WHITE PAPER

PARTICULATE AIR POLLUTION IN THE OCEANO DUNES - NIPOMO MESA AREA: WHAT HAVE WE LEARNED

SAN LUIS OBISPO COUNTY
AIR POLLUTION CONTROL DISTRICT

SEPTEMBER 2016

PREFACE

Airborne particulate matter, if in enough concentration, can be harmful to humans. According to the US Environmental Protection Agency's (USEPA) publication, "Particulate Pollution and Your Health," small particulates less than 10 microns in size (PM10) -- about the width of a human hair -- can cause a number of health problems because such particles are small enough to bypass the body's natural defense mechanisms and penetrate into the lungs.

Those at most risk are children, and adults with heart or lung diseases. According to that USEPA publication, "...numerous studies link particle levels to increased hospital admissions and emergency room visits -- and even death from heart and lung diseases." Also, "short-term exposures to particles (hours or days) can aggravate lung disease, causing asthma attacks and acute bronchitis, and may also increase susceptibility to respiratory infections."

Both the USEPA and California Air Resources Board (CARB) have established ambient air quality standards for PM10 and fine particulate matter (PM2.5). The federal standards are set at the level below which it is deemed not to cause significant health effects, while also allowing for "an adequate margin of safety." [Federal Clean Air Act, Section 109(b)(1)] Note that this does not mean all health effects, but rather those deemed "significant" health effects. California, on the other hand, has established PM standards much more stringent than the federal EPA standards. According to ARB, "these standards define the maximum amount of particles that can be present in outdoor air without threatening the public's health." [Ref: www.arb.ca.gov/research/aaqs/pm/pm.htm]

The South County area, including the Oceano Dunes State Vehicle Recreation Area (ODSVRA) and the populated Nipomo Mesa area, is currently the focus of intense studies because of significantly higher levels of PM10 and PM2.5 measured in this region as compared to other areas of San Luis Obispo County. In some years, federal health based standards have been exceeded, while the more stringent California particulate standards are exceeded on a regular basis.

The purpose of this White Paper is to summarize the work that has been done by both the SLOAPCD and the Desert Research Institute, under contract to the California State Parks (which operates the ODSVRA), to gain insight into the specific conditions causing the high particulate levels and necessary mitigation efforts to reduce the airborne particulates. Targeted for a non-technical audience, the purpose and results of each study are described in lay terms to the greatest extent possible, with no attempt to synthesize the results or draw conclusions between the studies.

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Particulate Air Quality Perspective

Much of this paper will focus on particulate air quality in the south county region. It is relevant to provide some perspective as to how San Luis Obispo County compares to other counties in the State. For PM10, out of 58 counties, only 6 counties have sub-areas which have been designated by USEPA as non-attainment (CARB, 2013). All of those areas are desert areas susceptible to wind-blown dust. If the Nipomo Mesa area were to be designated non-attainment by USEPA due to violations of the federal 24-hour PM10 standard, it would be the only non-desert area in California so designated.

For the California PM10 standard, PM10 is so pervasive that only 5 counties have been designated as attaining the standards (CARB, 2013). Those five counties are primarily rural, low populated counties in the northern part of the State.

From this information, it can be derived that there is a uniqueness in this region to the higher PM10 levels which can exceed the federal standard threshold by its being a non-desert area with high observations of PM10, but at lower levels which can still exceed the State 24-hour and annual average standards, not that dissimilar from much of the rest of the State. However, due to a number of special conditions in the ODSVRA as described in this White Paper, high hourly concentrations of PM10 can occur during the mid-morning to late afternoon hours. While there are no air quality standards for one-hour or multiple-hour concentrations, this phenomenon makes this area more unique as compared to other areas in the state with levels exceeding the State standards.

The studies conducted and summarized in this report attempt to gain scientific insight into that uniqueness of conditions in the ODSVRA-Nipomo Mesa area.

San Luis Obispo County APCD 2007 Nipomo Mesa Study (2007) (also known as "APCD South County Phase 1 Particulate Study)

Conducted from April 2004 through March 2005, this was an exploratory study to gain initial insight into the particulate conditions in the Nipomo Mesa area and possible causes for the highest particulate readings in the County over the prior 20-year period. The study was designed and conducted by the SLOAPCD with support from the USEPA and CARB.

Measurements of both PM10 and PM2.5 were collected at 3 sites (CDF, Bendita, and Mesa 2); PM10 only was collected at 2 sites (Hillview and Nipomo Regional Park); PM2.5 only was collected at 1 site (Oso); and PM2.5 data were collected at Atascadero and Santa Maria for quality assurance purposes. (Except for Atascadero and Santa Maria, these monitoring sites are shown on the photo-illustration on the cover page.) Particulate data collected were analyzed for chemical components by Desert Research Institute to gain a better understanding of the chemical make-up of the particles collected.

This type of chemical analysis, called chemical speciation, helps to determine the types of sources which contribute to the particles collected in the samples. An illustration of these results are shown in Figure 1 for the annual PM10 concentrations measured during the study at 5 Nipomo Mesa sites.

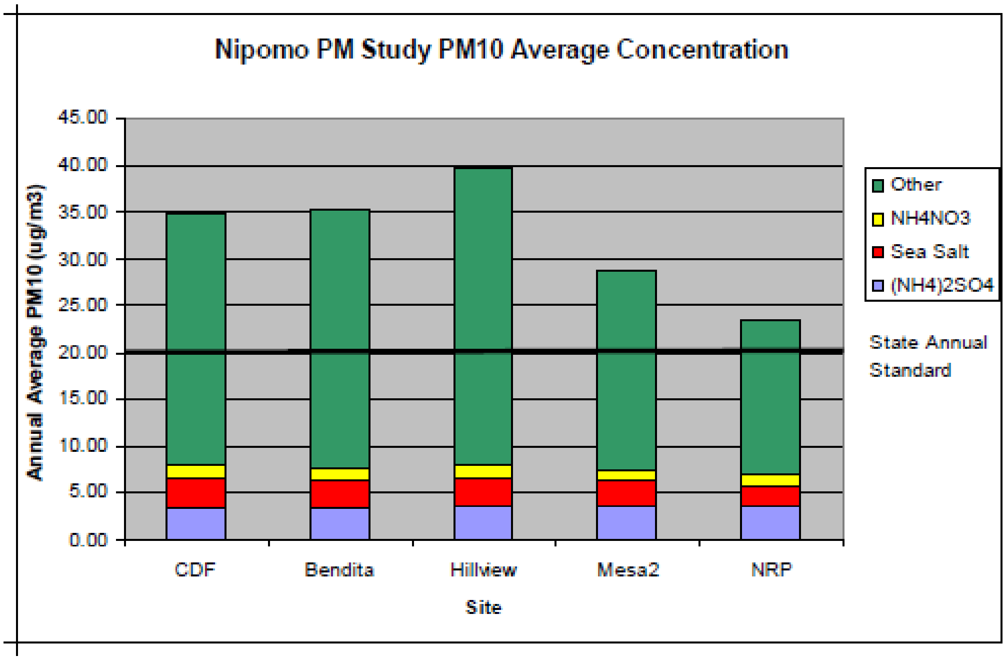

Figure 1. Chemical Speciation of PM10 Average Concentrations

It can be seen that anthropogenic (man-made) sources of nitrates (yellow) and sulfates (blue), and natural sea-salt (red) are relatively similar across all sites, except that sea salt tends to decrease further away from the ocean. The combination of these are dwarfed by the "other" category (green), which is primarily attributable to crustal materials, which include silica, very common in sand. Other analyses in the study confirmed the crustal dominance of particulate samples.

Wind analyses showed the strongest winds are directionally from the west northwest. Strong winds across a sand dune area, when above a certain velocity ("threshold friction velocity" or TFV), cause sand particles to begin moving (a process called "saltation." As the sand particles bounce along the ground they hit other sand particles, causing some to fragment into smaller particles, including those in the PM10 and smaller size range.. The smaller the particles, the more likely they can become airborne and be carried inland by the winds.

To determine the relationship between the west northwesterly winds and the impact of PM10 being transported inland from the dune areas, a directional sampler was installed at the CDF site. This type of sampler is tied to a wind monitor (anemometer) which activates the PM10 sampler only when the wind direction in this case is directionally from the ODSVRA. To determine the impacts from the ODSVRA, the results of the PM10 mass collected on the directional sampler were subtracted from that collected on the non-directional sampler. Results showed that the days with the highest PM10 concentrations predominantly occur when stronger winds blow from the ODSVRA area. For samples where the total PM10 mass is at or below the level of the state standard, winds from the SVRA area are of lower velocity, or are directionally blowing from other areas.

The study also examined the possible direct impacts from the vehicle activity in the ODSVRA by comparing particulate measurements at the monitoring sites on weekends compared to weekdays, since higher vehicular activities occur on weekends. Analyses did show generally higher concentrations on weekends, but the results were not statistically conclusive. Other factors related to indirect emissions from vehicular activity, including the denuding of existing vegetation, and destabilizing the dune structure leading to greater entrainment of fine particles into the air, were noted but not included in the design of this study.

APCD South County Phase 2 Particulate Study (2010)

The second particulate study built off the results of the first study, with more specific objectives. In particular, this study focused more on the evaluation of potential sources contributing to the high PM10 levels inland of the sand dunes and the ODSVRA, including: (1) the off-road vehicle activity at the ODSVRA; (2) fugitive dust emissions from the coke piles at the Conoco Phillips refinery; and (3) agricultural activities in the area. Another objective was to determine the contribution of direct and/or indirect emissions as causative factors in observed PM levels.

To accomplish these objectives, more specific measurements were required. Continuous particulate monitors were used which provide more details of particulate behavior over the course of a day, by tracking hourly values, rather than just a 24-hour composite. Wind and other appropriate meteorological measurements were necessary coincident with the PM10 measurements. Using specialized "drum" samplers, the Delta Group (a group of scientists mostly from the University of California, Davis) collected an array of samples from key locations downwind of the ODSVRA riding area and non-riding areas both north and south of the ODSVRA to measure for differences in particle size and elemental composition of the particles. In addition, the Great Basin Unified APCD (GBUAPCD) and CARB assisted with the use of equipment to monitor for overall sand flux as well as sand movement at specific points in time.

The monitoring sites included three sites downwind of the ODSVRA, three sites north of the ODSVRA, three sites south of the ODSVRA, and two additional sites for special purposes, for a total of 11 monitoring locations. Figure 2 below shows the locations of these sites .

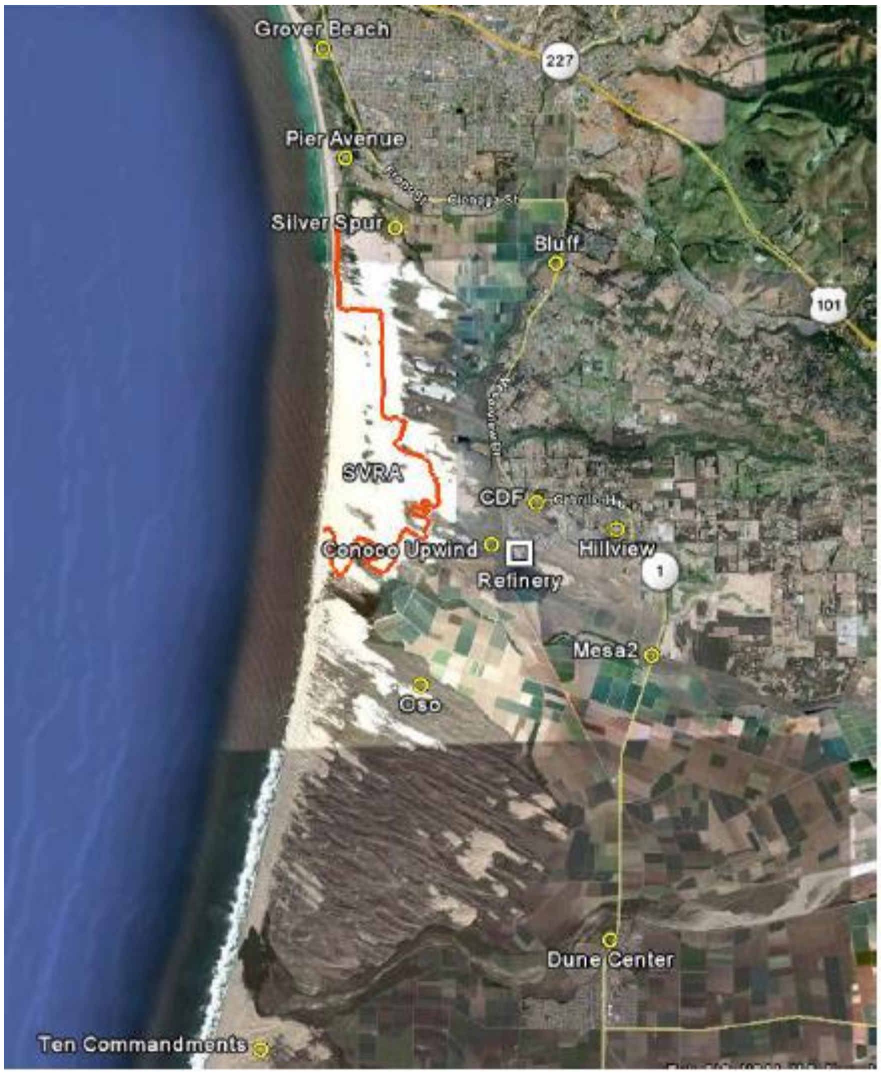

Figure 2. Locations of the 11 Monitoring Sites
(as indicated by the yellow circles)

One of the more interesting characterizations of conditions in the region is a comparison of graphical plots of wind speed vs PM10 concentrations on an hourly basis at Grover Beach, north of the ODSVRA, and the CDF site, immediately downwind of the ODSVRA. These are shown in Figures 3 and 4.

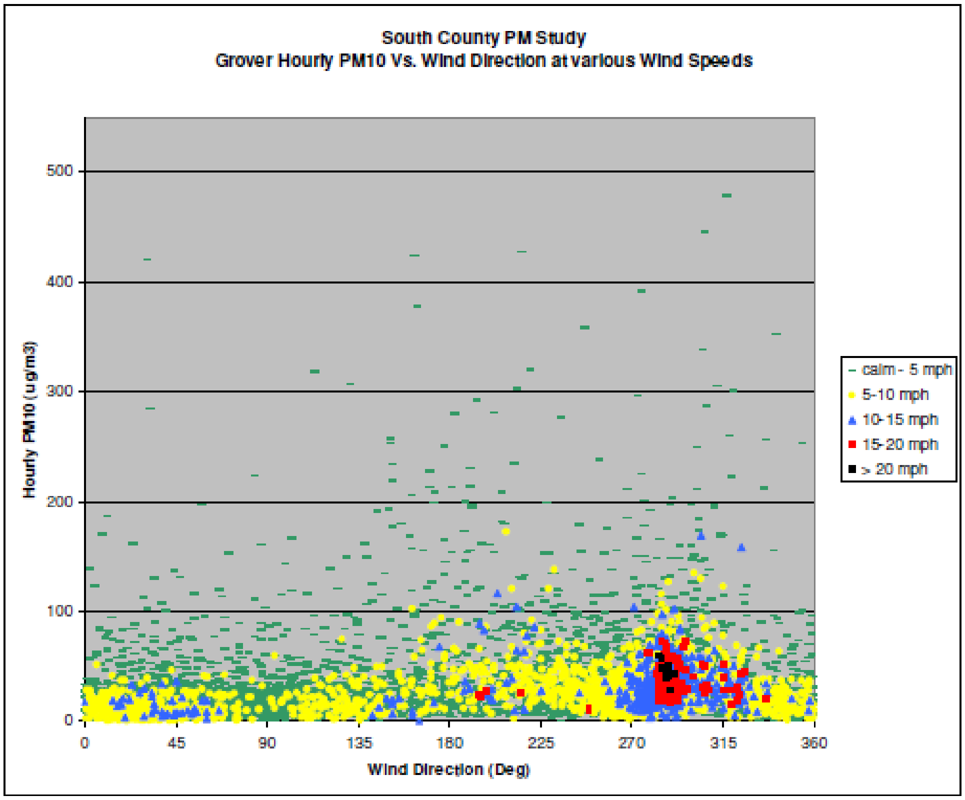

Figure 3. Plot of Hourly PM10 vs Wind Direction at Various Speeds at Grover Beach

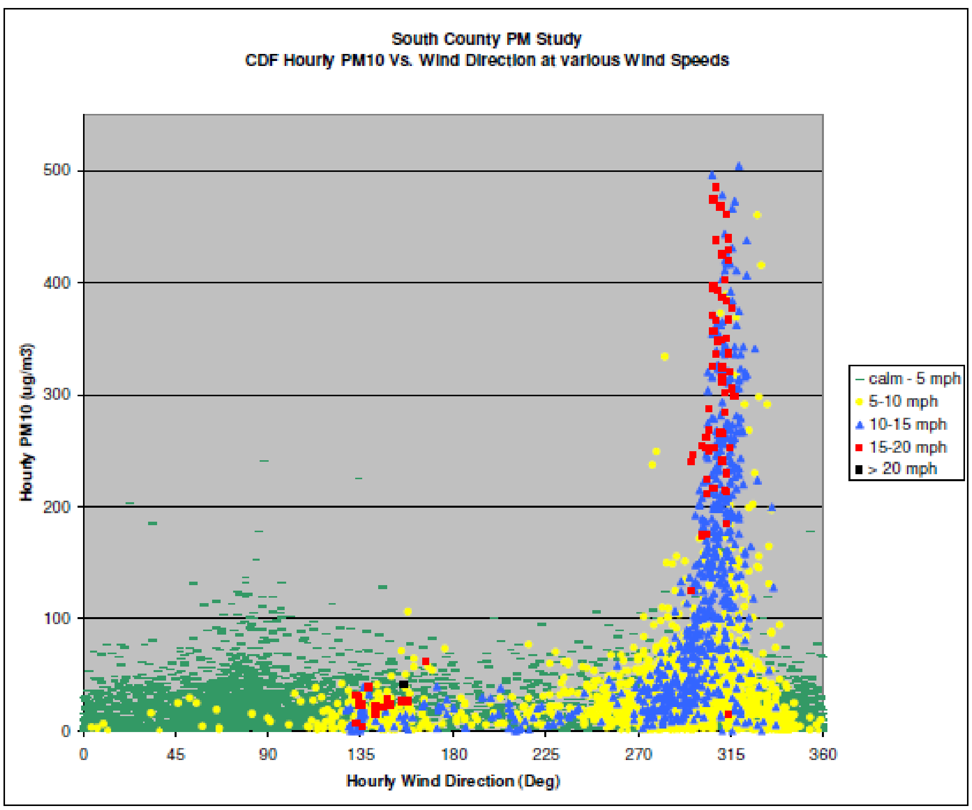

Figure 4. Plot of Hourly PM10 vs Wind Direction at Various Speeds at the CDF Site

Being separated by a distance of only approximately five miles, these two plots are about as different as could possibly be. At Grover Beach, there are noted high hourly values of PM10 and these are associated with calm or very light wind speeds. When winds speeds are above 10 mph, PM10 levels are generally low, about 50 ug/m^3 or lower. At CDF, there is a very narrow column of higher hourly PM10 levels at a direction near 315 degrees, or northwesterly. These higher values are associated with wind speeds dominantly above 10 mph. When wind speeds are low or from other directions, PM10 is mostly below 80 ug/m^3.

These two locations are clearly influenced by two different mechanisms. Grover Beach, very close to the ocean, is affected by fog off the ocean. Such conditions occur under very light wind speeds. Fog contains dissolved salt, which when heated by the sampler inlet, evaporates the water and leaves the remaining salt particles on the filter, which is analyzed as a component of PM10.

Conversely, at CDF, the highest PM10 is associated with both wind speeds and direction conducive to the transport of PM10 emissions emanating from the sand dunes immediately upwind of the monitoring site. There are some days, as indicated by some PM10 values above 100 ug/m^3, with calm or light wind speed conditions, when there are some fog effects at CDF, but not nearly as pronounced as the transport events.

One of the key goals of this study was to determine if the vehicular activity in the ODSVRA had noticeable PM10 impacts at the downwind monitoring sites, mainly CDF and Mesa 2. Analytical results did not show a strong relationship with vehicular activity, though a stratification analysis did show a slight influence. The key here is that such direct emission influences from the vehicular activity is relatively small compared to the windblown emissions emanating from the ODSVRA. Also, the study noted the significant potential for indirect emissions. These indirect emissions are likely from vehicular activity which cause de-vegetation, destabilization of the dune structure and loss of possible natural surface crusting of the sand -- all of which contribute to increased emissions from the ODSVRA which impact the downwind areas on the Nipomo Mesa.

The Oso control site to the south of the riding area is also downwind of sand dunes and also more vegetative coverage than is observed in the riding areas. Analysis of sand flux measurements, taken in both areas, showed that the sand in the ODSVRA is more erodible than that upwind of the Oso site, and that greater wind speeds are necessary to start moving the sand at Oso than in the ODSVRA. Also, in and around the vegetative areas, no sand flux occurred, indicating that vegetation has a substantial positive effect on the reduction of windblown sand.

Figure 5 shows the 2005 view of the southern portion of the current riding area. It can be seen that the riding area is virtually void of all vegetation, but surrounded by more significant areas of vegetation.

Figure 5. 2005 Aerial View of the Southern Section of the ODSVRA, Looking East.

Other findings in this study showed:

(1) The petroleum coke piles at the ConocoPhillips facility are not a significant source of ambient PM10 in the region, as chemical analyses of collected samples did not detect significant levels of coke pile tracer chemicals;

(2) Offshore sources of particulate matter transported into the area do not contribute any significant amounts to the observed high levels of PM10;

(3) Some localized sources may impact the Oceano area. Visual observations suggest that re-entrainment of sand particles by vehicles traveling over deposited sand on roadway surfaces may be causing some elevated levels in this area. Vehicles exiting the ODSVRA at Pier Avenue may be the source of the sand tracked onto the roadway surfaces;

(4) Monitors located downwind of agricultural sources showed agricultural activities were not a significant source of airborne particulates during three episode days on the Nipomo Mesa;

(5) Elemental analyses of the particulates at the Mesa 2 site on windy, high PM10 days showed a predominance of crustal material elements, such as silicon, iron, aluminum, and potassium. This, in conjunction with the other analyses, confirms that the high PM10 days are dominated by windblown material in the open sand sheets in the dune area of the coast.

Oceano Dunes Pilot Projects (2011)
(By Desert Research Institute)

The purpose of this study is to provide information and pilot demonstration sites to support the development of a Particulate Matter Reduction Plan by the California State Parks (CSP). CSP, in conjunction with the SLOAPCD, identified three pilot projects to gain better insight into appropriate mitigation strategies to reduce sand transport and dust emissions from the ODSVRA: (1) the use of hay bales to artificially increase "surface roughness" which in turn reduces the wind velocity over the sand surface, thereby reducing windblown emissions; (2) the effectiveness of vegetative areas, which in the Phase 2 study previously described, showed virtually no sand movement in the existing vegetation areas; and (3) the reduction or elimination of sand surface disturbances by off-road vehicular activity in the ODSVRA.

For measurement purposes, a number of different techniques were utilized to get field data to evaluate each pilot study. Certain sensors were used to evaluate sand movement (sand flux). A special device developed by DRI (called a PI-SWERL) was employed. The device creates, in a controlled setting, the equivalent of various wind speeds. The device is placed over the sand, and as emissions increase with increased rpm to create simulated wind, the emissions are measured by a PM10 collector. This helps to determine the "emissivity" of the sand in the area being tested. Samples of sand were also collected and analyzed for particle sizing, as smaller particles require less wind to make them become airborne.

The locations of each of the pilot studies in reference to the ODSVRA is shown in Figure 6.

Pilot Study #1: Hay Bales

Approximately 210 hay bales were laid in an array over part of the riding area, as depicted in Figure 6, covering a size of 100 m long by 50 m wide, or a little larger than a football field. The bales were arranged in 20 alternating rows of 10 and 11 per row with the orientation of the longer dimension rows parallel to the northwesterly winds -- typically associated with high PM10 days. The size of each bale was approximately 4' long x 2' wide x 1.3 feet high. For a photo of the array, see Figure 7.

Figure 6. Photo-Illustration of the ODSVRA and Location of the Pilot Studies

Visual results (Figure 7) showed that the upwind side of the hay bales resulted in a loss of sand causing the bales to tilt to the windward side, while downwind of the bales, noticeable dunes developed up to the approximate height of the bales. Over time, the bales became more engulfed by the sand.

Based on the sand flux measurements, it was shown that there was considerable variability over the array field. Data further suggest that the bales were most effective in reducing the sand movement during the first few days, by 75%-84%, with effectiveness gradually decreasing over time and stabilizing at about 40%-50% reduction. Based on that level of sand movement reduction, it was estimated that the PM10 emission reduction potential could be as high as 98% if it takes a greater wind speed to move sand when bales are present than without bales.

Figure 7. Photo of Hay Bales in April 2011 (after deployment, top) and May 2011 (bottom)

Pilot Study #2: Vegetation

Prior research has shown that vegetation can significantly reduce sand flux and associated particulate emissions. Other restoration efforts have shown that it is possible to establish dense vegetation ground cover in the Oceano Dunes area. However, vegetative growth takes time, often several years to become established. It was therefore not feasible to conduct a pilot study with newly planted vegetation. The approach here was to take measurements at an existing vegetative covered area and also in an adjacent area that is denuded of vegetation. Comparisons of the two data sets should give a reasonable estimation of the effectiveness of this potential mitigation approach.

See Figure 6 for the location of the vegetative effectiveness area, and Figure 8 for a photo of the established vegetation at the demonstration site, which was a re-vegetated area in a trough between two dunes.

Figure 8. Photo of the Vegetative Cover in the Vegetation Pilot Study Site

PI-SWERL data indicate that sand in the vegetation areas have the potential to emit PM10, but there is a low probability of such emissions due to the effectiveness of the vegetation to dramatically reduce sand transport and associated PM10 emissions. It was observed that in three years following planting, the vegetation achieved nearly 100% control of sand movement and PM10 emissions.

Pilot Study #3: Sand Disturbances from Off-Road Vehicular Activity

To accomplish the objectives of this pilot study, an area was selected with a transect crossing the fence line between the active riding area and the non-riding area. (See Figure 5.) Comparisons of measurements between the two can compare riding area sand movement and emissions potential between the riding areas and non-riding areas.

The PI-SWERL measurements, at equivalent wind speeds of 14 mph, 23 mph, 33 mph, and 41 mph, showed that riding area emissions were higher than non-riding area emissions by 56%, 49%, 70%, and 70%, respectively, for the four levels of equivalent wind speeds. These were found to be statistically significant at the 95% confidence level for the three highest wind speeds. It was noted, however, that due to equipment problems and the variability of emission potential across the full riding area, the results may not be fully representative of the riding area/non-riding area comparison.

Overall, from the data collected for all the pilot studies, it was estimated that the PM10 emissions potential across the ODSVRA varies by a factor of two.

APCD South County Community Monitoring Project (2013)

The Community Monitoring Study, designed in 2011 and conducted during the windy season between March and May 2012, utilized a network of special semi-portable PM10 monitors, many of which included wind sensors. The purpose of the study was to obtain data to help define the wind-driven PM10 plume emanating from the ODSVRA and it's impact in the more populated areas of the Nipomo Mesa,, and to also assess the PM10 conditions in and around the Oceano area. A total of 18 temporary sites were used for the Nipomo Mesa data collection, with another four sites in the Oceano area. The project study areas are shown in Figure 9.

Figure 9. Study Locations for the Community Monitoring Project

In addition to defining the PM10 plume concentrations and geographic reach in these areas, the study also aimed at using this information to define air quality forecast zones so that forecasts of expected PM10 levels across the Nipomo Mesa and the Oceano area can be more accurately provided to the public.

Nipomo Mesa Monitoring

The location of the monitors on the Nipomo Mesa was based on a modified grid approach across the project areas so that the data are representative of the region. Using a grid laid over the study area, modifications were made based on sensitive receptors (such as schools), relative population density, micro-meteorological conditions, and results from prior monitoring. Further, it was decided to include a few monitors outside the populated grid to enhance the knowledge of plume extent.

Results of the monitoring provided details of the dust plume, concentration gradients, and how the wind influences the dust plume. The typical pattern observed on the Mesa is shown in Figure 10. It is apparent that PM10 concentrations are typically low across the northern and northeastern part of the Mesa, with a sharp increase in concentrations moving southward in the direction of the plume. The highest concentrations in and around the CDF site are immediately downwind of the ODSVRA, and this is a consistent result on windy days.

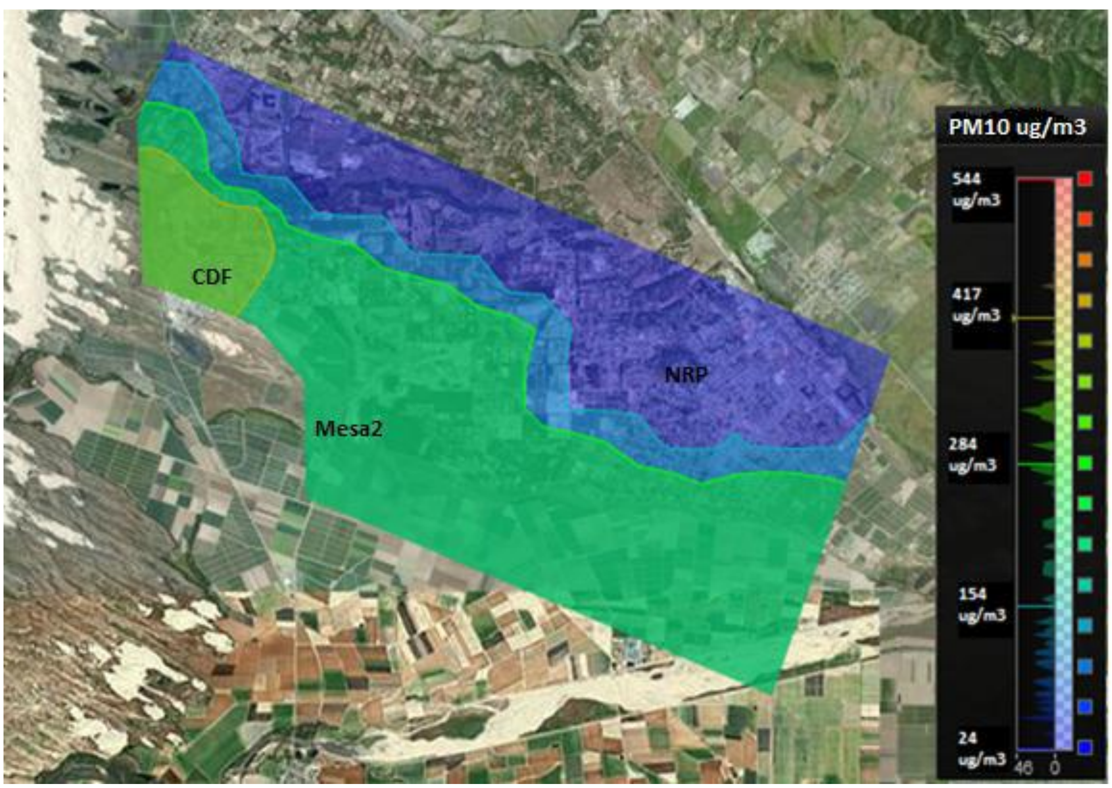

Figure 10. Typical Peak Concentration Pattern of PM10 Concentrations Across the Nipomo Mesa on Dust Episode Days

Aerial photos were taken on one of the windy days which visually shows the plume across the Mesa, illustrated in Figure 11.

Figure 11. Photo of Plume Emanating from the ODSVRA (right side of image) Moving Inland Across the Mesa. (The hazy area across the middle of the photo is the plume of airborne particulate matter.)

Further analysis of both wind conditions and PM10 concentrations showed that while the winds on high wind days are strongest and persistently from the west-northwest in the ODSVRA, wind conditions and PM10 concentrations become more variable inland. The plume tends to spread out more toward the south, while the northern part of the Mesa is typically not affected by the plume. If the winds toward the Nipomo Regional Park (NRP) monitoring site are from the north, the plume is pushed more to the south, leaving the NRP with lower concentrations and evidence of plume movement toward Santa Maria. If the winds at the NRP site are more westerly, then the fringe of the plume does increase the PM10 levels at that site, though still much, much lower than the levels at the CDF monitoring site.

Oceano Monitoring
For the Oceano, area, the monitors were located near the immediate coast and relatively small distances inland to determine local gradients of concentration and also to determine possible sources of PM10 impacting the community. One monitor was located at the location that recorded high particulate concentrations during the Phase 2 study. Three monitors were in operation from April 12 to May 10, and a fourth monitor was added from May 10 through the end of the month. One sampler had problems prior to April 12, so the full data availability was more limited here than it was for the Nipomo Mesa portion of the study.

Results showed PM10 sources affected the sites closest to the shore and dropped off fairly rapidly moving inland. During the period in May when all four monitors were operating, the site just off the edge of the sand had the highest levels under windy conditions, with the site 0.2 miles inland from the sand about 10% lower. The drop off at the two most inland sites, still less than a mile from the beach sand, was about 40% in the vicinity of Pier Avenue, but virtually no plume presence at the site away from street activity. It is evident that there is PM10 emanating from the sand, but the drop-off is significant in less than a mile distance inland. The relatively smaller drop-off near Pier Avenue is suggestive, but not conclusive, of dust sources from re-entrained road dust from vehicles traveling over the sand on Pier Avenue tracked out onto the street from SVRA vehicles leaving the ODSVRA.

Based on the data from all the special monitoring sites, a statistical analysis was done to determine the relationship between each of those sites and the three permanent SLOAPCD monitoring sites at CDF, MESA2, and NRP. Each special site aligned more closely to one of these three, and from this a map was produced showing the areas that could be represented by each permanent site, and therefore useful as a basis for establishing forecast zones. The results of that analysis are shown in Figures 12 and 13.

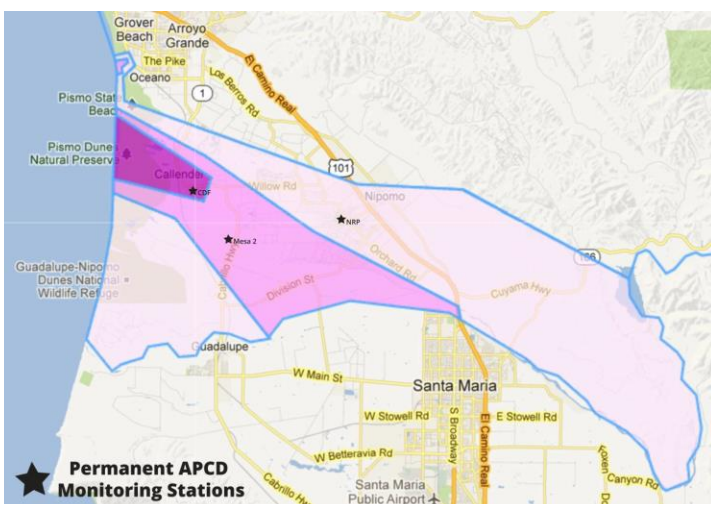

Figure 12. Forecast Zones Tied to Each of Three Permanent Monitoring Sites: Dark Pink = CDF; Medium Pink = MESA2; Light Pink = NRP

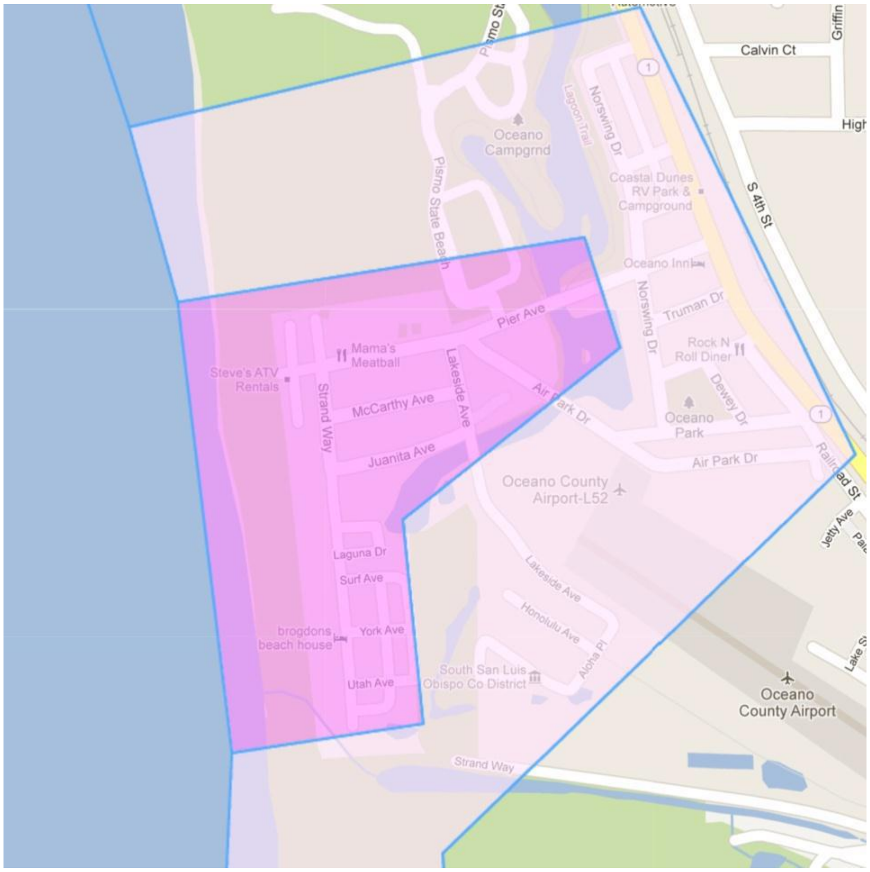

Figure 13. Forecast Zones in Oceano Tied to Permanent Monitoring Sites: Medium Pink = MESA2; Light Pink = NRP

Wind and PM10 Characteristics at the ODSVRA from the 2013 Assessment Network (2014)
(Desert Research Institute for the California State Parks)

In this study, wind and PM10 data were collected during a two-month period, May 10, 2013 through July 15, 2013, and were analyzed along four west-to-east transects within the ODSVRA were analyzed. The transects are shown in Figure 14. Transect #1 is to the north of the active riding area and Transect #4 is to the south of the active riding area. Transects #2 and #3 are primarily within the riding area.

At each of three measurement positions along each transect (i.e., position "A" closest to the shoreline, position "C" at the easternmost location, and position "B" in the middle), wind data were collected at 3m and 10 m above the ground. This provides good information on the general wind characteristics across the ODSVRA and the Dune preserve.

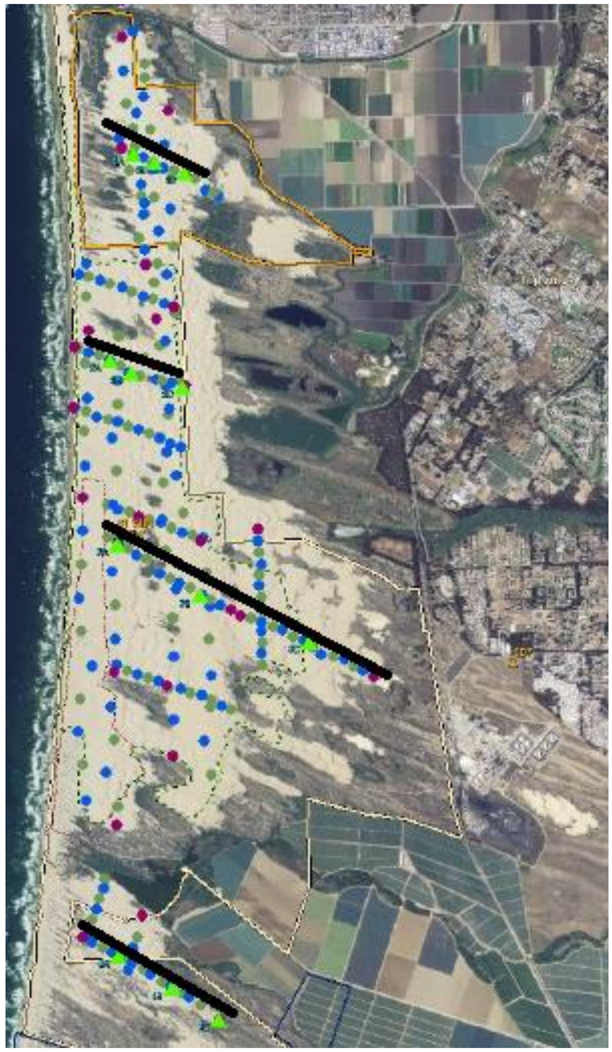

Figure 14. Four Transects Used for Measurements at the ODSVRA
(Transects are shown with black lines, with Transect #1 at the top, progressing downward to Transect #4 at the bottom. Green triangles show each wind site. Transects 1&4 are located in non-riding areas; Transects 2 & 3 are located within the riding areas.)

Results show that the dominant wind direction at Transect #1 is westerly at the shoreline, turning more west-northwesterly inland. The winds at Transect #2 show about equal frequency of westerly and west-northwesterly winds at the shoreline. Winds are generally stronger at Transect #2 than at Transect #1, and the magnitude of the winds increases inland from the shoreline. At Transect #3, winds are more frequent from the west-northwest at the shoreline and at greater magnitude than at either Transect #1 or #2. Again, winds increase from west to east, but not quite as much as either Transect #1 or #2. For the southernmost transect, #4, winds are predominantly west-northwesterly at all three locations, A, B, and C, and wind speeds for this wind direction are higher than at any of the other three transects. Wind roses for each transect are shown in Figure 15.

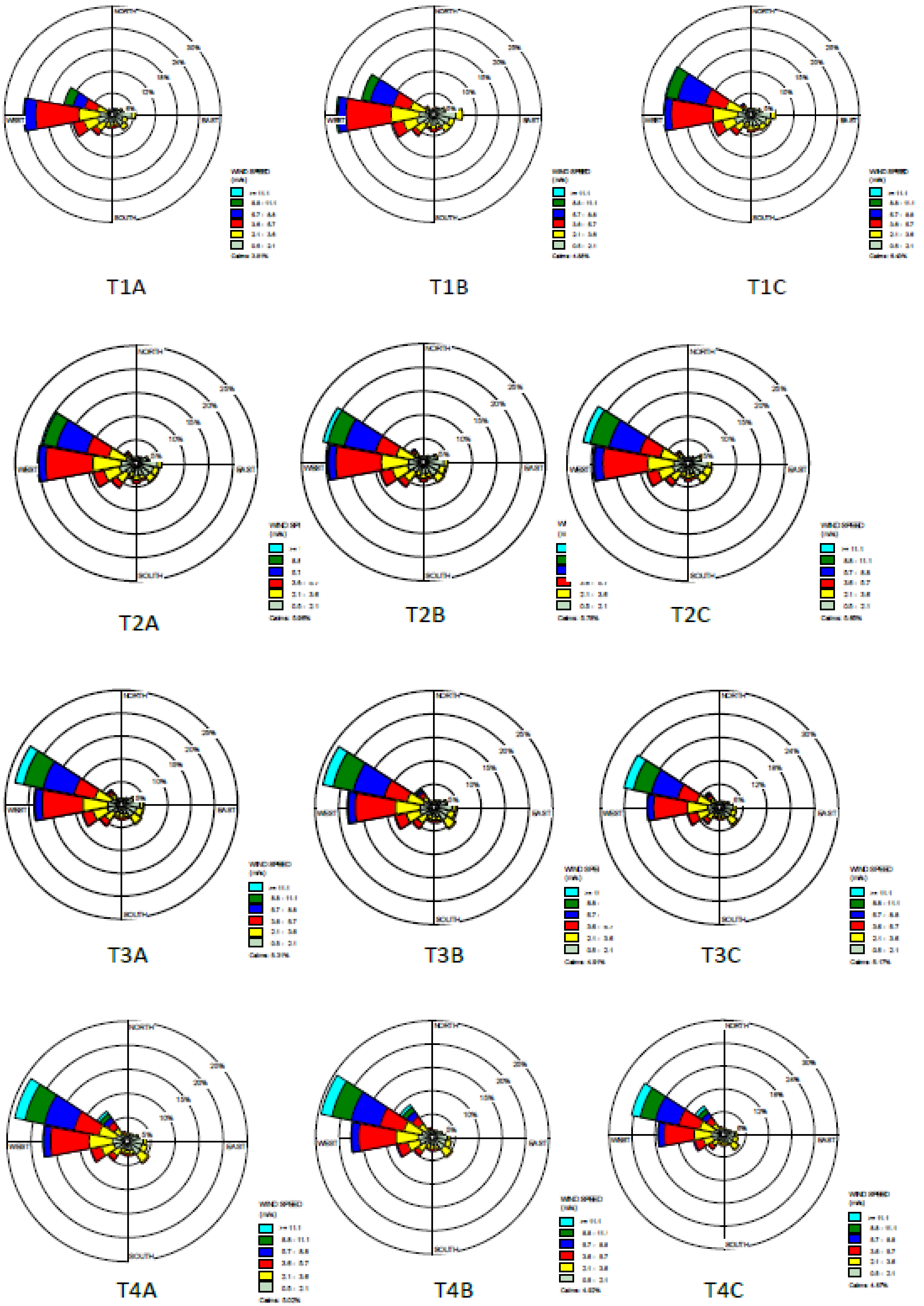

Figure 15. Wind Roses at Each of the Four Transects, at Transect Sites A, B & C at Height of 3 Meters Above Ground Level

One can then characterize west-northwesterly wind speeds as increasing in strength from north to south across the ODSVRA. Also, data indicate that there is not much difference in wind conditions at 3m height versus 10m height, so either level can be used to characterize the winds at a specific location.

Using special sensors to detect sand movement, the study also examined the threshold wind speeds necessary to begin sand particle movement and dust emissions. In general, the results showed that on an overall basis, the lowest wind speeds necessary was about 3.7 m/sec, or 8.3 mph averaged over a one-hour period. This varied, however, across the four transects, and within each transect. The observed patterns were varied, with Transect #1 showing an increase in wind speeds needed for sand movement from the shoreline, whereas, Transects #2 and #3 showed the opposite -- a decrease in wind speed from the shoreline. In other words, it was more likely that sand and dust emissions would occur at lower wind speeds near the shoreline at Transect #1, but more likely that sand and dust emissions would occur at lower wind speeds more distant from the shoreline along Transects #2 and #3. No such pattern was observed along Transect #4.

Another focus of this study was to determine PM10 levels along each transect. The results for 10-meter height of wind conditions along each of the four transects is shown in Figure 16. These results are taken from the "C" or third most inland position along each transect, except for Transect #4, for which no data were available for the "C" position. In this one case, the "B" position was used.

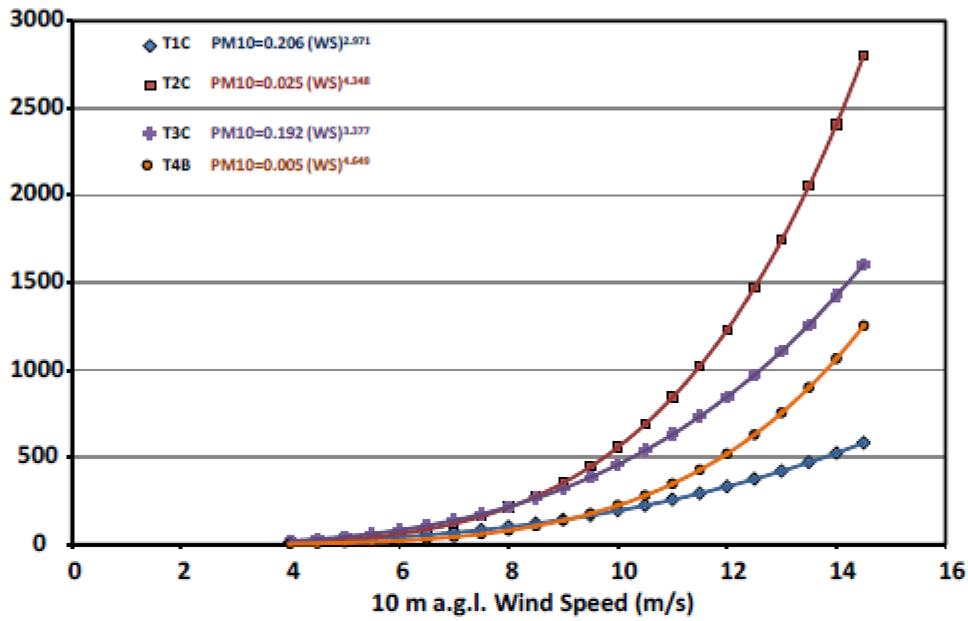

Figure 16. Graphical Plots of Wind vs PM10 Concentrations Along Each of the Four Transects. (The numbers on the left of the graph depict PM10 concentrations in units of micrograms per cubic meter.)

From this plot, it can be seen that the highest concentrations, for wind speeds above 6 m/s (about 13 mph) consistently were along transects 2 and 3 which are the only two transects traversing the riding areas. At the highest wind levels (about 15 m/s or 33 about mph), the PM10 concentrations were between 2500 and 3000 micrograms per cubic meter.

Similar analyses were performed at the SLOAPCD air monitoring sites at CDF and Mesa 2. Results for high PM10 conditions were associated with more northwesterly winds at CDF, presumably due to a turning of the winds progressing inland. There was also correlation of winds throughout the ODSVRA suggesting to the authors that it is "difficult to definitively ascribe a relationship between a source region (i.e., a sub-region of the whole ODSVRA) and a receptor site such as CDF."

2013 Intensive Wind Erodibility Measurements at and Near the Oceano Dunes State Vehicular Recreation Area: Report of Findings (2015)

(Desert Research Institute for the California Department of Parks and Recreation)

In this study, PI-SWERL measurements to determine the emissions potential (emissivity) at various areas within and near the ODSVRA were conducted between August 26 and September 5, 2013. In all, 360 individual PI-SWERL tests were conducted.

For comparative purposes, the study area was divided into six specific regions, as shown in Figure 17 (next page), with three regions in the riding areas, and three regions in the non-riding areas.

Tests were conducted at each location for equivalent wind speeds of 23 mph, 32 mph, and 36 mph. As an example, the plotted results for 23 mph are shown in Figure 18 (next page). As per the legend, the most emissive areas are those shown in the blue and dark green dots; the least emissive areas are shown with orange and yellow dots.

Data were summarized for each of the six regions, and aggregated for the three within the riding areas, and the three within the non-riding areas. The results of the test showed that the PM10 emissions, in units of milligrams per square meter per second (mg/m^2sec), were consistently higher in the riding areas than the non-riding areas. For wind speeds of 23 mph, emissions in the riding areas were 5.2 times higher than the non-riding areas; at 32 mph, the emissions were 4.3 times higher in the riding areas, and at 36 mph, the emissions were 2.4 times higher in the riding areas.

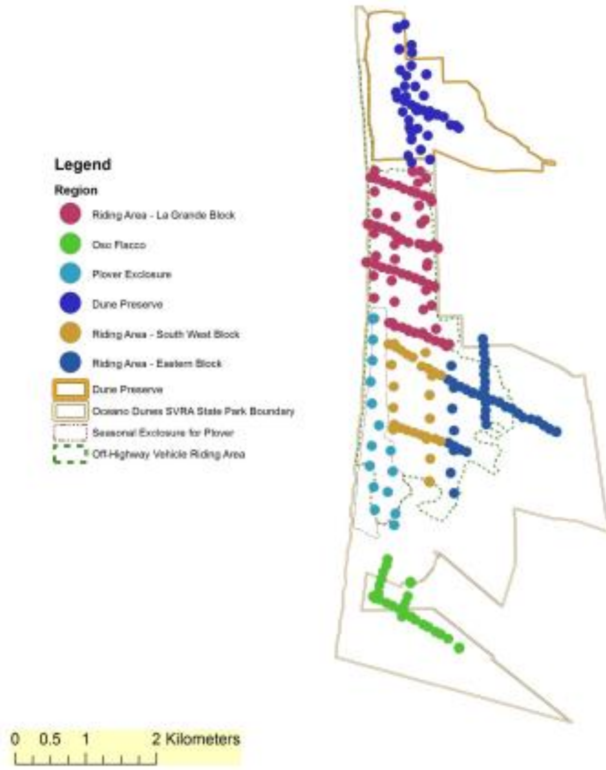

Figure 17. Locations of PI-SWERL Measurements in and Near the ODSVRA Divided into Six Regions

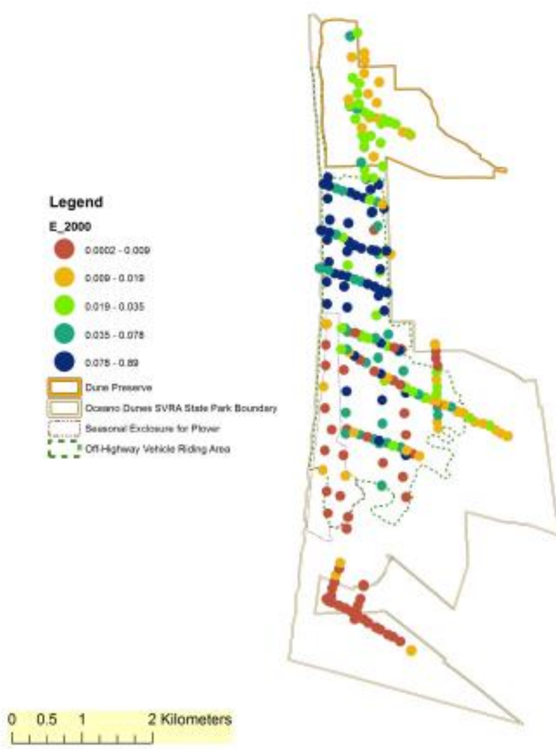

Figure 18. Results of the PI-SWERL PM10 Emissivity Measurements for Equivalent Wind Speeds of 23 MPH.

Looking at Figure 18, the emissivity was greatest within the La Grande Block. Comparing this area to the non-riding areas resulted in emissions 8.1, 5.4, and 2.9 times higher than the non-riding areas for wind speeds of 23 mph, 32 mph, and 36 mph, respectively.

Epilogue

Presented in this White Paper are concise summaries of each of six very detailed scientific reports. The summaries are presented in a form that purposefully minimizes scientific terminologies and complex data depictions to the degree feasible for better public understandability. Anyone interested in the details of any or all of these specific reports can download them from the San Luis Obispo County Air Pollution Control District website at www.slocleanair.org.

Also, there is no subjective intent to synthesize the results from these studies, but rather to summarize each as a stand-alone component of the vast extent of research conducted over nearly a decade in the Nipomo Mesa and the ODSVRA.