Appendix 5.8B
The Low Paleontological Sensitivity of Alluvial Fans in the Desert

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Alluvial fans underlie significant portions of many project ROWs in the Mojave Desert and, for this reason, the formation, evolution, and paleontological sensitivity of these units need to be considered in some detail.

Most alluvial fans are long-lived, constructional features. They are easily recognized as wedge-shaped deposits of alluvium (poorly consolidated rock debris to silts and sands) that radiate outward from channels issuing from a mountain front (Fenneman, 1931). These deposits possess highly complex stratigraphy and depositional histories (Lecce, 1990; Dorn, 2009). Most alluvial deposits on fans are relatively thin, and start as bar and swale deposits, and then decrease in roughness as they age until they become relatively flat surfaces. This planation takes millennia, and it is not unusual for erosional processes to begin to incise mature alluvial fan surfaces during its accumulation (Frankel and Dolan, 2007). Recent research confirms the accepted wisdom that high-energy depositional processes dominate the formation of many alluvial fans (Lecce, 1990; Blair and McPherson, 1994; McDonald et al., 2003). Normal stream processes contribute very little sediment to most fans, and these low-energy depositions are often reworked by high magnitude, low frequency events (Lecce, 1990). Moreover, there are long hiatuses, characterized by desiccation and chemical weathering, as well as mechanical planation, separating depositional events. The original depositional fabric of an alluvial fan is therefore highly altered by processes ranging from desert pavement to soil development (Harvey and Wells, 2003). This alteration can obscure the original fabric to such an extent that the original depositional processes cannot be identified (Lecce, 1990). The alternating depositional/erosional events are recorded in ancient alluvial fans as numerous unconformities (Harvey and Wells, 2003).

The dominant processes acting on and in alluvial fans are not conducive to the preservation of paleontological resources, and primary organic matter and even bone is almost always absent from alluvial deposits in the arid interior. This is due to several factors typical of alluvial fans:

- Any given depositional event is generally in a narrow, very limited portion of the fan, with the remainder of the fan weathering and eroding
- In the arid interior, the middle to upper reaches of alluvial fans generally consist of boulder debris flows; fluid, muddy debris flows; stony matrix-poor debris flows; fluvial boulder bars; fluvial cobble bars; and fluvial gravel sheets (Harvey and Wells, 2003), all of which are generally high-energy deposits and consequently have no potential for fossil preservation
- High-energy depositional events also rework the previously deposited sediments, and will mechanically degrade or destroy any bones or other biological remains in the sediment

- Oxidation, bacterial activity, and chemical weathering (soil formation) including alternating desiccation and dissolution from occasional rainfall, further degrade and destroy any biological remains

Conclusion

The combination of high-energy deposition and postdepositional weathering provide no opportunities for primary fossil preservation on alluvial fans in the Colorado and Mojave deserts. To illustrate this point, Table 1 presents a summary of the types of paleontological localities typically encountered in the desert interior. These known fossil records (one from near the Project) come from environments ranging from ancient spring discharge (paleospring) deposits, to ancient lake sediments, to those laid down in slowly moving river systems. No fossil records are known from alluvial fan deposits (the shaded column). In some cases, there are fossil-rich deposits laid down on top (palimpsest) of alluvial fans, such as when the surface of ancient Lake Cahuilla reached well up onto the fans of the surrounding mountains, and when artesian discharge along the San Andreas fault led to the development of spring discharge deposits on the alluvial fans of the Indio Hills (Table 2). These exceptions prove the rule to the extent that their fossiliferous deposits do not include the alluvial fans themselves.

Endorsement:

W. Geoffrey Spaulding, Ph.D.
Paleontological resources Specialist
CH2M HILL

TABLE 1
Examples of Significant Quaternary and Late Neogene Fossil Localities in the Mojave and Colorado Deserts. Note that of the three found on alluvial fans, none reflect alluvial deposition.

	Past Environment of Deposition					Present Setting				
Locality	**Lacustrine**	**Littoral / Palustrine**	**Paleospring / Paludal**	**Fluvial / Flood Plain**	**Alluvial Fan**	**Valley Bottom**	**Alluvial Fan**	**Hill Slope / Upland**	**Tectonically deformed**	**Other / Remarks**
Manix Lake	√	√	-	√		√	-	-	-	Beds of the lake deeply eroded and exposed
China Lake	-	√	-	-		√	-	-	-	Beds of the lake not eroded, not exposed except near outlet
Lake Cahuilla	√	√	-	-		-	√	-	-	Late Holocene lacustrine palimpsest overlying alluvial fan toes, limited to lower and middle reaches of alluvial fans
Indio Hills (Pushawalla)	-	-	√	-		-	√	-	-	Pleistocene paleospring palimpsest on middle reaches of alluvial fan; associated with scarps of the Banning Fault Zone.
Las Vegas Valley (Tule Springs)	-	-	√	-		√	-	-	-	Associated with fault lineaments
Pahrump Valley (Stump Springs)	-	-	√	-		√	-	-	-	Associated with Stateline fault system; older deposits more widespread and potentially more fossiliferous
Victorville Fan	-	-	-	√		√	√	-	-	"Upper Fluvial Unit" of the ancestral Mojave River (Cox et al. 2003)
Borrego Badlands (ABDSP 1277)	-	-	-	√		-	-	√	√	Uplifted area once a basin of deposition
Horned Toad Hills	-	-	-	√		-	-	√	√	Uplifted area once a basin of deposition

Notes:

The following site types are not considered in this analysis: Caves and rock shelters; archaeological sites (primary context).

References consulted: Cox et al., 2003; Dibblee, 1967: Giambastiani and Bullard, 2010; Jefferson, 2003; McDaniel and Jefferson, 2005; Quade et al., 1995; Scott and Cox, 2008; Waters, 1983; Wormington and Ellis, 1967.

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