Map Unit Properties Table: Wupatki National Monument

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Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral and Potential Economic Resources	Caves and/or Karst	Habitat	Recreation*	Geologic Significance
QUATERNARY (Holocene)	Artificial fill and quarries (Qaf)	Excavated alluvium and bedrock material removed from bar-pits and trenches to build livestock tanks, drainage diversion dams, roads, and other construction projects (map does not include all highway road excavations). Includes uranium mine excavations, tailing deposits, and mine restoration sites in the Little Colorado River Valley area.	Variable.	Used as road base and for construction projects.	None.	None.	None.	Borrow pits (sand and gravel).	None.	Disturbed areas.	None. Sites of limited areal extent.	None.
	Stream-channel deposits (Qs)	Poorly sorted, lenses of silt, sand, pebbles, and gravel. Interlayered with young alluvial fan (Qa1), young terrace-gravel (Qg1), and upper part of valley-fill (Qv) deposits; overlaps flood-plain (Qf) and ponded sediment (Qps) deposits. Contacts are approximate with other alluvial deposits. Qs deposits of the Little Colorado River are mapped as shown on 1968 black and white aerial photographs and do not necessarily reflect stream-channel deposits of today due to extensive low-gradient channel changes caused by yearly flooding events. About 2 to 9 m (6 to 30 ft) thick.	Low.	Low. Flood-prone areas.	Stream channels subject to high-energy flows and flash floods.	Plant material and food waste from 22 packrat middens (see Tweet et al. 2009). Quaternary fossils, primarily bones of large mammals (see text) have been discovered in the monument area. Quaternary fossils have not been correlated with specific map units.	Possible early settler and American Indian artifacts transported by streams.	Sand and gravel.	None.	Sparse vegetation. Tamarisk (Salt Cedar), Russian olive, cotton-wood trees.	Crossed by road to Wukoki Pueblo.	Tributaries that provide sediment to the Little Colorado River.
	Flood-plain deposits (Qf)	Gray, brown, and light-red clay, silt, sand. Includes some lens-shaped gravel deposits. Partly consolidated by gypsum and calcite cement. Intertongue or overlap stream-channel (Qs), valley-fill (Qv), young terrace-gravel (Qg1), and young alluvial fan (Qa1) deposits. Similar to valley alluvial (Qv) deposits in small tributary drainage valleys that form broad, flat, valley floors subject to widespread and frequent overbank flooding along the Little Colorado River and in highland valleys west of Gray Mountain. Subject to temporary ponding and often mixed with ponded sediments (Qps) or young mixed alluvium and eolian deposits in broad drainage floodplains on the Coconino Plateau. Vegetation at higher elevations over 1,524 m (5,000 ft) help trap and accumulate fine-grained sediment on floodplains of Coconino Plateau. About 2 to 9 m (6 to 30 ft) thick.	Low. Subject to lateral and vertical erosion.	Low. Flood-prone areas.	Overbank flooding.		Potential for early settler and American Indian sites. About 2,400 sites have been found in the monument.	Borrow (gravel) pit.	None.	Tamarisk trees, sagebrush, tumble weed plants, desert shrubs, grass, cliffrose bush.	One outcrop of limited areal extent near the monument's eastern border. Crossed by secondary roads.	Traps sediment being transported to the Little Colorado River.
	Dune sand and sand sheet deposits (Qd)	White, gray to light-red, fine- to coarse-grained sand composed mainly of quartz, chert, and minor feldspar grains derived from pre-existing Triassic and Jurassic sedimentary strata east of the Little Colorado River. Include topographically controlled climbing and falling dunes and sand sheets that mantle gentle slopes of bedrock at Ward Terrace and Red Rock Cliffs and within tributary drainages northeast and east of the Little Colorado River below Moenkopi Plateau (northeast of the monument). Sand that has been originally transported by fluvial erosion down tributary drainages from the southwestern edge of Moenkopi Plateau to the Little Colorado River is re-transported upstream by southwesterly winds onto Triassic and Jurassic bedrock surfaces forming significant deposits on Ward Terrace and against Red Rock Cliffs. Includes topographically controlled climbing and falling dunes, complex dunes, parabolic dunes, and barchan dunes. Arbitrary and gradational lateral and vertical contacts between other alluvial or eolian deposits. About 1 to 61 m (3 to 200 ft) thick.	Low, except where sand is stabilized by vegetation.	Low. Shifting sand. Underlying bedrock would provide any foundation.	None.			Sand and some gravel.	None.	Moderate growth of grass and high desert shrubs that stabilize extensive sand sheet and dune deposits on Moenkopi Plateau.	One exposure in the back-country, which is closed to hiking.	Unit records wind direction and sediment availability.
	Young eolian sand sheet deposits (Qes)	White to gray, fine- to coarse-grained, windblown sand composed of quartz and chert grains derived from Qs. Form northeast and east of the Little Colorado River. Intertongue with Qae. Arbitrary and gradational lateral and vertical map contacts that intertongue with Qd and other surficial deposits. Thickness is 0.3 to 4.5 m (1 to 15 ft).	Low, except where sand is stabilized by vegetation.	Low. Flood prone areas and shifting sand.	None.	Unknown.	Potential for early settler and American Indian sites.	Quartz sand.	None.	Grass and small high-desert shrubs.	Not mapped in the monument.	Unit records wind direction and sediment availability.
	Young linear dune deposits (Qdl)	White, gray, and light-red, fine- to medium-grained, well sorted, unconsolidated quartz sand accumulation aligned in a general northeast direction. Associated with Qes northeast of the Little Colorado River. Generally 12 to 24.5 m (40 to 80 ft) in width and commonly less than 0.8 km (0.5 mi) in length, but dunes can reach to over 5 km (3 mi) in length northeast of map area on Moenkopi Plateau. Thickness: 2 to 6 m (6 to 20 ft).	Low.	Low. Limited areal extent and shifting sand.	None.	Unknown.	Limited potential. Linear feature that is easily eroded.	Quartz sand.	None.	Little or no vegetation.	Not mapped in the monument.	Unit records wind direction and sediment availability.
	Young barchans dune deposits (Qdb)	White, gray, light-red, fine- to coarse-grained, well-sorted quartz sand. Forms a barchan dune along a tributary northeast of the Little Colorado River. Arbitrary and gradational contacts (not dashed) with other eolian, alluvial, or bedrock deposits; subject to change on yearly basis due to seasonal storms. Thickness is 8 ft (2.4 m).	Low.	Very minor areal extent. Shifting sand.	None.	Unknown.	Limited potential. Sand dune is easily eroded.	Quartz sand.	None.	Little or no vegetation.	Not mapped in the monument.	Unit records wind direction and sediment availability.

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QUATERNARY (Holocene)	Young terrace-gravel deposits (Qg1)	Light-brown, pale-red, and gray well-sorted, interbedded mud, silt, sand, pebbles, cobbles, and some boulders; partly consolidated by matrix of mud and sand cemented by calcium carbonate and gypsum. Composed mainly of subangular to well-rounded Paleozoic and Mesozoic sandstone, limestone, and chert clasts of local origin. Includes well-rounded clasts of quartzite, quartz, and assorted metamorphic crystalline rocks reworked from Tertiary conglomerates southeast and south of the monument. In south and southwest part of map area, unit includes well-rounded volcanic clasts derived from the San Francisco Volcanic Field. Locally overlaps Qa1, Qf, and Qv deposits. Contacts with adjacent alluvial and eolian deposits are approximate. Form terraced benches about 1 to 3.6 m (3 to 12 ft) above Qs deposits on Coconino Plateau and 1.5 to 2 m (4 to 6 ft) above the Little Colorado River channel and Qf deposits. Fill erosion channels cut into bedrock, Qa1, and Qf deposits. Thickness is 2 to 6 m (6 to 20 ft).	Low to moderate, depending on amount of consolidation. Subject to sheet wash erosion.	Very minor exposures of limited extent. Crossed by unimproved roads.	Subject to flash flooding.	Potential for Quaternary fossils in packrat middens.	Potential for early settler and American Indian sites. About 2,400 sites have been found in the monument.	Sand, gravel, and landscape boulders but only minor exposures in the monument.	None.	Little to no vegetation, mainly grass and some cottonwood trees along the Little Colorado River.	Backcountry exposures of minor areal extent.	Represents the most recent downcutting by tributaries in the Little Colorado River drainage network.
	Young alluvial fan deposits (Qa1)	West and southwest of the Little Colorado River: Gray-brown silt, sand, pebbles, cobbles, and boulders. Composed mainly of subangular to rounded limestone, chert, and sandstone clasts derived from Permian and Triassic strata of the Coconino Plateau area. Includes medium to small, subrounded to rounded pebbles and cobbles of basalt and andesite and pyroclastic fragments of the San Francisco Volcanic Field. Partly consolidated by gypsum and calcite cement. East and northeast of the Little Colorado River: Gray, light-brown, and light-red mud, silt, sand, as well as cobble and pebble clasts of chert, limestone, and sandstone. Overlapped by Qps, Qf, and Qd deposits. Intertongues with Qg1 and Qae deposits. Thickness is 1 to 6 m (3 to 20 ft).	Variable. Subject to extensive sheet-wash erosion and small arroyo erosion.	Crossed by Wupatki Park Road and unimproved roads. Monument headquarters buildings.	Potential flash flooding and debris flows.	Plant material and food waste from 22 packrat middens (Tweet et al. 2009). Quaternary fossils, primarily bones of large mammals have been discovered in the monument area. Quaternary fossils have not been correlated with specific map units.	Potential for early settler and American Indian sites. About 2,400 sites have been found in the monument.	Sand, gravel, and landscape boulders.	None.	In monument area: Light to moderate growth of sagebrush, cactus, juniper, and grass. Wupatki Spring.	Crossed by Wupatki Park Road, road to Wukoki Pueblo, and jeep trail.	Most recent fan-shaped deposit resulting from stream erosion and transporta-tion of sediment.
QUATERNARY (Holocene and Pleistocene)	Intermediate terrace-gravel deposits (Qg2)	Southwest of the Little Colorado River: Gray and brown silt, sand, and gravel; unconsolidated. Lithologically similar to Qg1 deposits. Composed mainly of gray and brown siltstone and fine-grained sandstone matrix mixed with subangular to rounded pebbles and boulders of local Permian limestone and Triassic sandstone. Includes well-rounded basalt clasts derived from the San Francisco Volcanic Field. Locally intertongues with Qa1 and Qa2 deposits. Form terrace benches about 4.5 to 9 m (15 to 30 ft) above modern streambeds and about 1.5 to 6 m (5 to 20 ft) above Qg1 deposits. East and northeast of the Little Colorado River: Isolated deposits of gray and red silt, sand, and multi-colored, angular cherty fragments. Terrace benches 3 to 15 m (10 to 50 ft) above the modern Little Colorado River bed. Thickness is 2 to 30 m (6 to 100 ft).	Variable, depending on clast size and vegetation.	Low. One mesa with limited, flat topography near the eastern border; one outcrop of limited areal extent near Doney Fault. Both in backcountry.	None.			Sand and gravel, but limited exposures.	None.	Support minor growth of high desert shrubs and grass.	Primarily a backcountry mesa with no roads or trails.	Record a history of uplift and erosion in the monument area.
	Intermediate alluvial fan deposits (Qa2)	Lithologically similar to Qa1 deposits; partly cemented by calcite and gypsum, but surfaces are more gravelly and often cut by arroyos as much as 3 m (10 ft) deep southwest of the Little Colorado River area. Northeast of the Little Colorado River, surfaces are sandy and often covered by young sand sheet deposits too thin to show at map scale. Commonly overlapped by Qa1 deposits near the Little Colorado River area and intertongue or overlapped Qv, Qtr, and Qg1 and Qg2 deposits west and southwest of the Little Colorado River. Includes abundant subrounded to subangular basalt clasts in southwest quarter of the map area and abundant subangular chert clasts northeast of the Little Colorado River. Thickness is 2 to 15 m (6 to 50 ft).	Variable, depending on clast size and vegetation.	Crossed by Wupatki Park Road and unimproved roads. Would not provide solid footing for buildings.	None.			Gravel.	None.	Grass, cactus, and sagebrush, southwest of the Little Colorado River. Little to no vegetation northeast of the Little Colorado River.	Crossed by Wupatki Park Road, but primarily a backcountry unit.	Unit may help reconstruct the history of sedi-ment erosion and transportation.
	Ponded sediments (Qps)	Gray to brown clay, silt, sand, and minor lenses of gravel; partly consolidated by calcite and or gypsum cement. Locally includes small chert, limestone, and sandstone fragments or pebbles. Similar to Qf deposits but occupy manmade or natural internal drainage depressions. Internal drainage basins and sinkholes in the western part of Wupatki National Monument and Coconino National Forest formed intermittent shallow freshwater ponds that were likely an important water source for early human inhabitants of this area. Thickness is 1.5 to 12 m (5 to 40 ft).	High. Unit occupies depressions.	Low. Crossed by roads near Box Canyon and Lomaki Pueblos, but near faults and sinkholes.	None.			None.	None.	Desiccation cracks often develop in dry, hardpan surfaces. Clay content restricts plant growth	Road to Box Canyon and Lomaki Pueblos.	Geologically insignificant deposits. Temporary water sources.
	Young mixed alluvium and eolian deposits (Qae)	Gray, light-red, and brown clay, silt, and fine- to coarse-grained sand interbedded with lenses of pebbly gravel. Includes white angular chert fragments locally derived from Permian strata on Coconino Plateau and white, gray, brown, and red chert fragments derived from the Chinle Formation east of the Little Colorado River. Interbedded sequence of thin-bedded, mixed mud, silt, sand, and gravel accumulated from both alluvial and eolian processes. Commonly occupies broad flatland or gently sloping topography downwind (northeast) of local drainage valleys. Thickness is 3 to 40 ft (1 to 12 m).	Variable. Sheet-wash erosion during wet conditions and often covered by Qd when dry.	Crossed by Wupatki Park Road and undeveloped roads but unit is unstable for buildings.	Potential sheet-wash flooding.			Coarse sand and gravel.	None.	Support light to moderate growth of grass, cactus, and high desert shrubs.	Crossed by Wupatki Park Road.	Record a combination of alluvial and eolian processes.

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QUATERNARY (Holocene and Pleistocene)	Eolian cinder dune deposits (Qdc)	Black, gray, and red coarse-grained fragments of angular to subangular, glassy basaltic and andesitic cinders and scoria. Derived primarily from Sunset Crater eruption 16 km (10 mi) southwest of map area about 1,000 years ago. Includes pyroclastic deposits from other volcanic vents in the San Francisco Volcanic Field in west part of map area and near Doney Mountain. Pyroclastic fragments are commonly vesicular fallout deposits transported by southwesterly winds; particles accumulated against or downslope of local topographic obstructions such as basalt flows, steep-walled drainages, rock ledges, and fault scarps. Form extensive thin cover of eolian cinder deposits over all terrain in southwest part of map area. Cinder fragments become smaller and more rounded farther downwind (northeast) of eruptive centers. Thickness is 1.5 to 12 m (5 to 40 ft).	Low.	Low. Mostly deposited on steep slopes.	Unstable slopes.	Plant material and food waste from 22 packrat middens (see Tweet et al. 2009). Quaternary fossils, primarily bones of large mammals (see text) have been discovered in the monument area. Quaternary fossils have not been correlated with specific map units.	Potential for early settler and American Indian sites. About 2,400 sites have been found in the monument.	Volcanic cinders.	None.	Little or no vegetation on relatively steep slopes of Woodhouse, West, and North Mesas.	Exposures adjacent to monument headquarters.	Deposits transported by southwesterly winds.
	Eolian cinder sand sheet deposits (Qsc)	Sand sheets composed of black, gray, and red coarse-grained fragments of angular to subangular, glassy, basaltic cinders and scoria. Similar to Qdc deposits but form extensive surface deposits of volcanic particles downwind (northeast) of eruptive centers in south part of the map area. Volcanic cinder fragments become smaller and more rounded farther downwind (northeast) of eruptive centers. Form discontinuous cinder ground cover over the south-central part of map area within and near the monument. Northeast of the monument, Qsc deposits are present as detected on aerial photos and in the field but are too discontinuous to show at map scale. Volcanic cinders are commonly mixed with quartz sand. Thickness is 0.3 to 1.5 m (1 to 5 ft).	Low.	Crossed by roads but unit is too thin to provide any stable footing for buildings.	None.			Volcanic cinders, but the unit is not very thick in the monument.	None.	Thin, surficial deposits. *Penstemon clutei* (Sunset Crater beardtongue) thrives on cinder fields.	Road to Box Canyon and Lomaki Pueblos.	Deposits transported by southwesterly winds.
	Talus and rock fall deposits (Qtr)	Brown, gray, slope-forming, unsorted mixture of mud, silt, sand, pebbles, cobbles, and large angular boulders. Forms talus debris slopes in steep-walled canyons near base of Doney Mountain Fault and below basalt flows near the monument's Visitor Center. Includes individual car- and house-size basalt boulders. Clasts are mostly angular and unsorted; partly cemented by calcium carbonate. Gradational and arbitrary contacts with Ql, Qa1 and Qa2, Qg1 and Qg2, and Qv deposits. Only thick or extensive deposits shown. Thickness is 1 to 7.5 m (3 to 25 ft).	Subject to extensive sheet-wash and arroyo erosion.	Low. Unstable deposits near steep slopes.	Subject to flash-flood debris flows.			None. Composed of coarse rock debris.	None.	Supports little or no vegetation.	Backcountry exposures along the Black Point Monocline.	Unit records the process of canyon widening by cliff collapse.
	Landslide deposits (Ql)	Unconsolidated to partly consolidated masses of unsorted rock debris. Includes detached blocks that have rotated backward and slid down slope as loose masses of broken rock and deformed strata; talus and rockfall debris on lower slopes adjacent to and below landslide masses. Some landslide blocks may become unstable in wet conditions below edges of basalt flows south of the monument's Visitor Center. Gradational and arbitrary map contacts with Qa1, Qa2, Qg1, and Qg2 deposits. Thickness of landslides is 3 to 36 m (10 to 120 ft).	Subject to extensive sheet-wash and arroyo erosion.	Low. Unstable deposits near steep slopes.	Subject to flash-flood debris flows.			None. Composed of coarse rock debris.	None.	Supports little or no vegetation.	Backcountry exposures along the Black Point Monocline.	Unit is an example of dynamic equilibrium as unstable slopes tend to stabilize.
	Valley-fill deposits (Qv)	Gray and light-brown silt, sand, and lenses of gravel; partly consolidated by gypsum and calcite cement west and southwest of the Little Colorado River. Includes minor rounded clasts of limestone and sandstone, subrounded to angular chert, and subrounded to angular basalt southwest of the Little Colorado River. Intertongue with or overlapped by Qa1, Qa2, Qg1, and Qg2 deposits. Commonly reflects low energy and low-gradient shallow drainages. Thickness is 1 to 9 m (3 to 30 ft).	Low, except where cemented by gypsum and calcite.	Low. Crossed by roads in western Wupatki but subject to flooding.	Subject to sheet-wash flooding.			Sand and gravel.	None.	Ponding due to sagebrush, grass, cactus, and juniper trees in west half of map area.	Road to Citadel, Nalakihu, Box Canyon, and Lomaki Pueblos.	Unit records the process of how valleys fill with sediments.
	Old terrace-gravel deposits (Qg3)	Gray and light-brown silt, sand, pebbles, cobbles, and boulders composed primarily of local Permian and Triassic clasts; partly consolidated by calcite and gypsum cement; unsorted. Lithologically similar to Qg1 and Qg2 deposits, but includes abundant rounded volcanic clasts and some well-rounded quartzite clasts. Basalt clasts as much as 0.3 m (1 ft) in diameter; smaller basalt cobbles form desert pavement surface in southeast quarter of map area. Forms terraces about 3.7 to 12 m (12 to 40 ft) above modern streambeds; about 43 m (140 ft) above the Little Colorado River. Thickness is 0.6 to 6 m (2 to 20 ft).	Low where disturbed; higher where cemented and forming desert pavement.	Low. Forms two mesas and buttes in the backcountry of eastern Wupatki.	None.			Sand, gravel, and landscape boulders.	None.	Sagebrush, grass, cactus.	Backcountry mesas without roads or trails.	Record a history of uplift and erosion in the monument area.
	Old alluvial fan deposits (Qa3)	Gray and light-brown, silt, sand and gravel. Lithologically similar to Qa1 and Qa2 deposits, but unit extensively eroded by arroyos; partly consolidated by calcite and gypsum cement. Surface has thin calcrete soil that forms resistant rocky surface east of Doney Mountain Fault and Black Point Monocline. Thickness is 1.5 to 7.6 m (5 to 25 ft).	High. Surface has resistance from calcrete soil formation.	Low. Thin deposits of limited areal extent.	None.			None. Minor exposures at the base of the Black Point Monocline.	None.	Supports moderate growth of grass, sagebrush, and cactus.	Crossed by secondary roads in the back-country.	Landscape reconstruction and sediment transportation.

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QUATERNARY (Pleistocene)	VOLCANIC ROCKS OF THE SAN FRANCISCO VOLCANIC FIELD	Basalt flow of Merriam Crater (Qmcb)	Dark-gray alkali olivine basalt. Contains scattered phenocrysts of olivine, clinopyroxene, and rare plagioclase in groundmass of the same minerals plus opaque oxides. Basalt flow occupies valley of the Little Colorado River in northeast part of map area where the river flows over the basalt flow and forms a rapid called Black Falls. Downstream of Black Falls, the Little Colorado River flows adjacent to basalt flow where it had spread out onto Qs and Qf deposits of the Little Colorado River. Age: 19,600±1,200 years old. Thickness is 2 to 4 m (6 to 13 ft).	High.	Potential for good foundations, but limited areal extent along eastern border.	None. Backcountry exposures.	If lava tubes exist in the unit, fossils may be in the caves.	If lava tubes exist in the unit, cultural artifacts may be in the caves.	Phenocrysts of clinopyroxene, olivine, and plagioclase.	Potential for lava tube (non-dissolution) caves.	Vegetation limited by lack of soil development.	Secondary road to Black Falls Crossing.	Originated from Merriam Crater, 17.5 km (11 mi) southeast of the monument.
		Basalt flows (Qb)	Dark-gray and black porphyritic and aphyric, clinopyroxene-olivine and alkali-olivine basalt. Flows occur locally adjacent to present stream drainages; are moderately young in appearance; and are locally covered by thin alluvium, eolian sand, or airborne cinder deposits. Little dissected. Age dates in millions of years before present: 0.22±0.05, 0.46±0.05, 0.66±0.11, 0.74±0.08, and 0.77±0.04. Thickness is 1 to 20 m (3 to 65 ft).	High.	Good potential, but located in southwestern Wupatki's backcountry.	None. Backcountry exposures.			Phenocrysts of clinopyroxene and olivine.		Juniper woodland is replacing grasslands.	Backcountry exposures. Minor secondary road.	Flowed into the monument area from the southwest.
		Pumice of San Francisco Mountain (Qsfp)	White to light-gray, poorly sorted, massive bedding of rhyolite airfall pumice. Unit is matrix-free, except for locally reworked zone in upper 1 m (3 ft) of unit. Lapilli range from several millimeters to several centimeters in size, are colorless vesicular glass, and lack visible crystals. Contains xenoliths of greenschist and blue-gray dense rhyolite with feldspar and quartz phenocrysts. Overlies Qmb and is correlated with lower aphyric pumice deposits on San Francisco Mountain south of map area because of similarities in petrography, composition, and xenoliths. Age date: 0.80±0.11 million years old. Not mapped in the monument. Thickness is 3 to 5 m (10 to 15 ft).	High.	Unknown. Not mapped in the monument.								Deposits from the eruption of the San Francisco Mountain stratovolcano.
		Basalt dike (Qmbi)	Dark-gray to black plagioclase basalt with abundant 1- to 3-cm (0.4 to 1.2 in) plagioclase lath-shaped phenocrysts in a groundmass of olivine, clinopyroxene, plagioclase, and magnetite. Contains baked xenoliths of sandstone of the Moenkopi Formation. Dike is 0.3 to 0.5 m (1 to 1.5 ft) wide.	High.	Low. Thin feature with limited areal extent.	None.	None.	Limited areal extent. Limited potential for cultural artifacts.	Plagioclase phenocrysts.	None.	Sparse vegetation (grasses, sagebrush, rabbitbrush) scattered between the volcanic rocks on Doney Mountain.	Adjacent to Wupatki Park Road, but limited extent.	Igneous intrusion.
		Pyroclastic deposits (Qmp)	Dark-gray to red-brown plagioclase, porphyritic basalt. Consists of granular groundmass of plagioclase, clinopyroxene, olivine, and magnetite. Scattered olivine and clinopyroxene phenocrysts may be present. Includes 5 small cones at south-central edge of map area and 17 fissure vents of Doney Mountain aligned with the strike of the Doney Mountain Fault. Cones are in early stage of erosion, slightly eroded, and gullied. Thickness is 1 to 92 m (3 to 300 ft).	High.	High. Crossed by Wupatki Park Road.	Potential rockfall on Doney Mountain.	None.	Limited potential for cultural artifacts.	Scattered phenocrysts of olivine and clinopyroxene.	None.		Doney Mountain Trail (1.6 km [1 mi] round-trip).	Cinder cone eruptions that parallel the Doney Mountain Fault.
		Basalt flows (Qmb)	Dark-gray plagioclase-aphyric and porphyritic basalt of similar composition to Qmp deposits. Weathers yellow or brown. Surfaces are subdued and slightly eroded and gullied. Age dates in millions of years before present: 0.83±0.04, 1.04±0.04, 1.20±0.05, and 1.38±1.01. Flows generally followed older drainages and now represent inverted topography above present drainages. Thickness is 4.5 to 48 m (15 to 160 ft).	High. Inverted topography.	Good potential, but limited areal extent in the monument.	None.	If lava tubes exist in the unit, fossils may be in the caves.	If lava tubes exist in the unit, cultural artifacts may be in the caves.	Plagioclase phenocrysts.	Arrowhead Sink (dissolution of underlying Permian limestone.)	Sparse vegetation.	Located near Wupatki Park Road in Doney Mountain Wash.	Flowed into the monument from the southwest.
		Basalt flow of Lava Point (Qmlp)	Dark-gray to black plagioclase basalt. Similar composition to Qmb basalt flows. Flowed north for several kilometers from an unknown source southwest of map area; similar to and adjacent to the Black Point Basalt (Tbpb). Age date: 1.01±0.13 million years ago. Thickness, 6 to 15 m (20 to 50 ft).	High.	Low. Only exposed in extreme northwest corner.	None.			Plagioclase phenocrysts.	Potential for lava tubes (non-dissolution) caves.	Exposed in far northwestern corner of the monument.	Backcountry exposure west of U.S. Highway 89.	Flowed from the southwest. Forms Lava Point.
		Basalt flows of Woodhouse Mesa (Qwb)	Dark-gray, alkali olivine basalt and minor alkali-rich-alumina basalt. Contain phenocrysts of olivine, clinopyroxene, and plagioclase in fine- to medium-grained matrix of same minerals. Age dates in millions of years before present: 0.786±0.14, 0.84±0.13, and 0.87±0.14. Form basalt-capped mesas southeast and south of Wupatki National Monument Visitor Center. Thickness is 2 to 15 m (6 to 50 ft).	High.	High. Caps the mesa southwest of the Visitor Center.	Potential rockfall at edge of mesa.			Scattered phenocrysts of clinopyroxene, olivine, and plagioclase.		Sparse vegetation.	Mesa south of monument headquarters. Access from outside park.	Flowed into the monument from the southwest.

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QUAT. or NEOGENE	VOLCANIC ROCKS OF THE SAN FRANCISCO VOLCANIC FIELD	Basalt flows (QTb)	Dark-gray, yellow-brown to brown, aphyric and slightly porphyritic basalt and microporphyritic olivine basalt; surfaces mostly smooth, relatively flat, and undissected. Includes thin, interbedded pyroclastic deposits near pyroclastic cones. Thickest near flow margins and filled ancestral Deadman Wash drainage southwest of Wupatki National Monument Visitor Center. Thickness is 10 to 60 m (30 to 200 ft).	High.	Unknown. Not mapped in the monument.								Filled ancestral Deadman Wash drainage.
NEOGENE (Pliocene)	VOLCANIC ROCKS OF THE SAN FRANCISCO VOLCANIC FIELD	Black Point Basalt (Tbpb)	Dark-gray to black plagioclase-aphyric basalt; surface weathers smooth; locally dissected. Contains scattered to abundant tabular plagioclase phenocrysts up to 1 cm (0.4 in) in diameter. Forms two flow lobes in the map area: 1) Black Point lobe to the northwest, 2) lobe extending for 14 km (8.5 mi) in the western part of the monument. Sourced from the southwest. Basalt flowed down Little Colorado River tributary drainages that were eroded into the Moenkopi Formation 2.4 million years ago. Age: 2.43±0.32 million years old. Flows average about 12 m (40 ft) thick. Form inverted valleys on Coconino Plateau (named West Mesa, South Mesa, East Mesa, and North Mesa) in the western part of the monument. Thickness is 6 to 40 m (20 to 132 ft).	High. Originally deposited in valleys, unit now caps mesas (inverted topography).	High, but located mostly in western Wupatki's backcountry. Crossed by Wupatki Park Road and U.S. Highway 89.	Potential rockfall at edge of mesas.	If lava tubes exist in the unit, fossils may be in the caves.	Citadel and Nalakihu Pueblos. Other ruins on East Mesa, Middle Mesa, Magnetic Mesa, West Mesa and other locations in western Wupatki.	Plagioclase phenocrysts as large as 1 cm (0.4 in) in diameter.	Potential for lava tube (non-dissolution) caves.	Sparse vegetation. Juniper woodland replacing grasslands.	Trail to Citadel and Nalakihu Pueblos (0.8 km [0.5 mi] round-trip).	Two basalt lobes originating from a single flow southwest of the monument.
NEOGENE (Pliocene or Miocene)	Old stream-channel deposits (Ts)		Light-red, gray, and brown interbedded siltstone, sandstone, arkosic gravel, and lenticular conglomerate. Unsorted and partly consolidated deposits cover part of an incised meander channel of Antelope Wash west of Doney Mountain. Antelope Wash, an ancestral Deadman Wash drainage, was superimposed onto the Kaibab Formation west of the Doney Mountain Fault and onto the Moenkopi and Chinle Formations east of the Doney Mountain Fault. Pebbles and cobbles are well-rounded quartzite, chert, and minor clasts of granite and metamorphic rocks derived from older gravel deposits southwest of the monument. Includes abundant gray limestone clasts derived from the Kaibab Formation and red sandstone clasts derived from the Moenkopi Formation. Well-rounded quartzite clasts form a lag gravel deposit. The ancestral Deadman Wash (Antelope Wash) is likely Miocene age. Thickness is 0.6 to 3.6 m (1 to 12 ft).	Variable, depending on clast size and composition.	Low. Thin exposures of limited areal extent along the Black Point Monocline.	None.	Unknown.	Potential for American Indian and early settler sites.	Sand and gravel but exposures are limited to minor outcrops near the crest of the Black Point Monocline.	None.	Unknown.	Most of the exposures are located west of the Visitor Center, beyond the boundaries of the monument.	Oldest Little Colorado River terrace-gravel deposit in the area.
REGIONAL UNCONFORMITY (Approximately 195 million years of geologic history is missing from the monument's stratigraphic record.)													
TRIASSIC (Upper)	Chinle Formation	Petrified Forest Member (TRcp)	Purple, blue, light-red, red-purple, and gray-blue, slope-forming mudstone and siltstone and interbedded white, coarse-grained lenticular (lens-shaped) sandstone. Includes large erosional channel structures and large-scale low-angle trough crossbedding. Petrified logs and wood fragments common in white or yellow-white sandstone in lower part that may be within upper part of TRcs. Contact with TRcs marked at lithologic and topographic change from sloping multicolored mudstone of TRcp to coarse-grained, light-brown sandstone ledges of TRcs. Weathers into rounded hills or slopes with a rough, puffy, popcorn surface owing to swelling of clay content when wet. Thickness northeast of the monument, 122 to 153 m (400 to 500 ft). Thickness is 3 to 9 m (10 to 30 ft).	Low for a consolidated rock unit. Forms slopes.	Exposed northeast of the monument, east of the Little Colorado River, well beyond the boundaries of the monument.								Terrestrial depositional environments including stream, lake, and flood-plains.
TRIASSIC (Upper)	Chinle Formation	Shinarump Member (TRcs)	White, light-brown, and yellow-pink, cliff-forming, coarse-grained sandstone and conglomeratic sandstone. Includes low-angle crossbedded sandstone interbedded with purple, light-red, and blue poorly sorted siltstone and mudstone. Lithology is highly variable laterally but relatively homogeneous from a regional viewpoint; unit consists of about 75% sandstone, 20% conglomerate, and 5% mudstone. Pebbles are generally brown to light-colored, well-rounded quartzite and a black siliceous composition. Petrified logs and wood fragments common at some localities but generally scattered throughout unit. Some petrified wood and associated sandstone include uranium mineral deposits that were mined along the Little Colorado River Valley during the 1950's just north of the monument. Forms resistant caprock of Tse Lichii Point, northeast of the monument. Unconformable erosional contact with underlying red siltstone and sandstone of Moenkopi Formation. Thickness: 12 to 30 m (40 to 100 ft).	High. Forms cliffs.									Mined for uranium along the Little Colorado River in the 1950s. Open-pit mines have been abandoned and many have been reclaimed.

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Age	Unit Name (Symbol)		Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral and Potential Economic Resources	Caves and/or Karst	Habitat	Recreation*	Geologic Significance
REGIONAL UNCONFORMITY (Approximately 10 million years of geologic history is missing from the stratigraphic record.)													
TRIASSIC (Lower and Middle?)	Moenkopi Formation	Holbrook and Moqui Members, undivided (TRmhm)	Red-brown, slope-forming, alternating sequence of claystone, siltstone, and sandstone. Include large to medium-scale trough crossbedding and abundant cusp-type ripple marks that testify to fluvial origin. Fossil casts of reptile tracks are often preserved on bottom surfaces of sandstone beds. Include interbedded, thin-bedded limestone and lenses of conglomeratic sandstone, and some lenses, nodules, veins, and thin-bedded gypsum. Primary bedrock in eastern Wupatki. Thickness is 25 to 37 m (80 to 120 ft).	Low for a consolidated rock unit. Forms slopes.	Currently contains roads and Wukoki Pueblo trail. Exposed in backcountry.	None.	Within the monument: *Chirotherium* (reptile) tracks, amphibian swimming tracks, archo-sauromorph-like trackway, tetra-pod tracks, ammonite fragment, and plants. Vertebrate body fossils and trace fossils outside of the monument are listed in Tweet and others (2009).	Wukoki Pueblo. Potential for additional cultural sites.	None.	None.	Stone used for Sinagua culture pueblos. Sparse (sagebrush) vegetation.	Wukoki Pueblo Trail (0.8 km [0.5 mi] round-trip). Crossed by unimproved roads.	Sedimentary features suggest that the unit was deposited in a fluvial system.
TRIASSIC (Lower)		Shnabkaib Member and lower massive sandstone (TRmss)	Yellow-white and light-brown, cliff-forming, crossbedded, fine-grained, calcareous siltstone and sandstone. Consists of two or more sandstone beds that form prominent isolated mesas or flatiron ridges along the Black Point Monocline. Lowermost ledge-forming sandstone is the most widespread part of unit. Represents a tidal flat and continental lowland fluvial environment in the monument area. Thins in all directions from the monument and correlates to the Shnabkaib Member of the Moenkopi Formation in northwestern Arizona. Minor erosional contact with underlying TRmw marked at base of lowest sandstone cliff. Thickness is 15 m (50 ft).	Variable. Sandstone (high) forms cliffs; siltstone (low) forms slopes.	Low for back-country expo-sures on steep slopes; crossed by loop road near the Visitor Center.	None.		Crack-in-Rock Ruins and ruins at the base of Black Pont Monocline and Doney Fault.	None.	None.	Vegetation that can grow in a dry climate from about 1,370 m (4,500 ft) to1,430 m (4,700 ft).	Primarily back-country expo-sures, closed to hiking. Crossed by a jeep trail that connects to the loop road.	Continued terrestrial deposition. Eolian deposits interbedded with ephemeral stream deposits.
		Wupatki Member (TRmw)	Red and red-brown, slope-forming, thin-bedded siltstone and sandstone and interbedded crumbly red-brown mudstone. Thin, flat sandstone beds (0.5 to 1 m [1 to 3 ft]) form resistant ledges within slopes. Bedding surfaces often contain small-scale ripple marks, salt crystal casts, or raindrop impressions. Unconformably overlies the Kaibab Formation and forms the regional Permian-Triassic boundary. Unit gradually thins southwest and southeast of the monument. Thickness is 6 to 10 m (20 to 35 ft).	Variable. Siltstone (low) forms slopes; few sandstone beds form ledges.	High in vicinity of Visitor Center. Crossed by roads and trails.	None.		Wupatki Pueblo. Crack-in-Rock Ruins and ruins at the base of Black Pont Monocline and Doney Fault.	None.	None.	Sparse (sage-brush vegeta-tion. Contains Heiser and Peshlaki Springs.	Wupatki Ruin Trail (0.8 km [0.5 mi]) round-trip. Wupatki blowhole.	Type locality is not designated, but unit is probably named for the monument.
REGIONAL UNCONFORMITY (Approximately 20 million years of geologic history is missing from the stratigraphic record.)													
PERMIAN (Cisuralian or "Lower")	Kaibab Formation	Harrisburg Member (Pkh)	Red-gray to brownish-gray, slope-forming gypsum, siltstone, sandstone, and thin-bedded limestone. Includes a yellowish-gray fossiliferous sandy limestone at the top that has been largely removed by erosion from parts of the region. Forms surface bedrock in central part of the monument. Contact with underlying Pkf is gradational and placed at topographic break between white-gray, slope- and ledge-forming sandy limestone and sandstone sequence of Pkh and cliff-forming white to light-brown, cherty limestone of Pkf. Unit gradually thins from west to east and undergoes a shoreward (eastward) lithologic change from limestone and sandy limestone to calcareous sandstone and sandstone. Thickness is 25 to 37 m (80 to 120 ft).	Less resistant than under-lying lime-stone and sandstone of Pkf.	Potential for stable founda-tions, but exposed in monument's backcountry. Crossed by Wupatki Park Road.	None. Exposed as relatively flat tableland in central Wupatki.	Scattered, rare mollusks (gastropod *Bellerophon*) in calcareous sandstone.	Box Canyon and Lomaki Pueblos. Other ruins on the tableland in the central part of the monument.	None.	Dissolution caves and karst topography (sinks and sinkholes). Citadel Sink.	High elevation (above 1,585 m [5,200 ft]) juniper woodlands.	Box Canyon and Lomaki Trails (0.8 km [0.5 mi]) round-trip. Wupatki Park and secondary roads. Jeep trails.	Formation records the westward regression of the Kaibab Sea.
		Fossil Mountain Member (Pkf)	Light-gray, cliff-forming, fine- to medium-grained, thin- to medium-bedded (0.3 to 2 m [1 to 6 ft]), fossiliferous, cherty, sandy limestone and minor dolomite. Weathers dark gray or brown, often stained by black magnesium oxide. Characterized by gray to white fossiliferous chert nodules and chert breccias. Chert breccia beds are less than 1 m (3 ft) thick and commonly mark uppermost part of Pkf in west half of the monument area. Gradually thins from west to east and undergoes a shoreward (eastward) lithologic change from sandy limestone to calcareous sandstone, similar in texture, composition, and appearance to Pkh. Typically forms cliff or series of ledges along Doney Mountain Fault overlain by ledges of sandy limestone and sandstone of Pkh. Unconformable contact with underlying Toroweap Formation (Pt) attributed mostly to shallow channel erosion; average erosional relief, about 3 m (10 ft). Thickness is 55 m (180 ft).	High. Forms cliffs and ledges.	Low. Cliffs in Antelope Wash and other washes that cut the Black Point Monocline.	Potential rockfall.	Invertebrate marine fossils: Brachiopods, trilobites, crinoids from sandy lime-stones; sponge spicules and bryozoans from chert nodules and chert beds. Abundant invertebrate fossils and shark teeth in the Kaibab Forma-tion outside of the monument's boundaries.	Exposures limited to cliffs and canyons carved through the Black Point Monocline. May contain undiscovered artifacts crafted from chert.	Chert.	Subsurface dissolution of Pkf and Pkh limestone has enlarged the fracture system that supports the blowholes and expands the sinkholes in the monument.	Cliff former.	Backcountry exposures.	Formation documents the eastward trans-gression of marine environ-ments into the Wupatki National Monument area.

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PERMIAN (Cisuralian or "Lower")	Toroweap Formation (Pt)	Includes, in descending order, Woods Ranch, Brady Canyon, and Seligman Members, undivided. All three members are present at Grand Canyon National Park, but all three members undergo a rapid shoreward (eastward and southeastward) lithologic change from the Grand Canyon to Wupatki National Monument to form a white, low-angle, crossbedded sandstone cliff unit in Citadel Wash and Antelope Wash along Doney Mountain Fault. Gradually thins southeast of the monument in the subsurface where drill holes near Leupp, Arizona, indicate that only 6 to 9 m (20 to 30 ft) of Pt is present in that area. In the subsurface, on the basis of exposures west of Cameron, Arizona, Pt has a sharp unconformable contact with the underlying Coconino Sandstone, a high-angle, crossbedded sandstone. Dunes of the Coconino Sandstone were beveled off by marine wave erosion and sand was redistributed as flat-bedded or low-angle crossbedded sandstone within the lower part of Pt. Thickness northwest to southeast, 24 to 9 m (80 to 30 ft).	High. Forms cliff.	Low. Cliffs in Antelope Wash canyon; limited areal extent.	Potential rockfall.	Limited exposures in the monument. No fossils in the park, but includes corals, brachiopods, crinoids and other inverte-brates outside the monument.	Exposures limited to cliffs and canyons carved through the Black Point Monocline. May contain undiscovered artifacts.	None.	Unknown. Cliff collapse may lead to alcove formation.	Cliff former.	Backcountry exposures.	Records the initial advance of marine environ-ments into the monument area following deposition of a sand sea (erg) represented by the underlying Coconino Sandstone.

Map references:
Billingsley, G.H., S.S. Priest, and T.J. Felger. 2007A. Geologic map of Wupatki National Monument and vicinity, Coconino County, northern Arizona. U. S. Geological Survey Scientific Investigations Map 2958 (scale 1:24,000).
Billingsley, G.H., S.S. Priest, and T.J. Felger. 2007B. Geologic map of the Cameron 30′ x 60′ quadrangle, Coconino County, northern Arizona. U. S. Geological Survey Scientific Investigations Map 2977 (scale 1:100,000).