GALATI | BLEK LLP

455 Capitol Mall Suite 350
Sacramento CA 95814
Tel • 916.441.6575
Fax • 916.441.6553

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Enclosed for filing with the California Energy Commission is the electronic version of **PALEN SOLAR HOLDINGS, LLC'S FINAL SAND TRANSPORT STUDY**, for Palen Solar Electric Generating System (09-AFC-7C).

Sincerely,

Marie Fleming

SAND TRANSPORT IN AND ADJACENT TO THE PALEN SOLAR ELECTRIC GENERATION SYSTEM (PSEGS) PROJECT AREA – A RE-EXAMINATION OF POTENTIAL EFFECTS OF FACILITY CONSTRUCTION AND OPERATION

Fred L. Nials
P.O. Box 1005
Laveen, Arizona
fnials@earthlink.net

Geoarchaeological Consultant to
Centerline

INTRODUCTION

A solar generation facility (PSEGS) has been proposed for the Chuckwalla Valley, Riverside County, southern California. The anticipated project footprint is situated on the Corn Springs alluvial fan (Figure 1), near the Sonoran Desert/Mojave Desert border in the Great Basin physiographic province. Distal portions of this fan coincide with a major sand transport corridor (Figure 2), the Chuckwalla Sand Corridor (CSC), in which sand from various sources is transported downwind, generally to the southeast. The sand corridor is resource-rich relative to other parts of the fan, and the majority of prehistoric archaeological sites are located in and near aeolian deposits in the corridor. In addition, corridor sands in some areas in and near the proposed project footprint provide suitable habitat for the Mojave Fringe-Toed Lizard (MFTL).

Collison, et al. (2010), in a study related to the then-proposed Palen Solar Power Project, analyzed eight earlier iterations of the proposed project in relation to parts of the CSC. For facility of discussion, that study is hereafter referred to simply as the Collison model. The Collison model concluded that construction of the facility would have serious effects on natural sand entrainment, transport, and deposition processes that would impact MFTL habitat.

The Collison model is a valuable attempt to predict and quantify sand movement, but did not incorporate significant natural variables, and did not recognize that dunes and aeolian deposits in that portion of the corridor adjacent to the PSEGS appear to be in an on-going state of degradation due to a variety of off-site natural and human-related processes and features. Since completion of the model, the Palen solar generation project has been significantly revised, and a re-examination of the CSC leads to the conclusion that revisions to facility footprint location, modifications to facility design, and pre-existing conditions and processes not considered render the model no longer applicable to the proposed facility. Pertinent information leading to this conclusion is the subject of this report.

The primary objectives of this discussion are to:

- Briefly describe the existing CSC system
- Discuss the dynamic nature of the distribution and character of aeolian deposits in the CSC, including recent changes in sand distribution and environmental factors that influence dune equilibrium

- Discuss the parameters of the Collison model analysis, and why the modeled conclusions no longer apply
- Discuss, in subjective terms, potential impacts of the proposed PSEGS project on the existing CSC

EXISTING CHUCKWALLA SAND CORRIDOR

The sand transport corridor, initially identified by Zimbleman, et al. (1995), was first called the Clark's Pass sand path. Parts of the corridor have been described in varying detail since that time by Clarke and Rendell (1998), Muhs, et al. (2003), Kenney (2010), and Collison (2010), among others. Since its initial identification various parts of the corridor have been called other names, with that part of the corridor in Chuckwalla Valley most recently being called the Chuckwalla Sand Corridor (CSC) by Collison, et al. (2010).

As shown in Figure 3, the corridor extends more than 70 miles southeastward from the Dale Lake Valley to the Colorado River valley near Blythe, CA. A portion of the sand eroded from the Dale Lake basin is captured in the Pinto Mountains on the southeastern margin of Dale Lake Basin, but most of the remainder passes through Clark's Pass into Pinto Valley. The corridor loses definition in Pinto Valley, where it is widely deposited on alluvial fan and bajada slopes. Sand deposited in these areas is redistributed by wind and runoff in local drainages, to be eventually concentrated in the Pinto Wash alluvial system in the southeastern end of Pinto Valley. Another portion of the sand is captured in the northern and eastern Eagle Mountains and "temporarily" removed from the transport system, but a combination of aeolian and fluvial processes transports most of the remainder through the Pinto Wash gap between the Eagle Mountains and Coxcomb Mountains to enter Chuckwalla Valley. From there, the corridor basically follows the present and former path of Pinto Wash into and through Chuckwalla Valley. In Chuckwalla Valley, a portion of the sand forms active and semi-stabilized dunes on the bajada south of the Coxcombs, but most reaches the floor of Palen Dry Lake to form a large field of active and semi-stabilized dunes covering more than 25 square miles on the southern part of the playa floor that can be attributed primarily to the Dale Lake/Pinto Valley source. Along the southern margin of Palen Dry Lake (PDL), the CSC impinges on the distal end of Corn Springs alluvial fan and the PSEGS project area. A "tributary" sand corridor, the Palen Valley Corridor (PVC), transports sand southward along the eastern side of PDL and joins the CSC at the southeastern corner of PDL (see Figure 2). The combined corridors continue to follow the poorly-defined former path of Pinto Wash around the south end of the Palen Mountains and into the Ford Dry Lake (FDL) basin, the lowest point in Chuckwalla Valley. A second "tributary" corridor, the Palen-McCoy Valley sand corridor, brings sand southward to join the CSC near the eastern end of FDL (Kenney 2010), and the combined corridors continue eastward to the Mule Mountains and Colorado River Valley.

In the vicinity of Palen Dry Lake and the PSEGS project area, the CSC has been divided into four loosely-defined zones based on the geomorphology of aeolian deposits (Kenney 2010). Each of the zones (I through IV) is characterized by differing magnitudes of aeolian sand transport and each possesses distinctive types of aeolian deposits and duneforms. As defined, Zone I is the most "active", while Zone IV is least active and contains only minor residual aeolian deposits. It should be noted that, while the generalized zones are relatively easily identified on remote imagery, on-ground boundaries between zones are typically gradational and are often difficult to precisely define.

Zone I

Zone I (Figure 4) is the most active of the zones, and is characterized by abundant active transverse and barchanoid dunes, some of which are more than 20 feet high (Figure 5). Kenney notes that many of the dunes exhibit well-defined form, with sharp crests, active leeward-side avalanche faces, and are non- to moderately-vegetated. Most dunes in Zone I are actively migrating in the direction of net prevailing wind. These dunes are generally moving across hard playa deposits, and interdune areas typically expose playa sediments. Kenney (2010) notes that Zone I near the PSEGS represents merging of the Palen Valley sand corridor and Chuckwalla sand corridor (CSC) at the southern end of Palen Dry Lake, and that strong prevailing winds capable of transporting aeolian sand come both from the northwest and the north. No portions of Zone I lie within the boundary of the PSEGS footprint.

Zone II

Zone II (Figure 6) assumes additional importance because sandy deposits in this zone also serve as habitat for MFTL. Zone II consists of several different types of aeolian deposits, but within the PSEGS project area it does not exhibit the actively migrating transverse dunes seen in Zone 1. Active aeolian sand deposits within Zone II along the northern boundary of the project area typically do not exhibit active avalanche faces and are generally moderately to strongly vegetated. Degrading older coppice mounds are common. Kenney (2010) states that active aeolian sand deposits within Zone II are primarily in the form of relatively thin sand sheets (Figure 7) and small active coppice dunes within moderately to strongly vegetated zones. This is also the case in the northeastern portion of the site where relatively thin sand sheets are depositing on older parabolic dunes. Northern parts of Zone II overlap with playa deposits of Palen Dry Lake (see Figure 2), where "islands" of eroded sand sheets and dunes are interspersed with interdune playa deposits (Figure 8). Sand deposits in these areas are generally no more than several feet thick, and usually exhibit no more than 2-3 feet of topographic relief.

Several lines of evidence indicate that Zone II currently receives much less sand than in the past. These include degrading older parabolic dunes deposited during late Pleistocene or early Holocene dune-building events and thin, similarly degrading, middle Holocene (?) relict sand sheets. In many areas of Zone II, there is considerable evidence of erosion of older dunes by wind indicating that Zone II is a source of aeolian sand for downwind parts of the CSC. As expected, small northeast-flowing drainages within Zone III are often locally blocked by both older and modern aeolian deposits near the southern boundary of Zone II, but some drainages pass through Zone II and appear to be eroding through the aeolian sands and transporting the sand to the playa floor.

At the easternmost boundary of the project area, sand-blasted growing vegetation and minor avalanche faces indicated short-term reversals of the prevailing wind direction in June, 2013 (Figure 9).

Zone III

Zone III (Figure 10) is characterized by preserved relict sand sheets, and coppice dune and mound deposits that are strongly vegetated and bioturbated (Kenney 2010). Kenney (2010) also notes "minor isolated areas of loose migrating sand sheets, particularly close to the Zone II/III contact." Collison describes this zone as shallow vegetated sand dunes and less degraded sand sheets with more abundant sand than the dunes in the mid-fan [Zone 4], and vegetation that "transitions from creosote bushes to grasses" (2010: 17). Kenney (2010) dug numerous test pits across the site and found most relict dune deposits to be less than one foot thick. Zone III is also characterized by abundant rodent activity and strong bioturbation of sediments (Kenney 2010, Collison 2010, Nials 2013). Relict aeolian sediments were deposited during an older dune aggradational event that involved a more robust and wider sand migration corridor than exists today.

An interesting point of contrast, however, lies in interpretations of the stability of Zone III. Although all who have described portions of Zone III have observed indications of modern wind-transported sand, Kenney (2010) notes that dunes in this zone are currently degrading, and emphasizes that much of the zone displays northeast-flowing drainages that have eroded into and pass through the relict dune deposits. These drainages also transport relatively minor amounts of sand into Zone III and beyond, some of which is re-deposited by wind. In contrast, Collison (2010) suggests that the dunes of Zone III appear to be in relative equilibrium with sediment losses to deflation matched by deposition of sand from upwind sources. The degree of stability of the zone is important in that it controls the amount of sand available for transport and accumulation in other parts of the CSC.

Zone IV

Most of the PSEGS project area lies within Kenney's (2010) Zone IV. This zone includes mostly mid-fan segments within the footprint and the zone appears to have been dominated by fluvial processes throughout much, if not all, of the Holocene. Minor areas of thin relict aeolian sediments are locally present, however. Some ephemeral fan-surface channels transport sufficient fine and medium sand from uplands and higher fan locations to be a source of aeolian sand for Zone IV following infrequent surface flows, but wind-transported sand from this source is very minor and is insufficient to maintain loose sand deposits (Kenney 2010). The Collison model does not evaluate impacts within Zone IV.

DYNAMIC NATURE OF DISTRIBUTION AND CHARACTER OF AEOLIAN DEPOSITS IN THE CSC

Genesis of Dunes in the CSC

Corridor boundaries and relative quantities of sand transported in the CSC have changed significantly since its initial development, and the dynamic nature of dune deposits dictates that change continues through the present. Within the Mojave and Southwestern areas of the Basin and Range physiographic province, wetter climates prevailing at times during the Pleistocene generated large supplies of fine-grained sediment within regional drainages (Dohrenwend, et al. 1991; Lancaster and Tchakerian, 2003), and resulted in the formation of soils. Wet intervals were followed by drier climates, and pluvial lakes that had formed in some internally-drained basins shrank and desiccated. It was during these drier intervals that winds entrained and moved available sand across the landscape resulting in aggregation and growth of dunes. Soils formed during wetter intervals reduced sand mobilization and dune formation multiple times in the Sheephole Mountains (Smith 1967; Dohrenwend, et al. 1991) during the latter half of the Pleistocene Epoch. Luminescence dating of sand ramps in the Dale Lake-Sheephole Mountains indicate major periods of aeolian deposition between >35 and 25 thousand years ago (kya), and 15-10 kya (Rendell, et al. 1994, Lancaster and Tchakerian 2003). The latter dune aggradational event appears to have occurred near the Pleistocene-Holocene boundary (Dohrenwend, et.al. 1991). A global dry period during the mid-Holocene, the so-called Altithermal (7-5kya) (Antevs 1955; Forman, et al. 2001; Jenny et al. 2002; Fahu et al. 2003; Umbanhowar et al. 2006; An et al. 2006; Jenny et al. 2002), also allowed dune growth in the Mojave Desert region *ca*. 7 to 4 thousand years ago (kya) (Dohrenwend, et al. 1991; Lancaster, 1997). In addition, some dune fields in the Mojave Desert observed dune rejuvenation starting about 400 years ago (Dohrenwend et al. 1991, pg. 246; Lancaster, 1997). In terms of total sand volume, most major southern California dune deposits existing today are considered fossil landforms, as they likely have not actively grown or migrated to a large degree during the late Holocene (Dohrenwend, et al. 1991), and large parts of the CSC and other Mojave regional sand corridors are "stabilized by vegetation and experience little or no eolian activity in present climatic regimes" (Lancaster and Tchakerian, 2003: 231; Bach, 1995).

Variables Influencing Sand Movement in the Chuckwalla Valley

A wide range of variables influence the entrainment, transportation, and deposition of aeolian sand. Many investigators (e.g., Bagnold 1941; Cooke, Warren and Goudie 1993) have described the mechanics of sand movement, but more definitive studies the interplay of variables involved in the movement and growth of some large dune fields and sand corridors are relatively recent innovations (e.g., Lancaster 1997; Lancaster and Baas 1998; Okin and Gillette 2001). Long sand corridors such as the Dale Lake-CVC lend themselves to such studies by their very length and the variety of topographic and environmental settings involved.

Climate is obviously one of the most important variables. Precipitation and temperature drive weathering processes that generate sand as bedrock is broken down into smaller components. These variables also control to a large extent the processes that move (or inhibit movement of) weathering products to lower points in the landscape and sort the particles into sizes that can be moved by wind. Wind velocity and direction of wind flow over sediments amenable to erosion determine the efficacy of aeolian entrainment and transport. The velocity and direction of larger "steering" wind currents responsible for sand corridors are typically influenced by climate patterns and topography, while more localized near-surface wind characteristics are influenced by topography and vegetation. Climate obviously varies through time and climate change can may alter aeolian processes and landforms. Shorter-term weather patterns may also assume similar importance at both local and regional levels. Because climate and weather are dynamic, as are the environmental responses to changes in either, aeolian deposits and processes are subject to both long- and short-term changes in stability and movement. A major weakness in any analysis of aeolian activity in the PSEGS footprint area is the lack of long-term local weather data.

The growth and stability of particular types of aeolian deposits are controlled by the supply of available sand, surface conditions, vegetation, and the duration, direction, and intensity of wind. Aeolian deposits and the processes responsible for their accumulation or destruction are thus dependent on multiple regional and local variables; changes in any one of the variables can completely alter the processes and products of movement of sand by wind.

As noted above, most sand movement in the CSC occurred during the Pleistocene more than 10,000 years ago. Massive sand deposits in Clark's Pass, at the base of the Coxcomb Mountains, and in many other locations along the greater CSC are highly dissected, giving testament that the relative efficiencies of aeolian and fluvial processes have reversed during the Holocene. At a level more local to the PSEGS, fluvial erosion also now prevails over aeolian accumulation in some parts of the corridor, particularly in Zone III (Fig. 11). Aeolian deposits in some parts of the CSC within the PSEGS footprint are now being consumed by fluvial erosion concentrated along ephemeral channel originating in higher parts of the fan. Sand appears to have covered much larger areas of the Corn Springs Wash alluvial fan in the past (Collison, et al. 2010) than at present, further evidence of the diminishment of modern sand supply and the prevalence of fluvial processes in upper and mid-parts of the fan.

Most sand dunes in southeastern California are/were produced by sand moving east to southeast associated with weather fronts originating in the Pacific Ocean. However, this migration is also altered by topographic controls on wind when channeled along mountain fronts and within valleys (Laity, 1987). Although wind data from some parts of the region indicate that strong summer monsoonal winds from the south do occur, they apparently do not play a large role in terms of sand transport in the project area during most years. Dune morphology shown in historic imagery provides the most conclusive evidence of longer-term wind directions and <u>net</u> sand movement, and emphasizes the role of topography in influencing wind direction. Measurements of aeolian landforms within approximately 1 mile of the northern project boundary indicate net sand movement in a 135˚ - 142˚ azimuth (South 45˚- 52˚ East). The important point of this discussion, however, is that the relative distributions and quantities of sand transported in the CSC have changed through time, and are likely to change in the future as climate changes. The distributions of resources associated with the sand corridor, including vegetation, MFLT, and various sand-dependent rodents have also changed with the distribution of sand, and will continue to do so as a part of the evolution of local environments.

THE COLLISON MODEL

Collison et al. (2010) considered eight earlier configurations of the Palen Solar Power Project proposed at the time of their study (Solar Millennium 2009a) and came to the following conclusions:

> "The Proposed Project is located close to or inside of a major sand transport corridor identified by Muhs et al. (2003), referred to as the Chuckwalla sand corridor.…. Sand delivered from upwind passes through dune areas including MFTL habitat and is deposited, replenishing sand that has been lost downwind. In addition to the obvious biological impact of constructing a project in a dune area

> (direct loss of habitat), construction activities have two potential offsite impacts on sand transport corridors. Firstly, if the project footprint is constructed in a dune area it will cut off a supply of sand that would otherwise have been transported downwind to other dune areas. Dunes downwind of a constructed site will deflate over time as sand output is not matched by sand input. Secondly, new sand that would have been transported across the project footprint from upwind will potentially be cut off by drainage ditches, wind fences and above ground infrastructure. Thus, if a project is built into a wind corridor it will create a 'sand shadow' area where dune deflation occurs over time" Collison, et al. (2010:8).

Some of the eight site locations and facility configurations considered at the time of his study intruded into the CSC by more than a mile, cutting its width in half; the model concluded that the facility would create a "sand shadow" downwind, in which sand would be deflated with the result that MFTL habitat would be degraded or destroyed. The total direct impacts modeled for the eight configurations varied from 51 to 1,120 acres, and combined direct and indirect impacts ranged from 201 to more than 2,270 acres. Figures 12, 13, and 14 exhibit three typical iterations of the model, showing locations and modeled amounts of deflation anticipated to be caused by construction of the facility.

Changes in Footprint Location, Technology, and Design
As noted above, a number of aspects of the Collison model and its conclusions no longer apply to the re-designed PSEGS project. Features of previously-proposed site locations, design, and technology that no longer apply include:

- The original facility footprint configuration has re-designed to minimize intrusion into the sand transport zone and to minimize impact on aeolian processes inherent in the Collison model. While the northern boundary does still intrude into the sand transport corridor (CSC), its width has been significantly reduced, and the orientation of the boundary fence has been modified to the extent possible to approximately parallel prevailing wind direction. The northern facility boundary has been further modified to the extent possible in order to minimize boundary irregularities within the CSC that could act as sand traps.

- The Collison model was based on solar trough technology using reflectors within the CSC oriented at steep angles to prevailing wind direction. The revised PSEGS design replaces solar trough technology with two 750-feet tall towers surrounded by concentrically-arranged heliostats. In most areas where heliostats intrude into the CSC, the orientation is such that the long axis of the heliostat is parallel or shallowly oblique to prevailing wind direction, further minimizing wind resistance and turbulence. Exceptions to this generalization are discussed below.

- The Collison model assumes significant grading of the project footprint. This has been modified to limited grading in most of the footprint, with the exceptions of a perimeter road and the minimum number possible on-site roads within the perimeter. Vegetation will not be eradicated, but will be mowed to a height of 18-24 inches.

- The model asserts that new sand that would have been transported across the project footprint from the upwind direction will potentially be cut off by drainage ditches. There are no drainage ditches in the proposed PSEGS footprint.

- The Collison model correctly states that if a project is built into a wind corridor it will create a ‘sand shadow’ area where dune deflation occurs over time. His model, however, assumes “a perimeter sand fence that is 30 feet high and that is designed to stop sand from entering the solar array” (2010: 21). Such a fence could exert a significant localized wind-steering effect in addition to sand deprivation. He cites (2010: 8) several studies that showed that downwind sand dunes experienced deflation and surface coarsening within 4-17 years of the erection of a “relatively small wind barrier” consisting of a single row of tamarisk trees. As shown in Figure 15 and described in text below, however, his model ignores existing date palm orchards and fields upwind from the PSEGS footprint area. These agricultural features constitute a more effective wind barrier than a single row of tamarisk trees.

- Modeled effects of the fence no longer apply, for the boundary fence has been re-designed to a configuration composed of an 18-inch tortoise fence surmounted by a 7-foot chain link fence that is significantly more permeable to wind than the original 30-feet design and that will exert less “steering effect” on winds. The re-designed perimeter fence will still present some interference to wind velocity, causing deposition of some sand on both upwind and downwind sides of the fence (Figure 2), particularly if the fence is not maintained and cleared of wind-blown debris. In addition, long fence segments situated in the most active parts of the CSC have been redesigned to minimize corners and parallel prevailing winds.

- A major weakness in <u>any</u> analysis of aeolian activity and MFTL habitat in the PSEGS footprint area is the lack of long-term local weather data. The Collison, et al. model is primarily based on short-term observations, and the few longer-term wind records in his model are from as far away as Blythe, where wind patterns are significantly different. It must be pointed out that observations of dune activity described herein suffer the same limitations. Insofar as possible, we have attempted to base interpretations of long-term trends in sand movement and dune activity in this report on the distribution and morphology of larger aeolian landforms that are relatively less sensitive to high-frequency weather phenomena.

Pre-existing Conditions Not Considered in the Collison Model

In addition to aspects of re-designed facility location, design, and technology that bring into question the Collison model conclusions, a number of other pre-existing conditions appear not to have been accounted for in the model.

- The CSC was largely deposited during the Pleistocene, under climate conditions significantly different than exist today. Sand deposits in large areas of the corridor have been dissected by fluvial erosion and/or no longer supply or transport previous quantities of sand through the corridor (e.g., Clark’s Pass area, south side of Coxcomb Mts.).

- Comparison of historic imagery suggests that aeolian landforms (sand sheets, coppice accumulations, relict dunes, active dunes) in those portions of the CSC in and adjacent to the proposed PSEGS are <u>not</u> in a general state of equilibrium as suggested by Collison, et al. (2010). Relict patches of aeolian accumulations in Zones II, III, and IV attest to the fact that sand was more extensive in the past than at present.

    - Re-direction of natural fan-surface drainage by I-10 construction-related features has led to the fluvial erosion and degradation of part of the corridor suitable for MFLT habitat in and adjacent to the proposed PSEGS footprint.

    - Pre-existing agricultural features (date orchards, fields, windbreaks) are upwind from, and some immediately adjacent to, the proposed PSEGS footprint. These features, not considered in the Collison model, are situated in parts of the CSC, and create an equally effective wind barrier and sand trap as the proposed facility.

    - Similar agricultural features for a distance of 10 miles and more upwind from the proposed PSEGS footprint have already deprived large portions of the CSC of part of its sand supply.

    - Pinto Wash formerly supplied and re-distributed large amounts of sand to the eastern side of Palen Dry Lake basin. This ephemeral stream has essentially ceased to be a significant factor in sand transport. Drought conditions and groundwater pumping for agricultural purposes in the western side of Chuckwalla Valley is probably a factor.

    - In many areas of Zone II, there is evidence of deflation of older dune deposits. In and near the corridor dune tops are eroding, but sand is accumulating in vegetation-stabilized depressions between dunes. As a result, dunes are degrading and the quantity of sand being transported is diminished. Kenney (2010) notes that active aeolian sand deposits within Zone II (along portions of the northeastern perimeter fence) typically do not exhibit active avalanche faces and are generally moderately to strongly vegetated. In addition, there are abundant older degrading coppice dunes within Zone II.

- Collison, et al. (2010) recognizes that the CSC is a dynamic assemblage of landforms, and that it has undergone major changes in distribution with climate and weather variations during and since the Pleistocene. This fact has not been incorporated into understanding of MFTL ethology. The corridor has undergone major and minor changes through time; it is likely that MFTL distribution has similarly changed through time.

POTENTIAL IMPACTS OF THE RE-DESIGNED PSEGS PROJECT ON THE EXISTING CSC

The proposed PSEGS facility configuration will impact sand deposition and erosion. Sand will accumulate at the base of the tortoise/chain link fence, but in significantly less quantity than suggested in the model. Similarly, some deflation will occur downwind from the fence in some areas. In addition, the location potentially most strongly impacted will shift to an area just downwind from the extreme eastern end of the project area. Importantly, however, the amount of area impacted is estimated to be significantly less than Collison model estimates for earlier-proposed project areas of similar size.

In general, perimeter fence effects on Zones II and III are estimated to be significantly less than shown in the Collison model. As noted above, minimal sand accumulation should occur in a very narrow zone both up-and downwind from the fence, if the fence is regularly maintained and cleared of windblown debris such as tumbleweeds, paper, etc. Although the change from trough to heliostat technology significantly modified the degree of ground disturbance within the project footprint, the number and size of heliostats can potentially significantly impact aeolian sand entrainment, transportation, and deposition within and downwind from the perimeter fence. Figure 16 shows the distribution of heliostats within the perimeter. Of necessity, heliostats are oriented to reflect to specific points on one of the two solar generation towers. This means that some heliostats will be oriented with maximum dimensions perpendicular to the wind (maximum effect on when velocity and turbulence), while others will be aligned approximately parallel to prevailing wind directions (minimum effect on wind velocity and turbulence). Near the northern perimeter fence, heliostat orientation is primarily parallel to wind direction, reducing effects on wind velocity. Near the southwestern perimeter fence, however, heliostat orientation is nearly perpendicular to prevailing wind direction, concentrating the “wind shadow” effect on areas just outside the perimeter.

As noted above, relict features in Zones II and III appear to be degrading at the present time. As of now it cannot be stated with certainty whether this degradation is the product of removal of sand from the CSC by artificially concentrated fluvial activity, removal of sand caused by agricultural features upwind from the PSEGS area, or because of climate related mechanisms.

Lancaster (2013) has completed preliminary modeling activities on sand movement using the revised PSEGS footprint (Figure 17). Results available at the time of this writing were preliminary, and no acreage estimates were given. Examination of Figure 17, however, suggests a relatively narrow zone of significant disturbance in Zones II and III outside the perimeter fence.

A number of on-ground and remote examinations were made of various agricultural and other cultural features in Chuckwalla Valley by the author at various times during winter, spring, and early summer months of 2013. Sand movements should be at a maximum at this time because of long-term drought in the area and seasonal winds. In general, it appeared that significant ground disturbance activities, such as plowing for fields, areas regularly disturbed by vehicle traffic, etc., yielded the most obvious evidence of deflation. Based on these observations of aeolian features and estimates of net directions of sand movement, a subjective estimate of indirect impacts on

Zones II and III was made (Figure 18, Table I). In terms of the loci of indirect impacts, this estimate appears to approximately agree with the Lancaster (2013) preliminary model, although the indirect impact of the PSEGS is thought to be slightly less.

The distribution of indirect impacts is shown in Figure 18, and tabulations are shown below. Indirect impacts affecting Zones II and III may be summarized as follows:

- Sand will accumulate in a narrow zone paralleling the perimeter fence both inside and outside the project boundary. This zone will be slightly wider in areas of Zone II, where relatively more sand is available for aeolian transport
- Maximum impacts (estimated 50%-100%) are primarily concentrated in Zone II, again roughly paralleling the perimeter fence, just downwind from the above-mentioned accumulation belt. Two small areas of maximum impact are located along the northern most boundary in Zone III
- A relatively narrow belt of lesser impacts (0%-50%) forms a transition zone between maximum indirect impact and no indirect impact.

Table I. Estimated area of indirect impact resulting from construction of PSEGS facility.

Degree of Indirect Impact	**ZONE III**	**ZONE III**
0% - 50%	23 acres	158 acres
50% - 100%	67 acres	111 acres

It is important to note again that the tabulation of indirect impacts is an estimate based on observations of features in the general area. It is also important to note that, while deflation will obviously occur as a result of facility construction, deflated sediments will be re-deposited further downwind, mitigating to some extent the loss of sand and habitat within the area of indirect impact. Within the facility perimeter deposition will be the primary process except very locally along corridors between heliostats aligned with prevailing wind directions. Further, impacts will not occur overnight, but will take place over a period of time, giving the MFTL time to adjust, in part.

It is obvious that the large number of heliostats to be emplaced within the project will have an impact on wind velocity, turbulence, and sand transportation. Aside from the indirect impacts tabulated above, the majority of facility-related indirect impacts are concentrated within the perimeter fence (deposition) and in areas of Zone IV to the south and east of the project area. Zone IV in most areas has a well-developed desert pavement not subject to significant wind erosion.

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BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA
1516 NINTH STREET, SACRAMENTO, CA 95814
1-800-822-6228 – WWW.ENERGY.CA.GOV

PALEN SOLAR ELECTRIC GENERATING SYSTEM AMENDMENT

Docket No. 09-AFC-07C
PROOF OF SERVICE
(Revised 07/09/2013)

SERVICE LIST:

APPLICANT
Palen Solar Holdings, LLC
Clay Jensen
Charlie Turlinski
Amanda McCoy
1999 Harrison Street, Suite 2150
Oakland, CA 94612
cjensen@brightsourceenergy.com
cturlinski@brightsourceenergy.com
amccoy@brightsourceenergy.com

APPLICANT'S CONSULTANT
Centerline
Andrea Grenier
1420 E. Roseville Parkway
Suite 140-377
Roseville, CA 95661
andrea@agrenier.com

APPLICANT'S COUNSEL
Scott Galati, Esq.
Marie Fleming
Galati/Blek, LLP
455 Capitol Mall, Suite 350
Sacramento, CA 95814
sgalati@gb-llp.com
mfleming@gb-llp.com

INTERESTED AGENCY
California ISO
e-recipient@caiso.com

County of Riverside
Office of Riverside County Counsel
Tiffany North
3960 Orange Street, Suite 500
Riverside, CA 92501
tnorth@co.riverside.ca.us

South Coast Air Quality
Management District
Mohsen Nazemi
21865 Copley Drive
Diamond Bar, CA 91765-4178
mnazemi1@aqmd.gov

INTERVENORS
Center for Biological Diversity
Lisa T. Belenky, Senior Attorney
351 California St., Suite 600
San Francisco, CA 94104
lbelenky@biologicaldiversity.org

Center for Biological Diversity
Ileene Anderson
Public Lands Desert Director
PMB 447, 8033 Sunset Boulevard
Los Angeles, CA 90046
ianderson@biologicaldiversity.org

Basin and Range Watch
Kevin Emmerich
Laura Cunningham
P.O. Box 153
Baker, CA 92309
atomictoadranch@netzero.net
bluerockiguana@hughes.net

Californians for Renewable Energy
Alfredo Acosta Figueroa
424 North Carlton Avenue
Blythe, CA 92225
lacunadeaztlan@aol.com

California Unions for Reliable Energy
Tanya A. Gulesserian
Elizabeth Klebaner
Adams Broadwell Joseph & Cardoza
601 Gateway Boulevard, Suite 1000
South San Francisco, CA 94080
tgulesserian@adamsbroadwell.com
eklebaner@adamsbroadwell.com

Hildeberto Sanchez, Eddie Simmons, and Laborers' International Union of North America, Local Union No. 1184
c/o Richard T. Drury
Christina M. Caro
Lozeau|Drury LLP
410 12th Street, Suite 250
Oakland, CA 94607
richard@lozeaudrury.com
christina@lozeaudrury.com

ENERGY COMMISSION STAFF
Christine Stora
Project Manager
Siting, Transmission and Environmental Protection Division
1516 Ninth Street, MS-2000
Sacramento, CA 95814-5512
christine.stora@energy.ca.gov

Jennifer Martin-Gallardo
Staff Counsel
Office of the Chief Counsel
1516 Ninth Street, MS-14
Sacramento, CA 95814-5512
jennifer.martin-gallardo@energy.ca.gov

*Indicates change

<u>ENERGY COMMISSION –</u>
<u>PUBLIC ADVISER</u>
*Alana Mathews
Public Adviser
1516 Ninth Street, MS-12
Sacramento, CA 95814-5512
publicadviser@energy.ca.gov

<u>COMMISSION DOCKET UNIT</u>
California Energy Commission
Docket Unit
Attn: Docket No. 09-AFC-07C
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512
docket@energy.ca.gov

<u>OTHER ENERGY COMMISSION</u>
<u>PARTICIPANTS (LISTED FOR</u>
<u>CONVENIENCE ONLY)</u>:
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Adviser to Presiding Member

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Eileen Allen
Commissioners' Technical
Adviser for Facility Siting

DECLARATION OF SERVICE

I, Marie Fleming declare that on July 23, 2013, I served and filed copies of the attached PALEN SOLAR HOLDINGS, LLC'S FINAL SAND TRANSPORT STUDY, dated July 23, 2013. This document is accompanied by the most recent Proof of Service, which I copied from the web page for this project at: http://www.energy.ca.gov/sitingcases/palen/compliance/.

The document has been sent to the other persons on the Service List above in the following manner:

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__X__ Instead of e-mailing the document, I personally delivered it or deposited it in the U.S. mail with first class postage to all of the persons on the Service List for whom a mailing address is given.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct, and that I am over the age of 18 years.

Dated: July 23, 2013

Marie Fleming