As requested, MIG has prepared a basic introduction to the geology and dust emissions system at Oceano Dunes SVRA.

**Overview of the Oceano Dunes Dust Emission System**

The Oceano dunes are part of a natural coastal dune system that has existed for tens of thousands of years. The dunes that you see today from the vicinity of Pismo Beach formed approximately 7,000 years ago, but other parts of the dunes that are not visible are much older. Today, the oldest areas of the dunes system are located several miles inland from the Pacific Ocean. In fact, much of the present day Nipomo Mesa, where many new residential and recreational (golf course) facilities have been developed, consists of old sand dune formations.

Active sand dunes around the world are known to be sources of dust and particulate matter, or PM. This dust is released through a physical process - wind passes over a sand dune and causes sand grains to move. The movement of the sand grains in turn releases smaller dust particles. These dust particles are then carried away by the wind. Without this process, which is called saltation, there would be no sand dunes as we know them in the world today. On a basic level, the total amount of dust that could be released from a sand dune system depends on the total size of the dune system. But several key factors influence the amount of dust that is actually emitted by a sand dune. These include:

1) **How strong is the wind that passes over the sand dunes?** This is important because stronger winds have more energy and can move larger sand grains.

2) **How big are the sand particles that are exposed to the wind?** This is important because smaller sand grains are lighter and require less energy to move while larger sand grains are heavier and require more energy to move.

3) **How much surface coverage is there?** This is important because surface coverage such as vegetation absorbs the wind's energy and blocks the wind from passing over the surface of the dune, preventing dust from being generated.

In addition, the Oceano dunes are unique because there is a fourth factor that influences the amount of dust that is emitted from the Oceano dunes system: human activity. Obviously, this includes the off-highway vehicle (OHV) activity that takes place within the Oceano Dunes SVRA, but human activities at the dunes
Introduction to Oceano Dunes SVRA Geology and Dust Emission System
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also include ecosystem management, including historical vegetation planting activities and the introduction of invasive exotic weed species that alter the physical habitat of the dunes and can increase vegetation density.

**Evaluating Dust Levels at Oceano Dunes SVRA**

The simplest way to answer what effect OHV recreation has on sand movement and dust generation at Oceano dunes would be to compare the amount of dust generated at the Oceano dunes today against the amount of dust generated at the Oceano dunes before OHV recreation began. Unfortunately, there are no historical measurements of the dust emissions that occurred before OHV activity and human management of the Oceano dunes started. The resources at Oceano dunes have long attracted humans to the dune system for sustenance, rest, relaxation, and recreation, and it is known that vehicles have been recreating near Pismo Beach and Oceano Dunes SVRA for more than 100 years. Over time, the area where vehicles can be driven has gotten smaller, and there has been no expansion or substantial change to the Oceano Dunes SVRA open riding and camping area for more than 30 years. Although there are no historical dust measurements that predate modern human activity on the dunes, journal entries from the 1800’s recorded high dust levels in the area, and the presence of eucalyptus rows may be an indicator of a desire to shelter structures and people from the wind.

The San Luis Obispo County Air Pollution Control District (SLOAPCD), the Off-Highway Motor Vehicle Recreation (OHMVR) Division, the California Air Resources Board (CARB), and other experts in the field of dune systems and dune dust generation, including researchers from the University of California and the University of Nevada’s Desert Research Institute, have undertaken multiple studies to determine what effect OHV recreation has on the dust emissions at the Oceano dunes. The 2007 Nipomo Mesa Particulate Study (Phase 1) and 2010 South County Phase 2 Particulate Study essentially addressed where the dust that is measured on the Nipomo Mesa comes from. The Phase 1 Study generally evaluated wind patterns near the Nipomo Mesa, PM concentrations on the Mesa, and the composition of the particles measured on the Mesa. The Phase 2 Study more specifically addressed whether OHV recreation played a role in high dust levels measured on the Nipomo Mesa.

The Phase 1 Study found that the single largest contributor to the high levels of PM measured on the Nipomo Mesa is the northwesterly winds that entrain crustal particles upwind from the Mesa and transport them to the Mesa. The Phase 2 Study confirmed this finding and also found that the primary source of the high PM levels measured on the Nipomo Mesa was the open sand sheets in the dune areas of the coast. More specifically, the Phase 2 Study concluded that open sand sheets where OHV activity occurs emit significantly greater amounts of particles than open sand sheets where OHV activity does not occur.

Although the Phase 1 and Phase 2 studies increased understanding of where dust emissions are generated from within Oceano Dunes, they did not answer why dust emissions vary between sand sheets where OHV activities do and do not occur. The reports inferred that the difference in emissions was due to OHV activity;
however, neither the Phase 1 Study nor the Phase 2 Study found a direct relationship between OHV activity and dust emission levels. That is, the studies did not conclude that vehicle exhaust and sand that is lifted into the air by tires is a substantial contributor to high dust levels. Rather, the key finding of the Phase 2 Study was that OHV activity stops vegetation from growing, destabilizes dune structure, and destroys the “natural crust” that would otherwise form on the dune surface, all of which indirectly increases the ability of winds to entrain sand particles from the dunes and carry them to the Mesa.

The OHMVR Division has conducted field studies almost every year since the SLOAPCD Board received and filed the Phase 2 Study in 2010. These follow-up studies have measured wind, saltation, and dust patterns closer to the dunes and have confirmed some of the findings of the Phase 1 and Phase 2 studies while contradicting other findings, such as the presumption that the wind patterns that persist at Oceano Dunes SVRA are uniform and consistent with patterns measured several miles inland (see Determining the Amount of Dust Generated by OHV Activities).

**Determining the Amount of Dust Generated by OHV Activities**

The foundation of Rule 1001 is the siting and operation of APCO-approved PM10 monitors that measure the 24-hour average PM10 concentrations directly downwind of areas where OHV activity is and is not (i.e., a Control Site) permitted. Rule 1001 does not explicitly define the term “Control Site”; however, the Control Site concept is articulated in Rule 1001, Section B.7 (emphasis added):

> “B.7. “Control Site Monitor”: An APCO-approved monitoring site or sites designed to measure the maximum 24-hour average PM10 concentrations directly downwind from a coastal dune area comparable to the CDVAA but where vehicle activity has been prohibited.”

In the vicinity of Oceano Dunes SVRA, there are four main areas where OHV activity is prohibited that could be a suitable Control Site for Rule 1001 purposes. Moving from north to south these are the Pismo Dunes Natural Preserve, the private lands east of the SVRA, the private and public (both state and federal) lands near Oso Flaco Lake, and Rancho Guadalupe Dunes County Park (in Santa Barbara County). The SLOAPCD’s Phase 1 and Phase 2 studies did not thoroughly evaluate any of these areas and as result it was necessary to evaluate the conditions in these areas to determine whether they were comparable to the OHV activity area.

Subsequent studies conducted by the OHMVR Division have more thoroughly evaluated the strength of the wind and the size of the sand grain particles throughout most of the SVRA. The OHMVR Division now knows that Oceano Dunes SVRA is not “the same” in every place, and that the key factors that influence how much dust is emitted change as you move from Oceano in the north to Oso Flaco in the south. For example, the average wind speed increases from north to south, meaning that for the same time of day the strength of the wind is, on average, a bit higher in the south. Furthermore, while the size of the sand grains has a high degree of variability, the data indicate that the areas with high dust emissions are the areas of the dunes where sand begins to move under lower wind conditions,
which also means the sand is smaller in diameter. Together, these wind and particle size patterns, which are independent of OHV activity, may mean that dust emissions are higher in the northern part of Oceano Dunes SVRA (where OHV activity occurs most frequently) because the sand grains are finer and require less wind energy to move and release dust.

The studies conducted to date have significantly increased the OHMVR Division’s understanding of how and where dust emissions are generated within Oceano Dunes SVRA, how the dust is carried by the wind to areas downwind of the SVRA, and what areas should be prioritized for dust emissions control. The studies conducted to date also suggest that OHV activity may play a role in augmenting the dust emission system at Oceano Dunes SVRA. But, despite the numerous studies, it is still not possible to state how much of the dust is from natural sources and how much of the dust is man-made. This frustrating truth is the result of two facts:

1) **The Oceano dunes dust emission system is not the same everywhere.** The differences in average wind speed and sand grain size, along with varying amounts of vegetation in different parts of Oceano Dunes SVRA and its vicinity, make it difficult to find an “apples to apples” comparison of dust levels between areas where OHV activity is and is not allowed. In other words, after years of study, it has been determined there no areas that are clearly comparable in all important aspects except OHV activity. The comparison that needs to be made is between an OHV area and a non-OHV area that has the same size sand and is subject to the same wind patterns. Unfortunately, this condition does not exist at or near Oceano Dunes SVRA.

2) **The non-OHV areas at the Oceano dunes are not in a “natural” condition.** The presence and density of surface or vegetation cover is a very critical aspect of any dune system because surface cover arrests sand movement and reduces the amount wind energy that reaches the surface, causing sand to move and dust to be released. Humans have changed the “natural” condition of Oceano Dunes in other ways besides recreation. Today, non-native and invasive plant species persist throughout the dunes, and are the dominant vegetation type in some areas of the dunes, such as the Pismo Dunes Natural Preserve. This non-native vegetation grows at a higher density than native vegetation, altering dune systems. The OHMVR Division also actively manages sand dunes that encroach upon existing infrastructure, houses, and other resources. As a result of human management of the dunes, there is more vegetation within Oceano Dune SVRA now than at any point in at least the last 90 years.

These two facts exacerbate the difficulty of finding areas that are clearly comparable in all important aspects except OHV activity. There is a perception that “natural” sand dunes (i.e., dunes where OHV activity is not allowed), do not emit dust. This is not true. Strong winds cause particles to creep, bounce, and disperse in both OHV and non-OHV areas, including areas where OHV activity has been prohibited for at least 30 years or more; however, less emphasis has been placed to
date on understanding the dust emission system in non-OHV areas. For example, Oceano Dunes SVRA includes more than 500 acres of open sand dunes where OHV activity is prohibited. The emissions from these non-OHV areas have not been studied as thoroughly as the emissions from within the SVRA’s open riding and camping area. Similarly, there are private lands between the SVRA and the Nipomo Mesa that include approximately 250 acres of open sand dunes that are not open to OHV recreation and the emissions from these areas have not been studied at all.

Controlling the Forces that Create the Dunes is a Challenge

Geologic and meteorological conditions pre-dispose parts of coastal southwestern SLO County and northwestern Santa Barbara County to natural dust generation. The region is situated in the Guadalupe-Nipomo Dunes Complex, an approximately 18,000-acre, 18-mile long coastal dune landscape that contains a balance of large open sand areas and vegetated sand dunes. The entire dune system, including the area in which Oceano Dunes SVRA is located, is exposed to frequent and strong winds generally from the northwest (i.e., blowing towards the southeast), especially during the springtime. OHV recreation on the dunes does not interfere with the underlying geologic setting or the wind patterns that led to the creation of the dunes. When strong winds occur, dust is generated from all open sand areas, leading to cumulatively high dust levels. The direct control of OHV recreation will not provide timely relief of high dust levels because such action does not stop the wind from blowing, does not absorb any of the wind’s energy, and does not provide any clear threshold for what constitutes natural background dust levels.

Regardless of the source of the sand and dust, when strong winds occur from the west, the sand on the beach and dunes begins to move and dust is emitted in levels that can approach or exceed the state and federal ambient air quality standards at monitoring stations and populated areas on the Nipomo Mesa. The OHMVR has expended considerable resources to implement reasonable controls in “hot spot” areas. While there is strong evidence that dust control projects implemented to date have been locally successful at reducing the amount of sand moving in the dunes, the downwind effect on measured dust levels is less clear. One reason for this may be the scale of the overall dust emission system. The OHMVR Division manages thousands of acres of land within the SVRA and the open riding and camping area is 2.3 square miles in size. Even with implementation reasonable controls of current hot spots, there would remain a large amount of lower-emitting areas that would release dust. A second reason is that the amount of sand moving during high wind events has been massive enough to overwhelm a portion of the engineered dust control measures installed at Oceano Dunes SVRA to date. For example, several rows of four-foot high wind fences (installed approximately 0.5 miles from the ocean and thousands of straw bales (installed more than 1 mile from the ocean) were buried in sand in as little as one or two wind events.

The measurement and control of dust from an active coastal dune setting on the scale required by Rule 1001 is unprecedented and will require a substantial investment of materials, staff, and economic resources by the OHMVR Division, as
well as significant coordination with other government agencies. There is strong concurrence from the OHMVR Division, SLOAPCD, and CARB to plant vegetation as the primary form of dust control. The OHMVR Division will continue to employ an adaptive management approach to dust control that uses resources in the most efficient manner possible by assessing existing conditions, prioritizing dust control measures, and monitoring their effectiveness. But the size and scale of the Oceano dunes system is such that it poses numerous economic, technical, and logistical challenges to all parties involved that will continue to take time to solve.

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