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**Oceano Dunes State Vehicular Recreation Area  
Rule 1001 Draft Particulate Matter Reduction Plan**

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**Third Draft**

**March 29, 2013**

**ATTACHMENT 1  
Assessment Monitoring Program**



**State of California  
Department of Parks and Recreation  
Off-Highway Motor Vehicle Recreation Division**

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**Oceano Dunes SVRA Particulate Matter Reduction Plan  
Third Draft**

**Attachment 1 – Assessment Monitoring Program  
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## List of Acronyms and Abbreviations

APCD	Air Pollution Control District
APCO	Air Pollution Control Officer
APP	Met One Instruments Model 212-1 Ambient Particulate Profiler
ARB	California Air Resources Board
CDVAA	Coastal Dune Vehicle Activity Area
CEQA	California Environmental Quality Act
DRI	Desert Research Institute
E-BAM	Met One Instruments Environmentally-protected Beta Attenuation Mass Monitor
FEM	Federal Equivalent Method
MSSP	Monitoring Site Selection Plan
OHMVR	Off-Highway Motor Vehicle Recreation
OHV	Off-Highway Vehicle
PI-SWERL	Portable In-Situ Wind Erosion Laboratory
PMRP	Particulate Matter Reduction Plan
SLO	San Luis Obispo
SVRA	State Vehicular Recreation Area

## 1 INTRODUCTION

This Attachment describes the Off-Highway Motor Vehicle Recreation (OHMVR) Division's Assessment Monitoring Program referenced in Section 3.2 of the OHMVR Division's Particulate Matter Reduction Plan (PMRP). This attachment is organized as follows:

- **Section 1 Introduction** describes the need for this Assessment Monitoring Program.
- **Section 2 Assessment Monitoring Program Description** describes the program, including monitoring locations, activities, equipment, schedule, and quality assurance / quality control procedures.

### 1.1 ASSESSMENT MONITORING PROGRAM NEED

The OHMVR Division is proceeding with this Assessment Monitoring Program to support two fundamental steps the OHMVR Division must undertake to comply with the requirements of Rule 1001: Selection of comparable Coastal Dune Vehicle Activity Area (CDVAA) and Control Site PM10 Monitors and prioritization of dust control project areas. Figure 1 depicts how the OHMVR Division would use this Assessment Monitoring Program to support compliance with Rule 1001.

#### 1.1.1 Selection of Comparable CDVAA and Control Site PM10 Monitor Locations

Table 3 of the OHMVR Division's May 4, 2012 Monitoring Site Selection Plan (MSSP) identifies several scientific factors the OHMVR Division will consider when comparing and selecting the CDVAA and Control Site monitors required by Rule 1001. These include but are not limited to: vehicle activity, topography, and wind direction and wind speed (average and peak). This Assessment Monitoring Program will provide the information on vehicle activity and wind conditions necessary to evaluate and select comparable CDVAA and Control Site Monitor locations in accordance with the OHMVR Division's conditionally approved MSSP<sup>1</sup>.

#### 1.1.2 Prioritization of Dust Control Project Areas

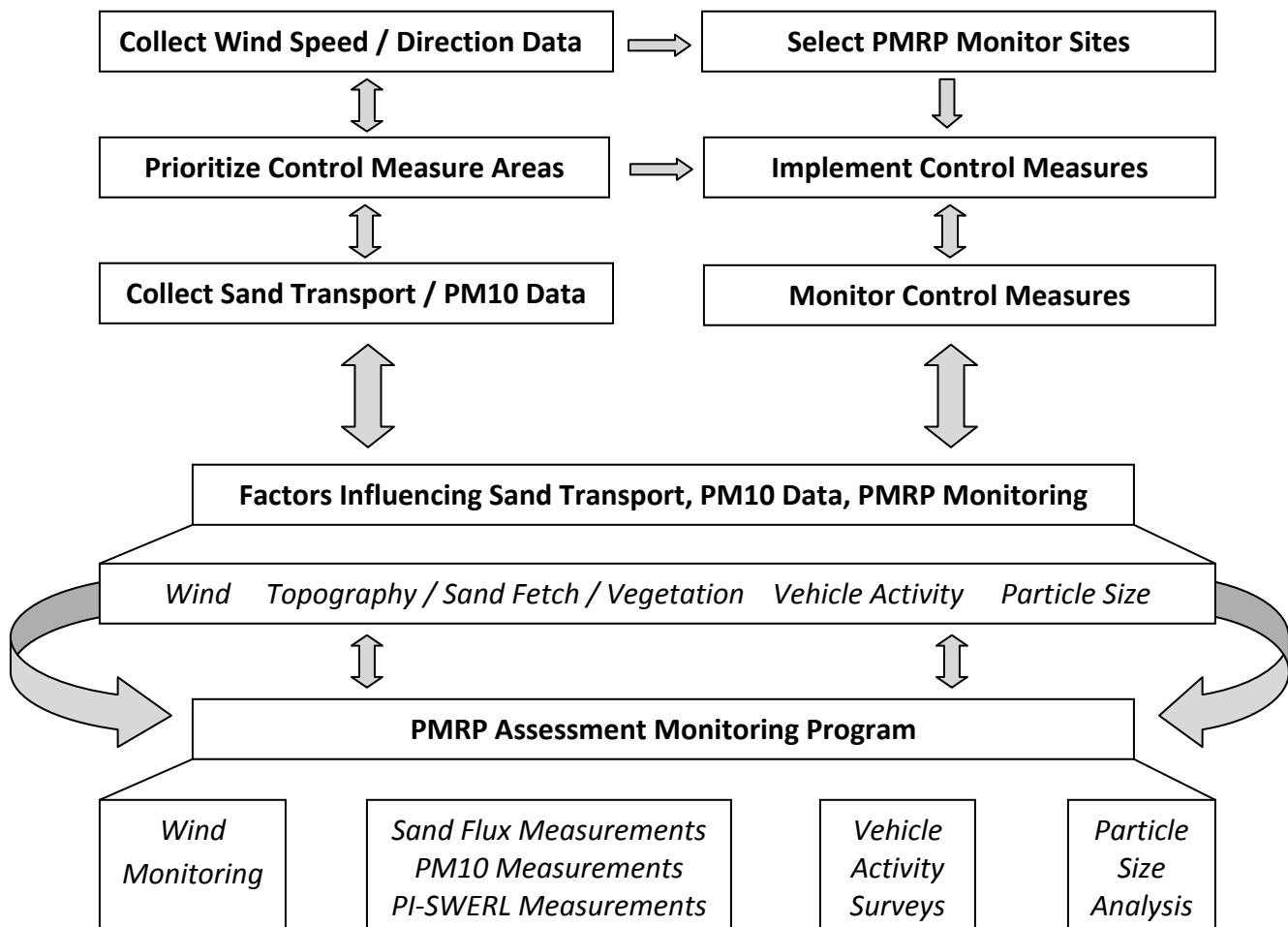
Section 3.2 of the PMRP describes the need for the OHMVR Division to use staff, materials, and economic resources in the most efficient manner possible. Oceano Dunes SVRA stretches from approximately Grand Avenue in the north to the Oso Flaco Lake region in the south, a distance of approximately seven miles. The inland extent of the sand sheet varies significantly from north to south and is largest in the center of Oceano Dunes SVRA. Information regarding the

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<sup>1</sup> The Air Pollution Control Officer (APCO) conditionally approved the OHMVR Division's MSSP on May 22, 2012. Per this conditional approval, the OHMVR Division must submit and obtain approval of a detailed measurement plan and operating procedures for all proposed MSSP measurements, including data handling and quality assurance protocols. This PMRP Attachment constitutes the measurement plan; the OHMVR Division will submit detailed operating procedures for review prior to equipment deployment on the dunes.

dust emissivity and wind regimes that exist within the dunes is largely incomplete; the OHMVR Division’s S1 meteorological tower is the only meteorological tower operating within Oceano Dunes SVRA, although several towers are located downwind of the SVRA, including the APCD’s CDF and Mesa2 meteorological stations. The lack of information regarding dust emissivity and wind regimes reduces the OHMVR Division’s ability to effectively locate dust control measures that will achieve the requirements of Rule 1001. This Assessment Monitoring Program will provide information on existing meteorological, sand transport, and air quality conditions within the CDVAA and two of the four Control Sites described in the PMRP so that the OHMVR Division may adequately characterize sand transport rates and PM10 emissivity and prioritize areas for control.

**Figure 1 PMRP Assessment Monitoring Program Flowchart**



## 2 ASSESSMENT MONITORING PROGRAM DESCRIPTION

The Assessment Monitoring Program consists of monitoring the scientific factors that influence sand transport, dust generation, and PM10 dispersion, thereby influencing the selection of comparable CDVAA and Control Site PM10 Monitor and the prioritization of dust control project areas. These scientific factors generally are: 1) Wind speed and direction; 2) Topography and sand/fetch vegetation; 3) Sand and particle transport rates; 4) PM10 concentrations; 5) Vehicle activity rates; and 6) Particle size distribution. Monitoring locations, activities, and timelines are described below.

### 2.1 MONITORING LOCATIONS

The Assessment Monitoring Program includes monitoring locations along a minimum of four transects aligned to the prevailing wind direction (approximately 300 degrees). Figure 1 depicts the monitoring transects and individual monitoring locations. Moving from north to south, Transect (T) 1 is located within the Pismo Natural Dunes Preserve Control Site, T2 and T3 are located within the CDVAA, and T4 is located within the Oso Flaco Control Site. A fifth transect, T5, may be located in the Rancho Guadalupe Dunes Preserve Control Site in the future if landowner authorization is obtained. The individual monitoring sites are located to provide data from the fore-, mid-, and back dune regions of the CDVAA and Control Sites as well as certain perimeter boundaries of the CDVAA (i.e., the CDVAA “fence line”). The individual monitoring sites would contain a combination of meteorological (wind speed, wind direction, temperature, relative humidity), sand flux, and PM10 monitoring equipment as listed in Table 1.

<b>Transect</b>	<b>Site A</b>	<b>Site B</b>	<b>Site C</b>
T1	A, M, SF	A, M, SF	A, E, M*, SF
T2	A, M, SF	A, M, SF	A, E, M, SF
T3	A, M, SF	A, E, M, SF	A, E, M*, SF
T4	A, M, SF	A, E, M* SF	A, M, SF
T5	A, M, SF	A, M, SF	A, E, M*, SF
<b>Table Legend<sup>(A)</sup></b>			
A = APP device E = E-BAM monitor	M = Meteorological devices M* = Meteorological devices on 10-meter tall lattice tower	SF = Sand flux equipment	

(A) Refer to Section 2.2 for a description of this monitoring equipment and activities.

Figure 2 Conceptual Assessment Monitoring Sites



- Assessment Monitoring Site (not shown to scale)
- ▲ APCD Monitoring Site
- Coastal Zone Boundary
- Park Boundaries

Figure 2 Conceptual Assessment Monitoring Sites

Oceanos Dunes SVRA PMRP - Attachment 1



## 2.2 MONITORING ACTIVITIES

Table 2 summarizes Assessment Monitoring Program activities, equipment, and intended data use.

<b>Table 2 Summary of Monitoring Activities, Equipment, and Intended Data Use</b>		
<b>Activity</b>	<b>Equipment</b>	<b>Summary of How Data Will Be Used</b>
Wind Monitoring	Anemometer Wind Vane	1) Apply MSSP criteria 2) Identify and prioritize dust control project areas that have relatively higher winds and higher sand transport/PM10 rates.
Sand and Particle Flux Monitoring	Ambient Particulate Profiler BSNE Dust Catcher Cox Sand Catcher Sensit	1) Identify and prioritize dust control project areas that have relatively higher sand and particle transport rates and high winds.
PM10 Monitoring	E-BAM	1) Identify and prioritize dust control project areas that have relatively higher PM10 concentrations. 2) Estimate or refine estimates of control measure effectiveness.
PI-SWERL Monitoring	PI-SWERL	1) Identify and prioritize sand transport and PM10 emission that are relative "Hot Spots".
Vehicle Activity Surveys	Surveys	1) Assess the effect vehicle activity levels have on measured sand transport and PM10 concentration data (e.g., do relatively higher vehicle activity areas have relatively higher sand transport and/or PM10 concentrations that should be prioritized for control?).
Particle Size Analysis	Saturn Digisizer	1) Identify and prioritize dust control project areas that have a relatively higher percentage of fine particles that may become suspended under high wind conditions.

### 2.2.1 Wind Monitoring

The OHMVR Division will install at least one anemometer and one wind vane at each monitoring site. At some sites the OHMVR Division will install three anemometers using a

logarithmic spacing, with the highest anemometer positioned at 10 meters above ground level. This vertical array would allow the OHMVR Division to estimate friction velocity associated with sand transport.

In addition to transect monitoring sites, the OHMVR Division has already installed wind speed and wind direction monitoring devices at Oceano Dunes SVRA marker posts 1, 3, and 5 (see Figure 2). These instruments are located approximately seven meters above ground level<sup>2</sup>.

The OHMVR Division will use wind monitoring data collected from the stations depicted in Figure 2 to:

- 1) Determine if comparable wind speeds (average and peak) and prevailing wind direction exist at potential CDVAA and Control Site Monitor locations; and
- 2) Assess if certain areas of the CDVAA and Control Sites are subject to relatively higher wind speeds and potentially relatively higher sand transport rates that should be prioritized for control.

### 2.2.2 Sand and Particle Flux Measurements

The OHMVR Division will install surface and near-surface sand and particle transport measurement devices at each monitoring site. Surface devices would include either a Cox Sand Catcher or a Sensit. Near-surface devices would include either a Big Springs Number Eight (BSNE) or an Ambient Particulate Profiler (APP).

The OHMVR Division will use sand and particle flux data to:

- 1) Assess if certain areas of the CDVAA and Control Sites are subject to relatively higher sand and/or particle transport rates that should be prioritized for control.

High sand transport rates may be attributable to one or more variables such as wind speed or vehicle activity. In addition, the relationship between sand transport rates and PM10 emissions (both local and regional) is not well understood (i.e., do high sand transport rates result in high PM10 emissions). Thus, the OHMVR Division will examine and consider sand transport rates in relation to the other data collected as part of this Assessment Monitoring Program to see if there are sand transport patterns that may be used to inform the OHMVR Division's dust control management strategies.

The APP devices are proposed for use because they provide time-resolved aerosol particle flux information that can be compared to time-resolved wind and PM10 monitoring data. This

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<sup>2</sup> Based on conversations with the California Coastal Commission, the installation of instruments on an existing structure did not require a Coastal Development Permit. The installation of new structures (i.e., instruments), however, may require a Coastal Development Permit.

strengthens the OHMVR Division's ability to accurately assess the nature of sand and particle flux at Oceano Dunes SVRA. The OHMVR Division field-tested the APP device in Summer 2012 to evaluate the performance of this instrument. Appendix A presents the results of this evaluation, which appear satisfactory for the intended use of the device.

### 2.2.3 PM10 Measurements

The OHMVR Division will install up to five environmentally-protected beta attenuation mass (E-BAM) PM10 monitors. Four of the E-BAMs will be located approximately at the eastern extent of the monitoring transects, including two at the CDVAA fence line. The remaining E-BAM will be located in the middle of the CDVAA. Prior to deployment on the dunes, the OHMVR Division will co-locate the E-BAMs with a federal equivalent method BAM monitor for calibration purposes.

The OHMVR Division will use PM10 data to:

- 1) Assess if certain areas of the CDVAA and Control Sites have relatively higher PM10 concentrations that should be prioritized for control; and
- 2) Estimate or refine predicted effectiveness of dust control measures at meeting Rule 1001 performance requirements.

High PM10 may be attributable to one or more variables such as wind speed, vehicle activity, or particle size mix. In addition, the relationship between PM10 and sand transport rates is not understood (i.e., do high PM10 concentrations occur in areas with high sand transport rates). Thus, the OHMVR Division will examine and consider PM10 concentrations in relation to the other data collected as part of this Assessment Monitoring Program to see if there are PM10 concentration patterns that may be used to inform the OHMVR Division's dust control management strategies.

### 2.2.4 PI-SWERL Measurements

The OHMVR Division will have experts from Desert Research Institute (DRI) perform surface emissivity testing throughout the CDVAA and Control Sites to develop a database of dust emission strength as a function of wind shear velocity (or wind speed) and with regard to surface conditions such as soil moisture and particle size distribution.

The OHMVR Division will use PI-SWERL data to:

- 1) Assess if sand transport and PM10 emission "Hot Spots" are present (and should be prioritized for control) or absent from the dunes;

- 2) Compare controlled (i.e., potential) sand flux and surface emissivity against actual sand transport rates and PM10 concentrations for potential use in dispersion modeling, estimating control measure effectiveness, controlling for other influencing variables.

Appendix B to this Attachment contains the full PI-SWERL sampling program.

### **2.2.5 Vehicle Activity Surveys**

In June and July 2012, and at the request of the APCO, the OHMVR Division conducted vehicle activity surveys to categorize vehicle activity into low, medium, and high vehicle use areas. Eight locations were chosen to map vehicle use across the landscape. Some small differences were noted in the distribution of vehicle traffic in Oceano Dunes SVRA, however, all areas had evidence of recent heavy vehicle activity (more than 50% of the sand surface disturbed by vehicle tracks) during the survey period. Appendix C to this Attachment contains the OHMVR Division's initial vehicle activity survey results.

The OHMVR Division will use vehicle activity data to:

- 1) Assess the affect vehicle activity levels have on measured sand transport and PM10 concentration data (e.g., do relatively higher vehicle activity areas have relatively higher sand transport and/or PM10 concentrations that should be prioritized for control?).

### **2.2.6 Particle Size Analysis**

The OHMVR Division will have DRI analyze the size distribution of particles at PI-SWERL sampling locations. The OHMVR Division will use particle size data to:

- 1) Assess if certain areas of the CDVAA and Control Sites have a relatively higher percentage of fine particles that may become suspended under high wind conditions and should be prioritized for control.

## **2.3 ASSESSMENT MONITORING PROGRAM SCHEDULE**

The OHMVR Division will commence assessment monitoring as soon as applicable environmental reviews are complete and applicable permits are obtained, including but not limited to: the California Environmental Quality Act, wildlife agency permits, and California Coastal Commission permits.

The OHMVR Division will deploy assessment monitoring for as long as permitted. Preferably include deployment of equipment in Spring and Summer 2013. At a minimum, the OHMVR Division will conduct assessment monitoring during a sufficient number of sand transport and dust events to inform the selection of monitoring sites and prioritization of dust control measures.

## 2.4 QUALITY CONTROL / QUALITY ASSURANCE

The OHMVR Division anticipates that monitoring equipment will be subject to operating limitations due to the harsh field conditions that exist in Oceano Dunes SVRA. For example, E-BAMs are documented to have operating issues under moist conditions due to the instrument's low-power inlet heater.

The OHMVR Division recognizes an accurate and valid data set is essential to meeting the goals of this Assessment Monitoring Program. Inaccurate or invalidated data collected from malfunctioning instruments or instruments with unresolved technical operating issues would not be used to site comparable PM10 monitors or identify and prioritize dust control project areas.

The OHMVR Division will contract with qualified personnel as necessary to perform or supervise Oceano Dunes SVRA staff on the calibration, installation, data collection, processing, validation, and maintenance of all proposed monitoring equipment. These qualified personnel and OHMVR Division staff would meet or exceed the procedural specifications for meteorological and air quality parameters outlined in the California Air Resources Board's (ARB) Air Monitoring Web Manual or other appropriate regulatory or guidance document. The OHMVR Division will provide all appropriate installation, operation, and maintenance procedures for APCO review and approval prior to the deployment of equipment on the dunes.

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**OCEANO DUNES SVRA PARTICULATE MATTER REDUCTION PLAN  
Third Draft**

**ATTACHMENT 1, APPENDIX A  
APP DATA REVIEW**

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**OCEANO DUNES SVRA PARTICULATE MATTER REDUCTION PLAN  
Third Draft**

**ATTACHMENT 1, APPENDIX A  
APP Data Review  
Updated: October 15, 2012**

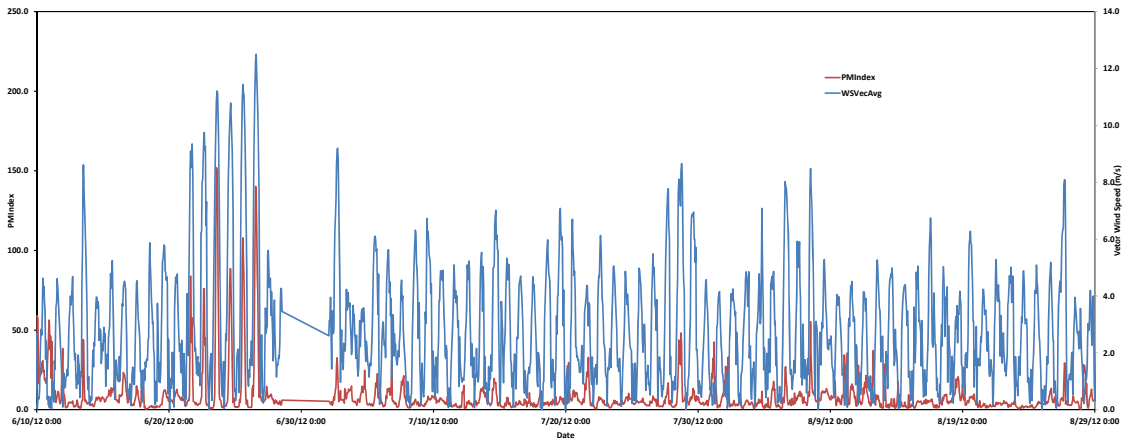
As part of a preliminary effort to evaluate the performance of the portable MetOne Model 212 Ambient Particulate Profiler (APP) device for measuring suspended dust during emission events at the Oceano Dunes SVRA, one unit was deployed at the S1 tower in June 2012 to collect particle count data from June 8 to August 28, 2012. The instrument was set up by DRI and then routinely maintained by Oceano Dunes SVRA personnel. The instrument operated at a resolution of total particle counts per one minute (i.e., total particle counts in eight size bins every 60 seconds).

The  $PM_{Index}$  and vector wind speed ( $m\ s^{-1}$ ) time series (one hour averages) for the collection period is shown in Figure A1-1. As this Figure shows higher  $PM_{Index}$  levels correspond to higher wind speeds with the highest recorded values occurring in June 2012. The frequency distribution of the wind speed in one  $m\ s^{-1}$  bin ranges is shown in Figure A1-2, which indicates a skewed distribution with a low frequency of high speed winds  $>6\ m\ s^{-1}$  and a dominance of winds between 1 and  $6\ m\ s^{-1}$ . During the monitoring period the wind rose (Figure A1-3) shows winds are most frequent and strongest from 281 through 325 degrees, which is blowing on shore.

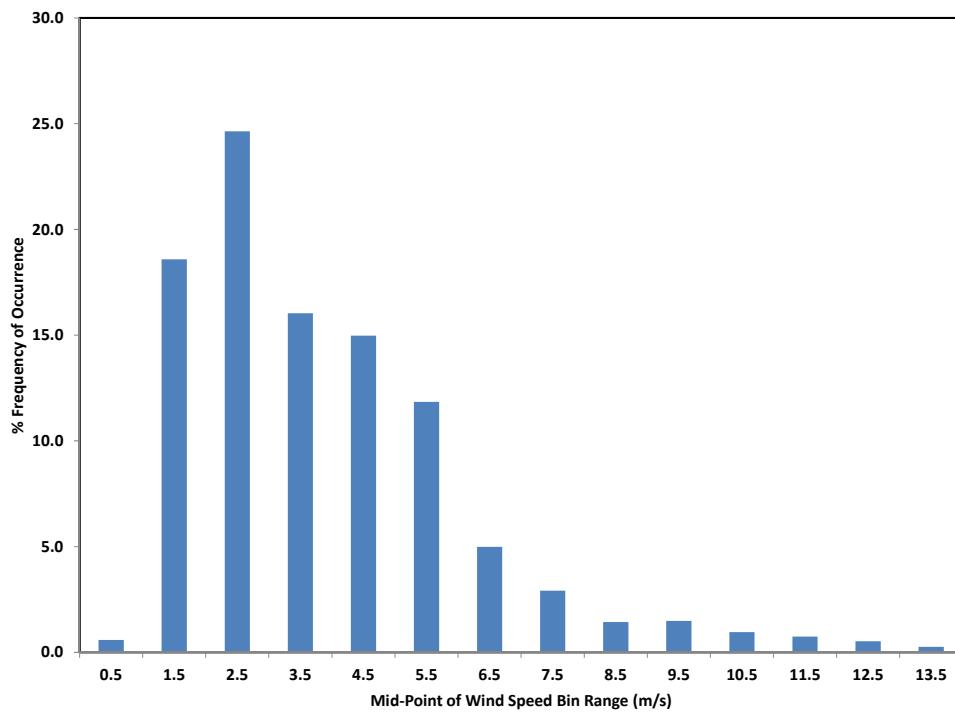
Figure A1-4 shows a time series of  $PM_{Index}$  estimated from the output of the APP and the average hourly wind speed vector for the period 6-8-2012 through 8-28-2012, for the wind direction range 277.5 to 322.5 degrees that corresponds to on-shore winds.  $PM_{Index}$  was calculated by assuming the particles being measured are spherical and their density regardless of their size is the same (i.e., all the same mineral type [ $\rho_{particle}=2.600\ g\ cm^{-3}$ ]). The index is the sum of all estimated mass (volume $\times$ density) divided by the flow volume ( $0.0017\ m^3$ ) for eight size bins for each hour of observation. This index can be refined if information on particulate matter mineralogy as a function of particle size can be obtained, for example by scanning electron microscopy of particles collected by filter-type samplers. Figure A1-4 indicates that when mean vector wind speed exceeds a speed of  $\geq 6$  meters per second ( $m\ s^{-1}$ ) there is a corresponding increase in  $PM_{Index}$ . The general relationship between wind speed and  $PM_{Index}$  shown in Figure A1-4 (i.e., the black solid line) is only for winds  $\geq 6\ m\ s^{-1}$ .

Figure A1-5 shows the mean  $PM_{Index}$  as a function of mean hourly vector wind speed for the entire sampling period for the wind direction range 277.5 to 322.5 degrees. Essentially Figure A1-5 shows the relationship between mean wind speed and mean  $PM_{Index}$  for an average day June through August. These data indicate that the APP can identify the threshold wind speed at which the sands begin to emit dust. Over the entire period available the mean wind speed that causes emissions to begin is  $6.5\ m\ s^{-1}$ . There is little variability in the threshold speed only  $\pm 0.3\ m\ s^{-1}$ , which indicates that the threshold wind speed for dust emissions is very consistent.

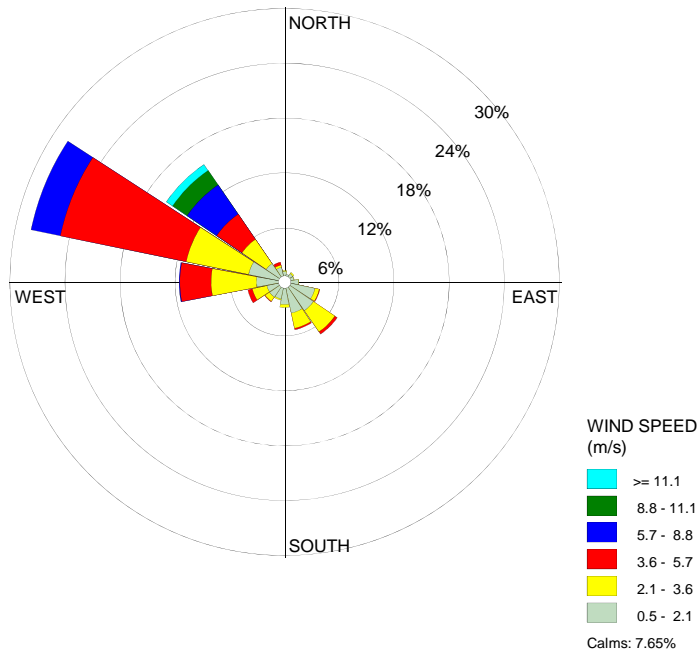
The data presented in Figures A1-4 and A1-5 does not include data from other wind directions. This is due to the fact that once all data are partitioned by direction (in 45



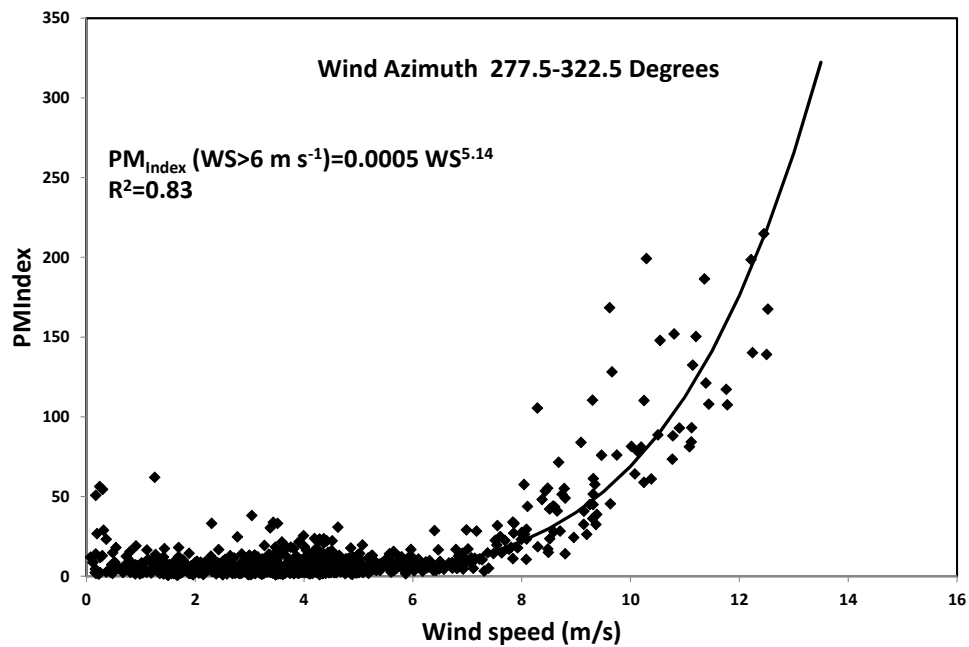
**Figure A1-1.** PM<sub>Index</sub> and vector wind speed data for the APP pilot monitoring period, June – Aug., 2012.



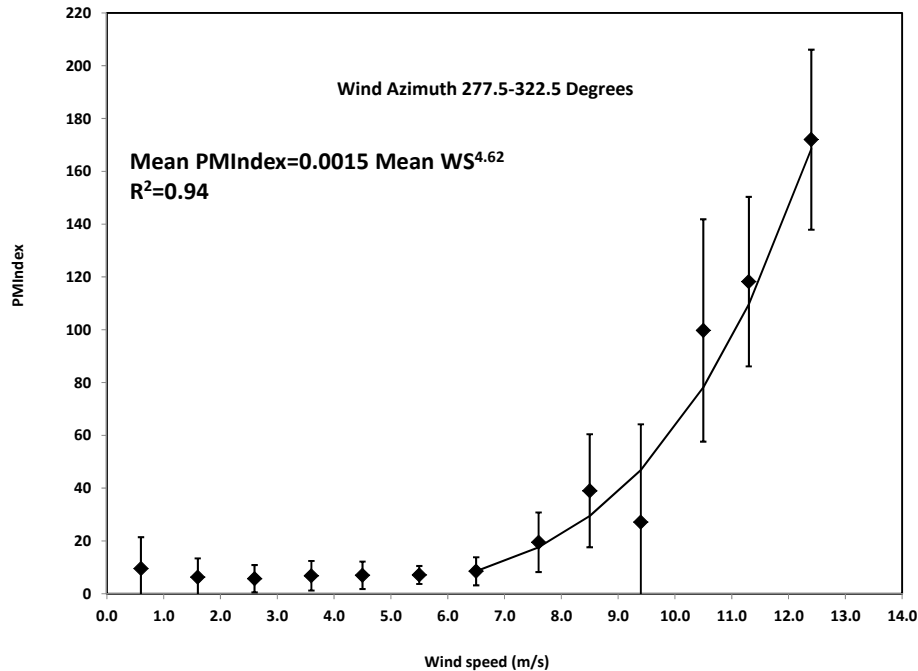
**Figure A1-2.** The frequency distribution of wind speed for the APP pilot monitoring period, June – Aug., 2012.



**Figure A1-3.** Wind rose for the APP pilot monitoring period, June – Aug., 2012.



**Figure A1-4.** The  $PM_{Index}$  data as a function of mean vector wind speed when wind azimuth was on-shore for the range 277.5-322.5 degrees (solid black diamond symbol) and the relationship between wind  $PM_{Index}$  and mean vector wind speed  $\geq 6 \text{ m s}^{-1}$  (solid black line).



**Figure A1-5.** The mean  $PM_{Index}$  data as a function of mean vector wind speed when wind azimuth was on-shore for the range 277.5-322.5 degrees, and the relationship between mean wind speed and mean  $PM_{Index}$  for wind speed  $\geq 6 \text{ m s}^{-1}$  (solid black line).

degree bins around the on-shore direction of 277.5 to 322.5 degrees), there is no evidence of a dependence on  $PM_{Index}$  with wind speed. This pattern is illustrated in Figures A1-6 through A1-12. In some of these directional bins, there is in fact a suggestion that as wind speed increases the  $PM_{Index}$  decreases. This can be explained by the increased diffusion associated with higher wind speeds that are transporting non-mineral dust emissions from inland sources towards the position of the monitoring location (i.e., S1 Tower), with no, or very limited, sources of PM in the intervening space. There are no cases when wind speed rises above the threshold of  $6.5 \text{ m s}^{-1}$ , hence no mineral dust is being emitted for any direction outside of the range 277.5-322.5 in this data set.

Figures A1-6 through A1-12 reveal that that  $PM_{Index}$  can become elevated between values  $>10$  and reaching over 50 when there are no direct emissions of mineral dust from the sand due to wind erosion (winds  $<6.5 \text{ m s}^{-1}$ ). This indicates that for monitoring of  $PM_{10}$  within the ODSVRA it will be important to measure wind direction simultaneously so that PM associated with emissions originating outside of the ODSVRA are accounted for as part of the accounting for the hourly and 24 hour mean PM concentrations that will be used to evaluate compliance with the Dust Rule.

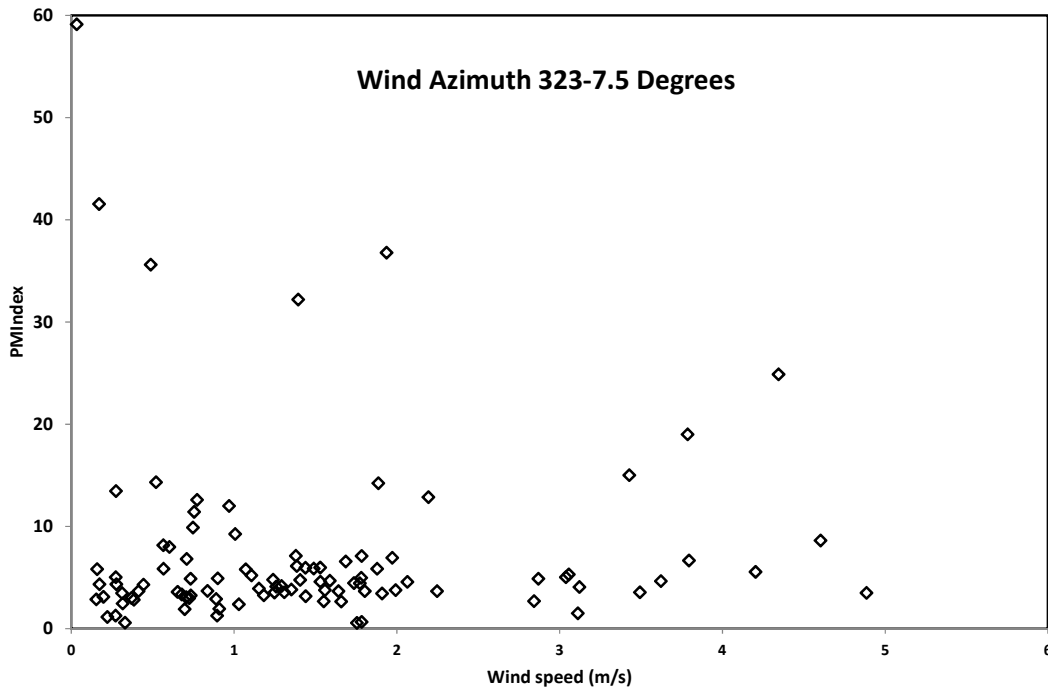


Figure A1-6.  $PM_{Index}$  as a function of wind speed for the wind azimuth range 323 to 7.5 degrees.

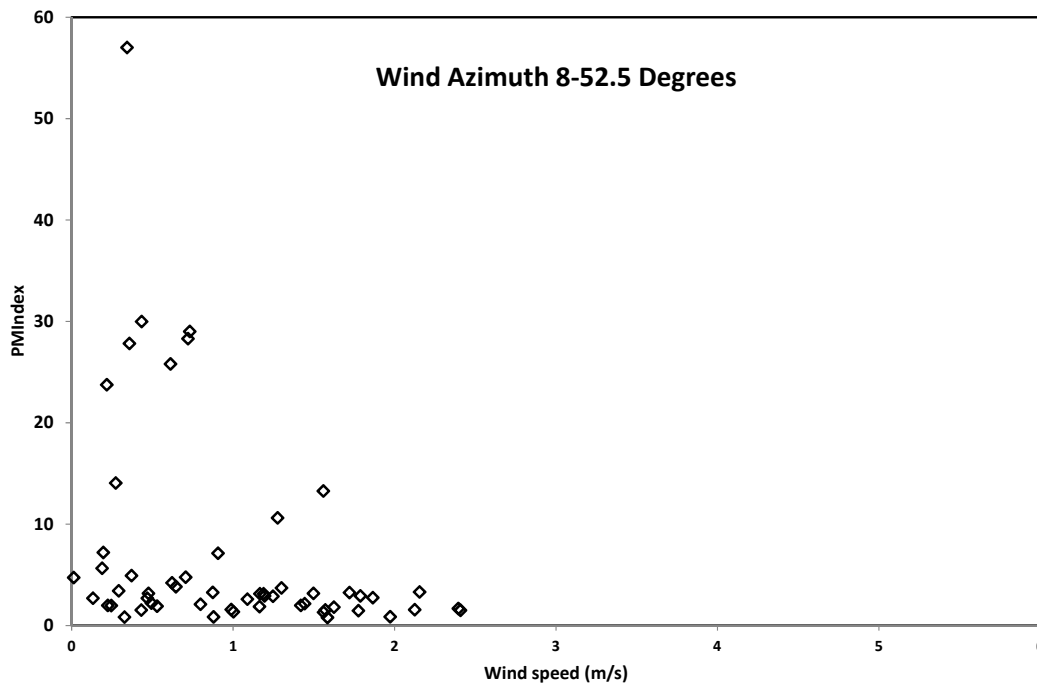


Figure A1-7.  $PM_{Index}$  as a function of wind speed for the wind azimuth range 8 to 52.5 degrees.

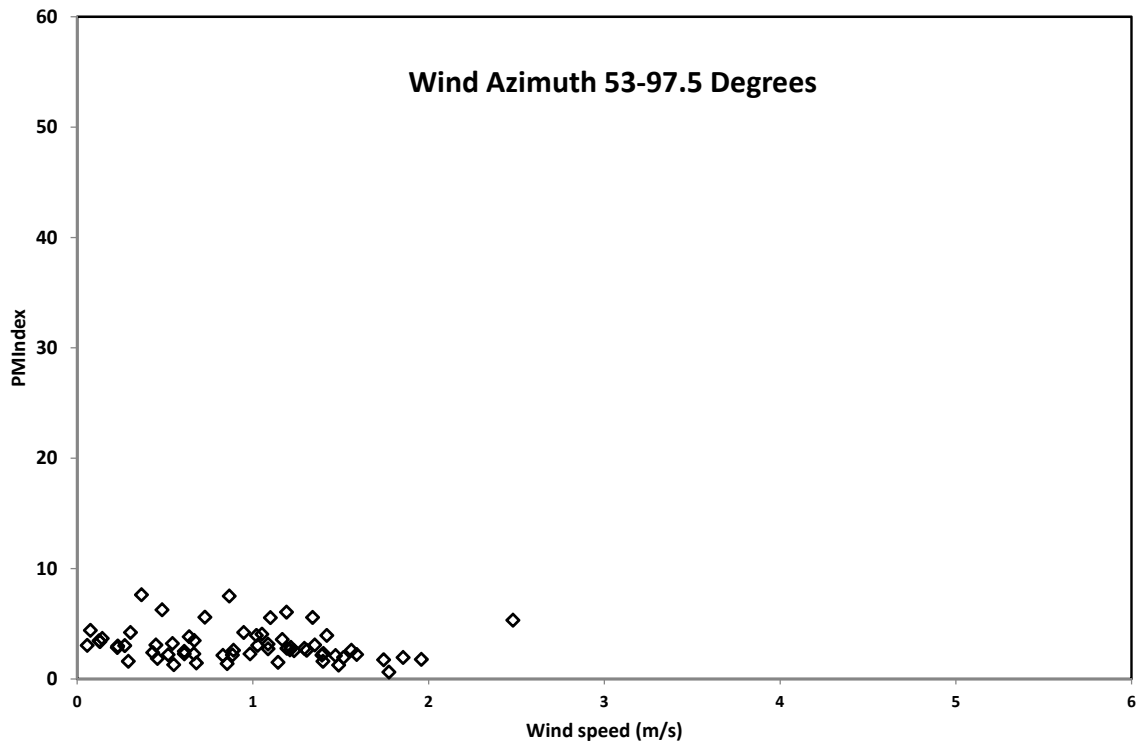


Figure A1-8.  $PM_{index}$  as a function of wind speed for the wind azimuth range 53 to 97.5 degrees.

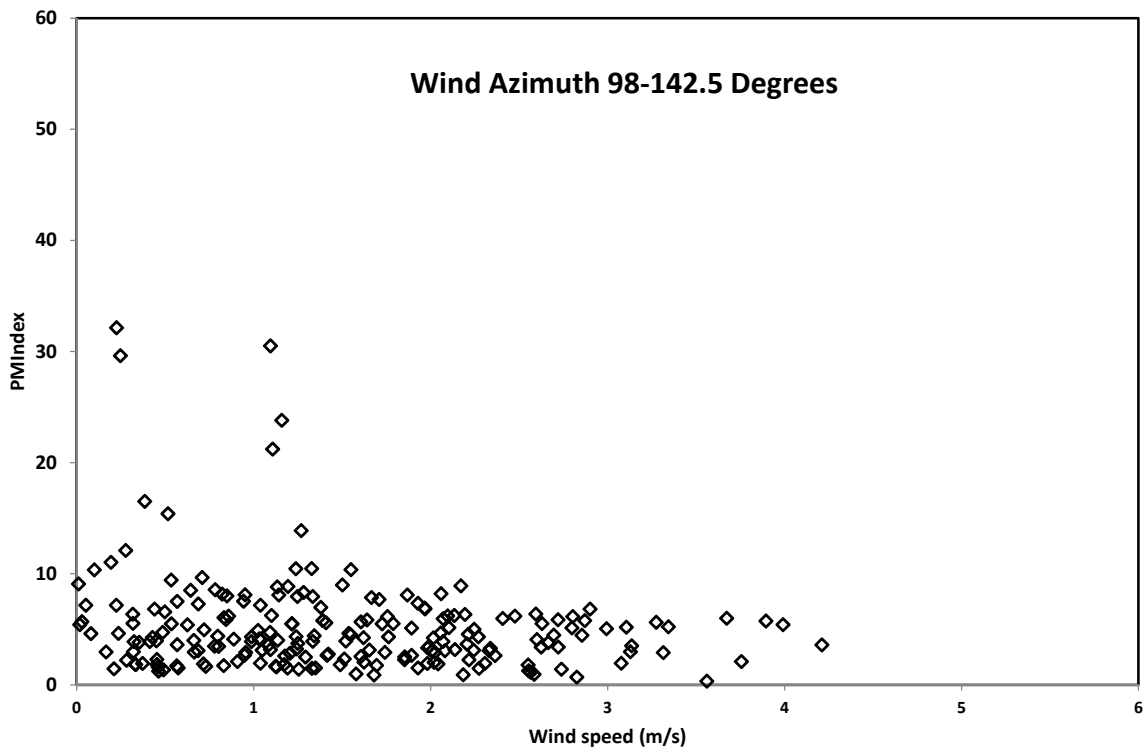
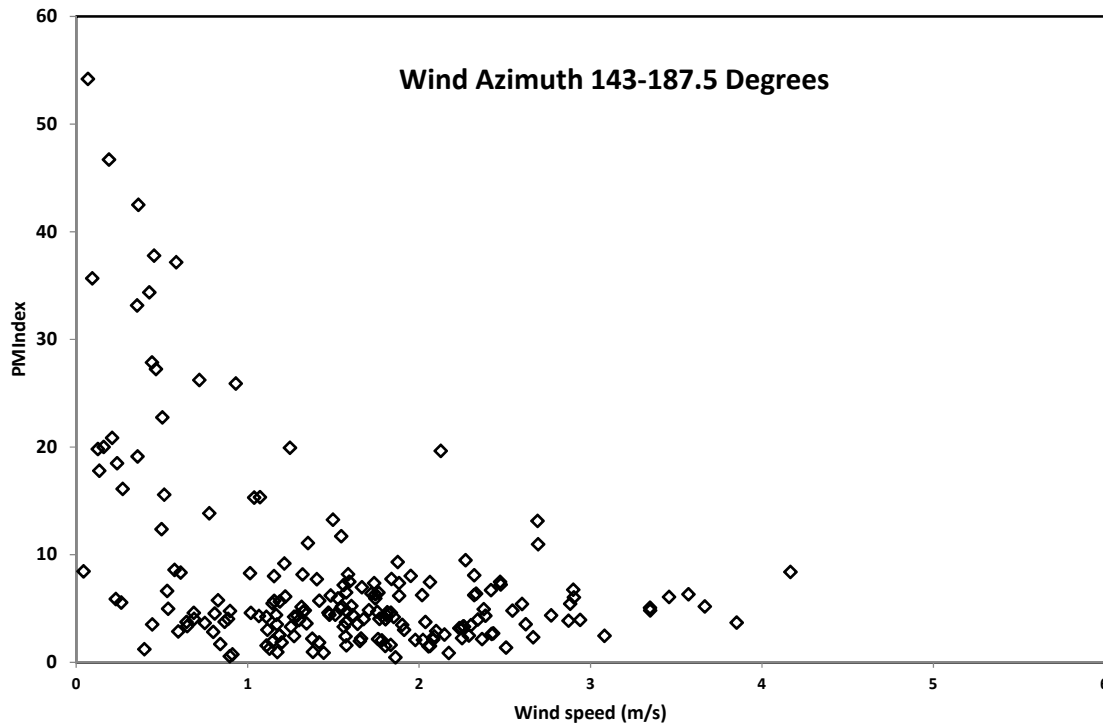
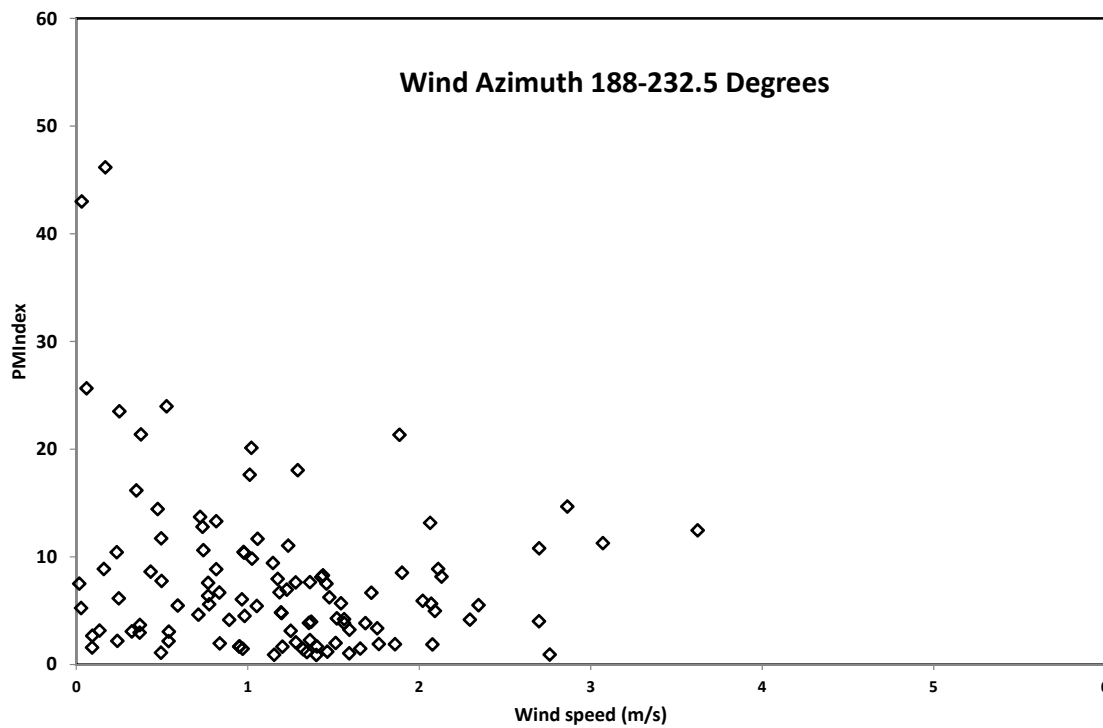


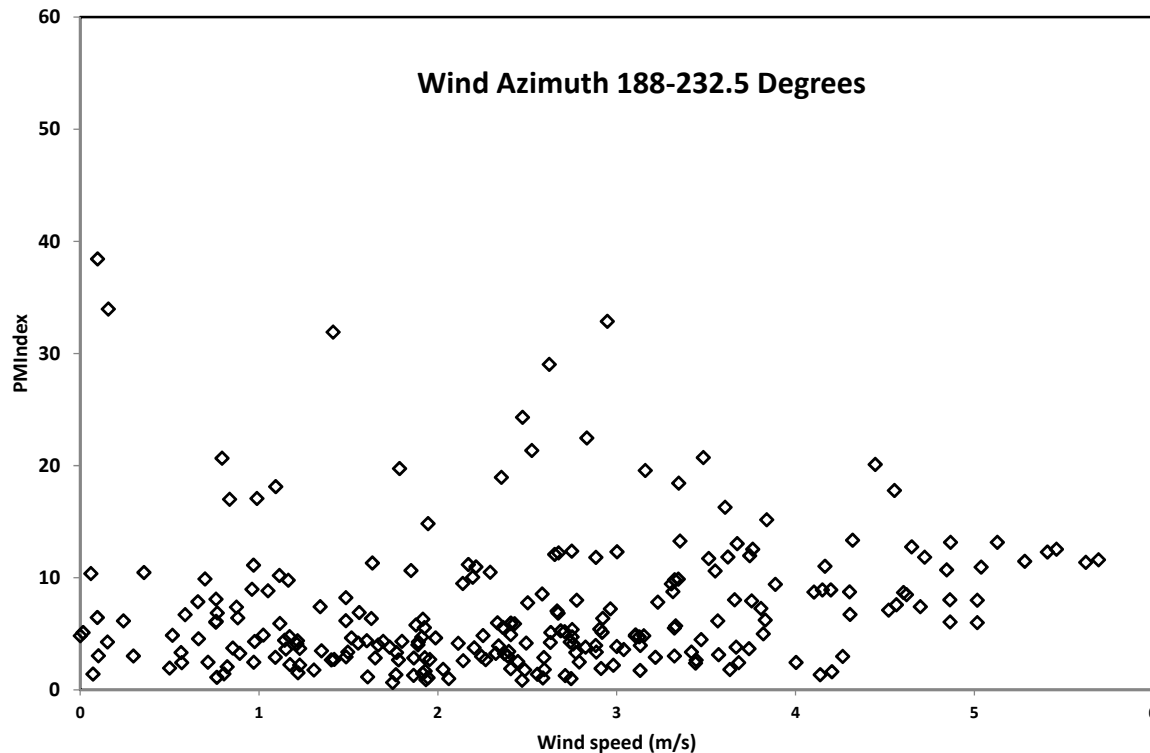
Figure A1-9.  $PM_{index}$  as a function of wind speed for the wind azimuth range 98 to 142.5 degrees.



**Figure A1-10.**  $PM_{Index}$  as a function of wind speed for the wind azimuth range 143 to 187.5 degrees.



**Figure A1-11.**  $PM_{Index}$  as a function of wind speed for the wind azimuth range 188 to 232.5 degrees.



**Figure A1-12.**  $PM_{Index}$  as a function of wind speed for the wind azimuth range 188 to 232.5 degrees.

The OHMVR Division recognizes that at this time units cannot be assigned to the APP output. However, it is not essential to know actual mass concentrations of the dust to evaluate the characteristics of the dust emission system at Oceano Dunes SVRA and to provide critical information on the siting of monitors that will eventually provide absolute measures of  $PM_{10}$  concentrations. By deploying APP monitors that have been internally calibrated (i.e., how they compare to each other), the acquired data will provide a robust index of aerosol particulate values and how this changes across space and over time in and within the vicinity of Oceano Dunes SVRA. The value of these data would be further enhanced with established calibration relationships between the APP and a Federal Equivalent or Federal Reference Method monitor following accepted US EPA methods to establish collocated precision of instruments.



**OCEANO DUNES SVRA PARTICULATE MATTER REDUCTION PLAN  
Third Draft**

**ATTACHMENT 1, APPENDIX B  
DRAFT PI-SWERL SAMPLING PROPOSAL**

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03-05-2013

*Using the Portable In-situ Wind ERosion Lab (PI-SWERL) to Characterize the Dust Emission Potential of the ODSVRA and Associated Dunes Natural Preserves.*

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**Prepared for: California State Parks Service**

PM<sub>10</sub> measurements downwind of the Oceano Dunes, made by the San Louis Obispo Co. Air Pollution Control District indicate that under certain defined environmental conditions (high westerly wind speeds), particulate matter concentrations sometimes exceed state and federal air quality standards for PM<sub>10</sub>. The source of the PM<sub>10</sub> originates from the vicinity of the Dunes; the attribution of the PM<sub>10</sub> to specific sources, both inside the ODSVRA, the Reserve areas, and even external to the domain of the Park and surrounding areas, remains in debate. It will be critical for the development of effective mitigation that it be determined whether the observed high PM<sub>10</sub> levels are originating from specific areas of the dunes (within the ODSVRA riding areas and reserve areas) or that the strength of the dust emissions varies only within a small range over the dune complex, and hence there are no “hot spot” emitting areas with dust emission strengths that are perhaps orders of magnitude more emissive than neighboring areas. The available evidence to date (Lancaster et al., 2011), indicates from a limited sample of dust emission potential measurements made with the PI-SWERL instrument (Etyemezian et al., 2007) that it varies over space by less than a factor of two. To characterize the relative emission potential of various components of the dune system (e.g., above the swash zone, fore-dunes, beach platform, and the vehicle impacted and exclosure areas of the main dune ridges) that may be contributing to the overall PM<sub>10</sub> burden caused by wind erosion processes, the Desert Research Institute (DRI) proposes to undertake a measurement campaign in 2013, utilizing the DRI-developed Portable In-situ Wind ERosion Lab (PI-SWERL) to measure the strength of dust

emission potential across a representative sample of the ODSVRA domain and reserve areas. Targets of specific interest will include areas of known high traffic and concentration of park guests (e.g., established camping areas where travel to and from the recreational riding zones potentially impacts emissivity).

## Methods

The PI-SWERL is being used increasingly as a primary tool to evaluate windblown dust emissions from natural and artificial soil surfaces (Fig. 1). PI-SWERL is a portable device that aims to fulfill many of the same measurement functions that until now have required the use of larger portable field wind tunnels (e.g., Nickling and Gillies, 1989). Unlike large (10 meter or longer) field wind tunnels, the PI-SWERL does not meet many of the scaling criteria that are theoretically required for realistic simulations of aeolian sediment transport processes. However, recent research and cross calibration with a large portable field wind tunnel indicate that the PI-SWERL does provide a reliable measure of windblown dust emission potential (Sweeney et al. 2008).



**Figure 1.** The current configuration of the PI-SWERL showing the cylindrical sampling chamber (left side of image) and the carriage used to transport it from site-to-site, which also holds the computer controlled data acquisition system.

The PI-SWERL has been used in a number of published papers to characterize the emission potential of desert surfaces (Sweeney et al., 2008, 2011; Bacon et al., 2011) and desert dune sands (Goossens et al., 2012). Other uses of the PI-SWERL include relating emissions to soil parameters such as salt content at the Salton Sea in California (Etyemezian et al., 2006a), quantifying the longevity and efficacy of soil surface treatment products with respect to reducing dust emissions (Kavouras et al., 2009), determining the potential for radionuclide contaminated soil dust emission at the Nevada Test Site (Etyemezian et al., 2006b), determining the magnitude of aerodynamic entrainment of dust from unpaved road shoulders (Etyemezian et al., 2007b), and characterizing dust emission potential of exposed beaches surrounding the Williston Reservoir in northern British Columbia, Canada (Nickling et al., 2009, 2010, 2011, 2012). These studies have all utilized the ability of the PI-SWERL to economically provide an estimate of the amount of dust that is suspendable when varying amounts of shear stress are applied to a soil surface and including the effect of the accompanying sand mobilization. Many published studies have demonstrated that for most dust emission systems the flux of the dust-sized particles is directly linked with the wind shear via the saltation system (e.g., Gillette et al., 1997; Gomes et al., 1990; and Shao, 2004).

The PI-SWERL is highly portable, operated by one person, and economical for field measurements with a typical test completed in less than 15 minutes. Direct comparison of PI-SWERL measurements with the University of Guelph, straight-line field wind tunnel at seventeen sites in the Mojave Desert (Sweeney et al., 2008) showed very good correspondence between the two measurement methods.

The PI-SWERL is a cylindrical chamber ( $D = 30$  cm,  $H = 20$  cm) that has an open end that is placed over the soil surface to be tested. Ventilation of the PI-SWERL chamber is accomplished by a DC blower (AMETEK, Mini-Jammer) and monitored by a mass flow meter (TSI, Model 42350101). Filtered air that is introduced by the blower, mixes with the air in the chamber and the flow is exhausted through a port (diameter = 5.0 cm) at the top of the chamber. Dust suspension within the chamber is induced by a rotating, flat annular ring (inner diameter = 16 cm, outer diameter = 25 cm). Once the measurement cycle is initiated, one-second concentrations of  $PM_{10}$  (particles with aerodynamic diameter  $<10$   $\mu\text{m}$ ) are measured by a nephelometer-style dust monitor (TSI, DustTrak Model 8520/8530).

Within the PI-SWERL chamber are two sensors positioned at 3.3 cm and 10.9 cm above the bottom of the PI-SWERL chamber that measure sand transport. These sensors utilize an optical gate with an infrared light source and detector separated by 20 mm to detect moving sand grains. This sensor provides a consistent measure of sand movement that is proportional to sediment transport measured by other real-time instruments such as piezoelectric sensors (e.g., Baas 2004) and sediment traps. The PI-SWERL provides a means to measure the critical threshold shear velocity ( $u_{*t}$ ,  $\text{m s}^{-1}$ ), which can be related to a wind speed at a set height (e.g., 10 m above ground level [AGL],  $u_{10t}$   $\text{m s}^{-1}$ ) and marks the onset of the wind condition that initiates sand transport and dust emissions. It also provides a means to define the dust emission potential of  $\text{PM}_{10}$  ( $F$ ,  $\mu\text{g m}^{-2} \text{s}^{-1}$ ) for a given wind speed and saltation flux (e.g., counts of sand grains moving through a sensing area in one second) for essentially a point measurement on a surface of interest. Through multiple measurements a relationship between shear velocity (or wind speed for a set height, e.g., 10 m [ $u_{10}$   $\text{m s}^{-1}$ ]), sand transport, and dust emissions can be derived for a surface of interest. In addition, multiple measurements allow for the estimations of mean values of the parameters of interest as well as provide information on the variance of the measurements to provide an understanding of the spatial variability of the parameters of interest (i.e., threshold shear velocity and emission potential).

For the ODSVRA and dune nature preserves we propose to undertake a systematic evaluation of  $u_{*t}$  (or  $u_{zt}$ ), and  $F$  as function of shearing stress ( $u^*$  and wind speed  $u_{10}$ ) and saltation activity (counts of sand particles moved through a sensing area in one second) as simulated within the PI-SWERL for the above-identified key components of the dune system. We propose to undertake a series of measurements along transects through identified areas of the dunes that contain these critical areas. The sampling transects and focus areas of known high traffic volume will be defined based on input from California State Parks and San Luis Obispo County Air Pollution Control District personnel.

At a designated sampling location the following steps will be taken: 1) at the beginning of a transect the PI-SWERL clean cycle program will be run to remove as best as possible any sediment residing in the PI-SWERL chamber from previous tests, 2) the PI-SWERL will be placed onto the test surface, 3) the PI-SWERL test cycle will be initiated, 4) a digital image will be taken of the surface at the test location, 5) a GPS reading will be recorded, 6) a sample of the beach or dune sediments, to the depth of  $\approx 0.5$  cm, will be collected exterior to the PI-SWERL

and placed into a sealed container and submitted for moisture content and particle size analysis. The cycle of blade RPM for the testing is chosen to balance the need to obtain a range of shear stresses to quantify the threshold and emission characteristics of the test surface and maintain the PI-SWERL dust and sand movement measurement instruments in good working order. The highest test RPM needs to produce dust concentrations that are consistently below the limits of measurement of the DustTrak monitor (i.e.,  $150 \text{ mg m}^{-3}$ ) to collect concentration data within its operating parameters, and protect it from damage by exposure to excessively high concentrations of dust.

A typical test cycle has the following pattern: 1) a 60 second flush of the chamber by the pump with no movement of the blade, 2) an increase in RPM (referred to as a ramp) to a target value of 1000 RPM, 3) a 60 second period of time when the computer holds the blade RPM at the first target value of 1000, 4) a second ramp of RPM to 2000, 5) a second 60 second period of time when the second target RPM of 2000 is maintained, 6) a third ramp to 3000 RPM, 7) a third 60 second period when the target RPM of 3000 is maintained, 8) a fourth ramp to 4000 RPM, and 9) a fourth 60 second period when the target RPM of 4000 is maintained. This range of RPM values correspond to wind speeds measured at 10 m AGL of approximately  $6 - 18 \text{ m s}^{-1}$  (14 – 35 mph). The flow within the PI-SWERL chamber is axially symmetric (i.e., in a circle) so that there is no equivalent wind direction associated with a PI-SWERL measurement. During the test, concentration of  $\text{PM}_{10}$  in the exhaust flow of the PI-SWERL is measured at 1 Hz. The optical gate probes provide a count of sand-sized particles that have passed through the sensing area of the probe at 1 Hz as well. The test cycle pattern may be altered based on a few preliminary tests to determine the RPM value that causes over-ranging of the instrument that measures the  $\text{PM}_{10}$ . Based on the PI-SWERL measurements described in Lancaster et al. (2011) the original test cycle used in the 2011 pilot project was well chosen. Although at the highest RPM step (4000), the OGS sensors were frequently saturated and therefore not providing useful sand movement data, measurements of  $\text{PM}_{10}$  dust by DustTrak continued to be valid and provided useful information about the potential for dust emissions at high, but reasonable wind speeds (about 35 mph), i.e., they do not exceed the range observed at the S1 tower. Nevertheless, a few preliminary collocated tests with both PI-SWERLs will be undertaken to ensure that the DustTrak is not in danger of over-ranging and that the OGS sensor readings

remain within the desired range for the majority of the test (i.e., through the end of the RPM = 3000 step).

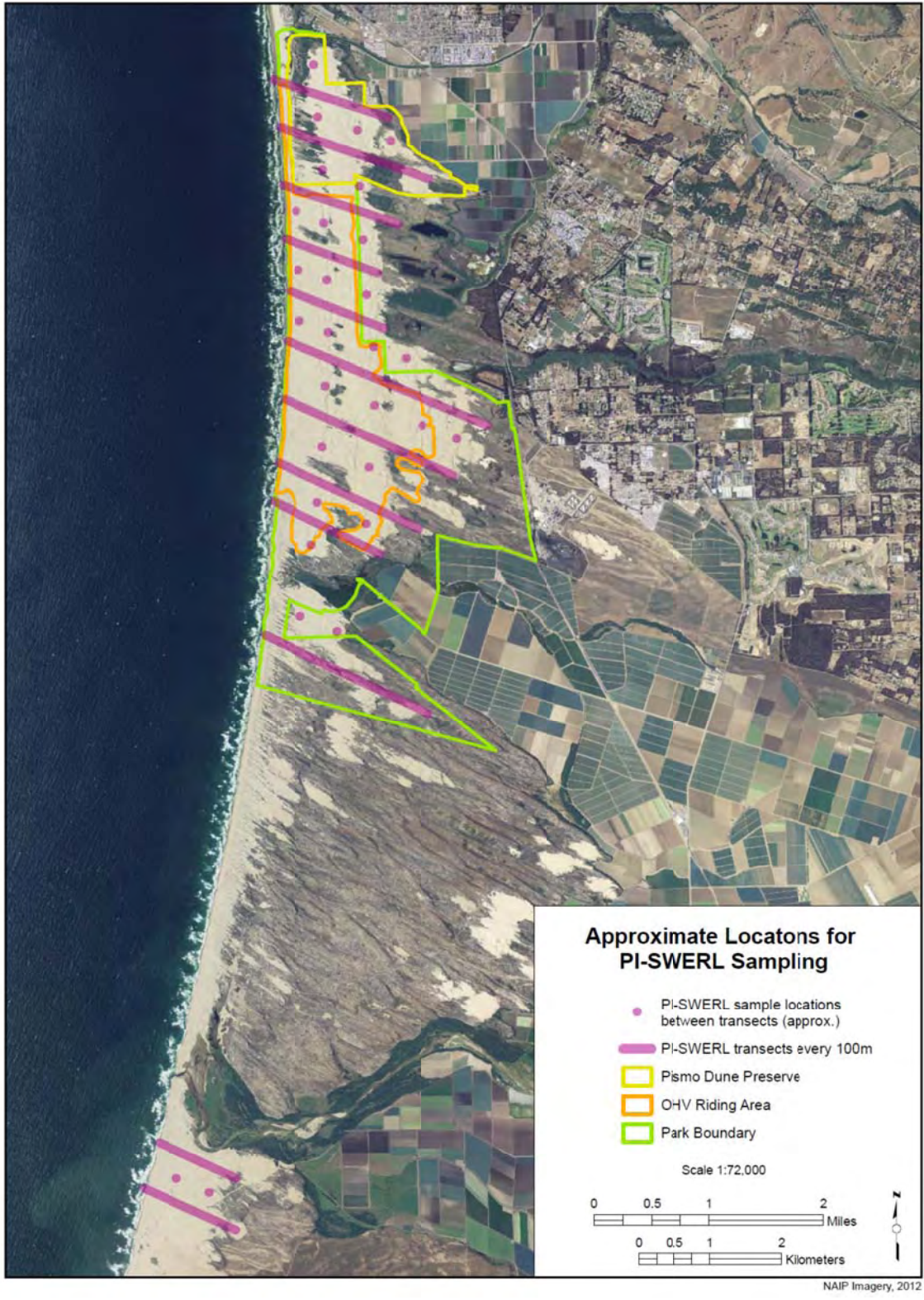
As the designated sampling areas are quite large in areal extent it is necessary to devise a sampling strategy to collect representative emission and surface characteristic data. The strategy proposed is regularly spaced samples along west-east transects and measurements in specific areas of interest (e.g., known areas of high camping density with high ingress-egress activity by vehicles). We are proposing to spend 15 days sampling the dune areas using two PI-SWERL instruments, in order to generate as many data points as possible. Based on previous experience sampling with the PI-SWERL at the ODSVRA by walking and pushing the carriage that supports the instrument between tests along a transect, with major movements accomplished with a 4-wheel drive vehicle carrying the PI-SWERL (configured as shown in Fig. 1), it is expected that approximately 20 tests per 8 hours can be accomplished (running 2 PI-SWERLs) for a total of approximately 300 tests in the 15 day sampling period. Assuming the expected rate of sampling (10 tests per PI-SWERL per 8 hours) in 1000 meters of transect the distance between equal spaced samples would be 100 m. This would likely, by necessity of the topography, have to be adjusted when encountering positional obstacles to sampling such as the brink of dune crests, the steep leeward side of a dune, and the presence of vegetation or other physical obstruction.

To avoid the possibility that the measurements from the two PI-SWERLs are diverging due to a malfunction in the DustTrak instruments, as occurred during the Pilot Study (Lancaster et al., 2011), we will increase the quality assurance in the proposed project using an additional DustTrak instrument as an independent check on the two DustTraks that are associated with the PI-SWERLs. Prior to the beginning of sampling, four DustTraks (two PI-SWERL designated, one reference, and one spare) will be collocated in the DRI lab for collocation characterization, a procedure whereby all units sample the same dust-laden air over a range of PM<sub>10</sub> concentrations that is representative of the range likely to be encountered at the ODSVRA. This procedure, put in place following the experience gained during the pilot project serves to relate the DustTrak signals from all of the units tested to one another over a range of concentrations. In the field, one DustTrak (the designated reference unit) will be periodically attached to the exhaust port of each PI-SWERL, at a minimum, every 5<sup>th</sup> measurement so that its readings can be compared to the DustTrak that is mounted on the PI-SWERL. The reference unit will be programmed to collect data for the entire test and provide the average reading. The operator will cross-check the



average  $PM_{10}$  value against the average reading from the PI-SWERL-mounted DustTrak and compare this relation to the in-lab calibration curve. A divergence of greater than 15% will require that testing stop until the source of the divergence is identified. The spare unit will be tested at this point and if it meets the criterion of a mean test value less than 15% from the reference unit it will be used to continue the sampling. This will allow the operators to assess any major changes in calibration of the DustTraks used by the two PI-SWERLs while continuing measurements uninterrupted.

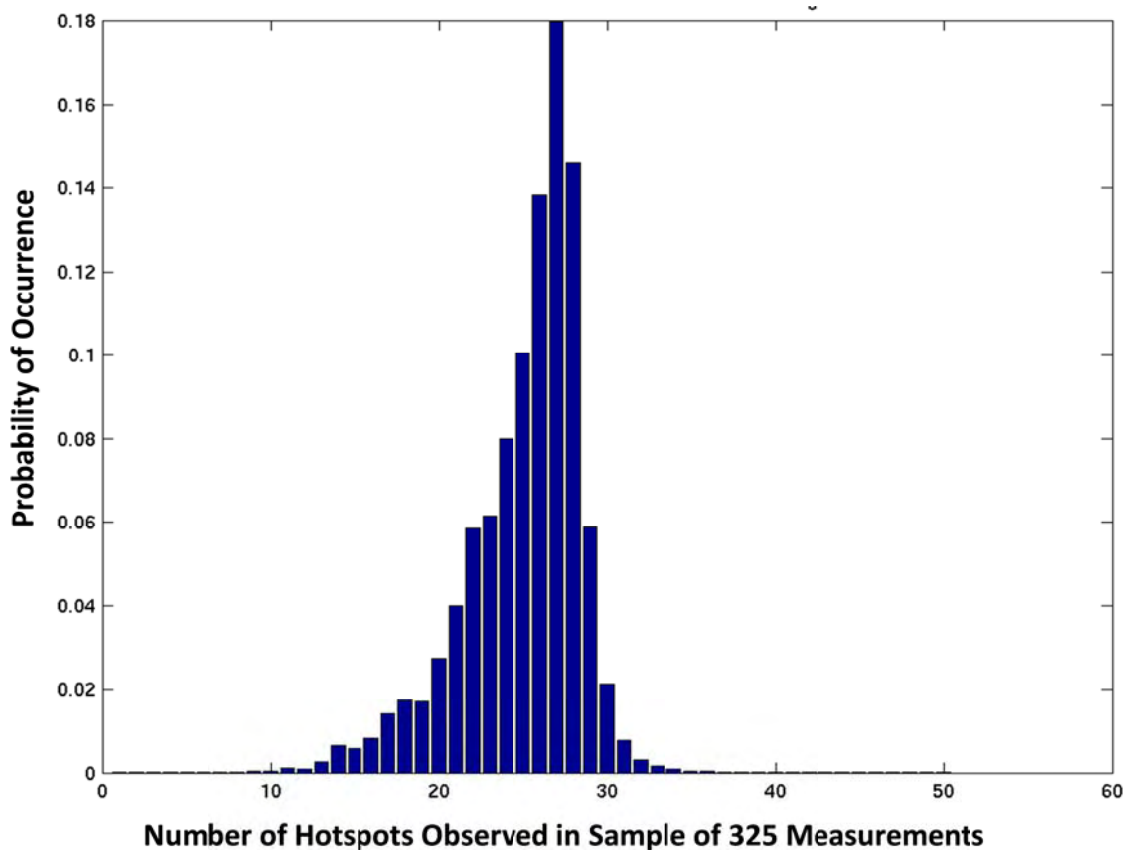
A concern that may arise from reviewers of the proposed sampling plan is whether there are sufficient numbers of PI-SWERL tests spread over the areas of interests to capture the range of variability of the potential emissions within the ODSVRA and the dune preserve areas, and identify areas with enhanced emissions. We are proposing that for the major east-west transects the horizontal distance between PI-SWERL tests be approximately 100 m (taking into account topographic obstacles). This will be sufficient to identify if major changes in dust emission potential as a function of position (and the associated location characteristics) are present in the east-west direction, the major sand and dust transport direction. That the distance between tests of 100 m is sufficient to identify “hot spots” is supported by the Pilot Study measurements (Lancaster et al., 2011). At two locations, the straw bale site and the preserve site, measurements were made with the PI-SWERL at distances between 5-30 m, and showed variability less than a factor of two. The north-south extent of coverage will be approximately 8.5 km, with a north-south spacing between major east-west transects of  $\approx 550$  m and  $\approx 250$  m for the between transect measurements in the ODSVRA (Figure 2). Within the dune preserve the distance between transects is  $\approx 400$  m with between transect measurements at  $\approx 200$  m north/south of the major transect (Figure 2). The location of the transects that we propose to acquire measurements of  $PM_{10}$  emission potential and sediment samples for particle size analysis are shown in Figure 2.



**Figure 2.** Proposed transect and between transect locations for PI-SWERL testing.

Four of the transects correspond with those identified in the PMRP for measuring the west-east gradient of PM<sub>10</sub> mass and particle number concentration. The other transects and target areas were selected based on insuring sufficient spatial coverage to evaluate if there are quantifiable differences in the gradient of PM<sub>10</sub> flux in the west-east and north-south directions and between non-riding and riding areas. In specific target areas (e.g., known areas with high volume ingress/egress by vehicles) the distribution of test locations, or the distance between tests, will be tightened up. We will require vehicle support to transport the instruments and the operators working separately at different parts of the dunes during the sampling period.

The probability of missing highly emissive “hot spots” that are  $\geq 100$  m in length in the east-west direction using the proposed transect approach is extremely low. If “hot spots” exist they must be of sufficient length in the east-west direction to be recognizable at the scale proposed. To demonstrate this we use a Monte Carlo simulation to randomly distribute “hot spots” of circular size between 100 m<sup>2</sup> (11.2 m diameter) and 545,454 m<sup>2</sup> (883 m diameter), the size of “hot spots” is normally distributed around the mean within an area of 6 km<sup>2</sup> (approximate size of riding area). The mean and standard deviation of the generated “hot spot” diameters are changed by a random number generator each model run so the size range of “hot spots” changes (within the set upper and lower bounds), but the total “hot spot” area is always the same. The model then overlays a sampling grid that measures emissions every 100 m along an east-west transect, with 250 m between transects in the north-south direction and determines the frequency of occurrence that a sampling point lands within a “hot spot”. After one million simulations, there was no case where the sampling grid missed all the “hot spots”. Figure 3 shows the probability distribution for finding “hot spots” for all one million model runs. The Figure is interpreted as follows: if 325 samples were taken, there is <0.1% chance that you would measure <10 “hot spots” and approximately a 2.5% chance that you would measure >30, with the highest probability of occurrence being that 18% of the time 26 “hot spots” would be observed. The proposed sampling grid could not miss measuring inside areas in the ODSVRA that are roughly circular in nature with diameters between 11 and 883 m that have an order of magnitude greater emissions than the mean emission rate (from Lancaster et al., 2011). The geometry of a “hot spot” would have to have a form very different from a circle to be missed, which we feel is unlikely.



**Figure 3.** Probability of observing “hot spots” from 325 measurements in an area of 6 km<sup>2</sup> for one million sampling sets.

Long, thin (<100 m width) high emission zones in the north-south direction would be less effective contributors to the majority of the PM<sub>10</sub> burden due to their limited east-west fetch. If “hot spot” areas exist at scales less than 100 m (length or width) it would be difficult to reconcile how they could be effectively managed based on their size, their potential mobility, and whether by virtue of their size they could contribute significantly to the overall PM<sub>10</sub> burden originating from the ODSVRA and preserves. If there are groups of “hot spots” in close proximity to each other the sampling methodology will identify them as larger units, which are more amenable to management.

Although the PI-SWERL provides “at-a-point” measurements for measuring wind erodibility, it is likely the best tool available for the purpose of assessing spatial variability of dust emission potential within the coastal dune environment. A vehicle-based monitoring system would allow

for coverage of much larger areas than the PI-SWERL. However, it is unlikely that the assessment of variability would be any more accurate for several reasons. First, measuring dust in the wake of a moving vehicle is probably related to a surface's wind erodibility, but it is not as directly related as the dust emitted by the PI-SWERL, which is a closer simulation of the wind erosion process. Second, the measurement variability of a vehicle-based system is inherently large because: i) the process that leads to dust emissions (vehicle interaction with the surface) is highly variable and depends on parameters such as acceleration, tire slip, and other mechanical forces, ii) the plume dispersion process in the wake of a vehicle is variable, resulting in variable rates of dilution prior to sample procurement, and iii) because vibrations inherent to the measurement likely influence the quality of the measurement from PM instruments.

By way of example to illustrate issues with variability in mobile monitoring, in recent tests of vehicle-based measurements of emission potential of PM<sub>10</sub> on unpaved roads for a Department of Defense-supported research project at the Dugway Proving Ground, Utah, DRI measured the spatial variability of emission of a test road over a distance of 500 m. This flat, graded, road was chosen for its homogeneous appearance as a suitable location for estimating variability inherent to the mobile monitoring system. The concentration of PM<sub>10</sub> was measured by DustTraks in the wake of a test vehicle that was carefully operated at one of three nominal constant speeds (10, 15, and 25 mph). Our measurements, based on approximately 15 passes at each of the three nominal speeds (10, 15, and 25 mph) over the same road segment revealed that the variability of emissions expressed as the standard deviation was between 18% (15 mph) and 35% (25 mph) of the average value of PM<sub>10</sub> measured in the wake of the test vehicle. Since at the ODSVRA the driving conditions would be more variable, the plume dispersion behind the test vehicle would be more variable, and vibrations and shocks to the instruments would be greater, it is reasonable to state that the variability in measured emissions on the scale of 500 m will be much greater than that observed under the Dugway Proving Ground controlled conditions and that this variability would be greater still if measurements are considered as averages over 100 meter test segments.

### **Particle Size Analysis**

Particle size analysis of the samples of material taken at the PI-SWERL test location will be done using a Saturn Digisizer in the DRI Soils Laboratory. The procedure is, briefly, a sample is

internally dispersed using ultra-sonication in an aqueous medium of 0.005% surfactant and circulated through the path of the laser light beam. As the particles pass through the laser beam, the light scatters at angles inversely proportional to particle size and with intensity directly proportional to particle size. A 45° rotational charge-coupled device collects the scattered light intensity, which is converted to electrical signals and analyzed in a microprocessor. Data reduction consists of a mathematical convolution based on scattering model sets, each calculated from the general Mie theory for narrow distributions of isotropic spheres having a specific index of refraction and suspended in a liquid having a specific index of refraction. Data reported by the Saturn DigiSizer relates directly to an equivalent Mie sphere. The Mie theory consists of a "real" refractive index (1.550 for soils) and an "imaginary" refractive index (0.100 for soils) determined by Micromeritics Laboratories. The predictive model error (weighted residual) is proportional to the measure of the calculated Mie theory model to predictions of the observed laser-light scattering pattern. An example of the data from a DigiSizer analysis run is shown in Figure 4 and reveals exceptional detail of the silt and clay fraction wherein resides the PM<sub>10</sub> reservoir. Following analysis of the PM<sub>10</sub> emission data selected samples (100 in total) that represent different areas within the ODSVRA and dune preserves will be submitted for particle size analysis. Particle size statistics will be determined using GRADISTAT software (Blott and Pye, 2001).

### Data Analysis

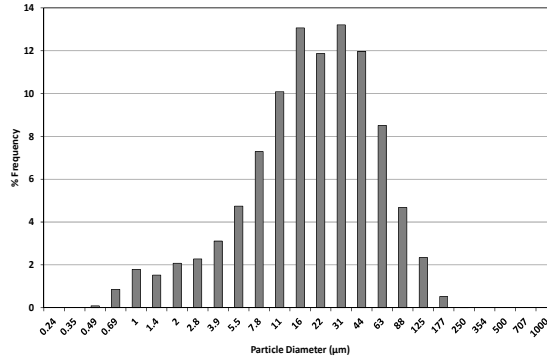
The dust flux, which is the amount of PM<sub>10</sub> produced per unit area per second from a PI-SWERL test is determined from the measurement of the PM<sub>10</sub> concentrations ( $C$ ,  $\mu\text{g m}^{-3}$ ) and the air flow ( $V$ ,  $\text{m}^3 \text{s}^{-1}$ ) through the instrument, and the known dimensions of the PI-SWERL annular blade ( $\text{m}^2$ ). An emission flux ( $F$ ,  $\text{mg m}^{-2} \text{s}^{-1}$ ) can be calculated as:

$$F_{i,cum} = \frac{\sum_{begin,i}^{end,i} C \times V}{A_{eff}(t_{end,i} - t_{begin,i})} \quad (1)$$

where the summation occurs over every 1 s measurement during level  $i$ , beginning at  $t_{begin,i}$  and ending at  $t_{end,i}$ , with  $t$  as integer seconds. The measured dust concentration and flow rate are converted to an emission flux by the effective area of the PI-SWERL,  $A_{eff}$ , which is  $0.035 \text{ m}^2$  (Etyemezian et al., in review). The PI-SWERL tests measure the potential PM<sub>10</sub> dust emissions from the surface at different RPM values that are converted via a calibration relationship based

Diameter ( $\mu\text{m}$ )	% Frequency
1000	0
707	0
500	0
354	0
250	0.01
177	0.52
125	2.34
88	4.67
63	8.51
44	11.97
31	13.21
22	11.86
16	13.07
11	10.08
7.8	7.29
5.5	4.75
3.9	3.11
2.8	2.28
2	2.08
1.4	1.52
1	1.79
0.69	0.86
0.49	0.09
0.35	0
0.24	0
<b>SUM</b>	<b>100</b>

Geometric		
MEAN:	21.42	$\mu\text{m}$
SORTING (s):	3.066	$\mu\text{m}$
SKEWNESS (Sk):	-0.673	
KURTOSIS (K):	3.276	

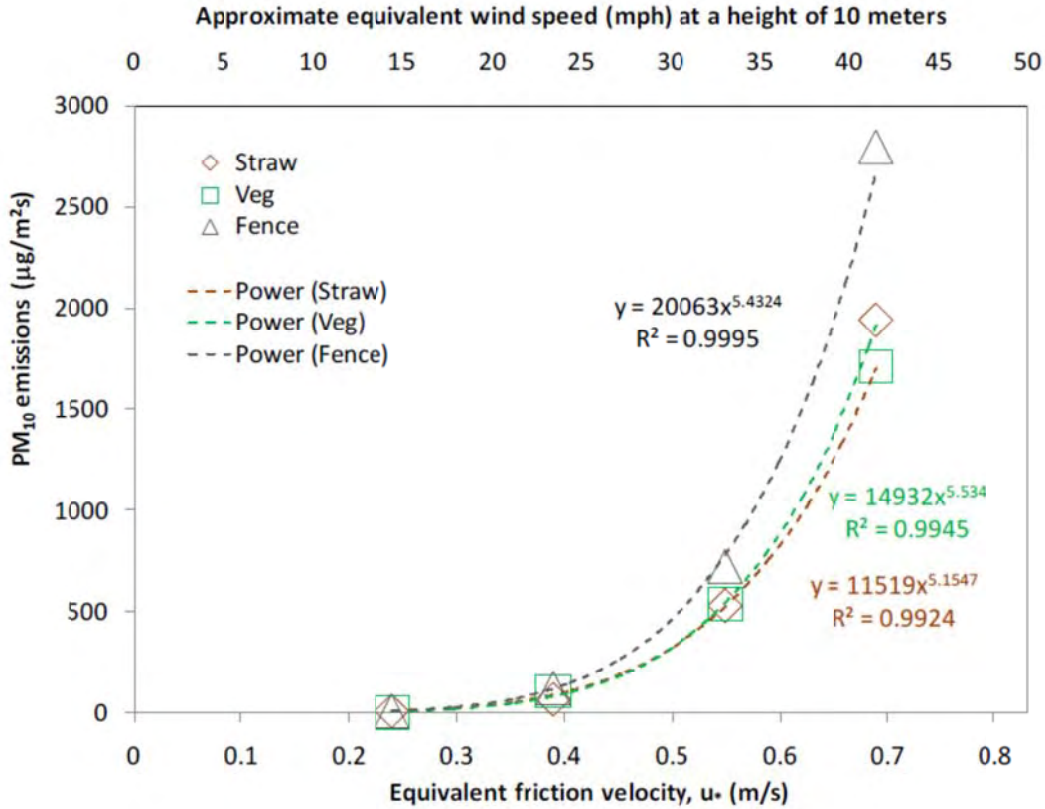


**Figure 4.** Example particle size distribution data from the Digisizer instrument and particle size statistics generated using GRADISTAT (Blott and Pye, 2011).

on surface roughness conditions (Etyemezian et al., in review) to equivalent wind shear velocities (i.e.,  $u_*$ ,  $\text{m s}^{-1}$ ). The tests are conducted at pre-set equivalent shear velocities that can span the range 0.1 to  $1.2 \text{ m s}^{-1}$ .

For each period of the PI-SWERL test cycle where the RPM (i.e.,  $u_*$ ,  $\text{m s}^{-1}$ ) is held constant for 60 s, the average  $\text{PM}_{10}$  flux ( $F$ ) is calculated along with a standard deviation for  $F$ . For each test a relationship is established between  $F$  and  $u_*$  (Fig. 5). Individual tests can be combined or pooled based on their position or other known attributes to evaluate similarities and differences in emissions as a function of position (or location) or different ranges of known attributes (e.g., areas with different percent silt and clay content, activity levels, etc.). For each equivalent  $u_*$ , a t-test or analysis of variance can be performed to determine if the mean emission rates are significantly different from each other.





**Figure 5.** Power fits to  $PM_{10}$  dust emission measurements at three test areas within the ODSVRA and dune preserve (Lancaster et al., 2011).

The determination of what constitutes a high emission rate is arbitrary, but two aspects of how a hotspot is defined are important. The first aspect is areal extent and the second is emission strength with respect to a baseline. In one approach, one could define a “hot spot index” ( $HSI$ ) that could be used to compare the relative importance of variations in emissions and decide what a reasonable threshold would be for defining a hot spot. One proposed version of this index is given by:

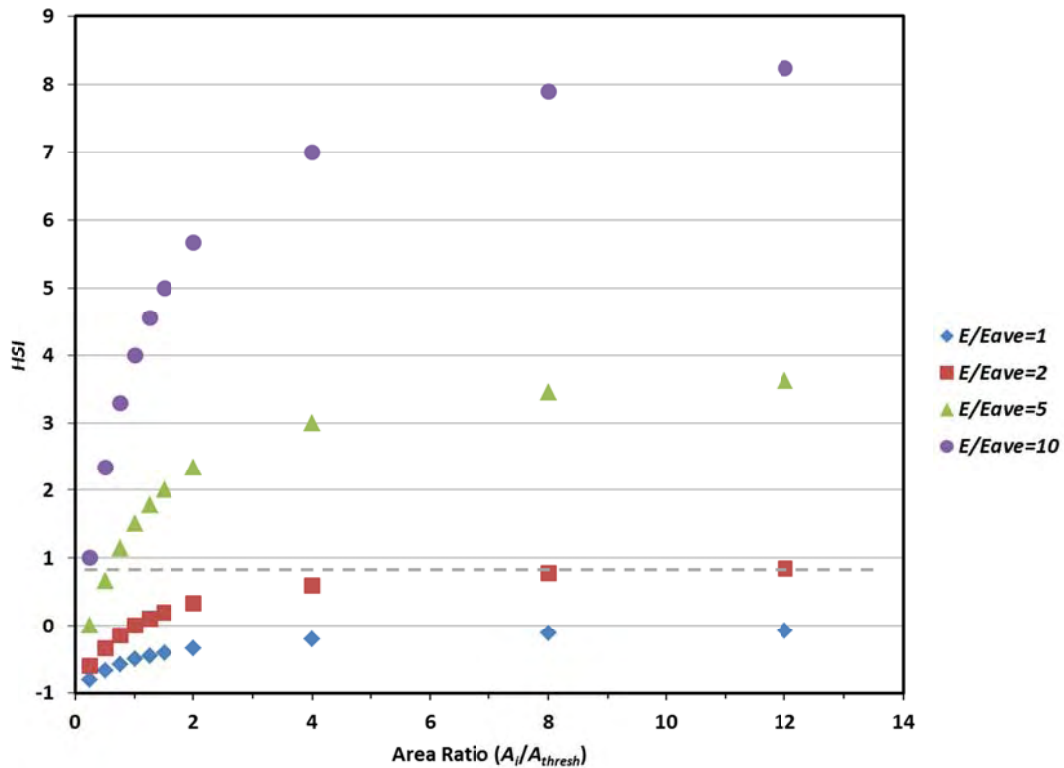
$$HSI_i = \frac{E_{ave,i}}{E_{ave,ref}} \times \frac{(A_i)}{(A_i + A_{thresh})} - 1 \quad (2)$$

where the subscript  $i$  refers to a contiguous surface,  $A$  is equal to surface area, and  $E_{ave}$  is the emission of  $PM_{10}$  per unit area per unit time (averaged over surface being considered) under some prescribed condition (e.g., equivalent 35 mph winds). The subscript  $ref$  indicates the



surface to which the hot spot is referenced and the subscript “*thresh*” indicates a guideline for a minimum physical area that would be considered for any mitigation measure. Figure 6 shows how *HSI* as defined above changes with different values of relative emission potential on different spatial scales. A value smaller than zero indicates that resources would be much better spent treating a randomly selected surface with equal area as *i* instead of treating *i* with any mitigation measures. Values larger than zero indicate that a benefit would be gained by treating *i* with mitigation measures. Although somewhat arbitrary, we propose to use values larger than two as a means to identify “hot spots”. Note that this type of analysis allows for hot spots to be considered at multiple scales.

The particle size distribution data will be used to evaluate how the emission data are linked with the silt/clay fraction distribution data. An increase in emissions should be related, in part, to an increase in the amount of silt or clay in the surface sediment layer. Silt will be measured as well as clay because the silt-sized particles may serve as a source of  $PM_{10}$  created by abrasion due to interaction with sand sized particles during saltation.



**Figure 6.** *HSI* as calculated by Eq. 2 for different combination of enhanced emissions ( $E/E_{ave}$ ) and areas being considered as referenced to the threshold area ( $A_i/A_{thresh}$ ).

## Deliverables

The data derived from the PI-SWERL tests will be individual and mean values of threshold shear velocity ( $u_{*t}$ ) and PM<sub>10</sub> emission ( $F$ ) as a function of shear velocity ( $u_*$ ), sand transport (total particle counts), and surface moisture content. These data will be grouped with respect to transect position and its allocation to a designated source-type area. The collected data will also include other measures of central tendency including: minimum, maximum, and standard deviations for aggregated data. These data can be used to test the following hypotheses:

- 1) Is the threshold shear velocity different along and among transects from the selected locations for the conditions at the time of measurement?
- 2) Is the PM<sub>10</sub> emission potential for equivalent shear velocity different among the sites (for surfaces with similar moisture contents [ $<0.5\%$  difference in moisture content]) at the time of measurement? If moisture content exceeds 0.5%, the data will be grouped together into 1% moisture content bins for comparison of emissions.
- 4) Are the mean PM<sub>10</sub> emission rates for driving areas significantly different than for surfaces within the nature reserves? Mean emission rates may be statistically different as determined by a t-test, but it will also be important to determine how these data should be used to guide a management strategy.
- 5) Are mean PM<sub>10</sub> emission rates significantly different for those measured in high traffic areas versus those in low traffic areas? Mean emission rates may be statistically different as determined by a t-test, but it will also be important to determine how these data should be used to guide a management strategy.
- 6) Do mean PM<sub>10</sub> emission rates change (i.e., increase or decrease) significantly with increasing distance from the shoreline in the off-road driving areas indicating changes in the enrichment of PM<sub>10</sub> in the source material (i.e., surface sands) as a function of distance from the shoreline?
- 7) Does the fraction of measured silt and clay correlate with strength of the dust flux ( $F$ )?
- 8) Does the fraction of measured silt and clay change significantly as a function of location in the ODSVRA and nature preserves?

By testing these hypotheses we will be able to evaluate whether there are differences in the potential for mobilization of the sand and activation of the dust emission system as well as the

strength of the PM<sub>10</sub> emission potential in the ODSVRA and dune preserves, which can be used to guide decisions on where to apply control measures to best achieve reductions in PM<sub>10</sub> emissions to obtain compliance with the Dust Rule. The results of this study will be documented in report format.

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**OCEANO DUNES SVRA PARTICULATE MATTER REDUCTION PLAN  
Third Draft**

**ATTACHMENT 1, APPENDIX C  
VEHICLE ACTIVITY SURVEY RESULTS**

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# Results of 2012 Vehicle Activity Survey Oceano Dunes State Vehicular Recreation Area

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## Background

In the May 4, 2012 Revised Monitoring Site Selection Plan the Off Highway Motor Vehicle Recreation Division (OHMVR) includes a methodology (Attachment I) to survey vehicle activity at Oceano Dunes State Vehicular Recreation Area (ODSVRA/Oceano Dunes SVRA). This monitoring method involved collecting visual counts of vehicle activity at eight locations within OSDVRA and assessing evidence of vehicle activity in the vicinity of the survey points. Survey dates were targeted for March through May and on dates with more than 700 registered campers.

## Survey Details

Three surveys were conducted on July 6, 13 and 20, 2012 and registered campers were 1,000, 785, and 1,000 respectively. Surveys were conducted from south to north and started in the afternoon.

## Results

### Time Vehicle Counts

Vehicle use at each site ranged from 9 – 151 vehicles during the 20 minute survey period. Average use ranged from 15-126 vehicles per survey period. The eight sites were sorted into high, medium and low use areas as follows:

High Use with an average of 80 vehicles or greater per survey period

Medium Use with an average of between 30 and 79 vehicles per survey period

Low Use with an average of fewer than 29 vehicles per survey period

Of the eight sites, three were found to have a high level of observed vehicle activity, three had a medium level of vehicle activity, and two sites had a low level of observed vehicle activity. The sites are mapped in Attachment "A". Areas highlighted blue are high observed activity, areas in pink are medium observed activity areas, and areas in yellow are low observed activity areas.

It is noteworthy that the high use areas are at the north and south ends of the park. It is likely that this survey methodology did not adequately record travel patterns or at least the path of travel that most visitors were using to get to the southern portion of the park.

## Vehicle Tracks at Survey Points

Vehicle tracks within a 300 foot area were assessed prior to and immediately after survey periods. Tracks were given a score of high, medium, and low vehicles tracks as follows:

High: More than 50% of the sand has visible tracks

Medium: Between 11 and 49% of sand has visible tracks

Low: Less than 10% of the sand has visible tracks

Too Windy: Wind conditions obscure vehicle tracks

Each survey site recorded a high level of vehicle tracks at one point during the vehicle activity surveys. High levels of vehicle tracks were reported most often during the July 13 survey period. The days leading up to July 13 were not windy so tracks from multiple days were visible.

## Discussion

The observations of vehicle tracks would call into question the results of the timed vehicle counts. All sites had a high percentage of vehicle tracks within 300 feet of the survey point. This result could indicate that the timed vehicle counts were not truly representative of the amount of vehicle activity near the survey site. It is possible that the timed vehicle counts did not occur during heavy vehicle use periods. The wind will typically obscure vehicle tracks over the course of a 24 hour period. If the surveys were conducted during a low wind period, it is possible that the amount of vehicle activity observed is sufficient to disturb the sand surface more than 50%.

## Limitations of Surveys

1. The visible area at each survey location was different. The survey method involved finding a high point and surveying all vehicles that passed a line from the survey point to a point to the west. In some locations, visibility allowed counting vehicles up to 1,000 feet away, while at other survey sites it was only possible to count vehicles less than 500 feet away.
2. Vehicle activity counts may not be representative of actual vehicle activity at the site. Twenty minutes is a relatively short period and may not be enough time to observe a truly representative vehicle activity level.
3. There is evidence that the survey locations did not capture the main path of travel for most vehicles heading to the southern portion of the park. It appears that most vehicles are travelling along the shoreline versus on Sand Highway. There were no survey locations that included vehicle activity on the shoreline.
4. Surveys were not conducted at the same time each day. Surveys started at approximately the same time each day but a survey day took more than 3 hours to complete. Since surveys started in the southern portion of the park, it is possible that vehicle activity levels had changed by the time observations were recorded at the northern portion of the park.

5. Only afternoon daylight hours were covered. There is no estimate of vehicle activity prior to 12:00 pm and after 5:00 pm.
6. No estimates were made of vehicle type (motorcycle, ATV, RUV, Street Legal Vehicle, etc).
7. No estimates were made of vehicle speed and activity.
8. No estimates were made of vehicle activity within or near the main camping area.
9. Surveys were not conducted during the target windy season from March – May
10. Estimates of vehicle tracks could differ between observers.

## **Conclusion**

The preliminary survey methodology was not robust enough to draw conclusions. The preliminary effort should only be considered a snapshot of a much larger pattern of vehicle use at ODSVRA. There is strong evidence that vehicle activity is having a large impact on all sand surfaces in the riding area as evident by the high level of vehicle tracks at sites that had a low observed vehicle use.

Due to the limitations on the data set, OHMVR is considering additional methods to assess vehicle activity in Oceano Dunes SVRA.



