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DOCKET
09-AFC-8
DATE JAN 14 2010
RECD. JAN 19 2010

January 14, 2010

California Energy Commission
Docket No. 09-AFC-8
1516 9th St.
Sacramento, CA 95814

Genesis Solar Energy Project - Docket Number 09-AFC-8

Docket Clerk:

Included with this letter is one hard copy and one electronic copy of ***Interim Preliminary Aeolian Sand Source, Migration and Deposition Letter Report for the Genesis Solar Energy Project.***

This report will be finalized and re-docketed near the end of January 2010.

Sincerely,

Tricia Bernhardt
Project Manager/Tetra Tech EC

cc: Mike Monasmith /CEC Project Manager

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January 11, 2010
52004617

Genesis Solar LLC
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Juno Beach, FL 33408

Attn: Mike Pappalardo, Environmental Manager

Re: Interim Preliminary Aeolian Sand Source, Migration and Deposition Letter Report for Genesis Solar Power Project, Chuckwalla Valley, Riverside County, CA

Dear Mr. Pappalardo:

This letter report provides preliminary findings regarding aeolian sand sources, migration and deposition within the Chuckwalla Valley with emphasis on the region of the Genesis Solar Energy Plant (Solar Array and Linears). This report was requested by members of the California Energy Commission (CEC) in Data Request Set 1A and was further agreed during a conference call Work Shop on December 31, 2009. The intent of this interim report is to provide a summary of our preliminary findings to date and provide the foundation of the understanding of the aeolian system in the Chuckwalla Valley since the latest Pleistocene. Specifically are looking for aeolian sand pathways contributing to sand dunes and loose sand deposits within the vicinity of the Project that are potential habitat for MFTL. We are providing the technical basis for assessing whether the project will have a significant affect on these deposits.

Attached Items: Limited glossary of terms utilized in the body of this report.
References

Methodology and Scope of Work

The results of this report are primarily based on review of existing literature, site field mapping, evaluation of high resolution orthophotographs, thin section analysis, and utilization of Google Earth. These are discussed individually below.

Literature Review

Reviewed literature is provided in the reference section of this report, and provided a great deal of information from studies regarding regional sand migration corridors, types of sources for dune systems in the Mojave Desert, and age of aggredational events of dune fields in the southwestern U.S. No local dune studies have been identified for the Chuckwalla Valley sand dune system, however, some studies do refer to the Dale Lake to Mule Mountains sand corridor system.

Field Mapping

Field mapping was conducted during seven days throughout the Chuckwalla Valley with an emphasis on the Project site. Field work provided the majority of the data utilized in this report concerning the type and age of aeolian deposits, areas of active sand transport, and characterizing areas containing active, dormant and relict dune fields.

Evaluation of High Resolution Orthophotographs

A series of high resolution orthophotographs were reviewed during the course of this study. The images were of sufficient resolution to identify active coppice dune tails that were at least 3 feet in length. Some source areas from washes the location of linear dunes could also be readily identified.

Thin Section Analysis

Twelve sand dune samples were collected and submitted for thin section analysis within the Palen Dry Lake to Ford Dry Lake sand corridor system. All twelve samples were collected within the upper two inches of aeolian sand. A petrographic analysis will be conducted on all 12 samples, and XRD will be performed on six of the samples. The analysis of the samples has not yet been completed, and thus were not available for this preparation of this interim report.

Google Earth

Google Earth is a free internet program available provided by Google. The program allows for evaluation of photographic images of the surface of the earth with scale and location. Locations are provided with latitude, longitude and elevation.

Additional work to be conducted for our aeolian analysis of the Ford Dry Lake region will involve minor additional field work, and evaluation of twelve thin sections collected in the region of the site. The thin section analysis is part of our proposed provenance sand study.

We propose here some minor changes to our proposed scope of work outlined in the WorleyParsons Group Data Request Set 1A responses submitted to the California Energy Commission (CEC) on December 12, 2009. These changes primarily result from our conclusion that site field mapping has proved to be a very successful analytical tool in evaluating the sand migration and overall dune system within the Ford Dry Lake region. The recommended changes include:

1. <u>Data Request Set 1A WorleyParsons Group Response</u>: *"The objective of the provenance study would be to attempt to determine the percentage of sand in the Ford Dry Lake dune field that derived from the Palen-McCoy axial wash versus the Palen-Ford Dry Lake sand corridor or other local sources."*

<u>Recommended Change in Scope</u>: We currently recommend providing relative magnitudes of aeolian sand migration sources as compared to actual percentage values. Relative magnitude values provided for each of the identified aeolian sand sources are provided in the conclusion section of this report.

2. <u>Data Request Set 1A Worley Parson Group Response</u>: *"The provenance study will include microscopic grain and thin section (composition) analysis, and laboratory grain size analysis."*

<u>Recommended Change in Scope</u>: We are performing a thin section analysis of twelve samples collected in the region. The change in scope involves wording regarding the laboratory grain size analysis, which was intended to indicate that part of the thin section analysis would evaluate grain sizes within those samples analyzed.

Sand Dune Aggredational Events Since the Latest Pleistocene

To understand the aeolian system within the Chuckwalla Valley region requires an understanding of the behavior of dune systems in the Mojave Desert since the latest Pleistocene (past 13,000 years). Within the Mojave Desert, sand dune deposition (aggregation-growth) generally occurred during relatively dry periods following wetter climates that generated considerable sediment supply within regional drainages and dried up pluvial lake basins (Dohrenwend, et. al., 1991; Lancaster and Tchakerian., 2003). The last major regional sand dune aggredational event occurred near the Holocene-Pleistocene boundary (Dohrenwend, et.al. 1991). However, a global dry period during the mid Holocene that followed the relatively wetter climate cycle (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 for sand dune growth of within the Mojave Desert region 7 to 4 ka (Dohrenwend, et. al., 1991). Most major sand dune deposits existing today are considered fossil formations as they have likely have not been actively forming during the late Holocene (Dohrenwend, et. al., 1991).

Most of the sand dunes in the Mojave Desert region are produced by sand moving east to southeast due to resultant annual wind directions. However, this migration is also altered by topographic controls on wind when channeled along mountain fronts and within valleys (Laity, 1987). Zombelman et. al. (1995) identified two primary sand corridor systems in the eastern Mojave Desert near the site. These include: The Bristol Trough system which extends over 150 km southeast from the Bristol Playa to the Colorado River and the Clarks Pass system that extends from Dale Dry Lake to just east of Ford Dry Lake (also see Lancaster and Tchakerian, 2003).

The source for sand dune sediment within most Mojave Desert dune fields comes from a combination of regional sand corridors, local active washes along the sand corridors and playa dry lakes (Lancaster and Tchakerian, 2003; Muhs et. al., 2003; Ramsey et. al., 1999).

Prevailing Wind Regimes in the Chuckwalla Valley Area

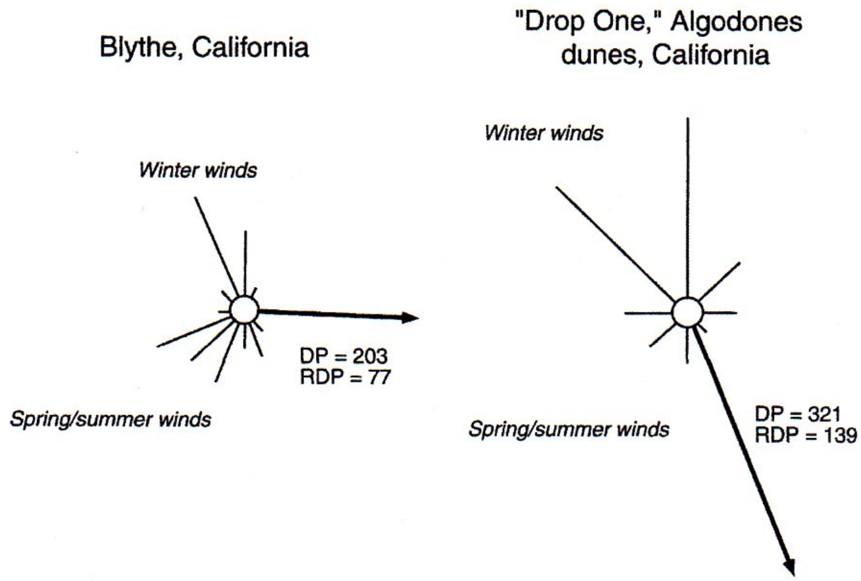
Annual and seasonal wind rose diagrams data from Blythe (ASOS data) which is located approximately 30 miles east of the Project site at the eastern most end of the Chuckwalla Valley (Plate 1) indicate two dominant wind directions during typical years. During the Spring and Summer months, the strongest winds are from the south associated with monsoonal storm events. During the Fall and Winter, the strongest winds are from the north-north west associated with Pacific Ocean derived weather fronts. Determining the primary wind direction responsible for sand migration can be evaluated by geomorphic mapping of dune types, orientations, and locations, which is described later in the report, and by determining the Resultant Drift Potential (RDP) from appropriate wind data (speed, time and duration data).

Determination of the RDP requires temporal velocity wind data from throughout the year. Thus, how fast the wind moved, for how long and for what time. To determine the RDD, the Drift Potential vector for each wind that occurred during the year exceeding the threshold wind velocity (~12 knots or ~14 mph) is evaluated which is proportional to the length of time the wind blew greater than the threshold wind velocity (Tsoar, 2004). Thus, an individual DP value and vector is determined for each wind direction that blew greater than the wind threshold velocity. The DP values are proportional to how much stronger it was relative to the threshold wind velocity and how long it blew at those speeds.

Adding up all the DP values provides a parameter of the potential maximum amount of sand that could be eroded by the wind during a year for all wind directions (Tsoar, 2004). By adding all the vector units of the DP values provides a resulting vector called the Resultant Drift Potential (RDP).

Muhs, et. al. (1995) determined the RDP for the Chuckwalla Valley to Blythe region for wind data collected at the Blythe Airport. Figure 1 below from Muhs, et. al., (1995) determined a RDP for the Blythe Airport that points nearly due east parallel to the Chuckwalla Valley (left diagram).

Figure 1 – Resultant Drift Potential (RDP) Data from Blythe and the Algodones regions. The Algodones dune field is located at the south end of the Salton Trough. These data indicate that the Pacific Cell winter weather fronts in combination with topographic (mountains and valleys) dominate the orientation of the RDP.



The nearly due east resultant vector RDP for the Blythe airport located at the eastern end of the Chuckwalla Valley is very consistent with field mapping data (this study) regarding the dominant direction of migrating sand (including long term field indicators such as ventifacts and dune alignment) in the Chuckwalla Valley axis corridor. This is discussed in more detail in the next section.

Aeolian Sand Sources.

There are numerous sources of aeolian sand that finally deposit in the sand depositional sink at the east end of the Chuckwalla Valley (Plate 1) which are consistent with regional dune systems. In the Mojave Desert, the primary aeolian sand sources are ephemeral streams soon after they flow, playa lakes, and older dune fields. After a stream flows it exposes potential sand for wind entrainment at the surface. Strong winds within just a few strong wind storms subsequent to stream flow will entrain most of the available sand (saltation) and begin to move the sand out of the channel. It does not take long for the fresh fluvial sands to form a protective cap composed of very coarse sand and/or gravel as the finer aeolian sands are removed by the wind. After the gravel cap forms, very little additional sand is entrained by the wind from the wash until it flows again. Thus, streams that flow often will produce substantially more aeolian sand than washes that flow infrequently. Eroding playa lake area sediments, many of which contain older dune deposits, are also a source of sand for Mojave Desert dune systems due to wind abrasion. Once sand reaches a major aeolian sand migration corridor, it will begin to migrate within the corridor.

Major Aeolian Sand Migration Corridors

Field mapping of sand migration geomorphic structures provides excellent data regarding the dominant direction of aeolian sand transport and for different time scales. For example, the orientation of graded scale (see glossary) coppice dune "tails", barchan and transverse dunes. In addition, field observations during storm wind events associated with a typical winter major storm from the Pacific Ocean on December 22 and 23, 2009 identified migrating sand directions in real time within the Chuckwalla Valley. Results of these data are provided on Plate 1 as blue vectors.

The dominant wind direction in the Chuckwalla Valley responsible for transporting sand is thus from the west and north via topographic valleys bounded by mountain ranges (Plate 1). Thus, there is strong evidence to support that Pacific Ocean winter storms events from the north west is the dominant source of wind energy sufficient to entrain migrating sand in the Chuckwalla Valley region. In the western portion of Palen Dry Lake (PDL) region, aeolian sand to feed the local barchan dunes is from the west along the Dale Lake-Palen Dry Lake sand Corridor. Sand is also transport from the north northwest via the Palen Valley located between the Coxcomb and Palen Mountains to merge with PDL sands from the west. The sand moving down the Palen Valley primarily migrates along the eastern side at the base of the late Pleistocene fans on the west side of the Palen Mountains. These two sand sources clearly mix at the eastern most end of PDL along the south tip of the Palen Mountains.

The sand then migrates nearly due east down the axis of the Chuckwalla Valley toward FDL where a very similar pattern occurs as that in the PDL region (Plate 2). Sand from the Chuckwalla valley from the west along the PDL-Chuckwalla Valley sand corridor migrates across FDL proper and mixes with sand that migrates toward the south-south east along the eastern side of the Palen-McCoy Mountain Valley. The magnitude of migrating sand from the PDL-Chuckwalla Valley sand corridor increases toward the south from the northern end of the Linears toward Highway 10. Aeolian sand from the Palen-McCoy valley sand corridor is the dominant source just east of the Project Solar Array site and east northern Linears, and gradually mixes with additional sand from the PDL-Chuckwalla Valley sand corridor toward the south. All the sand is eventually moving toward the east to primarily deposit in the eastern Chuckwalla Valley. How much of the sand enters the Colorado River Valley has not been evaluated during this study and is unknown.

Eolian Deposits of the Chuckwalla Valley

Mapping current active areas of wind blown sand deposits in the Ford Dry Lake region is problematical. This is because the region of the Chuckwalla Valley during the latest Holocene has experienced a greatly reduced rate of wind blown sand migration and deposition compared to periods during the latest Pleistocene to late Holocene. Thus many areas contain near surface sand deposits of latest Pleistocene to late Holocene age that are currently stabilized with vegetation and wind blown lag deposits. Most current active areas of wind blown sand transport continue to occur in the same regions since the latest Pleistocene but sand supply is only sufficient to produce limited areas of active aeolian deposition within these areas. Sand migration and deposition unit terms Qsa, Qsad, and Qsr (described below) attempt to discern relative magnitudes of the wind blown sand input and deposition within the region of the site (see Plates 1 and 2 attached).

Aeolian Sand Migration and Depositional Units

Qsa Areas of reasonable size to map that receive sufficient active aeolian sand migration to maintain dune system. Dunes within Qsa areas generally exhibit free avalanche faces and surficial loose sand. Qsa areas may exhibit active sand sheets (deposits from migrating ripples) and coppice dunes with tails (deposits associated with vegetation). Most dunes within Qsa are are not stabilized or strongly vegetated. Qsa areas are primarily located in Palen Dry Lake and east of Wiley Well road. Limited areas of marginal Qsa deposits occur east of the Genesis Power site.

Qsad Area dominated by latest Pleistocene to late Holocene dormant to relict stabilized dunes but remain regions of current sand transport with isolated areas exhibiting wind blown sand deposition (sand sheets, coppice and avalanche face of linear dunes). Thus, many areas within mapped Qsad do not exhibit loose sand on the surface and fall under the definition of unit Qsr. Small isolated areas of mapped Qsad also fall under the definition of unit Qsa.

Qsr Area containing relict wind blown sand sheet and degrading coppice dune sediments with very limited to no active sand transport. These deposits are typically stabilized with grasses, creosote and wind generated very coarse sand to small gravel abrasion lag deposits. The youngest members of this unit exhibit near surface soil Bw soil horizons with an estimated minimum age of 1000 years.

The Palen Dry Lake dune field (proper) is one of a few BRGP dune fields considered to be active and thus continuing to grow (Dohrenwend, et. al., 1991). The Palen Dune field exists within and adjacent to Palen Dry Lake and exhibits abundant active dunes (barchan – conscentric and transverse). Dominant graded scale resultant wind directions based on the orientation of the dunes is from the northwest and roughly parallel to the valley axis. Active barchan dunes in the Palen Dry Lake dune field migrate toward the east-south east (Dohrenwend, et. al., 1991).

CONCLUSIONS

The Chuckwalla Valley is a region of active aeolian sand migration and deposition but at a magnitude substantially less that it had experienced during dune aggredational events since the latest Pleistocene. In addition, the aerial extent of aeolian activity in recent times is moderately less that it once was during regional dune aggredational events. This can be seen on Plates 1 and 2 where unit Qsr (relict dune fields) extends beyond the northern boundary of the primary sand migration corridor from PDL through the FDL area south of the Project Solar Array. However, for the most part, the same sand migration corridors are currently utilized that once were during past dune aggredational events within the Chuckwalla Valley region.

Active aeolian sand migration occurs within existing sand migration corridors located south and east of the Project Solar Arrays (Plates 1 and 2). A relatively minor component of the overall sand migration within the eastern Palen-McCoy Valley sand corridor occurs within the eastern most region of the proposed Solar Array field. The aeolian sand migration within the eastern most area of the Project Solar Array site that has two sources. These include from the washes soon after they flow, which estimated to be approximately every 20 years (likely relatively large El Nino events), and from southward migrating sand down the Palen-McCoy sand corridor. This source is very minor because the vast majority of sand moving within the Palen-McCoy sand corridor moves east of the proposed Solar Array site. The relative magnitude from the potential removal of this aeolian sand source to the Mojave Fringe Toad Lizard mapped habitat east of the Project is considered minimal.

Aeolian sand sources in the area of the Linears are complex in that the region is within the area of mixing of the PDL-Chuckwalla Valley and Palen-McCoy Valley sand migration corridors. Orientations of coppice dune tails and linear dunes east of the Linears and even an active migrating set of mixed wind barchan dunes south of the Linears strongly suggest that the northern winds from the Palen-McCoy valley generally dominate sand transport in the area surrounding the Linears. However, strong aeolian transporting winds from N68W from the northern region of the Linears producing 1 to 3" long instantaneous scale ephemeral coppice dune tails were observed at the site on December 22, 2009. Based on the existing data, the relative magnitude of sources of sand for the region east of the Project Linears includes:

- The Palen Dry Lake sand corridor is a minor source for the northern portion of the linears and gradually increases to a major source of sand for the southern most section of the linears that run parallel to Highway 10. Thus, the relative contribution of sand east of the Linears gradually increases toward the south.
- The sand corridor along the eastern side of the Palen-McCoy Valley (Plates 1 and 2) from local washes is a major aeolian sand source feeding the dune system east of the Solar Array and Linears. The relative magnitude of the Palen-McCory sand corridor gradually decreases toward the south as it mixes with PDL-Chuckwalla Valley aeolian sands.
- Local washes along the rim of Ford Dry Lake proper (minor source)
- Erosion of older dune fields within Ford Dry Lake proper (minor source)

The aeolian sand source derived within the Palen-McCoy Valley is overwhelmingly due to streams, and in particular, streams that flow fairly frequently. Based on observation of active sand entrainment from the washes, and vegetation within the drainages, the streams that flow most frequently are located within Palen Pass proper (Plates 1 and 2), along the eastern side of the Palen-McCoy Valley where streams drain the western side of the McCoy mountains and a series of fast rain run-off Pleistocene age fan surfaces. These source areas will not be affected by the proposed Project.

Based on the evaluation of the current data, sand migration to the dune fields east of the Solar Array and Linears will not be adversely affected by the proposed development. Aeolian sand flux to the dunes east of the Solar Array derive nearly all their sand from the north via the eastern side of the Palen-McCoy valley. Aeolian sand currently depositing in the mapped dune fields east of the Linears currently receive most of their sand via the eastern side of the Palen-McCoy Valley to the north and a gradual increase in sand flux via the PDL-Chuckwalla Valley sand corridor. Aeolian sand migration was directly observed to occur across low profile man made structures, rough surfaced preserved alluvial fans, and very hummocky and vegetated topography within the sand migration corridors. Aeolian sand migration across the linears will occur during the lifetime of the project from the Palen-Chuckwalla Valley sand corridor, and if completely shut down could adversely affect the stability of the active dune areas east of the Linears. This magnitude of the adverse affects are higher toward the south within the Linears as the relative contribution of aeolian sand from the PDL-Chuckwalla sand corridor increases southward in the region. However, a low profile access road as proposed within the design would not adversely affect aeolian sand transport toward the east from the west as the sand was directly observed to easily transect such structures and to travel at heights of over five feet.

Streams transecting the proposed Solar Array field from the north and entering the northern edge of FDL are a negligible source of aeolian sand primarily because these streams flow infrequently. These streams are a minor source of sand once they flow and do feed some small coppice dunes south of the site, but most of this sand is primarily derived from the PDL-Chuckwalla Valley axis sand corridor.

Miles Kenney, Ph.D., P.G.
Supervising Geologist

Attachments: Glossary of Terms; References

GLOSSARY OF TERMS

AEOLIAN: Wind Blown. Aeolus was ruler of the winds in Greek mythology.

AGGRADATION: An increase in land elevation due to the deposition of sediment. Aggradation occurs in areas in which the supply of sediment is greater than the amount of material that the system is able to transport. For example, sand dunes will undergo aggradation if the supply of aeolian sand is greater than the flux of sand out of the system.

COPPICE DUNES: Vegetated sand mounds that are commonly scattered throughout sand sheets in semiarid regions where shrubs and blowing sand are abundant. Any shrub sticking up into the airborne stream of sand is an impediment to the flow, and the resulting turbulence and speed losses cause sand grains to settle out on the downwind side of the shrub and around its base. Coppice dunes range from about 0.5 to 3 m in height and from 1 to 15 m in breadth. Within any given field of coppice dunes, however, the dune size tends towards uniformity. Under certain conditions, individuals or clusters of dunes can become very large and are called vegetation mounds. Because the sand accumulates in piles around the plants and is swept from the surfaces between the plants, a hummocky, rough topography develops that is very different from the smooth, flat, and locally gentle undulatory surfaces of sand plains that are devoid of vegetation and are frequently barren, typically have firm, trough like, scoured surfaces of hard-packed soil, with thin patches of rippled sand or granules (Desert Processes Working Group).

Most active coppice dunes in the Chuckwalla Valley region exhibit “coppice tails” on the leeward side (downwind side) of the coppice mound at the base of the plant. The tails are triangular in shape and with the wide end attached to the plant sand mound and points (narrows) downwind from the plant. The coppice tails are generally 3-inches to 3 feet long and provide excellent wind vector data for approximately graded time (past 1 to 10 years). In addition, a lack of active coppice tails and degraded and/or vegetated coppice mounds at the base of plants is an excellent indicator that sand is not currently migrating within that area.

CORRIDOR SYSTEM (AEOLIAN) : An aeolian corridor system pertains to aeolian sand pathways extending for tens of miles and involving numerous subbasins within the Mojave Desert. Regarding the site, a number of studies have identified the Dale Lake to Mule Mountains sand corridor system that allows wind blown sand to travel approximately 70 miles toward the east via topographic valleys and playa lake basins (Palen and Ford Dry Lakes). Our study has identified that the simple single sand corridor is from Dale Lake to the north end of the Mule Mountains is also fed by considerable sand from north to south valleys as well (Palen Valley to Palen Dry Lake and the Palen-McCoy Valley which feeds the eastern end of Ford Dry Lake).

CYCLIC TEMPORAL AND SPATIAL SCALE: Cyclic scale includes a temporal scale involving periods of 10^3 to 10^5 years and spatial scale corresponding to that of large dune field areas (Lancaster, 1995). For this study, Cyclic scale involved the formation of the most of the larger dunes within the Chuckwalla aeolian system that took thousands of years during major aggredational events of the latest Pleistocene and mid Holocene.

GRADED TEMPORAL AND SPATIAL SCALE: Graded scale time is a temporal scale involving periods of 1 to 10^2 years and particularly concerns the dynamics and morphology of dunes, which tend towards an actual or partial equilibrium with respect to rates and directions of sand movements generated by surface winds (Lancaster, N., 1995). Aeolian structures or deposits that may have formed or existed between 1 to less than approximately 1000 years is considered to have formed during graded time. For example within this study, graded time structures include small active dunes and medium to relatively larger size active coppice dunes and their respective tails. In addition, graded special scale involves aeolian processes as the migration of individual dunes within a dune system.

HOLOCENE EPOCH: The Holocene is a geological epoch which began approximately 11,700 years ago[1] (10,000 ^{14}C years ago). According to traditional geological thinking, the Holocene continues to the present

INSTANTANEOUS TEMPORAL AND SPATIAL SCALE: Instantaneous temporal and spatial scale involves very short to instantaneous periods of time and small areas. Some examples of aeolian structures that form within instantaneous scale involve the formation of sand ripples that can develop in a few minutes and very small coppice dune tails behind shrubs.

INTERDUNE: Interdune areas of the desert floor occur between individual dunes in fields. Closed interdune areas may be poorly drained, contain playas and are typically flat. Where dry and floored by sandy sediment, they have many of the same characteristics as sand sheets. If near-surface moisture is present, interdune areas may contain grasses, shrubs, trees, or even settlements. Interdune areas range in size from a few to tens of square kilometers. In any given locality, the sizes and shapes of the interdune areas are similar, as are those of the intervening dunes

LEE (leeward side of a dune): The leeward side of a sand dune is down wind from the dominant resultant wind direction primarily responsible for its form. The lee side of an individual dune exists between the crest and the base of the avalanche face. On active dunes (Qsa), many active dunes exhibit a free avalanche face where sand sediment is deposited near the angle of repose. (related term – Stoss)

LINEAR DUNES: One of the most common dune types, linear dunes are generally straight to irregularly sinuous, elongate, sand ridges of loose, well-sorted, very fine to medium sand. The straight varieties are often called "sand ridges," and the sinuous varieties are often called "seifs." The lengths of individual dunes, which are much greater than the widths, can range from a few meters to many kilometers. They form in at least two environmental settings: where winds of bimodal direction blow across loose sand, and also where single-direction winds blow over sediment that is locally stabilized, be it through vegetation, sediment cohesion or topographic shelter from the winds. The latter is likely the mechanism of the linear dunes just east of the Genesis Solar Power Plant array.

Linear dunes have formed in areas now characterized by wide ranges of wind speeds and directions. Most are probably "fossil" dunes formed under more vigorous wind regimes during Pleistocene climatic conditions. Since then, wind regimes have apparently become less intense, although wind directions are apparently similar. Thus, where linear dunes are active today, they are commonly being modified into compound or complex features by the addition of secondary dunes. Nonetheless, the long axes of linear dunes are aligned generally within 15° of the prevailing wind or with the resultant drift direction of the local winds. The sinuosity and alternate slip faces develop because crosswinds change direction and alternately shepherd the sand to each side of the dune axes. Long standing opinion on linear dune migration is parallel and along the downwind axis of the dune. However, new evidence is emerging that indicates that linear dunes move oblique to the axis of the dune in the primary direction of the resulting wind drift direction which is often approximately 15° oblique to the dune axis.

PARABOLIC DUNES: In plan view, these are U-shaped or V-shaped mounds of well-sorted, very fine to medium sand with elongated arms that extend upwind behind the central part of the dune (opposite of Barchan dunes). Slip faces occur on the outer (convex) side of the nose of the dune and on the outside slopes of its elongated arms.

Parabolic dunes are always associated with vegetation--grasses, shrubs, and occasional trees, which anchor the trailing arms. In inland deserts, parabolic dunes commonly originate and extend downwind from blowouts in sand sheets only partly anchored by vegetation. They can also originate from beach sands and extend inland into vegetated areas in coastal zones and on shores of large lakes. Coppice dunes are commonly associated with parabolic dune fields. They are frequently found on sand sheets and on and around larger parabolic dunes.

Most parabolic dunes do not grow to heights greater than a few tens of meters except at their forward portions, where sand piles up as its advance is halted or slowed by surrounding vegetation. Parabolic dunes, like crescentic dunes (i.e. barchan), are characteristic of areas where strong winds are unidirectional. Although these dunes are found in areas now characterized by variable wind speeds ranging from low to high, the effective winds associated with the growth and migration of both the parabolic and crescentic dunes probably are the most consistent in wind direction. Some parabolic dunes exist south of Wiley Well rest stop (Plate 1).

PLEISTOCENE EPOCH: The Pleistocene is the epoch from 2.588 million to ~12,000 years before present (BP) covering the world's recent period of repeated glaciations. The Pleistocene Epoch is subdivided into Early (2.6 Ma to 781 kya), Middle (781 to 126 kya) and Late (126 to 12 kya). Time boundaries for the Pleistocene Epoch are still debated. Many publications reference the beginning of the Pleistocene at 1.6 Ma; however, this earlier date does not impact the findings in this report. Within this report the term Latest Pleistocene is considered the last 50 to 60 kya of the late Pleistocene described above.

SAND SHEETS: Sand sheets (or plains) are flat or gently undulatory broad floors of tabular wind blown sand deposits derived from accumulating sand ripple migration. The tabular deposits generally range in thickness from a few centimeters to a few meters). Some sand sheets, as in the southwestern U.S., are local deposits that extend only a few square kilometers in and around dune fields, where they are exposed on interdune floors and form the aprons or trailing margins of dune fields and along sand migration corridors.

Sand sheet deposits are composed of gently inclined or nearly horizontal layers, each less than about a centimeter thick, of coarse silt and very fine to medium sand separated by layers, one grain thick, of coarse sand and granules. Unlike dune sand, the unconsolidated sand and granules are closely packed and firm under foot. The surface is protected by a wind abrasion lag, one grain thick, of the coarsest particles that can be shifted by the wind, ranging from coarse sand to pea-size gravel. In any one place, however, the sizes of the lag particles are remarkably uniform, and the lag may be so closely packed that it forms a miniature desert pavement. In the Chuckwalla Valley, the wind abrasion lag often contains small gravel that may have been derived from burrowing animals moving coarser grained alluvial deposits containing gravel to the surface in the past (McAuliffe and McDonald, 1995). The existence of a wind abrasion lag containing gravel from underlying alluvial units suggests that the surface is a minimum of a few thousand years old in order to provide sufficient time for burrowing animals to mix the near surface units over a relatively large area.

Sand sheets in themselves indicate little about wind direction regimes, but the particle size of sand and gravel lag on ripple surfaces seems dependent on the strength of the winds in any given locality. Inactive sand sheet deposits near and at the surface however do provide evidence of past wind sand migration corridors.

STABALIZED DUNES: Sand dunes that are unable to migrate due to vegetation growth on the dune itself are considered stabilized dunes and also referred to as vegetated dunes. These types of dunes often develop due to insufficient aeolian sand input to the dune to allow for growth and migration. Within this study, dune areas mapped as Qsad and Qsr are dominated by stabilized dunes.

STOSS: The stoss side of the dune points toward the direction the dominant resultant wind responsible for the primary dune form originates. The stoss side exists between the toe and the crest of the dune. Thus, the stoss side of a dune is on the upwind side (related term – Lee).

VENTIFACTS: Rocks that have been abraded, pitted, etched, grooved, or polished by wind-driven sand. Ventifacts typically occur on gravel size rocks exposed on the surface to sand bearing wind. Common surfaces containing ventifacts within the Chuckwalla Valley consist of wind abrasion lag deposits and abandoned alluvial fan surfaces. Ventifacts are identified by rounded edges and a soft feel on the gravel side exposed to the atmosphere. Ventifact forms provide information regarding the prevailing wind direction. Triangular faceted ventifacts are believed to indicate multidirectional prevailing wind directions, and mono-direction "linear" ventifacts provide evidence of a dominant uni-direction resultant drift wind direction. However, prevailing wind evaluation of ventifacts should be conducted on homogeneous clasts such as quartzite that does not exhibit internal structures that may produce differential mechanical erosion in orientation close to perpendicular to prevailing wind directions.

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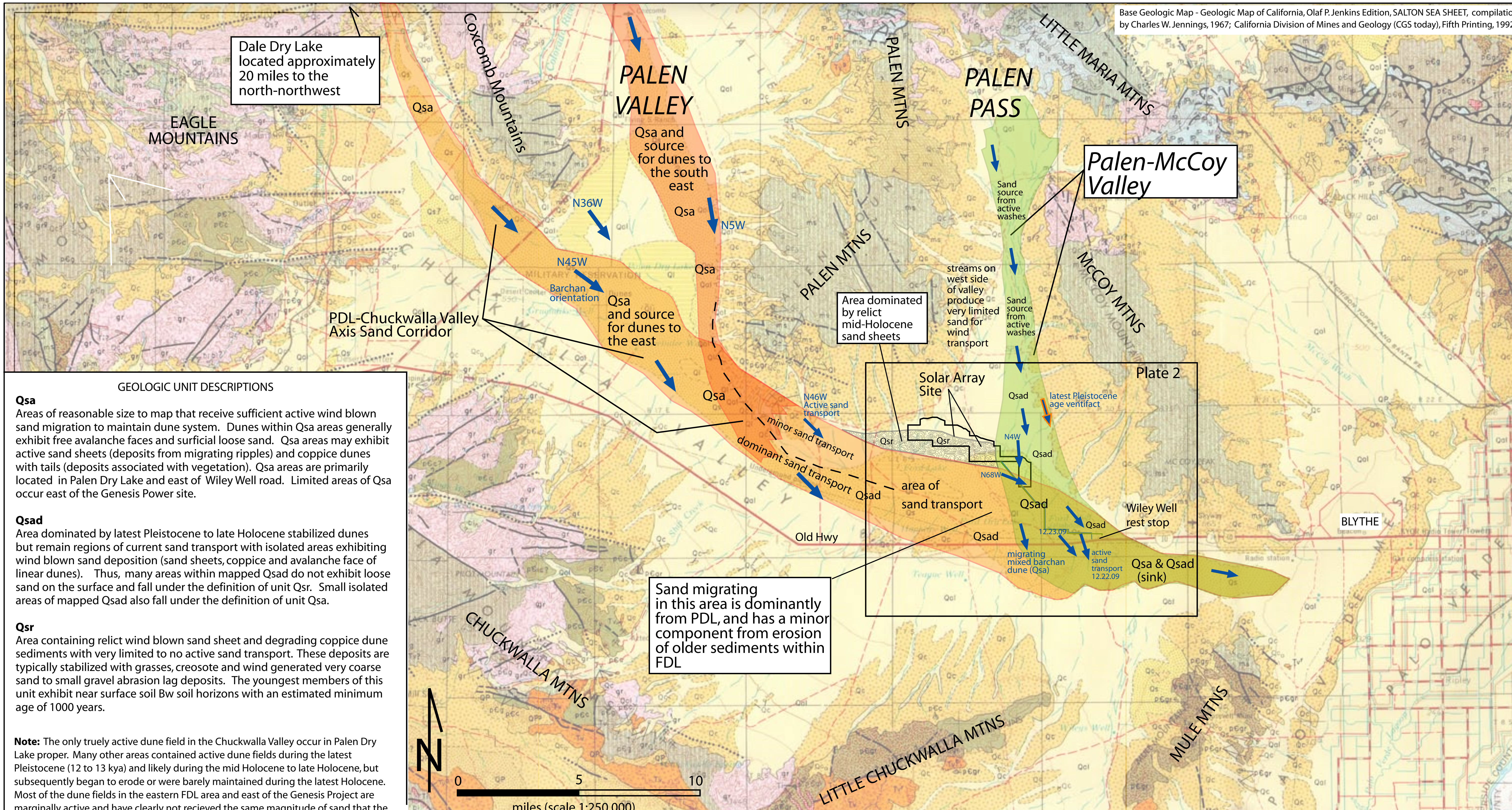

GEOLOGIC UNIT DESCRIPTIONS

Qsa

Areas of reasonable size to map that receive sufficient active wind blown sand migration to maintain dune system. Dunes within Qsa areas generally exhibit free avalanche faces and surficial loose sand. Qsa areas may exhibit active sand sheets (deposits from migrating ripples) and coppice dunes with tails (deposits associated with vegetation). Qsa areas are primarily located in Palen Dry Lake and east of Wiley Well road. Limited areas of Qsa occur east of the Genesis Power site.

Qsad

Area dominated by latest Pleistocene to late Holocene stabilized dunes but remain regions of current sand transport with isolated areas exhibiting wind blown sand deposition (sand sheets, coppice and avalanche face of linear dunes). Thus, many areas within mapped Qsad do not exhibit loose sand on the surface and fall under the definition of unit Qsr. Small isolated areas of mapped Qsad also fall under the definition of unit Qsa.

Qsr

Area containing relict wind blown sand sheet and degrading coppice dune sediments with very limited to no active sand transport. These deposits are typically stabilized with grasses, creosote and wind generated very coarse sand to small gravel abrasion lag deposits. The youngest members of this unit exhibit near surface soil Bw soil horizons with an estimated minimum age of 1000 years.

Note: The only truely active dune field in the Chuckwalla Valley occur in Palen Dry Lake proper. Many other areas contained active dune fields during the latest Pleistocene (12 to 13 kya) and likely during the mid Holocene to late Holocene, but subsequently began to erode or were barely maintained during the latest Holocene. Most of the dune fields in the eastern FDL area and east of the Genesis Project are marginally active and have clearly not recieved the same magnitude of sand that the area once did prior to the mid Holocene and older aggradational events. Minor late to latest Holocene dune growth events may have occured in the region but were minor relative to earlier periods of deposition (also see **Note** of Plate 2)

Approximate current limits of the active wind sand transport corridor from the Palan Dry Lake region down the Chuckwalla Valley. Dominant resultant sand movement toward the east.

Approximate current limits of the active wind sand transport corridor from the Palen Pass region down the Palen and McCoy Mountain Valley. Dominant resultant sand movement toward the south-southeast.

N20W

Wind direction vector measured in the field. Directions based on coppice tails (graded scale of 1 to 10 years), barchan and Linear dunes (cyclic scale - thousands of years), and ventifacts in rocks on late Pleistocene surfaces. Note, vector directions were not obtained from instaneously forming ripple directions, however, active ripples were very generally very consistent with older wind direction indicators. Orientation indicates direction the wind is from.

GENESIS SOLAR, LLC

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Generalized Sand Migration Corridors and Depositional Areas Chuckwalla Valley, California

MK	MT	01/11/2010
52011206	Plate 1	

SYMBOL DESCRIPTIONS

Qal Quaternary Alluvium consisting of fluvial distal fan deposits. Within the site these deposits are composed of fine to very coarse sand and small gravel, well bedded and generally only 6-inches to 2-feet thick. Soil horizons indicate that the deposits are between 1ky to approximately 8 ky old.

Qsa Areas of reasonable size to map that receive sufficient active wind blown sand migration to maintain dune system. Dunes within Qsa areas generally exhibit free avalanche faces and surficial loose sand. Qsa areas may exhibit active sand sheets (deposits from migrating ripples) and coppice dunes with tails (deposits associated with vegetation). Qsa areas are primarily located in Palen Dry Lake and east of Wiley Well road. Limited areas of Qsa occur east of the Genesis Power site.

Qsad Area dominated by latest Pleistocene to late Holocene stabilized dunes but remain regions of current sand transport with isolated areas exhibiting wind blown sand deposition (sand sheets, coppice and avalanche face of linear dunes). Thus, many areas within mapped Qsad do not exhibit loose sand on the surface and fall under the definition of unit Qsr. Small isolated areas of mapped Qsad also fall under the definition of unit Qsa.

Qsr Area containing relict wind blown sand sheet and degrading coppice dune sediments with very limited to no active sand transport. These deposits are typically stabilized with grasses, creosote and wind generated very coarse sand to small gravel abrasion lag deposits. The youngest members of this unit exhibit near surface soil Bw soil horizons with an estimated minimum age of 1000 years.

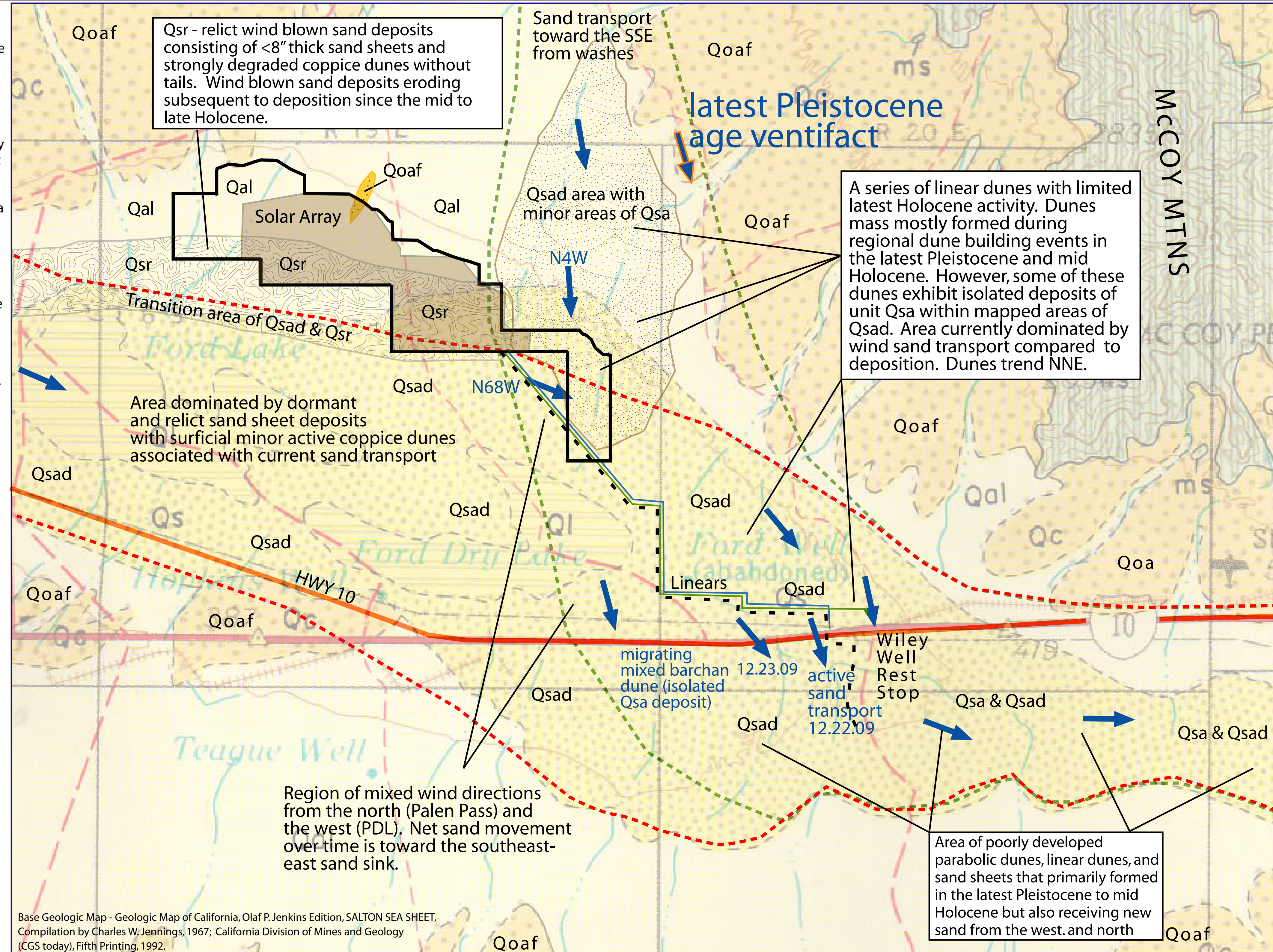
Qoaf Latest Pleistocene distal fan deposits. They are composed silty fine to very coarse sand and minor small gravel. The unit is generally within 1 to 2 feet of the surface within the Project Solar Array site and exhibits a pedogenic soil horizon sequence that is likely a minimum of latest Pleistocene age.

Note: Mapping current active areas of wind blown sand deposits in the Ford Dry Lake region is problematical. This is because the region of the Chuckwalla Valley during the latest Holocene has experienced a greatly reduced rate of wind blown sand migration and deposition compared to periods during the latest Pleistocene to late Holocene. Thus many areas contain near surface sand deposits of latest Pleistocene to late Holocene age that are currently stabilized with vegetation and wind blown lag deposits. Most current active areas of wind blown sand transport continue to occur in the same regions since the latest Pleistocene but sand supply is only sufficient to produce limited areas of active wind blown sand deposition within these areas (Qsad). Sand transport and migration terms Qsa, Qsad, and Qsr attempt to discern relative magnitudes of the wind blown sand input and deposition. Qsa depicts areas of reasonable size to map that receive sufficient sand input to maintain an active dune field. Qsad represents an region that is dominated by older stabilized dunes but is within a wind blown sand migration corridor to maintain limited areas of surficial active wind blown sand deposition (thin sand sheets, coppice dunes, and linear dunes). Qsr depicts regions that were once an area of wind blown sand migration and relatively minor deposition during the latest Pleistocene to late Holocene, but are dominantly no longer receiving sufficent wind blown sand to result in sand deposition.

N20W — Wind direction vector measured in the field. Directions based on coppice tails (graded scale of 1 to 10 years), barchan and Linear dunes (cyclic scale - thousands of years), and ventifacts in rocks on late Pleistocene surfaces. Note, vector directions were not obtained from instantaneously forming ripple directions, however, active ripples were very generally very consistent with older wind direction indicators. Orientation indicates direction the wind is from.

Approximate limits of sand migration corridor from Palen Dry Lake region toward the east along the Chuckwalla Valley.

Approximet limts of sand migration corridor from Palen Pass toward the south between the Palen and McCoy Mountains.



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Generalized Local Sand Migration Corridors and Depositional Areas - Proposed Genesis Solar Project, Chuckwalla Valley, California

MK	MT	1/11/10
52011206	Plate 2	

BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA
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APPLICATION FOR CERTIFICATION FOR THE
GENESIS SOLAR ENERGY PROJECT

Docket No. 09-AFC-8

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(Revised 1/04/10)

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DECLARATION OF SERVICE

I, Tricia Bernhardt, declare that on January 14th, I served and filed copies of the attached ***Interim Preliminary Aeolian Sand Source, Migration and Deposition Letter Report for the Genesis Solar Energy Project***, dated January 11, 2010. The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at: [http://ww.energy.ca.gov/sitingcases/genesis_solar].

The documents have been sent to both the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit, in the following manner:

(*Check all that Apply*)

FOR SERVICE TO ALL OTHER PARTIES:

__x__ sent electronically to all email addresses on the Proof of Service list;

__x__ by personal delivery or by depositing in the United States mail at Sacramento, California with first-class postage thereon fully prepaid and addressed as provided on the Proof of Service list above to those addresses NOT marked "email preferred."

AND

FOR FILING WITH THE ENERGY COMMISSION:

__x__ sending an original paper copy and one electronic copy, mailed and emailed respectively, to the address below (*preferred method*);

OR

______ depositing in the mail an original and 12 paper copies, as follows:

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 09-AFC-8
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512
docket@energy.state.ca.us

I declare under penalty of perjury that the foregoing is true and correct.

Original Signed By:

Tricia Bernhardt