Geomorphic Map Unit Properties Table: White Sands National Monument

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Age	Geomorphic Area (Symbol)	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
HOLOCENE AND PLEISTOCENE	**Active Holocene lake basin (ahlb)**	Active Holocene lake basin (ahlb and ahlb?)	Region west of the scour platform (**sp**) where there is evidence (on the ground and in air photographs) that flooding has occurred in the modern depositional system. Over most of the area, "lakes" that form are very temporary.	*Groundwater*—area of groundwater discharge. Wet or damp areas hold sand in place. *Surface Water*—ephemeral lakes, filled with water after storms. Sediment input by intermittent surface water flow. *Infrastructure and Gypsum Sands*—potential for corrosion, gypsum "glue," and dissolution (sinkholes). *Paleontological Resources*—wave activity along shorelines may expose fossil tracks in Lake Otero sediments (**sp_los**). *Climate Change*—lower water table and greater potential for deflation as a result of more severe and longer droughts. *Tamarisk*—invaded areas of the active Holocene lake basin. *White Sands Missile Range*—potential for contaminated runoff from rocket test site.	*Active Holocene Lake Basin, Lake Otero Strata*—mapped as gypsiferous lake deposits (**Qlg**)* by Seager et al. (1987). **Qlg** is equivalent to Lake Otero strata. *Source of Gypsum Sand*—composed of evaporite material, primarily from ancient Lake Otero, but also recent evaporation from modern Lake Lucero. *Alluvial Deposits*—coarsest sand on the western side of the active Holocene lake basin reflects input by intermittent channel flow and sheet flow. Active Holocene lake basin is east of the alluvial deposits (bajada) at the base of the San Andres Mountains.	The onset of regional aridity during the Holocene Epoch caused the contraction of ancient Lake Otero and the development of Lake Lucero and other smaller playas of the active Holocene lake basin.
HOLOCENE		Active playa (ahlb_ap)	Small, unnamed playas that occupy the low parts of the active Holocene lake basin.	*Groundwater*—may receive groundwater discharge. Wet or damp areas hold sand in place. *Surface Water*—existence of water is related to the frequency of flooding and elevation. Higher lakes to the east flood less frequently. *Paleontological Resources*—wave activity along shorelines may expose fossil tracks in Lake Otero sediments (**sp_los**). *Tamarisk*—invaded areas of the active Holocene lake basin.	*Source of Gypsum Sand*—playas form in gypsiferous beds of ancient Lake Otero.	The onset of regional aridity during the Holocene Epoch caused the contraction of ancient Lake Otero and the development of Lake Lucero and other smaller playas of the active Holocene lake basin. Today, active playas include many small unnamed low areas or depressions in the active Holocene lake basin.
		Quartz clastic wedge (ahlb_qcw)	Composed of quartz. Deposits of channelized flow and sheetflood deposits at the break of slope where alluvial fans meet the playa surface.	*Surface Water*—clastic material deposited by intermittent surface water flow. Wedges represent progradation of quartz clastic materials, mainly delivered by unconfined flows, onto the surface of the playa.	*Active Holocene Lake Basin*—**ahlb_qcw** found along the western margin of the active Holocene lake basin. *Alluvial Deposits*—mapped as younger piedmont-slope deposits (**Qpy**)* by Seager et al. (1987). Contains coarse clastic material transported through bajada by intermittent channelized flow and sheet flow.	The onset of regional aridity during the Holocene Epoch caused the contraction of ancient Lake Otero and the development of Lake Lucero and other smaller playas of the active Holocene lake basin.
		Few active parabolic dunes (ahlb_fap)	Parabolic dunes are considered active if the slip face and arms are composed of bare, moveable sand, which is shown as white on air photographs. Less active dunes have the arms mostly stabilized by vegetation with only the slip faces still active.	*Climate Change*—dunes may become more active as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	*Marginal Parabolic Dunes*—parabolic dunes that have formed within the active Holocene Lake basin. Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987).	The onset of regional aridity during the Holocene Epoch caused the contraction of ancient Lake Otero and the development of Lake Lucero and other smaller playas of the active Holocene lake basin.

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HOLOCENE	**Active Holocene lake basin (ahlb)**	More active sandy areas (ahlb_masa)	Areas interpreted to have active dunes and unvegetated interdunes within the active Holocene lake basin. Show sharp slip faces and clean, unvegetated sand between dunes.	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring location for 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for corrosion, gypsum "glue," and dissolution (sinkholes).	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). *Interdunes*—unvegetated areas between dunes.	The onset of regional aridity during the Holocene Epoch caused the contraction of ancient Lake Otero and the development of Lake Lucero and other smaller playas of the active Holocene lake basin.
HOLOCENE AND PLEISTOCENE		North Lake Lucero (ahlb_nll) and South Lake Lucero (ahlb_sll), active playa	Named portions of active Holocene lake basin. Occupy deepest part of the basin. Playa is composed of silt, clay, sand, gravel, and evaporite material.	*Groundwater*—local area of groundwater discharge. Represents basinwide groundwater system within White Sands National Monument. Holds local groundwater discharge and surface water runoff; proportion of surface water vs. groundwater is unknown. *Surface Water*—existence of water related to frequency of flooding. *Paleontological Resources*—wave activity along shoreline may expose fossil tracks. *Tamarisk*—invaded areas around North Lake Lucero and South Lake Lucero. *White Sands Missile Range*—potential for contaminated runoff from rocket test site.	*Active Holocene Lake Basin, Lake Otero Strata*—mapped as gypsiferous lake deposits (**Qlg**)* by Seager et al. (1987). **Qlg** is equivalent to Lake Otero strata. *Source of Gypsum Sand*—**Qlg**/Lake Otero strata are primary contributor of fresh gypsum sand to dune field. Wave activity breaks down Lake Otero beds, making gypsum available for eolian transport.	The onset of regional aridity during the Holocene Epoch caused the contraction of ancient Lake Otero and the development of Lake Lucero and other smaller playas of the active Holocene lake basin. Today, active playas include North Lake Lucero and South Lake Lucero in the active Holocene lake basin.
		Patchy sand (ahlb_ps)	Scattered areas of loose, mobile sand appear surrounded by less active eolian or non-eolian terrains. Thin active sand sheets with a few dunes. Found either atop sabkha-like areas with little obvious active sand, or in vegetated areas that may have become destabilized.	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	*Active Holocene Lake Basin, Lake Otero Strata*—mapped as gypsiferous lake deposits (**Qlg**)* by Seager et al. (1987). **Qlg** is equivalent to Lake Otero strata. *Source of Gypsum Sand*—**Qlg**/Lake Otero strata are primary contributor of fresh gypsum sand to dune field.	The onset of regional aridity during the Holocene Epoch caused the contraction of ancient Lake Otero and the development of Lake Lucero and other smaller playas of the active Holocene lake basin.
		Sand sheet (ahlb_ss)	One of the four major eolian facies groups—dune, interdune, sand sheet, and sabkha. See Fryberger et al. (1979) for a comprehensive discussion of eolian sand sheets. Sand sheets, with more or less vegetation, are a common linking facies between active dunes and older dune terrains at White Sands National Monument. Commonly rippled on surface.	*Paleontological Resources*—trace fossils; commonly bioturbated. *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	*Active Holocene Lake Basin, Lake Otero Strata*—mapped as gypsiferous lake deposits (**Qlg**)* by Seager et al. (1987). **Qlg** is equivalent to Lake Otero strata. *Barchanoid Dune Field* and *Marginal Parabolic Dunes*—widespread, flat-bedded or low-angle deposits found on the margins of dune fields or between belts of dunes such as active parabolic dunes. *Source of Gypsum Sand*—**Qlg**/Lake Otero strata are primary contributor of fresh gypsum sand to dune field. However, sand sheets have coarser sand grains or lack of sand supply.	

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HOLOCENE AND PLEISTOCENE	**Scour platform (sp)**	Scour platform (sp and sp?)	An extensive region upwind of the main dune field where wind scour of older sediments is the dominant process. This scour may include Lake Otero sediments; older, usually cemented dune strata; or recent material deposited during floods or by the wind. Area of net sediment loss.	*Paleontological Resources*—fossil trackways. *Climate Change*—greater scour/deflation as a result of more severe and longer droughts, with more dunes moving out of scour platform. Historically the scour platform has expanded and contacted with climate change. *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes). *Tamarisk*—invaded eastern edge of scour platform, immediately west of the central sands ridge of the barchanoid dune field.	*Active Holocene Lake Basin, Lake Otero Strata*—mapped as gypsiferous lake deposits (**Qlg**)* by Seager et al. (1987). **Qlg** is equivalent to Lake Otero strata. *Scour Platform*—Alkali Flat is representative feature of the scour platform. *Source of Gypsum Sand*—**Qlg**/Lake Otero strata are primary contributor of fresh gypsum sand to dune field.	Scour platform formed via stepwise deflation of ancient Lake Otero basin.
HOLOCENE AND PLEISTOCENE		Quartz clastic wedge (sp_qcw)	Composed of quartz. Mainly channelized and unchannelized sheetflood deposits at the break of slope where the alluvial fans meet the playa. They represent progradation of quartz clastic materials, mainly delivered by unconfined flows, onto the playa surface.	*Surface Water*—evidence of intermittent channelized flow and surface water runoff.	*Alluvial Deposits*—mapped as younger piedmont-slope deposits (**Qpy**)* by Seager et al. (1987). Contains coarse clastic material transported through bajada by intermittent flow.	
PLEISTOCENE		Deflation surface? (sp_d?)	Refers to local areas where deflation is occurring. Large area of possible deflation north of White Sands National Monument.	*Climate Change*—greater scour/deflation as a result of more severe and longer droughts.	*Active Holocene Lake Basin, Lake Otero Strata*—mapped as gypsiferous lake deposits (**Qlg**)* by Seager et al. (1987). **Qlg** is equivalent to Lake Otero strata. *Source of Gypsum Sand*—**Qlg** is primary contributor of fresh gypsum sand to dune field.	
HOLOCENE		Few active parabolic dunes (sp_fap)	Parabolic dunes were mapped as "active" if the slip face and arms had bare, moveable sand, which is shown as white on air photographs. Less active dunes had the arms mostly stabilized by vegetation with only the slip faces still active.	*Climate Change*—greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	*Marginal Parabolic Dunes*—parabolic dunes within the scour platform. Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987).	Scour platform formed via stepwise deflation of ancient Lake Otero basin.
PLEISTOCENE		Flat eolian deflation surface (sp_fe_ds)	Refers to an area where wind has scoured underlying deposits to a flat surface, rather than, for example, to yardangs (**yrdng**).	*Groundwater*—underlying water table may control the deflation surface (see Fryberger et al. 1988). *Climate Change*—greater area of wind scour as a result of more severe and longer droughts. *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	*Active Holocene Lake Basin, Lake Otero Strata*—mapped as gypsiferous lake deposits (**Qlg**)* by Seager et al. (1987). **Qlg** is equivalent to Lake Otero strata. *Source of Gypsum Sand*—**Qlg** is primary contributor of fresh gypsum sand to dune field.	

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Age	Geomorphic Area (Symbol)	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
PLEISTOCENE	**Scour platform (sp)**	Lake Otero stratification (sp_los)	Sediments of ancient Lake Otero exposed at the surface. Consist of laminated clays and silts, as well as gypsiferous marls, limestone, and massive silts containing large gypsum crystals; also greenish lacustrine shales. A few horizons of coarse-grained gypsum crystals. Outcrops on western shore of Lake Otero are coarser grained than on eastern side. Some cemented horizons hold up in outcrop.	*Erosion*—gully erosion produces fresh exposures along the trail to Lake Lucero. *Paleontological Resources*—fossil tracks. Source of paleoenvironmental material. *Climate Change*—more sediment available for eolian transport as a result of more severe and longer droughts. *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	*Active Holocene Lake Basin, Lake Otero Strata*—mapped as gypsiferous lake deposits (**Qlg**)* by Seager et al. (1987). **Qlg** is equivalent to Lake Otero strata. *Source of Gypsum Sand*—primary contributor of gypsum sand to dune field.	Deposited in pluvial Lake Otero during the Pleistocene Epoch. Scour platform formed via stepwise deflation of ancient Lake Otero basin.
HOLOCENE		Narrow area of active sand (sp_naas)	Refers to a narrow area of active sand (as seen on air photographs), downwind from deflation areas, which are often circular in appearance.	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring location for 10 vital signs (see Lancaster 2009).	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987).	Scour platform formed via stepwise deflation of ancient Lake Otero basin.
		Patchy active sand (sp_pas)	Areas of loose, mobile sand that form thin active sand sheets with a few dunes. Found either atop sabkha-like areas with little obvious active sand, or in vegetated areas that may have become destabilized. Mobile sand surrounded by less active eolian or non-eolian terrains. Appear as distinctively light-colored areas on air photographs.	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).		
		Scattered low domelike dunes (sp_sldd)	Referred to as "low" because these features are only about 0.3 m (1 ft) in height. Their low domelike forms in cross section dominate their character "in the field," though they may occur in a variety of shapes (barchanoid or transverse) in plan view. When trenched, some of these dune forms have cross-bedding, suggesting that from time to time, small slip faces formed.	*Climate Change*—observed decline in the number of dome dunes, possibly as a result of drier conditions. *Monitoring Eolian Processes*—potential monitoring location for 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	*Barchanoid Dune Field*—may be "embryonic" dune forms; evolve downwind into barchan dunes. Occur mostly along the upwind margins or sand-starved areas of the dune field. Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987).	
		Truncated older dune deposits (sp_todd_d)	A major deposit/unit along the upwind margins of the barchanoid dune field. Occur as an extensive (mappable) surface. Characterized by some deflation.	*Climate Change*—more sediment available for eolian transport as a result of more severe and longer droughts.	*Barchanoid Dune Field* and *Interdunes*—mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). *Interdunes*—**sp_todd_d** are very common in the flat interdunes. Miscellaneous Geomorphic Features, *Sabkhas*—distinguished from flat sabkha-like terrains that are dominated by salt ridges or muds.	
		Zibar dunes (sp_zd)	Low ridges of sand with dune-like form but no discernable slip face. Their morphologic evolution is uncertain: Some workers think they are true proto-dunes, while others think they are basically an independent form that does not evolve into anything else. Generally composed of rather coarse sand.	Unknown.	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987).	

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HOLOCENE	**Barchanoid dune field (bdf)**	Barchanoid dune field (bdf)	Geomorphic area east of the scour platform (**sp**). Divided into a central sand ridge (**bdf_csr**), scattered parabolic dunes (**bdf_spd**), barchan dune-outliers (**bdf_bd_o**), barchanoid dunes-active (**bdf_bd_a**), and possible barcan? (**bdf_b?**).	*Groundwater*—influenced by dune-field groundwater system. Relationship to basinwide groundwater system unknown. Very sensitive to changes in the level of the groundwater table. Groundwater salinity influences morphology of dunes (barchan dunes form under more saline conditions than parabolic dunes). *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue." *Tamarisk*—invaded some interdune areas of barchanoid dune field (**bdf**).	*Barchanoid Dune Field*—area represents the active, modern dune field. Mapped as active gypsum dunes (**Qega)*** by Seager et al. (1987). *Interdunes*—occur everywhere there are dunes. *Source of Gypsum Sand*—source of sand is lower/older Lake Otero sediments.	Formed with sand from scour platform (Lake Otero sediments) after formation of the marginal parabolic dunes. Dune field established by 2,100 years ago.
		Barchan dunes (bdf_b?)	Freely moving sand developed into crescent-shaped dunes with short arms that extend downwind. As interpreted from air photographs, some have questionable occurrence (**bdf_b?**).	*Groundwater*—influenced by dune-field groundwater system. Relationship to basinwide groundwater system unknown. Very sensitive to changes in the level of groundwater table. Groundwater salinity influences morphology of dunes (barchans form under more saline conditions than parabolics). *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."	Mapped as active gypsum dunes (**Qega)*** by Seager et al. (1987). *Interdunes*—occur everywhere there are dunes. *Source of Gypsum Sand*—source of sand is lower/older Lake Otero sediments.	Formed with sand from scour platform (Lake Otero sediments) after formation of the marginal parabolic dunes. Dune field established by 2,100 years ago.
		Barchan dunes - outliers (bdf_bd_o)	Freely moving sand developed into crescent-shaped dunes with short arms that extend downwind.	*Groundwater*—influenced by dune-field groundwater system. Relationship to basinwide groundwater system unknown. Very sensitive to changes in the level of groundwater table. Groundwater salinity influences morphology of dunes (barchans dunes form under more saline conditions than parabolic dunes). *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."	Mapped as active gypsum dunes (**Qega)*** by Seager et al. (1987). *Marginal Parabolic Dunes*—occur east of the main barchanoid dune field as an active outlier, spreading into an area of marginal parabolic dunes. *Interdunes*—the boundary between the barchanoid dune field and the marginal parabolic dunes is marked by damp interdunes. *Source of Gypsum Sand*—source of sand is lower/older Lake Otero sediments.	

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HOLOCENE	**Barchanoid dune field (bdf)**	Barchan dunes - active (bdf_bd_a)	Freely moving sand developed into crescent-shaped dunes with short arms that extend downwind.	*Groundwater*—influenced by dune-field groundwater system. Relationship to basinwide groundwater system unknown. Very sensitive to changes in the level of groundwater table. Groundwater salinity influences morphology of dunes (barchans form under more saline conditions than parabolics). *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). Make up the main, central part of the White Sands dune field. *Interdunes*—occur everywhere there are dunes. *Source of Gypsum Sand*—source of sand is lower/older Lake Otero sediments.	Formed with sand from scour platform (Lake Otero sediments) after formation of the marginal parabolic dunes. Dune field established by 2,100 years ago.
		Central sand ridge (bdf_csr)	A buildup of sand dunes forming a topographic ridge along the upwind margin of the barchanoid dune field (**bdf**). The ridge feature is more prominent north of White Sands National Monument. Origin unknown. Clearly visible on air photographs.	*Groundwater*—influenced by dune-field groundwater system. Relationship to basinwide groundwater system unknown. Very sensitive to changes in the level of groundwater table. Groundwater salinity influences morphology of dunes (barchans form under more saline conditions than parabolics). *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue." *Tamarisk*—invaded eastern edge of scour platform, immediately west of the central sand ridge.	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). *Interdunes*—dunes appear tightly spaced, with very small interdunes. *Source of Gypsum Sand*—source of sand is lower/older Lake Otero sediments.	

HOLOCENE	**Marginal parabolic dunes (mpd)**	Marginal parabolic dunes (mpd)	Parabolic dunes fringe the southern and eastern margins of the barchanoid dune field at White Sands National Monument. Dunes consist of central mass of sand with arms that extend upwind. Arms often anchored by vegetation.	*Groundwater*—influenced by dune-field groundwater system. Relationship to basinwide groundwater system unknown. Very sensitive to changes in the level of groundwater table. Groundwater salinity influences morphology of dunes (parabolics form under fresher conditions than barchan). *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."	*Marginal Parabolic Dunes*—representative features are active and inactive parabolic dunes. Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). *Interdunes*—the boundary between the barchanoid dune field and the marginal parabolic dunes is marked by damp interdunes.	Formed before barchanoid dune field. Dune field established by 3,500 years ago.

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HOLOCENE	**Marginal parabolic dunes (mpd)**	Abundant active parabolic dunes (mpd_aap)	Actively migrating central mass of sand with long arms extending upwind. Considered "active" during mapping if slip faces and arms had bare, moveable sand, shown as white on air photographs. Less active dunes had arms mostly stabilized by vegetation, with only slip faces active.	*Groundwater*—influenced by dune-field groundwater system. Relationship to basinwide groundwater system unknown. Very sensitive to changes in the level of groundwater table. Groundwater salinity influences morphology of dunes (parabolics form under fresher conditions than barchan). *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). *Interdunes*—occur everywhere there are dunes.	Formed before barchanoid dune field. Dune field established by 3,500 years ago.
		Active parabolic dunes (mpd_ap)	Actively migrating central mass of sand with long arms extending upwind. Considered "active" during mapping if slip faces and arms had bare, moveable sand, shown as white on air photographs. Less active dunes had arms mostly stabilized by vegetation, with only slip faces active.	*Groundwater*—influenced by dune-field groundwater system. Relationship to basinwide groundwater system unknown. Very sensitive to changes in the level of groundwater table. Groundwater salinity influences morphology of dunes (parabolics form under fresher conditions than barchan). *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."		
		Active small parabolic dunes (mpd_asp)	Actively migrating central mass of sand with long arms extending upwind. Considered "active" during mapping if slip faces and arms had bare, moveable sand, shown as white on air photographs. Less active dunes had arms mostly stabilized by vegetation, with only slip faces active. Appears as "choppy terrain" on air photographs.	*Groundwater*—influenced by dune-field groundwater system. Relationship to basinwide groundwater system unknown. Very sensitive to changes in the level of groundwater table. Groundwater salinity influences morphology of dunes (parabolics form under fresher conditions than barchan). *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). *Interdunes*—occur everywhere there are dunes.	Formed before barchanoid dune field. Dune field established by 3,500 years ago.
		Leading active ridge (mpd_lar)	Eastern edge of parabolic dune field. Very near visitor center.	*Climate Change*—may have greater area of eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987).	

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HOLOCENE	**Marginal parabolic dunes (mpd)**	More active sandy areas (mpd_masa)	Areas interpreted from air photographs to have active dunes and unvegetated interdunes, based on sharp slip faces and clean, unvegetated sand between dunes.	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). *Interdunes*—unvegetated areas between dunes.	Formed before barchanoid dune field. Dune field established by 3,500 years ago.
HOLOCENE		Parabolic dunes (mpd_pd)	Parabolic-shaped dunes composed of an actively migrating central mass of sand with long arms extending upwind. Parabolic dunes are considered active if the slip face and arms have bare, moveable sand, shown as white on the air photographs. Less active dunes have the arms mostly stabilized by vegetation, with only the slip faces still active.	*Groundwater*—influenced by dune-field groundwater system. Relationship to basinwide groundwater system unknown. Very sensitive to changes in the level of groundwater table. Groundwater salinity influences morphology of dunes (parabolics form under fresher conditions than barchan). *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). *Interdunes*—occur everywhere there are dunes.	Formed before barchanoid dune field. Dune field established by 3,500 years ago.
HOLOCENE AND PLEISTOCENE		Quartz dunes? (mpd_qd?)	Questioned occurrence of dunes composed of quartz. Appear as red reflectance on air photographs. Occur north of White Sands National Monument within an area of marginal parabolic dunes.	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand.	Mapped as eolian quartz sand (**Qes**)* by Seager et al. (1987).	The sand is derived largely from the Camp Rice Formation (**Qcp**).
HOLOCENE AND PLEISTOCENE		Quartz sand? (mpd_qs?)	Questioned occurrence of quartz sand on the eastern edge of the marginal parabolic dunes within White Sands National Monument. Appear as red reflectance on air photographs.	*Surface Water*—material contributed through fluvial activity. *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts.	Mapped as eolian quartz sand (**Qes**)* by Seager et al. (1987).	The sand is derived largely from the Camp Rice Formation (**Qcp**).
HOLOCENE		Scattered parabolic dunes (mpd_spd)	Actively moving sand in the form of parabolic dunes, though not contiguous with the main parabolic dune area. Occur north of White Sands National Monument.	*Groundwater*—influenced by dune-field groundwater system. Relationship to basinwide groundwater system unknown. Very sensitive to changes in the level of groundwater table. Groundwater salinity influences morphology of dunes (parabolics form under fresher conditions than barchan). *Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). *Interdunes*—occur everywhere there are dunes.	Formed before barchanoid dune field. Dune field established by 3,500 years ago.

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Age	Geomorphic Area (Symbol)	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
HOLOCENE	**Marginal parabolic dunes (mpd)**	Sand sheet or small dunes (mpd_ss_sd)	Marks a place where both a sand sheet and small dunes are found. In many places, sand sheets commonly have scattered, small dunes on their surfaces (see Fryberger et al. 1979).	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, and gypsum "glue."	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987).	An area of active sand within the marginal parabolic dunes. Dune field established by 3,500 years ago.
		The Pasture (mpd_tp)	A grassy area on the eastern margin of the marginal parabolic dunes.	*Climate Change*—loss of vegetation as a result of more severe and longer droughts would increase eolian activity.	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987).	Part of the marginal parabolic dunes, which formed before the barchanoid dune field; otherwise, origin is unknown.
HOLOCENE	**Miscellaneous Geomorphic Features**	Active lake (active_lake)	Non-alkaline lakes within the dune field or area of subdued eolian topography (**sbdd_eln_top**) east of the dune field.	*Groundwater*—relationship to basinwide groundwater system unknown. *Surface Water*—existence of water related to frequency of flooding.	Mapped as deposits of small, non-alkaline playa lakes and depressions (**Ql**)* by Seager et al. (1987).	Correspond to the onset of regional aridity during the Holocene Epoch.
HOLOCENE AND PLEISTOCENE		Active sand? (active_sand?)	Usually applied to areas that were not field checked by Fryberger (2001b). Gypsum sand, possibly active and probably not vegetated, east of the visitor center. Dunes are too small to be seen on air photographs. Whether these are areas of scour rather than deposition is unknown.	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	Mapped as basin-floor sediments (**Qbf**)* by Seager et al. (1987).	Correlated in time with ancient Lake Otero.
HOLOCENE AND PLEISTOCENE		Alluvial fan (allvl_fan)	Quartz clastic, low angle, sheetflood fan in the playa. Smaller quartz clastic alluvial and sheetflood fans, in places overlapping or "coalesced," that have formed where outwash from the alluvial fans of the mountain front reach the flat active lake basin. Mapped separately from **o_allvl_fan** by Fryberger (2001b).	*Groundwater*—part of basin-fill aquifer. *Surface Water*—runoff during storms adds material to basin as fans. Pathway for surface water to active Holocene lake basin. *Debris Flows and Rockfall*—part of bajada, where mass-wasting deposits originate.	Mapped as basin-floor sediments (**Qpy**)* by Seager et al. (1987).	Corresponds in time with the active Holocene lake basin
PLEISTOCENE		Inactive dunes, mostly parabolic dunes (i_dune_p)	Inactive sand dunes. Partly lithified internally. The older parabolic dunes are usually inactive in this region due to early cementation (of gypsum crusts) and vegetation.	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—prone to form blowouts or slowly migrating parabolic dunes. Potential for corrosion and gypsum "glue."	*Marginal Parabolic Dunes*—occur along the southern edge of White Sands National Monument in an area of both active and inactive marginal parabolic dunes. Mapped as inactive gypsum dunes (**Qegi**)* by Seager et al. (1987).	Correlated in time with ancient Lake Otero and younger playa deposits.

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Age	Geomorphic Area (Symbol)	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
PLEISTOCENE	**Miscellaneous Geomorphic Features**	Lake Otero outcrops (lo_outcrops)	Outcrops of sediments deposited by Lake Otero. 3 m (10 ft) to 8 m (25 ft) thick. Selenite crystal horizons common.	*Surface Water*—gullying common. *Paleontological Resources*—fossil tracks. *Climate Change*—more sediment available for eolian transport as a result of more severe and longer droughts.	*Active Holocene Lake Basin* and *Scour Platform*—**lo_outcrops** occur as cliffs—1 m (3 ft) to 2 m (7 ft) high—along the west side of Lake Lucero and the active Holocene lake basin, and as low ridges and planed-off, gypsiferous-sand strata on the scour platform. Mapped as gypsiferous lake deposits (**Qlg**)* by Seager et al. (1987). *Source of Gypsum Sand*—primary contributor of fresh sand to dune field.	Represents previous pluvial (wetter) conditions during the Pleistocene Epoch.
HOLOCENE		More active sandy areas (masa)	Areas interpreted on air photographs to have active dunes and un-vegetated interdunes, based on sharp slip faces, and clean, unvegetated sand between dunes.	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	*Active Holocene Lake Basin* and *Marginal Parabolic Dunes*—mapped primarily in the active Holocene lake basin (**ahlb_masa**) and marginal parabolic dunes (**mpd_masa**), but also mapped north of White Sands National Monument near sabkha (**sabkha**) and subdued eolian topography (**sbdd_eln_top**). Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987).	Corresponds to the onset of regional aridity during the Holocene Epoch.
PLEISTOCENE		Older alluvial fans (o_allvl_fan)	The term "alluvial fan" refers to the conventional coarse fan deposits of sand and gravel with some mud that form large fans between the mountains and the active Holocene lake basin.	*Groundwater*—part of basin-fill aquifer. *Surface Water*—runoff during storms adds material to basin as fans. Pathway for surface water to active Holocene lake basin. *Debris Flows and Rockfall*—part of bajada, where mass-wasting deposits originate.	Mapped as older piedmont-slope deposits (**Qpo**)* by Seager et al. (1987). *Alluvial Deposits*—alluvial fans, mostly weakly consolidated gravel and sandy gravel, grading downslope to gravelly loam, with thin horizons (surficial and buried) of soil-carbonate and clay accumulation	Ancient Lake Otero and pre-Lake Otero deposits.
PLEISTOCENE		Older basin floor (o_bas_floor)	Mostly red and green gypsiferous clay and silt interbedded with gypsite.	Unknown.	Mapped as older gypsiferous basin-floor deposits and lake beds (**Qbfg**)* by Seager et al. (1987).	Pre-Lake Otero deposits.
unknown		Plateau (plateau)	Labeled on map but not defined by Fryberger (2001a). North of White Sands National Monument.	Unknown.	Unknown.	Unknown.
HOLOCENE AND PLEISTOCENE		Quartz clastic input to dune system (qci_ds)	Represents progradation of quartz clastic materials, mainly delivered by unconfined flows, onto the surface of the playa. Found along the western margin of the Holocene lake basin.	*Surface Water*—runoff during storms adds material to basin as fans. Pathway for surface water to the active Holocene lake basin.	Mapped as undifferentiated piedmont-slope deposits (**Qpa**)* by Seager et al. (1987). *Alluvial Deposits*—associated with alluvial fan (**o_allvl_fan**) on western edge of active Holocene lake basin.	Postdates river valley incision by Rio Grande.
HOLOCENE AND PLEISTOCENE		Quartzose dunes (quartzose_d)	Includes quartzose dunes north of White Sands National Monument. Commonly found along course of Rio Grande. Appear as red reflectance on air photographs.	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sands*—potential for blowing sand.	Mapped as eolian quartz sand (**Qes**)* by Seager et al. (1987). The sand is derived largely from Camp Rice Formation (**Qcp**).	Postdates river valley incision by Rio Grande.

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Age	Geomorphic Area (Symbol)	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
HOLOCENE	**Miscellaneous Geomorphic Features**	Sabkha (sabkha)	Refers to flat salty areas, often partly flooded by tides, along the coast of the Arabian Gulf. Used as a means for describing subsurface sediment packages at White Sands National Monument. Common (though too small for map scale) on Alkali Flat and margins of Lake Lucero.	*Groundwater*—research on sabkhas at White Sands indicates lowering of water table. *Climate Change*—low water table may result from more severe and longer droughts.	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). *Miscellaneous Geomorphic Features, Sabkhas*—prominent mapped sabkhas north of White Sands National Monument between the barchanoid dune field and marginal parabolic dunes.	Part of the Holocene dune system.
PLEISTOCENE		Subdued eolian topography (sbdd_eln_top)	Occurs beyond/east of the marginal parabolic dunes within White Sands National Monument. Topography as a whole suggests eolian dunes by its gentle rise and fall and systematic organization. Interpreted as "subdued" because dunes are not particularly obvious or active.	*Climate Change*—may have greater eolian activity as a result of more severe and longer droughts. *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	Mapped as older gypsiferous basin-floor and distal piedmont-slope deposits (**Qpg**)* by Seager et al. (1987).	Ancient Lake Otero and pre-Lake Otero deposits (?).
HOLOCENE AND PLEISTOCENE		Sandy gypsiferous outcrops (sg_outcrops)	Outcrops composed of a mixture of quartz and gypsum sand, apparently wind-scoured and of eolian origin. Occur along the western side of White Sands National Monument.	*Groundwater*—recharge area for basinwide groundwater system. *Surface Water*—runoff during storms adds material to basin as fans. Pathway for surface water to active Holocene lake basin. *Debris Flows and Rockfall*—part of bajadas, where mass-wasting deposits originate.	Mapped as undifferentiated piedmont-slope deposits (**Qpa**)* by Seager et al. (1987).	Postdates river valley incision by Rio Grande.
		Shoreline dune (shrln_dune)	A dune that has developed along a lake shoreline, commonly non-migratory, held in place by vegetation or early cementation.	Unknown.	Mapped as eolian deposits associated with Tularosa Basin lakes (**Qegs**)* by Seager et al. (1987).	Correlated in time with ancient Lake Otero.
		Shoreline "lunette" dunes (shrln_l_dune)	A type of shoreline dune (**shrln_dune**) but formed on the downwind side of a standing lake in the shape of a quarter moon, thus the term "lunette." The curve of the lake determines the shape of the dune. Composed of material blown off the beach (or lake bottom when dry). Lunette dunes are commonly anchored in place by early cementation or vegetation.	Unknown.	Mapped as eolian deposits associated with Tularosa Basin lakes (**Qegs**)* by Seager et al. (1987).	Correlated in time with ancient Lake Otero.
HOLOCENE		Vegetated dunes (veg_d)	Stabilized areas of gypsum sand dunes held in place by vegetation.	*Climate Change*—loss of vegetation as a result of more severe and longer droughts would increase eolian activity.	Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987).	Associated with deflation of Lake Otero sediments.
		Yardangs (yrdng)	Long, sharp-crested ridge of coherent gypsum sand. Typically have the shape of an inverted boat hull. Form in the direction of dominant wind. In some places at White Sands National Monument, yardangs have formed in groups (or fields), for example downwind of South Lake Lucero.	*Climate Change*—may have greater wind scour as a result of more severe and longer droughts. *Infrastructure and Gypsum Sands*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	*Scour Platform* and *Marginal Parabolic Dunes*—Mapped as active gypsum dunes (**Qega**)* by Seager et al. (1987). Yardangs occur in the scour platform (sp) and within the marginal parabolic dunes (mpd) geomorphic areas.	Part of the Holocene dune system.