# A GEOARCHAEOLOGICAL LANDSCAPE PERSPECTIVE ON EARLY HOLOCENE RAPID AND DEEP SITE BURIAL ON THE CALIFORNIA COASTAL PLAIN

CHARLES M. HODGES
PACIFIC GEOARCHAEOLOGICAL SERVICES, SEATTLE, WASHINGTON

*Recent archaeological testing and data recovery excavations at CA-SBA-1547 along the central California coast on Vandenberg Air Force Base included the discovery of deeply buried archaeological materials dating to 10,900-10,600 cal B.P. The early component of the site is buried under more than 8 ft. of alluvial fan sediments that accumulated during an active construction period commencing sometime around 10,600 years ago and attenuating by about 8,000 years ago. These fan sediments now underlie the modern surface of the coastal plain. The depositional sequence encapsulating the site offers an unparalleled opportunity to reflect on the extent, variability, and formation history of buried landscapes associated with the Late Pleistocene-Holocene transition and Early Holocene archaeological record along the California central coastal plain in light of rapid geomorphic response to postglacial climate change.*

## LOCATION AND GENERAL SETTING

The archaeological site SBA-1547 lies at the back of a narrow coastal plain on Vandenberg Air Force Base (VAFB), just southeast of Point Arguello. This section of coastline is at the western end of the western Transverse Ranges physiographic subprovince. Point Arguello is the northern margin of the larger California continental borderland province (Figure 1), which extends south from Point Arguello to Cedros Island off the coast of Baja California, Mexico (Chaytor et al. 2008; Crouch 1979; Hanson et al. 1994). The section of coastline beginning at Point Pedernales, 3 km north of Point Arguello, and extending south to San Clemente Island in the Santa Barbara Channel, is particularly noteworthy for well-preserved flights of marine terraces associated with rapid tectonic uplift of the western Transverse Ranges due to compression accompanying crustal rotation (Chaytor et al. 2008; Warrick and Mertes 2009). In the immediate vicinity of Point Arguello, the coastal plain is underlain by an extensive marine platform ranging in elevation from 15 to 60 m above present sea level (Figure 2). Dissected remnants of older uplifted platforms are locally preserved nearby at higher elevations.

The bedrock geology immediately surrounding the site is dominated by the upper member of the Miocene-aged Monterey Formation (Figure 3). This formation consists primarily of hard, laminated, platy, siliceous shale beds interbedded with soft, thin-bedded shale and limestone (Dibblee 1950; Dibblee 1988), and comprises the lower flanks of the mountains immediately north of the site (Tm and Tml? on Figure 3). Farther north, some volcanic rocks outcrop at higher elevations on the flanks of Honda Ridge leading up to Tranquillon Mountain. Even though the wave-cut marine platform exposed in the sea bluffs along the coastline near the site is underlain by tilted and deformed rocks of the Monterey Formation, just inland a section of horizontally bedded rock at the back of the marine platform is exposed in a railroad cut just west of the site (Figure 4).

The coastal plain in the southern portion of VAFB south of Honda Canyon also is underlain by variably thick Quaternary alluvial deposits overlying a marine platform (Johnson 1984, 1989; Woodring and Bramlette 1950). Older alluvium (map unit Qao) mantles higher uplifted marine platforms immediately north of the site area, while the site itself is in sediments mapped as younger alluvium (Qa) that buries the underlying wave-cut marine platform. The coastal plain surface dips seaward to the southwest and exhibits gently rolling to subdued local relief. The archaeological site is at the upper

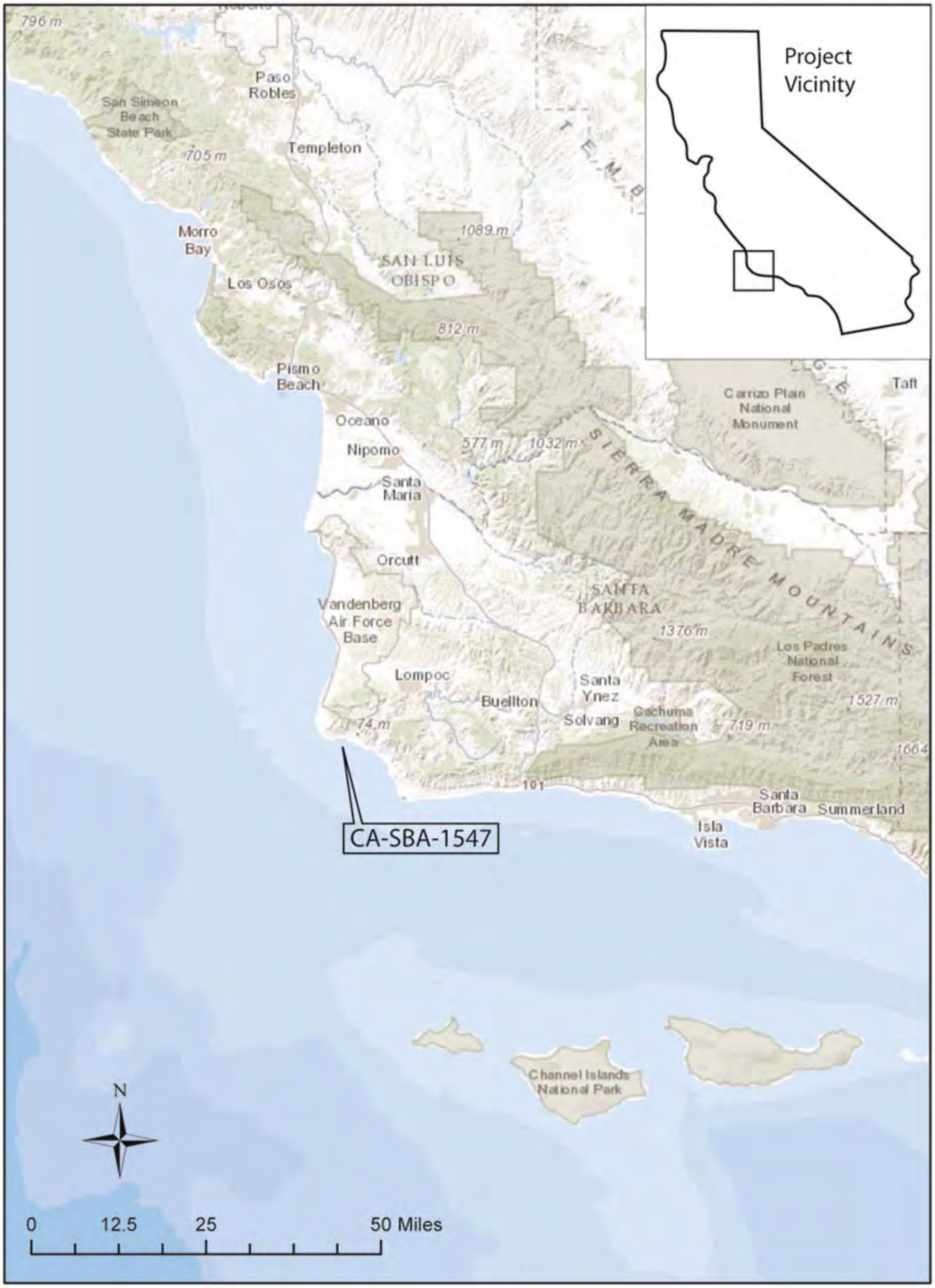


*Figure 1. General location of CA-SBA-1547 along the California coast.*

*Figure 2. View north along the sea bluff south of the site, showing alluvial fan deposits overlying wave-cut platform of deformed Monterey Formation rocks.*

(north) margin of the coastal plain at the mouth of a small, steep-gradient, unnamed basin just west of Oil Well Canyon (Figure 5). The basin is wholly contained in Monterey Formation rock.

The gully that exposed the site formed as a result of modern land use. Due to culvert installation under the railroad tracks, the gully does not align with the current mouth of the unnamed drainage because the gully is not coupled directly to discharge from the drainage basin. Destabilization at the head of the fan, and the resulting gully formation, has been caused by routing higher amounts of runoff, with concomitant higher discharge velocities, from Coast Road through the culvert under the railroad onto the coastal plain surface at the head of the gully. Sheetwash deposits containing reworked archaeological materials at the mouth of the gully are expressed as a set of elongate, linear or levee-like, low-lying landforms extending from the mouth of the gully to the coastal bluffs.

Minor inflections in contour lines indicate the gully and the archaeological site are at the head of a small alluvial fan which joins the western margin of a larger alluvial fan extending from the mouth of Oil Well Canyon. Whereas the Oil Well Canyon fan exhibits a well-expressed fan channel extending the length of the fan, the smaller fan expresses a relatively smooth surface unmarked by continuous up-dip or down-dip inflections in the contour lines that would indicate locations of former fan channels.

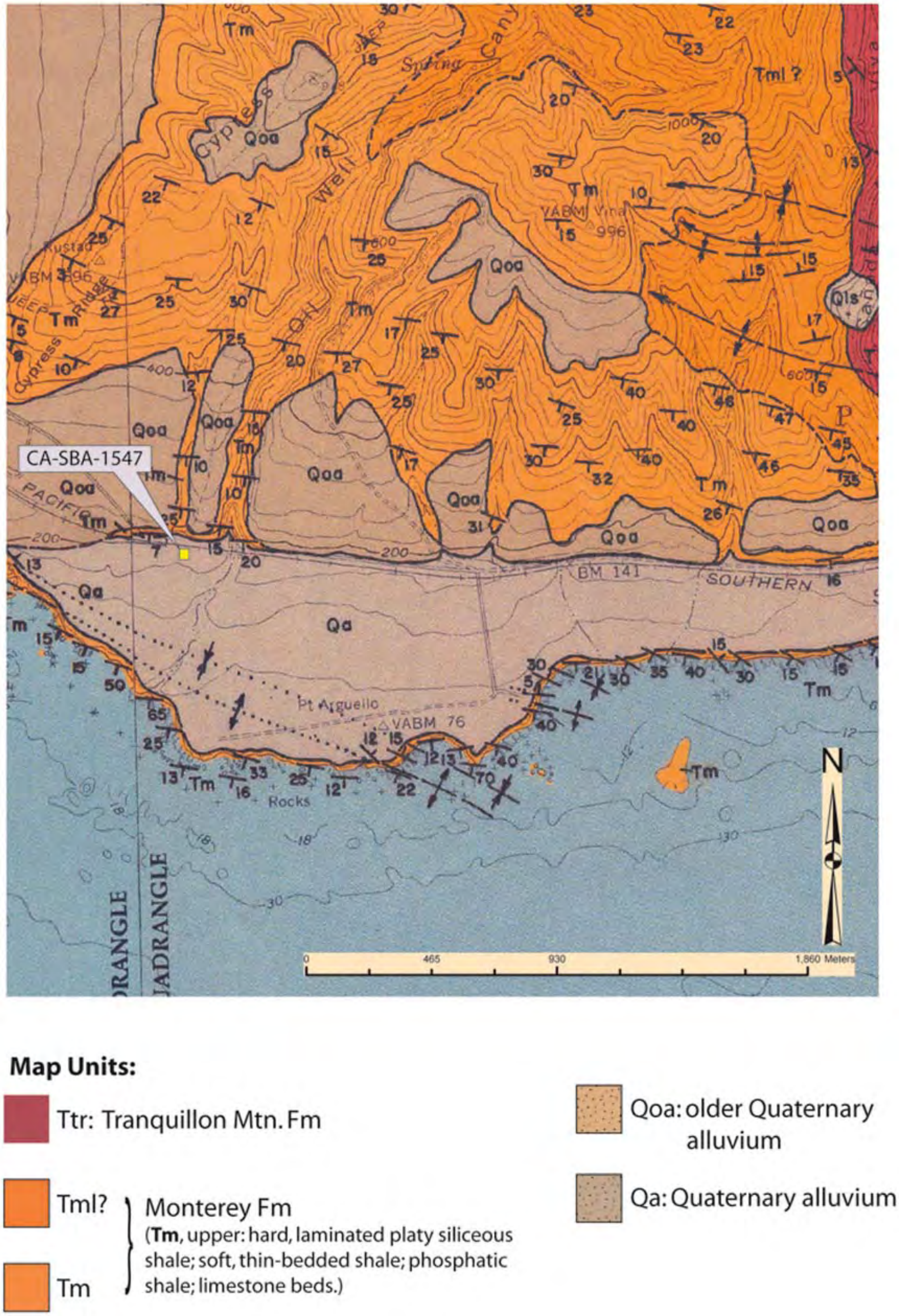


*Figure 3. Local geology in the site vicinity (modified from Dibblee 1988).*

*Figure 4. View of railroad cut showing horizontally bedded Monterey Formation rock just west of CA-SBA-1547.*

## OBJECTIVES AND METHODS

One goal of the geoarchaeological field investigations, in addition to determining the physical context of the archaeological materials, was to develop a preliminary historical model of landform development applicable to this section of the central California coast. The long-term objective for building such local site-specific models is to eventually build a regional historical perspective relating to the various physical contexts and depositional trends that inform on Holocene human-land relationships since the end of the last glacial maximum about 16,000 years ago. The methodology used in order to build this site model combines lithostratigraphic and allostratigraphic relationships (for example, see Heinrich 1993; Räsänen et al. 2009). The depositional sequence within the site boundaries was classified based on the recurrence of discrete sedimentary depositional units called facies (also called lithofacies or facies types). These facies were the fundamental units around which the observations and analyses were organized, and are the smallest observable depositional units that form under specific conditions of sedimentation in a particular depositional setting (Teichert 1958). Facies analysis, which is the basis for interpretations of landform history, depends on the observation that changes in a conformable vertical succession of facies in a depositional sequence represent lateral changes in the depositional environment over time (Miall 2000); that is, in a conformable vertical succession, the facies that occur together in vertical succession are those that occurred side by side in nature (Middleton 1973).

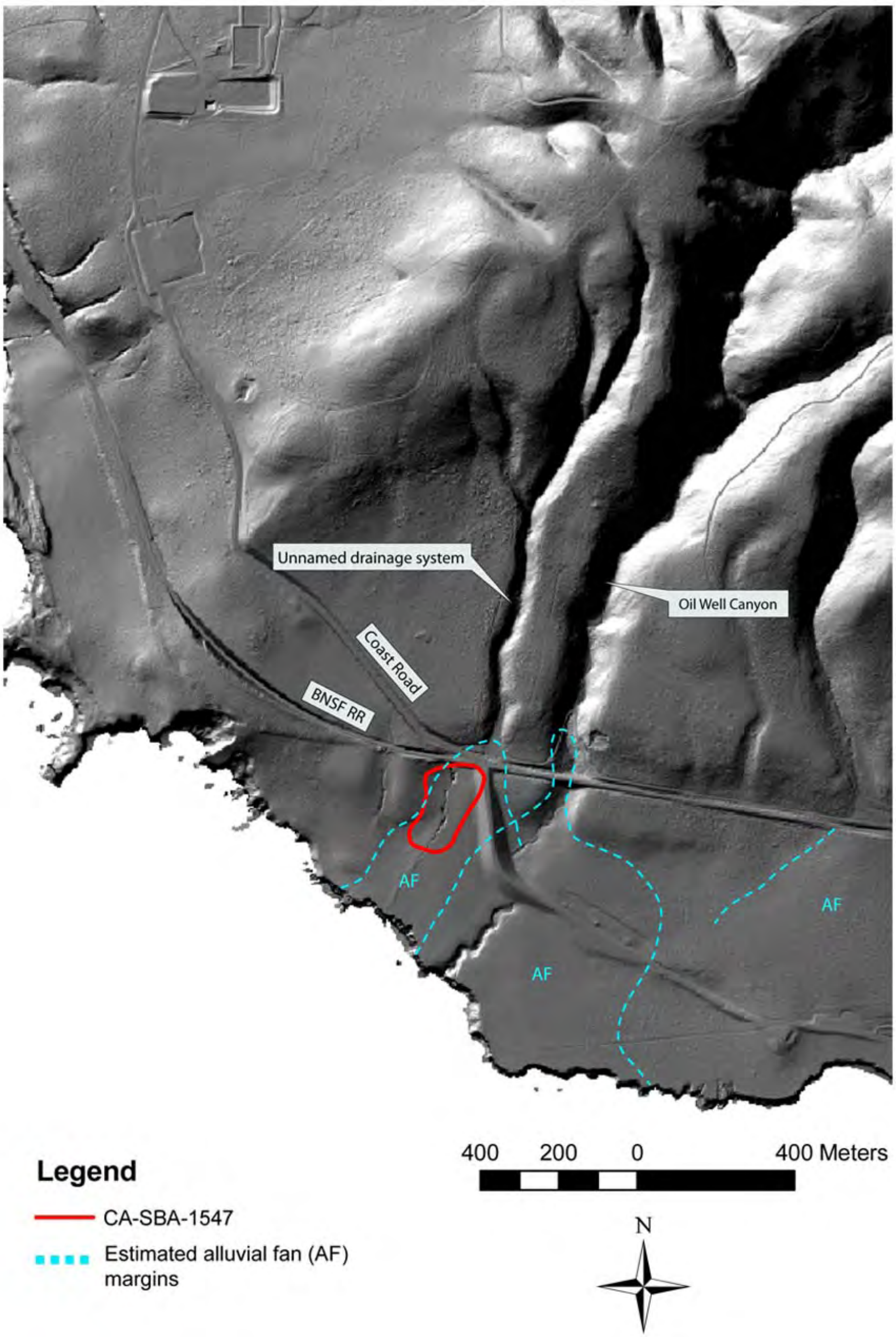


*Figure 5. LiDAR image showing site location relative to local geomorphic features (image courtesy of VAFB).*

*Table 1. Facies nomenclature system.*

| MODAL GRAIN SIZE | SECONDARY PROPERTIES |
|---|---|
| G – gravel<br>S – sand | g – gravelly<br>s – sandy<br>x – cross-bedded<br>y – cemented (gypsum) |

The facies types are identified by a simple two-part code in which a capital letter represents the dominant or modal grain size of the facies (G for gravel and S for sand), and lowercase letters denote distinctive secondary characteristics such as textural or other sedimentary properties (for example, s for sandy or y for cemented) (Table 1). As necessary, the sand fraction is further subdivided into grain-size classes designated by a prefix in front of the S. Thus, a gypsum-cemented gravelly coarse sand is coded as cSgy.

Sediment grain size was determined in the field by hand-texturing and classified using the Udden-Wentworth system (Birkeland 1984; Boggs 1995; Friedman and Sanders 1978). Although soil horizon sequences were not delineated, selected soil features were described following standard Natural Resources Conservation Service nomenclature (Schoeneberger et al. 2002; Soil Survey Staff 1993, 1999).

## RESULTS

Three archaeological excavation units (EXU) were described in detail and drawn to scale (Figure 6). Broader site-scaled depositional contexts were provided by using 18 cutbank profiles approximately evenly spaced along the length of the gully (Figures 7 and 8). The total length of the gully is about 300 m, and is divided into upper (UG) and lower (LG) sections where a cattle trail crosses the shallowest portion of the gully about 70 m below the railroad culvert. Field investigations in the upper gully section employed the three EXU (EXUs 1, 3, and 4) and six cutbank profiles (UG 1 through UG 6). The lower gully section is 230 m long and was characterized with 12 cutbank profiles (LG 1 through LG 12).

### Stratigraphy and Depositional Systems

The bulk by volume of the deposits exposed in the gully walls is poorly sorted, gravelly and sandy alluvial fan deposits. Both the sand and gravel fractions comprising the fan deposits exhibit poor sorting with very poorly expressed bedding exposed in places along the gully walls, predominantly in the lower (downstream) section of the gully where the bedding is expressed primarily as slight variations in the ratio of gravel to sand content. The gravel-sized fraction is poorly sorted, and clasts are supported in a sandy fabric with very little silt content. Tabular-shaped clasts larger than about 8 cm long tend to be oriented horizontally to subhorizontally with respect to presumed bedding planes. Nearest the mouth of the culvert upstream from the focus of the archaeological data recovery investigations is an exposure of weakly cemented medium to coarse dune sand, and in the lower gully section, bedrock, well-cemented marine sediments, and weakly cemented pebbly and sandy dune sediments are exposed.

A total of seven facies types grouped into four strata were identified during the course of field investigations (Table 2). The following discussion begins with the basal Stratum IV.

#### *Stratum IV*

Stratum IV is bedrock of the Monterey Formation exposed in the lower gully between cutbank profiles LG 7 and LG 10 (Figures 7 and 9). This bedrock is the surface of the same wave-cut marine platform visible in the sea cliff farther south (Figure 2).

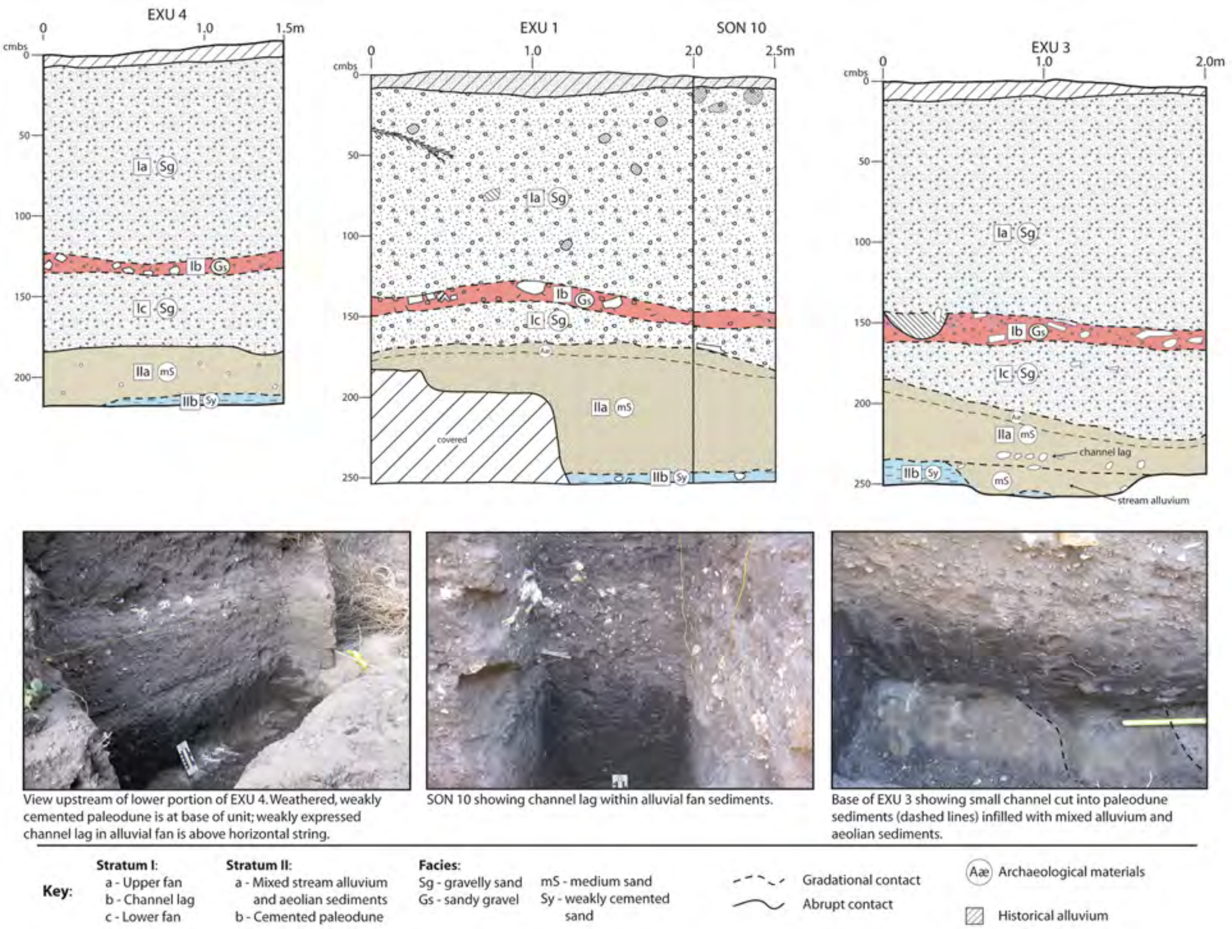


*Figure 6. Detailed section drawings of archaeological excavation units in the upper portion of the gully.*

*Stratum III*

This stratum consists of stratified, well-cemented, well-sorted granules in a well-sorted medium sand matrix (Sgxy) (Figures 7 and 10). In most of the gully exposure between LG 8 and LG 9, the granules are arranged in well-defined low- and high-angle, south-dipping (seaward) bedding planes which become less well-defined the farther one proceeds upstream. The seaward-dipping beds and the well-sorted sediments suggest that this stratum may represent a location within an upper foreshore beach zone where wave energy was high. Upstream (north), this facies grades into medium sand (mSy) and pebbly sand (mSgy) facies that form the southern extent of Stratum II. The transition may represent a shift from the upper foreshore and backshore zone to washover and dune sediments accumulating behind a small beach ridge.

*Stratum II*

Stratum II consists of three facies variously exposed along the length of the gully (Figures 7 and 8). In the lower gully section between LG 9 and LG 12, the best exposure of this stratum is in the vicinity of LG 9 and is expressed as a well-cemented medium sand (mSy) with few dispersed pebbles. Beginning in the vicinity of LG 10 and extending upstream to LG 12, this sandy facies grades into a pebbly, also well-cemented sand (mSgy) that incorporates increasing amounts of pebble-sized angular gravel

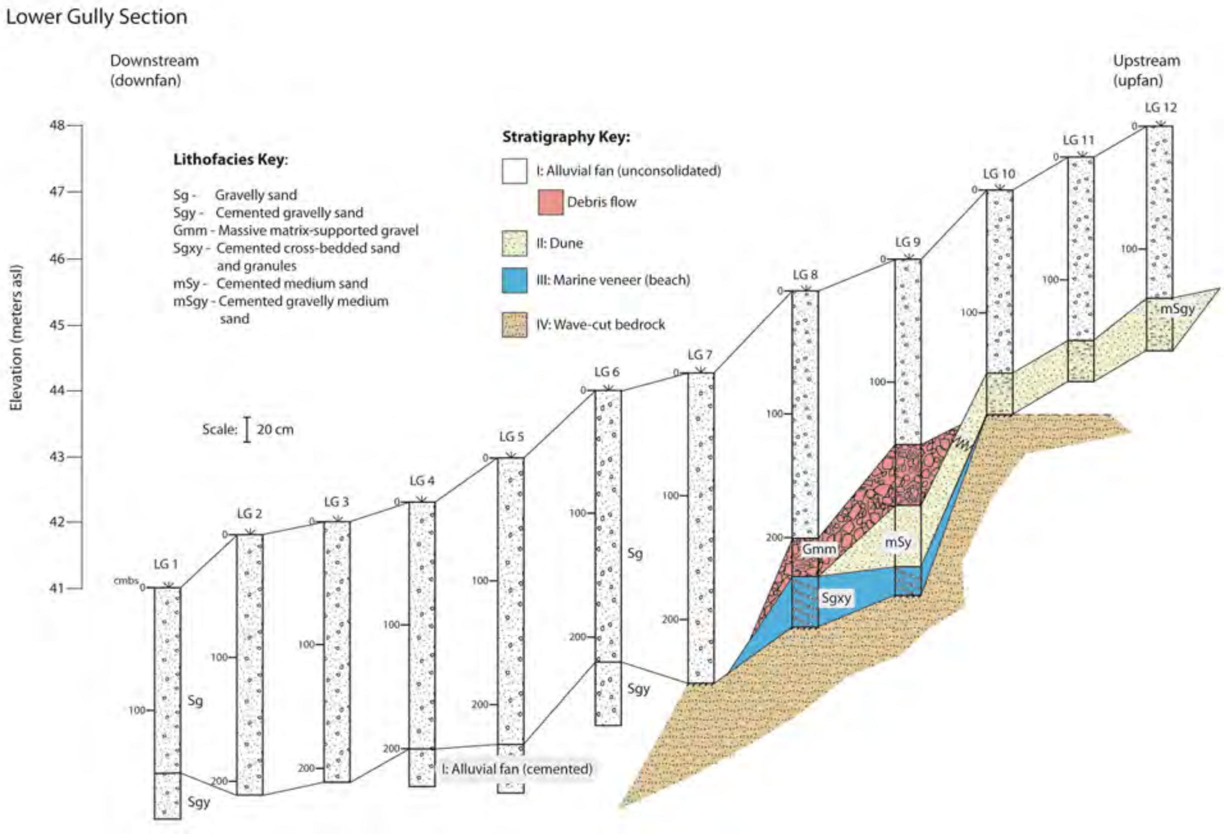


*Figure 7. Section showing lithofacies and stratigraphic relationships among deposits in the lower gully (see Figure 8 for graphical log locations).*

dispersed throughout the matrix. Though well-cemented, the mSgy facies is easily eroded, as evinced by numerous corrasion potholes eroded into its upper surface by stream flow in the gully.

In the upper gully section (Figure 8), another facies of Stratum II is exposed at the base of the archaeological excavation units as a well-sorted sand (Sy) exhibiting varying degrees of cementation depending on the amount of local soil moisture content. Horizontal exposures of this facies in the archaeological units revealed polygonal patterning defined by a neutral gray-colored clayey matrix. The clay texture and patterning suggest lateral and vertical migration and diffusion of the cementing agent binding the sand, probably as a result of wetting and drying of the matrix. Cemented sand associated with Stratum II is exposed continuously along the gully walls from the vicinity of EXU 3 to just below the mouth of the culvert, and the upper bounding contact rises rapidly in elevation in the gully walls along this distance.

A narrow, shallow channel cut into Stratum II was exposed in the base of EXU 3 in the upper gully (Figure 6). The channel is infilled with moderately well-sorted medium sand, and the fill is capped by channel lag. Unfortunately, the channel bed associated with this upper lag could not be defined, due to weathering and de-cementation of the Stratum II matrix. The matrix above this lag deposit is medium sand with few dispersed rounded and subrounded granules and fine pebbles that shifts upward into the more poorly sorted matrix and exhibits an increase in angular medium pebbles of the overlying Stratum I. Archaeological materials are found at the top of Stratum II, just below the first appearance of the angular pebbles of Stratum I. Based on the quality of exposure, this sequence is interpreted to represent stream flow, probably intermittent, in an inter-dunal topographic low. The paleochannel fill and the matrix overlying the channel lag deposit are probably a mix of aeolian sediment reworked by low-amplitude

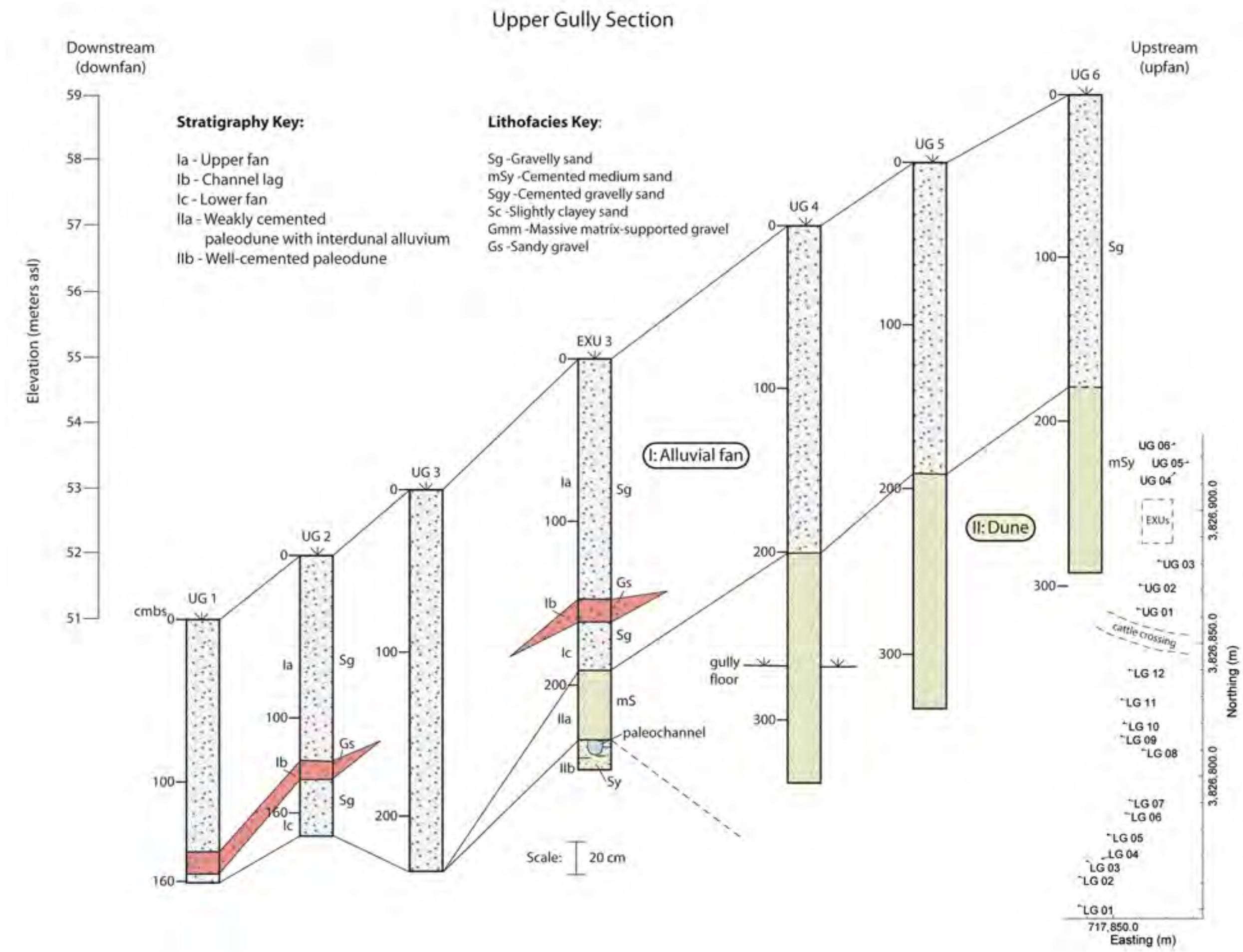


*Figure 8. Section showing lithofacies and stratigraphic relationships among deposits in the upper gully.*

*Table 2. Facies composition of gully stratigraphy.*

| STRATUM | FACIES TYPES | COMMENTS AND INTERPRETATION |
|---|---|---|
| I | Sg: Gravelly sand; gravel fraction is poorly sorted, fabric-supported, and ranges in size from angular to subangular granules to small cobbles.<br>Sgy: Cemented Sg.<br>Gs: Sandy gravel; occurs in short discontinuous segments along both gully walls in upper gully section.<br>Gmm: Poorly sorted, fabric-supported gravels in muddy matrix. | Alluvial fan deposits. Lithofacies Gs, where it occurs, divides the alluvial fan deposits into upper and lower fan; cemented fan deposits (Sgy) are more common at the base of the fan sequence in the lower gully section. |
| II | mS: Medium sand.<br>mSy: Cemented medium sand.<br>mSgy: Cemented gravelly medium sand; gravels are mostly angular pebbles. | Dune deposits. Cementation varies from strong to weak in upstream direction and in relation to matrix moisture content. |
| III | Sgxy: Cemented cross-bedded gravelly sand. | Marine terrace veneer. Rests directly on bedrock in lower gully section. |
| IV | Bedrock | Top of uplifted wave-cut platform. |

*Figure 9. Close-up view of exposed Monterey Formation rock at top of wave-cut platform.*

stream flows. The increase in angular pebbles at the upper bounding contact of Stratum II in this locality indicates the burial of this local landscape feature by Stratum I fan construction.

*Stratum I*

By far the greatest volume of the site landform is comprised of the various facies of Stratum I. The facies include a minor debris flow deposit (Gmm) exposed in the lower gully; a thin, poorly defined concentrated layer of cobbles (Gs) occurring in the upper gully section marking the thalweg of a shallow fan channel; and, comprising the majority of the stratum, poorly sorted gravelly sand that exhibits varying amounts of cementation (Sg and Sgy) (Figure 11). Cementation of the Sg facies is better expressed in the lower gully (Sgy), but in general, the basal portions of Stratum I are cemented well enough to form small benches outcropping locally along the gully walls for the length of the gully.

The debris flow deposit (Gmm) is exposed in the lower gully in the left bank just above the point where the gully floor intersects the modern surface. This facies consists of poorly sorted pebbles and cobbles supported in a muddy matrix, and occurs in two locations just above the floor of the gully, resting directly on the upper bounding contacts of both Strata II and III. The lateral extent of exposure for this along the cutbank is short, and the debris flow does not extend to the right bank of the gully.

The layer of concentrated gravels (Gs) is exposed intermittently along both of the gully walls in the upper gully section and divides the alluvial fan deposits vertically into upper and lower substrata. Although this facies contains a greater number of cobble-sized clasts than the fan deposits above and

*Figure 10. Close-up of marine veneer sediments resting on the wave-cut terrace.*

below, the lack of grain-to-grain contact suggests that this was deposited as a hyperconcentrated flow, which is characterized by high concentrations of sediment but low levels of suspended fines. Hyperconcentrated flows fall between water floods and debris flow, with the low level of fines permitting the flow to maintain separate flow velocities for sediment and water (Costa 1988; Smith 1986).

As noted previously, the bulk of the alluvial fan is comprised of gravelly sand (Sg) which exhibits varying degrees of cementation (Sgy). Both the sand and gravel fractions in these sediments are poorly sorted, though sorting within the sand fraction tends to be slightly better and restricted to a size range between medium and coarse. Except in a few places (Figure 11), bedding is absent or can be discerned only as poorly defined, short, discontinuous lenses containing greater or lesser amounts of sand. Generally, the only indication of bedding is that larger, tabular-shaped clasts tend to rest in horizontal or slightly subhorizontal orientations, marking places where these particles came to rest during deposition. In addition, pedogenic features associated with the presence of buried soils, and so indicating periods of landscape stability, are absent. Soil development is limited to the upper near-surface portion of the alluvial fan deposits, and soil horizon differentiation in the modern soil profile is weak to nonexistent. The A horizon is over-thickened, especially in the upper gully, indicating the modern A horizon is a cumulic horizon formed by incorporating ongoing thin, incremental deposits of sediment during the waning stages of fan construction. Overall, the cumulic modern A horizon and the lack of buried soils in the alluvial fan depositional sequence suggest that early fan construction was characterized by high rates of sediment influx which attenuated over time.

Another instance of channel lag, Gs (Stratum I)(arrowed), exposed in EXU 3 on left bank of the upper gully.

Shallow channel lag (thalweg), Gs (Stratum I), exposed in upper right bank in the upper gully.

Debris flow, Gmm (Stratum I) (arrowed), resting on marine sediments of Stratum III in the left bank of the lower gully.

Bench of cemented fan, Sgy in Stratum I (arrowed), exposed at base of fan on left bank of lower gully. Note horizontal orientation of larger tabular clasts, bedding exposed by differential erosion (lower right foreground), and base of soil in upper section (dashed line).

*Figure 11. Photographs of various aspects of the alluvial fan sediments (Stratum I).*

## Stratigraphic Context of the Archaeological Materials

In most places along the gully, the contact between the aeolian sediments of Stratum II and the overlying alluvial fan sediments of Stratum I is easily demarcated, though the contact is often gradational, being marked by a gradual increase in poorly sorted gravels indicating the arrival of alluvial fan sediments. This contact, however, is more subtle in the vicinity of SON 10 and EXUs 1 and 3 in the upper gully (Figure 6; Table 3) due to de-cementation and weathering of Stratum II as a result of gully formation.

In spite of this, archaeological materials in EXUs 1, 3, and 4 are found in a well-demarcated zone just below and at the beginning of the shift from Stratum II to Stratum I. Though low-level contacts among facies are lacking, as distinct from the higher-level bounding contacts for the strata, the matrix of the weathered, de-cemented upper sediments of Stratum II can be distinguished by the overall better sorting of the sand fraction, the presence of few gravels, and the fact that the gravels that are present tend to be rounded and range in size from granules to fine pebbles (2-8 mm). The presence of these gravels can be accounted for by fluvial transport, and because of the low bulk density and greater surface area of the shale particles, also by near-surface aeolian transport as bed load or saltation load. In contrast, the Stratum

*Table 3. Summary descriptions of facies types for EXUs 1, 3, and 4, left gully wall.*

| STRATUM | FACIES | DESCRIPTION | INFERRED DEPOSITIONAL ENVIRONMENT |
|---|---|---|---|
| Ia | Sg | Very dark gray (10YR 3/1 mr*) very poorly sorted silty gravelly medium to coarse sand. Highly bioturbated. Stains fingers but no soil structure. Massive, loosely consolidated. Cumulic soil with incremental up-building. Gravels are predominantly angular medium to large pebbles, few cobbles, mostly shale. | Upper fan. |
| Ib | Gs | Very dark brown (10YR 2/2mr; 10YR 3/3dr) medium to coarse sand gravel. Gravels are predominantly dispersed but exhibit concentrations in places along gully walls. Overall distinct lithology and sedimentology from units above and below. Tends to be weakly cemented and forms bench near the gully floor or as the gully floor farther downstream. | Channel lag of shallow alluvial fan paleochannel. |
| Ic | Sg | Very dark gray (10YR 3/1 mr) very poorly sorted silty gravelly medium to coarse sand. Highly bioturbated. Stains fingers but no soil structure. Massive, loosely consolidated. Cumulic soil with incremental upbuilding. Gravels are predominantly angular medium to large pebbles, few cobbles, mostly shale. | Lower fan. |
| IIa | mS | Dark brown (7.5YR 3/3mnr) slightly gravelly mostly medium sand with very slight amount of silt – slightly stains fingers. Gravels are predominantly rounded to subrounded ranging in size from granules to fine pebbles with few angular medium pebbles; mixed lithology (lithic and diatomite shale). Upper portion contains archaeological materials. Upper gradational bounding contact. | Intermittent stream alluvium; inter-dune wetland. |
| IIb | Sy | Reddish brown (5YR 4/3mnr) sandy clay with few dispersed weathered cobbles of shale and cherty shale; cobbles appear to be weathered in place. Polygonal pattern of leached white clay (weathered gypsum cement) which also coats cobbles and infills tubules. Sand fraction is moderately well sorted and is mostly fine to medium. Upper bounding contact is conformable. | Weathered paleodune; cemented. |

*m = moist; r = rubbed; nr = not rubbed.

I matrix is well-demarcated by the increase in poor sorting overall, as well as in both the sand and gravel size fractions, accompanied by an increase in the size and angularity of the gravel-sized clasts.

Given the above considerations, the archaeological deposits are considered to be in primary provenience, and appear to have been deposited in a sheltered area in a topographic low in a field of low-lying dunes. The timing of the occupation appears to have just prior to initiation of fan construction, with the latter induced by either a shift in climate or a change in basin characteristics due to tectonic uplift.

## DISCUSSION

Since the Stratum I alluvial fan sediments comprise the bulk of the site landform, this section briefly reviews geomorphic processes and lithostratigraphy of alluvial fans. In particular, focus is on the formation of a certain type of alluvial fan known as a sheetwash or sheetflood fan.

### Alluvial Fan Construction Processes

Alluvial fans commonly form in areas of high relief, most commonly at changes in gradient where tributaries leave the mountain fronts or valley walls. Fans tend to be cone-shaped and radiate downslope from the point where the stream channel emerges from the mountain front. The two main conditions controlling the formation of alluvial fans are the sudden change in slope, leading to deposition, and intermittent stream flow; the latter may be a result of heavy seasonal rainstorms, or the melting of snow in higher mountains with the onset of summer. The main cause for the deposition of debris on alluvial fans is the decrease in depth and velocity of water flow as the water spreads over the fan surface from its apex. The modes of sediment transport vary widely, ranging from streamflow to watery mudflow to viscous debris flows, but stream flow and debris flow dominate. The relative importance of these processes varies greatly from one fan to another and may vary significantly through time on any individual fan.

Sediments transported by stream flow are deposited as sheetflood deposits, channel deposits, or sieve deposits (which form when the fan surface is sufficiently permeable to allow complete infiltration of stream discharge). Debris flow deposits are poorly sorted but occasionally show crudely graded bedding. In more fluid debris-flow deposits, graded bedding is common and flat pebbles are more or less horizontally oriented (Dohrenwend 1987; Easterbrook 1993; French 1987).

Sheet floods can originate either as a result of flashy (high-intensity, short-duration) rainfall or from longer-duration, lower intensity rainfall or snowmelt (Blair 1999a:1026). The transformation of a sediment-charged flash flood in the catchment to a sheet flood on the fan is caused by the loss of lateral confinement of the flood when it reaches the active depositional portion of the fan, as a response to control exerted by the geometry of the fan surface (Blair 1999b:930). Deposition then occurs because the flow widens into shallow sheets accompanied by decrease in water depth and velocity of flow (Boggs 1995:300). The presence of fine sand and silt in these deposits is often the result of reworking and admixing of other sediments by aeolian processes between flood events. The lithology of the basin feeding the fan also affects whether fan formation will be dominated by sheet flow or debris flow. Particularly when basin weathering products are dominated by coarse sand and gravel, the transformation of colluvium into debris flows is rare (Blair 1999c:1026).

Stratigraphic relationships on alluvial fans can be quite complex, due to the continually changing pattern of channels and loci of deposition. Channel shifts (avulsion) may occur within a single flood or over the course of several successive floods, but channel shifting occurs primarily due to progressive filling and overflow of channels, so that over the long term fan form is maintained by the wide distribution of material over the surface (Cooke et al. 1993). However, the exact location of channels through time is indeterminate, and channel migration is best modeled as a stochastic process (Field 2001:93).

Overland flow is a critical component of the channel avulsion process, because the stream flows that overtop the banks of a channel during flood are located at the top of the water column and are thus relatively clear, devoid of bed load, and capable of erosion. Once out of the channel, any sediment carried by the overland flow is deposited rapidly at the channel and in the sheetflood zone margins in response to flow expansion.

In light of the above remarks, the slight variability in the gravel-to-sand ratios in the Stratum I Sg and Sgy facies exposed along most of the gully walls, coupled with the lack of clearly expressed channel infills and channel lag deposits, suggests the fan was constructed primarily by thin, sediment-laden water flows that were distributed widely across the surface of the fan. Besides variability in water flow across the surface, which would preferentially deposit coarse and fine-grained material depending on the strength of the flow, another process accounting for the slight variations in the gravel:sand content ratios is aeolian reworking and short-distance transport of surface sediment immediately following deposition.

The presence of debris flow deposits (Gmm) near the mouth of the gully, though included as a facies within Stratum I, suggests this deposit represents a large, high-magnitude event perhaps emanating from Oil Well Canyon and due to mass wasting of weathered Tranquillon Formation volcanic rocks from the upper slopes of Oil Well Canyon. The fact that the facies directly rests on Strata II and III, and is overlain by the Sg facies of Stratum I, indicates the debris flow was deposited before the Stratum I fan proper reached the lower gully area. If so, this suggests that Oil Well Canyon fan construction may have commenced prior to the site alluvial fan.

The channel thalweg facies, Gs, intermittently exposed in the upper gully walls, can be interpreted as a hyperconcentrated flow within a poorly defined channel during a larger-than-usual flood emanating from the unnamed drainage. Following Blair (1999a, 1999b, 1999c), and accounting for the

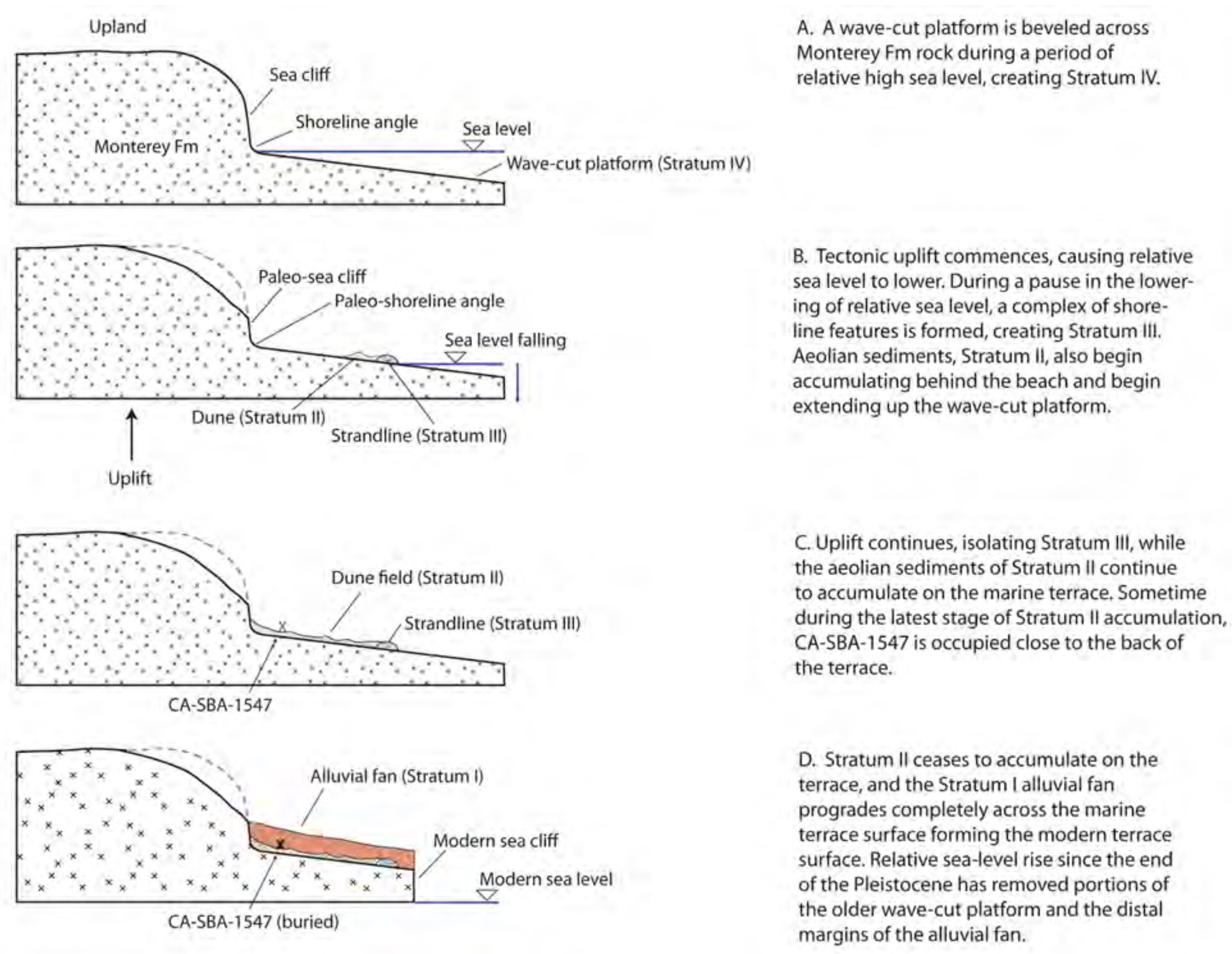


*Figure 12. Model of proposed depositional sequence for the site area.*

small size and marine shale lithology of the basin, this facies can be interpreted as a rare flash-flood event that carried channelized, sediment-rich water farther than usual out onto the fan surface.

**Landform History**

The strata underlying the alluvial fan deposits (Strata II, III, and IV) represent a long period of landform evolution prior to the construction of the Stratum I alluvial fan and human occupation of the coastal plain. Though based on the relatively small exposure afforded by the gully, enough depositional contexts and trends were observed to permit a preliminary reconstruction of the landform history along this section of coastline (Figure 12). As more exposures are examined by later researchers, this model will undoubtedly be refined, but this early stage of model construction is critical to support development of archaeological sampling methods to find early Holocene human occupations along this section of the California coastline.

The history of the landform begins with formation of a wave-cut terrace (Stratum IV) beveled across Monterey Formation rock during a time of higher relative sea level. During this time, a paleo-sea cliff was created that is now expressed as the well-defined linear mountain front immediately north of the archaeological site above (north of) Coast Road.

As relative sea level lowered due to either tectonic uplift of the western Transverse Ranges or global sea level lowering, the wave-cut terrace became exposed above sea level and the shoreline retreated down the platform. Periodic pauses in uplift would have created suites of shoreline features representing the location of sea level during those stillstands. Stratum III is interpreted to represent such a beach complex formed during a pause in sea-level lowering.

At the commencement of uplift, and as it continued, wind-blown sand accumulated behind the retreating shoreline and probably formed a low-lying dune field, Stratum II, behind the shoreline. As in the present-day dune field on San Antonio terrace to the north, topographic lows between dune hillocks would have been characterized by higher moisture levels, or even held small ponds, due to the reservoir capacity of the dune sand. The accumulation of aeolian sediment, mixed with occasional alluvium due to overland flow or intermittent stream flow out of the basin to the north, appears to have continued up to the time of the transition from the end of the Pleistocene to the Holocene. As climate conditions shifted to those characteristic of the full onset of the Holocene, aeolian deposition ceased and a small alluvial fan began prograding the terrace surface.

The lowest component of the archaeological site represents an occupation during the last stages of this transition to the Holocene (10,900-10,600 cal B.P.), and is located on the margins of a topographic low in the dune field at the back (north) of the terrace. The shallow channel was incised into cemented dune sand and subsequently infilled with alluvial and aeolian sediments. This suggests that the site location was along an intermittent channel. The rapid rise in elevation of the upper bounding contact of Stratum II to the north and the lack of topographic highs at similar elevations in Stratum II to the south also suggest the inhabitants had a relatively unobstructed view east along the mountain front and south over the coastal plain.

## CONCLUSION

Although this is only a local, and preliminary, study of the history of an archaeologically significant landform, the outcome suggests it may be worthwhile developing sampling methods aimed at gathering data pertinent to building landform historical models, especially during the Late Pleistocene-Holocene transition (LPH). The objectives of such data collection would include not only dating depositional sequences but characterizing former surfaces that would have been suitable for humans along the central California coast during the LPH. Even at a coarse-grained level of analysis, methods such as retrieval and characterization of continuous cores using geoprobes, augers, or vibracores, particularly along the back of paleomarine terraces, would advance our knowledge of the coastal landforms significantly.

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