National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Joshua Tree National Park

Geologic and Soil Resources Inventory Summary



Cover Photo: A view of the Lost Palms Oasis in southern Joshua Tree National Park. Fault zones form underground dams, forcing groundwater to the surface where it allows desert fan palms to grow. Photo by Matthew Harrington (Colorado State University).

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Abstract

This document summarizes the status of National Park Service (NPS) Geologic Resources Inventory (GRI) and Soil Resource Inventory (SRI) deliverables for Joshua Tree National Park. It also provides information on current geology and soil resources management concerns, with a focus on identified inventory needs related to geologic heritage, geohazards, and related soil features and processes. The purpose of this document is to help park staff prioritize technical assistance or new inventory and assessment funding requests in the near term (roughly 1–5 years).

The GRI hosted a scoping meeting for Joshua Tree National Park in 2003. Baseline bedrock and surficial geologic maps were delivered to the park in 2022. The SRI delivered a legacy soil database and map to the park in 2013. The Natural Resources Conservation Service (NRCS) is in the process of completing soil surveys for the five NRCS areas that cover the area of the park. Two are complete.

Geologic heritage resources of particular interest include Indigenous connections, ranching and early settlement, mining, and recreational climbing. Inventory needs include the location and recovery rate of desert crusts, groundwater quality, paleontological resources, and documentation of geoheritage resources.

Soils in the park are found in the basins and valleys between mountain ranges and granitic outcrops. Inventory needs include soil monitoring, assessments of nitrogen deposition from air and water influx from Los Angeles, and the relationship between soils, geology, and the Cholla Cactus Garden.

Geohazards are present in the park and include flash floods, landslides, earthquakes, and subsurface hazards. Inventory needs include potential rockfall sites and flash flood hazard zones.

Additional guidance for park staff regarding proposal processes and timeframes for the new Inventories and Assessment (I&A) program is available on the GSRI and I&A SharePoint sites.

Keywords: Geologic Features, Geologic Hazards, Geologic Heritage, Geologic History, Geologic Processes, GIS, GSRI, Map Units, Resource Management.

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GSRI Background

In the 1990s, the NPS Geologic Resources Inventory (GRI) and Soil Resource Inventory (SRI) programs were established as two of 12 original baseline inventories in the Inventory and Monitoring (I&M) program. These baseline inventories compiled existing information, acquired new information, and helped establish a minimum level of data across more than 270 parks, which served as a common starting point for natural resource monitoring. For both the GRI and SRI, the primary deliverable was a digital (GIS) map. Between the 1990s and early 2020s, a variety of associated reports, posters, and documents were also produced for most of the 270 parks. As of 2024, the I&M program is transitioning from a baseline inventory strategy to a park-proposed, management-need-focused inventory strategy.

The GRI and SRI are now unified as one inventory program, the Geologic and Soil Resources Inventory (GSRI). The new guidance is projected to be enacted in 2025 for FY2027 funding proposals. During this transition period before the new guidance is completed, 13 “priority” parks, including Joshua Tree National Park, were identified as still missing a narrative GRI report.

Moving forward, the GSRI program will fund projects that

- collect new data or derive new information from existing data regarding the presence, absence, abundance, distribution, and significance of geologic heritage, soil features or processes, or geohazards;
- include features or processes on an individual feature or landscape scale;
- include groups of features or maps of multiple features in a defined area of management needs;
- are a snapshot in time and may set a baseline for monitoring or assessment; and will
- typically include a geospatial (GIS) component.

This document serves as a substitute for a baseline GRI report is intended to support the park’s participation in the new inventories program. As such, it is a summary of the status of GSRI deliverables for Joshua Tree National Park and provides information on current geology and soil resources management concerns with a focus on identified inventory needs. Information in this report was compiled from existing reports, meeting(s) with park staff listed below, and the best professional judgment of geoscientists on the GRI and WASO Geologic Resources Division (GRD) staff.

Park Introduction

Joshua Tree National Park (referred to as the "park" herein) preserves more than 1,200 mi^2 (3,100 km^2) of intact desert habitat, with more than 85% managed as wilderness (Figure 1). The park lies along the east-west Transverse Ranges in southern California, where the hot and dry Colorado Desert converges with the relatively cooler and moister Mojave Desert. Joshua trees (*Yucca brevifolia*), emblematic tree-like yuccas, are found within the Mojave Desert regions of the park and are one of the most recognizable symbols of the Mojave Desert. Spectacular rock formations showcase both the ancient and ongoing erosional processes that have shaped the park's geology. The geologic features of the park are considered foundational aspects of the park's formation (National Park Service 2015a). Granite boulder piles, outcrops, and canyons have made the park a world-class destination for rock climbers. Situated roughly 30 km (100 mi) east of the Los Angeles metropolitan area, the park provides access to pristine wilderness and recreational spaces to more than 18 million people who live within three hours of the park.



Figure 1. A map of Joshua Tree National Park (National Park Service map).

The park's geological history is vast, spanning up to 1.8 billion years of active volcanism, metamorphism, tectonism, and erosion (Figure 2). The oldest rocks within the park, primarily gneisses (metamorphosed granite), are exposed across the Hexie, Pinto, Eagle, and northern Cottonwood Mountains. Roughly 250 million to 75 million years ago, tectonic activity led to the formation of massive granitic plutons (igneous intrusions) within the crust. Over the next 75 million years, both uplift and erosional forces exposed the granites and began eroding them into the picturesque forms seen across the park today. The massive monzogranite (a type of biotite granite rock that forms as the final fractionation product of magma) boulders strewn across the landscape, including in places such as Jumbo Rocks, Hidden Valley, and White Tank, are prime examples of exposed granitic plutons. From 25 million years ago to the present day, pervasive faulting allowed

basaltic magmas to intrude through weakened areas in the crust and erupt onto the surface. Malapai Hill, located off the Geology Road Tour, was formed during that time and showcases basaltic rocks (distinguishably darker than surrounding granites) and columnar jointing (parallel, prismatic columns, polygonal in cross section, in basaltic flows, and sometimes in other extrusive and intrusive rocks; form as a result of contraction during cooling; Figure 3).

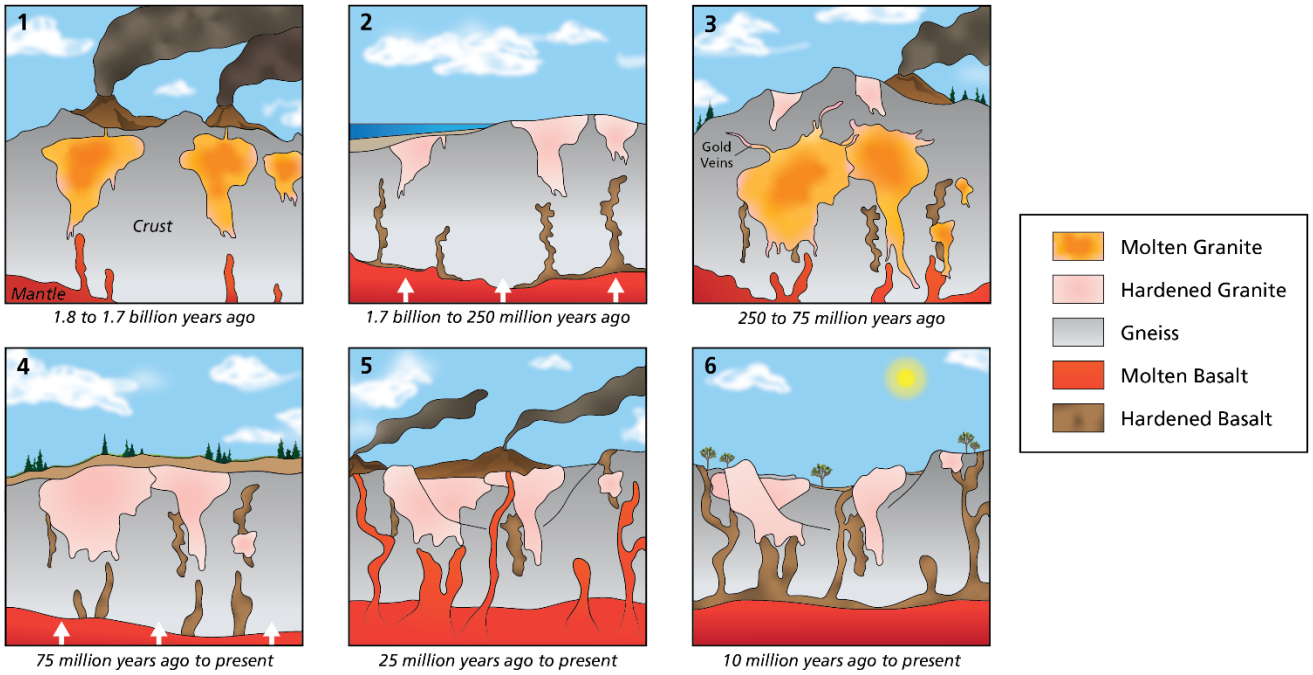


Figure 2. A brief geologic history of the park. (1) 1.8 billion to 1.7 billion years ago, gneisses formed during a major mountain-building event when all of Earth's continents were connected to form the supercontinent Rodinia. (2) From 1.7 billion to 250 million years ago, the supercontinent broke apart and the crust uplifted. Uplift increased erosional rates, and the mountains mostly eroded away, exposing gneiss and granites that were formerly deep within the crust. (3) From 250 million to 75 million years ago, there was active subduction of the oceanic lithosphere under the North American plate. A series of mountain-building events resulted from multiple flare-ups of arc magmatism (the creation of magma from melting rock at tectonic plate boundaries), forming massive granitic plutons within the actively deforming lithosphere. (4) From 75 million years ago to the present, continued uplift pushed up the formerly concealed granites and eroded the previously formed mountains away. More ancient gneiss was exposed during this uplift. (5) From 25 million years ago to the present, intense faulting fractured the crust and allowed basaltic intrusions to shoot toward the surface, cutting through cracks and joints. (6) From 10 million years ago to the present, mountain-building to the west created a rain shadow from the coast, creating a more arid climate. Continued erosion removed more of the surface, further exposing now-fractured granites, gneisses, and basalt to create the landscape seen today at the park. Graphic adapted from a graphic by Trent and Hazlett (2002).



Figure 3. Photographs of Malapai Hill. Malapai Hill is a basaltic intrusion into the surrounding granites; note the sharp contrast between the darker basalts on the hill and the lighter granites along the base and lower slopes. (A) Malapai Hill as viewed from the Geology Tour Road. (B) Columnar jointing within the basalt on Malapai Hill. (C) A close-up photo of the basaltic texture of the hill. Photos by Matthew Harrington (Colorado State University).

Geoheritage

Geologic heritage (also called “geoheritage”) evokes the idea that the geology of a place is an integral part of its history and cultural identity. In 2015, the National Park Service's GRD, in cooperation with the American Geosciences Institute, published a booklet introducing the American experience of geoheritage, geodiversity, and geoconservation: America's Geologic Heritage: An Invitation to Leadership. This publication introduces key principles and concepts of America's geoheritage, which are the focus of ongoing collaboration and cooperation on geologic conservation in the United States. That booklet introduced the American experience of geologic heritage and outlined key principles and concepts, including the following five big ideas:

- America’s geologic landscape is an integral part of its history and cultural identity, and Americans have a proud tradition of exploring and preserving geologic heritage.
- America’s geologic heritage, as shaped by geologic processes over billions of years, is diverse and extensive.
- America’s geologic heritage holds abundant values—aesthetic, artistic, cultural, ecological, economic, educational, recreational, and scientific—for all Americans.
- America’s geologic heritage benefits from established conservation methods developed around the world and within the United States.
- America’s geologic heritage engages many communities, and involvement by individuals will ensure its conservation for future generations.

This section highlights the park’s geoheritage and draws connections between geologic resources and key principles outlined above. The park’s significant geologic features, landforms, and landscapes are part of a rich geologic heritage that is, in part, the reason for the park’s establishment.

Indigenous Connections

The earliest evidence of human occupation within the park, by the Pinto Culture, traces back to more than 5,000 years ago in the early Holocene Epoch (Crochetiere 2019). Researchers have uncovered projectile points and cutting and scraping tools, all created from local geologic resources, in the Pinto Basin (National Park Service 2023a). This culture also recorded its existence by carving petroglyphs into the local desert varnish. Consisting of manganese, iron, and clays, desert varnish forms thin, dark yellow to black layers on the surfaces of many outcrops throughout the park (USGS n.d.). Desert varnish takes thousands of years to form and hundreds of thousands of years to darken (Trent and Hazlett 2002); the varnish in the park had already formed by the time ancient people carved artwork into it.

Following the Pinto Culture, four primary Indigenous cultures inhabited the area of the park: the Yuhaaviatam clan of Maara’yam (Serrano), the Kawiya (Cahuilla), the Nuwu (Chemehuevi), and the Aha Macave (Mohave). The Serrano oral history describes their arrival on Earth at *Maara*' (Twentynine Palms), whereafter a Serrano village existed beside the Oasis of Mara, the site of the present-day park headquarters (Bean and Vane 2002). People from all cultures utilized the abundant

monzogranite to create mortars and pestles, manos and metates, and hammerstones for grinding and food processing (Figure 4; Bean and Vane 2002). The availability of natural springs in the park provided year-round access to water. Most springs in the park exist due to localized fault zones beneath the bedrock. Faulting disrupts the flow and storage of groundwater, pushing it toward the surface, providing accessible surface water in places such as the Oasis of Mara, Fortynine Palms Oasis, and the oasis at Cottonwood (Trent and Hazlett 2002). Today, the park acknowledges 15 associated tribal communities as the original stewards of the land (National Park Service 2023b).



Figure 4. A stone mortar (roughly the size of a human fist) pounded into the granitic bedrock near Cottonwood Spring by the Cahuilla. Photo by Matthew Harrington (Colorado State University).

Ranchers and Early Settlers

Some of the earliest settlers to arrive in the region were cattle ranchers and rustlers looking for rangeland. In the 1870s, a band of outlaws called the McHaney Gang rustled cattle from Arizona and horses from California and drove them to Hidden Valley for rebranding (Figure 5: Crochetiere 2019). The granodiorite formations at Hidden Valley conceal a saprolite (soft, earthy, thoroughly decomposed rock) valley that at the time contained abundant grasses perfect for cattle grazing. The hidden and geographically contained valley made it an ideal haven for rustlers until the beginning of the 20th century, when a larger population and court of law entered the region.



Figure 5. A view of the granite inselbergs that kept Hidden Valley isolated and protected. This view is taken from within the valley. Photo by Matthew Harrington (Colorado State University).

The massive inselbergs that dot the Mojave Desert section of the park provided shade and protection to the livestock of ranchers. Inselbergs (meaning “island mountain” in German) are isolated bedrock hills, knobs, or mountains that abruptly rise from a surrounding flat plain or pediment (a gently sloping, erosional bedrock surface at the foot of a mountain or plateau escarpment). The numerous inselbergs within the park (see Figure 5) are among its most recognizable features.

Millions of years of erosion created natural impressions in the bedrock that could hold water after rains. Some of the early ranchers noted the natural catchments carved into the granitic landscape and enhanced them, creating dams and reservoirs to hold more water. Barker Dam, accessible from a trailhead near Queen Valley Road, was a prominent dam built for such a purpose in the early 1900s (Figure 6). The Keys family, well-known for their ranching and mining within the park, enhanced the dam to hold more water in 1949 by digging down to the bedrock, pouring a wider base, and raising the dam to the current height of about 2 m (6 ft; Linda Greene, Joshua Tree National Park, Archivist, personal communication, 3 December 2024). Although the dam is an artificial feature on the landscape, it has become a valuable resource for native wildlife in the park, where bighorn sheep and deer are often seen drinking the standing water.

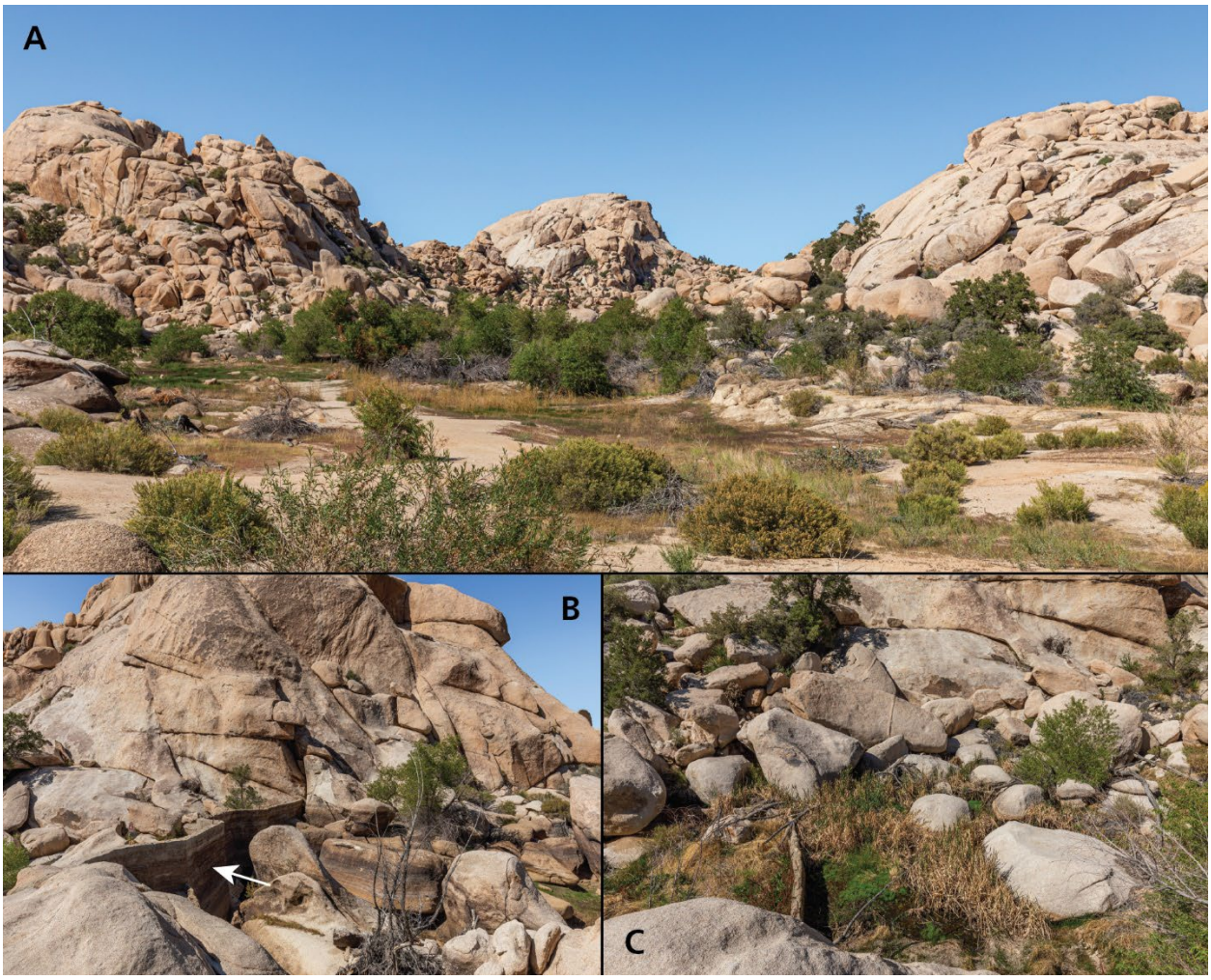


Figure 6. Barker Dam was constructed in the early 1900s to create a more permanent reservoir. (A) Barker Dam lies at the base of large granite structures and supports the riparian community surrounding the reservoir. (B) The concrete wall seen here (marked by a white arrow) was raised by the Keys family in 1950 to hold more water. (C) Although the reservoir rarely fills to its full potential, low levels of water still provide nourishment to plants that would otherwise struggle in the desert. Photos by Matthew Harrington (Colorado State University).

Mining

Mining within the park can be traced back to the 1870s, with activity peaking in the 1920s and 1930s (Trent 2004). Miners primarily sought intrusive, gold-bearing quartz veins within both the Mesozoic and Proterozoic rocks of the park. Eight mining districts exist within the park: Cottonwood, Dale, Eagle Mountain, Gold Park, Monte Negras, Pinyon, Rattler, and Twentynine Palms (Trent 2004). Well-known mines within the park include the Mastodon Mine, Lost Horse Mine, Desert Queen Mine, and Silver Bell Mine.

The NPS servicewide abandoned mineral lands (AML) database lists 283 AML sites and 2,164 AML features in the park (Jason Kenworthy, GSRI Program lead, personal communication, 28 June 2024). There are potentially more sites than listed in the NPS servicewide AML database: the California

Abandoned Mine Lands Unit (CAMLU) and Joshua Tree National Park data both have additional sites and features not currently in the GRD database. An ongoing project is working to create a cohesive database with all three sources, but current estimates put the AML site number as just over 300 (Anna Tegarden, Joshua Tree National Park, Science & GIS Program Manager, personal communication, 2 December 2024). Abandoned mine sites also exist just outside park boundaries, particularly in the Pinto Mountains (Trent 2004). The history of mining throughout the park has left behind thousands of mine shafts, pits, tailings, and pieces of rusted equipment (Eggers and Trent 2004). Historic litter can be found throughout the park as well, signifying the day-to-day lives of miners, ranchers, and rustlers (Figure 7).



Figure 7. An abandoned mine pit along Bighorn Pass Road. (A) This mine pit has been sealed and fenced off for visitor safety. (B) An example of historical litter, this rusted can was one of a few surrounding the sealed mine pit. Photos by Matthew Harrington (Colorado State University).

Many of the mines within the park have rich histories of gold mining, outlaws, and murder. For example, the operators of the Lost Horse Mine, which first opened in the early 1890s, initially struggled to develop the claim due to run-ins with the McHaney Gang and the very real risk of being killed (Trent 2004). Despite the danger, George Lang, John Lang, Ed Holland, and James Fife filed their claim and successfully operated the mine for decades, minimally producing a total of 298,000 g (10,500 oz) in gold (Trent 2004). The mine stopped production in the late 1930s, and after the park acquired the mine in the 1960s, the site was restored as an interpretive exhibit, and the mine shaft was sealed (Figure 8).

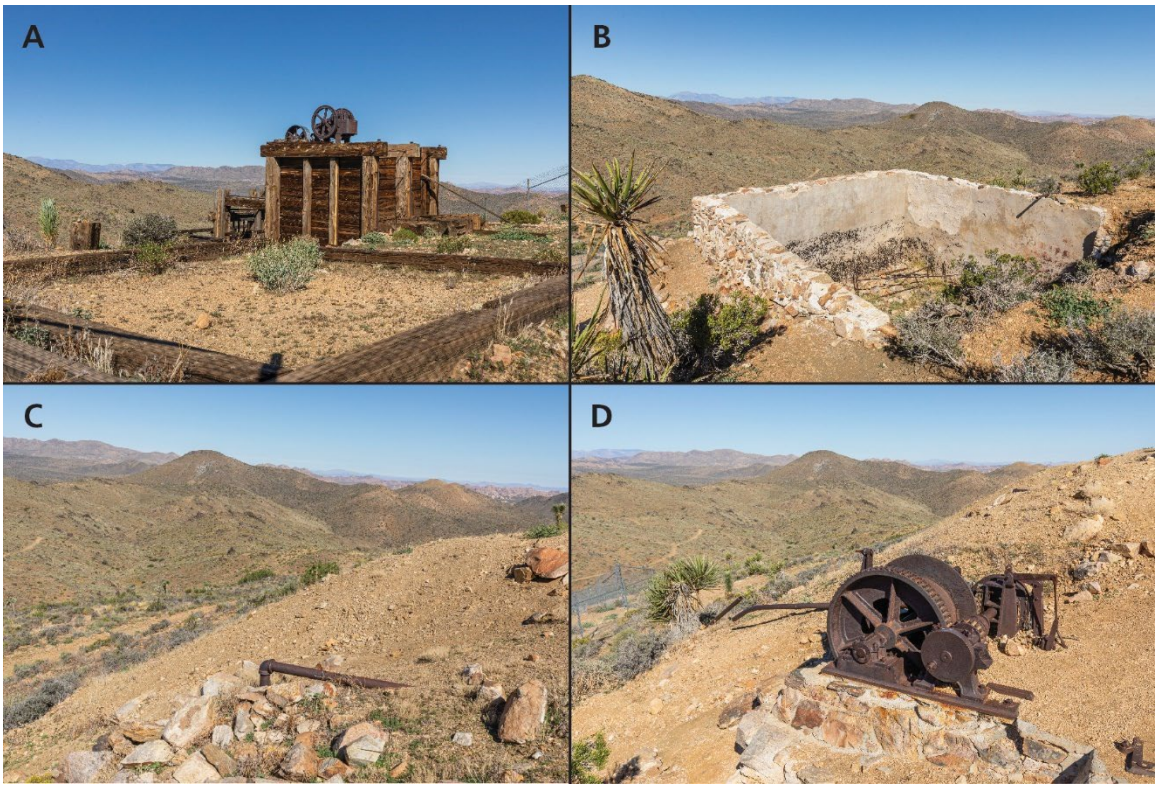


Figure 8. Lost Horse Mine was one of the more productive mining operations within the park. (A) The remains of the stamp mill at the mine site are fenced off from visitors for safety. (B) Locally available stone has been used to construct the building foundations that have withstood the test of time. (C) Old water pipes are still visible on the landscape. The historical road to reach the mine can be seen in the far left of the photo. (D) Old mining equipment is scattered around the site. Photos by Matthew Harrington (Colorado State University).

Another popularly visited mine, the Desert Queen Mine, boasts an even more colorful history (although the details of the story vary). Frank L. James, a local miner from the Lost Horse Mine, had been prospecting near the Desert Queen lode in 1894 (Trent 2004). Jim McHaney of the McHaney Gang paid one of his cowboys, Charlie Martin, to shoot James so McHaney could jump the claim. After insisting the shooting was in self-defense, the jury acquitted the men, and their claim on the Desert Queen Mine held. Over the next six years, the mine went on to produce 104,922 g (3,701 oz) of gold, becoming one of the most productive in the region (Trent 2004). The mine site hosted housing and office facilities, a mill, winches, and other structures. Many of the offices and living quarters were constructed from local stone and built directly into the ground or hillsides. Like the Lost Horse Mine, after the park's acquisition of the mine in the 1970s, efforts were undertaken to seal up the mine shafts and preserve the site as an example of late 19th-century mining expenditure (Figure 9).

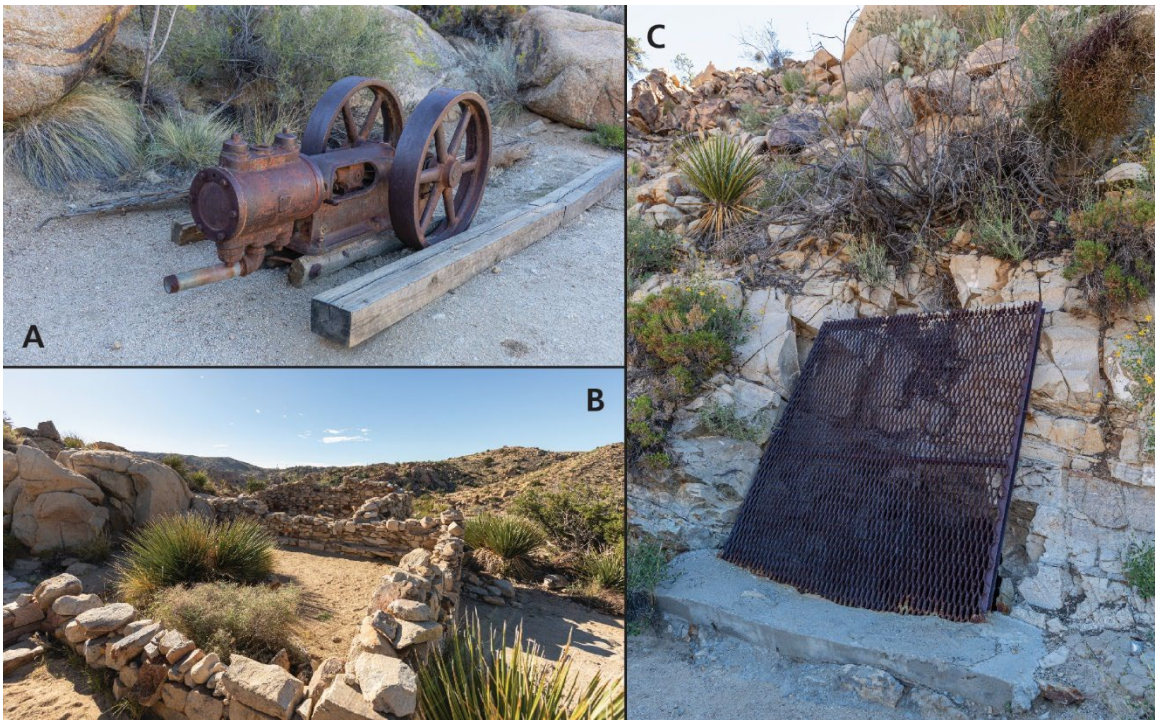


Figure 9. Desert Queen Mine is accessible by following hiking trails along the old mining access roads. (A) Old mining equipment such as this is commonplace around the mine. (B) Remnants of office buildings and living quarters still remain on the landscape. (C) Large metal grates such as this have been installed to close mine access to humans while still allowing wildlife access. Photos by Matthew Harrington (Colorado State University).

In contrast to the Lost Horse Mine and Desert Queen Mine, most mining operations within the park were small scale and unproductive. In many of these sites, evidence of mining operations is limited to small pits, rusting equipment, or mining debris.

Climbing

The unique granitic rock features at the park have cemented it as a climbing hot spot, with more than 10,000 documented climbing routes (Bernadette Regan, Joshua Tree National Park, Climbing Ranger - Emergency Services, personal communication, 14 March 2024). Mild winters at the park make it a premier winter climbing destination, while most other spots, such as Yosemite National Park, are cold and snowy. Unlike many climbing areas, the rock surfaces at the park are typically diverse, often forcing climbers to think as they climb, in contrast to falling into a predictable pattern (National Park Service 2024). While the climbing routes are not as intense or as tall as other climbing hot spots, the diversity in rock surfaces and varying difficulties open the park up to a wider range of skillsets, providing enjoyable climbs for novices and experts alike. Many sites are easily accessible, with more than 5,000 routes located directly alongside the park road; the longest approach to a climb is only 7.2 km (4.5 mi; Bernadette Regan, Joshua Tree National Park, Climbing Ranger - Emergency Services, personal communication, 14 March 2024).

The first documented climbs in the park occurred in the early 1950s, the first being Phil's Folly at Intersection Rock (Bernadette Regan, Joshua Tree National Park, Climbing Ranger - Emergency Services, personal communication, 14 March 2024). Over the following decades, the park entered a climbing renaissance, where many notable climbers spent weekends, weeks, and, in some cases, even months at the park (then a national monument). Military training has also taken place in the park, where renowned climber Bob Gaines trained Navy SEALs to improve their climbing skills on the park's granitic outcrops (National Park Service 2024). In recent years, bouldering has become more popular, with climbers often seen hauling crash pads toward popular sites. Despite hosting more than 250,000 climbers of various skill levels per year, major injuries are uncommon (Bernadette Regan, Joshua Tree National Park, Climbing Ranger - Emergency Services, personal communication, 14 March 2024).

Baseline Geologic and Soil Resources Inventory Product Status

The current geologic GIS data does not completely cover the recent boundary expansion in the northwest portion of the park. The need to acquire this data was discussed in the 2023 scoping call; the park can submit a proposal through the new proposal-based system for this additional mapping. The geologic GIS data is available here: https://irma.nps.gov/DataStore/Reference/Profile/2209598

Two of the five NRCS soil survey areas containing the park's boundary are complete. Both are posted to the Web Soil Survey (https://websoilsurvey.nrcs.usda.gov/app/).

- CA794: Joshua Tree National Park, California
- CA680: Riverside County, Coachella Valley Area, California

The following soil survey projects are incomplete, with digital products projected to be completed in 2026.

- CA695: Mojave Desert Area, California
- CA698: Mojave Desert Area, West Central Park, California
- CA803: Colorado Desert Area, California.

The NPS delivered SRI products in the form of an Access database and pdfs in 2013. These products are available here: https://irma.nps.gov/DataStore/Reference/Profile/2188489.

Geologic Resources, Issues, and Inventory Needs

This section briefly summarizes significant geologic resources and any associated hazards, issues, and inventory needs that have been identified by discussions with the park. Significant geologic resources include features that are essential to the park's geologic story, landscape, or creation. These resources are highlighted to summarize what is currently known and what needs may exist for future projects. Geologic hazards refer to notable hazards stemming from geologic features or processes that may require active management. Geologic issues refer to park problems that result in the damage or theft of geologic resources. Refer to the Guidance for Resource Management SharePoint for more information regarding geologic resource management. The following sections are listed alphabetically.

Geoheritage Resources: Theft and Damage

Theft and vandalism at old mine sites and ranches have increased. Trespassing and theft at Key's Ranch, Ryan Ranch, Black Eagle Cliff Mine, and Carey's Castle, which are significant to the park's geologic heritage, have been reported by park staff (Stacy Manson, Joshua Tree National Park, Physical Science Tech, personal communication, 23 September 2023). Some of these sites still contain items from the original owners, preserving a snapshot in time. Theft of historical items from a site diminishes the history and heritage provided by these items. In many cases, these items are irreplaceable. Some sites have required increased security or reduced access in order to limit illegal activities. Although undocumented, theft and damage to prehistoric cultural resources may also be occurring in hard-to-monitor areas.

Illegal murals and graffiti on exposed rock or historic structures are an issue at the park. An average of 200 reports of graffiti are received each year in the park, with a large portion occurring on geologic or historical features (Anna Tegarden, Joshua Tree National Park, Science & GIS Program Manager, personal communication, 2 December 2024). Vandals can deface entire boulders with illegal graffiti in a short time, requiring the park staff to clean and remove the illegal art. In the past, Barker Dam has been a target for graffiti. For illegal art on rock faces, the cleaning process alters the rock, increasing the erosion of the rock face. In cases where water must be used for cleaning, introduced water outside of precipitation events can alter the vegetation or the erosion around the graffiti site.

Mining Hazards

The abundance of abandoned mining sites continues to pose serious management challenges to the park. Although the exploration of abandoned mine shafts may sound appealing to some visitors, the risks associated with them are many. Hazards include vertical shafts, adits (horizontal shafts), inclines (angled shafts), rotted ladders, cave-ins, abandoned explosives, deadly gases accumulated within shafts, mine tailings contaminated with mercury and cyanide, rusted structures, deteriorating buildings, and abandoned heavy machinery. At least 120 of the 747 mine openings are classified as "extremely hazardous" (National Park Service 2023c).

Due to the park's vast number of AML sites and features, the strategy for sealing mine openings varies. Factors including the historic value of the mine, the hazard level of the mine, and the opportunity for the abandoned site to benefit local wildlife are all taken into consideration (National Park Service 2023c). For some of the larger openings, large metal grates have been installed to prevent visitors from accessing mine shafts while still providing opportunistic wildlife, such as bats, snakes, or desert tortoises, access to the artificial caves. In addition to grates, wire nets, cupolas, graded culverts, or fences can also be used. However, decades of weathering, rusting, and erosion on these features can occasionally require decisions to be made on the replacement, enhancement, or reinforcement of these openings.

One of the most effective strategies has been to fill the mine with expanding polyurethane foam (PUF) and top the PUF with dirt to conceal the opening (National Park Service 2023c). The strategy has several advantages to simply backfilling abandoned sites with rocks and dirt because not all sites have enough loose dirt or rock to seal an open pit or mine, and acquiring these sediments can be time-consuming and damaging to the landscape. PUF is lightweight, inexpensive, and doesn't leach hazardous chemicals. The plug is also removable if access to the mine is ever needed again. Mines plugged by PUF can still showcase depressions in the landscape where historical mining occurred while minimizing risk to visitors.

In addition to the hazards of the physical mines themselves, contamination from former mines into stream beds and soil remains an ongoing issue for the park. In 2023, off-trail areas near Cottonwood Spring were fenced off due to toxic contamination. Fencing off contaminated and potentially contaminated sites allows the park to protect visitors while determining proper strategies for clean-up, removal, or mitigation.

OHV Damage

Damage from off-highway vehicles (OHVs) is a major threat to park resources. OHV damage within the park typically occurs either as illegal OHVing or visitors taking personal vehicles off designated roads. In attempts to limit visitors taking their personal vehicles off the park road, the park has elevated the shoulder of the road throughout most of the park. The enhanced shoulder paired with numerous signs is a strong inhibitor to this activity. However, it is not an uncommon sight to see visitors ignore these signs and drive their vehicles over the raised shoulders to set up picnics, engage in photoshoots, or stargaze off the main road. These activities damage desert pavement, trample vegetation, and expose the roadway to increased sedimentation during rain events by damaging the raised shoulders.

While illegal OHV damage occurs throughout the entire park, the more remote regions, particularly in the Pinto Basin, see more frequent damaging activities due to the difficulty of patrolling such an isolated area. Heavy damage can result from the use of ATVs or other OHVs across basins or desert landscapes. These vehicles often leave trackway scars that do not dissipate on their own, causing damage to floral communities, desert pavement, and biological soil crust (see the Soils section of this summary), as well as potentially damaging fossil resources. Trackway scars from 1940s vehicles can still be seen today. An inventory of known trackway scars or damaged areas may aid in restoration

projects, particularly for biological soil crust damage. Assessments of damage can prioritize potential restoration projects.

Paleontological Resources

Paleontological resources (fossils) are any evidence of life preserved in a geologic context (Santucci et al. 2009). They may be body fossils (any remains of the actual organism such as bones, teeth, shells, or leaves) or trace fossils (evidence of an organism's activity such as nests, burrows, tracks, or coprolites [fossil feces]). All fossils are nonrenewable. Fossils in NPS areas occur in rocks or unconsolidated deposits, in museum collections, and in cultural contexts such as building stones or archeological resources.

At least nine documented, potentially significant paleontological sites occur within the park; most are located in the Pinto Basin (Covington 2003). These sites are Pleistocene in age (2.6 million years to 11,700 years ago) and preserve plant and vertebrate remains representing life during both glacial and interglacial stages. Vertebrate fossils found within the Pinto Basin include Columbian mammoth, horse, camel, llama, deer, wolf, badger, and tortoise. Both known and unknown fossil localities are under threat of destruction or dispersal from continual erosion. Many of these sites are in remote localities, further increasing the challenges to monitoring and/or collection projects. Localities closer to areas more heavily utilized by park visitors are subject to illegal collection and unintentional destruction.

Additional paleontological resources in the park are packrat (*Neotoma* spp.) middens. Packrat middens are piles of debris (pollen, seeds, leaves, bones, shells, and other materials) accumulated by packrats in hidden middens. Over time, packrat urine cements the materials together into a solid mass that maintains fantastic preservation, primarily in arid climates or humidity-controlled caves. Middens are an essential resource for determining environmental change over time, as they preserve an array of both plant and animal materials on the landscape at the time of formation. These materials are often prime subjects for isotopic analysis and dating, providing accurate climatic data to pair with physical evidence. In the park, middens located along the transition zone between the Mojave Desert and the Colorado Desert provide an opportunity to better understand the timing and intensity of faunal and floral community shifts between the two deserts (Holmgren et al. 2010).

Ongoing paleontological work in the Coxcomb Mountains by researchers at the Western Science Center is investigating potentially new fossil localities that have yet to be confirmed. Unlike most fossils in the park, any potential fossil resources in the Coxcomb Mountains are Jurassic or Cretaceous in age (201.3 million to 66 million years ago).

An inventory and surveys of the paleontological resources of the park are needed. A focused assessment of paleontological resources eroding out of alluvial fans and lacustrine deposits would be highly beneficial for better understanding erosion rates and fossil densities. In addition to monitoring and surveying, a generalized paleontological management plan is also highly needed.

Rockfall Hazards and Climbing Impacts

Despite the abundance and density of boulders, massive rock formations, and canyons throughout the park, rockfalls are relatively uncommon. Rockfalls and topples can occur, but these events are not major issues within the park (Covington 2003). Although their occurrence is low, monitoring of rockfall hazards is recommended to best ensure safety.

With the increasing popularity of climbing, its impact on the geology and landscape of the park has grown as well. Well-used bouldering sites have seen a significant decrease in vegetation as repeated large gatherings and crash pads have worn away plant life. Heavy use at these sites can also disrupt desert pavement, although a quantitative analysis has yet to be completed. Desert pavement is a slow-forming natural residual concentration of wind-polished, closely packed pebbles, boulders, and other rock fragments, mantling a desert surface where wind action or sheetwash have removed all smaller particles. As climbing continues to become more popular, monitoring site use and impact can provide insight into better management practices.

Heavily used climbing routes have become more slippery over time. A combination of oils from human hands, sweat, and chalk has degraded rock surfaces on heavily used routes; however, increased rockfalls resulting from these activities have not occurred. Monitoring the rate and extent of degradation, as well as the potential for rockfalls, would be beneficial.

The park contains widespread petroglyphs, many of which are difficult to spot with an untrained eye. Although known petroglyph sites are closed to climbing, climbers can unknowingly erode undiscovered sites.

Seismicity

The park lies along the San Andreas Rift Zone, the major boundary between the North American plate and the Pacific plate. The northern extent of the park is bounded by the Pinto Mountain fault, a left-lateral strike-slip fault that cuts through Morongo Valley and Twentynine Palms. The other major fault in the park is the Blue Cut fault, another left-lateral strike-slip fault that cuts through the center of the park toward the Pinto Basin and Coxcomb Mountains. While a major earthquake has not hit the park since roughly 1680, data suggest that a major earthquake occurs about once every 220 years, indicating the park may be overdue for an event (Trent and Hazlett 2002). In addition to the two major fault lines, hundreds of moderate to small faults exist throughout the park. The USGS monitors seismicity in the park via monitoring stations. The work is vital for predicting and understanding earthquakes in a seismically active and population-dense region.

The San Andreas Rift Zone can be seen from the overlook at Keys View when looking southwest toward Coachella Valley and Palm Springs. The Indio Hills (see Figure 1) mark where the North American plate and the Pacific plate slide past each other. The Blue Cut fault can be seen in multiple spots, but some of the best viewpoints are from the hilltop behind Lost Horse Mine or on top of Malapai Hill (Figure 10). Both large-scale faulting and smaller, localized faulting are evident across the park, allowing visitors to see the impacts of faults on multiple scales. Because these faults have

allowed groundwater to reach the surface at each of the five oases within the park, they are an essential element of the park's geologic story.

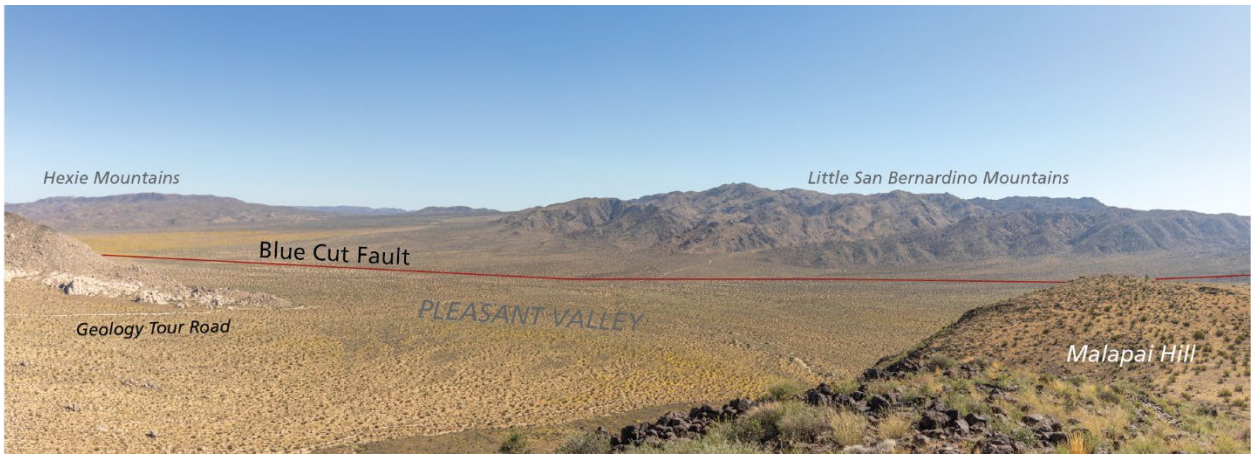


Figure 10. A photo of the Blue Cut Fault as seen from the top of Malapai Hill. The fault cuts across Pleasant Valley toward the Hexie Mountains. Photo by Matthew Harrington (Colorado State University).

Soils

Although much of the park consists of exposed bedrock and boulders, soils exist within many areas of the park. Among the most important is a living groundcover called biological soil crust (also known as desert crust). Primarily composed of cyanobacteria, some biological soil crusts also contain lichens, mosses, green algae, microfungi, and bacteria (National Park Service 2015b). These crusts bind soil particles and rock together, stabilizing the soil and increasing its resistance to wind and water erosion. Water, nutrients, and organic matter are trapped and stored within biological soil crust, providing accessible resources to plants. Even after the living organisms within soil crust die, the structural integrity of the soil crust can continue to provide stability to soil.

Unfortunately, soil crusts are fragile, and human activity can be extremely damaging. Foot traffic and off-road driving are the primary threats to soil crusts within the park. Off-road driving is particularly damaging, as tire trackways increase erosion from wind and water and can lead to channelization, permanently destroying the soil crust. Pietrasiak et al. (2011) inventoried and assessed soil crusts within wilderness areas of the park and determined that geology plays an essential role in driving crust distribution and predicting its occurrence. Future inventories or assessments should utilize known geologic features to increase the understanding of soil crusts within the park. An enhanced understanding of visitor use in areas with known soil crusts and the recovery rate of both soil crusts and desert pavement will also assist in the management of these resources.

Historically, soils across the park have been nitrogen-poor, and native plants have adapted to overcome this issue (Covington 2003). However, increased nitrogen deposition from air and water influx from the greater Los Angeles area has led to a significant increase in soil nitrogen. This has allowed nonnative plants that were historically incapable of survival to encroach into the park. The increase in some nonnative grasses, particularly red brome (*Bromus rubens*), has negatively altered

the fire regime. Joshua tree forests are not well adapted to wildfires, and increased fire activity stemming from encroaching nonnative grasses has threatened Joshua tree stands (Covington 2003). Soil inventory needs include assessing the amount and impacts of increased nitrogen deposition, investigating the relationship between the Cholla Cactus Garden and the underlying soil and geology, and analyzing the compaction of soils near oases, as well as inventorying the total area of disturbed lands.

Water Resources

Typical of a desert ecosystem, perennial streams are nonexistent within the park (Covington 2003). The availability of surface water is extremely limited, with few sources for plants and animals. At present, five desert fan palm oases can be found within the park, but only two, Fortynine Palms and Lost Palms, possess accessible surface water. Historically, all five oases possessed surface water, but a shifting climate and increased groundwater extraction from nearby communities have diminished availability.

The threat to groundwater levels has grown alongside the increase in wells across Twentynine Palms. From 1973 to 1998, Whitt and Jonker (1998) found that groundwater levels had dropped an average of 0.3 m (1 ft) per year. The levels have dropped low enough that the Oasis of Mara now requires supplemental water in order to avoid a mass death of the desert fan palms. Just outside the park's southern boundary, a proposed power project on an abandoned mine site on Eagle Mountain would fill a lower reservoir with water from the Chuckwalla Valley aquifer and use solar energy to pump water to an upper reservoir, creating a hydropower storage system; there are potential concerns over how this would affect available groundwater to the park. A groundwater quality study has been highlighted as a necessary future project for the park.

Ephemeral pools of water can be found seasonally and after rainstorms, providing temporary, but critical, access to water. At Rattlesnake Canyon, ephemeral pools form near the mouth of the canyon during wet spells. The proximity of these pools to an area popular for hiking, scrambling, and camping may impact the quality or accessibility of the water for wildlife, and focused monitoring may be beneficial.

When precipitation falls within the park, sheets of water flow down mountain and hill slopes across vast pediments, carrying water toward drainages and into basins. As pediments are actively being eroded during precipitation events, thin layers of eroded fluvial gravel and sediment overlying the bedrock wash downslope. When park roadways cut across pediments, sheet flow can deposit heavy amounts of sediment across park roadways, sometimes requiring full road closures for maintenance. In other locations, berms that were constructed to manage flooding and sheetwash to direct water away from park structures potentially alter erosional regimes.

Over the last 120 years, annual precipitation at the park has declined by 39%, while major precipitation events have increased in intensity (National Park Service 2023d). Shifting precipitation patterns and intensities impact rates of erosion and maintenance costs, as demonstrated by the 1,000-

year flood that occurred in nearby Death Valley National Park in 2022. For further assistance with water resources, the park should contact the Water Resources Division.

Summary of Geologic and Soils Hazards

The dynamic landscapes of many national park units present a variety of natural hazards that threaten NPS facilities, staff, visitors, or resources. Many of these natural hazards are geologic in nature (e.g., volcanoes, earthquakes, and landslides). The Addressing Climate Change and Natural Hazards Handbook (National Park Service 2015c, 2023e), grounded in NPS Policy Memorandum 15-01 (Jarvis 2015), provides a process and information to help teams and decision-makers identify, avoid, and mitigate risks associated with environmental change hazards and effects on proposed and planned facility investments. The handbook supports NPS planning guidance, policy directives, and executive orders and does not supersede existing mandated compliance processes and policies. Additional guidance for facility management, e.g., Climate-Smart Planning Principles and Recommended Practices, has been developed to support effective decision-making.

According to PM 15-01, managers should apply the handbook guidance to identify options to manage natural hazards and climate change risks throughout all levels of facility planning and design. Project teams are required to submit the completed Natural Hazards Checklist (Table 1) as part of Regional and Bureau Investment Review Board submissions. This information can also be used as part of the updated (2024) Automated Investment Review Board (AIRB) submittal process at the Investment Concept (IC) stage. Table 1 includes selected geologic and soils hazards listed in Part 1 of National Park Service (2023). The GSRI team has added additional hazards where appropriate for the park. If needed, Part 2 of the handbook could inform the completion of the checklist, such as whether a hazard is applicable. Contact the NPS Geologic Resources Division with any questions.

Table 1. Geologic and soils hazards checklist. This checklist, which includes selected hazards listed in part 1 of NPS (2023), is a screening tool to be used at the Investment Concept stage to help teams determine potential climate change effects and natural hazards to a proposed facilities investment. The checklist shall be completed for all investment concepts and schematic designs that require Investment Review Board review at the regional and/or bureau-wide levels. Its use is encouraged for all infrastructure investments. This table is a synthesis of existing GRI- or SRI-compiled map data and information, as well as published DOI, USGS, NPS, or state geological survey information. It is appropriate for use at park-scale discussions and assessments. It is not a substitute for site-specific investigations or National Environmental Policy Act (NEPA) analysis. Ground-disturbing activities should neither be approved nor denied based on the information here.

Hazard	Examples of Risk or Secondary Hazard	Best Professional Judgment	Source(s) of Information
Flash Flood	Sudden rising water, e.g., in a dry wash or canyon. Loss of life due to unexpected flooding. Destruction of infrastructure, e.g., through impact or saturation. Reduced or precluded visitation. Power failure due to areawide power outages. Geologic heritage resources (e.g., petroglyphs, paleontological features, historic mining equipment) may be washed away or covered.	Known hazard (extreme; SHIRA)	DOI Strategic Hazard Identification and Risk Assessment (SHIRA) SHIRA - Home (sharepoint.com) Climate Toolbox: Climate Mapper (for Western US) https://marine.usgs.gov/coastalchangehazardsportal/ FEMA: NFHL https://www.fema.gov/flood-maps/national-flood-hazard-layer
Riverine Flood	Inundation. Destruction of infrastructure, e.g., through impact or saturation. Stream channel migration and streambank erosion. Water quality effects. Water supply diminished. Reduced or precluded visitation.	Not applicable (no perennial rivers in the park; see Flash Flood)	DOI Strategic Hazard Identification and Risk Assessment (SHIRA) SHIRA - Home (sharepoint.com) Climate Toolbox: Climate Mapper (for Western US) https://marine.usgs.gov/coastalchangehazardsportal/ FEMA: NFHL https://www.fema.gov/flood-maps/national-flood-hazard-layer
Lake and Reservoir Level Change	Water supply diminished. Flooding and erosion impacts to infrastructure. Diminished or lost recreational opportunities.	Not applicable	University of Michigan: Great Lakes Integrated Science and Assessments (for Great Lakes only) https://glisa.umich.edu/ NOAA: Lake Level Viewer (for Great Lakes only) https://coast.noaa.gov/llv/ USGS: Lakes and reservoirs dataset https://waterdata.usgs.gov/nwis/current/?type=lake&group_key=state_cd US Bureau of Reclamation Water Operations https://www.usbr.gov/main/water/#GP

Hazard	Examples of Risk or Secondary Hazard	Best Professional Judgment	Source(s) of Information
Precipitation: Increased Extreme Events	Surface erosion. Floods. Water damage to structures from driven rain. Unstable saturated soils. Reduced or precluded visitation. Power failure due to areawide power outages.	Known hazard	NPS: National Park historical and projected climate change trends https://irma.nps.gov/DataStore/Reference/Profile/2266988 Climate Toolbox: Climate Mapper (for Western US) https://marine.usgs.gov/coastalchangehazardsportal/ NASA: Daymet gridded climate data https://daymet.ornl.gov/ DOI Strategic Hazard Identification and Risk Assessment (SHIRA) SHIRA - Home (sharepoint.com)
Precipitation: Altered Patterns and Changing Humidity	Local flooding. Mold growth. Wood decay. Drought. Fire. Water supply change.	Known hazard	NPS: National Park historical and projected climate change trends https://irma.nps.gov/DataStore/Reference/Profile/2266988 Climate Toolbox: Climate Mapper (for Western US) https://marine.usgs.gov/coastalchangehazardsportal/ NASA: Daymet gridded climate data https://daymet.ornl.gov/
Drought: Increased Frequency, Intensity, Magnitude, and Duration	Limited water supply for visitor, staff, and operational needs (e.g., potable and fire suppression water). Increased competition for available water and water supply impacts (e.g., water supply curtailment by state agencies). Crack/heave damage in drier soils. Increased vulnerability to wildfire.	Known hazard (high; SHIRA)	Climate Toolbox: Climate Mapper (for Western US) https://marine.usgs.gov/coastalchangehazardsportal/ FEMA: Drought risk https://hazards.fema.gov/nri/drought University of Nebraska-Lincoln: Drought Monitor https://droughtmonitor.unl.edu/ DOI Strategic Hazard Identification and Risk Assessment (SHIRA) SHIRA - Home (sharepoint.com)
Permafrost Dynamics	Thawing. Surface collapse. Increased landslide susceptibility. Road/service disruption. Frost heave.	Not applicable	NASA: Permafrost dataset https://neo.gsfc.nasa.gov/view.php?datasetId=PermafrostNSIDC NPS: Central Alaskan Network Permafrost Protocol Dataset https://irma.nps.gov/DataStore/Reference/Profile/2288714 DOI Strategic Hazard Identification and Risk Assessment (SHIRA) SHIRA - Home (sharepoint.com)
Landslide	Rockfall. Mud or debris slides or flows onto or from under structures. Reduced or precluded visitation.	Known hazard (susceptible to landslides)	FHWA Unstable Slope Management Program (USMP): Geologic and Geotechnical Services | FHWA (dot.gov). FEMA: Landslide risk https://hazards.fema.gov/nri/landslide USGS: Emergency Assessment of Post-Fire Debris-Flow Hazards https://landslides.usgs.gov/hazards/postfire_debrisflow/ DOI Strategic Hazard Identification and Risk Assessment (SHIRA) SHIRA - Home (sharepoint.com)

Hazard	Examples of Risk or Secondary Hazard	Best Professional Judgment	Source(s) of Information
Earthquake	Falling objects. Collapsing structures. Inoperability of major building systems, e.g., power, sewer, water. Liquefaction - loss of strength to foundations, silt deposition, standing water. Trigger to other hazards, e.g., landslides, debris flows.	Known hazard (very high; SHIRA)	USGS: Earthquake Probability Mapping https://www.usgs.gov/natural-hazards/earthquake-hazards/hazards FEMA: Earthquake risk https://hazards.fema.gov/nri/earthquake DOI Strategic Hazard Identification and Risk Assessment (SHIRA) SHIRA - Home (sharepoint.com)
Tsunami	Coastal area inundation.	Not applicable	State Tsunami Inundation Mapping FEMA: Tsunami risk https://hazards.fema.gov/nri/tsunami DOI Strategic Hazard Identification and Risk Assessment (SHIRA) SHIRA - Home (sharepoint.com)
Shrink/Swell Soils	Damage to structure. “Heaving” of ground beneath structure. Increased landslide susceptibility.	Potential hazard (low; SHIRA)	NPS: Soil Resources Inventory https://irma.nps.gov/DataStore/Reference/Profile/2188489 USDA: Soils Survey https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/ (look for “linear extensibility” interpretation. DOI Strategic Hazard Identification and Risk Assessment (SHIRA) SHIRA - Home (sharepoint.com)
Volcanic Eruption	Lava flows. Fire. Tsunamis. Toxic gas releases. Ash and air quality degradation. Reduced or precluded visitation.	Not applicable	USGS: Volcano Hazards Program https://www.usgs.gov/volcano FEMA: Volcanic activity risk https://hazards.fema.gov/nri/volcanic-activity Red Cross: Map of Volcano Risk Areas https://maps.redcross.org/website/maps/arc_map_links.html DOI Strategic Hazard Identification and Risk Assessment (SHIRA) SHIRA - Home (sharepoint.com)
Hydrothermal Activity (e.g., geysers)	Toxic gas release. Explosion. Boiling water. Steam. Surface collapse into void.	Not applicable	NREL: Geothermal resource data, tools, and maps https://www.nrel.gov/gis/geothermal.html USGS: Geothermal resources https://www.usgs.gov/programs/energy-resources-program/science/science-topics/geothermal DOI Strategic Hazard Identification and Risk Assessment (SHIRA) SHIRA - Home (sharepoint.com)
Subsurface Hazards: Abandoned Mineral Lands Cave/Karst (sinkholes)	Surface collapse. Contamination.	Known hazard	USGS: Karst in the United States: A Digital Map Compilation and Database (Weary and Doctor 2014) Evaluation of cave and karst programs and issues at US national parks (Land et al. 2013) DOI Strategic Hazard Identification and Risk Assessment (SHIRA)

Prior NRSS-Supported Work

Geologic or Soil Research Permits

The following tables (Table 2 and Table 3) are lists of completed research projects related to the geology or soils of Joshua Tree National Park. These items are located on the NPS Research Permit and Reporting System of IRMA (see https://irma.nps.gov/RPRS/Search; accessed 22 August 2024) and may require a government device or permission to access. Since 2000, there have been numerous (>45) geoscience research permits issued that include geologic and geophysical mapping; stratigraphic, volcanogenic, tectonic, and paleontological investigations; resource monitoring (e.g., springs, seeps, fossils); hydrocarbon assessments; geoenvironmental studies; and geologic substrate impacts on vegetation.

Table 2. Research permits related to geology for Joshua Tree National Park

Title	Year(s)
Paleontologic investigations in Joshua Tree National Park	2011–2013
Paleontologic investigations in the Eastern Pinto Basin, Joshua Tree National Park	2005–2009
Geologic investigations in Joshua Tree National Park	2016–2017
Balance (Basins and Landscape Co-Evolution)	2008–2009, 2012
Joshua Tree National Park Risk Assessment at Sunrise Mill Site under the Engineering Evaluation/Cost Analysis for 14 abandoned mill sites	2014
Structural and geochronologic history of the Precambrian North American margin and Mesozoic arc magmatism in Joshua Tree National Park	2008
Geology and landscape evolution in Joshua Tree National Park	2008
Petrology-mapping exercise for college geology majors in Rattlesnake Creek, Joshua Tree National Park	2008
Rock samples for Cottonwood Visitor Center Interpretive Exhibit	2008
Comparative phylogeography of three lizard species at the Mojave/Colorado Desert Transition Zone	2008
Evolutionary diversification of Encelia (Asteraceae: Heliantheae) in the Sonoran and Mohave Deserts based on multiple DNA sequences	2008
Geophysical and geological studies to valuate structural controls on rare earth element mineralization in Music Valley and vicinity, California	2008
Structural and geochronologic history of the Precambrian North American margin and Mesozoic arc magmatism in Joshua Tree National Park	2008
Mesozoic magmatism in Joshua Tree National Park	2008
Geology and landscape evolution of Joshua Tree National Park	2008
Monitoring evolution of Pacific-North America plate boundary through GPS observations in Joshua Tree National Park, Phase IV	2008
A phylogeographic study of Fouquieria splendens	2008
Geology of metamorphic rocks in Joshua Tree National Park	2008
Exploring mid-crustal MASH zone processes in the deepest exposed rocks of the Joshua Tree National Park	2008
Monitoring evolution of Pacific-North America plate boundary through GPS observations in Joshua Tree National Park, Phase IV	2008
Monitoring evolution of Pacific-North America plate boundary through GPS observations in Joshua Tree National Park, Phase Two	2008
Derivation of one-dimensional S-wave velocity structure using ambient noise and standard refraction, P-wave geophones and recording equipment at five measurement sites located on Cottonwood Springs Rd and Box Canyon Rd in Shavers-Maniobra Valley, California	2008

Title	Year(s)
Monitoring evolution of Pacific-North America plate boundary through GPS observations in Joshua Tree National Park	2008
Investigating the Neogene and Quaternary paleolakes of Joshua Tree National Park	2008
Investigation of pottery typology at Joshua Tree National Park	2008
Geophysical investigations Using seismic imaging and gravity measurements in the Smoke Tree Wash area of Joshua Tree National Monument	2008
Phylogenetic relationships between and within Phacelia (Hydrophyllaceae/Boragniaceae) sections Whitlavia and Gymnobythus	2008
Understanding strain accumulation and transfer between the Southern San Andreas Fault, San Gorgonio Pass, and the Eastern California Shear Zone: geologic and geodetic observations along faults of the Eastern Transverse Ranges, CA	2008
Geology and mineralogy of xenotime-monzanite deposits of the Music Valley area, Pinto Mountains, Riverside County, California	2008
Phylogeography of the Red-spotted Toad (*Bufo punctatus*): a cryptic species-group?	2008
Plate Boundary Observatory (PBO) component in Joshua Tree National Park to monitor tectonic and magmatic process using high precision Global Positioning Systems (GPS)	2008

Table 3. Research permits related to soil for Joshua Tree National Park

Title	Year(s)
Exploring biological soil crust and plant assemblage recovery in Joshua Tree woodlands along a one hundred-year chronosequence	2024
Investigating the effect of nutrient stress to extracellular polymeric substances in biological soil crust cyanobacteria: A comparison of species from granitic and gypsum substrates	2023
Specificity of native legume response to soil bacteria communities of Joshua Tree National Park	2023
Untangling the dry limit for microbial life in rock-inhabiting communities of US Western drylands (Acronym: DRYLIFE)	2023
Exploring biological soil crust recovery in Joshua Tree woodlands along a one hundred-year chronosequence	2022
Exploring biological soil crust recovery in Joshua Tree woodlands along a seventy year chronosequence	2022
Exploring biological soil crust sensitivity to climate change across the Mojave Desert	2022
Plant-soil feedbacks and population dynamics of two arid system shrubs with contrasting spatial distributions and life histories	2021, 2024
Identification and Discovery of Soil Bacteria from California National Parks	2019
The microbial role in pulsed greenhouse gas emissions from desert soils across a Nitrogen deposition gradient	2019
Effects of visitors disturbances on fungal diversity in biological soil crusts at Joshua Tree National Park	2015–2019
DNA characterization of soil microbes associated with degradation of borate-treated wood in geographic regions with high levels of naturally occurring borates	2018
Pulses of biogenic nitrogen cycling lead to atmospheric-based nutrient spiraling in southern California	2018
The microbial role in pulsed greenhouse gas emissions from desert soils across a nitrogen deposition gradient	2018
Exploring presence and function of biological soil crusts in the American southwest	2016
Joshua Tree National Park soil survey project-soil temperature data	2016
Using soil texture and rockiness to predict invasibility by exotic plants in areas of anthropogenic nitrogen deposition at Joshua Tree National Park	2009–2011
Long-term effects of poultry residue on Mojave Desert Soils	2009–2010
Joshua Tree National Park soil survey project	2007, 2011
The role of biological soil crusts in seedling establishment	2009

Title	Year(s)
Water soluble chemistry of desert pavement soils and associated non-pavement soils	2007
Physical geography of microbiotic crusts in Joshua Tree National Park	2004, 2006
Calibration of miniature ground penetrating radar	2002-2003, 2005-2007
Soil temperature study	2002, 2004–2005
Calibration of miniature ground penetrating radar (with water tables of known depth at Joshua Tree National Park HQ site)	2001, 2004
Predicting recovery of biological soil crusts	2004
Protozoan fauna of leaf litter and soil of Joshua Tree National Forest	2003
Microbial crusts in desert landscapes	2001

Previous or Ongoing Technical Assistance Requests

The following table (Table 4) provides previous or ongoing technical assistance requests submitted to the GRD related to the geology or soils of the national park. These items are located on the NPS Solution for Technical Assistance Requests (STAR) of IRMA (see https://irma.nps.gov/STAR/; accessed 22 August 2024) and may require a government device or permission to access.

Table 4. Technical Assistance Requests for Joshua Tree National Park

Fiscal Year	Title	Program Area	Lifecycle
2011	Solar millenium (document review for renewable energy project)	Energy and Mineral Development	Closed
2019	Paleontology Support for GIP Intern	Caves, Paleontology, and other Geologic Features	Closed
2019	Assistance with moving paleontology collections held at San Bernardino County Museum to Western Science Center in Hemet, CA	Caves, Paleontology, and other Geologic Features	Closed
2019	Funding assistance for relocation of JOTR paleontology specimen collection	Caves, Paleontology, and other Geologic Features	Closed
2024	Assistance answering mining questions related to proposed expansion of JOTR (Eagle Mtn Mining District)	Mining and Minerals	Park & Region Review

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