach
- Pismo Dunes Natural Preserve

3-2 Meteorological Data Locations

Oceano Dunes SVRA 2019 PMRP



Source: CDPR, Desert Research Institute

2/3/2019

- Marker post
- Sand Highway, approx.
- Open riding and camping area boundary fence

Wind monitoring towers

- CDF
- S1

Oceano Dunes District

- Oceano Dunes State Vehicular Riding Area
- Pismo State Beach

3-3 Oceano Dunes SVRA Digital Elevation Model

Oceano Dunes SVRA 2019 PMRP

An important capability of the LSPDM is that it is able to establish source and receptor relationships, i.e., the model can determine from which grid cell particles have been emitted from, and in what relative amounts they contribute to the measured concentration at a receptor site (such as the CDF air quality monitoring station). This is possible because particles emitted from a grid cell are tagged with information including their location and emission rate.

Refer to Attachment 2 for model details and supporting evidence of the model's capability to predict measured concentrations of PM_{10} mass concentration for specific days during the 2013 baseline period at the SLOAPCD's CDF and Mesa2 air quality monitoring stations.

3.3 Emissions Reduction Modeling Methodology

As noted earlier, CARB has expressed its support of the DRI-LSPDM model to estimate the control effectiveness and downwind benefits of different dust control strategies at Oceano Dunes SVRA. This section summarizes the methodology used to quantify the predicted reduction in downwind PM_{10} concentrations achieved by the PMRP.

Section 3.2.1 describes the initial gridded emission data set used in the DRI-LSPDM model. The gridded data set is based on PI-SWERL measurements from 2013 and characterizes the emission potential throughout Oceano Dunes SVRA absent any dust control measures.

The OHMVR Division has undertaken several tests to quantify the effectiveness of different dust control measures installed at Oceano Dunes SVRA, including multiple rows of porous fencing, roughness elements placed on the sand surface with a specified density (i.e., a prescribed number of elements per acre), and vegetation plantings. These different control measures were designed to have varying ranges of effectiveness, from approximately 50% for straw bales to 75% for wind fencing (depending on the density of the fence rows) to 100% control for vegetation (see Chapter 4 for additional information on control measure effectiveness).

To evaluate the effect of potential dust control measures on PM_{10} emissions and downwind PM_{10} concentrations, the underlying emission grid is modified to reflect control measure effects on sand flux, and correspondingly dust flux. For each grid cell within a defined controlled area, the emissions estimated by the model for that cell are fractionally reduced by the assigned effectiveness level of the control measure. To evaluate the effect of the reduction downwind on PM_{10} concentrations, the emissions from the modified emission grid are propagated through the dispersion model using the same meteorological conditions. No changes are made to CALMET or the LSPDM, only to the emission grid at locations where the potential dust control measure has been applied. The effect of the dust control measure on downwind PM_{10} concentration is determined by comparing the difference between the model-predicted concentration with and without the dust control measure in place.

3.4 Dispersion Model Assumptions

According to the USEPA's Guideline on Air Quality Models (40 CFR, Appendix W to Part 51), air quality measurements, such as those provided by the SLOAPCD's CDF station, can be used to characterize ambient concentrations of criteria pollutants but are generally not sufficient to characterize the ambient impacts of individual sources or demonstrate the adequacy of emissions limits for an existing source. The USEPA's Guideline also states that "modifications to existing sources that have yet to be implemented, can only be determined through modeling. Thus, models have become a primary analytical tool in most air quality assessments."

While air quality models are important tools that are used extensively in environmental impact and regulatory studies, it is important to recognize that models are a simplified representation of the environmental system of interest, which for the PMRP is the emission and dispersion of dust particles from Oceano Dunes SVRA. The veracity of model predictions is determined by how well the physics of the processes involved are captured by the mathematics of the model (i.e., the parameterization) and the quality and availability of the input data used by the model to generate predictions.

The USEPA's Guideline on Air Quality Models states "the formulation and application of air quality models are accompanied by several sources of uncertainty." The Guideline describes two specific sources of uncertainty. "Irreducible" uncertainty stems from unknown conditions, which may not be explicitly accounted for in the model, and which are likely to lead to deviations from the actual, observed concentrations for any individual event. "Reducible" uncertainties are caused by uncertainties in the "known" input conditions (e.g., emission characteristics and meteorological data, errors in measured concentrations, and inadequate model physics and formulation.

The OHMVR Division has identified a preliminary list of reducible uncertainties associated with the known model inputs. These include:

- The use of older PI-SWERL measurements from 2013 for prediction of future conditions
- The lack of robust information regarding changes in erodibility and emissivity between riding and non-riding areas outside the jurisdiction of the OHMVR Division
- Assumptions of wind profiles over rough terrain
- Assumptions regarding steady emission rates over long periods (i.e., the emissions rates presume PM_{10} is inexhaustible and is not depleted with time)
- Assumption of uniformity in emissivity between areas where measurements occurred (dune stoss and crest) and areas where measurements did not occur (lee face)
- Omission of sand moisture, antecedent rain, and relative humidity effects on emissivity
- The lack of site-specific upper level wind data at Oceano Dunes SVRA

The USEPA recommends evaluations of model accuracy focus on the reducible uncertainty associated with physics and the formulation of the model. As described in Section 2.2, The OHMVR Division, the SAG, and the SLOAPCD will evaluate the performance of the DRI-LSPDM model as the PMRP is implemented, and inform model physics and formulation as necessary and based on the results of subsequent studies, Work Plans, and Annual Reports. In addition, Chapter 7 describes potential actions that may be undertaken by the OHMVR Division, the SAG, and the SLOAPCD to further support and inform model development and the overall adaptive management approach to dust control at Oceano Dunes SVRA. As part of the process of incorporating new information and comparing model predictions to observations from air quality stations such as CDF, the OHMVR Division, the SAG, and the SLOAPCD would identify and prioritize key model improvements and facilitate public understanding and confidence in the model's results.

THIS PAGE INTENTIONALLY LEFT BLANK.

4 2013 Baseline Conditions

This chapter summarizes the starting, or "baseline", conditions – both measured and modeled - against which the success of the PMRP will, in part, be determined. This chapter also presents a discussion of certain aspects of the PMRP's baseline conditions analysis that have the potential to affect future dust control management strategies at Oceano Dunes SVRA.

4.1 SOA 2013 Baseline Time Period

The PMRP's baseline conditions are defined by SOA Condition 2.c as the time period between May 1, 2013 and August 1, 2013. The SOA does not list the basis for the selection of this baseline time period[2]; however, during this time period, the OHMVR Division operated a network of meteorological and air quality stations throughout Oceano Dunes SVRA (see Figure 3-2) and, on May 22, 2013, the SLOAPCD's CDF air quality monitoring station measured the highest 24-hour average PM_{10} concentration – 169.2 µg/m^3 - in its operating history[3]. The combination of a robust meteorological data set combined with high PM_{10} concentrations provide a logical starting point for evaluating the success of the PMRP's air quality modeling.

There are many potential ways to describe and present the 2013 baseline conditions - meteorology, PM_{10} emissions, and PM_{10} concentrations - that existed during the subject time period. This version of the PMRP partitions baseline conditions in ways that: 1) Best match the air quality objectives set by the SOA; and 2) Provide meaningful information and context for future management decisions regarding the placement of dust control measures at Oceano Dunes SVRA. The PMRP presents 2013 baseline condition data in the following ways:

- The days where the measured, 24-hour average PM_{10} concentration at the CDF station equaled or exceeded the CAAQS of 50 µg/m^3 (per SOA Condition 2.b).

---

[2] The SOA's Written Explanation in Support of Its Decision/Findings and Decision of the Hearing Board generally summarizes complaints and exceedances of air quality standards May 29, 2012 through October 19, 2017.

[3] According to the SLOAPCD's 2018 Ambient Monitoring Network Plan, the CDF station has been operational since 2010.

- The single day (May 22, 2013) where the measured, 24-hour average PM_{10} concentration at the CDF station equaled or exceeded the NAAQS of 150 µg/m^3 (per SOA Condition 2.b).
- The day with the maximum modeled 24-hour PM_{10} emissions level – also May 22, 2013 (per SOA Condition 2.c).
- The ten days with the highest modeled emissions levels, in terms of metric tons per day (to inform future management decisions at Oceano Dunes SVRA).

4.2 Maximum 24-Hour PM_{10} Baseline Emissions Analysis

4.2.1 Maximum Daily Emissions Levels

The PMRP's maximum 24-hour PM10 baseline emissions, in terms of metric tons per day, are summarized in Table 4-1. The values in Table 4-1 are based on the DRI-Lagrangian model; there are no actual, physical measurements of the amount of PM_{10} mass emitted from Oceano Dunes SVRA during the 2013 baseline time period (i.e., a comparison of measured versus modeled data is not possible).

Table 4-1: 2013 PM_{10} Maximum Baseline Emissions (10 Highest Modeled Emission Days)

Oceano Dunes SVRA PM_{10} Emissions (Metric Tons per Day)(A),(B)			Percent of Emissions from Riding Area(B)
Day	Riding Area Only	Riding and Non-Riding Areas	
05/22/2013	151.6	**195.3**	77.6%
05/23/2013	**152.5**	188.6	**80.9%**
04/08/2013	129.0	171.8	75.1%
05/18/2013	112.9	139.5	**80.9%**
06/18/2013	105.3	133.2	79.1%
05/29/2013	100.1	130.7	76.6%
05/26/2013	95.1	120.5	78.9%
05/30/2013	86.9	112.7	77.1%
04/15/2013	79.6	106	75.1%
05/27/2013	76.2	97.2	78.4%
Mean	108.9	139.6	78.0%

Source: DRI, 2019.
(A) 1 metric ton equals 1.10 U.S. tons, or 2,204.6 pounds.
(B) Maximum values are shown in **bold font**.

As shown in Table 4-1, the maximum 24-hour PM_{10} baseline emissions day depends on the geographic boundary defining the emissions modeling:

- May 22, 2013 had the highest total emissions from the entirety of Ocean Dunes SVRA (i.e., riding and non-riding areas). The modeled 24-hour PM_{10} emissions value on this day is 195.3 metric tons.
- May 23, 2013 had the highest total emissions from the Oceano Dunes SVRA riding area (i.e., excluding the SVRA's non-riding areas). The modeled 24-hour PM_{10} emissions value on this day is 152.5 metric tons, or approximately 0.9 metric tons more than May 22, 2013. The modeling also indicates that the riding area accounted for a higher overall percentage of total emissions (80.9%) than on May 22, 2013 (77.6%).

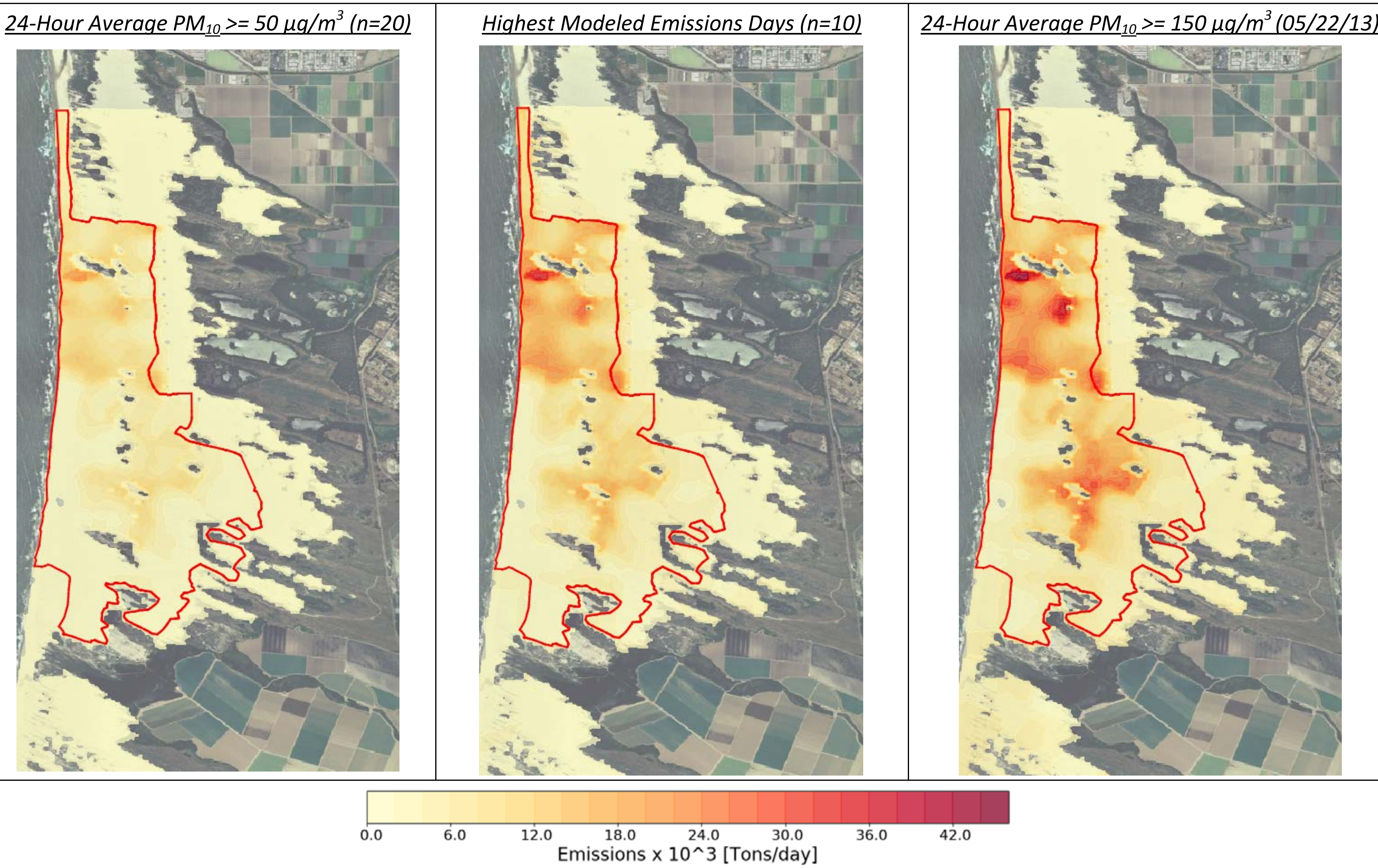
SOA Condition 2.c does not specify the geographic boundary to be associated with the maximum 24-hour PM_{10} baseline emissions day. The PMRP, therefore, focuses on May 22, 2013 as the maximum 24-hour PM_{10} baseline emissions scenario.

4.2.2 Modeled Differences in Grid Cell Emissivity

Research conducted by the OHMVR Division and SLOAPCD has indicated that emissivity, or how much PM_{10} mass is emitted from a dune surface once emissions have commenced (see Section 3.2.1), varies throughout Oceano Dunes SVRA. The value for a grid cell is based on calculating the emissions produced in a given hour by that hour's modeled wind shear (from CALMET) and the emissions for each hour of the day are then summed to represent the metric tons per day for that grid cell. The difference in emissivity, or the relative source strength, for the PMRP's modeled grid cells is shown in Figure 4-1. As shown in Figure 4-1, there are certain areas of Oceano Dunes SVRA that emit more PM_{10} than others. Therefore, to reduce maximum 24-hour PM_{10} baseline emissions pursuant to SOA Condition 2.c, it is logical for the OHMVR Division to install dust control measures in these higher emitting areas. This management strategy is explored in more detail in the discussion of the 2013 Baseline Conditions presented in Section 4.4.

THIS PAGE INTENTIONALLY LEFT BLANK.

Figure 4-1: Dust Emission Field / Distribution of Emissivity Strength Across The Modeling Domain



Source: DRI, 2019. Figure Notes: The red outline represents the boundary of the Oceano Dunes SVRA open riding area.

THIS PAGE INTENTIONALLY LEFT BLANK.

4.3 24-Hour PM_{10} Baseline Concentration Analysis

4.3.1 Daily PM_{10} Concentrations and Exceedances of Air Quality Standards

The PMRP's baseline 24-hour PM_{10} concentration data are summarized in Table 4-2. The values in Table 4-2 compare DRI-Lagrangian model predictions against the actual measurements of PM_{10} collected at the SLOAPCD CDF station during the baseline time period. The direct comparison between the PMRP model and CDF measurements can only be provided for an approximately 60-day subset (May 15, 2013 to July 15, 2013) of the 93-day SOA baseline period due to constraints on the availability of high quality meteorological data.

Table 4-2: 2013 Baseline 24-Hour Average PM_{10} Concentration

Baseline Time Period / Air Quality Metric	PMRP Model	CDF Measurement
May 22, 2013		
24-Hour Average Concentration	158 µg/m^3	169 µg/m^3
May 15, 2013 to July 15, 2013		
No. of Days with 24-Hour Average PM_{10} >= 50 µg/m^3	20 Days	22 Days
24-Hour Average PM_{10} Concentration for Days >= 50 µg/m^3	88 µg/m^3	99 µg/m^3
May 1, 2013 to August 1, 2013[(A)]		
Range in 24-Hour Average PM_{10} Concentration	-	3 – 169 µg/m^3
No. of Days with 24-Hour Average PM_{10} >= 150 µg/m^3	1	1 Day[(B)]
No. of Days with 24-Hour Average PM_{10} >= 50 µg/m^3	-	30 Days
24-Hour Average PM_{10} Concentration for Days >= 50 µg/m^3	49 g/m^3	51 µg/m^3

Source: DRI, 2019.

(A) A comparison between PMRP model predictions and actual CDF measurements is not available for this full time period due to the lack of high quality meteorological data for use in the PMRP model.

(B) May 22, 2013 was the only day during the SOA baseline time period with a 24-hour average PM_{10} concentration >= 150 µg/m^3

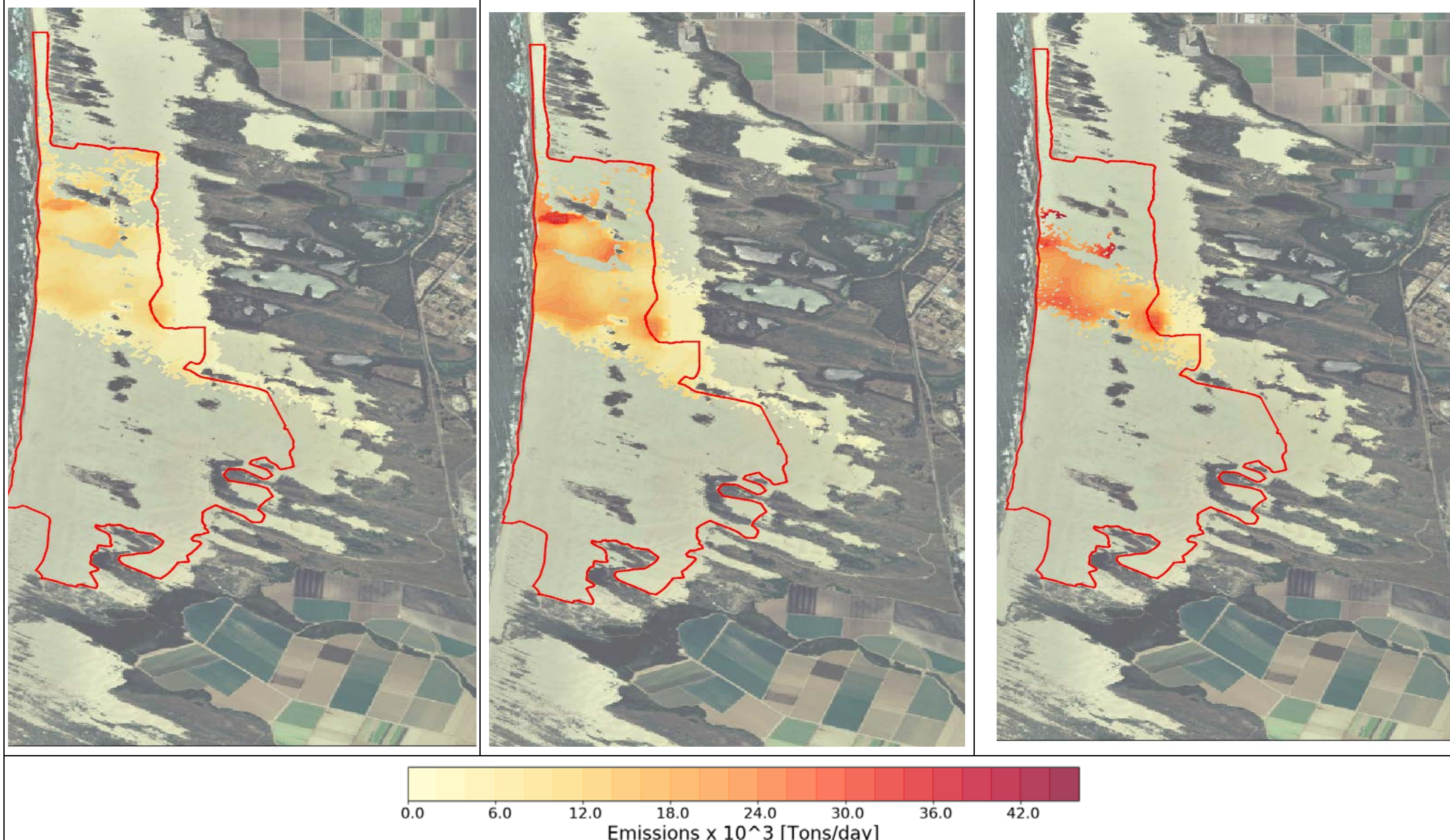
4.3.2 Modeled Grid Cell Contribution to CDF PM_{10} Concentrations

The DRI-Lagrangian model can determine which grid cells contribute to the modeled concentration at a receptor site (such as the CDF air quality monitoring station; see Section 3.2.3). The distribution of the grid cells that contribute to modeled PM_{10} concentrations at the CDF air quality monitoring station are shown in Figure 4-2.

THIS PAGE INTENTIONALLY LEFT BLANK.

Figure 4-2 Dust Emission Field / Grid Cell Contribution to Modeled PM_{10} Concentrations at CDF Station

24-Hour Average PM_{10} >= 50 µg/m^3 (n=20)	*Highest Modeled Emissions Days (n=10)*	*24-Hour Average PM_{10} >= 150 µg/m^3 (05/22/13)*



Source: DRI, 2019. Figure Notes: The red outline represents the boundary of the Oceano Dunes SVRA open riding area.

THIS PAGE INTENTIONALLY LEFT BLANK.

As shown in Figure 4-2, not all modeled grid cells contribute to PM_{10} concentrations at the CDF air quality station. In addition, as modeled concentrations at CDF increase (i.e., as the model moves from predicted days that exceed the state air quality standard (n=20) to the predicted maximum 24-hour average concentration on May 22, 2013), the total amount of grid cells contributing to modeled PM_{10} concentrations at CDF decreases (and conversely, the grid cells that do contribute to the conditions at CDF emit at higher levels than on other days).

Nonetheless, it is apparent from Figure 4-2 that there is a defined corridor from which dust particles originate, as driven by the meteorological conditions on May 22, 2013, and contribute to measured PM_{10} concentrations at the CDF station. The pattern of emissions suggests that focusing dust remediation efforts within this corridor would most effectively result in a reduction of PM_{10} concentration at CDF, provided meteorological conditions are near-identical to those that occurred on May 22, 2013, and erodibility and erodibility remain unchanged from the 2013 baseline period. This management strategy is explored in more detail in the discussion of the 2013 Baseline Conditions analysis presented in Section 4.4.

4.4 Discussion of 2013 Baseline Conditions Analysis

There are several aspects of the PMRP's 2013 Baseline Conditions analysis that warrant preliminary discussion because they have the potential to affect future dust control management strategies at Oceano Dunes SVRA. These include:

- The use of a single day – May 22, 2013 – for measuring success in achieving a 50% reduction in maximum PM_{10} baseline emissions.
- The ability of the OHMVR Division to optimize dust control measures to achieve the SOA's air quality standard and PM_{10} baseline emission reduction objectives.

4.4.1 Suitability of May 22, 2013 for Maximum Baseline Emissions

Figure 4-1 shows a generally consistent pattern of emissivity for each scenario presented (i.e., the same grid cells have the highest emissions levels on state exceedance days, the 10 highest modeled emissions days, and the federal exceedance day/maximum baseline emissions on May 22, 2013); however, as shown in Table 4-1, two days – May 22, 2013 and May 23, 2013 – stand out as having similarly high PM_{10} emissions levels from the riding area and the entirety of Oceano Dunes SVRA. A third day – April 8, 2013 - also stands out as having higher emissions from riding and non-riding areas. Despite similar predicted 24-hour PM_{10} emissions levels, these days (May 22, 2013 and May 23, 2013) did not produce similar 24-hour average PM_{10} concentrations at the CDF station (see Table 4-3).

Table 4-3: 2013 PM_{10} Maximum Baseline Emissions (10 Highest Modeled Emission Days)

Oceano Dunes SVRA PM_{10} Emissions (Metric Tons per Day)^(A),(B)			24-Hour Average PM_{10} Concentration at CDF^(B)
Day	**Riding Area Only**	**Riding and Non-Riding Areas**	
05/22/2013	151.6	195.3	169.2 µg/m^3
05/23/2013	152.5	188.6	139.7 µg/m^3
04/08/2013	129.0	171.8	164.7 µg/m^3
05/18/2013	112.9	139.5	136.1 µg/m^3
06/18/2013	105.3	133.2	133.5 µg/m^3
05/29/2013	100.1	130.7	119.9 µg/m^3
05/26/2013	95.1	120.5	108.0 µg/m^3
05/30/2013	86.9	112.7	132.6 µg/m^3
04/15/2013	79.6	106	136.2 µg/m^3
05/27/2013	76.2	97.2	122.3 µg/m^3

Source: DRI, 2019.
(A) 1 metric ton equals 1.10 U.S. tons, or 2,204.6 pounds.
(B) CARB, 2019d.

While not all PM_{10} emitted from Oceano Dunes should or will – under modeled or measured conditions - end up at the CDF station; however, the difference between May 22, 2013 – a high emission, high concentration day – and May 23, 2013 – a high emission, lower concentration day – may warrant a closer look at the meteorological conditions (and other non-erodibility and non-emissivity factors) that led to measured PM_{10} concentrations at CDF on May 22, 2013.

To provide context on the meteorological conditions observed on May 22, 2013, with respect to the recurrence of similar conditions, a more than 10 year-long record of observational surface wind data from the National Oceanic and Atmospheric Administration (NOAA)/National Weather Service's (NWS) KSWS (Santa Maria, CA) site and the California Irrigation Management

Information System (CIMIS) (Nipoma, CA, Station 202) were queried to evaluate how frequently winds of the magnitude observed on May 22, 2013 occurred. Using these two sources of data it is estimated that hourly mean surface wind speeds comparable to those of May 22 occurred approximately 0.5% of the time and approximately 0.1% of the time at Nipomo and Santa Maria, respectively during this period. If the data are further constrained by the wind direction range likely to transport dust from the Oceano Dunes SVRA to the area of CDF air quality station (west to north-north-west), the frequencies are reduced to approximately 0.2% and approximately 0.04% for Nipomo and Santa Maria, respectively. This suggests that wind conditions similar to those that occurred on May 22, 2103, occur very infrequently.

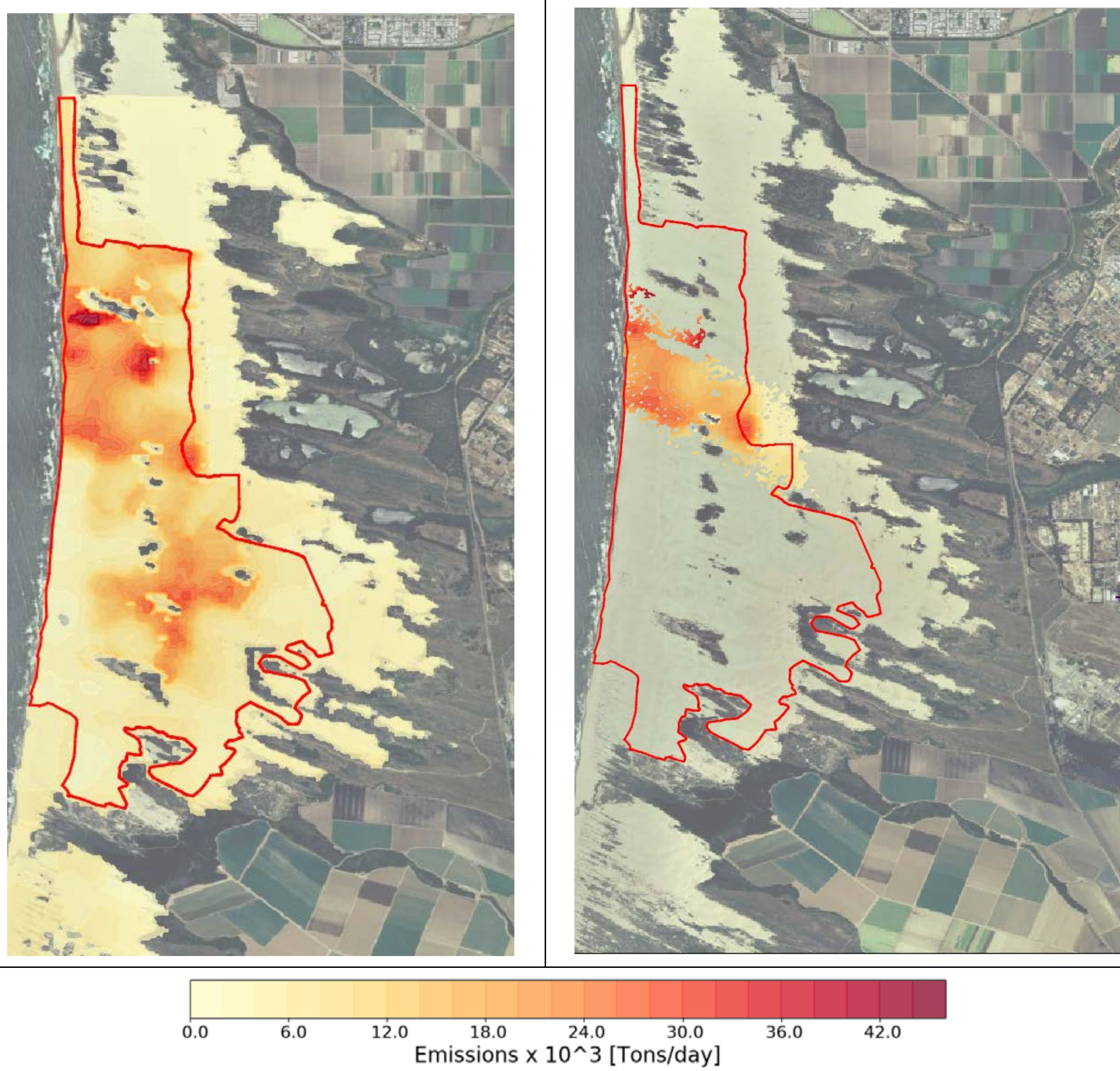
Although this PMRP establishes May 22, 2013 as the benchmark for meeting SOA Condition 2.c, careful consideration on the suitability and use of a single day to achieve this air quality objective may be warranted as future Work Plans, Annual Reports, and iterations of the PMRP is prepared.

4.4.2 Ability to Optimize Dust Control Measures

As described in Chapter 2, the SOA requires the PMRP be designed to achieve state and federal ambient air quality standards for PM_{10} and to reduce maximum PM_{10} baseline emissions by 50%. Ideally, the installation of any one dust control measure will further advance towards achievement of both objectives; however, the PMRP's 2013 Baseline Conditions analysis indicates the ability to optimize dust control measures to meet both objectives could be diminished over time. For example, a comparison of the May 22, 2013 dust emission field to the modeled grid cells contributing to PM_{10} concentrations at the CDF station shows there is a high emissions area in the southern part of Oceano Dunes SVRA that does not influence measurements at the CDF station (see Figure 4-3). Accordingly, the installation of a dust control measure in this southern part of Oceano Dunes SVRA may only further quantifiable achievements in emissions reductions goals. In this regard, meeting both SOA objectives is challenging because reducing emissions within Oceano Dunes SVRA source areas by 50% may not necessarily achieve the goal of eliminating exceedances of state and federal ambient air quality standards at the CDF station (or the SLOAPCD's Mesa2 station).

Figure 4-3: Comparison of May 22, 2013 Dust Emission Field / Grid Cell Contributions to CDF

May 22, 2013 Dust Emission Field | *May 22, 2013 Grid Cell Contributions to CDF*



Source: DRI, 2019. Figure Notes: The red outline represents the boundary of the Oceano Dunes SVRA open riding area.

5 PMRP Preliminary Compliance Analysis

This chapter describes the dust control measures the OHMVR Division has installed at Oceano Dunes SVRA since 2013, including wind fencing, straw bales, and vegetation. Some of these dust control measures remain in place as of February 1, 2019 and, therefore, serve to reduce PM_{10} emissions and PM_{10} concentrations as compared to the 2013 baseline conditions analyzed in Chapter 4. Dust control measures installed prior to 2018 predate the SOA and, for the purposes of this PMRP, are referred to as "Pre-SOA" dust control measures. In addition, in 2018 the OHMVR Division completed a series of "initial particulate matter reduction actions" pursuant to SOA Condition 1.a. These 2018 dust control measures, which are referred to in this PMRP as "Initial SOA" dust control measures, also reduce PM_{10} emissions and PM_{10} concentrations as compared to the 2013 baseline conditions.

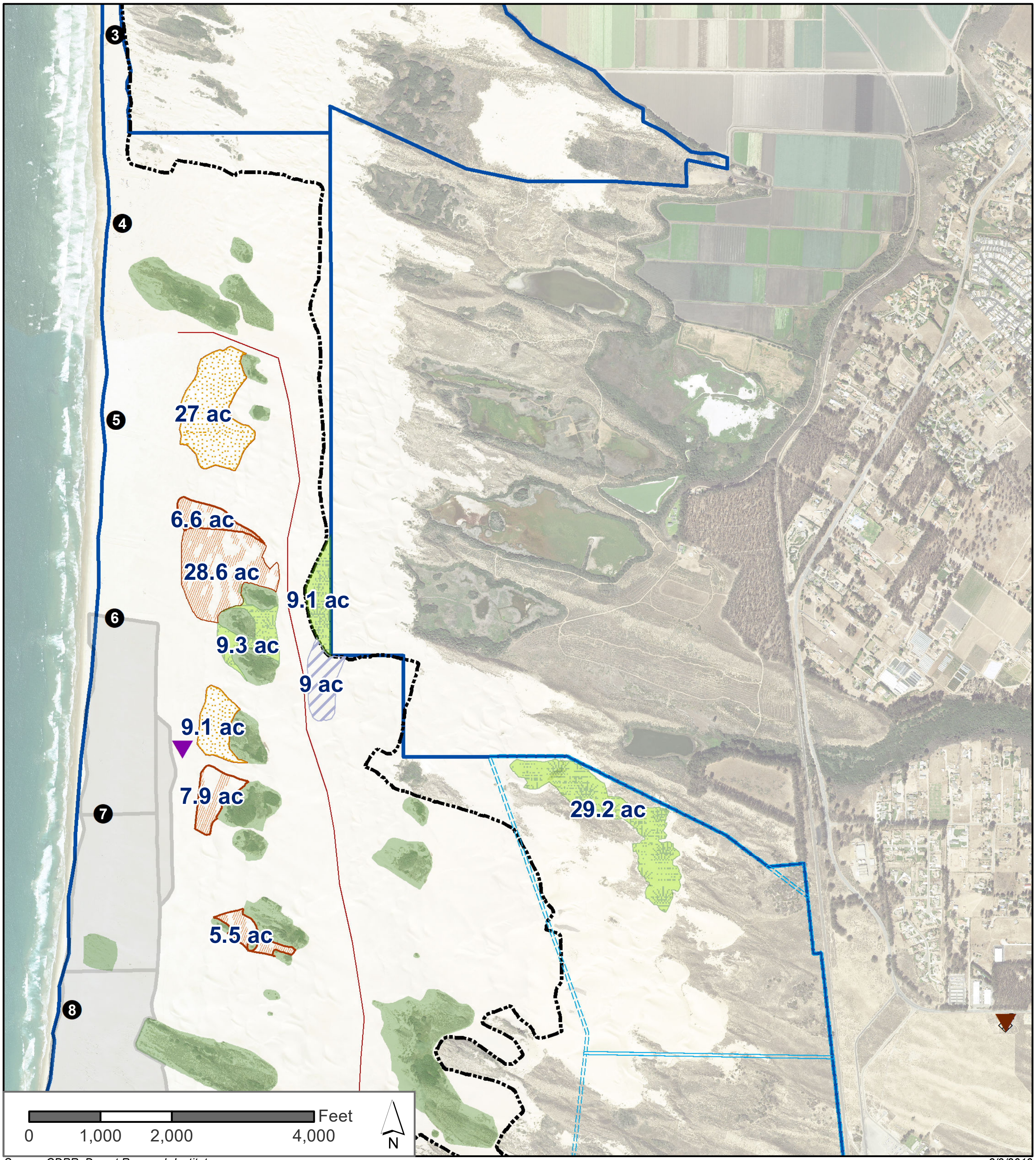
This chapter also investigates the conceptual level of dust control that would be needed to meet the SOA's air quality objectives, based on the results of a simplified sensitivity analysis , and provides a discussion of certain aspects of the PMRP's preliminary compliance analysis that have the potential to affect future dust control management strategies at Oceano Dunes SVRA.

5.1 Pre-SOA Dust Control Measures

There are two dust control measures in place as of February 1, 2019 that predate the SOA. These measures are shown on Figure 5-1 and described below[4].

- **2014 Vegetation Restoration Area (29.2 Acres):** In March 2014, the OHMVR Division installed approximately 5,000 straw bales along the eastern boundary of Oceano Dunes SVRA, outside of the SVRA's open riding and camping area. The straw bales were left in place, became partially buried by shifting sand formations over time, and ultimately provided ground cover for the planting of 29.2 acres of dune vegetation.

[4] In addition to these Pre-SOA measures, a CGS analysis of changes in vegetation at Oceano Dunes SVRA between the 1982 and 2010 found vegetation outside of the SVRA's open riding and camping area increased by 196 acres (CGS, 2011); however, since this vegetation was in place in 2013, no credit is applied in the PMRP for this vegetation.



Source: CDPR, Desert Research Institute

2/3/2019

Pre-SOA vegetation project (2014 and 2017)
Pre-SOA wind fencing project (removed)
Initial SOA wind fencing projects
Initial SOA straw bale projects
Existing fenced vegetation islands (186 acres)

Sand Highway, approx.
Open riding and camping area boundary fence
Marker post
Nesting exclosure
Park boundary

Wind monitoring towers

CDF

S1

Phillips 66 Lease area

5-1 Pre-SOA and Initial SOA Dust Control Measures

Oceano Dunes SVRA 2019 PMRP

- **2017 Vegetation Restoration Area (18.5 Acres):** During the 2017 planting season (which runs from fall 2017 to winter 2018), the OHMVR Division planted approximately 18.5 acres of vegetation around and between three existing vegetation islands. This planting project occurred inside the Oceano Dunes SVRA open riding and camping area.

As described in more detail in Chapter 6, vegetation is very effective at stopping sand movement and controlling PM_{10} emissions. The 2014 and 2017 vegetation projects described above are assumed to control 100% of PM_{10} emissions as compared to 2013 baseline conditions. This assumption is generally consistent with the SOA (pg. 6, line 24).

In addition to the 2014 and 2017 vegetation projects, the OHMVR Division has periodically installed seasonal wind fencing at Oceano Dunes SVRA. This seasonal wind fencing is usually installed in the spring and removed at the end of summer. The total amount of fencing installed over the 2014 to 2017 period was approximately 100 acres; however, since this fencing was removed it does not alter 2013 baseline conditions. Refer to Chapter 6 for additional details on wind fencing as a form of dust control at Oceano Dunes SVRA.

5.1.1 Effect on Reducing 2013 Maximum Baseline PM_{10} Emissions

The estimated emissions reductions resulting from Pre-SOA dust control measures for the 10 highest modeled emissions days are summarized in Table 5-1.

As shown in Table 5-1, Pre-SOA dust control measures reduce 2013 maximum 24-hour PM_{10} baseline emissions by approximately 1.8% for May 22, 2013 and 2.0% on average.

Table 5-1: Pre-SOA Dust Control Measure Emissions Reductions (Metric Tons per Day)						
Day	2013 Baseline Emissions[(A)]	Dust Control Measure Emissions Reductions			Remaining Emissions	Percent Reduction
		Pre-SOA 2014 (29.2 Acres)	Pre-SOA 2017 (18.5 Acres)	Total (47.7 Acres)		
05/22/2013	195.3	-0.6	-2.9	-3.5	191.8	-1.8%
05/23/2013	188.6	-0.4	-3.0	-3.4	185.2	-1.8%
04/08/2013	171.8	-0.4	-3.4	-3.8	168	-2.2%
05/18/2013	139.5	-0.3	-2.4	-2.7	136.8	-1.9%
06/18/2013	133.2	-0.4	-2.2	-2.6	130.6	-2.0%
05/29/2013	130.7	-0.3	-2.6	-2.9	127.8	-2.2%
05/26/2013	120.5	-0.3	-2.0	-2.3	118.2	-1.9%
05/30/2013	112.7	-0.3	-1.9	-2.2	110.5	-2.0%
04/15/2013	106	-0.3	-2.1	-2.4	103.6	-2.3%
05/27/2013	97.2	-0.2	-1.6	-1.8	95.4	-1.9%
Mean	139.6	-0.4	-2.4	-2.8	136.8	-2.0%

Source: DRI, 2019.

(A) 2013 baseline emissions are from Table 4-1. As described in Section 4.2.1, baseline emissions are for the entirety of Oceano Dunes SVRA.

5.1.2 Effect on Reducing 2013 Baseline PM_{10} Concentrations

The estimated reductions in modeled PM_{10} concentrations at the CDF station resulting from Pre-SOA dust control measures are summarized in Table 5-2.

Table 5-2: Pre-SOA Dust Control Measure PM_{10} Concentration Reductions at CDF			
Modeled PM_{10} Concentration Summary	State Exceedance Days	10 Highest Modeled Emissions Days	May 22, 2013
2013 Modeled Baseline Concentration[(A)]	88 μg/m^3	141.5 μg/m^3	158.1 μg/m^3
Dust Control Measure Effects			
Pre-SOA 2014 Concentration Reduction	-0.6 μg/m^3	-1 μg/m^3	-0 μg/m^3
Pre-SOA 2017 Concentration Reduction	-6.8 μg/m^3	-10.7 μg/m^3	-11.9 μg/m^3
Total Concentration Reduction	*-7.4* μg/m^3	*-11.7* μg/m^3	*-11.9* μg/m^3
Remaining Concentration Estimate	80.6 μg/m^3	129.8 μg/m^3	146.2 μg/m^3
Percent Reduction	-8.4%	-8.3%	-7.5%

Source: DRI, 2019.

(A) 2013 modeled baseline concentrations are from Table 4-2.

As shown in Table 5-2, Pre-SOA dust control measures reduce 2013 modeled PM_{10} concentrations by approximately 7% to 8%, depending on the scenario. This level of control reduces the modeled, 24-hour average PM_{10} concentration at CDF to a level that does not exceed the federal ambient air quality standard of 150 μg/m^3, as required by SOA Condition 2.b, but which does exceed the state ambient air quality standard of 50 μg/m^3.

5.2 Initial SOA Dust Control Measures

There are two Initial SOA dust control measures in place as of February 1, 2019. The locations of these measures are shown on Figure 5-1 and described below.

- **2018 Wind Fencing Projects (48.6 Acres):** In Summer 2018, the OHMVR Division installed three wind fencing arrays totaling approximately 48.6 acres in size. These arrays consisted of four-foot-high wind fencing rows, oriented perpendicular to the prevailing, sand-transporting, wind direction and spaced approximately seven times the fence height (or approximately 28 feet apart (8.5 meters), depending on topography). The three arrays are generally located adjacent to existing vegetation islands inside the Oceano Dunes SVRA open riding and camping area. The location of these treatment areas was established by the SOA and were informed by 1930's era aerial photography that shows the vegetation that existed prior to the State of California operating a beach camping and dune recreation area. Refer to Attachment 3 for the 1930's aerial photography used to locate the Initial SOA dust control measures.
- **2018 Straw Bale Projects (36.1 Acres):** In Summer 2018, the OHMVR Division installed a total of approximately 5,100 straw bales in two arrays totaling 36.1 acres in size. These arrays consisted of standard straw bales oriented perpendicular to the prevailing sand-transporting wind direction, spaced every 16.4 feet (5 meters) (depending on topography). The location of the straw bale treatment areas were established by the SOA and were informed by 1930s era aerial photography that shows the vegetation that existed prior to the State of California operating a beach camping and dune recreation area. Refer to Attachment 3 for the 1930's aerial photography used to locate the Initial SOA dust control measures.

As described in more detail in Chapter 6, wind fencing and straw bale arrays can be designed to provide a specific control efficiency, although such arrays are generally less effective than vegetation. Pursuant to SOA Condition 1.b., the Initial SOA wind fencing and straw bale measures are to remain in place and be maintained until such time as they are replaced by vegetation or the APCO approves alternate mitigation measures[5]. Accordingly, the 2018 wind fencing and straw bale projects described above are assumed to become vegetation and control 100% of PM_{10} emissions as compared to 2013 baseline conditions.

5.2.1 Effect on Reducing 2013 Maximum Baseline PM_{10} Emissions

The estimated emissions reductions resulting from Initial SOA dust control measures for the 10 highest modeled emissions days are summarized in Table 5-3.

Table 5-3: Initial SOA Dust Control Measure Emissions Reductions (Metric Tons per Day)

Day	2013 Baseline Emissions[(A)]	Dust Control Measure Emissions Reductions Initial SOA 2018 (84.5 Acres)[(B)]	Remaining Emissions	Percent Reduction
05/22/2013	195.3	-14.6	180.7	-7.5%
05/23/2013	188.6	-15.6	173	-8.3%
04/08/2013	171.8	-13.2	158.6	-7.7%
05/18/2013	139.5	-11.9	127.6	-8.5%
06/18/2013	133.2	-9.8	123.4	-7.4%
05/29/2013	130.7	-11.2	119.5	-8.6%
05/26/2013	120.5	-9.4	111.1	-7.8%
05/30/2013	112.7	-8.7	104	-7.7%
04/15/2013	106	-8.3	97.7	-7.8%
05/27/2013	97.2	-7.6	89.6	-7.8%
Mean	139.6	-11.1	128.5	-8.0%

Source: DRI, 2019.

(A) 2013 baseline emissions are from Table 4-1. As described in Section 4.2.1, baseline emissions are for the entirety of Oceano Dunes SVRA.

(B) As of February 1, 2019, a separate breakdown of the emissions reductions occurring from the 2018 wind fencing and 2018 straw bale projects was not available for presentation in the PMRP.

As shown in Table 5-3, Initial SOA dust control measures reduce 2013 maximum 24-hour PM_{10} baseline emissions (i.e., for May 22, 2013) by approximately 7.5% for May 22, 2013 and 8.0% on average.

---

[5] The OHMVR Division began the transition for approximately 40 acres of straw bale projects to vegetation in fall 2018/ winter 2019.

The combined emissions reductions resulting from both the Pre-SOA and Initial SOA dust control measures for the 10 highest modeled emissions days are summarized in Table 5-4.

Table 5-4: Pre- and Initial SOA Dust Control Measure Emissions Reductions (Metric Tons per Day)

Day	2013 Baseline Emissions[(A)]	Dust Control Measure Emissions Reductions				Remaining Emissions	Percent Reduction
		Pre-SOA 2014 (29.2 Acres)	Pre-SOA 2017 (18.5 Acres)	Initial SOA 2018 (84.5 Acres)	Total (132.2 Acres)		
05/22/2013	195.3	-0.6	-2.9	-14.6	-18.1	177.2	-9.3%
05/23/2013	188.6	-0.4	-3	-15.6	-19	169.6	-10.1%
04/08/2013	171.8	-0.4	-3.4	-13.2	-17	154.8	-9.9%
05/18/2013	139.5	-0.3	-2.4	-11.9	-14.6	124.9	-10.5%
06/18/2013	133.2	-0.4	-2.2	-9.8	-12.4	120.8	-9.3%
05/29/2013	130.7	-0.3	-2.6	-11.2	-14.1	116.6	-10.8%
05/26/2013	120.5	-0.3	-2	-9.4	-11.7	108.8	-9.7%
05/30/2013	112.7	-0.3	-1.9	-8.7	-10.9	101.8	-9.7%
04/15/2013	106	-0.3	-2.1	-8.3	-10.7	95.3	-10.1%
05/27/2013	97.2	-0.2	-1.6	-7.6	-9.4	87.8	-9.7%
Mean	139.6	-0.4	-2.4	-11.1	-13.9	125.7	-10.0%

Source: DRI, 2019.

(A) 2013 baseline emissions are from Table 4-1. As described in Section 4.2.1, baseline emissions are for the entirety of Oceano Dunes SVRA.

As shown in Table 5-4, Pre- and Initial SOA dust control measures (132.2 acres in total) reduce 2013 maximum 24-hour PM_{10} baseline emissions (i.e., for May 22, 2013) by approximately 9.3% for May 22, 2013 and 10% on average. This is primarily due to the size of the dust emissions field at Oceano Dunes SVRA, as shown in Figure 5-2.

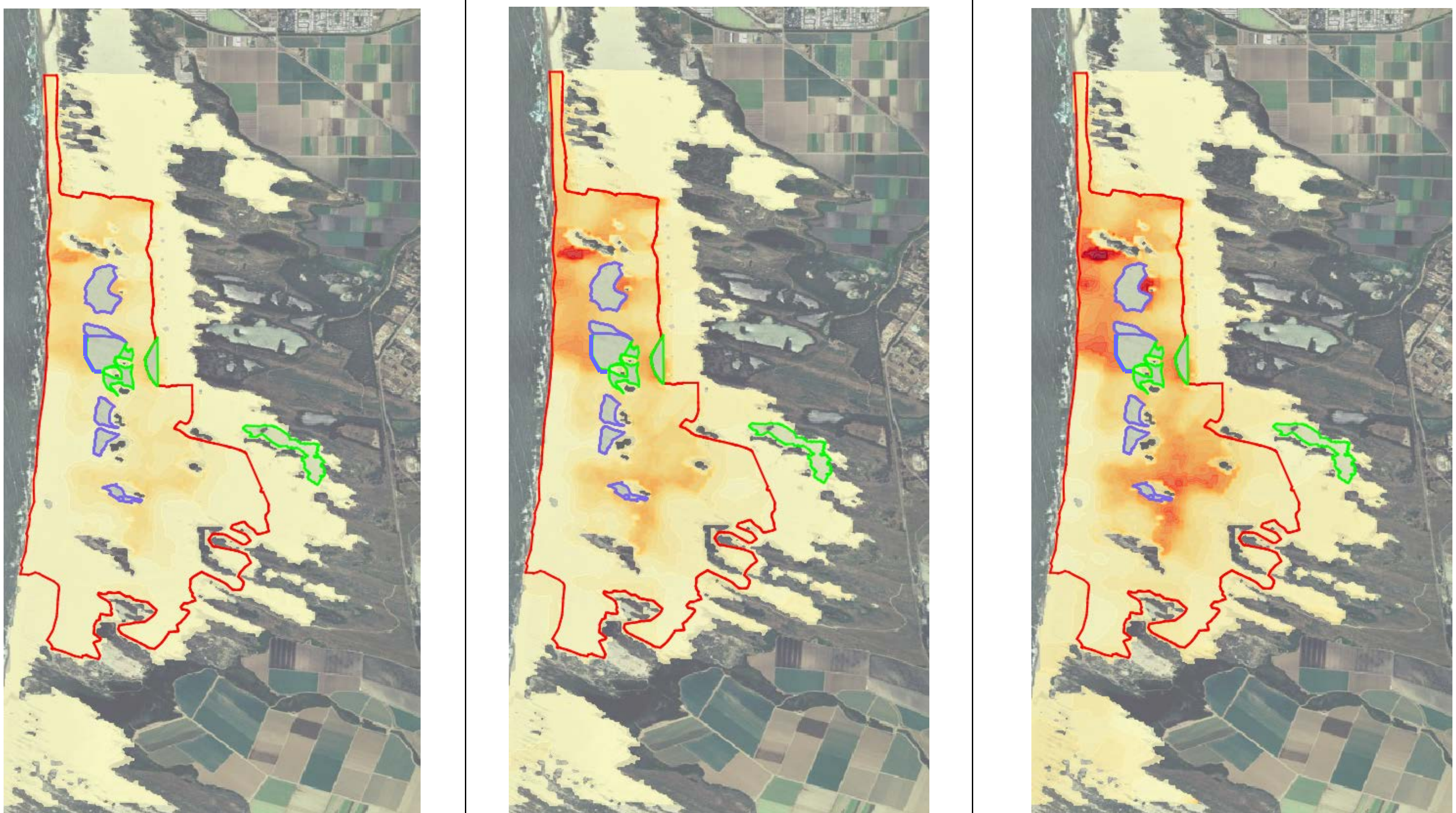
5.2.2 Effect on Reducing 2013 Baseline PM_{10} Concentrations

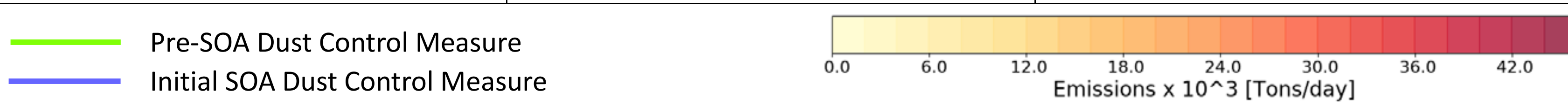
The estimated reductions in modeled PM_{10} concentrations at the CDF station resulting from Initial SOA dust control measures are summarized in Table 5-5.

THIS PAGE INTENTIONALLY LEFT BLANK.

Figure 5-2: Dust Emission Field / Distribution of Emissivity after Pre- and Initial SOA Dust Control Measures

24-Hour Average PM_{10} >= 50 µg/m^3 (n=20)	*Highest Modeled Emissions Days (n=10)*	*24-Hour Average PM_{10} >= 150 µg/m^3 (05/22/13)*





Source: DRI, 2019. Figure Notes: The red outline represents the boundary of the Oceano Dunes SVRA open riding area.

THIS PAGE INTENTIONALLY LEFT BLANK.

Table 5-5: Initial SOA Dust Control Measure PM_{10} Concentration Reductions at CDF			
Modeled PM_{10} Concentration Summary	**State Exceedance Days**	**10 Highest Modeled Emissions Days**	**May 22, 2013**
2013 Modeled Baseline Concentration^(A)^	88 μg/m^3	141.5 μg/m^3	158.1 μg/m^3
Dust Control Measure Effects			
Initial SOA 2018 Concentration Reduction	-15.9 μg/m^3	-25.0 μg/m^3	-27.6 μg/m^3
Remaining Concentration Estimate	72.1 μg/m^3	116.5 μg/m^3	130.5 μg/m^3
Percent Reduction	-18.1%	-17.7%	-17.5%

Source: DRI, 2019.
(A) 2013 modeled baseline concentrations are from Table 4-2.

As shown in Table 5-5, Pre-SOA dust control measures reduce 2013 modeled PM_{10} concentrations by approximately 17.5% to 18.1%, depending on the scenario. This level of control would result in modeled, 24-hour average PM_{10} concentrations at CDF that meet the federal ambient air quality standard but do not meet the state standard. The combined reductions in modeled PM_{10} concentrations at the CDF station resulting from both the Pre-SOA and Initial SOA dust control measures are summarized in Table 5-6.

Table 5-6: Pre- and Initial SOA Dust Control Measure PM_{10} Concentration Reductions at CDF			
Modeled PM_{10} Concentration Summary	**State Exceedance Days**	**10 Highest Modeled Emissions Days**	**May 22, 2013**
2013 Modeled Baseline Concentration^(A)^	88 μg/m^3	141.5 μg/m^3	158.1 μg/m^3
Dust Control Measure Effects			
Pre-SOA 2014 Concentration Reduction	-0.6 μg/m^3	-1 μg/m^3	-0 μg/m^3
Pre-SOA 2017 Concentration Reduction	-6.8 μg/m^3	-10.7 μg/m^3	-11.9 μg/m^3
Initial SOA 2018 Concentration Reduction	-15.9 μg/m^3	-25.0 μg/m^3	-27.6 μg/m^3
Total Concentration Reduction	*-23.3* μg/m^3	*-36.7* μg/m^3	*-39.5* μg/m^3
Remaining Concentration Estimate	64.7 μg/m^3	104.8 μg/m^3	118.6 μg/m^3
Percent Reduction	-26.5% μg/m^3	-25.9% μg/m^3	-25.0% μg/m^3

Source: DRI, 2019.
(A) 2013 modeled baseline concentrations are from Table 4-2.

As shown in Table 5-6, Pre- and Initial SOA dust control measures (132.2 acres in total) reduce 2013 modeled PM_{10} concentrations by approximately 25.0% to 26.5%. This level of control would result in modeled, 24-hour average PM_{10} concentrations at CDF that meet the federal ambient air quality standard but do not meet the state standard. The modeling indicates additional reductions of between 14.7 $\mu g/m^3$ to 68.6 $\mu g/m^3$ are needed to achieve the state standard for all modeled, 2013 baseline scenarios. To accomplish this, the OHMVR Division would need to evaluate the installation of dust control measures further east and/or west of where most Pre-SOA and Initial SOA dust control measures are installed, as shown on Figure 5-3.

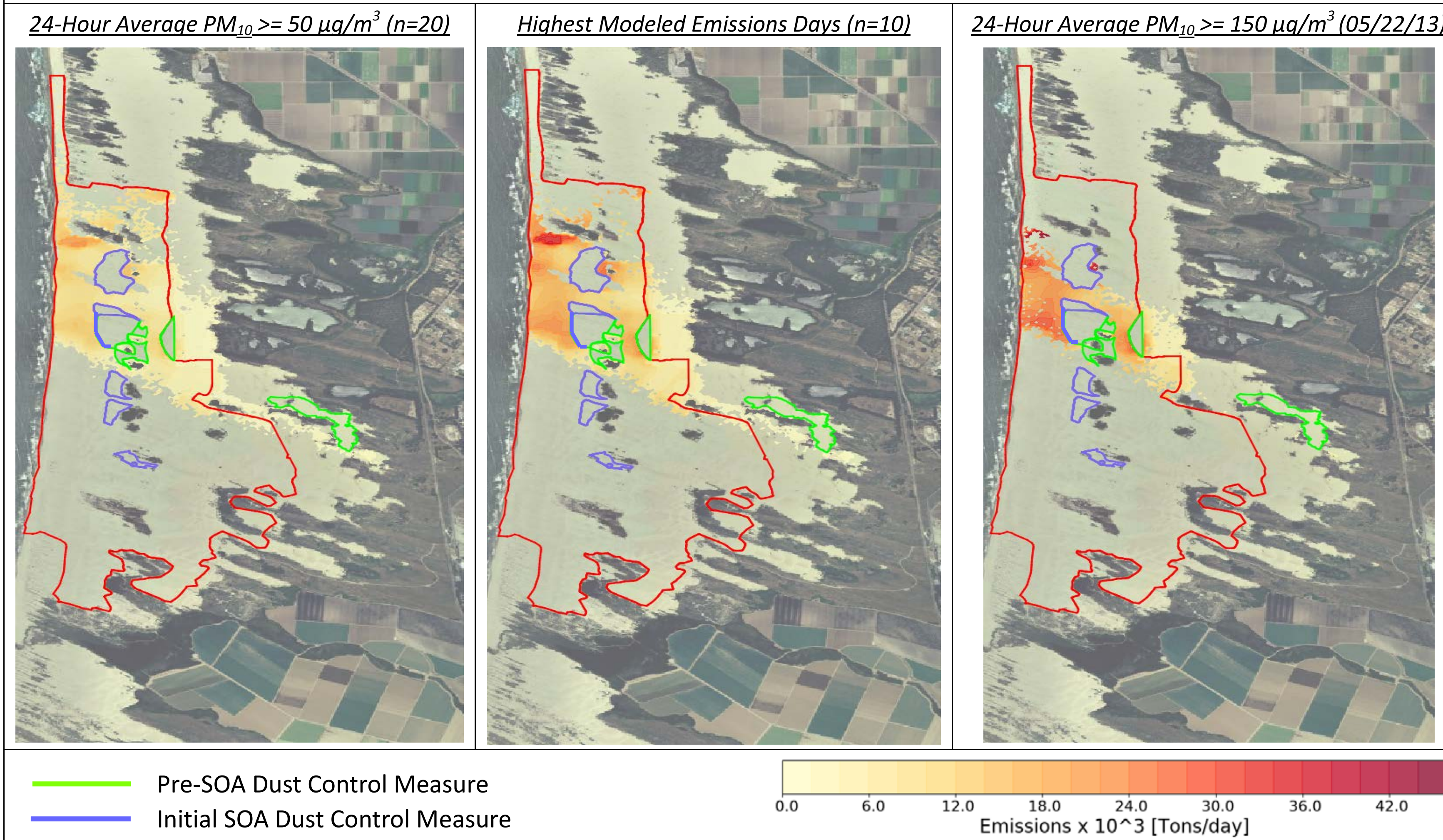
5.3 Preliminary Sensitivity Analysis

As summarized in Sections 5.1 and 5.2, the PMRP modeling indicates the 132.2 acres of existing Pre-SOA and Initial SOA dust control measures at Oceano Dunes SVRA:

- May achieve the federal ambient air quality standard at the SLOAPCD's CDF air quality monitoring station, as required by SOA Condition 2.b, provided existing dust control measures achieve 100% control effectiveness;
- Will not likely achieve the state ambient air quality standard at the CDF station, as required by SOA Condition 2.b, even if existing dust control measures achieve 100% control effectiveness; and
- Will not likely reduce 2013 maximum 24-hour PM_{10} baseline emissions by 50% from the open riding and camping area, as required by SOA Condition 2.c, even if existing dust control measures achieve 100% control effectiveness.

Given the above, the modeling shows additional dust control measures are required to meet SOA air quality objectives. As described below, DRI conducted additional PMRP modeling to estimate the conceptual size, scale, and level of effort necessary comply with the SOA's air quality objectives.

Figure 5-3: Dust Emission Field / Grid Cell Contribution to CDF after Pre- and Initial SOA Dust Control Measures



Source: DRI, 2019. Figure Notes: The red outline represents the boundary of the Oceano Dunes SVRA open riding area.

THIS PAGE INTENTIONALLY LEFT BLANK.

- **A Vegetated Foredune (approximately 23 Acres):** The SOA refers to the creation of a continuous foredune that simulates the historic foredune complex shown on 1930's aerial photographs of Oceano Dunes SVRA and vicinity. An analysis by CGS of past and present (2010 aerial photographs) vegetative cover at Oceano Dunes SVRA concluded the SVRA's open riding and camping area lost 79 acres of vegetation between the 1930's and 2010. In contrast, vegetation coverage outside the open riding and camping area has increased compared to 1930's conditions. Refer to Attachment 4 for the CGS Analysis. As described in this chapter and shown on Figure 5-1 and Figure 5-3, the OHMVR Division has already installed more than 130 acres of Pre-SOA and Initial SOA vegetation, wind fencing, and straw bale projects at Oceano Dunes SVRA. Approximately 50 acres of these dust control measures overlap with the historical foredune complex system identified in the SOA (i.e., 63.3% of the historical foredune complex is under dust control). For the purposes of this PMRP sensitivity analysis, an additional foredune system was modeled consisting of a 22.7-acre, rectangular foredune located to the west of the historical foredune complex identified by the SOA. The control effectiveness of this foredune was assumed to be 100%. Refer to Chapter 6 for additional discussion on the feasibility and effectiveness of foredune vegetation at Oceano Dunes SVRA.
- **High Emissivity Dust Control Areas (approximately 278 Acres)**: For the purposes of the PMRP sensitivity analysis, two conceptual, rectangular areas were targeted for dust control. Area 1 is approximately 164 acres in total size and Area 2 is approximately 114 acres in size. Both areas are located in the interior of the Oceano Dunes SVRA open riding and camping area, and were selected to coincide with relatively continuous areas of high emissivity, as shown on Figure 4-1. Both areas were assumed to ultimately become vegetation projects and, therefore, were assigned 100% control effectiveness.
- **Other Dust Control Projects (approximately 68 acres)**: For the purposes of the PMRP sensitivity analysis, additional areas totaling 68.1 acres were targeted for dust control. These areas were defined based on their potential emissivity - grid cells with emissions higher than 0.003 metric tons per day (6.6 pounds per day) were selected for additional control to achieve SOA air quality objectives. These areas were assumed to ultimately

become vegetation projects and, therefore, were assigned 100% control effectiveness.

The hypothetical future dust control actions listed above were added to the Pre-SOA and Initial SOA results described in Chapter 4 to estimate the ability of the OHMVR Division to meet SOA air quality objectives. The total amount of dust control measures incorporated into the sensitivity analysis is summarized in Table 5-7 and shown graphically in Figure 5-4; the results are summarized below.

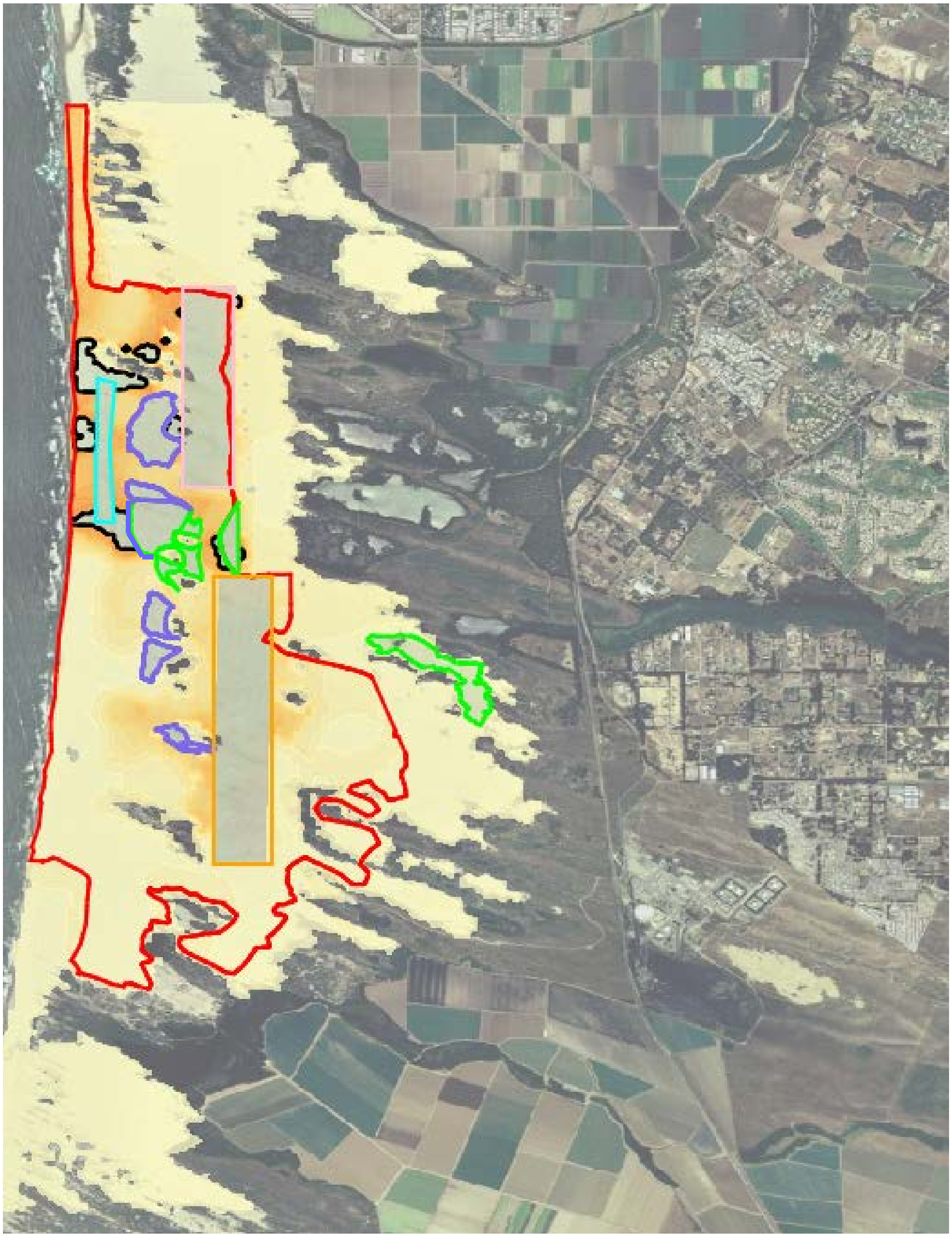
Table 5-7: PMRP Sensitivity Analysis – Modeled Dust Control Measures

Dust Control Project	Control Efficiency	Project Size	Cumulative Dust Control
2014 Vegetation (Pre-SOA)	100%	29.2 Acres	29.2 Acres
2017 Vegetation (Pre-SOA)	100%	18.5 Acres	47.7 Acres
2018 Wind Fencing (Initial SOA)	100%	48.6 Acres	96.3 Acres
2018 Straw Bales (Initial SOA)	100%	36.1 Acres	132.4 Acres
Future Foredune Restoration	100%	22.7 Acres	155.1 Acres
Future High Emissivity Area 1	100%	163.5 Acres	318.6 Acres
Future High Emissivity Area 2	100%	114.4 Acres	433.0 Acres
Future Other Dust Control Projects	100%	68.1 Acres	501.1 Acres

Source: DRI, 2019.

It is important to note the summary provided below is for a series of hypothetical dust control actions. These actions have been simplified for ease of modeling and to estimate the approximate level of dust control necessary to meet SOA objectives. Although the information will inform the OHMVR Division's future Work Plans, it does not constitute a discrete action plan for dust control at Oceano Dunes SVRA. Future proposed dust control efforts would need to be in compliance with applicable statute and permitting requirements, and be evaluated for potential environmental impacts in compliance with CEQA. The OHMVR Division will develop specific Work Plans in coordination with the SAG and SLOAPCD as required by SOA Condition 4, and will refine PMRP dust control measures as new field monitoring, modeling, and other PMRP supporting information becomes available (see Chapter 7). Therefore, the actual size, type, and location of dust control measures installed at Oceano Dunes SVRA over the next four years will vary from the conceptual actions described herein.

Figure 5-4: PMRP Sensitivity Analysis – Modeled Dust Control Measures



Pre-SOA Dust Control Measure	Future High Emissivity Area 1
Initial SOA Dust Control Measure	Future High Emissivity Area 2
Future Foredune	Future Other Dust Control

Source: DRI, 2019. Figure Notes: The red outline represents the Oceano Dunes SVRA open riding and camping area.

5.3.1 Effect on Reducing 2013 Maximum Baseline PM_{10} Emissions

The estimated emissions reductions for the PMRP sensitivity analysis for the 10 highest modeled emissions days are summarized in Table 5-8. The information in Table 5-8 is provided in two forms: the estimated emissions reductions based on the 2013 maximum 24-hour baseline emissions from the entirety of Oceano Dunes SVRA (top panel) and the estimated emissions reductions based on the maximum baseline emissions from the SVRA's open riding and camping areas only (bottom panel). As shown in Table 5-8, the PMRP sensitivity analysis indicates that, assuming a 100% efficiency in mitigation, approximately 500 acres of dust control measures at Oceano Dunes SVRA (including approximately 132 acres of existing dust controls) would reduce modeled 2013 maximum 24-hour PM_{10} baseline emissions on May 22, 2013 by approximately 36% (based on emissions from the entirety of Oceano Dunes SVRA) to approximately 47% (based on emissions from the SVRA's open riding and camping area). Expanding the results to include all 10 modeled days, emissions reductions range from 36.1% to 39.8% (based on emissions from the entirety of Oceano Dunes SVRA) to 46.6% to 51.9% (based on emissions from the SVRA's open riding and camping area).

5.3.2 Effect on Reducing 2013 Baseline PM_{10} Concentrations

The reductions in modeled PM_{10} concentrations at the CDF station resulting from the PMRP sensitivity analysis are summarized in Table 5-9. As of February 1, 2019, estimates of reductions in modeled PM_{10} concentrations from the future high emission Area 1, future high emission Area 2, and future other dust control projects was not available for presentation in the PMRP.

As shown in Table 5-9, the PMRP sensitivity analysis reduces 2013 modeled PM_{10} concentrations by approximately 31.6% to 50.0%, depending on the scenario, and assuming 100% efficiency in mitigation. The 24-hour average PM_{10} concentrations at CDF would continue to be below the federal ambient air quality standard of 150 $\mu g/m^3$. Furthermore, the sensitivity analysis indicates modeled dust control measures would reduce the 24-hour average PM_{10} concentration at CDF to levels below the state standard for some days; however, modeled concentrations at CDF for the 10 highest modeled emissions days continue to exceed the state standard.

Table 5-8: PMRP Sensitivity Analysis – Modeled Dust Control Measure Emissions Reductions (Metric Tons per Day)

Day	2013 Baseline Emissions[(A)]	Dust Control Measure Emissions Reductions (Oceano Dunes SVRA 2013 Baseline)							Remaining Emissions	Percent Reduction
		Pre-SOA (47.7 Acres)	Initial SOA (84.5 Acres)	Future Foredune (22.7 Acres	Future Area 1 (163.5 Acres)	Future Area 2 (114.4 Acres)	Future Other (68.1 Acres)	Total (501.1 Acres)		
05/22/2013	195.3	-3.5	-14.6	-5.2	-21	-9.6	-16.7	-70.6	124.7	-36.1%
05/23/2013	188.6	-3.4	-15.6	-5.6	-19.7	-11.4	-18	-73.7	114.9	-39.1%
04/08/2013	171.8	-3.8	-13.2	-4.9	-10.1	-14.6	-18.4	-65	106.8	-37.8%
05/18/2013	139.5	-2.7	-11.9	-4.3	-14.2	-8.1	-13.7	-54.9	84.6	-39.4%
06/18/2013	133.2	-2.6	-9.8	-3.6	-14.2	-7.2	-12.8	-50.2	83	-37.7%
05/29/2013	130.7	-2.9	-11.2	-4.2	-7.2	-12.3	-14.2	-52	78.7	-39.8%
05/26/2013	120.5	-2.3	-9.4	-3.5	-11.8	-7.2	-12.1	-46.3	74.2	-38.4%
05/30/2013	112.7	-2.2	-8.7	-3.1	-10.5	-5.8	-10.8	-41.1	71.6	-36.5%
04/15/2013	106	-2.4	-8.3	-3.1	-6	-9.1	-11.8	-40.7	65.3	-38.4%
05/27/2013	97.2	-1.8	-7.6	-2.7	-9.9	-5.2	-9.6	-36.8	60.4	-37.9%
Mean	139.6	-2.8	-11.1	-4	-12.4	-9.1	-13.8	-53.2	86.4	-38.1%

Day	2013 Baseline Emissions[(A)]	Dust Control Measure Emissions Reductions (SVRA Open Riding and Camping Area Baseline)							Remaining Emissions	Percent Reduction
		Pre-SOA (47.7 Acres)	Initial SOA (84.5 Acres)	Future Foredune (22.7 Acres	Future Area 1 (163.5 Acres)	Future Area 2 (114.4 Acres)	Future Other (68.1 Acres)	Total (501.1 Acres)		
05/22/2013	151.6	-3.5	-14.6	-5.2	-21	-9.6	-16.7	-70.6	81	-46.6%
05/23/2013	152.5	-3.4	-15.6	-5.6	-19.7	-11.4	-18	-73.7	78.8	-48.3%
04/08/2013	129	-3.8	-13.2	-4.9	-10.1	-14.6	-18.4	-65	64	-50.4%
05/18/2013	112.9	-2.7	-11.9	-4.3	-14.2	-8.1	-13.7	-54.9	58	-48.6%
06/18/2013	105.3	-2.6	-9.8	-3.6	-14.2	-7.2	-12.8	-50.2	55.1	-47.7%
05/29/2013	100.1	-2.9	-11.2	-4.2	-7.2	-12.3	-14.2	-52	48.1	-51.9%
05/26/2013	95.1	-2.3	-9.4	-3.5	-11.8	-7.2	-12.1	-46.3	48.7	-48.8%
05/30/2013	86.9	-2.2	-8.7	-3.1	-10.5	-5.8	-10.8	-41.1	45.8	-47.3%
04/15/2013	79.6	-2.4	-8.3	-3.1	-6	-9.1	-11.8	-40.7	38.9	-51.1%
05/27/2013	76.2	-1.8	-7.6	-2.7	-9.9	-5.2	-9.6	-36.8	39.3	-48.4%
Mean	108.9	-2.8	-11.1	-4	-12.4	-9.1	-13.8	-53.2	55.8	-48.8%

Source: DRI, 2019.
(A) 2013 baseline emissions from Table 4-1. The top and bottom panel presents baseline emissions for the entirety of the SVRA and the open riding and camping area, respectively.

THIS PAGE INTENTIONALLY LEFT BLANK.

Table 5-9: PMRP Sensitivity Analysis – 24-Hour PM_{10} Concentration Reductions at CDF			
Modeled PM_{10} Concentration Summary	**State Exceedance Days**	**10 Highest Modeled Emissions Days**	**May 22, 2013**
2013 Modeled Baseline Concentration[(A)]	88 μg/m^3	141.5 μg/m^3	158.1 μg/m^3
Dust Control Measure Effects			
Pre-SOA 2014 Concentration Reduction	-0.6 μg/m^3	-1 μg/m^3	-0.0 μg/m^3
Pre-SOA 2017 Concentration Reduction	-6.8 μg/m^3	-10.7 μg/m^3	-11.9 μg/m^3
Initial SOA 2018 Concentration Reduction	-15.9 μg/m^3	-25.0 μg/m^3	-27.6 μg/m^3
Future Foredune	-20.7 μg/m^3	-8.3 μg/m^3	-10.5 μg/m^3
Future High Emissivity Area 1	NA	NA	NA
Future High Emissivity Area 2	NA	NA	NA
Future Other Dust Control Projects	NA	NA	NA
Total Concentration Reduction	*-44.0* μg/m^3	*-45.0* μg/m^3	*-50.0* μg/m^3
Remaining Concentration Estimate	44.0 μg/m^3	96.5 μg/m^3	108.1 μg/m^3
Percent Reduction	-50.0%	-31.8%	-31.6%
Source: DRI, 2019. (A) 2013 modeled baseline concentrations are from Table 4-2.			

5.4 Discussion

There are several aspects of the PMRP's Preliminary Compliance Analysis that warrant discussion because they have the potential to affect future dust control management strategies at Oceano Dunes SVRA. These include:

- The modeled emissions reductions identified under the PMRP sensitivity analysis and the ability of the OHMVR Division to achieve a 50% reduction in 2013 maximum baseline emissions.
- The modeled reductions in PM_{10} concentrations at the CDF station under the PMRP sensitivity analysis and the ability of the OHMVR Division to achieve state ambient air quality standards.

5.4.1 Modeled Maximum 24-Hour PM_{10} Baseline Emissions Reductions

As shown in Table 5-8, the installation of approximately 500 total acres of dust control measures (including approximately 132 acres of existing dust control measures) is predicted to make demonstrable progress towards reducing the 2013 maximum 24-hour PM_{10} baseline emissions by 50%. This amount of dust control, assuming 100% control effectiveness, would reduce May 22, 2013 maximum baseline emissions by approximately 36% (based on emissions from the entirety of Oceano Dunes SVRA) to approximately 47% (based on emissions from the SVRA's open riding and camping area), and even more so if the results are expanded to emissions reductions averaged over the 10 highest emissions days from the 2013 baseline period. To achieve these estimated reductions, the OHMVR Division would need to install approximately 369 additional acres of dust control measures, namely vegetation[6]. Any future proposed dust control measures would need to be in compliance with applicable statute and permitting requirements, and be evaluated for potential environmental impacts in compliance with CEQA. The 369 additional acres estimate is likely to be a minimum value, as the actual size and success of future dust control projects would depend on topography, planting success, etc. Furthermore, while the modeling indicates substantial progress would be made, the predicted emissions reductions are below the objective set by SOA Condition 2.c. In light of this, the OHMVR Division, the SAG, and the SLOAPCD will need to carefully consider the use and application of resources towards meeting this SOA objective. Refer to Chapter 6 for details on the OHMVR Division's ability to support the extensive vegetation planting contemplated by the PMRP sensitivity analysis. The OHMVR Division, the SAG, and the SLOAPCD may also need to carefully consider and establish appropriate increments of progress towards reducing 2013 maximum 24-hour PM_{10} baseline emissions by 50%.

5.4.2 Modeled Maximum 24-Hour PM_{10} Concentration Reductions

As shown in Table 5-6, the OHMVR Division's existing Pre-SOA and Initial SOA dust control measures (132.4 acres) are predicted to achieve the federal ambient air quality standard but not the state air quality standard. The PMRP sensitivity analysis indicates the planting of an additional, approximately 23 acres of vegetated foredune would further reduce concentrations

---

[6] Since the 84.5 acres of Initial SOA wind fencing and straw bale dust control measures would be transitioned to vegetation, the total amount of additional vegetation needed to be would be approximately 453 acres. In the 2018/2019 growing season the OHMVR Division began transitioning approximately 40 acres of straw bale treatment to vegetation. Therefore, the total additional vegetation needed would be approximately 413 acres.

at CDF, but not to levels that are below the state standard of 50 µg/m^3; modeled concentrations are predicted to remain approximately twice as high as the state standard on the 10 highest modeled emissions days from the 2013 baseline period. Future projects in high emissivity Area 1, Area 2, and other areas would provide additional, yet unquantified, concentration reductions at CDF. Although modeled concentration reductions were not available for these future projects as of February 1, 2019, DRI did model the concentration reductions that would be achieved if the entirety of the Oceano Dunes SVRA open riding and camping area was placed under 100% dust control effectiveness. The results of this modeling are shown in Table 5-10.

Table 5-10: PMRP Sensitivity Analysis – Full Dust Control Treatment (No SVRA Operation)

Modeled PM_{10} Concentration Summary	State Exceedance Days	10 Highest Modeled Emissions Days	May 22, 2013
2013 Modeled Baseline Concentration[A]	88 µg/m^3	141.5 µg/m^3	158.1 µg/m^3
Dust Control Measure Effects			
Vegetated Open Riding and Camping Area	-66.6 µg/m^3	-104.3 µg/m^3	-117.2 µg/m^3
Remaining Concentration Estimate	21.4 µg/m^3	37.2 µg/m^3	40.9 µg/m^3
Percent Reduction	-75.7% µg/m^3	-73.7% µg/m^3	-74.1% µg/m^3

Source: DRI, 2019.
(A) 2013 modeled baseline concentrations are from Table 4-2.

As shown in Table 5-10, dune surfaces outside the Oceano Dunes SVRA open riding and camping areas accounted for nearly 26.3% of the modeled 24-hour PM_{10} concentration at CDF on the 10 highest emissions days from the 2013 baseline period (141.5 µg/m^3); the “background” PM_{10} concentration from these non-riding area dune sources was 37.2 µg/m^3. This indicates appreciable concentration reductions may be achieved through the emplacement of dust control measures outside the Oceano Dunes SVRA open riding and camping area, a notion conveyed in SOA Condition 2.e. In light of this, the OHMVR Division, the SAG, and the SLOAPCD may need to carefully consider the potential role and influence that sources of PM_{10} other than Oceano Dunes SVRA have on concentrations at CDF. Refer to Chapter 7 for details on field monitoring, modeling, and other supporting actions that could inform future Work Plans, Annual Reports, and iterations of the PMRP. In addition, the OHMVR Division, the SAG, and the SLOAPCD may also need to carefully consider and establish appropriate increments of progress towards achieving PM_{10} concentration reductions at CDF.

THIS PAGE INTENTIONALLY LEFT BLANK.

6 Potential PMRP Control Measures

This chapter describes the feasibility and modeled effectiveness, if known, of the different potential control measures that may be installed at Oceano Dunes SVRA.

6.1 Vegetation

Vegetation has long been identified as a method for stabilizing ground surfaces. Its benefits range from disrupting wind velocity, which minimizes the entrainment of soil particles that can generate dust, to erosion prevention (water and wind) through the establishment of a plant roots matrix. Vegetation also has the benefit of being self-sustaining if appropriate species are present, and contributing to the value of the ecosystem that develops with the vegetation.

Large patches of vegetation are present throughout Oceano Dunes SVRA, including in areas that experience high OHV activity. Visitors to the park, including OHV recreationists, enjoy the scenic value vegetation brings to the dunes, and have generally been willing to avoid vegetation that is properly marked or flagged. The Oceano Dunes SVRA open riding and camping area contains 186 acres of vegetation "islands" that are protected by fencing. The OHMVR Division's Pre-SOA 2014 and 2017 vegetation restoration projects (see Section 5.1) successfully established an additional 48 acres of vegetation, and the OHMVR Division has planted approximately 40 acres of the Initial SOA straw bale project areas during the winter of 2018/19.

The OHMVR Division anticipates proposing future vegetation projects as part of the annual Work Plans required by SOA Condition 4 (see Section 2.2.1). The amount of additional dust control measures will be described in the Annual Work Plans (see Section 2.2.1) and will be informed by new field monitoring, and modeling as it becomes available.

6.1.1 PM_{10} Reductions from Established Vegetation and Surface Cover

Vegetation is generally accepted to be effective at reducing sand movement when it reaches critical levels of cover. Vegetation physically covers the ground surface, stabilizes or holds sand in place with roots and plant litter, and breaks the flow of wind across the landscape. The degree of protection afforded by vegetation is a function of plant size, geometry, and spacing.

The 2011 pilot project study conducted at Oceano Dunes SVRA concluded vegetation reduced sand transport by as much as 90% to 95% within the first 165 feet (50 meters) from the upwind boundary of the vegetated area, and 90% to 99% farther downwind (DRI, 2011). Peer-reviewed studies suggest that with a percent coverage of approximately 12%, sand flux can be reduced by 90%, compared to a bare surface, and 95% when cover reaches approximately 18%, although, it has been observed in some environments that sand transport can occur even with vegetation cover reaching 45%. This likely reflects the vegetation's size and distribution. The Oceano Dunes District currently targets between 2,000 and 3,000 native plants per acre. With this planting density, there is sufficient vegetative cover within the first three to five years to provide effective suppression of saltation. During the early years of a new planting area, the area is typically covered with straw mulch and sterile annual grass, which should result in control of sand movement, likely near 100%.

Vegetation projects would be a permanent form of dust control at Oceano Dunes SVRA. Although these plantings would take time to become established and are somewhat hampered by the short growing season at Oceano Dunes SVRA, they have the inherent ability to respond and potentially stabilize dynamic dune conditions throughout the park (e.g., fore, mid-, and backdune regions) and reduce the need for regular and routine maintenance once the vegetation is established.

6.1.2 General Planting Methods

The OHMVR Division has an established method for stabilizing and revegetating dune surfaces at Oceano Dunes SVRA using locally collected, native vegetation. The method has a demonstrated history of success and involves first distributing certified, weed-free straw bales throughout the area designated for control. The straw bales physically cover the ground surface and break the flow of wind across the landscape and thus provide a surface roughness that immediately reduces dust emissions from the area occupied by the bales. When the planting operation is ready to be initiated, the bales are cut open, and the straw distributed in a thin mat over the sand, with straw covering the entire area targeted for planting. Seeds of a hybrid, sterile, annual grass are broadcast over the straw; these seeds germinate during the first rainy season and provide additional cover on the area.[7] After the seeds have been distributed, native plants that have been grown in a nursery setting are planted by hand through the straw bed. The spacing of the plants is approximately 4 feet apart, resulting in planting density between 2,000 and 3,000 plants per acre, depending on the species mix, topography, and plant material availability. Native seeds are also spread across the restoration areas for germination with an application rate between 50 and 200 pounds per acre. Fertilizer is used during the first year of restoration to stimulate the growth of the sterile grasses.

Since there is no current irrigation system in the shifting sand dunes at Oceano Dunes SVRA, it is important planting events are timed to take advantage of natural precipitation. Precipitation data for Nipomo (station 202) from 2011-2015 reflects the recent drought suffered by all of California; annual precipitation from 2011 to 2015 was approximately 15.7 inches, 8.5 inches, 6.0 inches, 14.1 inches, and 8.3 inches, respectively. Annual precipitation rates increase to 14.3, 15.5, and 11.6 inches per year in 2016, 2017, and 2018, respectively (CIMIS, 2019). Given these precipitation values, it is most desirable to plant in November or December, thereby allowing the newly installed plants to take advantage of three to four additional wet months before being exposed to warmer and drier conditions. If an exceedingly dry year is forecast, however, temporary irrigation (via truck-based application or helicopter crop duster) may be necessary to deliver water to newly installed plants (see Section 6.1.7).

6.1.3 Existing Plant Yield and Current Production Capacity

Survivorship of plants previously installed by the OHMVR Division has been relatively high; estimated to be generally greater than 50%, a number that varies among species, location of planting, and year. The OHMVR Division made preparations for the 2018/2019 planting period to ensure there were sufficient plants available to meet the anticipated 40-acre planting effort; over 114,000 plants have been/are currently being grown successfully at three different

[7] These grasses, which cannot reproduce, will eventually die and add their stems to the straw cover. Though the plants from this initial seeding add their stems to the straw cover, they will not result in new plant growth during the next year.

locations, including greenhouses at the Oceano Dunes District, Cal Poly San Luis Obispo, and at a local private nursery. Initially, 11 species were requested to be germinated and grown to planting size, all of which are present at Oceano Dunes SVRA. Seed was collected locally from within the dunes to ensure suitable pre-adaptation to the site for all plants being grown. In addition to the 11 species initially requested, the OHMVR Division added 11 additional dune species to increase the diversity and develop experience with the collection, germination, and growth of these other species for future reference. A breakdown of the plants that have been grown / are being grown by, or for, the OHMVR Division is summarized in Table 6-1.

Table 6-1: Inventory of Plants as of January 4, 2019

Species	Abbreviation	Number of Plants			
		Oceano Dunes District	Cal Poly	Private Nursery	Total
Abronia maritima	ABMA	5	-	-	5
Abronia umbellate	ABUM	3	-	-	3
Achillea millefoilium	ACMI	5,145	7,100	5,145	17,390
Acmispon glaber	ACGL	475	-	478	953
Ambrosia chamissonis	AMCA	49	-	-	49
Astragalus nuttallii	ASNU	67	-	-	67
Atriplex leucophylla	ASLE	147	-	-	147
Camissoniopsis chaeiranthifolia	CACH	206	-	-	206
Corythrogyne filaginifolia	COFI	967	180	1,960	3,107
Dudleya lanceolate	DULA	196	-	-	196
Ericameria ericoides	ERER	1,102	140	3,038	4,280
Erigeron blochmaniae	ERBL	1,531	3,300	3,766	8,597
Eriogonum parvifolium	ERPA	1,866	1,100	1,029	4,015
Eriophyllus staechadifolium	ERST	5,341	6,600	6,706	18,647
Erysimum insulare suffrutescens	ERIN	1,335	3,800	3,038	8,173
Fragaria chilensis	FRCH	54	-	-	54
Lupinus chamissonis	LUCH	13,855	10,300	10,290	34,445

Table 6-1: Inventory of Plants as of January 4, 2019					
Species	Abbreviation	Number of Plants			
		Oceano Dunes District	Cal Poly	Private Nursery	Total
Malacothrix incana	MAIN	20	-	-	20
Monardella crispa	MOCR	1,715	1,200	2,603	5,518
Oenothera elata	OEEL	1,225	-	-	1,225
Phacelia ramosissima	PHRA	637	-	-	637
Senecio blochmaniae	SEBL	3,785	350	2,590	6,725
Total		**39,746**	**34,070**	**40,643**	**114,459**

The greenhouses at the Oceano Dunes District, Cal Poly, and private nursery have / are anticipated to produce approximately 39,700, 34,000, and 40,600 plants, respectively, for the 2018/2019 planting season. The sum total for combined plant growing operations is approximately 114,460 plants. This total is approximately 6,500 plants more than what is anticipated to be required to finish planting for the 2018/2019 season (approximately 108,900 plants, based on a presumed density of 2,723 plants per acre over a 40-acre control area). Although there is a high degree of confidence that a sufficient number of plants will be available to finish the 2018/2019 planting season, not all species are equally easy to collect, germinate, and grow to a size suitable for transplant. The plant palette will evolve over time, but it will not likely deviate from a palette of native species already present at, and in the vicinity of, Oceano Dunes SVRA. The species presented in Table 5-1 are for the dune areas set back from the coast; for potential species that would be used for foredune planting, see Attachment 6.

Future plant production can be expected to continue at this rate, although Cal Poly has indicated additional space for growing plants may be available, and the facilities at the private nursery are extensive. Future planting efforts are unlikely to be limited strictly from the stand point of the amount of physical space needed to grow plants. Rather, the potential factors that could constrain future plant production are likely to be the availability of seed and the cost associated with plant production, site preparation, and plant installation. These issues are discussed in Section 6.1.6.

6.1.4 Non-foredune Vegetation Planting: Processes and Costs

Non-foredune vegetation planting is anticipated to be located together, in dune areas set back from the shoreline. Focusing vegetation establishment adjacent to existing vegetated areas would simplify the logistics and lower the cost of the endeavor during the implementation of the planting project. The entire effort for vegetating the dune areas would include several tasks, which are summarized here and detailed in Attachment 6 to the PMRP.

For the purpose of future planning, cost estimates per acre are assumed to be between $15,000 and $20,000. Special tasks related to foredune development are described in Section 6.2.1.

The revegetation process at Oceano Dunes is comprised of five primary tasks: seed collection, plant production, distribution and dismantling of straw bale, installation of container plants, and distribution of annual grass and native seeds. The first step in generating a supply of plants for revegetation begins with seed collection. Seeds are collected in bulk, and then cleaned to remove non-seed material of the collection. The cleaned seed is then distributed into trays with a potting mix and nurtured in a greenhouse until the seedlings are large enough to be transplanted into the container size that will ultimately be installed in the field. Prior to plant installation in the dunes, straw is distributed in a thin blanket (thee to six inches) across the treatment area. This can be accomplished mechanically with a straw blower or manually. For some projects, straw bales are brought to the site and distributed at a predetermined spacing.

Container plants that have been raised in a nursery are then transported to the site; workers install the plants directly in the sand, making an opening through the straw blanket to receive them. Sterile annual grass is applied to the straw to provide cover and organic material, but these grasses do not from part of the ongoing composition of the dune vegetation. Native dune seeds are also spread across the site for certain species.

During the implementation of Annual Work Plans, monitoring will be conducted at the sites targeted for restoration. Though the OHMVR Division has generally had a high degree of success with plant survivorship, some individual restoration sites in the future may require the installation of additional plant material to meet ecological restoration and emission control goals. The monitoring activities carried out at these revegetation sites would provide information on the status of control implementation (e.g., the size and status of plant growth), which in turn could be used to inform the model regarding the effectiveness of the control. Each revegetation site will have a desired plant community composition and be monitored to make sure it meets its targets.

6.1.5 Best Efforts to Increase Production/Yield

Efforts to increase plant production, which thereby support more rapid revegetation efforts, would be evaluated in the upcoming years if it is determined accelerating the rate of planting is necessary to meet SOA air quality objectives. An accelerated schedule would require additional plant production, annually. The critical obstacles to plant development include seed availability and nursery space. Seed availability can be approached by utilizing other nearby dune systems to acquire seed. For example, similar dunes located on the western edge of Morro Bay, approximately 20 miles north of Oceano Dunes SVRA, contain plant populations that could serve as donors for future planting. If OHMVR Division staff and Cal Poly students cannot expand their collection efforts, collections can be made by commercial suppliers. Other possible sources of seed could be from seed bulking by commercial seed providers. Nursery space can also be expanded by increasing the area for propagation at Cal Poly, or by increasing the number of plants contracted through private nurseries.

There are methods that could help to accelerate site preparation and plant/seed installation. Straw application could be increased with the use of different equipment or private contractor assistance. Plant and seed installation could be increased with the use of private contractors or with additional labor. The OHMVR Division is exploring other methods to increase annual revegetation production including methods to increase seed collection output, nursery material, site preparation, and plant installation.

6.1.6 Other Considerations

In addition to cost considerations, there are logistical and supply factors that could present a challenge to the large-scale installation of vegetation at Oceano Dunes SVRA:

- **Logistics:** There would considerable labor required for distributing the straw for the formation of the mulch blanket, seeding and imprinting the targeted dune surface, transporting plants to the dunes, and installing more than 100,000 plants per year.
- **Supply:** As of now, only two of the species under cultivation are common in the foredunes: *abronia* and *ambrosia*. Of these, only *ambrosia* has been successfully propagated. There are suggested methods for germinating and propagating *abronia*, but they have not yet been tested at Oceano Dunes SVRA. Other species could be considered for future foredune planting, such as *Cakile maritima* and *Atriplex leucophylla.* Refer to Attachment 5 for additional discussion regarding other plant species contemplated for foredune planting.

6.1.7 Temporary Irrigation

SOA Condition 2.e. requires the PMRP include analysis of the installation of temporary irrigation system(s) to ensure substantive plant growth and vigor in areas identified for revegetation and the application of liquid fertilizer through the irrigation water.

Given there is no potable water source at Oceano Dunes SVRA, and that installation of pipes from residential or commercial areas is prohibitive, there would only be two remaining options for temporary irrigation systems.

- **Truck-based water application**. If small water trucks were able to be brought into the dunes, irrigation could be done either with a side spray from such trucks, or with hose delivery from the trucks directly to the installed plants. If trucks are too large and heavy for the dunes, a water trailer, such as the 300-gallon capacity pump-equipped “Water Buffalo,” could be towed into the dunes with an ATV, distributing water from hoses. If irrigating a planted area, each plant would require several gallons to make a difference. Thus, the ATV and the tank would need multiple trips (several hundred) in order to supply water to a theoretical 40-acre revegetation site.
- **Helicopter application:** Delivery of water from a helicopter or aircraft would be a last resort option. Deployment of such aircraft is costly, and the capacity of such a tanker is perhaps 3,000 gallons. Distribution cannot be made specifically to an individual plant, so

water would be delivered as "rainfall" over the planted areas. Not accounting for the fact that such a drop would have tremendous power and could crush plants/initiate saltation under windy conditions, the amount needed to deliver the equivalent of 0.5-inches of rainfall would be over 500,000 gallons, or over 160 trips. This option is not considered to be a viable alternative to natural precipitation.

6.2 Other Potential Control Measures

6.2.1 Continuous Foredune Near High Water Line

Historical air photographs from the 1930's indicate a near-shore foredune complex was previously more extensive within Oceano Dunes SVRA (see Section 5.3 and Attachment 5). A foredune is typically the seaward-most sand ridges parallel to the shore. The morphological development and evolution of foredunes depends on a number of factors including sand supply, the degree of vegetation cover, plant species present (a function of climate and biogeographical region), the rate of aeolian sand accretion and erosion, the frequency and magnitude of wave and wind forces, and the occurrence and magnitude of storm erosion, dune scarping, and overwash processes.

In the case of Oceano Dunes SVRA, the historical photographic evidence suggests the foredunes that previously existed were discontinuous and formed of patches of vegetation with open sand corridors between them (see Attachment 3). They were elongated in form with the elongation aligned with the direction of the dominant sand transporting wind.

The re-establishment of a foredune complex at Oceano Dunes SVRA is considered desirable for several reasons. A foredune complex is expected to disrupt boundary layer airflow entering the dunefield from the ocean and reduce wind shear on downwind areas that are known to be highly emissive. By reducing wind shear, initial saltation of dust at these highly emissive areas would be inhibited. Additional benefits are expected to include the creation of more desirable camp site locations used by the public, which may translate into additional sand flux control due to the presence of trailers and vehicles acting as roughness elements.

Although the exact location for the establishment of a foredune above the high water line has not been selected, the PMRP's sensitivity analysis included a conceptual foredune approximately 22.7 acres in size installed in an area of high emissivity (see Figure 5-4). In addition to emissivity levels, the actual location selected for the establishment of a future foredune would also consider an areas comparison to more natural analogues, or reference foredune sites further south of the riding areas, and the observed success of self-sown native dune plants creating hummocks in the current seasonal snowy plover and least tern exclosure.

Foredunes can be created artificially by the accumulation of windblown sand in the lee of sand fences. Alternatively, they can be artificially created by mounding borrowed sand from the beachface, or elsewhere, using heavy equipment to transport the sand onto the upper beach, landward of the high water mark. Both methods, by themselves, lack stabilizing vegetation and proper airflow and sand transport dynamics required to maintain a properly functioning foredune. Sand fences also require maintenance and only function effectively for a limited amount of time.

To establish a foredune, the OHMVR Division would first enclose the area with a fence. Next, vegetation would be planted in clusters to mimic the approximate plant hummock spacing observed in the reference sites further south of the development area. Cluster planting would involve native foredune species (different from those planted landward, see Table 5-1) and localized use of straw mulch. The expectation is that the hummocky foredune landform would grow and develop as progressively more sand is trapped within the vegetation clusters.

Established monitoring methods, including measurement of sand flux at multiple locations and the use of UAV-based photogrammetry to monitor elevation and plant coverage changes, would be used to quantify the effectiveness in reducing sand flux and dust emissions, monitor changes in this index through time as the vegetation cover develops, and identify how much of the mulch cover is lost. The success of establishing a foredune complex would be controlled by a number of factors including: establishing a robust and thriving vegetation community; maintaining sand flux levels that do not overwhelm the growing plants, but rather promote their growth by providing them with a suitable environment with respect to moisture and nutrient needs; and restricting disturbances that could affect plant development. Regardless of where the foredunes may eventually be situated, visual monitoring of the site (for vegetation cover) and additional air quality monitoring downwind of the site (see Section 7.2) could provide valuable information regarding the effectiveness of the control, which could be used in the future to better inform the PMRP model.

Like most dust control measures undertaken at Oceano Dunes SVRA, a future foredune would be subject to review by other agencies for necessary permits. A particular concern for the re-establishment of a near-shore foredune may be the effect of this foredune on the western snowy plover nesting habitat, a species listed as threatened under the Federal Endangered Species Act.

6.2.2 Porous Fencing and Artificial Roughness Element Emplacement

Subsequent to 2013, two sand flux reduction control measures have been tested for their effectiveness at Oceano Dunes SVRA. These control measures include:

1) Multiple rows of four-foot tall porous fences (50% porosity), placed perpendicular to the prevailing sand transporting wind direction, and
2) The placement of roughness elements (straw bales) on the sand surface of prescribed areal density.

Through two years of testing it was established that the effectiveness of multiple rows of porous fencing spaced 10 times the fence height (10h, or approximately every 40 feet, depending on topography) reduces sand flux for the entire area by 40%, and 56% for the area at distances less than 93 fence heights (372 feet) from the upwind edge of the fence array. Decreasing the spacing interval to 7 times the fence height (7h, or approximately every 28 feet, depending on topography) reduced sand flux for the entire area by 78%, and 86% for the area at distances less than 27 fence heights (108 feet) from the upwind edge of the fencing array. Refer to Attachment 6 for the study published in the peer-reviewed scientific literature from which these results are drawn.

The application of large roughness elements, such as straw bales, at prescribed areal densities to modulate sand flux has been reported in the peer-reviewed scientific literature for several locations, including the Oceano Dunes SVRA. The roughness elements reduce the shear stress acting on the surface among the elements, which reduces the sand flux. The sand flux is further reduced by physical interactions between the moving sand and the roughness elements. When tested at the Oceano Dunes SVRA in 2011 as a control method to reduce sand flux by 50% in a riding area with relatively low topography, the mean sand flux reduction achieved was 58%. Tested again in 2014 in a more topographically complex area using a bale density designed to achieve the same target reduction of 50%, the mean sand flux reduction achieved was 89%; however, there was very high variability in effectiveness due to the complex dune topography. This method, although well-proven for relatively flat sandy areas, likely loses some effectiveness as topography becomes more complex (Gillies et al., 2015). Though the control effectiveness of porous fencing and straw bales has been studied in relatively great detail over the last decade at Oceano Dunes SVRA, additional monitoring may be conducted to further confirm these findings or draw additional conclusions for new fence / straw bale placement implemented through future Annual Work Plans.

The establishment of a continuous cover of vegetation or material, such as broadcast straw or mulch, on a sand surface should effectively reduce sand transport and the emissions of dust associated with the sand movement to zero, providing a control effectiveness of 100%. This effectiveness will remain as long as the treated area is not subject to a loss of cover to a critical amount or is covered by wind-transported sand moving onto the surface from the upwind direction.

6.3 Particulate Mitigation Plan

The OHMVR Division, in consultation with SAG and APCO, has developed a revised implementation plan detailing concrete step-by-step actions to achieve the particulate matter reduction goals set forth in the SOA. These "implementation actions" are listed under each of the eight objectives below. The objectives and implementation actions are informed by the evaluation and comments submitted on February 25, 2019 by SAG to the APCO on the February Preliminary Concept Draft PMRP.

Objectives 1 and 2 are management objectives that are time critical to the subsequent implementation of the technical mitigation objectives 3-8. Objectives 5 and 8 are air quality analytical tasks recommended by SAG to evaluate dust emission reduction from completed mitigation projects and to forecast additional needed emissions reductions and future mitigation project design. PMRP Attachment 9 provides detailed timelines for each of the objectives and subsidiary implementation actions. Further details on implementation actions will be provided in the required Annual Work Plans.

The SOA allows for "adaptive management," such that Annual Work Plans will be developed to continually improve upon the outcomes of implementation activities. To ensure a robust process for adaptive management, a series of detailed "evaluation metrics" have been developed to inform management decisions. These evaluation metrics, which are detailed in Attachment 8, are subdivided into preliminary “implementation metrics,” referring to measures of progress on tangible implementation actions, and preliminary “outcome metrics,” referring to measures of environmental change. While implementation metrics are directly tied to implementation actions, outcome metrics are subject to uncertainty related to natural variability in weather and dune dynamics. For example, survival rates for vegetation installed to mitigate dust emissions will depend, in part, on rainfall and sand transport activity.

Success criteria listed for each of the Objectives below are tied directly to evaluation metrics provided in Attachment 8.

Purpose Statement: To improve regional air quality in South SLO County in partnership with the SLO APCD in compliance with the SOA.

Goal: Reduce Oceano Dunes SVRA PM_{10} Emissions by 50% and reduce 24-hour concentrations at CDF within the timeframe set by the SOA (by 2023). Achieve compliance with Federal and State air quality standards through iterative analysis and implementation of measures to reduce PM emissions from Oceano Dunes SVRA.

Planning Considerations: In addition to the SOA, there are a number of State and federal laws (in no particular order) that set requirements that govern action taken in the SVRA.

- State and Federal Endangered Species Act
- U.S. Clean Air Act, Federal Air Quality Standards for Particulate Matter (PM)
- California Environmental Quality Act
- Health and Safety Code
- California Coastal Act
- Off-Highway Motor Vehicle Recreation Act

The requirements of the Stipulated Order of Abatement (SOA), include:

- Targets for emissions reductions
- Ongoing environmental monitoring to track incremental progress toward emissions reductions and success criteria
- Adaptive management in response to monitoring data
- Development of annual work plans informed by adaptive management

Objective 1: Accomplish necessary contracting and procurement actions. (Start March 2019 – End December 2022)		
Implementation Actions (details provided in Attachment 9, Proposed Implementation Schedule)		
1	Establish long-term contracts for Scientific Advisory Group members that are not already employees of the State of California	
2	Establish contracts for procurement of necessary air quality/meteorological monitoring equipment	
3	Establish contracts for plant propagation services and plant propagation materials	
4	Establish contract for labor resources needed for dune restoration efforts	
Success Criteria (details provided in Attachment 8, Evaluation Metrics)		Metrics I = Implementation O = Outcome
1	Number of contracts executed	I 4, I 13, I 16, I 21, I 26, I 27

Objective 2: Establish on-site project manager/District Superintendent (Start March 2019 – End December 2019) SAG recommended the creation of a dedicated project manager (SAG 2019, pg. 13).		
Implementation Actions (details provided in Attachment 9, Proposed Implementation Schedule)		
1	California Department of Human Resources job posting	
2	Recruiting though California Department of Human Resources	
3	Applicant Interviews – Hire	
4	Training	
Success Criteria (details provided in Attachment 8, Evaluation Metrics)		Metrics I = Implementation O = Outcome
1	Number of applicants for District Superintendent	I 28
2	Establish on-site project manager/District Superintendent	I 29

Objective 3: Development of a vegetated foredune just beyond the tidal zone as described in Section 5.3 of the Draft PMRP (Start May 2019 – End December 2023). SAG has recommended that emissions controls be implemented shoreward of the existing vegetated foredunes because PI-SWERL measurements and dispersion modeling indicate that high dust emissions originate in this area. Further, SAG concluded that the existence of foredunes elsewhere in the dune complex confirms that vegetated foredunes are appropriate in this location (SAG 2019, pg. 8).		
<u>Implementation Actions</u> (details provided in Attachment 9, Proposed Implementation Schedule)		
1	CEQA analysis and associated permitting	
2	Native plant propagation	
3	Install fencing while providing for public circulation and access	
4	Plant native plants to mimic natural plant cover of similar areas south of the camping and riding area	
5	Survey and monitoring (meteorological, sediment transport, emissivity, plant survivorship) before and after revegetation activities	
6	Education Campaign Instructional Video on appropriate campsite establishment – working title "The right size for camping at Oceano Dunes"	
7	Meetings for public input on planned camping changes	
8	Reduce camping capacity commensurate with camping area lost to the foredune and associated natural resource management efforts or utilize operation changes to increase camping density where feasible	
<u>Success Criteria</u> (details provided in Attachment 8, Evaluation Metrics)		Metrics I = Implementation O = Outcome
1	Mean fractional change in sand flux interior/exterior (effectiveness of control)	O 11
2	Reduction in the maximum 24-hour PM10 baseline emissions (initial 4-year goal: 50%)	O 1
3	Net reduction in wind speed over foredune restoration area	O 7, O 6, O 9, O 10, O 12
4	Net change in emissivity over foredune restoration area	O 8, O 9, O 10, O 12
5	Annual survival rate of plants	O 3
6	Increase in area covered by live plants	O 4, O 5
7	Changes in annual and average high wind day mean 24-hr PM10 by station	O 2
8	Area planted to foster natural foredune restoration	I 1
9	Area planted per average day	I 2
10	Frequency of plant inspection and viability monitoring	I 3

Objective 4: Convert existing wind fence areas (approx. 48.6 acres) established through initial SOA efforts identified on Figure 5-1 into natural vegetation cover similar to surrounding areas outside the riding area (Start October 2019 – End February 2021). The SOA directed Parks to erect this fencing by September 15, 2018, and to prioritize the fenced area for subsequent planting.		
Implementation Actions (details provided in Attachment 9, Proposed Implementation Schedule)		
1	Native plant seed collection	
2	Native plant propagation	
3	Wind fence removal	
4	Straw bale placement/straw mulch	
5	Plant native plants to mimic natural plant cover of similar areas	
6	Monitoring before and after revegetation activities (UAS surveys, Big Springs Number Eight (BSNE) transects, PI-SWERL emissivity measurements, plant survivorship surveys, weather station setup)	
Success Criteria (details provided in Attachment 8, Evaluation Metrics)		Metrics I = Implementation O = Outcome
1	Mean fractional change in sand flux interior/exterior (effectiveness of control)	O 15
2	Changes in annual and average high wind day mean 24-hr PM_{10} by station	O 2
3	Annual survival rate of plants	O 13
4	Planted areas buried by drifting sand	O 14
5	Net change in emissivity over backdune restoration area	O 17
6	Number of acres planted per average day	I 6
7	Number and locations of acres replanted annually to maintain backdune stability	I 7
8	Average number of plants per acre replanted	I 8
9	Frequency of plant inspection and viability monitoring	I 9
10	Average number of straw bales per acre installed	I 11
11	Quantities of native seed harvested annually by species	I 14
12	Numbers of plants by species cultivated annually for initial and replacement planting	I 15

Objective 5: Continue refinement of Lagrangian Stochastic Particle Dispersion Model (LSPDM) through robust and ongoing monitoring activities (Start April 2019 – End December 2023). SAG endorsed the DRI LSPDM as an appropriate and scientifically-based tool for assessing progress. But SAG also insisted that application of the model must be accompanied by a robust and continuous effort to monitor changing meteorology, topography, and dust emissivity (SAG 2019, pg. 7).		
Implementation Actions (details provided in Attachment 9, Proposed Implementation Schedule)		
1	Air quality and meteorological monitoring	
2	Emissivity – PI-SWERL Monitoring	
3	Remote sensing - LIDAR/Unmanned Aircraft System	
4	Particle analysis – Mass transport rate (sand traps)	
5	Incorporate data into LSPDM	
6	Performance of model validation studies	
7	Compare model results with PM monitoring data / refine LSPDM	
8	Ongoing use of LSPDM to design annual mitigation actions: location and scale	
Success Criteria (details provided in Attachment 8, Evaluation Metrics)		Metrics I = Implementation O = Outcome
1	Root Mean Square Error for model-observation comparison for a series of modeling scenarios	0 18, 0 19
2	Frequency of monitoring station inspection	I 27, I 19, I 20, I 22, I 23, I 25
3	Number of saltation monitoring stations operated in riding and downwind areas	I 17
4	Lidar survey for DEM of ODSVRA (for model input)	I 24
5	Number of meteorological monitoring stations operated in riding, downwind, and adjacent areas	I 18

Objective 6: Restore additional back dune areas (up to 60 acres total) to natural vegetation cover as necessary to continue progress toward achieving Goal (Start October 2020 – End February 2023). SAG recommended continued back dune vegetation campaigns (SAG 2019, pg. 11).		
Implementation Actions (details provided in Attachment 9, Proposed Implementation Schedule)		
1	CEQA analysis and associated permitting	
2	Selection of areas to be treated	
3	Native plant seed collection	
4	Native plant propagation	
5	Fencing installation	
6	Straw bale placement/straw mulch	
7	Plant native plants to mimic natural plant cover of similar areas outside the riding area	
8	Monitoring before, during, and after revegetation activities	
Success Criteria (details provided in Attachment 8, Evaluation Metrics)		Metrics I = Implementation O = Outcome
1	Mean fractional change in sand flux interior/exterior (effectiveness of control)	O 15
2	Number of acres planted annually to stabilize backdunes	I 5
3	Reduction in the maximum 24-hour PM10 baseline emissions (initial 4-year goal: 50%)	O 1
4	Net change in emissivity over backdune restoration area	O 17
5	Annual survival rate of plants	O 13
6	Planted areas buried by drifting sand	O 14
7	Area planted per average day	I 2
8	Number and locations of acres replanted annually to maintain backdune stability	I 7
9	Average number of straw bales per acre installed	I 11
10	Numbers of plants by species cultivated annually for initial and replacement planting	I 15

Objective 7: Deploy seasonal temporary wind fencing (up to 40 acres annually) as necessary to continue progress toward achieving Goal (Start March 2020 – End July 2023).		
Implementation Actions (details provided in Attachment 9, Proposed Implementation Schedule)		
1	CEQA analysis and associated permitting	
2	Selection of areas to be treated	
3	Fence installation	
4	Fence removal	
5	Monitoring before, during, and after (BSNE arrays, met stations, UAS surveys, and PI-SWERL measurements)	
Success Criteria (details provided in Attachment 8, Evaluation Metrics)		Metrics I = Implementation O = Outcome
1	Mean fractional change in sand flux interior/exterior (effectiveness of control)	O 15
2	Number of acres treated with temporary wind fence	I 10
3	Reduction in the maximum 24-hour PM10 baseline emissions (initial 4-year goal: 50%)	O 1
4	Mean fractional change in sand flux interior/exterior (effectiveness of control)	O 18
5	Length of wind fencing installed per average day	I 19
6	Fraction of average wind fence profile areas protruding above sand surface by area	O 16
7	Length of wind fencing installed per average day	I 12

Objective 8: Conduct baseline analysis and determine appropriate baseline approach (Start June 2019 – End December 2020). SAG recommended further study of the appropriate baseline period to understand downwind dust concentrations outside the current 2013 baseline period and to understand changes in the relationship of downwind dust concentrations with each year's mitigation activities (SAG 2019, pg. 22).		
Implementation Actions (details provided in Attachment 9, Proposed Implementation Schedule)		
1	APCO and SAG review of monitoring data and model outputs	
2	Recommended baseline approach to State	
3	State review of proposed baseline approach	
Success Criteria (details provided in Attachment 8, Evaluation Metrics)		Metrics I = Implementation O = Outcome
1	Establishment of a mutually agreeable baseline approach	O 20

7 PMRP Supporting Actions

This chapter describes the actions that the OHMVR Division, the SAG, and the SLOAPCD may take to support future PMRP modifications, modeling improvements, and the overall adaptive management approach to dust control at Oceano Dunes SVRA.

7.1 Updated PI-SWERL Measurements

As described in Section 3.2.1, the OHMVR Division, the SLOAPCD, and CARB have, historically, relied on PI-SWERL measurements to characterize the spatial variation in erodibility and emissivity throughout Oceano Dunes SVRA. The PMRP's 2013 baseline and preliminary compliance analysis modeling results presented in Chapter 4 and Chapter 5, respectively, are based on 360 PI-SWERL measurements collected in 2013. A key underlying assumption in the model, therefore, is that the 2013 PI-SWERL data are sufficiently representative of current environmental conditions of erodibility/emissivity at the Oceano Dunes SVRA, such that the model's predictions are also sufficiently representative to guide the development and execution of the PMRP. The OHMVR Division, in coordination with the SAG and the SLOAPCD, proposes to evaluate the correctness of this assumption by undertaking a second, intensive PI-SWERL measurement campaign of erodibility and emissivity in 2019. The 2019 PI-SWERL campaign would apply the same measurement protocols used in 2013, unless changes or improvements to the methodology are recommended by the OHMVR Division and approved by the SAG. The 2019 PI-SWERL campaign would sample erodibility and emissivity at some of the same test locations where samples were collected in 2013 (fraction to be defined by the OHMVR Division and approved by the SAG), as well as at locations where no measurements were made in 2013. Preliminarily, the OHMVR Division anticipates the same number of measurements would be carried out as in 2013 (n=360); however, a greater number would provide a better basis for determining if significant changes in erodibility and emissivity have occurred across the spatial domain. The resulting 2019 PI-SWERL campaign data would be used to update the emission grid, re-evaluate the effects of the areas that have been treated with dust controls since 2013, and evaluate the baseline conditions in areas that are proposed for additional dust controls. The OHMVR Division, working in conjunction with DRI, would compare and contrast the model predictions for the 2013 and 2019 versions of the PI-SWERL grid. In doing so, valuable information would be obtained on how the predictive capabilities of the model respond to new measurement data.

7.2 Additional Air Quality Monitoring (including Crystalline Silica)

As described in Chapter 2, the SOA requires that maximum 24-hour PM_{10} baseline emissions be reduced by 50% and that downwind PM_{10} concentrations achieve federal and state ambient air quality standards. It is therefore imperative that additional field monitoring be undertaken to observe the actual changes in PM_{10} emissions and PM_{10} concentrations resulting from PMRP dust control measures not only at SLOAPCD air quality monitoring stations but at additional locations closer to installed dust control measures. Preliminarily, the OHMVR Division proposes additional monitoring stations for measuring meteorological variables (wind speed, wind direction, temperature, relative humidity, barometric pressure, and precipitation) and PM_{10} concentrations both within and to the east of the Oceano Dunes SVRA border. These stations would serve five purposes: 1) better characterize the regional wind field and PM_{10} levels for improving model performance, 2) provide a larger data set to compare model predictions with measurements, 3) provide additional data on changes in PM_{10} that result from the implementation of dust control measures, 4) enhance the opportunity to evaluate changes in regional PM_{10} levels, which are limited at present to only two monitoring locations (the SLOAPCD CDF and Mesa2 air quality stations), and 5) provide the opportunity to investigate non-Oceano Dunes SVRA source contributions to regional PM_{10} levels. Air quality monitors would be set up upwind and downwind of control sites, prior to the control being implemented to establish how baseline PM_{10} concentrations vary in space and time at that location. After controls are implemented, these up and downwind stations could be used to track the efficiency of the implemented control.

In addition, data from the supplemental network of PM_{10} monitors (i.e., not from CDF or Mesa2) could be used to further validate the model's performance. For example, additional receptor locations could be placed within the model, based on actual monitoring locations in the field, to compare the model's estimated concentrations with those observed the field. This comparison would provide a better picture of how the model behaves at different locations, based on the inputs provided.

Given the public's concern that the mineral dust emitted from Oceano Dunes SVRA may contain crystalline silica, the OHMVR Division proposes to collect samples of the dust in the air during emissions events following accepted protocols for crystalline silica sampling, and to submit these samples to a laboratory accredited to analyze for the presence of crystalline silica. This sampling would be consistent with the SOA's requirements for preparing a comprehensive report on crystalline silica as it relates to Oceano Dunes SVRA emissions (see SOA page 3, item d). The sampling and report would build upon three previous airborne crystalline silica dust sampling and analysis efforts produced for the OHMVR Division, each of which concluded that the collected and reviewed data provide no evidence of realistic pulmonary (inhalation) risk with respect to airborne crystalline silica (Kelse, 2017a, 2017b, and 2018).

7.3 Analysis of Other Potential PM Sources

The SOA recognizes that PM_{10} concentrations measured at CDF and on the Nipomo Mesa, in general, may be impacted by sources of PM_{10} external to Oceano Dunes SVRA (SOA pg. 14, line 14). Accordingly, the SOA identifies that the SLOAPCD, OHMVR Division, and CARB will continue to refine knowledge of all the emission sources and their relative contributions to PM_{10} concentrations on the Nipomo Mesa (SOA, pg. 6, lines 19-23). This section identifies two potential sources of PM_{10} external to Oceano Dunes SVRA recreational operations and opportunities for studying their respective contributions to PM_{10} on the Nipomo Mesa.

7.3.1 Carbon and DNA Scripps Study

Several academic investigations have been undertaken at Oceano Dunes SVRA to evaluate potential contributions of PM_{10} from marine sources, including salt and biological material. One investigation found an increasing contribution to measured PM_{10} concentrations from sea-salt when dust saltation was inactive, and a decreasing contribution to PM_{10} concentrations when dust saltation was active (Huang, et al. 2018). This conclusion was supported by field measurements showing a coarser mean particle size distribution when saltation was inactive, consistent with sea-salt aerosols being coarser than dust aerosol. Also in 2018, an investigation by Brian Palenik, Ph.D., from the Scripps Institution of Oceanography (SIO) at UC San Diego, identified a marine contribution to aerosolized particles at Oceano Dunes SVRA (Palenik, 2018). The SIO investigation found that nearby coastal water is contributing biological material to PM_{10} detected and captured at temporary air quality monitoring stations installed at Oceano Dunes SVRA. The biological material included prokaryotes (bacteria) and eukaryotes, such as small diatoms. This biological material was identified using DNA sequencing of the PM collected on the filter tape of EBAM PM_{10} monitors installed at Oceano Dunes SVRA.

The OHMVR Division is coordinating with SIO on a follow-up investigation that will attempt to duplicate and expand on the initial findings regarding potential marine contributions to PM_{10} concentrations at and downwind of Oceano Dunes SVRA. To do this, material samples will be collected on different media. Samples will be collected from seawater offshore from the SVRA, from sand and foam on shore at the SVRA, from dune sand, and from filters on air quality monitoring equipment deployed within the SVRA and downwind (easterly) from the SVRA. Personnel at the Brian Palenik Laboratory at SIO will then isolate and sequence DNA on the samples to determine if specific species derived from the ocean are present in the collected samples.

The investigation will then incorporate the expertise of Lynn M. Russell, Ph.D. at SIO, who specializes in the identification and quantification of carbon in very fine airborne particulates (biogenic material is carbon-based). Dr. Russell will analyze filters collected from specialized equipment deployed to the dunes of the SVRA and downwind of the SVRA. The equipment includes pump apparatus and particulate segregators that enable the capture of very fine airborne particulate (approximately or less than 2.5 microns in diameter). These filter samples will be analyzed via infrared spectroscopy to determine the types of carbon (e.g., marine vs. terrestrial, more specific if possible) within the particulate as well as the respective amounts of carbon types relative to the overall mass of the particulate collected.

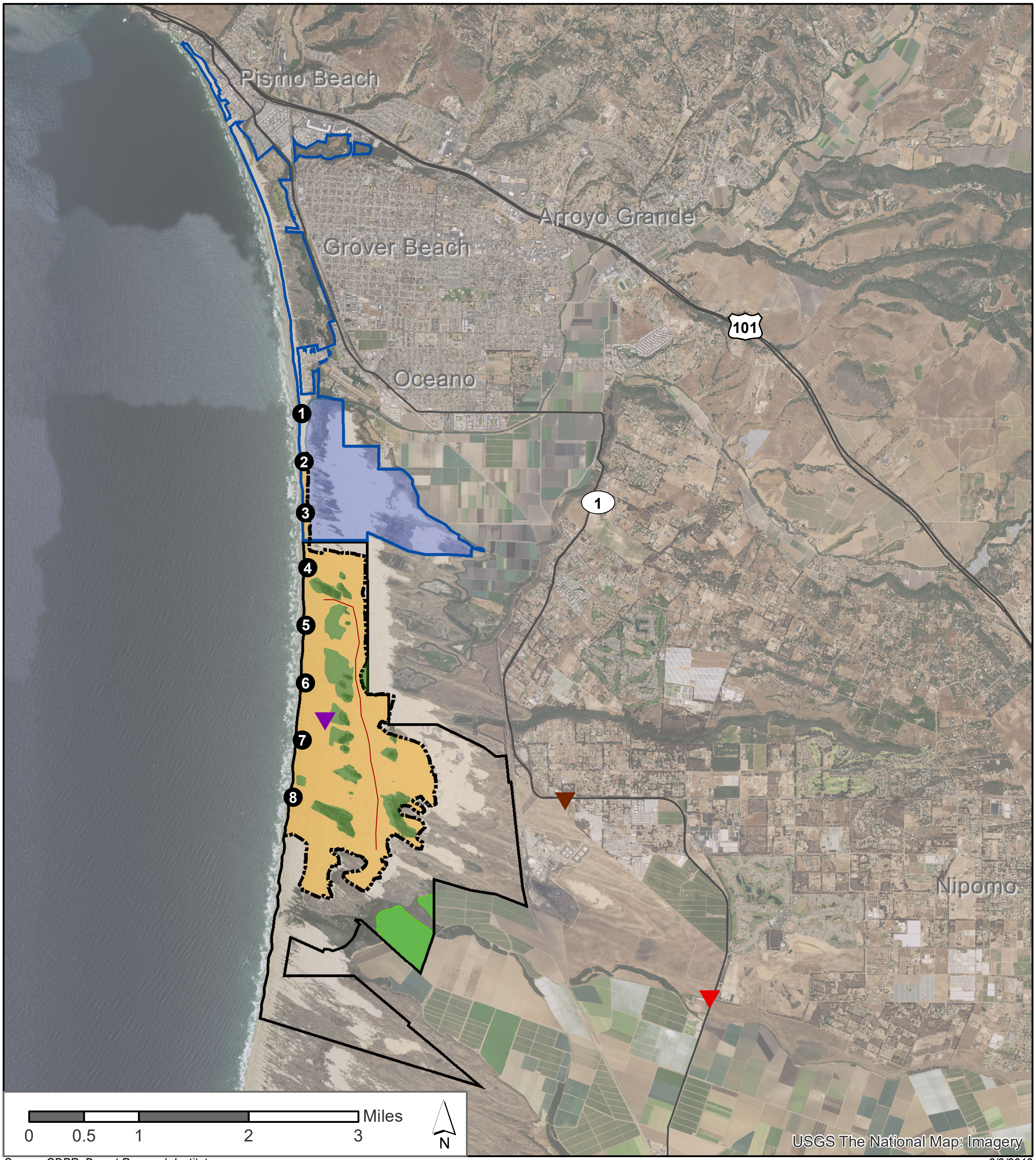
The third phase of the investigation will analyze activity of planktonic blooms offshore from Oceano Dunes SVRA via satellite imagery remote sensing. Mati Kahru, Ph.D. at SIO, specializes in the analysis of remote-sensed satellite imagery depicting sea surface chlorophyll concentrations and sea surface temperatures, both of which are indicators planktonic bloom activity. Dr. Kahru will review and analyze available imagery data for seasonal planktonic bloom activity trends offshore from the Oceano Dunes SVRA.

7.3.2 Agricultural Field Air Quality Study

Within the Oceano Dunes District, approximately 202 acres of state-owned land are leased to private agricultural operations (see Figure 7-1). The OHMVR Division may, in coordination with the SAG and the SLOAPCD, evaluate these agricultural operations to determine whether they contribute to measured PM_{10} levels at SLOAPCD air quality monitoring stations, and whether the removal of these lands from cultivation (for a return to natural land coverage) would assist in achieving the SOA's air quality objectives.

7.4 SODAR

To compliment the local and regional meteorological data used in the DRI-Lagrangian model (see Chapter 3), the OHMVR Division proposes to deploy a SODAR (SOnic Detection and RAnging) instrument (Vaisala Triton Wind Profiler model T295) to provide onsite boundary layer wind speed profiling within Oceano Dunes SVRA. The operational principle of SODAR is based on measuring the scattering of sound waves projected into the boundary layer to quantify wind speed and atmospheric turbulence. SODAR instruments are commonplace in wind engineering, wind power, meteorology, and air quality monitoring. The Vaisala Triton unit provides wind speed and direction measurements at 10 heights above ground level from approximately 131 feet (40 meters) to approximately 656 feet (200 meters) within the planetary boundary layer. The SODAR unit is proposed for installation near the eastern boundary of Oceano Dunes SVRA. The unit is autonomous, is powered by a solar panel-battery array, and has an onboard cellular communication link to facilitate data transfer and access to a potential online weblink.



Source: CDPR, Desert Research Institute

2/3/2019

- Marker post
- Sand Highway, approx.
- Riding area boundary fence
- Fenced vegetation islands (no vehicles allowed)
- Open riding and camping area

Wind monitoring towers

- CDF
- Mesa 2
- S1

Oceano Dunes District

- Oceano Dunes State Vehicular Riding Area
- Pismo State Beach
- Pismo Dunes Natural Preserve
- Leased agricultural lands

California State Parks Since 1864 OHV

7-1 Oceano Dunes District - Leased Agricultural Lands

The OHMVR Division, in coordination with the SAG and the SLOAPCD, will use the data collected from the SODAR to supplement and validate the modeled wind flow field at Oceano Dunes SVRA derived using the CALMET model from a mix of surface and upper air observations points (see Section 3.2.2). In addition, the SODAR unit will provide new resolution on boundary layer structure (velocity variations with height) and upper air properties (at approximately 656 feet) of wind flow after it has passed through Oceano Dunes SVRA. The SODAR velocity profile data could be used to estimate roughness effects and shear stress signatures in the lower boundary layer that can be related to observed sand transport activity and patterns of PM_{10} emissions within the dunes, The SODAR data could also be used to explore how changes in surface roughness, vegetation treatments, or other dust control measures affect boundary layer structure and flow properties.

7.5 Topographic and Sediment Budget Monitoring of Future Foredune

As described in Section 6.2.1, the re-establishment of a foredune system is being considered as a means to control dust emissions from Oceano Dunes SVRA. To create suitable conditions for foredune development, additional sand will need to be artificially mounded at the site. The establishment of a foredune system will result in instantaneous and incremental topographical changes as the sand brought to the site emerges into the established foredune system. As part of the potential development of the foredune, the OHMVR Division may propose high-resolution land surveying to identify baseline terrain conditions (in a DEM or digital orthophotograph mosaic format) as well as changes in vegetation cover and geomorphology following implementation of the foredune planting regime. This surveying may be conducted using an Unmanned Aerial Systems (UAS) methodology involving a commercial drone and high-resolution digital camera system. UAS imagery, coupled with survey grade Global Navigation Satellite System control monuments, can be used to generate high-resolution DEMs using Structure-from-Motion (SfM) multi-view stereo photogrammetry methods. In comparison to other high-resolution terrain mapping methods (e.g., aerial or terrestrial LiDAR), UAS-SfM has proven to be highly cost-effective and time-efficient and provides comparable resolution data products for landscape-scale terrain mapping and change detection assessments.

The UAS mapping could be undertaken at one or more of the following locations: the potential foredune development zone; the adjoining Snowy Plover exclosure; other natural, hummocky foredunes further south of the Oceano Dunes SVRA open riding and camping area. These additional sites would serve as a comparison to quantify morphological and sediment transport responses within a more natural plant regeneration site and a natural foredune morphology control site, respectively. Statistical change detection methods would allow a comparison of DEMs over time across these sites to quantify morphological responses, surface roughness changes, sediment volumetric changes, and sediment mass exchanges between beach, foredune, and back dune environments. The performance of the foredune development could then be assessed based on sediment budget and morphodynamic responses of the new foredune and related changes in observed sand transport activity and dust emissions derived from the air quality monitoring sites available for use in the analysis.

Refer to Attachment 6 for additional information on the methodology and logistics associated with a UAS mapping campaign.

7.6 Track-Out

Pursuant to SOA Condition 1.c, the OHMVR Division is required to install an APCO-approved track-out control device at the Grand Avenue and Pier Avenue entrances to Oceano Dunes SVRA in the City of Grover Beach and the unincorporated community of Oceano, respectively, by June 30, 2019.

The required track-out control devices are intended to prevent track-out of sand onto paved, public roadways. During a typical summer weekend (Friday to Sunday), up to 11,500 vehicles can pass through the Grand and Pier Avenue entrances to Oceano Dunes SVRA (OHMVR Division, 2013). A busy weekend like July 4th or Memorial Day could see over 5,100 vehicles entering and exiting the park in a single day (OHMVR Division, 2013). A wide range of vehicle types and sizes pass through these entrances, including cars, trucks, trailers, recreational vehicles, and commercial vehicles.

The proposed track-out prevention structures would remove sand from vehicles before it reaches Grand Avenue or Pier Avenue; however, the OHMVR Division must overcome technical and logistical challenges to install any structural track-out prevention device at Oceano Dunes SVRA. The greatest technical challenge is to develop a system that can deal with the quantities of sand expected to occur in the area. In addition to accommodating the sand that adheres to vehicles, the structural devices would need to function with the large quantity of naturally blowing sand from the beach area. The greatest logistical challenge is maintenance. Structural devices would need to be easy to use and would need to quickly remove sand attached to vehicles. In addition, the structures would need to accommodate a wide-array of vehicle types.

Preliminarily, the OHMVR Division is proposing to install V-shaped, grooved concrete panels west of the entrance kiosks at Grand Avenue and Pier Avenue. The concrete panels would be eight inches thick and supported by footings or a pier and beam foundation. The panels would be 30 to 45 feet wide in total, with 1- to 1 ½ inch-thick V-shaped groves that would run perpendicular to vehicle travel lanes (both ingress and egress). The concrete panels would be between 50 to 125 feet in length, and would be located in the Grand Avenue and Pier Avenue roadways, potentially extending down the entrances’ sand ramps. The preliminary site plan for the proposed Grand Avenue and Pier Avenue track-out prevention structures are shown in Figure 7-2 and Figure 7-3.

The proposed track-out control devices are part of an ongoing public works project which is funded as a distinct capital outlay project through the California State Budget process and subject to approvals by the California Public Works Board. Although the SOA requires the installation of these devices by June 30, 2019, the OHMVR Division will be submitting evidence of a delay beyond the OHMVR Division’s control to the APCO and intends to apply for a modification of the deadline contained in SOA 1.c. The OHMVR Division’s tentative schedule for completing the design and installation of track-out control includes the appropriation of funds for the final design of the project in Fiscal Year 2019-2020, permitting in Fiscal Year 2020-2021, and bid award and construction in Fiscal Year 2021-2022.

7.7 Educational Campaign

The SOA requires the OHMVR Division conduct an education campaign for the purposes of making the public aware of the air quality issues at Oceano Dunes SVRA and how they can be a part of the solution (SOA pg. 4, lines 4 – 6). The OHMVR Division proposed education efforts include, but are not limited to:

- Printed materials distributed to park visitors.
- Interpretive panels at dust treatment sites.
- Public service announcements.
- The creation of a public website that provides includes easy-to-interpret data and figures, and a comparison of modeled concentrations to observed conditions. This would demonstrate the value of the DRI model for estimating emissions reductions from the Oceano Dunes SVRA.
- Looking into collaborations with universities that would build external connections and potentially bring additional external scientific expertise to the dust control effort.

Figure 7-2: Preliminary Site Layout - Track-Out Prevention (Grand Avenue)

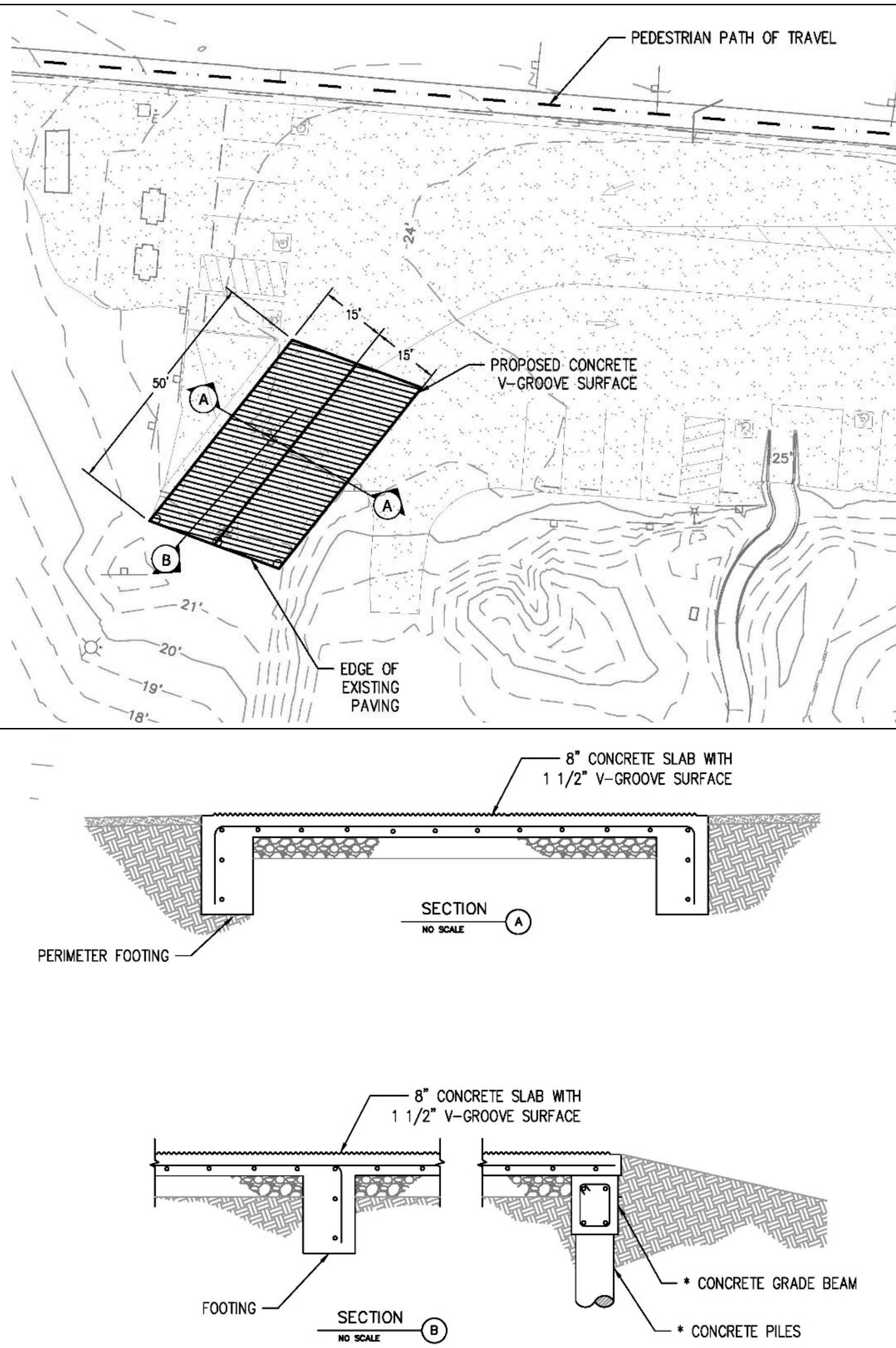


Figure 7-2. Preliminary site design depicting grooved concrete ramp and supporting foundation at Grand Avenue entrance. Source: California State Parks, 2017.

Figure 7-3: Preliminary Site Layout - Track-Out Prevention (Pier Avenue)

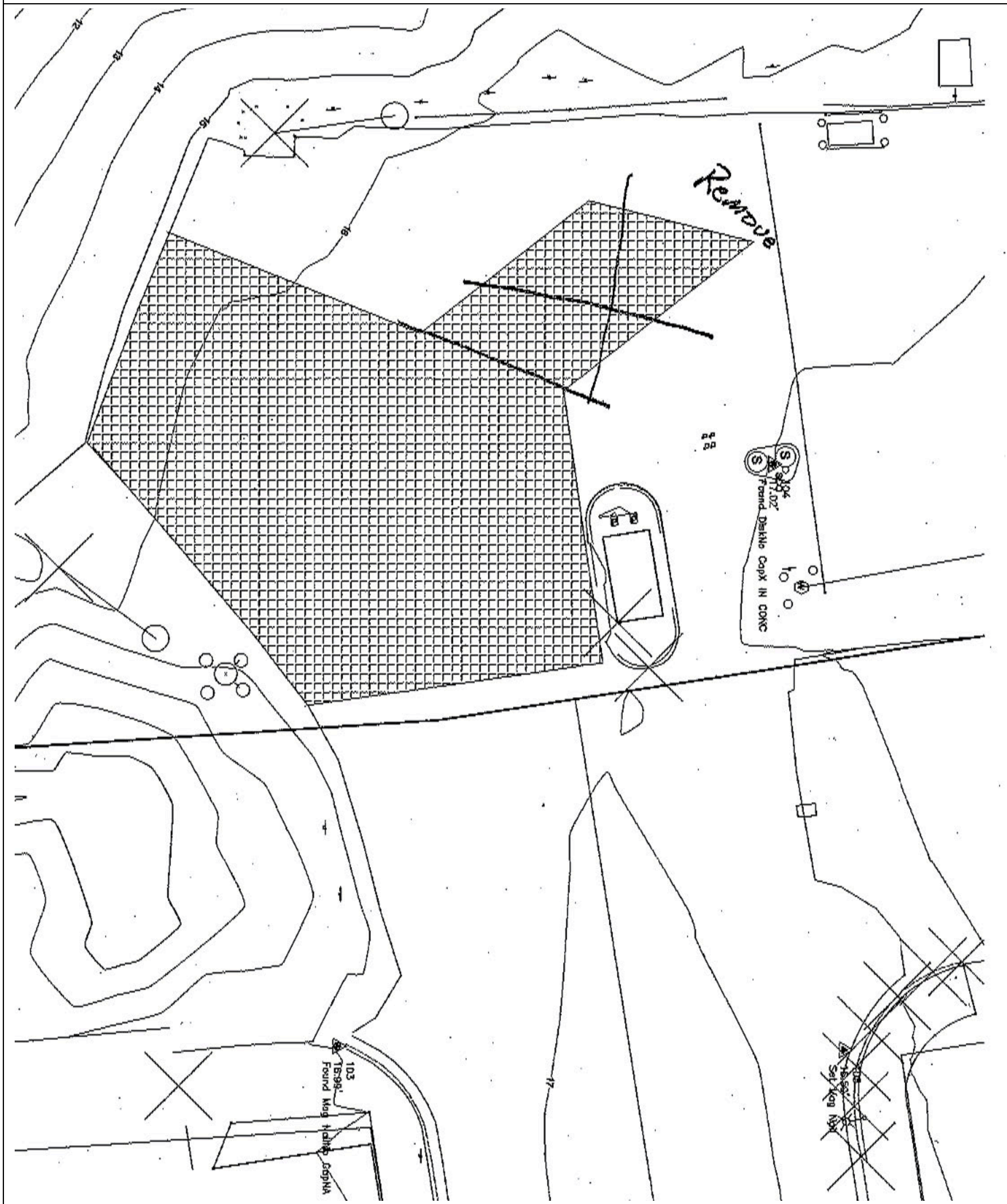


Figure 7-3. *Preliminary site design and demolition plan for track-out sediment control at Pier Avenue entrance. Source: California State Parks, 2018.*

8 References

The following references were used to prepare this PMRP. In addition to the specific references listed throughout the document, DRI provided a list of supplementary references pertaining to the DRI-LSPDM methodology and the effectiveness of vegetation and porous roughness elements as a means of dust control.

California Geological Survey (CGS) 2007. "Review of Vegetation Islands, Executive Summary, Oceano Dunes SVRA." Prepared for the Off-Highway Motor Vehicle Recreation Division. Sacramento, CA. August 30, 2007.

______2011. *In Consideration of Draft Rule 1001 proposed by the San Luis Obispo County Air Pollution Control District: An Analysis of Wind, Soils, and Open Sand Sheet and Vegetation Acreage in the Active Dunes of the Callender Dune Sheet, San Luis Obispo County, California*. Prepared for the Off-Highway Motor Vehicle Motor Vehicle Recreation Division of California State Parks. November 1, 2011.

California Air Resources Board (CARB) 2016a. *Ambient Air Quality Standards.* Sacramento, CA. May 4, 2016. Available online at: <https://www.arb.ca.gov/research/aaqs/aaqs2.pdf>

______2019a. Glossary of Air Pollution Terms. Available online at: <https://ww2.arb.ca.gov/about/glossary?f%5B0%5D=name%3AD#search_anchor>

California Air Resources Board (CARB) 2019b. California Ambient Air Quality Standards. Available online at: <https://ww2.arb.ca.gov/resources/california-ambient-air-quality-standards>

______2019c. "Oceano Dunes Model". Email communication from Earl Withycombe, Air Resources Engineer, CARB, to Jack Gillies, Research Professor, DRI. January , 2019.

______2019d. Air Quality and Meteorological Information System. n.d. Web. February 1, 2019. <https://www.arb.ca.gov/aqmis2/aqdselect.php>

California State Parks 2017. Preliminary Site Plan for Oceano Dunes SVRA Track Out Prevention – Grand Avenue. Sacramento, Ca. October 2017.

California State Parks 2018. Oceano Dunes SVRA Sediment Track Out Pier Ave Horizontal Control and Demolition Plan. Sacramento, Ca. August 2018.

California Irrigation Management Information System (CIMIS) 2019. Daily data for Station 202. http://www.cimis.water.ca.gov/

Desert Research Institute 2011. Oceano Dunes Pilot Projects Final Project Report. Reno, NV September 15, 2011.

______2019. "PMRP-DRI Supporting Modeling Material". Powerpoint presentation. January 27, 2019.

Gillies, J. A., V. Etyemezian, G. Nikolich, R. Glick, P. Rowland, T. Pesce, and M. Skinner (2017), Effectiveness of an array of porous fences to reduce sand flux: Oceano Dunes, Oceano CA, *Journal of Wind Engineering and Industrial Aerodynamics*, *168*, 247-259.

Huang, Y., J. F. Kok, R. L. Martin, N. Swet, I. Katra, T. E. Gill, R. L. Reynolds, and L. S. Freire (2018), Fine dust emissions from active sands at coastal Oceano Dunes, California, *Atmos. Chem. Phys. Discuss.*, *2018*, 1-29.

Jaison 2012. Greg Jaison, University of Southampton. 2012.

Kelse 2017a. Kelse, John. *Comments Concerning Crystalline Silica Monitoring Analytical Results Obtained from Air Sampling at the CDF Station, 291 Willow Road, Arroyo Grande, California in April/May/June of 2017*. December 14, 2017.

______2017b. *Determination of Airborne Crystalline Silica (Quartz) Exposure at Oceano Dunes State Vehicular Recreation Area*. Prepared for the OHMVR Division by John Kelse, Industrial Hygienist. December 14, 2017.

______2018. *Determination of Airborne Crystalline Silica (Quartz) Exposure at Oceano Dunes State Vehicular Recreation Area and CDF Air Monitoring Site, 291 Willow Road, Arroyo Grande, California, San Luis Obispo County, California*. Prepared for the OHMVR Division by John Kelse, Industrial Hygienist. March 16, 2018.

Mesinger, F., et al. (2006), North Americal Regional Reanalysis, *Bulletin of the American Meteorology Society*, *March*, 343-360.

Off-Highway Motor Vehicle Recreation (OHMVR) Division 2009. *Strategic Plan – 2009*. Sacramento, CA. 2009. <http://ohv.parks.ca.gov/pages/25010/files/ohmvr%20strategic%20plan.pdf>

Palenick, Brian and Maitreyi Nagarkar. *Marine Contributions to Aerosol Particulates in a Coastal Environment.* Scripps Institute of Oceanography, UC San Diego. La Jolla, CA. March 6, 2018.

Scientific Advisory Group (SAG) 2019. *Evaluation of Oceano Dunes SVRA Preliminary Concept Draft PMRP*. Feburary 25, 2019

San Luis Obispo County Air Pollution Control District (SLOAPCD) 2013. Rule 105 – Definitions. Adopted August 2, 1976, last revised November 13, 2013.

______2017. *2017 Annual Air Quality Report.* San Luis Obispo, CA. 2017.

SLOAPCD Hearing Board. *Case No. 17-01 Stipulated Order of Abatement.* San Luis Obispo, CA. Filed May 4, 2018.

United States Environmental Protection Agency (USEPA) 2017. "Air Quality Dispersion Modeling." *Dispersion Modeling.* U.S. EPA Support Center for Regulatory Atmospheric Modeling (SCRAM), Air Quality Models [Dispersion Modeling]. June 23, 2017. Web. February 1, 2019. <https://www.epa.gov/scram/air-quality-dispersion-modeling>

United States Environmental Protection Agency (USEPA) 2018a. "Particulate Matter (PM) Pollution." *What is PM, and how does it get into the air?.* U.S. EPA, Environmental Topics [Air], Particulate Matter Basics. November 14, 2018. Web. February 1, 2019. <https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM>

______2018b. "Health and Environmental Effects of Particulate Matter (PM)." *What are the harmful effects of PM.* U.S. EPA, Science and Technology [Air], Particulate Matter Basics. June 20, 2018. Web. February 1, 2019. <https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm>

LIST OF DRI SUPPLEMENTAL REFERENCES

Bauer, B. O., R. G. D. Davidson-Arnott, P. A. Hesp, S. L. Namikas, J. Ollerhead, and I. J. Walker (2009), Aeolian sediment transport on a beach: Surface moisture, wind fetch, and mean transport, *Geomorphology*, *105*(1–2), 106-116.

Davidson-Arnott, R. G. D., Y. Yang, J. Ollerhead, P. A. Hesp, and I. J. Walker (2008), The effects of surface moisture on aeolian sediment transport threshold and mass flux on a beach, *Earth Surface Processes and Landforms*, *33*(1), 55-74.

Etyemezian, V., J. A. Gillies, M. Shinoda, G. Nikolich, J. King, and A. R. Bardis (2014), Accounting for surface roughness on measurements conducted with PI-SWERL: Evaluation of a subjective visual approach and a photogrammetric technique, *Aeolian Research*, *13*, 35-50.

Etyemezian, V., G. Nikolich, S. Ahonen, M. Pitchford, M. Sweeney, J. Gillies, and H. Kuhns (2007), The Portable In-Situ Wind Erosion Laboratory (PI-SWERL): a new method to measure PM_{10} windblown dust properties and potential for emissions, *Atmospheric Environment*, *41*, 3789-3796.

Gillies, J. A., and N. Lancaster (2013), Large roughness element effects on sand transport, Oceano Dunes, California, *Earth Surface Processes and Landforms*, *38*(8), 785-792.

Gillies, J. A., V. Etyemezian, G. Nikolich, W. G. Nickling, and J. F. Kok (2018), Changes in the saltation flux following a step-change in macro-roughness, *Earth Surface Processes and Landforms*, *43*(9), 1871-1884.

Gillies, J. A., V. Etyemezian, G. Nikolich, R. Glick, P. Rowland, T. Pesce, and M. Skinner (2017), Effectiveness of an array of porous fences to reduce sand flux: Oceano Dunes, Oceano CA, *Journal of Wind Engineering and Industrial Aerodynamics*, *168*, 247-259.

Gillies, J. A., H. Green, G. McCarley-Holder, S. Grimm, C. Howard, N. Barbieri, D. Ono, and T. Schade (2015), Using solid element roughness to control sand movement: Keeler Dunes, Keeler, California, *Aeolian Research*, *18*, 35-46.

Lancaster, N., and A. Baas (1998), Influence of vegetation cover on sand transport by wind: field studies at Owens Lake California., *Earth Surface Processes and Landforms*, *25*, 68-82.

Namikas, S. L., and D. J. Sherman (1995), A review of the effects of surface moisture content on aeolian sand transport, in *Desert Aeolian Processes*, edited by V. P. Tchakerian, pp. 269-293, Chapman & Hall, London.

Scire, J. S., F. R. Robe, M. E. Fernau, and R. J. Yamartino (2000), *A User's Guide for the CALMET Meteorological Model (Version 5)*, Earth Tech, Inc., Concord, MA.

Sweeney, M., V. Etyemezian, T. Macpherson, W. G. Nickling, J. Gillies, G. Nikolich, and E. McDonald (2008), Comparison of PI-SWERL with dust emission measurements from a straight-line field wind tunnel, *Journal of Geophysical Research, Earth Surface*, *113*, F01012, doi:01010.01029/02007JF000830.

Wasson, R. J., and P. M. Nanninga (1986), Estimating wind transport of sand on vegetated surfaces, *Earth Surface Processes and Landforms*, *11*, 505-514.

THIS PAGE INTENTIONALLY LEFT BLANK.

.

Oceano Dunes SVRA Draft PMRP

ATTACHMENT 1

CASE NO. 2017-01 STIPULATED ORDER OF ABATEMENT (FILED MAY 4, 2018)

THIS PAGE INTENTIONALLY LEFT BLANK.

Oceano Dunes SVRA Draft PMRP

ATTACHMENT 2

Oceano Dunes Dust Dispersion Model Description

THIS PAGE INTENTIONALLY LEFT BLANK.

Oceano Dunes SVRA Draft PMRP

ATTACHMENT 3

DRI Wind and PM_{10} Characteristics at the ODSVRA from the 2013 Assessment Monitoring Network

THIS PAGE INTENTIONALLY LEFT BLANK.

Oceano Dunes SVRA Draft PMRP

ATTACHMENT 4

1930's Aerial Photography Used to Locate Initial SOA Dust Control Measures

THIS PAGE INTENTIONALLY LEFT BLANK.

THIS PAGE INTENTIONALLY LEFT BLANK.

Oceano Dunes SVRA Draft PMRP

ATTACHMENT 5

CGS Dune Vegetation Comparison, Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California

THIS PAGE INTENTIONALLY LEFT BLANK.

THIS PAGE INTENTIONALLY LEFT BLANK.

Oceano Dunes SVRA Draft PMRP

ATTACHMENT 6

Supplemental Vegetation Planting Information

THIS PAGE INTENTIONALLY LEFT BLANK.

THIS PAGE INTENTIONALLY LEFT BLANK.

Oceano Dunes SVRA Draft PMRP

ATTACHMENT 7

Unmanned Aerial System Mapping Campaign Methodology and Logistics Information

THIS PAGE INTENTIONALLY LEFT BLANK.

THIS PAGE INTENTIONALLY LEFT BLANK.

Oceano Dunes SVRA Draft PMRP

ATTACHMENT 8

PMRP Evaluation Metrics

THIS PAGE INTENTIONALLY LEFT BLANK.

THIS PAGE INTENTIONALLY LEFT BLANK.

Oceano Dunes SVRA Draft PMRP

ATTACHMENT 9

PMRP Proposed Implementation Schedule

THIS PAGE INTENTIONALLY LEFT BLANK.

THIS PAGE INTENTIONALLY LEFT BLANK.