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LANDFORM STRUCTURE AND ARCHEOLOGICAL SENSITIVITY IN THE BEACON SOLAR ENERGY PROJECT AREA.

Far Western
Great Basin Branch
PO Box 758
Virginia City, NV 89440
775-847-0223

Landform Structure and Archaeological Sensitivity in the Beacon Solar Energy Project Area

By:
D. Craig Young

May 2009

Submitted to:
EDAW, Inc.
1420 Kettner Boulevard, Suite 500
San Diego, CA 92101

FAR WESTERN ANTHROPOLOGICAL RESEARCH GROUP, INC.
2727 Del Rio Place, Suite A, Davis, California, 95618
http://www.farwestern.com 530-756-3941

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PROJECT SETTING

Fremont Valley extends from the foot of the southern Sierra Nevada trending southwest to northeast between the uplifted ranges of the El Paso and Rand mountains. Coalesced fan systems (i.e., bajadas) extend from the complexly faulted mountain fronts and hillslopes bounding the valley. Typically short drainages on individual small fans join to form axial washes that extend toward the basin sump of Koehn Lake. Larger drainage systems can extend from deep canyons in the Sierra Nevada to form expansive fans that overlap and join the range-front bajada and contribute large amounts of run-off and sediment to the axial washes and valley center. Red Rock, Jawbone, and Pine Tree canyons form particularly large drainage systems entering Fremont Valley.

Fluctuations in run-off and sedimentation emanating from these canyons have significant influence on the landform structure of the valley. Specific to the project area, Pine Tree Canyon and its broad alluvial fan contain a high-resolution record of regional erosion and deposition, processes that may preserve or alter a buried archaeological record. The fan, including Pine Tree Wash, is the major landform of the project setting. The surface deposits of the entire project area are comprised of recent sediments most of which have been deposited in the last 1,000 years.

The environment in the western Mojave Desert and Fremont Valley is characterized by hot-dry summers and cool-wet winters. Although Pacific storm systems bring winter precipitation, the orographic effect of Sierra Nevada significantly limits the moisture content of storms reaching the valley so that the overall condition is one of high aridity. This condition was established in the early Holocene as the Pleistocene-dominant storm tracks shifted to the north putting an end to wetter conditions in the western Mojave.

Fremont Valley and the Beacon Project area experienced relatively abrupt environmental change across the Pleistocene-Holocene boundary as well as more transitional change during the warming Holocene. Evidence of regional environmental change is provided by vegetation remnants and pollen profiles preserved in packrat middens from throughout the Mojave Desert and southern Great Basin (Koehler et al. 2005; Spaulding 1990). Elevational and latitudinal shifts in the regional woodland community along with the arrival of creosote bush (*Larrea tridentata*), marked the transition from temperate and seasonal conditions of the Late Pleistocene to arid desert that dominates the Holocene. Because individual species responded differently to climate variation, changes in plant communities did not necessarily occur in direct association with global climatic events. Creosote bush spread slowly northward across the Mojave in the early Holocene, and did not arrive as far north as Fremont Valley until about 7,000 years ago (Koehler et al. 2005). This cloning species became the dominate vegetation in the lower and middle elevations of the Mojave, and contained an understory of Mojave sage (*Salvia mohavensis*), shadscale (*Atriplex confertifolia*), desert rue (*Thamnosma montana*), and wolfberry (*Lycium cooperi*). By 4,500 years ago, this vegetation had coalesced to become the valley-bottom community (Koehler et al. 2005; Spaulding 1990).

As the broad vegetation community took shape, local environments and geomorphic processes continually responded to changes in global climate, including the seasonal timing and intensity of temperature and precipitation. Spring discharge as documented and modeled by Quade et al. (1998) provides a useful proxy for understanding the subtle transitions between mesic and xeric conditions in and around the Mojave Desert. The region remained relatively mesic through the global climate perturbations epitomized by the Younger Dryas (drastic wet-dry-wet global cycles) and into the Early Holocene. Spring discharge was quite high at the close of the Younger Dryas interval at about 11,300 years ago; however, discharge would never again approach this level as the Holocene warming and drying dominated the past 11,000 years. The warm/dry transition developing toward the Middle Holocene (as creosote begins and reaches its northern spread) was punctuated by monsoonal incursions that may have resulted in spring discharge and runoff peaks (Wigand and Rhode 2002:337). Alluvial fans might have been very active in this type of increasingly dry regime as vegetation density falls and floods have more erosive effect. Deposition occurs across broad portions of the fan, although especially large floods resulted in massive deposits in distal fan locations.

The dry interval continued until about 5,500 years ago when spring discharge approached Early Holocene (not Younger Dryas) levels and mesic plants returned by descending from higher elevations. Wigand and Rhode (2002:339-340) describe the Late Late Holocene of the northern Mojave region as multi-modal and organize it into its own early and late phases. Their Early Late Holocene locally highlights a Neoglacial increase in effective moisture which would have contributed to spring discharge, vegetation community coalescence (higher density, lower diversity) and local soil formation. Alluvial fans were generally stabilized though water reaching the distal fan in washes would have been more consistent and would have resulted in seasonal (i.e., periodic) deposition and distal fan aggradation. The relatively cool and wet Neoglacial climate had a significant and generally beneficial impact on the prehistoric occupants of the northern Mojave and southern Great Basin (Grayson 1993; Sutton et al. 2007; Warren 1984). The area began to dry sometime before 2,000 years ago with generally arid conditions identified as a Late Holocene interval (Wigand and Rhode 2002). Although generally dry, the Late Holocene (since 2,000 years ago) experienced several climatic (i.e., precipitation, evaporation, and/or temperature) reversals or fluctuations (Stine 1994). These cyclical events often resulted in abrupt landform or resource changes that may leave depositional signatures on the landscape.

Our understanding of paleoenvironments of the northern Mojave is often based on climate proxies derived or reconstructions from other areas, such as the well-studied areas of the adjoining Great Basin (Wigand and Rhode 2002). In general, these are useful and researchers continue to seek data sets that will fill gaps and resolve inconsistencies in the regional record (Koehler et al. 2005). This study provides additional data on depositional sequences within a portion of Fremont Valley where it may be possible to look beyond the individual profiles to better understand the processes and causes of valley-bottom alluviation not only in the Beacon Solar Project Area but across the region.

PROJECT GOALS

The goal of geoarchaeological studies in the Beacon Solar Project Area, including surface mapping and mechanical trenching, was to characterize the landforms in the project area. The valley-bottom landforms throughout the project area are comprised of Holocene-age deposits, and, in specific places, past depositional environments have been appropriate for preservation of an intact archaeological record. On the other hand, erosive events such as sheet floods and channel incisions, may have scoured now-buried surfaces producing unconformities in the local stratigraphy. Erosion of one landform produces deposition in downstream portions of the system. Periods of landform stability may be represented by soil or weathering profiles that can help constrain the temporal variability of geomorphic events.

In this manner, the complex geomorphic system of the Pine Tree Canyon alluvial fan and axial washes of Fremont Valley play an important role in the patterning and preservation of the local archaeological record. Landform identification and stratigraphic descriptions provide data on the geometry and chronology of landform development. This information can then be used to better understand and evaluate the archaeological potential of the project area. Identification of the chronology and structure of these events can provide a better understanding of the potential for locating buried archaeological resources in the project area. Cultural resources monitoring may not be required where Pleistocene-age landforms are identified.

FIELD TECHNIQUES

Preliminary mapping and stratigraphic trenching were conducted over two field sessions in January 2009. Field mapping, augmented by satellite imagery, resulted in the identification of five relatively distinct landforms and associated geomorphic surfaces (Figure 1). Informal designations were assigned based on depositional regime and relative chronology (Hf1, Hf1d, Hf2, Hf3, and Hf4). Preliminary mapping guided the selection of trenching locations for landform-specific stratigraphic studies.

Mapping was followed by mechanical trenching during which the author documented the stratigraphic profile of 17 trenches excavated across the five landforms that comprise the Beacon Solar Energy Project study area. The locations of the trenches with respect to project boundaries and landform categories are shown on Figure 1. Mechanical excavations focused on documenting a specific landform group during each day of fieldwork; typically, three or four trenches were excavated in each landform. Trench depths varied from five to six meters (16 to 20 feet) depending on sediment characteristics. It was necessary, due to the relatively deep level of each excavation, to bench and shore those trenches subjected to complete stratigraphic documentation. Considerable effort was made to provide a safe working environment. It was typical to document and sample one trench profile and closely monitor the excavation of each additional trench for stratigraphic variability. The author also documented an arroyo profile (PTW-01) where drainage incision has exposed a prominent paleosol (buried soil).

Once shoring and access ladders were in place, profiles on both sides of the trenches were cleaned using a trowel. Only one profile was selected for documentation and sampling. Documentation consisted of photography and measurements of illustration and description. Sediment characteristics, such as particle size, contacts, bedding geometry, and organic content were documented in each profile. Unless discrete organic or charcoal deposits were located, major stratigraphic boundaries were highlighted for radiocarbon sampling. Discrete charcoal samples were collected in separate containers. Once the samples were retrieved, all shoring was removed.

After complete documentation of the initial trench, additional trenches were excavated while closely monitoring the deposits (e.g., profile and backdirt) for variations in landform stratigraphy. In general, landform deposits appeared to be relatively consistent over large areas and the documentation of a single "type"-trench proved successful. Trenches were backfilled and re-contoured at the close of each day.

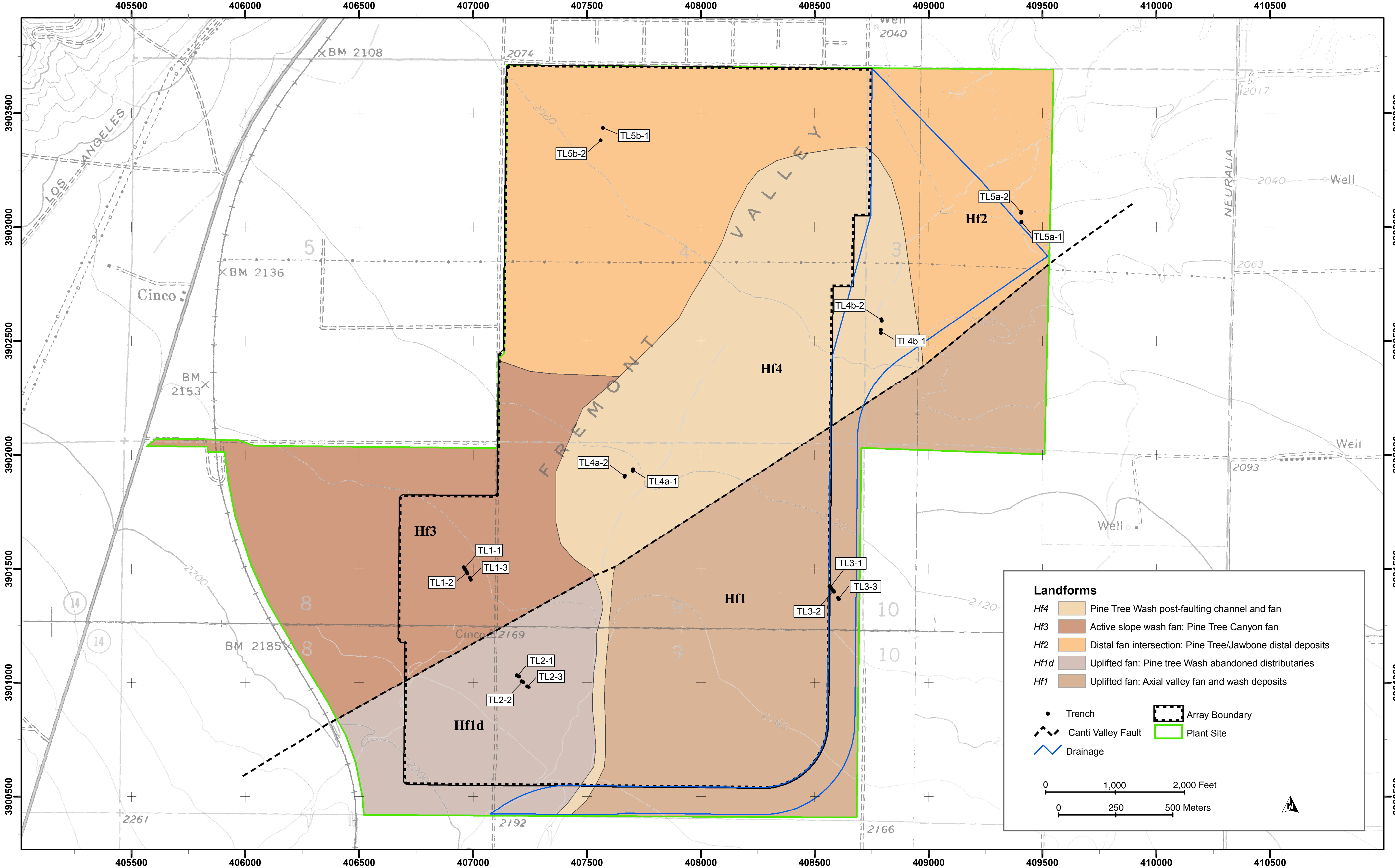


Figure 1. Holocene Fan Segments and Trenching Locations in the Beacon Solar Energy Project Area.

THE LANDFORMS OF THE BEACON SOLAR ENERGY PROJECT AREA

The five landforms encompassed by the project area comprise segments of the Holocene-age, Pine Tree Canyon alluvial fan (Hf) (Table 1). Although the absolute ages were unknown during initial mapping, the relative chronology was eventually supported by radiocarbon assays from stratigraphic profiles. For example, the depositional sequence and cross-cutting relationships suggested that the Hf1 landform is older than Hf2 and Hf3, respectively. Hf4 is the youngest landform in the study area. Subscripts used with landform designations highlight features associated with the paleo-channels or distributaries of Pine Tree Wash.

Table 1. Landform Groups of the Beacon Solar Energy Project Area.

LANDFORM	DESCRIPTION	TRENCH LOCATION
Hf4	Pine Tree Wash post-faulting channel and fan	TL4a, TL4b
Hf3	Pine Tree Canyon Fan; active alluvial fan	TL1
Hf2	Distal Fan intersection; Pine Tree and Jawbone distal deposits	TL5a, TL5b
Hf1d	Uplifted Fan; Pine Tree Wash abandoned distributaries	TL2
Hf1	Uplifted Fan; Axial valley fan and wash deposits	TL3

The landforms are divided or capped by two distinct landform features, the Cantil Valley Fault scarp and the young distal fan of Pine Tree Wash. These features influence local depositional and erosional regimes and understanding their role in landform development will aid in the assessment of the potential for buried cultural resources.

The Cantil Valley fault bisects the project area and has been a major influence on the shifting erosional and depositional regimes of Pine Tree Wash. Although capped by Holocene-age deposits, the near-surface landforms above (south) the fault are older than the young fan deposits below (north) the fault. Landforms above the fault (Hf1 and Hf1d) are derived from the axial system of Fremont Valley and older distributary channels of Pine Tree Wash. Profiles along the axial wash, which has captured the modern course of Pine Tree Wash, contain clear stratigraphic breaks (sheet flow and overbank flood events) along with one prominent soil/weathering profile almost two meters below the modern surface. Landforms below the fault (Hf3 and Hf4) are younger than those above the fault as these areas have been zones of deposition since the time of major tectonic off-set. Slip rates for faults along the Garlock swarm have been estimated (Gardner et al. 2002; McGill 1994), but these have not been applied to the Cantil Valley fault specifically. However, if the Garlock estimates (mostly left-lateral displacement) are correct, then some of the vertical offset of this fault may pre-date the Pleistocene-Holocene temporal boundary of approximately 11,300 years ago. Therefore, the potential to encounter stratigraphic markers of that boundary is greater on the Hf1 and Hf1d landforms.

The landform comprised of “lakebed sediments” (Hf2) in the north and northeast portion of the study area are actually distal fan deposits formed at the intersection of the Pine Tree Wash and Jawbone (Cottonwood Creek) fans. Comprised of silt and clay, with occasional sand and gravel lenses, these deposits are texturally similar to lacustrine sediments, but have been deposited as a result of very low-energy regimes near the terminus of the fans. These fine-grained deposits inter-finger with and grade into adjacent medial fan deposits and the area lacks constructional or erosional features often associated with lacustrine or littoral landforms. Shore zones of Koehn Lake, the basin sump of Fremont Valley drainage, where lake-oriented archaeological sites are known (Sutton 1991), are several kilometers east of the project area. In the project area, distal fan deposits are Holocene in age (surface deposits may be modern) and may have been deposited as local ponding impounded by floods that temporarily blocked drainage to the lake basin. The fan intersections, along with local faulting, may also produce spring locations where vegetation and surface waters impede sediment movement forming distal fan deposits. Although not a true lacustrine landform, resource characteristics might occasionally match littoral/paludal environments and would have been cyclically attractive to prehistoric people. Apple et al. (2008) have documented the presence of archaeological components buried in and partially exposed on the Hf2 landform. Radiocarbon assays on cultural features in the upper meter of the stratigraphic profile all date to the last 1,000 years.

During the course of preliminary mapping, the author visited CA-KER-3939 to investigate the contexts of the early Holocene dates reported by Gardner et al. (2002). This site was referenced in the Beacon Project geoarchaeological scope-of-work as an example of deeply buried archaeology in the region. The buried cultural hearths and ash-rich strata are situated in deeply incised channels at the proximal segment (adjacent to the mountain front) of the valley alluvium. Although part of the regional alluvial system, the landscape of deeply buried archaeology at KER-3939 is very different from that of the Beacon project area. Located 200 meters higher and four miles southwest of the Beacon Solar Energy Project Area, CA-KER-3939 is situated in the active portion of the fan where pulses of deep incision are separated by longer periods of colluvial and alluvial deposition. Left-lateral faulting along the Garlock Fault also contributes to geomorphic responses along the proximal fan. This does not necessarily reduce the potential for buried resources in the project area which is primarily a depositional set of landforms, but draws attention to local variability in geomorphic regimes.

LANDFORM STRUCTURE AND DEPOSITIONAL SEQUENCES IN THE DISTAL REACHES OF PINE TREE CANYON FAN

Based on preliminary mapping and in consultation with CEC Archaeological staff, we selected seven trench locations to best characterize landform stratigraphy. Trench locations are shown on Figure 1. Each landform was investigated by mechanical excavation of a minimum of three trenches; however, the Hf2 and Hf4 landforms had two trench locations with two trenches each. Radiocarbon dates on charred material and pooled organics provide chronological control of depositional sequences on several of the landforms (Table 2).

Trench excavation and profile documentation supported general observations of the initial surface mapping fieldwork. The trench profiles conform to the overall geometry of the local fan system; that is, landforms above the fault have been relatively stable for a long period of time and landforms below the fault are active, relatively young features. It also follows that profiles in mid-fan locations show high-energy depositional events and distal fan location show low-energy depositional regimes. Trench profiles and chronological information are presented with type sections from each location.

Table 2. Radiocarbon Results from Beacon Solar Energy Project Area.

Trench Location	Stratum	Depth	Material	Lab No.	Conventional	13C/12C	Calibrated Years BP
TL3	3	2.2 mbs	Organic Sediment	Beta-255187	9550 ± 50 BP	-21.3 o/oo	10910 ± 140
TL4a	1	0.2 mbs	Wood	Beta-255913	10 ± 40 BP	-24.6 o/oo	150 ± 90
TL4b	5	2.4 mbs	Organic Sediment	Beta-255910	2920 ± 40 BP	-22.4 o/oo	3080 ± 70
TL5b	2	0.8 mbs	Charred Material	Beta-255909	1690 ± 40 BP	-22.6 o/oo	1620 ± 60
TL5a	6	1.8 mbs	Charred Material	Beta-255911	3500 ± 40 BP	-22.0 o/oo	3780 ± 50
TL5a	8	2.8 mbs	Charred Material	Beta-255186	4250 ± 40 BP	-24.2 o/oo	4800 ± 60
TL5a	12	4.1 mbs	Organic Sediment	Beta-255912	7330 ± 50 BP	-21.0 o/oo	8130 ± 70
Pine Tree Wash	2	1.5 mbs	Organic Sediment	Beta-254726	12730 ± 70 BP	-22.1 o/oo	15260 ± 120

Notes: Radiocarbon data were collected from detailed trench profiles and may be correlated to other trenches in each study locality. Radiocarbon calibration using CalPal (Weninger and Jöris 2004). mbs – Meters below surface.

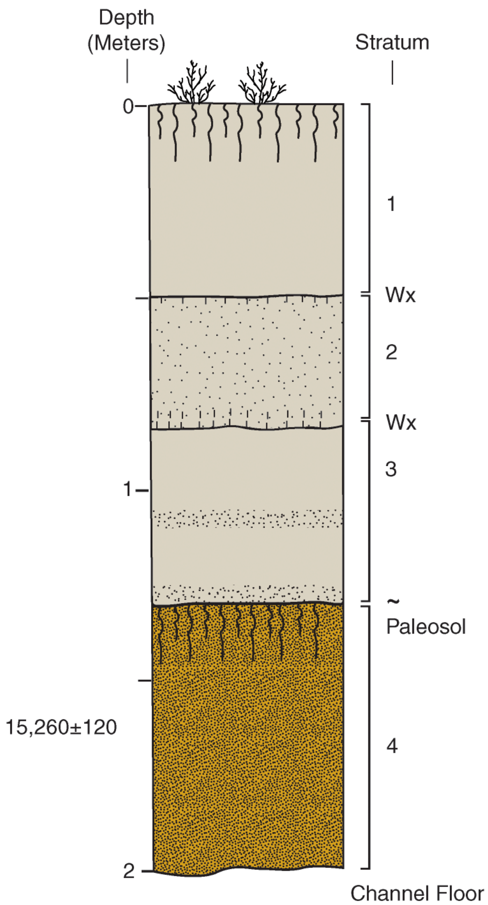
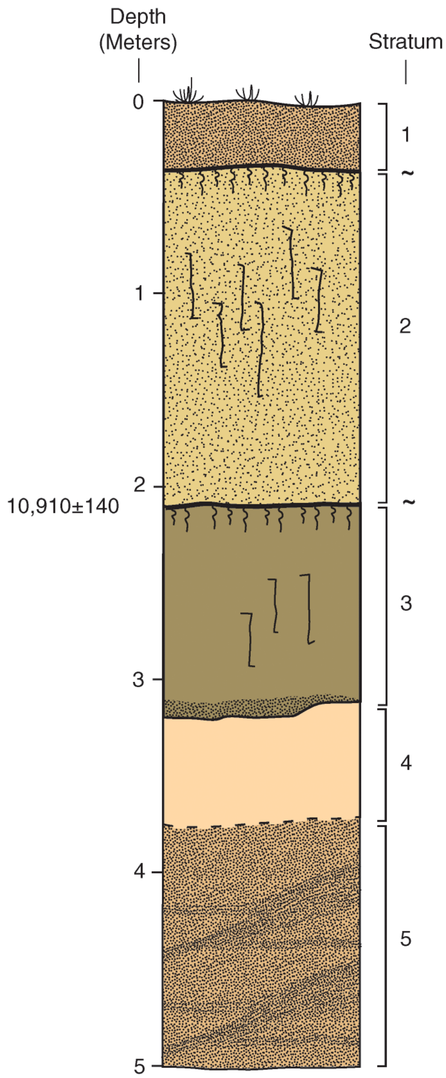


Figure 2. PTW-01:
West Facing Cutbank.

The Profile of Pine Tree Wash

Prior to trench excavation, reconnaissance of the modern arroyo of Pine Tree Wash (PTW) revealed a prominent paleosol buried beneath slightly weathered (Wx) sheet flow and overbank deposits (Figure 2). The paleosol developed on a stable landform of a Pleistocene-age alluvial fan; pooled organics from the B-horizon provided a date of 15,260 ± 120 calendar years ago (Beta-254726). The A-horizon was subsequently eroded and removed. Because they are derived from organics that have pooled in the soil profile over several millennia, soil dates are typically considerably younger than the sedimentary deposit sampled. For example, the fan may have been deposited during the last glacial maximum 24,000 years ago, but the soil took several thousand years to form. Also, soil formation may not begin until several millennia after sediment deposition. So, this date only provided a limiting or minimum date of landform deposition. However, we know that the overlying deposits are younger than the paleosol. I illustrate this here because there are several dates on pooled organics from project profiles. Although dates on charred material are preferred (dates on deposition), soil dates provide relevant information on the chronological sequence of landform development.



see key for fills on Figure 8

Figure 3. Hf1:
Trench Location 3.

Hf1: Trench Location 3

A series of trenches excavated into the Hf1 landform above (south of) the Cantil Valley fault scarp and east of Pine Tree Wash encountered a thick series of fine sands and silts below a shallow alluvial and aeolian cap (Stratum 1; Figure 3). The sand and silt deposits (Strata 2-4) comprise distal fan environments of the axial valley, probably deposited prior to significant uplift or warping along the fault. These strata are light-colored with weak to moderate carbonate precipitates influencing irregular, sub-angular structure. The strata were deposited over a short period of time but remained stable enough to allow periods of weak soil development, weathering, and carbonate translocation. Organics at the top of Stratum 3, a prominent silt bed two meters below the modern surface, have been dated at 10,910 ± 140 calendar years ago (Beta-255187). The date is derived from pooled organics and represents a minimum age due to the duration of soil formation and weathering as organics were introduced. There is a similar weak paleosol at the upper contacts of Stratum 2, just below the modern surface. The two soils are likely correlates to the strong paleosol evident in Pine Tree Wash (see above), although this portion of the fan was somewhat active and shows a strong depositional pulse (Stratum 2) separating two periods soil development (the PTW location remained stable and soil development was continuous). Stratum 4 is a massive silt deposit with weak cohesive structure; this unit lacks the carbonate of the overlying fan deposits. Strata 3 and 4 are likely silt-filled swales marking an older drainages or washes. The superimposed swales are cut into bedded, course to fine gravel of the Pleistocene-age alluvial fan (Stratum 5).

The upper portion of the profile (Strata 1 and 2) has moderate potential for containing archaeological contexts due to varying erosional and depositional energy. The great antiquity of the landform below two meters in depth precludes the deposition of archaeological remains. The Stratum 3 deposit is likely considerably older than the radiocarbon date obtained on pooled organics of the paleosol. The period of soil formation began sometime prior to 15,000 years ago, as shown by the same or similar paleosol of PTW-01. In any case, cultural deposits from the latest Pleistocene are as yet unknown for this area of the Mojave Desert.

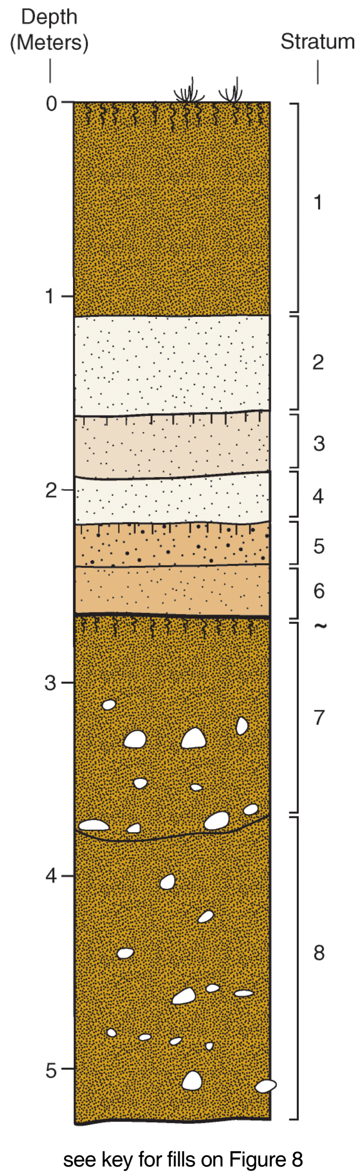


Figure 4. Hf1d:
Trench Location 2.

Hf1d: Trench Location 2

Trenches excavated into the Hf1d landform revealed an uplifted sequence of fan deposition. The upper stratum of the profile is predominantly Holocene-age fan deposits mixed with aeolian coppice dunes and sand sheets (Stratum 1; Figure 4). One meter below the surface this young deposit changes to a sequence (Strata 2-6) of fine sands and silts of a distal fan environment. These fine sedimentary deposits are common in the middle portion of the profile, below one meter, and likely reflect deposition in distal fan environments with localized ponding and very low berm and swales of distributary channels on the fan. These environments may be somewhat similar to the more recent Hf2 area to the north. However, these Hf1 deposits are much older than the Hf2 situated below the Cantil Valley fault scarp. The now-buried, distributary channels are likely Early Holocene in age. These channels, likely paleo-courses of the Pine Tree Wash, are the features that differentiate this landform from the Hf1 on the opposite side of the Pine Tree Wash. The distal fan deposits rest on steeply dipping gravels and cobbles (Strata 7-8) deposited in large flood and wash events; this deep portion of the profile is certainly Pleistocene in age. There is a paleosol at the top of Stratum 7 that is likely a correlate of the buried soils evident on Hf1 and within Pine Tree Wash. This Late Pleistocene to Early Holocene soil is a good buried marker for the Holocene-Pleistocene boundary; the fan deposits significantly predate soil development.

The upper portion of the profile (Strata 1-6) has moderate potential for containing archaeological contexts due to varying erosional and depositional energy. The great antiquity of the landform below two meters in depth minimizes the chances for encountering archaeological remains.

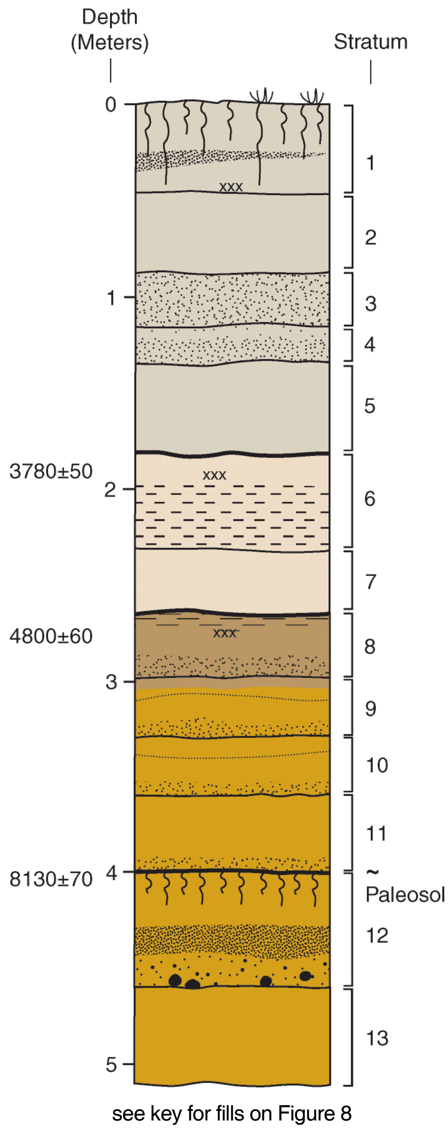


Figure 5. Hf2: Trench Locations 5a.

Hf2: Trench Locations 5a and 5b

A series of trenches in the distal fan environments of the Hf2 revealed a deep series of upward-fining sheetwash and low-energy flood deposits (Figure 5). Portions of the profile (Strata 3-11) show more than 16 preserved flood events per meter (i.e., individual fine sand to silt sequences) per meter. The top of each event shows evidence of playa formation with well-preserved clay films and polygonal cracking. Each sequence reflects an individual flood or high water event reaching the distal fan followed by gradual drying and playa formation (i.e., each sequence ends with conditions similar to the modern surface). The fine sands occasionally contain charcoal pieces scoured from presumed natural burns on the local landscape. These provide discrete dates of depositional events throughout the profile (see Table 2). The TL5a and TL5b excavations revealed consistent distal fan profiles even though the trench locations were separated by several hundred meters (see Figure 1).

The upper strata (1-3) of low-energy deposits in all trenches (and in nearby archaeological excavations [Apple et al. 2008]) are relatively thick (20 to 30 centimeters), when compared to underlying sequences, suggesting prolonged surface flow reaching the valley bottom. Surface flows were followed by relatively long-term pooling. Known archaeological features rest on the thick silt deposits resulting from this pooling; sites were occupied as the surface dried and distal fan pools contracted. An archaeological feature documented in Trench 5b was dated at 1620 ± 60 calendar years ago (Beta-25909); although in similar stratigraphic context, the features documented by Apple et al. 2008 date to almost a millennium later. The informal hearth encountered in TL5b-1 is 80 centimeters below surface and 120 centimeters wide, and is between two and four centimeters thick. The feature is a clearly defined charcoal lens with an oxidized sediment layer below and a thin lens of sediment above. The feature lacked associated fire-affected rocks or other constructed elements.

Prior to the depositional events of the past two millennia, the profile shows a long series of short-lived and repetitive floods. Radiocarbon dates on charcoal from the middle of the flood sequence (see Table 2) provide a deposition rate of almost a meter of deposit every thousand years. Each meter contains between nine and sixteen upward-fining sequences, typically medium sands to silts capped by playa films. Conservatively, this shows a recurring flood interval of between 50 and 100 years throughout the middle and late Holocene. These floods were significant enough to provide relatively well-watered environments, for short intervals, in the valley bottom. Also, the depositional regimes of these flood events have the potential to preserve archaeological assemblages and features, if present, on and in the Hf2 landform. This may be preserved to depths of up to four meters.

At approximately 4.0 meters below the modern surface the profile shows a significant change in flow regime and energy. A high-energy flood followed by prolonged drying may be evidence of the early Holocene environments in the region. A relatively strong paleosol formed on distal fan silts and sands (Strata 12 and 13). Pooled organics from this paleosol provided a date of 8,130 ± 70 calendar years ago. This soil formed in an arid, stable landscape where very slow rates of pedogenesis (soils take a very long time to form under arid conditions) suggest that the underlying deposit is significantly older than the pooled organics. This soil corresponds very well with the arid interval in the early Holocene documented in spring and pollen records in the region (Quade et al. 1998; Wigand and Rhode 2002).

The presence of dynamic, Holocene-age, low-energy depositional environments has implications for the local archaeological record. Low-energy sheetwash and flood events can result in a well-preserved archaeological and paleontological record. There is a greater likelihood that artifacts and ecofacts are preserved in primary context resulting in high data potential. For example, a well-preserved hearth feature with charcoal remaining in direct contact with oxidized and burned sediments was encountered in the upper profile of TL5b-1. Similar archaeological features have been documented in almost identical positions in other portions of this landform (Apple et al. 2008). Additional features may be encountered at this level, and preservation potential for older, deeply buried features is high.

The deposits below the abrupt contact and paleosol at four meters below the surface pre-date 8,000 years ago, probably by several thousand years. The deposits on which the dated paleosol formed show significantly higher energy depositional regimes in which gravels and cobbles are common. However, the high energy regimes are separated by fine-grained deposition. Late Pleistocene archaeological assemblages might be preserved by low-energy deposition. However, assemblages of this time period have not yet been documented in the region and chances of encountering them are low.

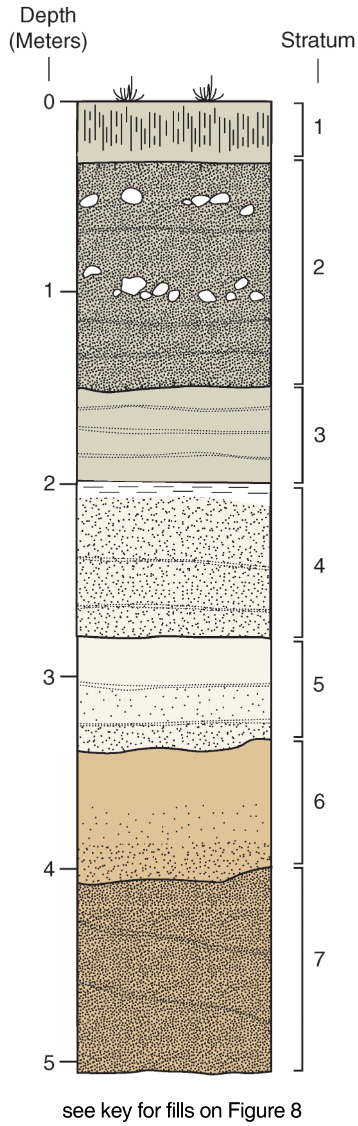


Figure 6. Hf3:
Trench Location 1.

Hf3: Trench Location 1

A trench into the Hf3 landform revealed a deep sequence (Strata 1-5) of recent, Holocene-age sheetwash and flood events (Figure 6). The landform is generally aggrading via a series of fining-upward (thick gravel to thin silt) deposits. Cobbles are present in the latest series of flood events, and the overall clast size of the profile reflects deposition in relative high-energy flows, some of which were confined to incised channels while others spread broadly across the ground surface. Stratum 6 below the relatively young fan can be correlated with early distributary channels and distal fan deposits of Pine Tree Wash that are evident above the Cantil Valley fault. It is unfortunate that this unit lacked dateable materials, as this might provide some temporal information regarding fault slip and off-set rates. The distributary deposits of Stratum 6 are underlain by cross-bedded sands, gravels, and occasional cobbles (Stratum 7) of the Pleistocene-age fan of Pine Tree Canyon.

The depositional environments documented within Hf3 are not conducive to site preservation. Occasional archaeological materials (i.e., lithic flakes) were collected from the trench excavations to a depth of almost four meters below the modern surface, but these have clearly been incorporated into the gravel deposits during flooding. In this case, the provenience of the sparse yet widely distributed cultural materials is unclear. Re-deposited material may be common on and in this landform. Overall sensitivity is low for intact and significant, buried sites on and in this landform.

Hf4: Trench Locations 4a and 4b

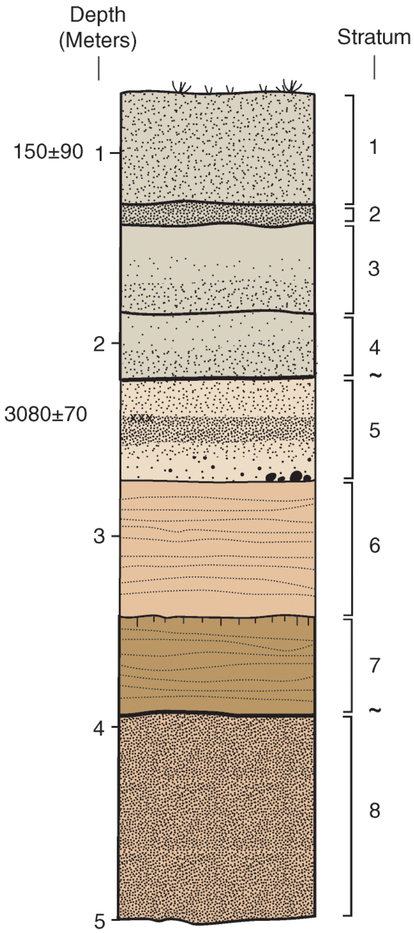


Figure 7. Hf4:
Trench Location 4b.

Trenches excavated into the recent fan (Hf4; Figure 7) at the terminus of Pine Tree Wash revealed that this deposit obscures a portion of the Holocene-age landforms (Hf2 and Hf3). It was clear from the profiles that the recent fan is a unique landform and that its upper profile contains the most recent sedimentary deposit in the area. While strata correlated with Hf2 (Strata 3-7) are buried a meter below the young fan of Hf4, the high-energy deposits of the Hf3 fan (Stratum 8) are buried approximately four meters below the modern surface of the western portion of Hf4.

The stratigraphy of the Hf4 landform, revealed in the TL4a and TL4b trenches, shows complex inter-fingering with adjacent landforms due to the shifting nature of depositional environments. The upper profile (0-1 meters below the surface) consists of gravels and sands of recent fan deposition due to floods emanating from Pine Tree Wash. The middle profile (2-4 meters below the surface) reveals a series of sheetwash and minor floods with deposits similar in character to the adjacent Hf2 distal deposits. This sheetwash may have originated from drainages other than the Pine Tree Wash (e.g., Jawbone or other unnamed washes to the west of the project area). This section of the profile is interesting because it illustrates a pattern of expansion and contraction of the distal reaches of the local fan; this may have implications for the resource productivity of valley-bottom environments. Low energy and/or consistent floods might allow the expansion of paludal marshes, while high energy events, along with associated fan expansions might encroach on once productive wetland habitat. The lowest portion of the profile (> 4.0 meters in depth) reveals high-energy sheetwash and channel flows that are very similar those underlying Hf3.

Overall this landform is deposited by moderate- to high-energy flood regimes that are not conducive to the intact preservation of archaeological sites. Interfingering with adjacent Hf2 occurs in the eastern and north portion of this landform (i.e., portions of the Hf2 landform may be shallowly buried). Due to the overall energy regime of the landform but considering the potential to encounter the buried Hf2 and its high archaeological potential, this Hf4 landform has moderate sensitivity for buried archaeological materials.

HOLOCENE LANDFORM DEVELOPMENT AND ARCHAEOLOGICAL SENSITIVITY

Geoarchaeological reconnaissance and trenching in the Beacon Solar Energy Project Area provides information on regional development of alluvial landforms which has direct implications for assessing archaeological sensitivity of appropriate local environments. Late Pleistocene and Holocene depositional and erosional patterns, separated by long-term stability and soil development, on the Pine Tree Canyon fan are influenced by a number of variables, including regional climate, topography, and tectonics. These processes are also spatially variable with only soil development altering large parts of the alluvial fan and valley bottom at any one time. Deposition and erosion are often localized events, though it is possible to consider general periods of fan progradation versus overall stability.

Figure 8 provides a schematic representation of Late Pleistocene and Holocene progradation on the Pine Tree Canyon fan. The oldest landforms in the project area are the fan segments above and south of the Cantil Valley fault (Figure 8). Although capped by a thin (~1 to 2 meters) veneer of Holocene valley fill, the Hf1 and Hf1d fan segments show Pleistocene fan progradation with deposition extending toward the axis of the valley; old fan deposits are present within the upper five meters of the fan profile in all fan segments except for the most distal reaches (Hf2). In the latest Pleistocene, broad sections of the fan stabilized, resulting in the formation of a now-buried soil profile. Stabilization of the Hf1 fan lasted for several millennia as evidenced by the moderately to strongly soil; the soil was forming prior to 15.3 thousand years ago (PTW-1) and may have continued to form until sometime after 10.9 thousand years ago (TL3-1). Multiple soil profiles in TL3-1 suggest that this overall stability was punctuated by local erosion and deposition. Tectonic movement along the fault may have resulted in deposition shifting toward the north into a deepening basin. Pine Tree Wash, or other fan distributary drainages, continued to scour the fan surface. Silt-filled washes are evident in the profiles of the Hf1 fan (TL3-1 and TL2-1).

Fan progradation continued throughout the late Pleistocene and into the Holocene on fan segments north of the Cantil Valley fault. Input from the uplifted segment of the fan ceased and local deposition was dominated by sheet wash and rilling with punctuated large events. The complex, multi-bedded stratigraphy of Hf3 is evidence of a dynamic, arid-land fan extending toward the valley bottom. The high energy deposits of Hf3 transition and inter-finger with the fine sediments of the distal fan (Hf2). These deposits illustrate episodic flooding from just prior to eight thousand years ago to just after five thousand years ago (TL5a).

Creosote-dominated, Mojave Desert plant communities mark the development of the Holocene landscape in northern Fremont Valley and on the Pine Tree Canyon fan. Axial valley processes with input from fans south of Pine Tree Wash provide erosive floods, scouring the A-horizons from now-buried paleosols, and eventually depositing the sand and silt stratigraphy of the shallow sedimentary veneer of the upper profile of Hf1. In the early Holocene, Pine Tree Wash began its shift toward the east and is eventually captured by the axial wash. This is likely a result of continued tectonic shifting along the Cantil Valley fault.

Drainage incision was underway at about four thousand years ago, when Pine Tree Wash became entrenched on the southern portion of its fan only to make a sharp north turn as it dominated the axial wash of Fremont Valley. As the arroyo of Pine Tree Wash became established, a new distal fan segment formed as the wash debouched onto the down-dropped (north) side of the Cantil Valley fault. A new wedge of sediment began to prograde from the fault toward the valley bottom. This sediment input is combined with the fine distal fan input extending from Hf3 as well as fine sediment impounded at the base of the Jawbone or Cottonwood fan. Radiocarbon dates between 4,000 and 3,000 years ago on non-cultural charcoal and between 1,600 and 700 years ago on charcoal from archaeological hearths suggest that these depositional sequences may be tied to increased runoff reaching the valley bottom, possibly the result of respective high amplitude precipitation events and development of local mesic environments (e.g., valley-bottom marshes) at the onset of the regional Neoglacial (Wigand and Rhode 2002) or in response to the fluctuations of the Medieval Climate Anomaly (Stine 1994). These climatic ameliorations within the generally arid Mojave environment likely influenced prehistoric cultural use of the valley bottom landscape.

Locally mesic landscape conditions in conjunction with low-energy distal fan/valley bottom deposition provide the environments appropriate for prehistoric site formation and subsequent preservation.

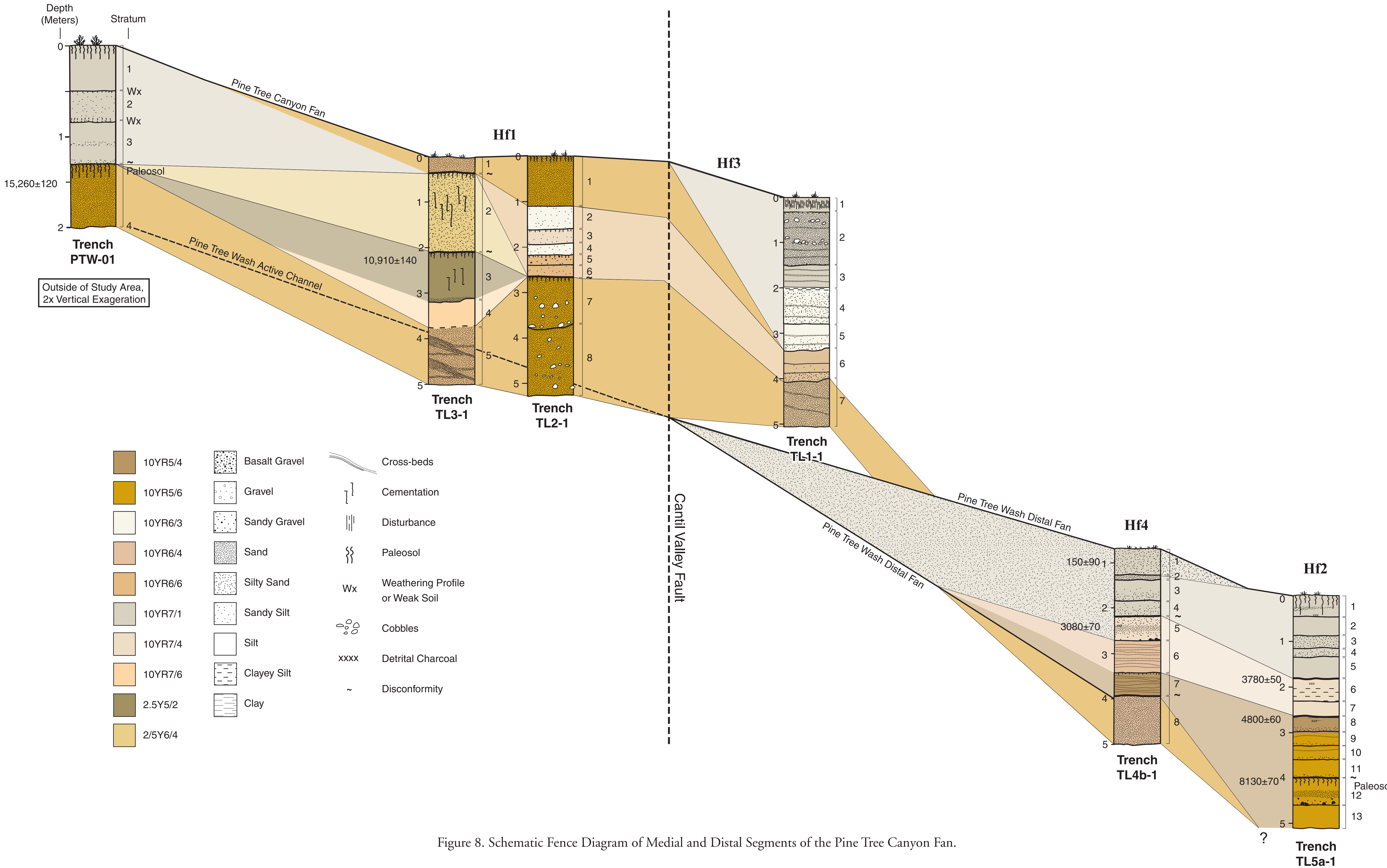


Figure 8. Schematic Fence Diagram of Medial and Distal Segments of the Pine Tree Canyon Fan.

Based on the timing and energy of landform development within and surrounding the proposed Beacon Solar Energy Project, it is possible to evaluate the possibility of encountering buried archaeological sites during project development. Table 3 presents sensitivity conditions for potential preservation of buried sites. The valley bottom landform of Hf2 contains both the resource potential (e.g., water and plant resources) and low-energy depositional sequences where sites are most likely to exist and be preserved. Hf2 is also the only landform segment in which buried sites have previously been documented. For these reasons, Hf2 is ranked with the highest archaeological potential in the project area.

Table 3. Archaeological Sensitivity of Landforms in the Beacon Solar Energy Project Area.

LANDFORM	LANDFORM DESCRIPTION	SENSITIVITY
Hf1	Uplifted fan: Holocene-age fan and wash deposits resting on Pleistocene age fan at 2 meters below surface.	Moderate
Hf1d	Uplifted fan: Holocene-age fan and distributary deposits resting on Pleistocene age fan at 2 meters below surface.	Moderate
Hf2	Distal fan intersection: Holocene-age distal fan environment to depths greater than 4 meters.	High
Hf3	Active slope wash fan: Moderate to high-energy alluvial fan channels and slopewash.	Low
Hf4	Holocene-age to recent fan of Pine Tree Wash	Moderate

Hf1, Hf1d, and Hf4 have moderate potential for holding a preserved and significant archaeological record. Hf1 and Hf1d have a thin veneer of Holocene-age sediment on which the low-productivity Creosote plain has been established for the duration of recent deposition. Although feature-laden sites are rare in mid-fan positions in the Mojave region (Byrd et al. 2005; Sutton et al. 2007), it is expected that those present would be exposed by turbation and localized erosion (alluvial and aeolian reworking) in this relatively active sedimentary veneer. The active and relatively continuous geomorphic processes of fan progradation make the mid-fan segments of Hf3 unlikely to retain a preserved archaeological record. The cobbles and gravels of this landform deposit may provide suitable materials for toolstone acquisition and reduction, or sites may form on surfaces during stable periods, but preservation of site integrity is unlikely. Well preserved sites are not expected in the Hf4 deposit due to the relative high energy of its depositional focus just below the fault; however, this fan segment interfingers with the Hf2 landform, making identification of the geographic boundary between the two landforms (i.e., Hf2 and Hf4) difficult. Therefore, the Pine Tree Wash distal fan of Hf4 has a moderate sensitivity ranking.

The results of trenching and stratigraphic documentation, along with supporting information from the project's radiocarbon record and from the regional climatic record, provide the basis for well-informed management decisions in regard to cultural resources that might be impacted, if present, by construction activities within the Beacon Solar Energy Project Area.

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BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA

APPLICATION FOR CERTIFICATION FOR THE BEACON SOLAR ENERGY PROJECT	DOCKET NO. 08-AFC-2 **PROOF OF SERVICE** (Revised 4/28/09)

APPLICANT Scott Busa Kenneth Stein, J.D. Meg Russell Duane McCloud Guillermo Narvaez, P.E. NextEra Energy Resources 700 Universe Blvd. Juno Beach, FL 33408 Scott.busa@nexteraenergy.com Kenneth.stein@nexteraenergy.com Meg.Russell@nexteraenergy.com Duane.mccloud@nexteraenergy.com Guillermo.narvaez@nexteraenergy.com Diane Fellman, Director West Region NextEra Energy Resources 234 Van Ness Avenue San Francisco, CA 94102 Diane.fellman@nexteraenergy.com	**COUNSEL FOR APPLICANT** Jane Luckhardt, Esq. Downey Brand, LLP 621 Capitol Mall, 18th Floor Sacramento, CA 95814 jluckhardt@downeybrand.com	**ENERGY COMMISSION** Karen Douglas Commissioner and Presiding Member kldougla@energy.state.ca.us Jeffrey D. Byron Commissioner & Associate Member jbyron@energy.state.ca.us Kenneth Celli Hearing Officer kcelli@energy.state.ca.us
APPLICANT CONSULTANT Sara Head, Vice President AECOM Environment 1220 Avenida Acaso Camarillo, CA 93012 Sara.head@aecom.com	**INTERESTED AGENCIES** California ISO e-recipient@caiso.com	Eric K. Solorio Project Manager esolorio@energy.state.ca.us Jared Babula Staff Counsel jbabula@energy.state.ca.us
Bill Pietrucha, Project Manager Jared Foster, P.E. Worley Parsons 2330 E. Bidwell, Suite 150 Folsom, CA 95630 Bill.Pietrucha@worleyparsons.com Jared.Foster@worleyparsons.com	**INTERVENORS** Tanya A. Gulesserian Marc D. Jacobs Adams Broadwell Joseph & Cardozo 601 Gateway Boulevard, Suite 1000 South San Francisco, CA 94080 **E-MAIL PREFERRED** tgulesserian@adamsbroadwell.com	Public Adviser's Office publicadviser@energy.state.ca.us

Declaration of Service

I, Sophia Rowlands, declare that on May 18, 2009, I served and filed copies of the attached **Landform Structure and Archeological Sensitivity in the Beacon Solar Energy Project Area.** 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: www.energy.ca.gov/sitingcases/beacon. The document has 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;

_____ 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.

AND

For Filing with the Energy Commission

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

OR

_____ depositing in the mail an original and 12 paper copies as follow:

California Energy Commission
Attn: Docket No. 08-AFC-2
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.

____
Shawn Prentiss

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