08-30-2023

Memo

To: California State Parks OHV Division and Oceano Dunes State Vehicular Recreation Area

From: Desert Research Institute

RE: Requested Reviews of SAG Excess Emissions Memo and APCD's Response Memo to SAG Excess Emissions Memo

As requested by California State Parks OHV Division and Oceano Dunes State Vehicular Recreation Area DRI personnel (Gillies, Etyemezian, and Mejia) provide comments to Parks based on review and discussions of the SAG Excess Emissions Framework (EEF) Memo and APCD's Response Memo to aid in their response document to both memos.

SAG Excess Emission Memo

Underlying Emissivity Grid

DRI notes that the first pre-disturbance scenario emissivity grid was developed by the SAG and represented at the time their judgement to be the best scientifically defensible approach to generating a reasonable approximation of the pre-disturbance emissivity conditions. For this grid the SAG recommended that all the years of PI-SWERL emissivity data collected in non-riding area should be pooled to generate emission relations that were extended into representative zones for the areas that lie within the riding area. The utilization of multiple years of data are also proposed for the developing excess emission framework, which DRI supports. DRI suggests that additional consideration be given to developing a methodological approach that in some way normalizes the measurements from different years to one selected year, either 2019 or 2013, for the pre-disturbance and current year scenarios. The database of emissivity could also be updated as new PI-SWERL emissivity data are collected.

DRI suggests that one way to build confidence in the model results could be to carry out a sensitivity analysis that seeks to understand how the different years of data or different spatial amalgamations of data effect the parameters of the regression derived emissivity factors and ultimately the total mass emissions estimates for either the current year or pre-disturbance conditions.

Spatial Sub-Division (Zones and Sub-regions) for Current Conditions (2023 and beyond)

DRI is in general agreement that zonation of the ODSVRA with emissivity relations based on pooled or amalgamated data, whether using the polygons proposed by the SAG or some other polygon configuration provides a good approach to modeling total emission estimates. This approach, however, loses some of the fidelity of the interpolated-extrapolated emission grid currently used to identify potential areas for dust control using the Lagrangian Particle Dispersion model. Moving to having zones of equal emissivity the Lagrangian Particle Dispersion model will be able to identify which 20 m grid cells are the most frequent sources areas to contribute to a receptor site such as CDF or Mesa2, but as the emissivity of each grid cell in a zone is equivalent, the model cannot discern which sub-areas of the zone influence the contributions of PM10 to a receptor site due to their being of potentially higher emissivity. Location and emissivity information are used to identify areas for potential mitigation actions in the interpolated/extrapolated emission grid approach, but the more finely detailed mapping of emissivity potential is not available in the zonal emission model so the identification of areas for potential control will have somewhat less certainty.

Spatial Sub-Division (Zones and Sub-regions)

DRI suggests that, and as the APCD has noted as well, further consideration be given to examining emissivity gradients in the west to east direction. As mean particle diameter likely decreases from west to east due to sorting and fining processes, data from 2013 suggest emissivity will increase as particle diameter decreases.

Emissivity Relations

DRI recommends additional discussion on the choice between using median values or mean values of sets of emissivity data from PI-SWERL. DRI recognizes that the median value is more mathematically stable than the mean, but does this compromise the emissivity relations by not taking into account the values on the high tail of the distribution that generate high emissions for high values of u_*? Said another way, which approach better captures the magnitude of the emission process as opposed to meeting statistical rigor criteria related to non-normal distributions of values (see further discussion below in comments to the APCD memo)? If the median value approach is chosen, refinement of the DRI emission/dispersion model will be required as the model values need to closely approximate the measured values to inform management and determination of a condition of excess emissions.

Regardless of the aggregation of the PI-SWERL data to generate zonal emissivity relations, the curve-fitting or least squared regression method needs to be standardized (i.e., use only the algorithm associated with a specific software package).

<u>APCD Response Memo to SAG Excess Emission Memo</u>

Threshold Wind Speed

As currently implemented in the DRI Emission/Dispersion model, threshold wind speed is spatially variable based on the land use classification for the ODSVRA as defined in Table 3 in Mejia et al. (2019). Threshold wind speeds were derived from PI-SWERL tests carried out in 2013 and the identified threshold friction velocity (u_* m s^{-1}) was converted to a 10 m above ground level wind speed using the "law of the wall" and an assumed aerodynamic roughness length (z_0, m) for a typical sand surface.

For the EEF, DRI acknowledges that a threshold wind speed is a necessary parameter in the model that needs to be defined. DRI suggests that either a single threshold wind speed value for the entire ODSVRA or a spatially changing threshold wind speed as is currently used in the model are both viable options. Adoption of a different method to prescribe threshold wind speed is also a viable option if a rationale for this change is explained. The refinement of the threshold wind speed as used in the model is, in DRI's opinion, not a critical issue that will have a significant effect on model predictions that will influence management decisions or impact the decision to evaluate the condition of excess emissions.

Sampling Bias

DRI recognizes that the PI-SWERL sampling grid that developed through the years is not ideal for establishing spatial and temporal trends in emissivity. The identified shortcoming is, however, revealed only in hindsight. In 2013, the use of the PI-SWERL was not unambiguously supported by the APCD, nor was there at the time any discussion that this would likely still be an ongoing activity 10 years later and PI-SWERL campaigns, subsequent to 2013, needed to be designed to define temporal and spatial trends in emissivity 10 years hence to inform an Excess Emission framework. Following the 2013 measurement campaign, the APCD openly questioned the need for any more PI-SWERL emissivity measurements. Through the last 10 years, DRI's sampling methodology was designed to revisit the 2013 measurement locations in their entirety (e.g., 2019) or sub-sampling the grid with a sufficient number of test locations to provide sufficient coverage to compare mean emissivity values. In some years specific areas of the ODSVRA were measured in an attempt to provide emissivity data to identify potential spatial pattern in emissivity, e.g., the rate of change in emissivity crossing the riding/nonriding area transition.

To fully define the spatial and temporal variability of emissivity at the ODSVRA was not logistically feasible with the resources available from 2013-2022. Moving forward, DRI can adopt a sampling strategy that can help to resolve questions of spatial and temporal variability with guidance from Parks, the SAG and the APCD, but the logistical and cost constraints will still have to be considered. The dust emission system of the Oceano Dunes changes on a seasonal basis due to changing environmental conditions, in response to OHV activity, and potentially over longer-term trends related to climate variability. Given that it is not stationary on multiple timescales DRI does not feel that it is feasible to fully-define the spatial and temporal variability of this dust emissions system.

Specific to the APCD's memo

Additional PE measurements

SAG provided a rationale for not including earlier PE measurements, i.e., while it was in its seasonal use phase. DRI supports having further discussions on the best method to characterize the PE in its current or future state.

Campaign-Weighted Medians

DRI concurs that median values are a more numerically stable measure of emissivity than mean values, but we are not yet convinced it is physically legitimate in the case of characterizing the dust emission potential of the ODSVRA surfaces. This may be especially the case for an emissions distribution that does not seem to follow a well characterized statistical distribution. Consider, as an example, that you wish to estimate the passenger weight load of a 4-seater airplane in order to calculate fuel needs. Say that a colleague measures the weights of the four passengers and they are 80 lbs, 90 lbs, 130, and 220 lbs (520 lbs total). If they convey to you that the mean weight of the four passengers is 130 lbs, then you would know that the full load is 520 lbs. If they convey that the median weight of the four passengers is 110 lbs, you would be off if you assume that the full load is 4 X 110 = 440 lbs. The same situation can arise for emissions. This is not to say that the idea of using medians is not valid, but only that the ramifications need to be explored in greater depth before adopting it.

DRI agrees that pooling of the available PI-SWERL emissivity data from the different years to characterize, for example, zones of emissivity does need consideration. The mean or median values would be biased towards campaigns with a greater number of samples. The estimation of more robust median values that reduce the bias can be done by, for example, artificially increasing the number of samples in each year to a common value by replicating the available data until the number of samples is equivalent in each year. For example, if year 1 had 20 emissivity measurements, year 2 had 10, and year

3 had 5, the 10 values in year would be replicated once and in year three the five values would be replicated three times (See Table 1).

Table 1. Effect of pooling unequal and equal numbers of tests on median emissivity for PI-SWERL emissivity values for 3500 RPM. Red values indicate the original values being replicated to match the total number of samples collected in Year 1.

Emissivity (mg m^{-2} s^{-1}) at 3500 RPM		
Yr 1	Yr 2	Yr 3
1.389	1.813	1.159
1.783	2.204	0.84
2.557	2.207	1.11
1.344	1.159	0.673
1.813	0.84	0.737
2.204	1.11	1.159
2.207	0.673	0.84
1.159	0.737	1.11
0.84	2.079	0.673
1.11	1.131	0.737
0.673	1.813	1.159
0.737	2.204	0.84
2.079	2.207	1.11
1.131	1.159	0.673
0.755	0.84	0.737
1.508	1.11	1.159
2.008	0.673	0.84
1.741	0.737	1.11
2.168	2.079	0.673
1.17	1.131	0.737

Pooled Data	Median Emissivity (mg m^{-2} s^{-1}) at 3500 RPM
Yr1, Yr2, Yr3 (unequal # tests)	1.159
Yr1, Yr2, Yr3 (equal 3 tests)	1.131

An approach to retrospectively account for the fact that the physical locations of PI-SWERL tests were not consistent among sampling campaigns would be to use regions of overlapping data to normalize emissions to a common sample period. For example, in Fig. 1 the X measurements were made at an earlier time than the O measurements. So, if we want to compare emissions in Box C to those in Box A, we run the risk that whatever difference we find is due solely to a temporal change in conditions and not representative of a spatial difference. We can use the overlapping measurements in Box B to help with this issue. If (for example) the X measurements in Box B have a mean (or median) value of 2 and the O measurements in Box B have a mean value of 4, then we know that to account for temporal variations, the O measurements must be divided in half in order to account for what might have changed over time from when the X measurements were completed. This relation can now be applied to Box C, where we take the mean of the O measurements and halve them, then compare that value to the mean of the X measurements in Box A. There are some assumptions that are inherent to this approach and it is not immediately clear if all of the data can be “referenced” to a common measurement period in this fashion, but there is reason to expect that in general this could reduce the effect of non-simultaneous sampling in different locations. A more systematic exploration and inventory of overlapping data would need to be completed if this approach is to be considered further.

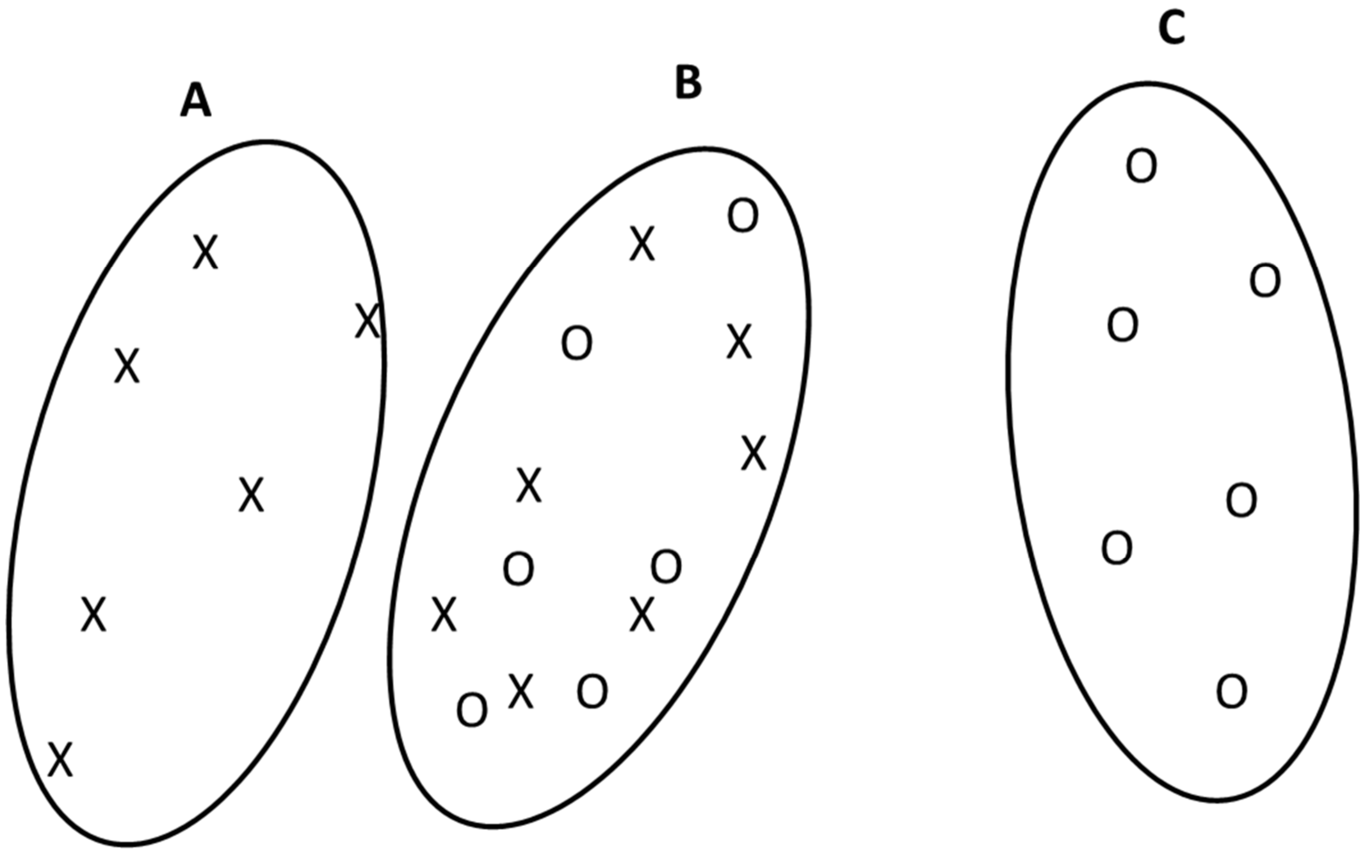

Figure 1. An example of using overlapping data in space to potentially adjust for the temporal difference.

Future Campaigns

DRI agrees with the APCD that future PI-SWERL measurement campaigns can adopt an agreed upon sampling plan that can be used to inform spatial and temporal changes in emissivity. DRI would work with Parks, the SAG, and the APCD to develop an agreed upon sampling strategy.

Emissivity at Recently Closed Areas

The APCD memo includes multiple instances of unsubstantiated claims being presented as alternative to positions put forward by the SAG. Intuition is not a basis for rejection of an alternative position and the APCD requests scientific defensibility for other stakeholders but does not apply this to their own suppositions.

The APCD intuits that the emissivity of, for example, the PE is unlikely to be to be lower in 2022 than it was in a pre-disturbance condition, but this may or may not be the case and is ultimately unknowable, although with some supporting study from the literature perhaps a case could be made. DRI suggests that it may be more appropriate when this much uncertainty of the past conditions exists to consider pooling the 2022 PE, foredune restoration, beach and corridors into the representation of the pre-disturbance emissivity relations, rather than identifying these areas with 2022 emissivity relations to represent past and unknowable conditions.

Emissions at Higher Shear Velocities

DRI recognizes that PI-SWERL generated emissivity curves used in the DRI emission/dispersion model would extrapolate an emission for shear velocity values that exceed the range over which they were developed. Currently the relation is based on the three steps of the PI-SWERL test cycle that reaches a maximum shear velocity value of 0.607 m s^{-1} (at 3500 RPM). This is approximately equivalent to a wind speed of 16 m s^{-1} at 10 m above ground level based on application of the “law of the wall” and an assumption for the aerodynamic roughness length (z_o m) for the sand surface.

As part of the development of the DRI emission and dispersion model (Mejia et al., 2019) initially 60 days between April and September 2013 were modeled using CALMET using all the assumptions presented in Mejia et al. (2019). The frequency of occurrence of hourly shear velocity estimates that exceed 0.607 m s^{-1} for these 60 days is approximately 4% of the total hours, but this does not occur simultaneously and continuously across the spatial (model) domain of the ODSVR. The highest frequency of occurrence of exceedance across the modeling domain is in the southwest area as shown in Figure 2, which corresponds to areas of lower emissivity. DRI can re-examine the hourly shear velocity data for the 10 baseline days to estimate the contribution from emissions when u_* is in excess of 0.607 m s^{-1}.

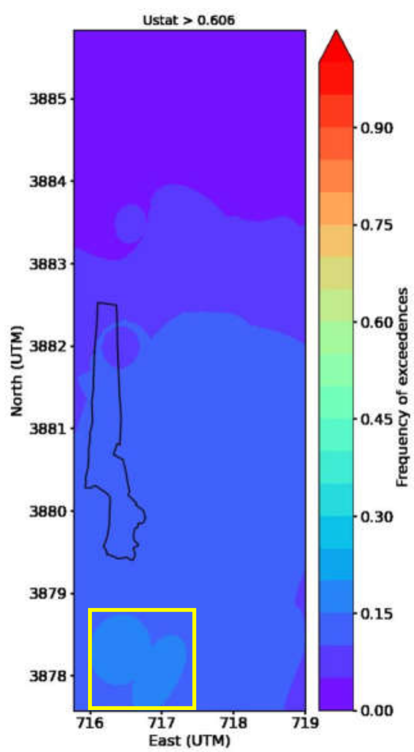

Figure 2. The frequency of exceeding 0.607 m s^{-1} shear velocity across the modeling domain based on 60 days of hourly modeled wind speed. The black outline represents the plover exclosure and the yellow square highlights the area where the shear velocity has the highest frequency to exceed $u_* > 0.607$ m s^{-1}.

The S1 10 m above ground level (AGL) wind speed data from 2010 to 2019 (representing 70,005 hours of validated data) show that at this position within the ODSVRA that the number of hours when wind speed was >15.5 m s^{-1} was 28, which represents 0.04% of the time.

In 2022, for the period April to September the S1 wind speed data had the highest value of total Wind Power Density (the summation of hourly wind speed for all hours when the corresponding hours wind speed at CDF or Mesa2 was ≥3.5 m s^{-1} [corresponding to approximately 8.5 m s^{-1} at S1 tower] and filtered for wind direction range 248° to 326°) compared with the same period for the years 2011 to 2021. During this period (April-Sept) in 2022 there were no hours that exceeded 16 m s^{-1} at the S1 tower. (See Increments of Progress 2022 Report).

These data suggest that the occurrence of wind speeds in excess of 16 m s^{-1} is infrequent at the ODSVRA and available wind speed data from the S1 tower from 2011 to 2013 were used initially to help define the upper limit of testing for the PI-SWERL as higher shear velocities (or RPM values >3500) were initially observed in 2013 to over-range the PM10 sensor in the PI-SWERL for some surfaces. DRI, at the time, considered it more valuable to have valid tests for estimating emissivity relations for a range of shear velocity that could likely be expected at the ODSVRA than having fewer valid tests completed due to over-ranging the PM10 sensors. DRI had to consider balancing the need for obtaining valid data in the time allotted against trying to have a wider range of shear velocities but having fewer valid tests at the same cost.

DRI feels that the likelihood of hourly wind speed estimates exceeding 16 m s^{-1}, and biasing the emission estimates from the DRI emission and dispersion model are limited. DRI is of course open to discussions on how to best deal with this issue.

DRI suggests that moving to a percent cover of vegetation effect to modulate emissions in sparsely vegetated areas, as the APCD suggests, is not advised as % cover is not the attribute of vegetation that most influences emissions. The literature suggests other metrics to describe the effect of vegetation on wind erosion and dust emission are more appropriate, but they require more information on the physical characteristics of the vegetation. Acquiring the necessary data to better characterize the role of vegetation to modulate emissions does not, in DRI's opinion, warrant the effort given all the other and perhaps larger uncertainties we are dealing with.

The APCD assumes it is not reasonable that non-riding areas may, at high shear velocities, become more emissive than riding areas, but this statement is not supported by any data or references in the literature. It is not impossible that this could occur and there are currently no data to support either position, i.e., it is or is not possible.

DRI acknowledges that the APCD's observation on curve fitting and the estimation of regression-derived parameters from different software algorithms is an important point. DRI has consistently used EXCEL for deriving the parameters for the emissivity relation, so that has remained consistent through the years, but recent analysis by the SAG, and as noted in the APCD memo, show different software algorithms give different parameter estimates. DRI suggests that an agreed upon regression method and software package should become standardized for estimating relations between emissions (mg m^{-2} s^{-1}) and u_* (m s^{-1}).

Conclusions

DRI does not agree with the APCD that higher emissivity of the sand in the pre-disturbance scenario defies common understanding. As there are no measurements from 1939, but there are from 2022, although these are limited, they are "real". The PI-SWERL is measuring the emissivity of the sand, not the emission from the vegetated areas, which are then modulated in the model by vegetation if present.

The APCD's statement on erring on the side of public health and potentially rejecting reasoned scientific debate or objectivity brings into question the process that has been developed as framed by the SOA and the role of the SAG to provide defensible-science based information for management and quantification of the effects of dust management on air quality and for evaluating Parks efforts to meet the SOA.