Geologic Map Unit Properties Table: White Sands National Monument

Gray-shaded rows indicate units not mapped within White Sands National Monument by Seager et al. (1987). "*" Indicates additional information on Geomorphic Map Unit Properties Table. "?" Indicates uncertain occurrences as noted on the source map.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
HOLOCENE AND PLEISTOCENE	Younger piedmont-slope deposits (Qpy)	Unconsolidated sand, gravel, and loamy sediments, of drainageways that cross and are inset below or bury older piedmont slopes, and of fans constructed on distal piedmont slopes at the lower end of such drainageways. Up to 5 m (15 ft) thick.	*Groundwater*—recharge area for basinwide groundwater system. *Surface Water*—location of intermittent streams on western side of White Sands National Monument. *Debris Flows and Rockfall*—site of mass wasting.	*Alluvial Deposits*—serve as pathway for surface water runoff and sediment input to the active Holocene lake basin (**ahlb**).* Part of bajada.	Corresponds in time with ancient Lake Otero and modern Lake Lucero.
HOLOCENE AND PLEISTOCENE	Undifferentiated piedmont-slope deposits (Qpa)	Qpa consists of the following units: Younger piedmont-slope deposits (**Qpy**): See description above. Older piedmont-slope deposits (**Qpo**): See description below.	*Groundwater*—recharge area for basinwide groundwater system. *Surface Water*—location of intermittent streams on western side of White Sands National Monument. *Debris Flows and Rockfall*—site of mass wasting.	*Alluvial Deposits*—serve as pathway for surface water runoff and sediment input to the active Holocene lake basin (**ahlb**).* Part of bajada.	Postdates river valley incision by Rio Grande.
HOLOCENE AND PLEISTOCENE	Undifferentiated piedmont-slope deposits (Qpa) and eolian deposits associated with Tularosa Basin lakes (Qegs), undifferentiated (Qpa + Qegs)	Qpa + Qegs consists of the following units: Undifferentiated piedmont-slope deposits (**Qpa**): See description above. Eolian deposits associated with Tularosa Basin lakes (**Qegs**): See description below.	*Groundwater*—recharge area for basinwide groundwater system. *Surface Water*—east of the White Sands dune field. Surface water intercepted by dune field. *Climate Change*—increased eolian activity as a result of longer and more severe droughts. *Monitoring Eolian Processes*—mostly inactive dunes at present. Potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sand*—potential for corrosion, gypsum "glue," and dissolution (sinkholes).	*Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**)* and active sand (**active_sand?**).* *Alluvial Deposits*—occurs east of White Sands dune field. *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Correlated in time with ancient Lake Otero.
HOLOCENE OVER PLIOCENE	Undifferentiated piedmont-slope deposits (Qpa) overlying Qpu (older sediment deposits [Qpo] and Camp Rice Formation [Qcp]) (Qpa/Qpu)	Qpa/Qpu consists of Qpa (Qpy and Qpo units) overlying Qpu (Qpo and Qcp units): Younger piedmont-slope deposits (**Qpy**): See description above. Older piedmont-slope deposits (**Qpo**): See description below. Camp Rice Formation (**Qcp**): See description below.	*Groundwater*—part of basin-fill groundwater aquifer. *Surface Water*—east of the White Sands dune field. Surface water intercepted by dune field.	*Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**)* and active sand (**active_sand?**)* east of White Sands dune field. *Alluvial Deposits*—occurs east of White Sands dune field.	Deposited after incision by ancestral Rio Grande.
HOLOCENE AND/OVER PLEISTOCENE	Basin-floor sediments (Qbf)	Mostly loam, silt, or clay. Some locations have thin zones of pebbly gravel. Deposits in eastern Tularosa Basin are commonly gypsiferous and up to 5 m (15 ft) thick.	*Infrastructure and Gypsum Sand*—potential for corrosion, gypsum "glue," and dissolution (sinkholes).	*Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**)* and active sand (**active_sand?**)* east of White Sands dune field. *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Correlated in time with ancient Lake Otero.

Gray-shaded rows indicate units not mapped within White Sands National Monument by Seager et al. (1987). "*" Indicates additional information on Geomorphic Map Unit Properties Table. "?" Indicates uncertain occurrences as noted on the source map.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
HOLOCENE AND/OVER PLEISTOCENE	Basin-floor sediments (Qbf) overlying gypsiferous lake deposits in the Tularosa Basin (Qlg) (Qbf/Qlg)	Unit consists of Qbf overlying Qlg: Basin-floor sediments (**Qbf**): See description above. Gypsiferous lake deposits in the Tularosa Basin (**Qlg**): See description below.	*Erosion*—erosion of beds may reveal fossils or other paleontological information about ancient Lake Otero. *Paleontological Resources*—potential for fossil trackways. *Climate Change*—greater potential for deflation as a result of longer and more severe droughts. *Infrastructure and Gypsum Sand*—potential for corrosion, gypsum "glue," and dissolution (sinkholes).	*Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**)* and shoreline dunes (**shrln_dune**)* south of White Sands dune field. Also correlated with with **sp_los*** and **lo_outcrops*** (see "Lake Otero Strata" section in report). *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Correlated in time with ancient Lake Otero.
	Basin-floor sediments (Qbf) overlying older gypsiferous basin-floor and distal piedmont slope deposits (Qpg) (Qbf/Qpg)	Qbf/Qpg consists of Qbf overlying Qpg: Basin-floor sediments (**Qbf**): See description above. Older gypsiferous basin-floor and distal piedmont slope deposits (**Qpg**): See description below.	*Surface Water*—east of White Sands dune field. Surface water flow intercepted by dune field. *Climate Change*—greater potential for deflation as a result of longer and more severe droughts.	*Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**).* *Alluvial Deposits*—not part of bajada. Occurs on east side of national monument. *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Correlated in time with ancient Lake Otero.
	Deposits of small, non-alkaline playa lakes and depressions (Ql)	Mostly clay and silt. Up to 5 m (15 ft) thick.	*Groundwater*—relationship to groundwater system unknown. *Surface Water*—less saline source of water. Occur outside of the active Holocene lake basin (**ahlb**).*	*Miscellaneous Geomorphic Features*—active lake (**active_lake**).*	Corresponds to onset of regional aridity during Holocene Epoch.
	Gypsiferous lake deposits in the Tularosa Basin (Qlg)	Mostly gypsite, gypsiferous red and green clay, and gypsiferous silt, locally covered by thin, loamy to silty, eolian deposits of alluvium. Includes ancient Lake Otero with highest shoreline near 1,204 m (3,950 ft) above sea level and several smaller lake beds in the eastern Tularosa Basin. At least 8 m (25 ft) thick.	*Erosion*—erosion of beds may reveal fossils or other paleontological information about ancient Lake Otero. *Paleontological Resources*—lake beds host fossil trackways. *Climate Change*—more sediment available for eolian transport as a result of longer and more severe droughts. *Infrastructure and Gypsum Sand*—potential for corrosion, gypsum "glue," and dissolution (sinkholes). *Tamarisk*—invaded around Lake Lucero (**ahlb_nll** and **ahlb_nll**)* and between widespread area of **Qlg** and **Qega** in White Sands National Monument.	*Active Holocene Lake Basin*—corresponds to active Holocene lake basin (**ahlb**).* *Scour Platform* and *Miscellaneous Geomorphic Features*—correlated with **sp_los*** and **lo_outcrops*** (see "Lake Otero Strata" section in report) and shoreline lunette dunes (**shrln_l_dune**)* and subdued eolian topography (**sbdd_eln_top**)* south of White Sands dune field. *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Correlated with ancient Lake Otero.
	Eolian deposits associated with Tularosa Basin lakes (Qegs)	Mostly inactive, ridge-like dunes of yellowish to tan, gypsiferous quartzose silt and fine quartzose sand with gypsite layers. Located on the lee (eastern) side of lake (**Qlg**) beds. Many have 0.3 m (1 ft) to 0.6 m (2 ft) of pedogenic gypsite (gypcrete) capping the deposits. Up to 23 m (75 ft) thick.	*Climate Change*—increased eolian activity as a result longer and more severe droughts. *Monitoring Eolian Processes*—mostly inactive dunes at present. Potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sand*—potential for corrosion, gypsum "glue," and dissolution (sinkholes).	*Miscellaneous Geomorphic Features*—correlated with Lake Otero outcrops (**lo_outcrops**).* Similar to lunettes (**shrln_l_dune**).* The larger patch at NW 30 includes non-lunette stabilized dunes, probably older than the other lunette dunes (Rip Langford, University of Texas at El Paso, professor, written communication, 8 April 2012). *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Correlated in time with ancient Lake Otero.

Gray-shaded rows indicate units not mapped within White Sands National Monument by Seager et al. (1987). "*" Indicates additional information on Geomorphic Map Unit Properties Table. "?" Indicates uncertain occurrences as noted on the source map.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
HOLOCENE AND/OVER PLEISTOCENE	Eolian deposits associated with Tularosa Basin lakes (Qegs) overlying older gypsiferous basin-floor and distal piedmont slope deposits (Qpg) (Qegs/Qpg)	Qegs/Qpg consists of Qegs overlying Qpg: Eolian deposits associated with Tularosa Basin lakes (**Qegs**): See description above. Older gypsiferous basin-floor and distal piedmont slope deposits (**Qpg**): See description below.	*Groundwater*—recharge area for basinwide groundwater system. *Surface Water*—east of White Sands dune field. Surface water flow intercepted by dune field. *Climate Change*—greater potential for deflation as a result of longer and more severe droughts. *Monitoring Eolian Processes*—mostly inactive dunes at present. Potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sand*—potential for corrosion, gypsum "glue," and dissolution (sinkholes).	*Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**)* east of White Sands dune field. *Alluvial Deposits*—not part of bajada. Occurs east of White Sands dune field. *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Correlated in time with ancient Lake Otero.
	Eolian deposits associated with Tularosa Basin lakes (Qegs) and older gypsiferous basin-floor deposits and lake beds (Qbfg), undifferentiated (Qegs + Qbfg)	Qegs + Qbfg consists of the following units that have not been differentiated: Eolian deposits associated with Tularosa Basin lakes (**Qegs**): See description above. Older gypsiferous basin-floor deposits and lake beds (**Qbfg**): See description below.	*Climate Change*—greater potential for deflation as a result of longer and more severe droughts. *Monitoring Eolian Processes*—mostly inactive dunes at present. Potential monitoring of 10 vital signs (see Lancaster 2009).	*Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**)* east of White Sands dune field. *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Correlated in time with ancient Lake Otero.
HOLOCENE AND PLEISTOCENE OVER PERMIAN	Eolian deposits associated with Tularosa Basin lakes (Qegs) overlying Hueco Formation? (Ph?) (Qegs/Ph?)	Qegs/Ph? consists of Qegs overlying Ph?: Eolian deposits associated with Tularosa Basin lakes (**Qegs**): See description above. Hueco Formation (**Ph?**): See description below.	*Climate Change*—greater potential for deflation as a result of longer and more severe droughts. *Monitoring Eolian Processes*—mostly inactive dunes at present. Potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sand*—potential for corrosion, gypsum "glue," and dissolution (sinkholes).	*Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**)* east of White Sands dune field. *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Correlated in time with ancient Lake Otero.
HOLOCENE AND PLEISTOCENE	Active gypsum dunes (Qega)	White dunes of pure gypsum sand located east of and derived from modern (see note) and ancestral Lake Lucero. Up to 18 m (60 ft) thick. *Note: Fryberger (2001a) concluded that very little gypsum sand is supplied by modern Lake Lucero, as suggested here by Seager et al. (1987).*	*Groundwater*—associated with dune-field groundwater system. *Climate Change*—dunes may become more active as a result of longer and more severe droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sand*—potential for blowing sand, corrosion, and gypsum "glue." *Tamarisk*—invaded dune field, particularly interdune areas.	*Active Holocene Lake Basin*—**Qega** deposits cover a small portion of the active Holocene lake basin (**ahlb**).* *Barchanoid Dune Field* and *Marginal Parabolic Dunes*—represent the modern, active White Sands dune field. Part of barchanoid dune field (**bdf**) and marginal parabolic dunes (**mpd**). *Miscellaneous Geomorphic Features*—cover yardang (**yrdng**) east of South Lake Lucero. *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Started forming about 7,000 years ago during deflation event. Marginal parabolic dunes (**mpd**) formed first, followed by barchanoid dune field (**bdf**).
	Eolian quartz sand (Qes)	Dunes and irregular hummocks of quartz sand, especially extensive on western piedmont slopes of San Andres Mountains, on the La Mesa surface southwest of Las Cruces, east of San Diego Mountain, and in the southern Tularosa Basin. The sand is derived largely from the Camp Rice Formation **(Qcp)** (see description below).	*Climate Change*—greater potential for eolian activity as a result of longer and more severe droughts. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure*—potential for blowing sand.	*Alluvial Deposits*—occurs on western piedmont slopes of San Andres Mountains. Commonly found along course of Rio Grande. Comprises scattered coppice dunes on a stabilized surface of piedmont alluvium and Camp Rice Formation (**Qcp**) sand (Rip Langford, University of Texas at El Paso, professor, written communication, 8 April 2012).	Formation of coppice dunes during Holocene Epoch.

Gray-shaded rows indicate units not mapped within White Sands National Monument by Seager et al. (1987). "*" Indicates additional information on Geomorphic Map Unit Properties Table. "?" Indicates uncertain occurrences as noted on the source map.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
HOLOCENE OVER PLEISTOCENE AND PLIOCENE	Eolian quartz sand (Qes) overlying older piedmont-slope deposits (Qpo) and Camp Rice Formation (Qcp), undifferentiated (Qes/Qpu)	Qes/Qpu consists of Qes overlying Qpu: Eolian quartz sand (**Qes**): See description above. Older piedmont-slope deposits (Qpo) and Camp Rice Formation (Qcp), undifferentiated (**Qpu**): See description below.	*Groundwater*—part of basin-fill groundwater aquifer. *Surface Water*—location of intermittent streams on western side of White Sands National Monument. *Monitoring Eolian Processes*—potential monitoring of 10 vital signs (see Lancaster 2009).	*Alluvial Deposits*—occurs on western piedmont slopes of San Andres Mountains. Commonly found along course of Rio Grande. Comprises scattered coppice dunes on a stabilized surface of piedmont alluvium and Camp Rice Formation (**Qcp**) sand (Rip Langford, University of Texas at El Paso, professor, written communication, 8 April 2012).	Postdates Rio Grande incision.
HOLOCENE OVER PLEISTOCENE	Eolian quartz sand (Qes) overlying older gypsiferous basin-floor deposits and lake beds (Qbfg) (Qes/Qbfg)	Qes/Qbfg consists of Qes overlying Qbfg: Eolian quartz sand (**Qes**): See description above. Older gypsiferous basin-floor deposits and lake beds (**Qbfg**): See description below.	*Surface Water*—east of White Sands dune field. Surface water intercepted by dune field. *Climate Change*—dune shrublands have expanded historically at the expense of grasslands (Rip Langford, written communication, 8 April 2012). *Monitoring Eolian Processes*—mostly inactive dunes at present. Potential monitoring of 10 vital signs (see Lancaster 2009).	*Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**)* east of White Sands dune field. *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Pre-Lake Otero deposits.
HOLOCENE OVER PLEISTOCENE	Eolian quartz sand (Qes) overlying Camp Rice Formation, sediments associated with La Mesa surface (Qcl) (Qes/Qcl)	Qes/Qcl consists of Qes overlying Qcl: Eolian quartz sand (**Qes**): See description above. Camp Rice Formation, sediments associated with La Mesa surface (**Qcl**): See description below.	*Climate Change*—greater potential for eolian activity as a result of longer and more severe droughts. Dune shrublands have expanded historically at the expense of grasslands (Rip Langford, written communication, 8 April 2012). *Monitoring Eolian Processes*—mostly inactive dunes at present. Potential monitoring of 10 vital signs (see Lancaster 2009).	*Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**)* east of White Sands dune field.	Deposited after incision by ancestral Rio Grande.
PLEISTOCENE	Older piedmont-slope deposits (Qpo)	Fan and terrace deposits and erosion-surface veneers on piedmont slopes graded to closed-basin floors. Mostly weakly consolidated gravel and sandy gravel, grading downslope to gravelly loam, with thin horizons (surficial and buried) of soil-carbonate and clay accumulation. Gravelly carbonate horizons are commonly indurated and form thin pedogenic calcretes. At least two generations of fans are present at most places along the San Andres–Organ-Franklin Mountains front. Up to 15 m (50 ft) thick.	*Groundwater*—recharge area for basinwide groundwater system. *Surface Water*—location of intermittent streams on western side of White Sands National Monument. *Debris Flows and Rockfall*—site of mass wasting.	*Alluvial Deposits*—serve as pathway for surface water runoff and sediment input to the active Holocene lake basin (**ahlb**).* Part of bajada.	Ancient Lake Otero and pre-Lake Otero deposits. Postdates river-valley incision by Rio Grande.
PLEISTOCENE AND PLIOCENE	Older piedmont-slope deposits (Qpo) and Camp Rice Formation (Qcp), undifferentiated (Qpu)	Qpu consists of Qpo and Qcp, undifferentiated: Older piedmont-slope deposits (**Qpo**): See description above. Camp Rice Formation (**Qcp**): See description below.	*Groundwater*—part of basin-fill groundwater aquifer. *Surface Water*—location of intermittent streams on western side of White Sands National Monument.	*Alluvial Deposits*—serve as pathway for surface water runoff and sediment input to the active Holocene lake basin (**ahlb**).* Part of bajada. Deposits also occur east of the dune field.	Deposited by ancestral Rio Grande and associated with extension of Rio Grande rift.

Gray-shaded rows indicate units not mapped within White Sands National Monument by Seager et al. (1987). "*" Indicates additional information on Geomorphic Map Unit Properties Table. "?" Indicates uncertain occurrences as noted on the source map.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
PLEISTOCENE	Older gypsiferous basin-floor and distal piedmont slope deposits (Qpg)	Primarily distal piedmont deposits in east-central Tularosa Basin. Mostly gypsiferous red clay and silt, tan, eolian gypsum sand, yellow, limonitic quartzose sand, tan, clayey siltstone (adobe), all moderately hardened, and gypsite. Capped everywhere by 0.3 m (1 ft) to 0.6 m (3 ft) of gypsite, which probably developed in conjunction with soil formation. Up to 8 m (25 ft) thick.	*Groundwater*—recharge area for basinwide groundwater system. *Surface Water*—east of White Sands dune field. Surface water intercepted by dune field. *Infrastructure and Gypsum Sand*—potential for corrosion, gypsum "glue," and dissolution (sinkholes).	*Alluvial Deposits*—not part of bajada. Occurs on eastern side of White Sands National Monument. *Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**).* *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Age is uncertain but probably late Pleistocene, younger than 400,000 years old. Ancient Lake Otero and pre-Lake Otero deposits (?).
	Older gypsiferous basin-floor deposits and lake beds (Qbfg)	Mostly red and green gypsiferous clay and silt interbedded with gypsite. Upper 0.3 m (1 ft) to 0.9 m (3 ft) is gypsite of probable pedogenic origin. Crops out as high as 1,218 m (3,995 ft) above sea level and underlies much of the central Tularosa Basin north of the Jarilla Mountains. Grades to **Qpg** above 1,219 m (4,000 ft) above sea level. At least 8 m (25 ft) thick.	*Infrastructure and Gypsum Sand*—potential for corrosion, gypsum "glue," and dissolution (sinkholes).	*Scour Platform*—part of the scour platform (**sp**). *Miscellaneous Geomorphic Features*—corresponds to subdued eolian topography (**sbdd_eln_top**)* south and east of White Sands dune field. *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Pre-Lake Otero deposits. Age of exposed beds is uncertain, probably late Pleistocene, younger than 400,000 years old.
	Inactive gypsum dunes (Qegi)	Dunes of gypsite with well-developed gypcrete crusts. May be sandy or silty (quartz) locally, grading into **Qegs** (see description above). Up to 15 m (50 ft) thick.	*Climate Change*—dunes may become active as a result of longer and more severe droughts. *Monitoring Eolian Processes*—mostly inactive dunes at present. Potential monitoring of 10 vital signs (see Lancaster 2009). *Infrastructure and Gypsum Sand*—potential for blowing sand, corrosion, gypsum "glue," and dissolution (sinkholes).	*Marginal Parabolic Dunes*—mostly marginal parabolic dunes (**mpd**).* *Miscellaneous Geomorphic Features*—includes stabilized shoreline lunette dunes (**shrln_l_dune**)* and shoreline dunes (**shrln_dune**).* *Source of Gypsum Sand*—composed of gypsum from Yeso Formation (**Py**) and other Permian rocks recycled in ancient Lake Otero beds.	Correlated in time with ancient Lake Otero and younger playa deposits.
PLEISTOCENE AND PLIOCENE	Olivine basalt (Qb)	Mostly, if not entirely, alkali-olivine basalt. Forms cinder cones and flows.	*Infrastructure*—areas around lava flows are prone to dissolution.	*Geothermal Features and Processes*—volcanic features are associated with elevated groundwater temperatures.	Coeval with Camp Rice Formation (**Qcp**) before incision by ancestral Rio Grande. Flows range in age from 1.23 million to 25,000 years old.
	Camp Rice Formation, piedmont-slope facies (Qcp)	Deposits associated with piedmont slopes graded to basin floors predating river-valley incision. Weakly to moderately cemented, boulder to cobble fan deposits and erosion-surface veneers near mountain fronts, grading to gravelly silt, loam, or clay on distal piedmont slopes. Surficial layers, up to 3 m (10 ft) thick, usually with prominent horizons of soil-carbonate accumulation and, locally, reddish-brown horizons of clay accumulation. Gravelly carbonate horizons are commonly indurated forming pedogenic calcrete zones up to 1.5 m (5 ft) thick. Multiple buried soils are present in thicker deposits; generally less than 24 m (80 ft) thick.	*Groundwater*—part of basin-fill groundwater aquifer. *Surface Water*—location of intermittent streams on western side of White Sands National Monument. *Debris Flows and Rockfall*—site of mass wasting.	*Alluvial Deposits*—serve as pathway for surface water runoff and sediment input to the active Holocene lake basin (**ahlb**).* Part of bajada.	Deposited by ancestral Rio Grande and associated with extension of Rio Grande rift. Discontinuous lenses of volcanic ash (600,000 to 700,000 years old) are locally present.
	Camp Rice Formation (Qcp) and Camp Rice Formation, fanglomerate facies (QTcc), undivided (QTcu)	QTcu consists of Qcp and QTcc, undivided: Camp Rice Formation, piedmont-slope facies (**Qcp**): See description above. Camp Rice Formation, fanglomerate facies (**QTcc**): See description below.	*Groundwater*—part of basin-fill groundwater aquifer. *Surface Water*—location of intermittent streams on western side of White Sands National Monument. *Debris Flows and Rockfall*—site of mass wasting.	*Alluvial Deposits*—serve as pathway for surface water runoff and sediment input to the active Holocene lake basin (**ahlb**).* Part of bajada.	Deposited by ancestral Rio Grande and associated with extension of Rio Grande rift.

Gray-shaded rows indicate units not mapped within White Sands National Monument by Seager et al. (1987). "*" Indicates additional information on Geomorphic Map Unit Properties Table. "?" Indicates uncertain occurrences as noted on the source map.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
PLEISTOCENE AND PLIOCENE	Camp Rice Formation, sediments associated with La Mesa surface (Qcl)	Basin-floor sediments, the constructional top of which is the La Mesa geomorphic surface (shown on geologic map with horizontal-line pattern). Generally consists of sand, silt, loam, or clay. Surficial layers, up to 3 m (10 ft) thick, have prominent horizons of soil-carbonate accumulation and, locally, reddish-brown horizons of clay accumulation. Carbonate horizons are commonly indurated (hardened), forming pedogenic calcrete zones up to 1.5 m (5 ft) thick. Overlain by discontinuous veneer of Holocene eolian sand or, locally, by upper Quaternary playa or alluvial-flat deposits. Up to 15 m (50 ft) exposed, may be locally thicker in subsurface.	*Groundwater*—part of basin-fill groundwater aquifer. *Surface Water*—location of intermittent streams on western side of White Sands National Monument. *Debris Flows and Rockfall*—site of mass wasting.	*Alluvial Deposits*—serve as pathway for surface water runoff and sediment input to the active Holocene lake basin (**ahlb**).* Part of bajada.	Deposited by ancestral Rio Grande and associated with extension of Rio Grande rift. Includes fluvial, playa, and alluvial-flat deposits that are commonly reworked by the wind.
	Camp Rice Formation, fanglomerate facies (QTcc)	Calcite-cemented, reddish-brown to tan fanglomerate and conglomerate underlying **Qcp**, **Qct**, or **Qcf**. Locally intertongues with **Qcf**. As thick as 90 m (300 ft) where it filled late Pliocene valleys cut into uplifts, probably much thicker in grabens below range-boundary faults.	*Groundwater*—part of basin-fill groundwater aquifer. *Surface Water*—location of intermittent streams on western side of White Sands National Monument. *Debris Flows and Rockfall*—site of mass wasting.	*Alluvial Deposits*—serve as pathway for surface water runoff and sediment input to the active Holocene lake basin (**ahlb**).* Part of bajada.	Deposited by ancestral Rio Grande and associated with extension of Rio Grande rift. Locally contains basalt flows.
OLIGOCENE	Intermediate-composition plutonic rocks (Tii)	Medium- to dark-gray, equigranular monzodiorite stock in the Organ Mountains.	*Mining and Energy Development*—related to mineralization in the Organ mining district.	None reported.	Batholith and volcanism. Exposed in San Andres Mountains. 33 million years old.
	Nonfoliated rhyolite intrusives (Tri)	Nonporphyritic to slightly porphyritic siliceous dikes, sills, and small plugs in the Robledo Mountains–Selden Canyon area and northwest Organ Mountains. Yellow-brown intrusive rhyolite and breccia, devitrified (converted from glass to crystalline material) and chaotic (with randomly oriented crystals), in the western Dona Ana Mountains.	*Mining and Energy Development*—related to mineralization in the Organ mining district.	None reported.	Batholith and volcanism. Exposed in San Andres Mountains. 35 million years old.
	Silicic plutonic rocks (Tis)	Quartz-monzonite porphyry, granite, quartz syenite, and syenite of the Organ batholiths. Monzonite-porphyry dikes, small stocks, and a laccolith of the Dona Ana Mountains. Monzonite-porphyry dikes, sills, and stocks of the Jarilla Mountains. Syenitic sills and associated stocks (?) or laccoliths (?) in the Hueco Mountains.	*Mining and Energy Development*—Organ intrusives are related to mineralization in the Organ mining district. Jarilla intrusives (late Eocene? or Oligocene?) are related to mineralization in the Orogrande district.	None reported.	Batholith and volcanism. Exposed in San Andres Mountains. Organ and Dona Ana intrusives are 32.8 million years old and 33.7 million years old, respectively, and associated with thick cauldron-fill, ash-flow tuffs.
	Love Ranch Formation (Tlr)	Pebble to boulder conglomerate, red mudstone, and sandstone derived from Paleozoic rocks and (locally) Precambrian granite. As thick as 610 m (2,000 ft) in southern San Andres Mountains.	*Groundwater*—part of basin-fill groundwater aquifer. *Debris Flows and Rockfall*—contributes material to debris-flow deposits.	*Alluvial Deposits*—exemplifies valley-filling process of Tularosa Basin.	Alluvial-fan and fluvial deposits formed as a result of erosion during Laramide uplift.

Gray-shaded rows indicate units not mapped within White Sands National Monument by Seager et al. (1987). "*" Indicates additional information on Geomorphic Map Unit Properties Table. "?" Indicates uncertain occurrences as noted on the source map.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
TERTIARY AND CRETACEOUS	Sarten and Dakota Sandstone, undivided and rocks correlative with Mancos Shale and Gallup Sandstone (TKru)	Yellow-, tan-, and gray-weathering, soft sandstone, shale, and siltstone and massive, cross-bedded, gray quartzite.	*Paleontological Resources*—pelecypods and pelecypod coquina (deposit of fossil-shell debris) in Sarten and Dakota Sandstone. Mancos Shale has petrified wood, pelecypods, and ammonites.	None reported.	Marine and fluvial settings.
PALEOZOIC ERA	Paleozoic rocks, undifferentiated (PZu)	No description provided by Seager et al. (1987).	Unknown.	*Alluvial Deposits*—supplies material to alluvial fans and bajada.	Open marine setting.
PERMIAN	San Andres Formation (Ps)	Gray to dark-gray, medium-bedded to massive, fetid limestone with a basal (Glorieta) sandstone. Basal sandstone is yellowish and cross-laminated. 60 m (200 ft) to 180 m (600 ft) thick.	*Paleontological Resources*—fossiliferous limestone.	None reported.	Marine setting.
	Yeso Formation–San Andres Formation, undivided (Psy)	Thick- to medium-bedded, light- and dark-gray, fine-grained limestone. Minor beds of soft, yellow, fine-grained sandstone. Approximately 170 m (550 ft) thick.	*Groundwater*—significant for groundwater-flow model and deposition of gypsum in Tularosa Basin.	*Gypsum*—source of gypsum in the Tularosa Basin.	Marine setting.
	Yeso Formation (Py)	Light-brown to light-red sandstone, light-gray to white gypsum, and sandy, medium- to dark-gray, fetid limestone. 200 m (660 ft) to 274 m (900 ft) thick.	*Groundwater*—significant for groundwater-flow model and deposition of gypsum in Tularosa Basin. *Paleontological Resources*—limestones are moderately to sparsely fossiliferous; contain brachiopods, gastropods, and algae.	*Source of Gypsum Sand*—source of the bulk of gypsum in the Tularosa Basin. Ultimate source of gypsum sand for dunes.	Cyclic deposition within marine and eolian environments.
	Yeso (?) beds and Abo Formation (Pya)	Consists of beds of Yeso Formation (**Py**)? (see description above) and Abo Formation (**Pa**) (see description below).	*Groundwater*—significant for groundwater-flow model and deposition of gypsum in Tularosa Basin.	*Source of Gypsum Sand*—source of gypsum in the Tularosa Basin.	Marine setting.
	Abo Formation (Pa)	Reddish-brown siltstone, fine sandstone, and arkosic sandstone, with red, green, and gray shale. 130 m (425 ft) to 194 m (615 ft) thick.	*Debris Flows and Rockfall*—forms valley and ridge topography. *Paleontological Resources*—vertebrate tracks and plant impressions (elsewhere).	None reported.	Continental setting. In places, the Abo and Hueco formations intertongue, suggesting shifting shorelines of terrestrial (Abo) and marine (Hueco) settings.

Gray-shaded rows indicate units not mapped within White Sands National Monument by Seager et al. (1987). "*" Indicates additional information on Geomorphic Map Unit Properties Table. "?" Indicates uncertain occurrences as noted on the source map.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
PERMIAN	Hueco Formation (Ph)	Algal limestone, gastropod-echinoid-brachiopod limestone, fusulinid limestone, chert-pebble conglomerate, sandy limestone, gray shale, shaly limestone, siltstone, massive cherty limestone. As much as 690 m (2,250 ft) thick.	*Groundwater*—significant for groundwater-flow model. *Paleontological Resources*—fusulinids, gastropods, and ostracodes.	None reported.	Only bedrock unit mapped within White Sands National Monument. Later intruded by stocks and dikes of plutonic rocks (**Tis**, **Tri**, and **Tii**). Marine setting. In places, the Abo and Hueco formations intertongue, suggesting shifting shorelines of terrestrial (Abo) and marine (Hueco) settings.
PENNSYLVANIAN	Panther Seep Formation (PNps)	Brown to gray shale, sandstone, siltstone, gypsum, and fine-grained, laminated limestone. Mostly of Late Pennsylvanian age. Grades downward into Middle Pennsylvanian beds and upward into Hueco Formation. As much as 690 m (2,500 ft thick).	*Groundwater*—significant for groundwater-flow model and deposition of gypsum in Tularosa Basin. *Debris Flows and Rockfall*—soft and easily eroded. *Paleontological Resources*—stromatolitic algae and fusulinids.	*Source of Gypsum Sand*—source of gypsum in Tularosa Basin.	Later intruded by stocks and dikes of plutonic rocks (**Tis**, **Tri**, and **Tii**). Restricted marine or sediment-laden setting.
	Lead Camp Limestone (PNlc)	Massive, thick- to medium-bedded, fossiliferous, cherty, gray limestone and dolomite cyclically interbedded with shale; sandstone, conglomerate, and quartzite form local pods lower third of the unit. Becomes very dolomitic, shaly, and gypsiferous at top where it weathers orange, yellow, or olive and grades into Panther Sheep Formation (**PNps**). As much as 370 m (1,200 ft) thick.	*Paleontological Resources*—fusulinids.	None reported.	Later intruded by stocks and dikes of plutonic rocks (**Tis**, **Tri**, and **Tii**). Open marine setting.
	Lead Camp Limestone overlying limestone (PNlc/ls)	PNlc/ls consists of PNlc overlying ls: Lead Camp Limestone (**PNlc**): See description above. Limestone (**ls**): Seager et al. (1987) provided no information.	*Paleontological Resources*—fusulinids.	None reported.	Later intruded by stocks and dikes of plutonic rocks (**Tis**, **Tri**, and **Tii**). Open marine setting.
MISSISSIPPIAN AND DEVONIAN	Mississippian and Devonian rocks (MDr)	Undifferentiated unit of Mississippian and Devonian rocks, including the following: Mississippian—Helms Formation (limestone), Rancheria Formation (micrite), Las Cruces Limestone, Lake Valley Limestone, and Caballero Formation (siltstone and limestone). Devonian—Percha Shale and Canutillo Formation (limestone).	*Debris Flows and Rockfall*—Lake Valley Limestone is cliff forming. Percha Shale is exceptionally soft and fissile, forming erosional slopes. *Paleontological Resources*—Mississippian rocks have conodonts, crinoids, corals, brachiopods, bryozoans, snails, and other mollusks. Devonian rocks have primarily brachiopods.	None reported.	Mississippian—open marine setting. Devonian—restricted marine setting.
SILURIAN AND ORDOVICIAN	Fusselman Dolomite and Montoya Group, undivided (SOfm)	Fusselman Dolomite: Massive, dark-gray, cherty dolomite in northern part of map area; pale-tan-weathering, light-gray, massive dolomite in southern areas. Up to 195 m (640 ft) thick. Montoya Group: Basal, tan, coarse-grained Cable Canyon Sandstone overlain by massive, dark-gray Upham Dolomite, followed upward by cherty, light- and dark-gray Aleman Dolomite. Capped by light-gray, fine-grained, thin-to medium-bedded Cutter Dolomite. Up to 140 m (470 ft) thick.	*Debris Flows and Rockfall*—Cutter Dolomite forms ledges and cliffs. Fusselman Dolomite forms cliffs and ridge crests. *Mining and Energy Development*—Fusselman Dolomite has barite-fluorite and base-metal deposits.	*Alluvial Deposits*—supplies material to alluvial fans and bajada.	Open marine setting.

Gray-shaded rows indicate units not mapped within White Sands National Monument by Seager et al. (1987). "*" Indicates additional information on Geomorphic Map Unit Properties Table. "?" Indicates uncertain occurrences as noted on the source map.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
ORDOVICIAN AND CAMBRIAN	El Paso Group and Bliss Sandstone, undivided (OCeb)	El Paso Group: Thin-bedded, siliceous, sandy, orange- to brown-weathering limestone in lower third, thick- to medium-bedded gray dolomite or limestone in upper two-thirds. Up to 410 m (1,340 ft) thick. Bliss Sandstone: Brown, gray, or black hematitic sandstone, shale, siltstone, and quartzite. Up to 60 m (200 ft) thick.	*Paleontological Resources*—El Paso Group has burrows. Fossils are sparse in Bliss Sandstone.	*Alluvial Deposits*—supplies material to alluvial fans and bajada.	Open marine setting.
PRECAMBRIAN	Precambrian rocks, granite (PCg)	Pink to brown, coarse-grained granite cut by systems of northeast- or east-trending diabase-amphibolite dikes.	Unknown.	*Alluvial Deposits*—supplies material to alluvial fans and bajada.	Arc or rift setting. Batholith is 1.4 billion to 1.3 billion years old. Forms core of Laramide uplift. Exposed in San Andres Mountains
	Precambrian rocks, quartzite (PCq)	Variable-colored, fine- to medium-grained quartzite, feldspathic quartzite, and arkose interbedded with lenses and beds of phyllite and mica schist.	Unknown.	*Alluvial Deposits*—supplies material to alluvial fans and bajada.	
	Precambrian rocks, schist and phyllite (PCs)	Medium- to fine-grained, quartz-mica schist and phyllite with interbeds of quartzite, talc, and minor bodies of amphibolite.	Unknown.	*Alluvial Deposits*—supplies material to alluvial fans and bajada.	
	Precambrian rocks, amphibolite (PCa)	Black to greenish-black dikes, sills, and irregular bodies of hornblende-plagioclase amphibolite; includes gneissic bodies locally, mixed with amphibolite.	*Mining and Energy Development*—gold-copper-quartz mineralization.	*Alluvial Deposits*—supplies material to alluvial fans and bajada.	
	Precambrian rocks, metadiabase (PCmd)	Black to greenish-black metadiabase sills and dikes.	Unknown.	*Alluvial Deposits*—supplies material to alluvial fans and bajada.	
	Precambrian rocks, gneiss (PCgn)	Quartz-feldspar-mica gneiss with granite pods; locally migmatic.	Unknown.	*Alluvial Deposits*—supplies material to alluvial fans and bajada.	