National Park Service
U.S. Department of the Interior

Great Basin National Park

Lehman Caves Management Plan

June 2019

ON THE COVER
Photograph of visitors on tour of Lehman Caves
NPS Photo

ON THIS PAGE
Photograph of cave shields, Grand Palace, Lehman Caves
NPS Photo

Lehman Caves Management Plan
Great Basin National Park
Baker, Nevada
June 2019

Approved by:

James Woolsey, Superintendent Date

Executive Summary

The Lehman Caves Management Plan (LCMP) guides management for Lehman Caves, located within Great Basin National Park (GRBA). The primary goal of the Lehman Caves Management Plan is to manage the cave in a manner that will preserve and protect cave resources and processes while allowing for respectful recreation and scientific use. More specifically, the intent of this plan is to manage Lehman Caves to maintain its geological, scenic, educational, cultural, biological, hydrological, paleontological, and recreational resources in accordance with applicable laws, regulations, and current guidelines such as the Federal Cave Resource Protection Act and National Park Service Management Policies.

Section 1.0 provides an introduction and background to the park and pertinent laws and regulations.

Section 2.0 goes into detail of the natural and cultural history of Lehman Caves. This history includes how infrastructure was built up in the cave to allow visitors to enter and tour, as well as visitation numbers from the 1920s to present.

Section 3.0 states the management direction and objectives for Lehman Caves.

Section 4.0 covers how the Management Plan will meet each of the objectives in Section 3.0. Topics include improving safety; maintaining and updating cave infrastructure; expanding interpretive opportunities both in and out of the cave; protecting biological, cultural, and geologic resources, and more. This section contains the majority of the management recommendations for the cave.

Section 5.0 covers surface management such as development and herbicide use above caves. It includes a map of no-retardant areas near Lehman Cave. Fire retardant dropped in this area could have negative impacts on various cave biota, especially the Model Cave amphipod, which is currently only known to exist in one cave in the world.

Section 6.0 lays out how the plan can be changed. Section 7.0 specifies plan updates, Section 8.0 contains literature cited, and Section 9.0 lists the plan preparers.

Appendices and Standard Operating Procedures follow the main document.

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Acronyms

ARPA	Archeological Resources Protection Act
BLM	Bureau of Land Management
CCC	Civilian Conservation Corps
CFR	Code of Federal Regulations
CPR	Cardiopulmonary Resuscitation
CWA	Civil Works Administration
DRI	Desert Research Institute
EMS	Emergency Medical Services
EPA	Environmental Protection Agency
FCRPA	Federal Cave Resource Protection Act
GRBA	Great Basin National Park
GRD	Geologic Resources Division
JHA	Job Hazard Analysis
LAKE	Lake Mead National Recreation Area
LCMP	Lehman Caves Management Plan
LCNM	Lehman Caves National Monument
LCVC	Lehman Caves Visitor Center
LED	Light-emitting diode
MOU	Memorandum of Understanding
MSHA	Mine Safety and Health Administration
NAGPRA	Native American Graves Protection and Repatriation Act
NHPA	National Historic Preservation Act
NPS	National Park Service
NSS	National Speleological Society
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
PPE	Personal protective equipment
SAR	Search and Rescue
SNPLMA	Southern Nevada Public Lands Management Act
SOP	Standard Operating Protocol
SUP	Special Use Permit
UF	Underground Feeder
USFS	United States Forest Service
USGS	United States Geological Survey
VIP	Volunteer in Park
V&RP	Visitor and Resource Protection
WACC	Western Archeological and Conservation Center
WNPA	Western National Parks Association
WNS	White-Nose Syndrome

1.0 Introduction & Background

Introduction

Lehman Caves National Monument was designated on January 24, 1922 by President Warren G. Harding to protect "certain natural caves, known as Lehman Caves…which are…of unusual scientific interest and importance…" (Appendix A; Figure 1). On October 27, 1986, under Public Law 99-565, the Lehman Caves National Monument was "abolished and the lands incorporated within the Great Basin National Park" (Appendix B).

Cave resources include cave walls, ceilings, floors, and speleothems as well as cultural, hydrological, geological, paleontological, and biological features.

Figure 1. Dedication ceremony for Lehman Caves National Monument, which was designated on January 24, 1922.

Purpose and Need

The purpose of developing a Lehman Caves Management Plan (LCMP) is to create an integrated approach to manage Lehman Caves.

Background

Lehman Caves is located in the northern part of Great Basin National Park (GRBA). The park encompasses over 77,000 acres of the South Snake Range (Figure 2), which is in east-central Nevada. The nearest large cities are Salt Lake City, Utah, 234 miles to the northeast, and Las Vegas, Nevada, 291 miles to the southwest. The park is surrounded by land managed by the Bureau of Land Management (BLM) and private land.

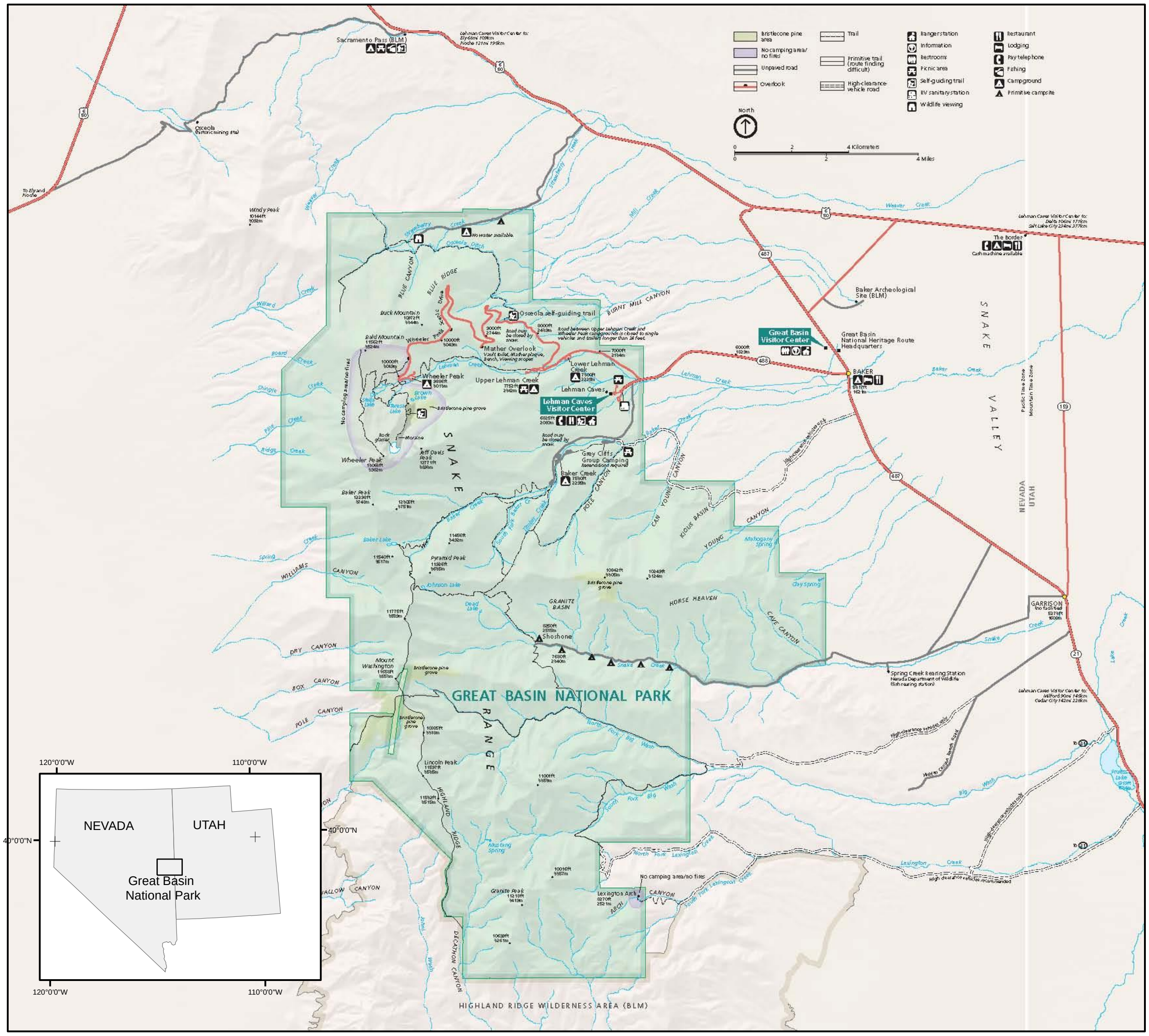

Figure 2. Great Basin National Park is located in east-central Nevada and includes over 77,000 acres in the South Snake Range, as well as 80 acres near the town of Baker used as an administrative site.

Lehman Caves is one of over a dozen caves in the National Park Service to offer cave tours (Figure 3). Although the historic name is "Lehman Caves," it is just one cave. About 33,000 visitors tour the cave each year. The cave is known for its concentrated speleothems, including over 300 cave shields. The cave trail is about one-third of a mile long, and the total length of the cave is about two miles (Figure 4). Visitation to the cave is by ranger-guided tour only. Tours are available year-round.

Relationship to Other Park Laws, Regulations, Policies, and Plans

The National Park Service was established within the Department of the Interior through the Organic Act of 1916. Its key management-related provision is:

> " [The National Park Service] shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified... by such means and

measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." (16 USC 1)

Congress supplemented and clarified the provisions of the Organic Act through the General Authorities Act. That act, as amended, provides, in part:

> "Congress, recognizing that the enjoyment by future generations of the national parks can be ensured only if the superb quality of park resources and values is left unimpaired, has provided that when there is a conflict between conserving resources and values and providing for enjoyment of them, conservation is to be predominant."

Figure 3. Great Basin National Park is one of over a dozen NPS units to offer cave tours.

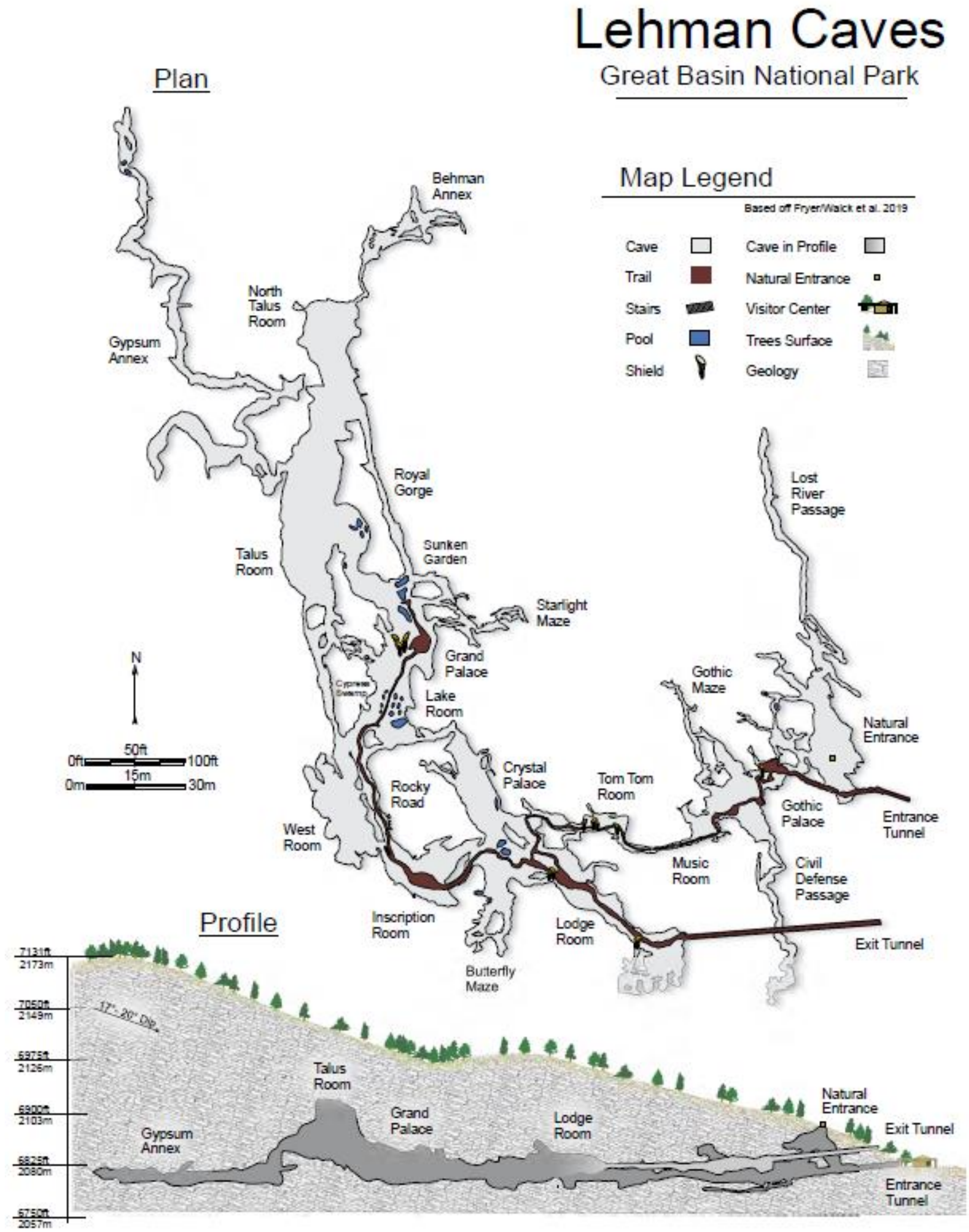

Figure 4. Plan and profile map of Lehman Caves, showing over 10,000 feet of passageway. The red line highlights the current cave tour,

Lehman Caves National Monument was established by Presidential Proclamation 1618, issued by Warren G. Harding on January 24, 1922. This proclamation provides specific legal authority and direction for the monument. The key management provision of the proclamation states in part:

> "whereas, certain natural caves, known as Lehman Caves, which are situated upon partly surveyed lands within the Nevada National Forest in the state of Nevada, are of unusual scientific interest and importance, and it appears that the public interest will be promoted by reserving this cave with as much land as may be necessary for the proper protection thereof, as a National Monument."

GRBA was established by Congress on October 27, 1986 (Public Law 99-565). Lehman Caves National Monument was incorporated into the much larger NPS-managed area. This larger area included additional caves, which are treated in a separate cave management plan. Specific statutory guidance for the management of federal cave resources came from Congress in the Federal Cave Resource Protection Act of 1988 (FCRPA). A key provision is found in Section 2c, which states: "It is the policy of the United States that Federal lands be managed in a manner which protects and maintains, to the extent practical, significant caves."

NPS Management Policies (NPS, 2006 § 4.8.2.2), articulate service wide policy consistent with FCRPA (**emphasis added**):

> "As used here, the term "caves" includes karst (such as limestone and gypsum caves) and nonkarst caves (such as lava tubes, littoral caves, and talus caves). **The Service will manage caves in accordance with approved cave management plans to perpetuate the natural systems associated with the caves**, such as karst and other drainage patterns, air flows, mineral deposition, and plant and animal communities. Wilderness and cultural resources and values will also be protected.
>
> **Many caves or portions of caves contain fragile nonrenewable resources** and have no natural restorative processes. In these cases, most impacts are cumulative and essentially permanent. As a result, **no developments or uses, including those that allow for general public entry (such as pathways, lighting, and elevator shafts), will be allowed in, above, or adjacent to caves until it can be demonstrated that they will not unacceptably impact natural cave resources and conditions**, including subsurface water movements, and that access will not result in unacceptable risks to public safety. Developments already in place above caves will be removed if they are impairing or threatening to impair natural conditions or resources.
>
> Parks will manage the use of caves when such actions are required for the protection of cave resources or for human safety. Some caves or portions of caves may be managed exclusively for research, with access limited to permitted research personnel. In accordance with the Federal Cave Resources Protection Act of 1988, recreational use of undeveloped caves will be governed by a permit system, and cave use will be regulated or restricted if necessary to protect and preserve cave resources.
>
> **Under 43 CFR Part 37 regulations for the act, all caves in the national park system are deemed to be significant.** As further established by this act, specific locations of significant cave entrances may be kept confidential and exempted from FOIA requests."

The Great Basin National Park Foundation Document (NPS 2015) was written to provide basic guidance for planning and management decisions. One of the fundamental resources identified in the document was caves, karst, and cave-forming processes, including Lehman Caves. Geology, hydrology, biology, paleontology, and archeology are called out. The Foundation Document notes that the park has limited cave management guidance and calls for the development of a cave and karst management plan.

A number of specific NPS regulations apply to cave management at GRBA and have been considered in the preparation of this Cave Management Plan. Key regulations include:

Closures and Public Use Limits (36 CFR 1.5) This regulation authorizes a park superintendent to establish visiting hours, establish public use limits, and close all or part of a park area to all use or to a specific use or activity, consistent with applicable legislation and administrative policies and based upon a determination that such an action is necessary for one or more of the following reasons:

- Maintenance of public health and safety
- Protection of environmental or scenic values
- Protection of natural or cultural resources
- Aid to scientific research
- Implementation of management responsibilities
- Equitable allocation and use of facilities
- Avoidance of conflict among visitor use activities

Permits (36 CFR 1.6) This regulation authorizes park superintendents to issue permits for activities that are otherwise restricted or denied to the general public and requires superintendents to "include in a permit the terms and conditions that the superintendent deems necessary to protect park resources." Issuance of a permit is based on a determination by the park superintendent that the following factors "will not be adversely impacted":

- Public health and safety
- Environment or scenic values
- Natural or cultural values
- Scientific research
- Implementation of management responsibilities
- Proper allocation and use of facilities
- Avoidance of conflict among visitor use activities

Preservation of natural, cultural, and archeological resources (36 CFR 2.1) This regulation prohibits the possession, destruction, defacement, digging, removal, disturbance, sale, or commercial distribution of or injury to a mineral resource or cave formation, or part thereof. It further authorizes a superintendent to restrict hiking or pedestrian use to a designated trail or walkway system.

Research Specimens (36 CFR 2.5) This regulation authorizes park superintendents to issue research specimen collection permits if the collection is necessary to scientific or resource management goals and only if such collections would not damage park resources.

Cave Management (43 CFR 37) These regulations implement the Federal Cave Resources Protection Act of 1988. Among other important considerations, they designate all NPS caves as ‘significant’ for the purposes of the act and prohibit the disclosure of the locations of significant caves.

National Historic Preservation Act of 1966 as amended (NHPA; 36 CFR 800) These regulations establish a process for evaluation and preservation of important historic, prehistoric, and ethnographic resources.

The Archeological Resources Protection Act 1979 (ARPA) This act clarifies and defines "archeological resources, and was enacted “to secure, for the present and future benefit of the American people, the protection of archeological resources and sites which are on public lands.” ARPA establishes permitting guidelines and professional qualifications for study of archeological resources and public lands and outlines substantial penalties for removal, sale, receipt, and interstate transport of archeological resources obtained illegally.

Native American Graves Protection and Repatriation Act 1990 (NAGPRA) This act establishes legal authority for protection of Native American burial sites and establishes guidelines for consultation and control of Native American human remains, funerary objects, sacred objects, and items of cultural patrimony found on Federal or tribal lands.

National Parks Omnibus Management Act of 1998 Section 207 of this act authorizes the NPS to withhold information from the public in response to a FOIA request concerning the nature and specific location of threatened, endangered, rare, or commercially valuable objects, or objects of cultural patrimony located in units of the National Park System.

2.0 Natural and Cultural History of Lehman Caves

2.1 Geology

Geology Overview

The southern Snake Range consists of a vast array of rock types and ages. Of primary interest for this document is the Cambrian-age (541 to 485 million years ago (mya)) Pole Canyon Limestone, located on the fringes of the Snake Range at about 6,500 feet elevation. This limestone layer once covered the entire area, but today is only found in the park along the eastern border, the middle section of Snake Creek, most of the North Fork Big Wash drainage, Mount Washington, and near the South Forth Big Wash trailhead (Drewes and Palmer 1957, Hose and Blake 1976, Miller et al. 2007). The limestone can be found in units up to 1840 ft. (557 m) thick. This and other Cambrian age units were deposited when the area was a shallow and nearshore marine environment (Drewes and Palmer 1957, Hose 2018a).

Approximately 140 mya (early Cretaceous), major surface compression to the east caused the Sevier Orogeny, creating many mountain ranges within the Great Basin. The section of Pole Canyon limestone containing Lehman Caves was metamorphosed into a low-grade marble due to the pluton intrusion during the early Tertiary (now Paleogene) 35 mya, or late Cretaceous (Miller et al. 1989).

The next major geologic event with a significant impact on Lehman Caves occurred about 35 million years ago, when a major extension period caused the younger rock layers (e.g., Pole Canyon Limestone) to slip and tilt off the older rock layers (e.g., Prospect Mountain quartzite, the dominant rock on Wheeler Peak). With the weight removed, this allowed the metamorphic core complex to rise, creating what we now know as the northern part of the park (Miller et al. 1987, Graham 2014). Continued stretching produced the ranges (horsts) and basins (grabens) that we see today across the Great Basin geographic region. The mountain-building phase created many fractures in the rock (Hose 2018a).

Read Louise Hose’s 2018 “The Geologic Story of Lehman Caves” for much more information, along with her more in-depth geologic explanations listed in the References.

Lehman Caves Speleology

The relatively horizontal nature of the passages of Lehman Caves indicates that the cave formed after the last Snake Range uplift, which ended with the Pole Canyon Limestone dipping to the southeast approximately 5.3 million years ago. The cave was formed by two distinct processes: hypogenic and epigenic. Hypogenic cave-forming occurs when warmer, acidic groundwater, that does not have contact with the surface, rises from below and dissolves away the limestone (Klimchouk 2007, Palmer 2007). Epigenic cave-forming occurs when surface water and groundwater flow through fractured limestone and dissolve away the calcium carbonate creating cavities. Lehman Caves shows many characteristics of hypogenic cave formation, including abundant gypsum, rising wall channels, and ceiling cupolas. It is likely that the cave first formed by hypogenesis (Hose 2018a), with dissolution occurring near the top edge of the water table (Hose 2018a). Fast moving water was also present at some time in the cave’s past, as indicated by scallops. Jasper (2000) measured scallops in 20 locations in the cave. Using Curl’s equation, he determined water velocity to range from 0.1 to 9.5 m^3/s.

Recent formation dating has shown that some formations in Lehman Cave are at least 2.2 million years old (Lachniet and Crolly 2017). Given that a void must already have formed prior to the creation of the speleothem, the cave itself may be older.

After the water table dropped, and as surface water percolated through soil and organic debris and became slightly acidic, it dissolved away part of the marble above the cave. When the calcite-rich water reached the air-filled passages, it deposited speleothems of many types (Hose 2018a). Several speleothem types are present in Lehman Caves (Table 1). Most are made of calcite ($CaCO_3$). Pool deposits, where calcium carbonate usually crystallizes as calcite, include rimstone, shelfstone, folia, and cave rafts. Flowing and dripping water create gravitationally influenced speleothems of calcite and include cave pearls, flowstone, stalactites, soda straws, stalagmites, columns, and draperies. Speleothems formed by capillary water include helictites, anthodites, shields, and welts (including turnip stalactites). Evaporative speleothems such as coralloids (cave popcorn is the most common example), frostwork, and gypsum crusts are present in Lehman Caves. Speleothems influenced by microbial activity include moonmilk (Hill and Forti 1997, Palmer 2007).

Research has shown that these speleothems do not grow at an even pace (see section 2.11), and that gaps of tens of thousands of years in growth are possible (McGee 2011). Over time, some speleothems lose their color and luster. This often occurs due to drying, which can cause the disintegration of the crystal structure of the speleothem. Bacteria can also break down calcite, often forming moonmilk in the process. Condensation-corrosion can cause speleothems to be worn down where carbon dioxide content is high, with a chalk-white speleothem remaining. This process may only have started within the last ten thousand years, as the climate got drier (Hose 2018a).
Just as oversaturated waters create speleothems, undersaturated water can dissolve them away (Hill and Forti 1997). Speleothems in many different states of formation and dissolution are present in Lehman Caves.

Table 1. Selected speleothem types in Lehman Caves (based on Hill and Forti 1997, Palmer 2007).

Type	Speleothem	Description
Pool deposit	Rimstone	Deposit of calcite around edges of cave pools
	Shelfstone	Flat ledges of calcite that grow inward along the water surface from the shore
	Folia	Shelf-like tiers of calcite resembling upside down rimstone dams
	Cave rafts	Thin mineral deposits that crystallize on pool surfaces
Flowing & Dripping Water	Cave pearls	Calcite or aragonite coating tiny grains of sand or other small materials under water drips
	Flowstone	Calcite deposited where water runs down cave walls or across sloping surfaces
	Stalactites	Formations hanging from ceilings or ledges; contain a hollow central tube through which water initially flows; often aligned along ceiling fractures
	Soda Straws	Thin-walled tubes with nearly uniform diameter along the length hanging from ceiling or ledges
	Stalagmites	Conical or cylindrical features that form where drops of falling water hit the cave floor
	Columns	Calcite deposits formed when a stalactite and stalagmite grow together
	Draperies	Curtain-like sheet of calcite formed by water flowing down an inclined cave ceiling; surface tension keeps the water next to the cave wall rather than dripping
Capillary Water	Helictites	Twisted speleothems formed by water that seeps in tiny amounts through internal canals due to capillary pressure
	Anthodites	Long, quill-like spikes composed of calcite or aragonite
	Shields	Two parallel hemispherical plates of calcite separated by a thin medial planar crack, which forms by water seeping through the medial crack; Over 300 present in Lehman Caves
	Welts	Outward growths from fractures in speleothems; resemble rudimentary shields
	Turnip Stalactites	Appear like turnips; The bulbous part of the stalactites may be welts covered by travertine
Evaporative	Coralloids/Cave Popcorn	Small balls that are nodular, globular, or coral-like in shape that project outward from bedrock and other speleothems; most commonly found in windy areas
	Frostwork	Delicate, white, needle-shaped aragonite crystals that branch in delicate clusters. Aragonite has the same chemical composition of calcite, $CaCO_3$, but a different crystal pattern
	Gypsum crust	Deposit of gypsum on floor, walls, or ceiling that ranges in thickness from 0.1 mm to several cm in Lehman Caves
	Gypsum flower	Flower-like speleothem made of gypsum; in Lehman Caves small and weathered

Type	Speleothem	Description
Microbial	Moonmilk	White deposit of microscopic crystals; pasty when wet and powdery when dry

Lehman Caves Hydrology

Lehman Caves has several perennial pools (e.g., Sunken Garden, Grand Palace, bottom of Talus Room, end of Gypsum Annex) and ephemeral pools (e.g., King's and Queen's bathtubs). Basic water quality measurements have been conducted at selected pools quarterly since 2006. These water quality measurements have helped quantify when these pools have water. Of the four pools measured, the Sunken Garden was the only one with perennial water (Figure 5). The Queen's Bathtub had water in it approximately at half the visits (Figure 6). The pool on the way to the Lost River Passage was wet for seven springs between 2006 and 2016, as well as additional seasons in 2011 and 2014 (Figure 7). The little pool at the top of the transformers by the Cypress Swamp was only wet in 2011 (Figure 8). Basic water quality measurements, including water temperature, dissolved oxygen, specific conductance, and pH were taken at these pools (Table 2). Water quality was consistent with what is expected in cave pools.

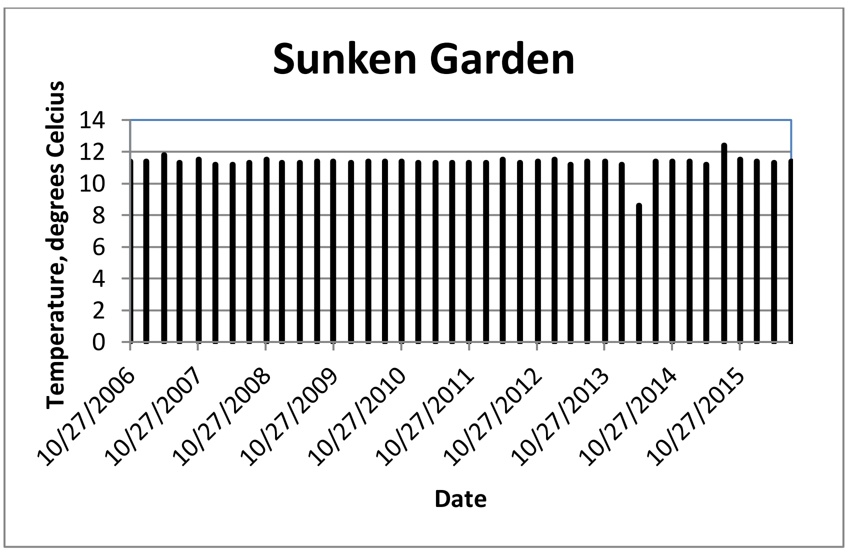

Figure 5. Water temperature at the Sunken Garden pool, measured quarterly from October 2006 to October 2016. This pool had water in it at every visit. Water temperature averaged 11.4°C.

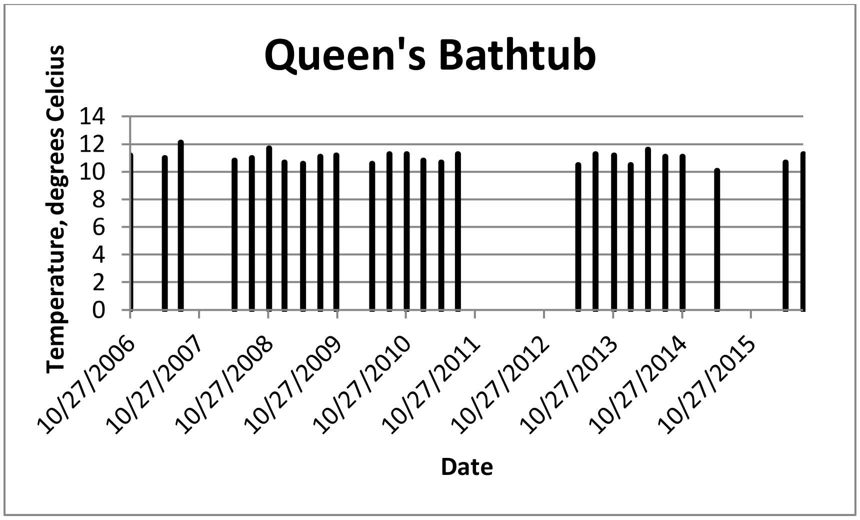

Figure 6. Water temperature in the Queen's Bathtub pool, measured quarterly from October 2006 to October 2016.Water temperature averaged 12.4°C.

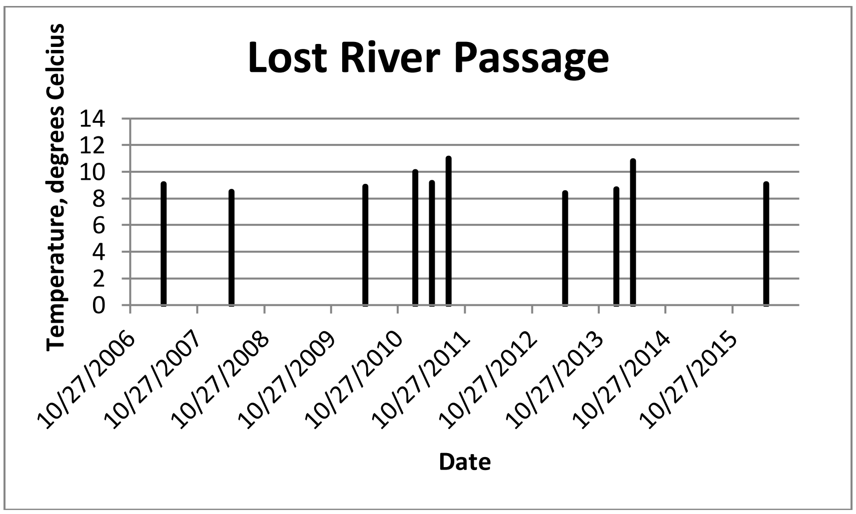

Figure 7. Water temperature in the pool on the way to the Lost River Passage, measured quarterly from October 2006 to October 2016. This pool typically only has water in it during wet springs.Water temperature averaged 9.5°C.

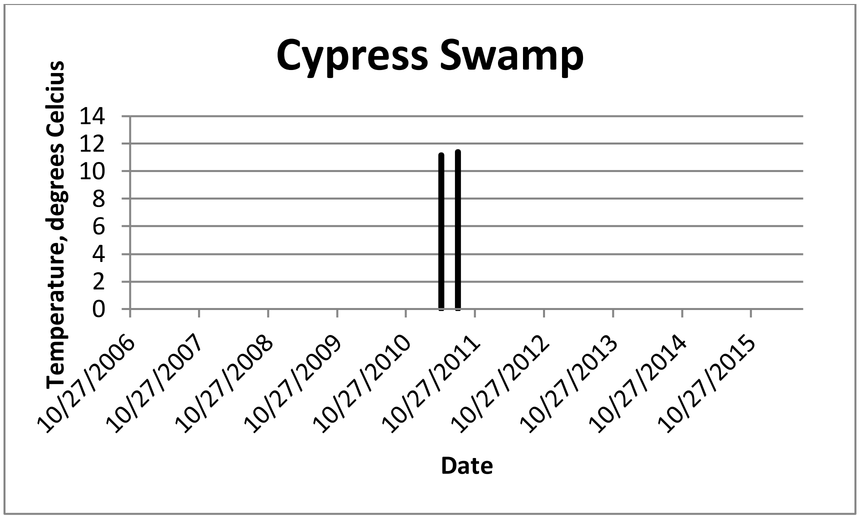

Figure 8. Water temperature in the pool after the Cypress Swamp and above the transformer box, measured quarterly from October 2006 to October 2016. This pool is usually dry and only had water in it for two visits, during the wet spring and summer of 2011. Water temperature averaged 11.3°C.

Table 2. Water quality measurements at selected pools from 2006-2016, averaged over seasons.

Location	# Times measured	Average of Water temp (deg C)	Average of dissolved oxygen (mg/L)	Average of specific conductance (uS/cm)	Average of pH (standard units)
Queen's Bathtub	34	12.4	3.8	355.4	8.0
Cypress Swamp	2	11.3	3.3	573.0	8.1
Sunken Garden	45	11.4	3.7	409.4	8.0
Lost River Passage	15	9.5	4.2	425.6	8.0

More in-depth water chemistry was conducted on the perennial pool in the Sunken Gardens by the USGS as part of a study assessing the water quality of Cave Springs (Appendix C). The pool water had very little iron, but was higher than nearby springs for most dissolved constituents such as calcium, magnesium, and sodium, which is expected given the nature of the surrounding rock. Stable isotopes of deuterium and Oxygen-18 (^{18}O) were heavier, which means that the water in the cave pool came from local sources, with most from summer precipitation. The cave water also showed evidence of undergoing some evaporation. This is not surprising as the average humidity of the cave is less than 90%. Based on chlorofluorocarbon analyses, the average age of the water in the Sunken Gardens pool was estimated to be less than 19 years old (Prudic and Glancy 2009).

2.2 Discovery

The area near present day Lehman Caves has been used by various tribes for over 12,000 years. In 1963, the Nevada State Museum excavated eighteen fire hearths, ten artifacts, and human remains from the Entrance Room. The cave was obviously known and utilized by Native Americans, but no evidence has been found that they ventured farther into the cave (see section 2.9 Cultural for more information).

Figure 9. Shack over Natural Entrance, approximately 8 feet by 10 feet.

Snake Valley was settled by European descendants starting about 1869, largely for ranching and farming. Some miners staked claims in nearby Snake Creek and Osceola. Miners needed food, and Snake Valley became known as a purveyor of fruits and vegetables, as well as meat (Trexler 1966, Unrau 1990).

Although numerous stories exist about who found Lehman Caves (Trexler 1966), the credit for the early development of the cave (Figure 9) goes to Absalom Lehman. Absalom Lehman was one of the ranchers in the area, with a ranch about one and a half miles east of Lehman Caves. Lehman entered the cave in 1885 as reported by the *White Pine Reflex* on April 15:

> "Ab Lehman of Snake Valley, reports that he and others have struck a cave of wondrous beauty on his ranch near Jeff Davis Peak. Stalactites of extraordinary size hang from its roof and stalagmites equally large rear their heads from the floor. A stalactite about 500 pounds has been taken from the cave and planted beside the monument erected by Ivers to mark the spot where he observed the last transit of Venus on Leahman's (sic) ranch. The cave was explored for about 200 feet when the points of the stalactites and stalagmites came so close together as to offer a bar to further progress. They will again explore the cave armed with sledgehammers and break their way into what appears to be another chamber."

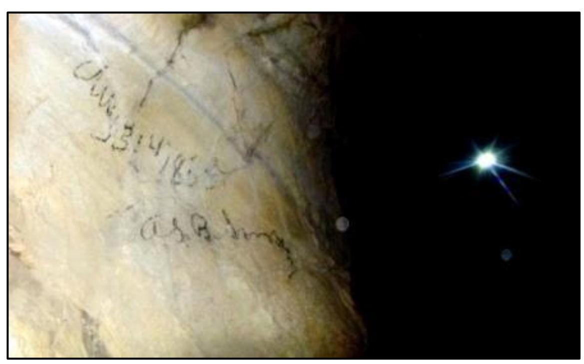

Figure 10. Signatures in Behman Annex

The earliest known signature in the cave is July 4, 1885 with the names "Dock" Baker and Dan Simonsen and the initials BM and GH, presumably for Bill Meecham and George Hickman. Signatures were left two days later by George Robison, Brick Hockman, E.W. Meecham, and E.H. Lake. Signatures in the Talus Room are dated September 12, 1885 (Trexler 1966). The Behman Annex, a side passage off the Talus Room, has three signatures of P.B. McKeon and A.S. Behman from August 31, 1885 (Figure 10). These signatures in distant areas of the cave indicate that most of the cave was found during the first year of exploration. In June 1936, Monument Custodian (similar to today's

Superintendent) H. Donald Curry reported, “Exploration of less accessible portions of the caves has resulted in the discovery of several small rooms probably never before visited.” The location of these rooms is unknown.

The next major discovery wasn’t until October 20, 1947, when Tom Sims, Lawrence Fielding, John Fielding, and Superintendent Max Wainwright found what became known as the Lost River Passage (Figure 11), to the north of the natural entrance. Tom Sims wrote (http://www.elkonv.com/~tsims/):

> “…we finally managed to chisel over that little bank, and I was lowered down while I was holding a rope because at that point you couldn't see where the Floor was. We were the first people down into that particular area from that Direction. In breaking down in to this area on our first trip, we found the Skeleton of a dog, which apparently had entered from some crack or small cave Opening by the old powerhouse. There was only a skeleton remaining, which we left intact. And then continuing down the same passage that is now called the lost River passage. But we went down as far as you could go there. There were two rough spots that you had to squeeze through to get into that Passage. On that trip was the only time I ever wrote anything in the cave. My Initials and the date are in that passage. They should be on a wall close to where we came down into it.”

Figure 11. The Lost River Passage in Lehman Caves was found in October 1947, one of only two major discoveries in the cave since the 1800s.

On October 8, 1952, Ray de Saussure removed a small boulder next to a wall in the Talus Room. He found the entrance to what became known as the Gypsum Annex (Figure 12), and explored it with three other members of the Western Speleological Institute. They found two main passages, with many walls coated with white gypsum (Trexler 1966).

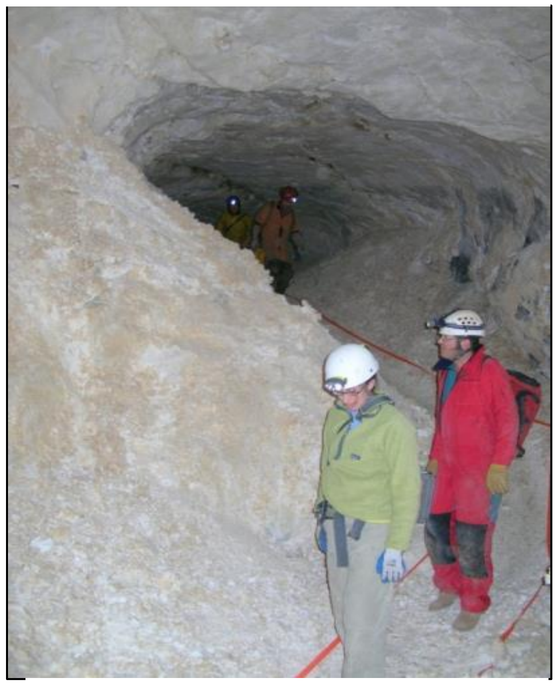

Figure 12. The Gypsum Annex is unlike any other part of Lehman Caves, with gypsum-coated walls and floors. It was found in 1952.

Since 1952, no large discoveries have been made in Lehman Caves.

Maps

The first maps of Lehman Caves have been lost over the years. In 1937, NPS surveyors produced a map of the cave focused on the cave trail (Figure 13). It did not include the Talus Room, West Room, or other side passages.

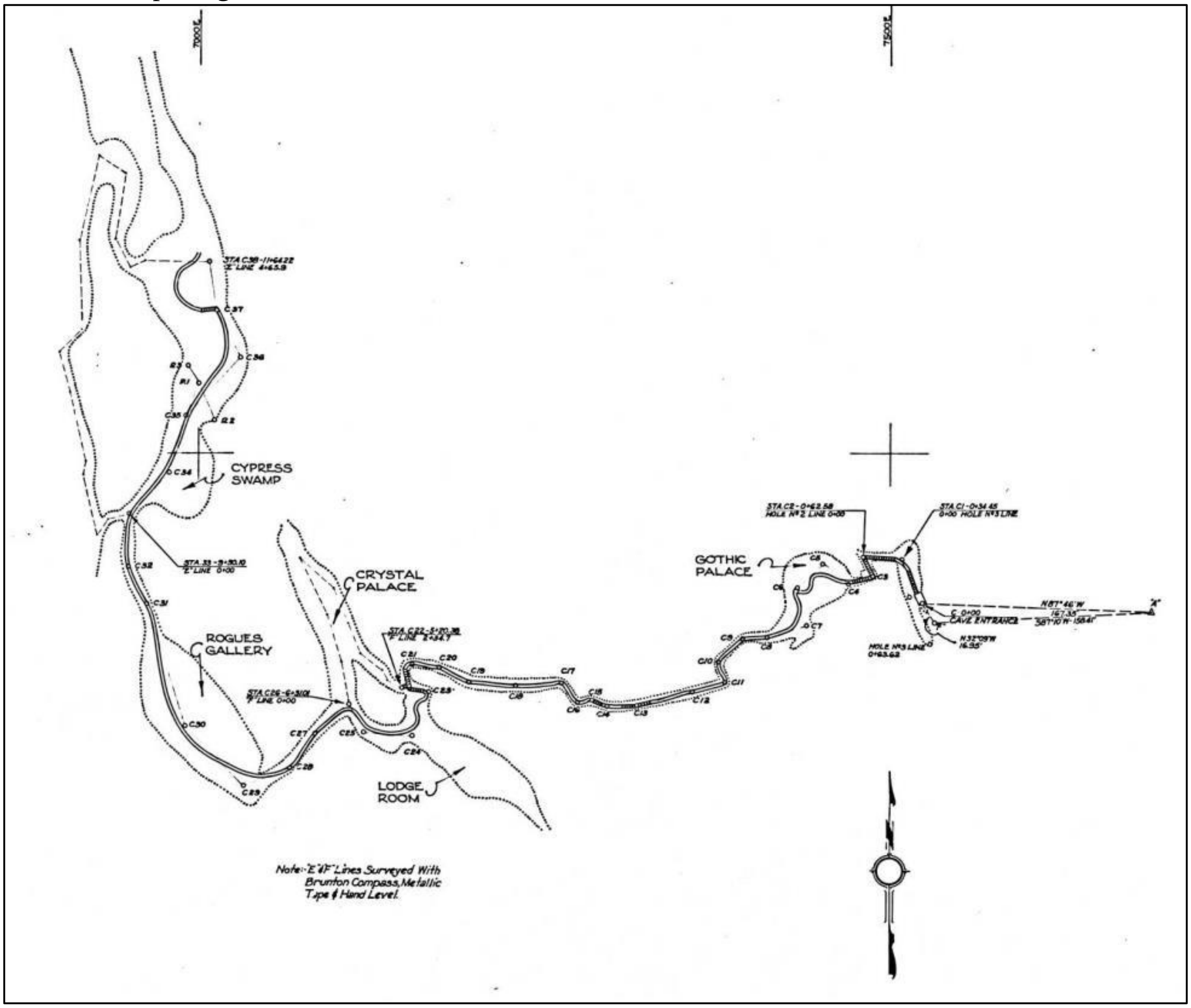

Figure 13. NPS map of Lehman Caves, November 1937.

The next map used by the park was begun on December 21, 1957 by the Salt Lake Grotto of the NSS. Grotto members used a Brunton-type compass and steel tape to produce a complete map of the cave at a scale of 1 inch to 20 feet. Dale Green, the project leader and cartographer, noted that "An effort was made to make the map as complete as possible and every nook and cranny in the cave was looked in to. Not a single passage was found that had not been explored before." The map was completed in 1959 (Figure 14) and the total passage surveyed was just under 8,000 feet (1962).

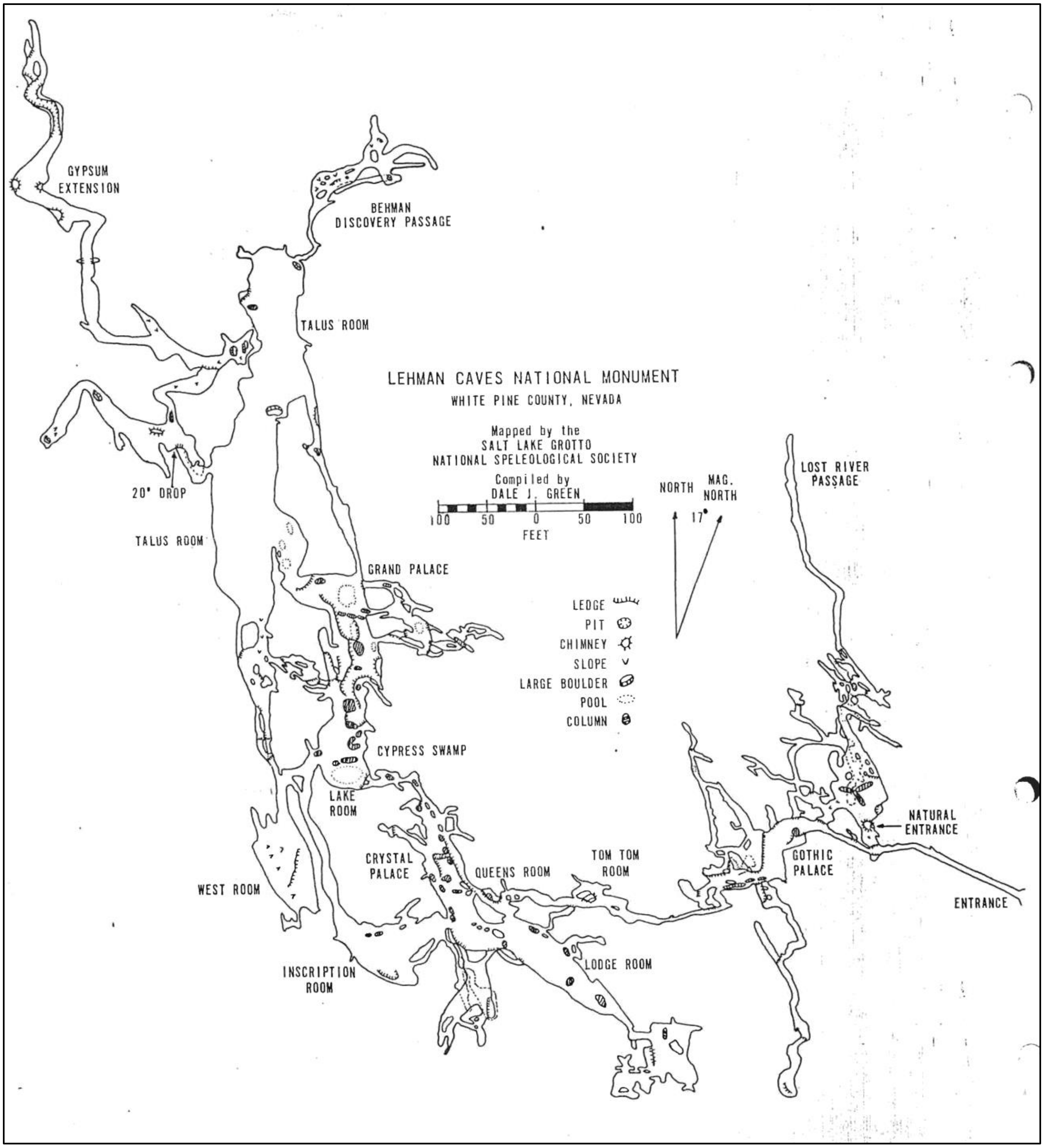

Figure 14. 1959 map of Lehman Caves by the Salt Lake Grotto.

In 1981, a map of the cave and surface was drafted by Lee Eisenberg (Figure 15). No other information is available about this project.

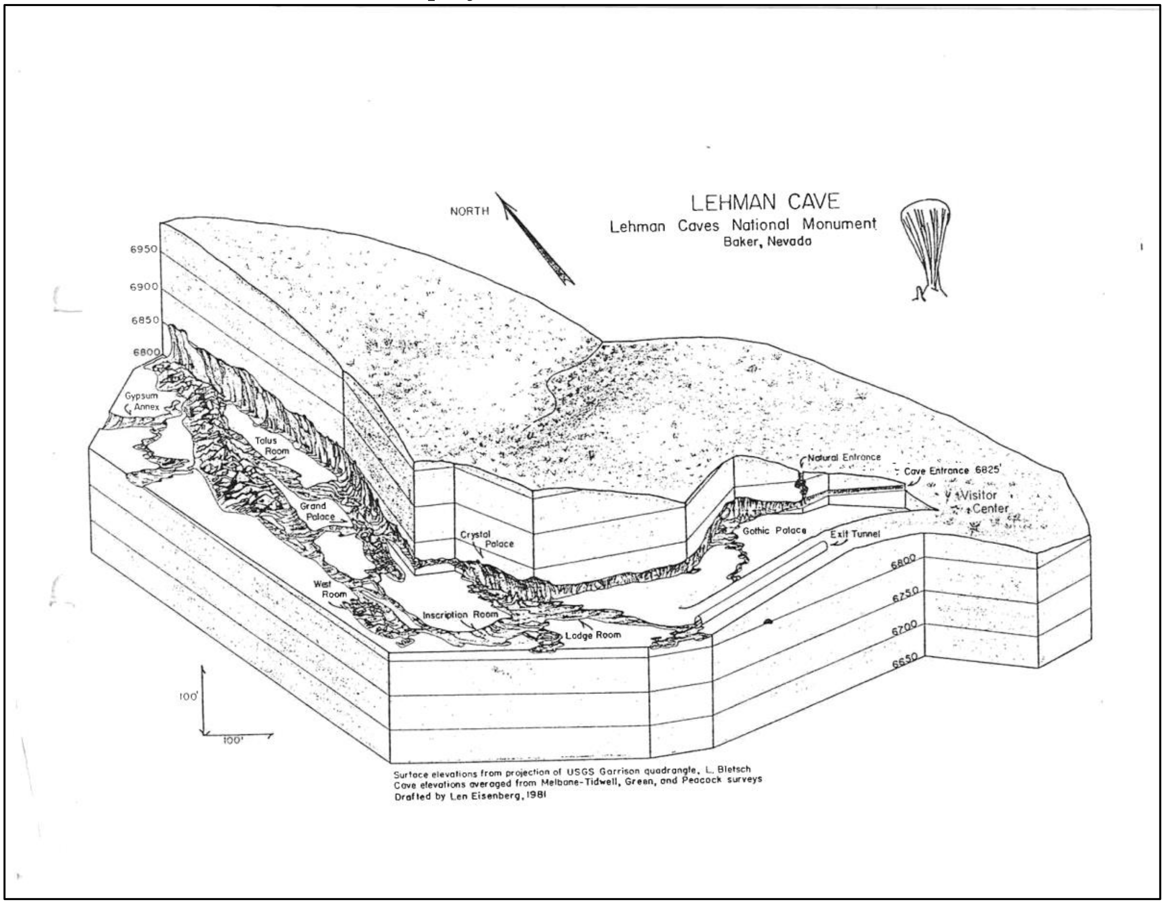

Figure 15. Rendering of Lehman Caves passages with the overlying terrain.

In 1996, GRBA Cave Management Specialist Rod Horrocks began resurveying Lehman Caves, including plan, cross section, and profile views. The teams also included inventory data, with the goal of integrating it all into a GIS layer. The surveys found some sections of the cave that had not been included on the 1959 map. The resurvey was not totally completed when Horrocks left in 1999. However, GRBA Cave Management Specialist Jon Jasper digitized most of the sketches and began work on developing a digital map. He also produced a 3D model/visualization of the cave (Figure 16). Total cave passage was estimated at over 10,800 feet.

In 2003, Steve Deveny of the Southern Nevada Grotto began a Total Station Survey of Lehman Caves. Total Stations are laser devices that use prisms to reflect the beam and calculate the target position to within a few millimeters. They are extremely accurate since they use triangulation for each shot. He produced a draft map for the NSS Ely Convention in 2016 and provided an updated map to the park in 2018, which had portions of the cave completed.

In 2018 and 2019, Shane Fryer and Cyndie Walck, at the request of the park, began a resurvey of the cave in order to produce an updated cave map with plan, profile, and cross-sections that could be used for new park exhibits, cultural resource documentation, and designing a new lighting system. The exhibit map is shown in Figure 4.

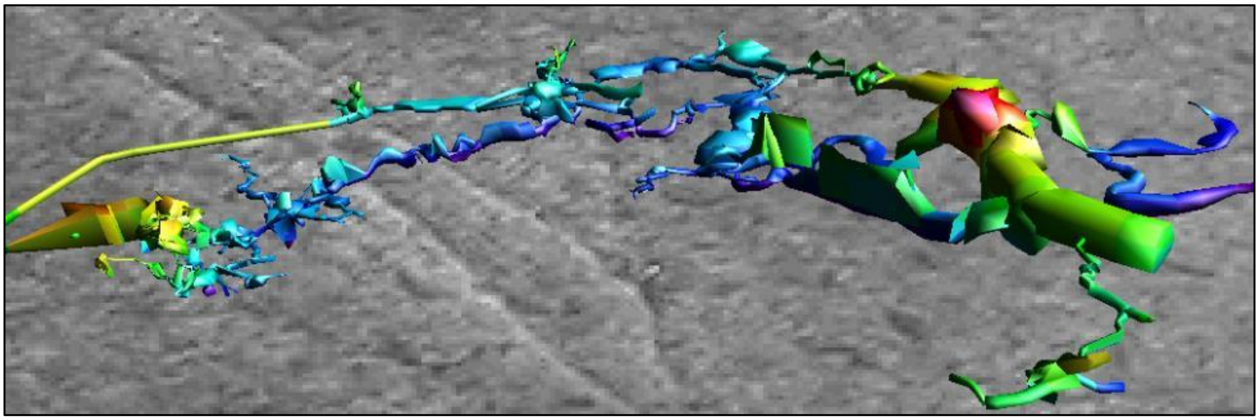

Figure 16. Lehman Caves represented as a 3-D model/visualization, with the entrance and exit tunnels on the left, and Talus Room on the right. Darker colors indicate deeper passages.

2.3 Development of Trails

Main Trail

Nearly as soon as Absalom Lehman entered the eponymous cave, he began developing it so that more people would be able to visit. By September, 800 people had been reported to have entered (Courier 1885). Mrs. Minnie Fillmore recalls visiting the cave in 1885 at the age of about ten. She states, "Entry was made down the steep passage where the caves were discovered – by means of a single long timber through which holes had been drilled and hardwood pins inserted to extend out on each side, making a sort of ladder. A rope was tied around children to save them from falling" (Ely Daily Times 1958).

Figure 17. Historic photo of the Natural Entrance with wooden stairs.

After descending about 15 feet, visitors wrote their names on a large board, lit their candles, and then descended another ladder to enter the first "lofty chamber." They continued on to the Music Gallery, where they were impressed by the sound produced by drawing a piece of broken stalactite along the draperies. Then they "ascended by climbing over rocks and by means of ropes, into another series of galleries and chambers" (Courier 1885). They continued as far as they could conveniently, then "we got some beautiful specimens and retraced our steps; but we never could have found our way out had we not had an experienced guide with us, for there were so many different galleries (Courier 1885).

In spring 1886, the *White Pine News* reported that a note from A. S. Lehman had been sent to a friend in Taylor, NV, stating that "he and several men have been at work all winter and have opened up all the narrow passages in that subterranean palace. Stairways have been substituted for ladders, and ladies can walk right through without fatigue" (April 17, 1886; Figure 17). Lumber for the stairs reportedly came from Hendry's Creek in the North Snake Range (Baker 1961).

A description of the three-hour tour through Lehman Caves was written by USFS Inspector of Grazing, Ernest Winkler. He visited the cave on 25 October 1916, reporting a small lumber shack constructed over the entrance of the cave, about 8 ft. x 10 ft. in size and kept locked by Mr. Ed Adams, who guided people through the cave. "On entering the cave one goes down a flight of stairs probably fifteen feet, and reaches a landing. Again from here the stairs continue about ten feet, where the cave comes out into a comparatively large room…There are a series of steps and ladders…wood deteriorates rapidly in this Cave and consequently must be watched and replaced." On his tour he was very impressed with the Music Hall, where they took a candle or knife to make musical tones; the Congress Room with pillars of stalagmites; and most of all, the Jungles (possibly the Lake Room), with "a small… lake and innumerable formations of all sizes and shapes, with frost-like whiteness, so that in the candle light it creates a most beautiful effect" (Unrau 1990).

Assistant District Forester R.E. Gery inspected Lehman Caves National Monument (LCNM) in April 1925, noting "considerable improvement in the interior of the cave: and the entrance had "been inclosed (sic) by a small creditable looking building" (Unrau 1990). Boak had written that the State Legislature had appropriated some additional money for the cave due to the "game preserve" nomination that helped fund building cement stairways Etc. in the caves."

When the National Park Service took over administration of the cave in 1933, two inspectors surveyed the cave. They stated that 1,500 feet of trail and existing wooden stairways would require considerable work to make them more usable. They recommended more headroom throughout the tour, and that the debris on the floors and the smudges on the walls be cleaned up. One inspector, architect Harlan Stephanson, was concerned that the trail did not adequately protect the speleothems. "The original trail was evidently built with too little thought toward protecting or saving the interesting formations. In many places the stalagmites and stalactites were unnecessarily broken away and merely pushed to one side of the trail." He advised, "Work within the cave would need careful supervision." He also advocated for a concealed electric lighting system, but did not think a tunnel was necessary (Trexler 1966).

In the spring of 1934, the Civil Works Administration (CWA) employed crews who removed "loose stones, dirt, dead lumber and debris from the trails," washed walls, leveled and widened old trails, built stone walls, and replaced stairways (Trexler 1966). At that time, it took about an hour or two to take a tour (Nielson 1934). The Civilian Conservation Corps (CCC) did some work in the caves in 1934-35, reconstructing trails and doing "stone work," which consisted of placing small stones along the edges of the trail to define it. An inspector didn't like the "stone work" and instructed to have it removed. A different inspector in spring 1935 noted that every crevasse in the cave was filled with boards, cans, boxes, and rocks that did not leave a favorable impression. Some of this was taken out in December 1935, including "several hundred feet of lumber.. and four gunny sacks of tin cans" (Trexler 1966).

There is mention that in 1936 calcium chloride was used to firm the trails. By January 1947, all the stairways had been replaced and much of the trail levelled and re-sanded.

In 1951, trail work included removing projecting stone, lowering the depth of the floor, chipping off stone hazards overhead, and packing sand to give the trail a smooth surface. They worked from the Lodge Room to the Sunken Garden. Blacktop was placed in the Entrance Tunnel and Gothic Palace (Wainwright 1951).

Figure 18. Prentice C. Kaufmann putting down road mix for trails in the Grand Palace of Lehman Caves, winter of 1955-56.

Beginning in January 1955, the entire cave trail was surfaced with asphalt (Figure 18). The process was to carry the more than 20 tons of blacktop into the caves by hand, a bucketful at a time. A wheelbarrow made it only to the Gothic Palace. Each worker carried in an average of six loads a day, and sometimes as many as ten. The resurfacing was completed in July 1958 (Trexler 1966). Construction of the Talus Room section of the cave started in November 1960, with a loop of about 900 feet added to the tour route. Work was finished by April 1961 (Trexler 1966).

In the winter of 1964, about three and a half tons of blacktop were packed into the cave to resurface 200 linear feet of trail, to widen the cave trail in places, and to make larger interpretative areas in the Lodge and Inscription Rooms (Jacobsen 1964d). In addition, 75 feet of trail was seal-coated to provide a skid resistant surface. Six handrails totaling 65 feet in length were installed, and 260 feet of trail was lined with rock barriers to confine visitors to the paved areas (Jacobsen 1964c; Jacobsen 1964d).

From March to May and November to December 1974, the cave trail was resurfaced with concrete because the old asphalt surface became slippery when wet, stuck to people's shoes and clothing, and was tracked into the visitor center (Moore 1975). Maintenance staff took 1,255 90-pound bags of Sakrete into the cave. An electric cement mixer, which had been disassembled and brought into the cave and reassembled, was used. The total weight was 112,950 pounds. The cost per bag was $2.25 for a total supply cost of $2824 (Trexler addendum 1977).

In 1981, the Talus Room was closed due to concern about an unstable rock mass (see next section).

During three winters from 1998-2000, GRBA maintenance staff worked in the cave to replace staircases, install handrails and drains, and lay down non-slip surfaces. About 170 feet of trail were refinished using 6.5 bags of Thorite 300 and 18 feet with one bag of Thoroseal.

Talus Room

The 1940 lighting schematic (Figure 19) shows lights in the Talus Room, but no reports could be found of tours going back in that area. It is not known if these lights and the transformer at the bottom of the Talus Room were actually installed at this time.

When the Salt Lake Grotto surveyed Lehman Caves, they found that the West Room and the Inscription Room were only a short distance apart, and an opportunity to make a loop trail existed with a bit of cave modification. The NPS liked this idea and was able to get funds to blast a short connecting tunnel. This extended the tour route into a loop, and alleviated backtracking. About the same time, a study was done by Dr. Kenneth Bullock of Brigham Young University about the geology of the Talus Room, measuring it 385 ft. long, with a maximum width of 65 ft. and a maximum height of 80 ft. He found the ceiling to be composed of three high domes and one lower dome, separated by three low arches. Six main high-angle faults run through the room (Bullock 1960). Bullock was also asked to evaluate the safety of the room. In his report, he stated, "The Talus Room can be regarded as being perfectly safe for visitors to the Lehman Caves. Although the Talus Room is brecciated, the rocks have been keyed together, and one can be assured reasonable safety. The area is much safer than many active underground mines and engineering projects." An asphalt trail was installed in 1960-61, and the Talus Room opened for tours in 1961. In 1974, the trail was topped with concrete.

In 1981, concern over the stability of an area on the west wall in the northern end of the Talus Room, called the Roadmap, caused the room to be shut down to protect the public from possible injury. A letter from Superintendent Al Hendricks to the Western Regional Director on November 10, 1981 states, Shortly after my arrival at Lehman Caves, it was brought to my attention that a large area of loosely aggregated rock adjacent to and nearly overhanging the cave tour route, posed a potential threat to visitor and staff safety. The rock mass (known as the "Roadmap") encompasses an area approximately 50 feet wide by 40 feet high. It is highly fractured with some seams being secondarily filled with clay. Some of the open seams have been observed over the past three years to have widened by as much as 2 to 3 inches. The entire mass is closely adjacent to the main cave tour route (within 10 feet, at one place) in an area known as the Talus Room. The material slopes outward from its base and would appear to threaten the cave trail in two places, in the lower portion of the Talus Room where the tour toute enters the room, as well as directly beneath the "Roadmap" as the trail switches back toward the exit.

The letter went on to explain that the area had been investigated that morning by Mine Safety and Health Administration (MSHA) investigators from Boulder City, NV, along with the Superintendent, maintenance worker leader John Innes and Chief of Interpretation and Resource Management Ed Wood. The MSHA staff said the Roadmap area was dangerous and that the hazardous material should be removed or the area stabilized. They also recommended contact with the MSHA Denver Technical Support Center for more specific recommendations on how to remove or stabilize the Roadmap area. Superintendent Hendricks closed the area to public tours at this time.

The park prepared a proposal for an "evaluation to recommend corrective actions for effective elimination of visitor safety hazards in the Talus Room of Lehman Caves." On December 2-4, 1981, Regional Safety manager Richard Wilburn and structural engineer from the Western Archeological Center, Todd Rutenbeck, toured the Talus Room. Mr. Rutenbeck provided a write-up of six possible options:

1. Continue to use the trail and take the risk of failure.
2. Keep the trail section closed until the rock falls of natural causes.
3. Stabilize the rock mass.
4. Remove the rock mass.
5. Construct a new tunnel to complete the trail loop by by-passing the dangerous area.
6. Construct a tunnel or shield through the Talus Room that could withstand the impact of massive rock fall.

During the tour, some kind of monitoring device was installed.

The Western Regional Director said in a letter to the Superintendent, dated December 9, 1981, that "we agree that the potential is serious and that the portion of the trail passing through the Talus Room be excluded from your public tours…we also concur that this creates a major disruption of your visitor use patterns and some solution must be found quickly, preferably before the normal heavy visitor use in the spring." A meeting was scheduled for January 13, 1982 in the regional office.

No notes of this meeting was found in park files, but apparently a week after the meeting, the cave was visited by Regional Maintenance Engineer Ed Otake, and Geotechnical Engineer James Ellis with the Denver Service Center. Mr. Otake contacted Mr. Rutenbeck on February 9, 1982 asking him to postpone his work pending receipt of Mr. Ellis' report. Mr. Ellis sent a memo April 20, 1982 offering some avoidance and stabilizing options for the Roadmap area. He mentions that he has contacted the Engineering Branch of the USGS in Denver for review. Superintendent Hendricks notes in a memo to the regional director on May 3, 1982 that he is not satisfied with Mr. Ellis' report, as he has not answered all the questions posed in the proposal prepared in December 1981.

The Western Region responded by asking the Denver Service Center in a memo dated May 24, 1982 to assist with the short range solution to the problem and identify long-term problems and possible studies needed for resolution. The memo states that the Western Region would like an in-depth report discussing two options with a cost breakdown: 1) provide a by-pass tunnel or 2) construct a shielding conduit through the Talus Room.

From July 14-16, 1982, a meeting was held at Lehman Caves with the Chief of the Water Resources Division, Gerry Witucki, The Chief of the Division of Maintenance and Engineering Services, Ed Otake, Jim Ellis from the Denver Service Center, and US Geological Survey (USGS) geologist John Ege. Also in attendance were Al Hendricks, Superintendent, and Ed Woods, Chief, Interpretation and Resource Management. Handwritten meeting notes state "additional monitoring devices would be installed before reaching a decision regarding final corrective action."

A memo on July 22, 1982 from Mr. Otake to the Assoiciate Regional Director of Operations in the Western Region adds to the meeting notes, saying that a year of acoustic monitoring was agreed upon, as well as a geologic map. Mr. Ege also suggested pouring concrete grout in the cavities below the Road Map.

Mr. Ege prepared a report from the visit, "Preliminary evaluation of the stability of the west wall and roof in the Talus Room, Lehman Caves, Lehman National Monument, Nevada." The report begins by reiterating points from Bullock's "Geology of the Talus Room." He goes on to stay that "stabilization of the roof was achieved through a voussoir arch mechanism, a means where natural rock stresses acting on the jointed roof rock key the blocks together through friction, thereby establishing a stable arch." The report continues with a description of a large block, estimated to be 10 ft. by 4 ft. enclosing a smaller block in the shape of the state of Nevada. "The smaller 'map' block has moved three inches eastward into the room, an event that probably took place within the past year. A dial-gage extensometer, placed across the left (south) joint of the smaller block after the initial movement was noted, recording a closing of the joint indicating two movements had taken place, and opening of the joint followed by a closing." Mr. Ege continues by noting that part of the Gypsum Extension is very close to this part of the Talus Room, and states, "the proximity of the two underground openings could result in high stresses action on the pillar…" He recommends mapping in detail the geologic structures and the topography of the two areas in order to do a better analysis.

A memo on December 20, 1982 reports that seasonal park technician Dave Shafer, a graduate geology student at the University of Tennessee, has been completed. In the accompanying notes, Shafer remarks, "A case could be made that the Roadmap has already 'collapsed' and that it is now brecciating."

A project proposal by Mr. Ege titled, "Effect of geologic processes on cave morphology and stability," would do more mapping and monitoring of the area. It appears that $25,000 was approved to fund this study, but no results or reports are in the file. In addition, there are no other memos from the 1980s indicating what, if anything, was happening with regards to the Talus Room. No records of the measurements taken are found either.

The next notable entry is from Philip Cloues, Mining Engineer of the Mineral Operations Branch, Geologic Resources Division (GRD), to the Chief of said division. He inspected the Talus Room on April 10-11, 1996 at the request of Ron Kerbo, cave specialist with the GRD, and Becky Mills, Superintendent of GRBA. Mr.Cloues provides a nine-page review of what has happened to date. He calculates risks of having 2,700 groups per year spend 3 minutes per group near the Roadmap. That would be 8,100 minutes per year of exposure. "In 100 years, the probability of a group being involved with an incident (5-8 ton rock falling on a portion of the group) is about 1:6,400. It could happen tomorrow or in the year 2095. No one knows." None of the potential solutions seemed feasible, so the temporary solution of closing the Talus Room became the permanent solution (Cloues 1996).

The infrastructure in that part of the cave was deteriorating, and in 2003, the park received $24,000 from Regional Program Block Allocations to remove three sets of wooden stairs, two wooden benches, and multiple sections of metal handrails from the Talus Room trail. Between 2008 and 2011, Southern Nevada Public Lands Management Act (SNPLMA) funds of $232,691 allowed for the removal of the 1,500 foot-long electrical system and 800 feet of trail. This included using a jackhammer to break up old sections of concrete and asphalt trail. No movement of the Roadmap or other parts of the Talus Room were seen during the many months of work in this area. All the trail pieces were removed from the cave in five-gallon buckets on wagons and dollies, with the help of many volunteers over several years. The Talus and West Rooms were restored to wild cave status (Figures 20-22).

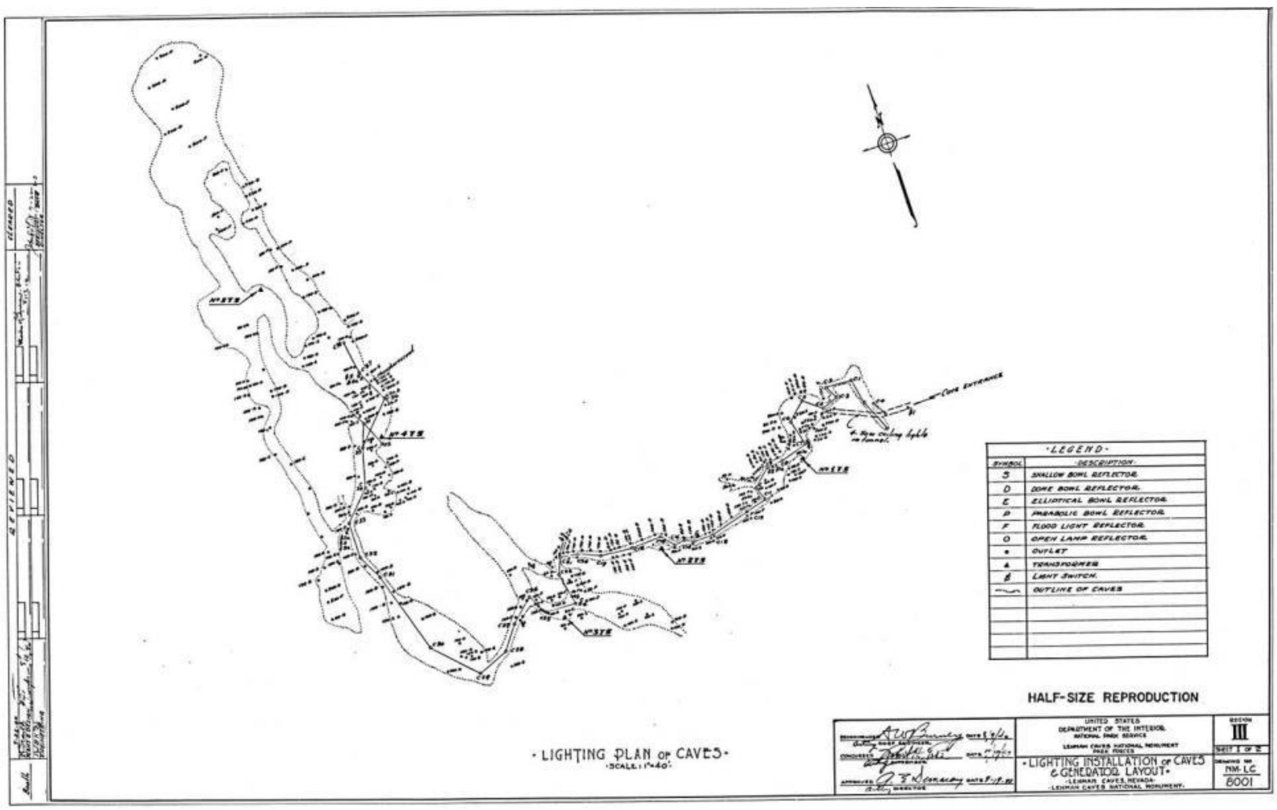

Figure 19. The 1940 electrical lighting plan for Lehman Caves. Note lights that go beyond the surveyed cave trail into the Talus Room and West Room.

Figure 20. The Talus Room had a paved tour route through it beginning in 1961. Tours stopped in 1981 due to rockfall, and the trail was removed between 2008 and 2011.

Figure 21. Sunken Gardens before trail removal. Photo by Rick Bowersox, Southern Nevada Grotto.

Figure 22. Sunken Gardens after trail removal. Photo by Rick Bowersox, Southern Nevada Grotto.

Roads

In 1920, Mr. Lawrence Snyder from a nearby ranch (currently Home Farm) was appointed county road supervisor for the Snake Valley area and built a road from the cave, across Lehman Creek, past his ranch, and in a northeast direction to the county road for about six miles (Baker 1961).

In 1921 a second road was started from the cave, down Baker Ridge, across Baker Creek, and down to about a mile south the town of Baker to help attract those coming from the direction of Garrison and Milford, Utah . It took two years to complete the road; the Forest Service took it over and funded its completion in 1922. The tools used included picks and shovels, drills, hammers, and powder. Machinery included a six-horse case grader, tongue and Frisno scrapers, a plow with a wooden beam known as a prairie breaker, and a Martin ditcher (Baker 1961).

About 500 people came out to the dedication ceremony for Lehman Caves National Monument on August 6, 1922. This included "ten autos loaded to the gunwales with prominent citizens of Delta." Delta Chronicle editor Frank Beckwith wrote, "And we must certainly compliment our county commissioners for the excellent condition of the Grand Central highway…well graded…hard and smooth…but the fullest indorsement of the road is the time that can be made over it. Ed Bunzer and Delbert Searle made from Delta to Baker, 104 miles in 5½ ; others made it in an hour or two longer."

As the idea of making Lehman Caves into a national park was considered, C. C. Boak proposed that "an auto road can be built up Baker Creek to within possibly a couple of thousand feet of the south rim [of Wheeler Peak], from where a trail could easily be built to the rim" (The Ely Record 1924).

A new road to connect Baker to the cave was proposed as early as 1935 (Figure 23). The road was completed in 1947 to the monument boundary, with the section from there up to the cave completed in 1948. U.S. Highway 6 from Baker to Ely was paved in 1947, and from Delta to Baker in 1952. The highway from Milford was paved in 1955 (Trexler 1966).

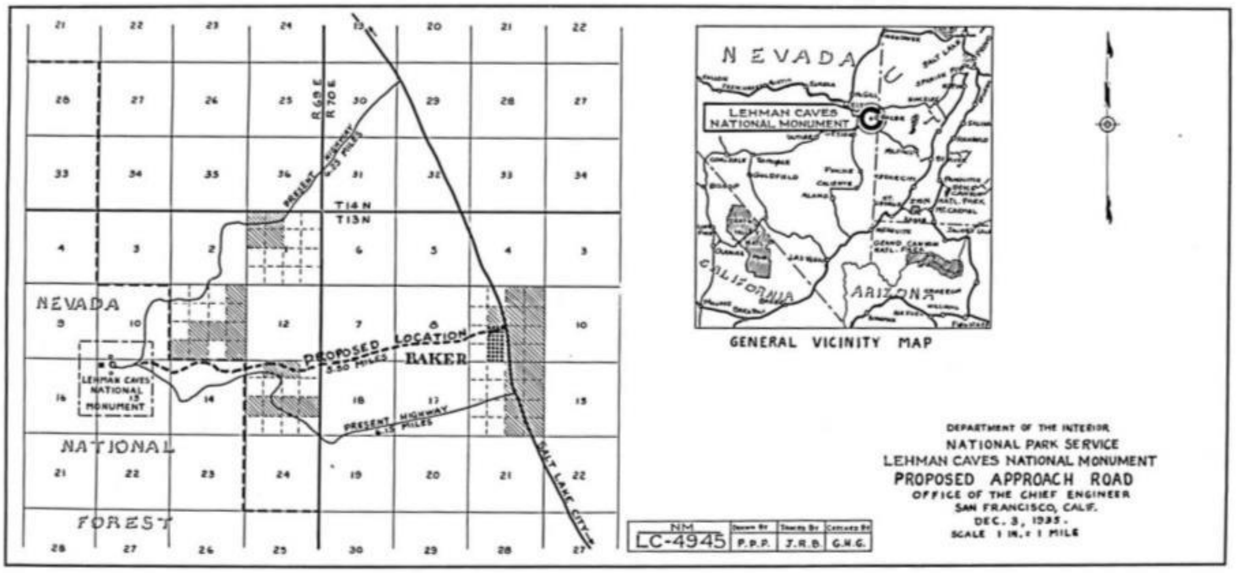

Figure 23. 1935 proposal for a straighter road from Lehman Caves National Monument to Baker, NV.

2.4 Visitation

Visitors have come to Lehman Caves ever since it was publicized in 1885. Early visitation records consist primarily of signatures on cave walls, diaries, and newspaper accounts. Starting in 1922, when the national monument was established, more formal records were kept. Figure 24 shows both Lehman Caves visitation and overall visitation to the monument and national park. Cave visitation peaked in 1998 with 50,786 visitors to the cave. In the last few years, cave visitation has been nearly steady with close to 30,000 visitors per year. Overall park visitation has been increasing, surpassing the 100,000 mark in 2014.

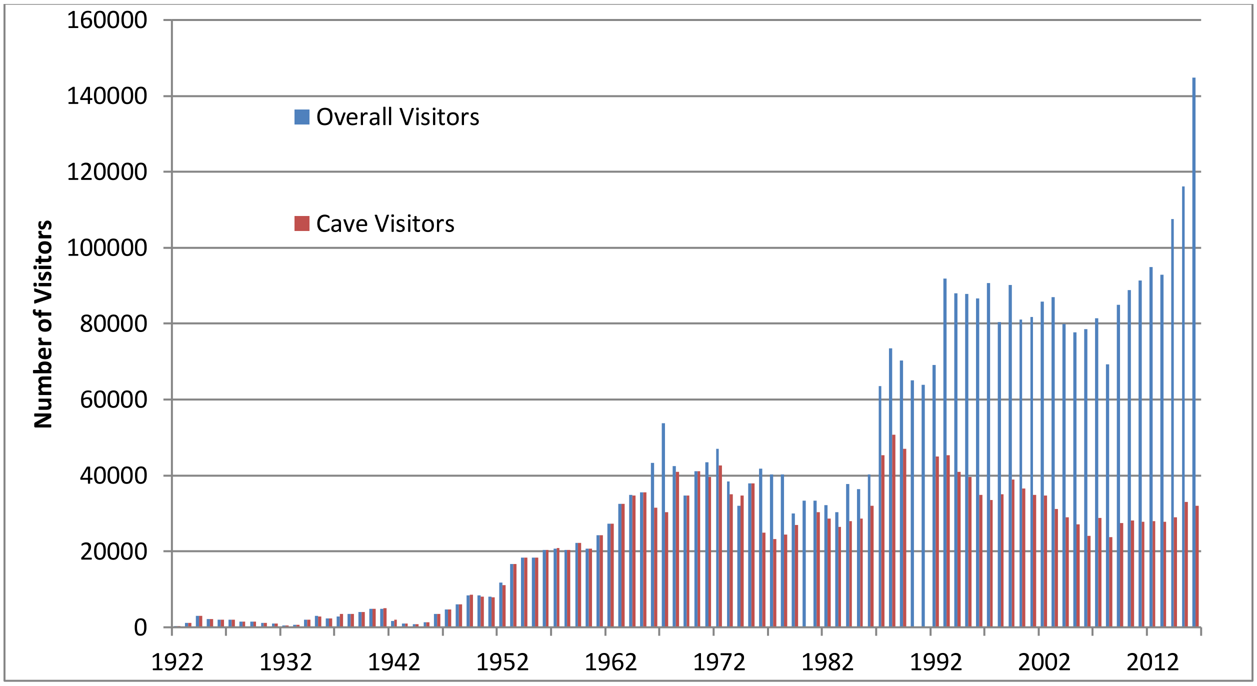

Figure 24. Visitation to Lehman Caves and to Lehman Caves National Monument (1922-1985) and Great Basin National Park (1986-2016). Sources: Cave visitation: *Ely Record* (1922, 1924, 1926); Trexler 1966 (1923, 1925, 1927-1970, 1974-75); Superintendent's Annual Reports (1971-73, 1976-79, 1981-89, 1992-93, 1995-97); Pamela Zeisler, NPS, email (1994, 1998-2005); Park Files (2006-2016). Overall visitation: https://irma.nps.gov/Stats/SSRSReports/Park%20Specific%20Reports/Annual%20Park%20Recreation%20Visitation%20(1904%20-%20Last%20Calendar%20Year)?Park=GRBA,

The 1974 Natural Resources Management Plan for Lehman Caves stated that "More than 1,100 visitors have toured the caves on individual peak days. Cave tours are given every twenty minutes, or as the guides are available, and are limited to not more than 50 persons at a time." For many years, 90-minute cave tours were the only option. Beginning in the late 1990s, three tour lengths were available to visitors. Data was available from 2006 to 2015 about the number of visitors who took 30-minute, 60-minute, 90-minute, or educational tours (usually 60-minutes; Table 3). The 90-minute tour has been the most popular, with an average of 15,116 visitors per year, followed by the 60-minute tour, with 11,352 visitors per year. The 90-minute tours have also been the most offered tour during this time frame. A more in-depth tally of cave visitation is available in Appendix D.

Table 3. Average number of tours and visitors per year from FY2008-FY2015. Data source: annual visitation reports.

Tour	Available	Went	# Visitors
30 Minute	1387	63	170
60 Minute	1029	907	11,352
90 Minute	992	1005*	15,116
Educational	na	58	1157

* More 90-minute tours went than were regularly available due to additional tours added.

The monthly number of visitors to Lehman Caves shows a clear bell curve, with the peak in July and minimum in January and December (Figure 25).

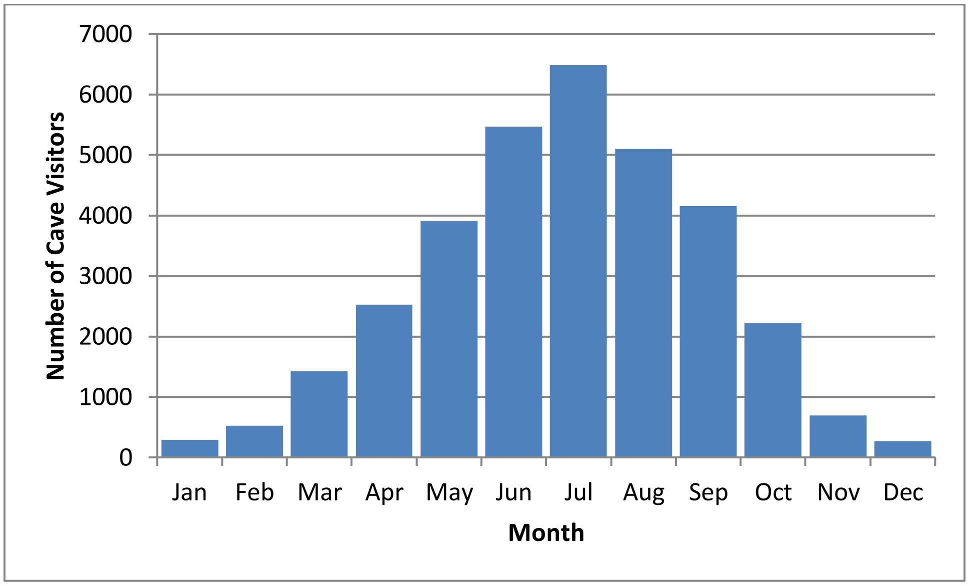

Figure 25. Number of visitors to Lehman Caves by month in 2015.

Cave visitation has also included some special events, such as candlelight tours and spelunking tours. On September 5, 1948, free cave tours were offered to celebrate the completion of the highway from Ely to Lehman Caves. In 1949, to help persuade the governor of Utah with the need to pave the road from Milford, Utah to Lehman Caves, a huge celebration was held with free cave tours. Both these events were estimated to have about 2,000 people in attendance (Trexler 1966).

More information about the Lehman Caves tour is presented in Section 2.7, Interpretation.

2.5 Lighting

The first cave tours were lit by candles. Several newspaper articles report that visitors received a candle before entering the cave (Genoa Weekly Courier 1885, The Ely Record 1919, The Ely Record 1922). Oil wick lamps and flame safety lamps were used extensively by miners from the mid-1800s to the early 1900s and were likely used in the cave as well. Oil powered lamps were surpassed by carbide and electric lights. The first record of carbide lamps in Lehman Caves was the early 1920s. An unspecified type of lighting was added to the Lodge Room in 1925 for use by the Ely Elks and the Knights of Pythias. Official custodian of the caves, C.T. Rhodes, and his wife marketed the Lodge Room as a meeting location (Trexler 1966).

The desire for an electrical lighting system throughout the cave began in the 1920s. In 1939, Federal funds became available, and construction of the cave's first electrical system started in October 1940 and was completed in April 1941 (Trexler 1966). Mr. H. A. Smith, foreman for the Timpanogos Cave lighting project, led the project (Edwards 1940). A 1940 schematic of the cave (Figure 11) entitled "Lighting Installation of Caves and Generator Layout" shows that lights were installed not only throughout the surveyed cave, which was from the entrance to the Sunken Garden, but also through the Talus Room and West Room. The fifth transformer in the cave was to be installed at the lowest point of the Talus Room. It is not listed if this was actually installed, and it is unlikely as no tours went through the Talus Room at this time. This first system was difficult to maintain, and excessive fuel costs shut down the generators in December 1941 for an unspecified amount of time (Trexler 1966).

New generators installed in 1949 helped to keep the cave lighted (Trexler 1966). In 1951, an electrician from Lake Mead NRA came to the monument to help replace one of the transformers that had developed a faulty switch with one on loan from the Kennecott Copper Corporation (Wainright 1951). The spring of 1952 was especially wet, causing more water to infiltrate the cave. When water reached the cave lights, it frequently caused them to explode. A diversion ditch around the natural hole on the surface only helped slightly. In 1962, two new generators were installed after years of troubles maintaining the ones in the park (Trexler 1966).

In 1969-70, the Exit Tunnel was constructed. A lighting system was installed from the Lodge Room to the new exit. A new dry transformer and a dry switch were placed in the "Giant's Ear." A telephone cable was also installed (Trexler addendum 1977).

By the mid-1970s, the electrical system in the cave was having major issues, as much of the original wire was from 1939 (Moore 1977). During the springs of 1975 and 1976, a few cave visitors received electric shocks by touching the handrails, including wet wooden handrails. A lighting engineer visiting the cave recommended that two-thirds of all the wiring in the cave be replaced (Moore 1976, Moore 1977). In May 1977, the Secondary Electrical Rewiring Project began under a contract with Webber Electric, Inc., and was completed by December 1977 (Moore 1977). All existing cave lighting fixtures, except fixtures in the exit tunnel, were rewired. All lighting fixture outlet boxes were replaced with non-metallic boxes. Six new transformers were installed. New power panels and relay panels were installed at all these transformer locations. A solid-state modular dimming system was installed at the first transformer location to control the three lighting circuits in the Gothic Palace (Trexler 1977 addendum). A new low voltage remote switching system was installed that allowed shorter sections of the tour route to be lighted as tours passed through, thereby inhibiting the growth of algae. This was a major recommendation from Dr. Raymond Lynn, who had been studying the biology of the cave for several years (Moore 1977).The number of lighting sections in the cave was doubled. Twenty-five new switches were installed and 6,250 feet of UF switching cable installed. A total of 13,250 feet of new underground feeder (UF) type circuit cable was installed throughout the cave. A new grounding system was installed throughout the cave and terminated at a new ground rod installed at the existing transformer site near the Visitor Center. (Trexler addendum 1977).

During 1999 and 2000, 25 corroding electrical boxes, as well as numerous outlets and lights were replaced with noncorrosive ones. In addition, maintenance staff repaired five light switches (of the eight present in the cave) and four switching relays.

Figure 26. Lampenflora, a combination of algae, moss, and bacteria, which grows unnaturally in the cave due to the presence of cave lights.

In 2006, a National Park Foundation grant provided funding for some renovation of the cave lighting system. During that year, many light fixtures, receptacles, and switches were repaired or replaced with non-corrosive materials. A comparison of different LED bulbs, compact florescence, and incandescent bulbs was also begun. Different types of light bulbs were studied for use in the cave to reduce the amount of lampenflora (algae, moss, bacteria) that grows near lights (Figure 26). To restrict lampenflora, LEDs in the 592-595 nm wavelength can be used. In-cave testing, however, showed that this wavelength produced an unnatural appearing orange/red light that disguised the true colors of the cave and had safety concerns due to the dim light on trails.

In 2009, it was decided to change all the lightbulbs in the cave to LED lightbulbs. Optiplex and Enlux brands were chosen. Lampenflora still exists at many cave lights but the patch size and density have been greatly reduced. Further reductions are accomplished through the annual cleaning of lampenflora with a 10% bleach solution.

A second multi-park study was completed in 2011. Both studies showed that light-emitting diodes (LEDs) were the preferable light source as they emitted less heat than incandescent or compact fluorescent light bulbs.

Between 2008 and 2011, the trail and the electrical lighting system in the Talus Room was removed, including all light fixtures, electrical line, conduit, and the transformer located at the lowest point of the Talus Room.

As of 2016, Lehman Caves has four transformer locations with eight transformers, 265 light fixtures, and 17 switches. Evidence of past lighting systems is still evident in many sections of the cave.

2.6 Other Cave developments/infrastructure

Staircases and Platforms

The first recorded infrastructure put into the cave were wooden ladders and ropes, which were then replaced by wooden staircases (Trexler 1966).

In the spring of 1934, the CWA did many improvements in the cave, including replacing the wooden staircases (Trexler 1966). Landscape architect A. M. Doerner was not impressed, and recommended that permanent steel ladders be used to replace the wooden steps (1935).

From 1947 to 1951 all six stairs along the tour route were replaced. Aluminum handrails and wooden platforms were installed. By the fall of 1952, it was decided that the wooden platforms in the Cypress Swamp had to be replaced and concrete ramps were built there that winter (Trexler 1966).

The extension of the tour route into the Talus Room in 1961 necessitated the addition of staircases in the Royal Gorge and between the Talus Room and West Room corridor.

During three winters from 1998-2000, GRBA maintenance staff worked in the cave to replace staircases, install handrails and drains, and lay down non-slip surfaces. All the wooden staircases in the cave were removed, including the seven along the main tour route. They were replaced with fiberglass stairways with fiberglass tread, stainless steel handrails, and a PVC material as a lint trap. About 200 feet of stainless steel handrails were installed in multiple locations to protect cave features and allow for visitors to more easily and safely navigate the cave. Four drains were installed to help remove standing water from the trail surface. Trail sections that were steeper were refinished with a non-slip surface. About 170 feet were refinished using 6.5 bags of Thorite 300 and 18 feet with one bag of Thoroseal (Glen Dearden, personal communication).

In 2003, the park received $24,000 from Regional Program Block Allocations to remove three sets of wooden stairs, two wooden benches, and multiple sections of metal handrails from the Talus Room Trail.

Tunnels

The Panama Canal, essentially a bypass tunnel around Fat Man's Misery, was mentioned in *The Ely Record* in both 1921 and 1922. The 1921 account even goes so far as to call it "the historic "Panama Canal"." Details about its construction are not known.

The idea of an Entrance Tunnel in the cave surfaced in 1925, when the USFS agreed that it would facilitate entrance into the cave. However, funds did not become available until 1937. In that year, NPS workers started digging under the natural entrance to try and find another way out. They found bones, and an archeologist was hired to help oversee the excavation (see section 2.9 Cultural Resources). A crew started blasting the Entrance Tunnel and it opened in 1939 (Figure 27). The project cost $9,337 (Trexler 1966). Careful drilling and blasting minimized impacts to the cave features, but they noted an increased flow of water to the first room immediately after blasting was completed (Trexler 1966).

While the Entrance Tunnel helped get people in the cave, it consisted of just one entrance. The Ely Chamber of Commerce Committee in May 1952 submitted a report stating, "With only one entrance to the caves, escorting of visitors through is greatly slowed down, necessitating long waits by visitors…who can ill afford to lose several hours in getting on their way. Moreover this slow process means that the guides put in unusually long hours."

Figure 27. An entrance tunnel was constructed for Lehman Caves in 1938-39 and allowed for easier access into the cave.

The next year, an inspection was made to determine the feasibility of a separate exit. The NPS Chief Geologist, the Regional Naturalist, and the Monument Superintendent supported the idea. Guides complained that the tours got backed up on busy days inside the narrow passages of the cave. They proposed that if there was an Exit Tunnel, it would help with the flow of people through the cave. In 1953 plans for an Exit Tunnel connecting to the Lodge Room area were made. The tunnel was approved in 1965, and the 200-foot long tunnel was constructed in 1969-70 at a cost of $111,405 by the Centennial Development Company of Eureka, Utah (Trexler addendum 1977).

Both tunnels had as much as a two-inch gap under the doors that allowed rodents and lizards into the cave. These gaps were reduced as part of the 1998-2000 Lehman Caves Rehab Project but still allow airflow.

Cave entrance

There is a lot of speculation about what the original entrance to Lehman Caves looked like. No photo is available, but records show that the entrance was quickly enlarged to allow easier passage into the cave (Trexler 1966). This may have included blasting away rock (Ely Record 1918). In September 1885, the entrance was reported to be about 35 feet in circumference or 11 ft. across (Courier 1885). A shack was erected above the entrance with a lock on it (Trexler 1966).

With the opening of the Entrance Tunnel in 1939, the natural entrance was no longer needed to enter the cave. In a letter dated April 16, 1941, Park Ranger Claude McKenzie reports to the Superintendent at Boulder Dam Recreation Area:

> "The almost continuous snow we have been having here since the 10th. Of April has caused a great deal of moisture to run in the old cave opening from above, and as a result, approximately 15 tons of mud and rock has come loose, and is now deposited on the trail into the cave."

In 1958, the natural entrance was covered with boards from the 1939 shack. In 1959, this was replaced with a cement and steel slab with a plastic dome over the natural entrance (Trexler 1966). The plastic dome didn't allow for surface-subsurface connectivity, and in 1998 was replaced with a bat-friendly gate.

2.7 Interpretation

The focus of telling the story of Lehman Caves has changed over the years. The first visitors were impressed with the many fanciful names for different rooms and speleothems. Over time, more scientific and conservation messages were included by the rangers.

Names

Names for the main cave rooms have changed over the decades. Table 4 shows the main names. Names for particular formations have changed, with many of those first used in the late 1890s or early 1900s very different from the "Formation Name Map" of the 1960s.

Table 4. Current and past names of rooms and passages in Lehman Caves. Dates in parentheses indicate first recorded time name was used.

Current Name	Past Names
Gothic Palace	Room of the Ancient Gods (1885), Temple of the Ancient Gods (1888), Congress Room (1916)
Rose Trellis Room	Bridal Chamber (1888)
Civil Defense Room	unknown
Music Room	Music Gallery (1885), Music Hall (1888)
Tom Tom Room	Cabinet Shop (1921)
Queen's Dressing Room	Shoshone Falls (1885)
Lodge Room	Convention Hall (1934)
Crystal Palace	unknown
Panama Canal	Mentioned in 1921 and 1922 newspaper articles
Inscription Room	Skating Rink (1885), Rogue's Gallery
Rocky Road	Rocky Road to Dublin (1885)
Lake Room	The Jungles (1916); Lake Como (1961); Swamp Lake (1961)
Cypress Swamp	unknown
Grand Palace	Grand Museum (1885), Grand Theater (1921)
Sunken Garden	Lake Como (1885)
Talus Room	Big Room (1885)
West Room	Earthquake Room (name changed to West Room in August 1962)

A record of a cave tour in 1919 describes how "genial old guide" Ed Adams led the group into the cave after presenting them with candles. They visited places called the Temple of the Gods, Washington's Column, Coral Reef, Lincoln, Grant and Garfield Monuments, Bridal Altar, Musical hall, Victoria's Side Saddle, The Congressional Chamber, Easel of the Angels, Dance Hall, Rocky Road to Dublin, Cypress Swamps, Lake Como, Bath Tub, Cleopatra's Needle, and Alpine Pass. On the return, Mr. Adams told them, "Take all that is loose but break nothing down." Upon exiting, he charged "One fifty, please," and "It was cheerfully paid" (The Ely Record 9/5/1919).

Tour routes

As described in the 1919 tour, the place names indicate that the tour went back to the Sunken Garden and then returned to the entrance. This was likely the most common tour route for many decades. The tour took about four hours (The Ely Record 1919). In the 1920s, carbide lanterns replaced the dimmer candles or oil lamps. Cave tours were one dollar for adults and free for children under 12. If there were twelve or more persons in one party, it was five dollars. Tours took three hours or more (Trexler 1966). Rhodes allowed those who desired to crawl through "Fat Man's Misery" (Trexler 1966).

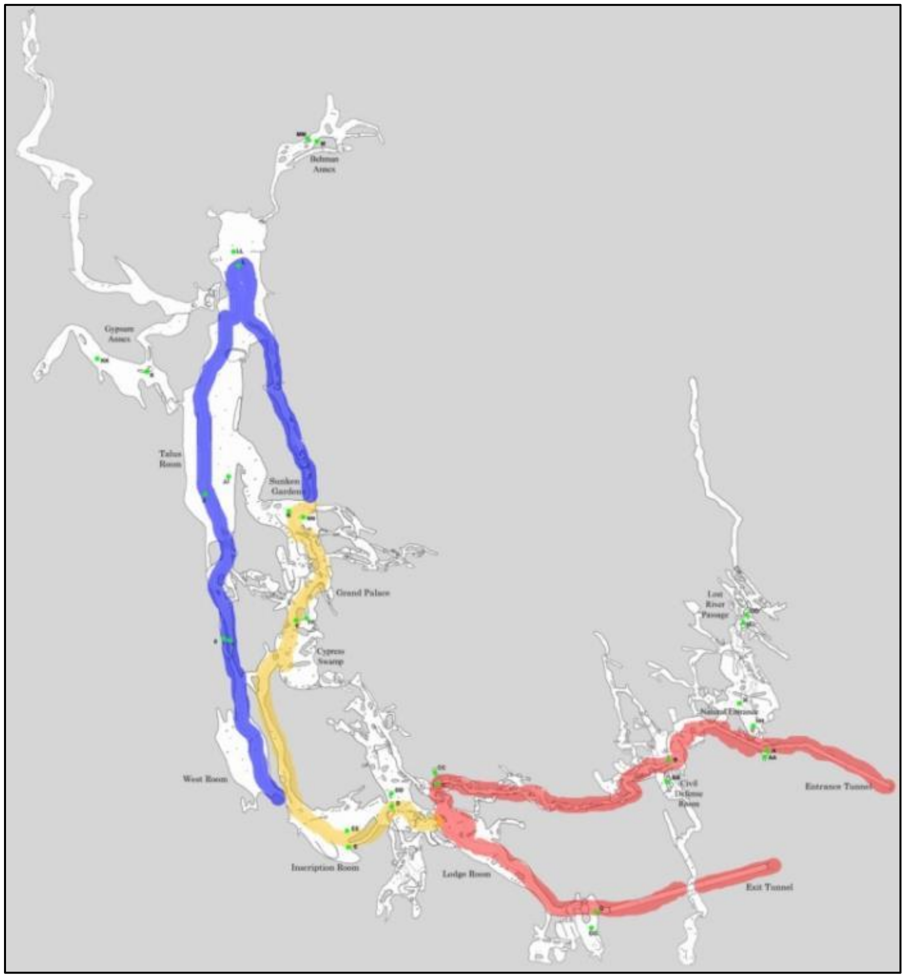

Figure 28. Map of Lehman Caves showing the 60-minute Lodge Room tour in red, the 90-minute Grand Palace tour as an additional part in yellow, and the Talus Room tour as an additional part in blue.

The 1937 cave map showed the route to the Sunken Garden to be the tour route, as did the 1959 map. In 1960, this tour took one hour (Trexler 1966).

In 1961, the main tour route expanded to include the Talus Room and West Room (Figure 28). This tour took an hour and a half. Upon closure of the Talus Room in 1981, the tour route returned to the previous trail, turning around at the Sunken Garden.

At some point, the cave tours became known as the 90-minute (Grand Palace), 60-minute (Lodge Room) and 30-minute (First Room) tours.

Sizes of tours

The sizes of cave tours has varied greatly over the years. For some special events, the numbers swelled. For example, during the dedication ceremonies on August 6, 1922, 325 people passed through the cave as one group. Cada C. Boak, who had helped get the national monument declared, stated, "We were so few and so scattered that all got lost, save the guide, and he was several hours rounding up his flock." (Unrau 1990).

Generally tour sizes depended on the number of people who came to the cave at one time. Ron Bridgemon, a park guide from 1964-67, recalls that Labor Day tours were the largest. "… the staff didn't want to turn people away. When the groups got huge, as soon as one guide exited the cave with his group, he ran back in to break a tour in half or stay at the end. There were many Labor Day tours of more than 100. I think my largest was 127! You can't ever talk to the group; it's just a slow walk through and you hope the formations survived" (Bridgemon 2016).

The 1974 Natural Resources Management Plan for Lehman Caves stated that "More than 1,100 visitors have toured the caves on individual peak days. Cave tours are given every twenty minutes, or as the guides are available, and are limited to not more than 50 persons at a time." In 1977, a "Statement of Management" was established for Lehman Caves National Monument. It set a limit of five tours a day from Labor Day to Memorial Day and 16 tours a day during the summer months. All tours were 90-minutes long and had a 40-person limit (Unrau 1990).

The GRBA General Management Plan specified that the maximum cave use would be 20 tours per day with 30 persons per tour, for a total of 600 persons per day, all on the 90-minute tour (NPS 1993). About 2010 the maximum tour size was designated as 20 in order to better protect the cave and provide a higher quality visitor experience. No limit on the number of tours or the length of tours was specified but have been primarily driven by staffing levels.

Candlelight tours

All of the first tours in Lehman Caves were candlelight tours. In the 1920s, carbide lights started being used in the cave. With the first electrical lighting system in 1941, candles were no longer needed, except when the generator had problems, which was often. LCNM was connected to the electrical grid in the 1970s.

In 1982, candlelight tours were offered to the public. In 1983, these tours were offered daily from Memorial Day to Labor Day at 12:30 p.m. with a limit of 15 visitors. Seventy-five tours ran with 554 visitors. In 1988, the candlelight tours were moved to 6 p.m., and 1,149 people participated. In 1989, seasonal rangers experimented with a living history approach and dressed in period clothing and 1,391 visitors participated (Superintendent Annual Reports for 1983, 1988, 1989). Visitors appeared to enjoy seeing the cave "in a different light," as the candle lanterns were much dimmer than the electrical lights and cast many shadows, providing an altered appearance of the cave. Since 2014, simulated candlelight tours have been offered utilizing LED bulbs. These appear to be well received, offering a similar experience without the safety and environmental concerns associated with open flames and dripping wax.

Spelunker tours

In 1965, a Spelunker Tour was developed in Lehman Caves, traversing an area near the Natural Entrance and the front part of the Lost River Passage. The goal of the tour was to give visitors a more intense experience of the cave and was likened to Yosemite's seven-day backcountry-led naturalist hikes. Most of the tour was on hands and knees. The tour included more in-depth information about cave-forming processes, speleothems, cave conservation, and caving safely. The tour was successful enough that it was again conducted in 1966 and 1967. In 1967, the tour also included a demonstration of vertical caving techniques under the Natural Entrance. The guides who led these tours were NSS members also active in caving. Some of them helped explore and map caves in the Baker Creek area (Bridgemon 2016). No records could be found if the Spelunker Tour continued past 1967.

2.8 Paleontology

Lehman Caves developed within the Pole Canyon Limestone which, in the area of the cave, has been locally metamorphosed to marble by igneous intrusion. This geological scale process tends to obliterate fossil evidence. Additionally, large surface exposures of the Pole Canyon Limestone have produced virtually no fossils. No bedrock fossils have been verified after decades of intensive visitation. Therefore, it is not likely that bedrock fossils would ever be found in this cave (Bell 2015).

However, the cave is rich in paleontological resources in the form of faunal remains. The primary paleontology studies in Lehman Caves were done in association with the excavation of the Entrance Tunnel in 1937-38. S. M. Wheeler initiated an archeological excavation, during which a total of 219 animal bones were found, cleaned, and catalogued. The predominant bones were jackrabbit, cottontail rabbit, and marmot (Rozaire 1964).

In 1963, Dr. Charles Rozaire conducted an archeological excavation of the natural entrance area. A 30-foot trench was laid out north and south and taken down to bedrock, which varied from 21 inches to over 9 feet. A 35-foot long trench was then dug in Room 1. A total of 19 pits were dug in the two rooms, which was about 30% of the soil surface of the area. The sediments were layered, with fluvial deposition of cobbles, gravels, sands, and silts deeper, and aeolian (windblown) sediments piling up on top in the northern part of the room. Rocks from the cave ceiling were mixed in the sediment layers. The animal bones were found in the deeper fluvial deposits (Rozaire 1964). This implies that some are probably Pleistocene in age. Several specimens of the desert tortoise, *Gopherus agassizi*, were found in the deeper parts of the excavations along with horse remains. Jass and Bell (2010) reported specimens of this gopher tortoise from a Pleistocene fauna in Cathedral Cave in the North Snake Range, which reinforces the implication that the tortoises from Lehman Cave are likely Pleistocene in age. Presence of the horse tooth at the same depth and less than ½ meter away from the tortoise bones even further suggests the bones from that depth are Pleistocene age. Thus, available literature indicates that the fauna recovered from Lehman Cave probably ranges from Late Pleistocene to the present and that the deposits are stratified sufficiently to produce chronologically controlled sampling. Materials resulting from the Rozaire excavations are stored at the Western Archeological and Conservation Center (WACC), in Tucson, Arizona (Bell 2015).

Alan Ziegler of the Museum of Vertebrate Zoology at the University of California at Berkeley identified 483 animal bones to genus or lower and 118 bones to phylum or lower. In total almost 30 species were identified (Rozaire 1964). Animal bones found during both the 1938 and 1963 expeditions are listed below, in order of predominance, with the species no longer found near the cave in red italics.

- Jackrabbit
- Marmot
- *Tortoise*
- Cottontail rabbit
- Bushy-tailed woodrat
- Ground squirrel
- Coyote
- Hoofed animals (Artiodactyl)
- Bobcat
- Dog
- Red fox
- *Marten*
- Bat
- Kit fox
- Pocket gopher
- Horse
- Pronghorn
- Snake (medium to large)
- Deer
- Mountain sheep
- Badger
- *Pygmy rabbit*
- Grouse or prairie chicken
- *Northern pocket gopher*
- Chipmunk
- Bird (very small)
- Very large mammal (cow, horse)
- *Toad*

A letter from Jim Mead in 1980 indicated that he had identified bones in the Lost River Passage as marmot, chipmunk, and mountain rabbit. Dr. Gorden Bell returned to this area with park staff in 2013. Throughout the length of the passage they found "discrete but slightly scattered piles of small reddish rodent bones, mostly *Peromyscus* sp. The sediments in the tunnel are mostly clay with sandy particles and occasional clusters or associations of white chalky marmot bones (Figure 29). This is usually characteristic of advanced age, as bones lose collagen and become soft over extended periods of time. At one location we recovered a portion of a partially articulated marmot skull. At another location we recovered a thin flashing of travertine deposited on top of the sediment that also contained fragments of chalky white bone. The combination of soft white bone condition and a flashing of travertine capping the sediment strongly suggests that the bones in the sediment are very old and possibly of Pleistocene age. The age could be accurately determined using U-Th dating techniques" (Bell 2015).

Bell (2015) also notes the Inscription Room as a location in the cave that would be ideal for doing a test pit for looking for fossil or sub-fossil bones.

Figure 29. Bones in the Lost River passage of Lehman Caves. Some of the bones in this passage are thought to be of Pleistocene age. Mouse and marmot bones are prevalent.

2.9 Cultural Resources

Prehistoric

Little is known about prehistoric use of Lehman Caves.

In 1937, funds became available to build an entrance tunnel into the cave. NPS work crews began digging in the natural entrance room and found three human skulls and other human and animal bones. These were sent to the Smithsonian for identification. In 1938, the NPS consulted with M. R. Harrington, Curator of the Southwest Museum, who recommended the hiring of S. M. Wheeler as archeological Foreman. Wheeler and an assistant conducted a small excavation and collected the bones that were being found during the tunnel construction, which included 95 human bones (Wheeler 1938, Rozaire 1964).

In 1963 the Nevada State Museum negotiated a contract with the NPS to excavate the original entry room of the cave under the care of Dr. Charles Rozaire, Curator of Archeology at the Museum. From September 22 to October 8, 1963, 19 pits were dug, covering about 30% of the soil surface of the room. The lowest deposits were fluvial and encompassed the animal bones (see section 2.10 Paleontology), as well as some human bones. Upper windblown deposits discovered 18 hearths, 10 artifacts and 65 pieces of human bone.

A study of the human remains concluded that they represented a maximum of 21 individuals. Based on all the evidence, including anthropometric, archeological, and environmental, these human bones were not representative of a single population. They were found associated with strata of different time periods and may even represent different cultures. Rozaire notes that it is interesting that none of the individuals who ended up in the cave had any artifactual associations (Rozaire 1964). No evidence of a primary burial was found, as shown by the lack of frequencies of ribs, vertebrae, and hand and foot bones (Brooks and Brooks 1964). Further research indicated that the human remains appear to date from about AD 1100-1930 (McManamon 1998).

Prehistoric artifacts found included a few wood fragments representing a bow and projectile shafts, stone flakes, hammer stones, and hearths. The hearths were basin-shaped and not very regular in outline. No artifacts, cultural debris, or other features were associated with any of them, thus they were probably used for light or heat. No drawings or ceremonial objects were found in the cave (Rozaire 1964).

In 1998, the remains removed from the cave were repatriated according to provisions of the Native American Graves Protection and Repatriation Act (NAGPRA), 43 CFR 10.9 (e). A detailed assessment of the human remains was made by NPS staff in consultation with the Confederated Tribes of the Goshute Reservation, Duckwater Shoshone Tribe of the Duckwater Reservation, Ely Shoshone Tribe of Nevada, Kaibab Band of Paiute Indians, and Skull Valley Band of Goshute Indians (McManamon 1998). A wall in the entrance area was built around the remains, sealing them from disturbance.

Ethnography

Different tribes have various stories about caves. During a 1999 meeting at Lehman Caves, Clifford Jakes of the Southern Paiute told of the little people who used Lehman Caves, retreating in there at night. He explained how you can hear them whistle or howl at night, and how they can turn into a tree, rock, or anything in an instant (Meeting Notes 1999).

In 2016 consultation with the Shoshone Tribes, elders provided information to share with people (park service) to provide a "broader cultural presentation about the indigenous peoples of the region." In their words, "The goal is to make people (park service) aware that *Newe* [Shoshone] have a connection to caves and places that is a continuum from the time of creation to the present which encompasses spiritual, cultural and historic elements. Newean relationship, interaction and connection to caves is ongoing. Each is different in its use, i.e. animals, little people, doctoring, refuge for the people, places to acquire doctoring and/or songs, burials, caches, women's place during their moon."

They further request "When approaching a cave the behavior is the same: Give acknowledgement to the cave, humbly and respectfully give prayer and offering and provide explanation the purpose of being there. One never assumes the right to enter without prayer and offering." The public should be made aware that Lehman Cave is a burial cave and ask that the public show respect and honor the ancestors.

Historic

Many historic elements are present in Lehman Caves, including:

- Historic cave inscriptions, dating back to 1885
- Historic cave infrastructure
    - Wooden staircase near natural entrance
    - Panama Canal (1921)
    - Historic trail segments
    - Entrance tunnel (1938-1939)
- Historic artifacts, such as old candles, nails (Figure 30), and coins found throughout the cave

No systematic survey has been done for historic resources in the cave except for cave inscriptions, which researcher David Harwood began in 2005 and has continued since then. He has found about 2,200 cave signatures, initials, and messages in the cave. The earliest were done with charcoal, graphite pencil, and soot from a candle or carbide lamp (Harwood 2015). The oldest inscriptions date back to 1885. One very large inscription on "The Billboard" in the Talus Room is 'Southern Utah Times,' a newspaper published in Frisco, Utah in the 1880s (Steel 1962b).

Figure 30. Nails found in Lehman Caves during a restoration camp.

The wooden staircase near the natural entrance is shown on most cave tours. It appears to be deteriorating in the damp environment, with two steps nearly broken through. A portion of the entrance staircase was removed and preserved in the park museum collection. Many other wooden staircases have been removed from the cave.

The Panama Canal bypasses Fat Man's Misery, a belly crawl into the Inscription Room (called the Skating Ring in early days). The *Ely Record* mentions its existence in 1921 and 1922. However, the

CCC often gets credit for building it in 1934-35 (Trexler 1966). This was one of the largest infrastructure projects in the early cave history (see more in section 2.3 Development of Trails).

The Entrance Tunnel was created in 1937-1939. Sections of historic cave trail can still be seen in some spots, such as the step carved into the flowstone that leads to the Crystal Palace, now seen from the stairs leading up into the Lodge Room.

Many historic artifacts were found during the 1963 Rozaire expedition. These included 117 nails, 52 matches, 44 glass fragments, three bottles, three buttons, two cartridge shells and 16 miscellaneous items (Rozaire 1964). Historic artifacts found in the cave nowadays are found during the Lint and Restoration camps. These camps take place near the cave trails, which is where most of the artifacts have been deposited. With many layers of cave trails, the most common find is nails used for staircase construction.

2.10 Biology

Over 100 species of plants and animals have been found in Lehman Caves (Appendix E; Desert Research Institute 1968, Stark 1969, Taylor et al. 2008). Several are endemic to the South Snake Range.

Bats

The first recorded observations of bats in Lehman Caves are from superintendent reports from the 1930s. Most bat observations occur in the natural entrance area, but there are records of bats using other parts of the cave including the Cypress Swamp, Civil Defense Room, and Talus Room. Bat use has been documented in Lehman Caves for an extended period from mid-April to November with the heaviest use during the summer months. Bats also use the cave during the winter months (January-February). Three bat species of management concern have been recorded from Lehman Caves: Townsend's big-eared bat (*Corynorhinus townsendii*), long-legged myotis (*Myotis volans*) and silver-haired bat (*Lasionycteris noctivagans*), with one anecdotal report of a spotted bat (*Euderma maculatum*).

Only three bats were captured during mist net surveys in 1946. In the 1950s, Superintendent's Reports again indicated sporadic bat use of Lehman Caves, although in February 1952, it was noted that bats were hibernating on the roof of the entrance tunnel. The natural entrance of Lehman Caves was sealed shut in 1959 and remained closed for almost 40 years. In 1998, a bat gate was installed to allow natural debris, bats, and other wildlife to enter the cave.

More bat research has been conducted in Lehman Caves recently. In 2014, exit counts documented up to 75 bats in one night exiting the cave through the natural entrance. Thirty-four bats were captured with mist nets in August of that year – two long-legged myotis and 32 Townsend's big-eared bats. Many of these bats were juveniles and lactating females, suggesting that Lehman Caves is being used as a maternity roost. Acoustic surveys revealed two additional species – hoary bat and Mexican free-tailed bat – foraging near the cave entrance (Horner and Hamilton 2014).

In 2015, a Passive Integrated Transponder (PIT) tag reader was installed at the natural entrance of Lehman Caves. This device records the unique identification number of bats that were implanted with a PIT tag as they enter and exit the cave. This data will allow park staff to better understand survival, seasonal activity patterns, and timing of movements to and from Lehman Caves.

<u>White-nose Syndrome</u>

First detected in 2006, white-nose syndrome (WNS) is a devastating disease that affects hibernating bats and causes widespread mortality at bat hibernacula. Models predict WNS spreading to White Pine County, NV and GRBA by 2021 (Maher et al. 2012; Ihlo 2013). Currently, three bat species affected by WNS, or the fungus that causes it, occur in the park: little brown bat (*Myotis lucifugus*), big brown bat (*Eptesicus fuscus*), and silver-haired bat (*Lasionycteris noctivagans*).

Invertebrates

<u>History of Monitoring</u>

Numerous invertebrates have been found in Lehman Caves. A complete listing is found in Appendix E. Although some mention was made of creatures in the cave during trip reports, the first systematic study of cave biology wasn't done until the 1960s by the Desert Research Institute (DRI). These studies included identifying vertebrates, invertebrates, algae, mosses, protozoans, cave climate, and more. DRI recommended that the entrance tunnel doors be made double, that the proposed exit tunnel also have double doors, and that an opening be made in the plastic dome over the original entrance (Desert Research Institute 1968). After those studies, very little was done with regards to cave biota until 2006, when a cave bioinventory was funded by the National Park Service.

Contracted cave biologists came to the park to conduct the study, which included training park staff. Fifteen paired stations were set up throughout Lehman Caves, with one station on-trail and one station off-trail. Bait was applied to a rock at the station, and then the station was revisited 24 hours later to assess what had been attracted to within one-meter of the station. In addition, microhabitat data was collected during each assessment. This study was repeated by park staff monthly for the next year. Results showed that most specimens were found near the entrance, which is also the same area as highest visitation in the cave. The sampling periods with the highest number of specimens was September though January. White and grey springtails dominated the overall number of specimens counted. While grey springtails were more common closer to the entrance, white springtails increased in abundance when more than 600 ft. (200 m) from the nearest entrance, indicating they may be more cave adapted. There was no clear trend in proximity to trail except for the pseudoscorpion *Microcreagris grandis* and millipede *Nevadesmus ophimontis,* which were both notably more abundant far from the trail than near it (Taylor et al. 2008).

Park staff have continued the Lehman Caves biomonitoring study, changing the frequency to quarterly. Data are currently being analyzed to submit a paper to a peer-reviewed journal. Preliminary data indicate over two thousand specimens have been counted. The stations with the most individuals varied in distance from entrance. Areas with lower visitation had over fifty percent of the biota counted. Usually at least one millipede and one pseudoscorpion are seen on each trip. Some of the cave biota have very low detection probabilities, with a symphyla seen on the 17th trip and a new cave fly on the 24th trip. The quarterly biomonitoring serves as a good way to do an overall assessment of cave conditions as well as introduce park staff to off-trail areas of the cave.

Cave Biota

Springtails (Collembola) are an extremely important part of the cave ecosystem. They may be the most numerous arthropod, and their tiny size means they are prey. At least eight species are present in the cave (Taylor et al. 2008). The most common colors are white, grey, and pink. Presumably the white springtails are the most cave adapted.

Probably the most iconic creature in Lehman Caves is the Lehman Caves Pseudoscorpion - *Microcreagris grandis* (Figure 31). It was discovered in the 1930s by Park Custodian T.O. Thatcher, but it wasn’t until identified until 1962 by Dr. W. B. Muchmore (Muchmore 1962). Males and females have different appearances, with the females lighter in color. Pseudoscorpions molt numerous times over their lifetime. They appear to be found most commonly in the parts of the cave closer to the Natural Entrance, but they have been spotted in the Talus Room and Gypsum Annex. Some searching has been done for them outside the natural cave entrance, but to date they have not been found on the surface.

Figure 31. A *Microcreagris grandis* pseudoscorpion was first found in Lehman Caves and is endemic to the mountain range.

They are also found in other caves in the park, including high elevation caves (Taylor et al. 2008). However, they have not been found in caves in the northern Snake Range or the Schell Creek Range (Gilleland 2012).

Figure 32. This 0.5-cm long millipede, *Nevadesmus ophimontis*, is found in Lehman and other nearby caves but nowhere else in the world.

Several other invertebrate species new to science have been found in Lehman Caves. In 2006, a new genus of millipede was identified from Lehman Caves, as well as several nearby caves, *Nevadesmus ophimontis* Shear (Figure 32). This tiny, all-white millipede was first found in the cave near the Queen's Bathtub adjacent to the trail (Shear 2009). Flies (order Diptera) can be numerous in the cave. In some locations, dead flies have been covered with calcite and are now part of cave formations. In 2010, a fly was collected under the natural entrance and it was discovered to be a new species, *Megaselia necpleuralis* (Disney et al. 2011).

Other invertebrates are also seen in the cave. Cave crickets of the genus *Ceuthophilus* are occasionally spotted in the entrance and exit tunnels and near the natural entrance area. Various beetles and spiders are also seen near the entrances.

The artificial lights in the cave provide an unnatural habitat for cave biota. This habitat can elevate numbers of cave biota in some places. Stark (1969) found Collembola (springtails) at 30.5% of the 200 lights studied, and an oligochaete worm at 10% of the lights. Recent biomonitoring finds springtails always on an algae-covered rock next to a light by the Queen's Bathtub.

Other Vertebrates

Paleontological records show over 30 species of animals in the cave (see section 2.10 Paleontology). However, some of those animals were most likely dead before they entered the cave. Vertebrates besides bats that use the cave on a regular or semi-regular basis include woodrats, mice, chipmunks, and lizards.

Numerous woodrat middens are found throughout Lehman Cave. These are nests made of sticks, dirt, and whatever debris a woodrat has brought to it. The woodrats urinate on the midden, making it stick together. These middens are passed down from generation to generation, and some are found in the Great Basin that are thousands of years old and very useful for climate studies.

Two species of woodrats live in Nevada, the bushy-tailed woodrat (*Neotoma cinerea*) and the desert woodrat (*Neotoma lepida*). The bushy-tailed woodrat's habitat is in caves and rocky areas from pinyon-juniper to alpine areas. The desert woodrat's habitat is rocky outcrops and cliffs from arid shrublands to pinyon-juniper. Both of these species appear to be declining (Rickart et al. 2008). The restriction on the Natural Entrance from 1885 to 1998 likely limited woodrat access to Lehman Caves. Middens found in the cave do not have any sign of recent occupation.

In 1968, a mammal survey was conducted in Lehman Caves. From June 27-30, three deer mice (*Peromyscus maniculatus*) were caught in Sherman live-traps. From November 28-30, eleven rodents were captured, including three deer mice and eight cliff chipmunks (*Eutamias dorsalis*), all in the Natural Entrance and Gothic Palace areas (Ralston 1968).

Reports of occasional mice and voles are received from cave interpreters nearly every year. The rodents tend to be found in the Gothic Palace area.

Microbes

Very little is known about microbes in Lehman Caves. They are often overlooked because of their small size, but microbes in caves are known to have an important role in recycling nutrients, decomposition, geomicrobiology, and primary productivity. Microorganisms are extremely diverse and include bacteria, archaea, fungi, single-celled protozoa and algae. Microorganisms are known to interact with geologic processes, and they play important roles in the formation of some secondary minerals in caves, including moonmilk, helictites, and cave pearls (Baker et al. 2015).

The orange ceiling in the Inscription Room is due to colonies of microorganisms, but little is known about them.

Plants, Lichens, Mosses, Fungi

The overwhelming number of plants, lichens, and mosses are found at or near the artificial lights in the cave. Stark (1969) found 77.5% of the 200 lights studied contained algae, 20.5% had mosses, and 75% had evidence of fungi.

2.11 Cave climate

Temperature and humidity

Cave climate generally fluctuates greatly near the cave entrance and becomes stable farther in the cave (Figure 33).

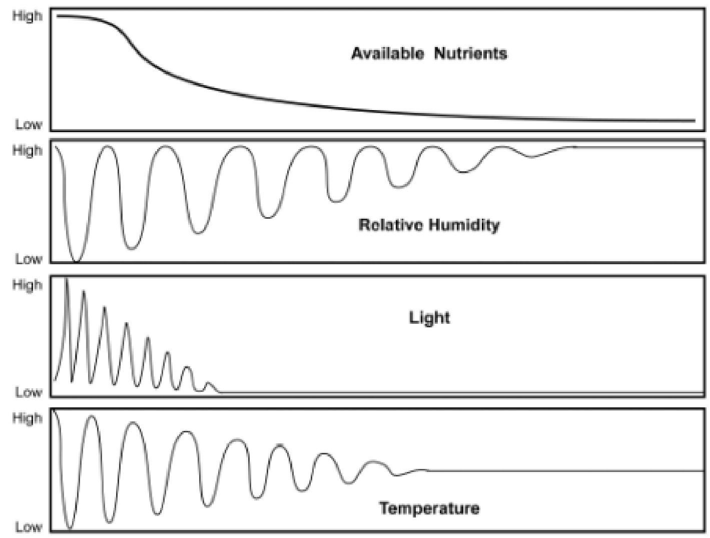

Figure 33. Graphs of how available nutrients, relative humidity, light, and temperature tend to stabilize once away from the entrance area.

A weather station was established outside Lehman Caves in October 1937[1], but the first climate studies in the cave weren't done until 1958 by the National Speleological Society (NSS). These did not provide reliable data and were abandoned in 1960 (Trexler 1966).

In 1962, Keith Trexler conducted a two-year cave atmosphere study (Figure 34). From July 1, 1962 to November 6, 1964, he found an average temperature throughout the cave of 50°F (range 41°-53°F), in the Gothic Palace an average of 48.5°F (range 41°-53°F), and in the Talus Room an average of 50.6°F (range 50°-53°F). The average relative humidity was 89.9% throughout the cave, with 85.2% at the Gothic Palace and 94.7% in the Talus Room, with no obvious seasonal variation in the last room (Trexler 1967).

Figure 34. Keith Trexler measuring cave temperature in Lehman Caves in the early 1960s.

Trexler noted that water had been added to the Cypress Swamp, Lake Como (Lake Room), and Sunken Garden regularly since 1961. Water was also used often to clean the cave trails and for various construction and maintenance projects. This additional water increased relative humidity at Lake Como from 78% when dry to 93-97% when full (Trexler 1966).

From 2006-2010, six temperature dataloggers were placed throughout Lehman Caves (Natural Entrance, Queen's Bathtub, Cypress Swamp, Talus Room, Behman Annex, and West Room) and monitored and analyzed. The dataloggers logged between five

[1] Monthly temperature and precipitation data from outside Lehman Caves from 1937 to present is available at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nv4514

months (Behman Annex) and 43 months (Queen's Bathtub) of complete data. The average temperature was 11.1°C (52.0°F).

During this time interval, the monthly mean temperature varied 1.5°C (Figure 35). Minor variations in temperature were found by location, depth in the cave, and year. For example, the Natural Entrance and Queen's Bathtub data varied the most, and these are also closest to the surface. Some datalogger locations reflected outside mean air temperatures better than others. Surprisingly, none of the dataloggers showed a steady correlation with outside seasonal mean temperatures, including a datalogger just below the natural cave entrance. Cave temperatures were found to be consistently warmer than the mean annual outside temperature by 1-4°C. No obvious differences were found in monthly mean temperatures at datalogger locations near vs. far from the tourist trail, nor between high season and low season months. Due to the muted effect of surface air temperature on cave temperature, much of the daily and seasonal fluctuation of the surface data is reduced. Thus, environmental conditions in caves may potentially be used to track rising temperatures associated with climate change (Baker 2011).

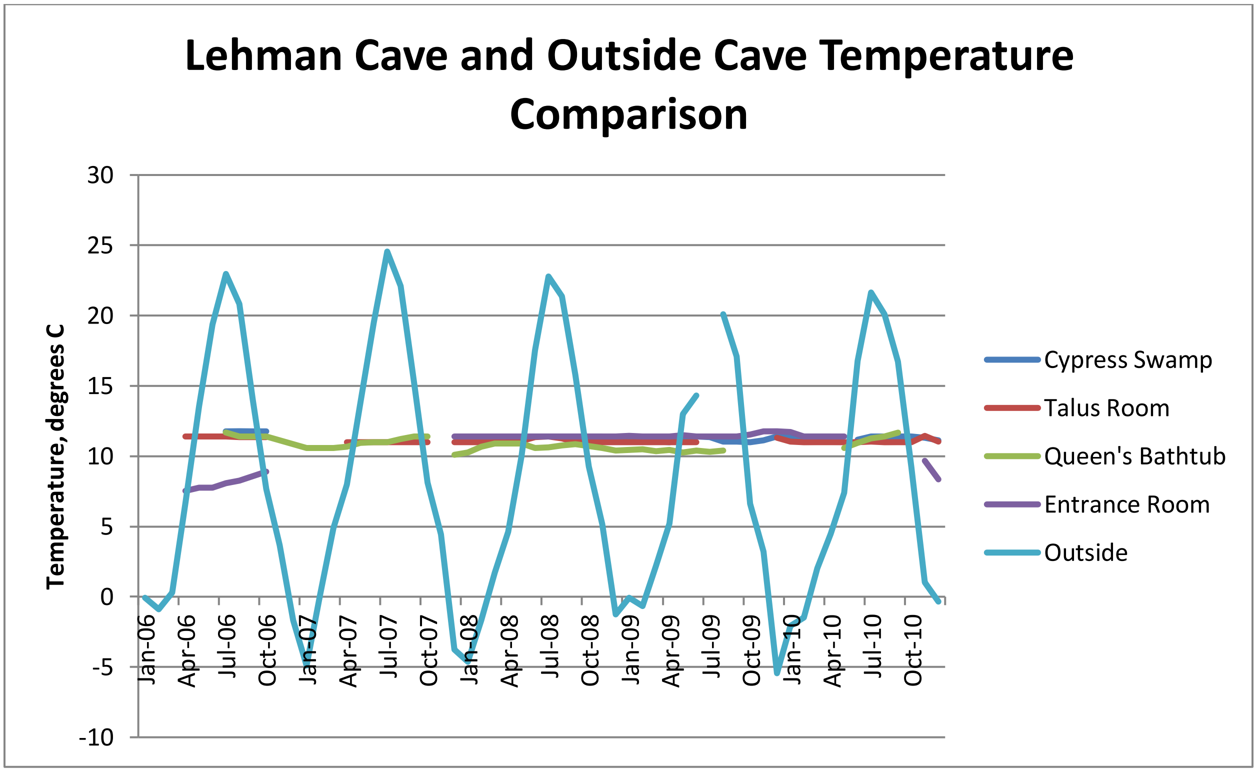

Figure 35. Comparison of temperature in Lehman Caves in various locations with the outside temperature, 2006-2010.

Microhabitat data was measured during each of the quarterly biomonitoring surveys from October 2006 to October 2016, using a digital pocket thermometer and an Extech Precision Psychrometer RH390. Soil temperature readings were the most stable, with an overall average of 52°F. The average air temperature at these sites over the ten years was 52.7°C, and relative humidity was 77.6% (Table 6).

Table 5. Summary of microhabitat data collected quarterly from October 2006 to October 2016.

Location	# Times Measured	Identifier	Average Soil Temperature (deg F)	Average Air Temperature (deg F)	Average Relative Humidity (%)
A	47	Trail under Natural Entrance	49.0	49.8	64.2
B	47	Civil Defense Passage	49.9	50.8	70.6
C	47	Bottom of Lodge Room Stairs	51.9	52.4	78.6
D	47	Queen's Bathtub	52.4	53.0	80.5
E	47	Inscription Room	53.4	54.1	81.0
F	47	Cypress Swamp	53.2	54.0	81.2
G	47	Near Exit Tunnel	52.3	53.3	80.4
H	22	Natural Entrance-Original	49.3	49.7	72.6
I	47	West Room	53.0	53.8	81.2
J	47	Talus Room - Middle	53.4	54.2	80.4
K	12	Gypsum Annex	52.8	53.6	84.2
L	45	Talus Room North	53.4	54.3	81.8
M	47	Behman Annex	52.9	53.4	81.7
N	47	Sunken Garden	53.3	53.7	81.2
O	47	near Lost River Passage	49.4	50.1	72.4
Z	25	Natural Entrance-Replacement	50.5	50.9	68.5
AVERAGE		Throughout Cave	52.0	52.7	77.6

Airflow

Airflow has been of interest for many decades, as one often feels a breeze in some passages in the cave. Air circulation generally depends on the number of entrances, the general shape of the cave, the presence of a stream and sometimes on the barometric pressure (Cigna 2004).

Trexler also looked at air currents in the cave, and noted that during the summer of 1962, when some nonskid surfacing was applied to the cave trail near Lake Como, dense smoke was produced which quickly filled nearby cave passages. Within an hour, the smoke was present in all parts of the cave except the Talus Room. Within four hours, all smoke cleared from the cave (Trexler 1967). In 1968, a study conducted from June to December showed that the predominant direction of air movement in the cave was toward the entrance in summer and early fall. In the middle of October it reversed (Bamberg 1973). In 2000, Jon Jasper took measurements of airflow in the cave with an anemometer and made a map of airflow movements, showing air moving from the natural entrance back into the cave. In addition, airflow was found to come from the Behman Annex into the Talus Room (Jasper 2000).

Radon

In 1976, radon levels in caves were being mentioned as something that could be a human health risk. Dr. Keith Yarborough from the Southwest Regional Office took measurements January 6-8, 1976 and again in August 1976, finding much higher readings in August. As a result, weekly radon testing in the cave was prescribed (Yarborough 1977).

Beginning in December of 1977 until January of 1979, the EPA tested Lehman Cave for radon and found that the average working level was 0.7995 pCi/l (picocuries per liter). This was much lower than the Environmental Protection Agency (EPA) action level of 4 pCi/l. Additional sampling was conducted with an active sampler from 1996-2001 and from 2002-2002 with a passive sampler. The ambient radon levels in the cave during these studies appear to average slightly lower than the 1970s (Roberts, unpublished report 2005).

As quoted from an Occupational Safety and Health Administration (OSHA) Standard Interpretations letter dated August 16, 1989, "If environmental radon-222 concentrations have not been artificially enhanced, they are very much lower than the permissible exposure limit (PEL). Accordingly, only artificially enhanced concentrations of environmental radon-222 would be sufficiently high that provisions of 29 CFR 1910.1096 would go into effect." These two items seem to indicate that there is no need to continue monitoring radon levels in Lehman Cave to meet EPA or OSHA standards (Roberts, unpublished report 2005).

Other cave atmosphere

In 1968 and 1972, carbon dioxide concentrations of the air were monitored with an infrared gas analyzer in the Gothic Palace. In addition, air samples were collected throughout the caves in large plastic bags and analyzed for CO_2 content. CO_2 was generally highest in June-July at 1040 ppm and decreased to December to 390 ppm. The lowest concentrations were found near the entrance, with concentrations increasing towards the Talus Room. Air flow into the cave decreased the CO_2 concentrations. It was also noted that the cave dried out during this time, so less CO_2 would be released from water dripping off speleothems (Bamberg 1973).

2.12 Research

Research has been conducted at Lehman Caves for decades in various fields (Figure 36). Currently research in Lehman Caves is administered via an NPS Scientific Research and Collecting Permit. The application process is online, at https://irma.nps.gov/rprs/. Information from past studies can also be found at the same site by searching Investigator Annual Reports. An annotated bibliography of research from Lehman Caves is found in Appendix F.

Figure 36. Some research in Lehman Caves has focused on dating speleothems and learning more about wet and dry periods.

2.13 Maintenance

Cleaning

Cleaning the cave has long been recognized as a necessary task. The definition of cleaning has changed over the years. In addition, techniques have changed in order to have less impact on the cave.

In 1933-34, Civil Works Administration (CWA) workers helped to clean the cave and repair stairs and trails (Trexler 1966). In December 1934, several hundred feet of lumber and four gunny sacks of tin cans were removed from the cave. The Wishing Well was also cleaned out, both by a desert woodrat and park staff, who recovered more than 700 objects (Supt Rept 1936).

In 1934, Otto Nielson, Custodian, cleaned smudge marks and initials in some of the rooms near the cave entrance. He remarked that farther in, "the deposits of calcium had covered the marks so they could not be erased without scratching the rock, which could leave a mark almost as bad as the ones that are there now." The possibility of using thick paint to cover marks was going to be experimented with, "especially for the ceiling of the room in the caves that is so badly marked" (Doerner 1935). It appears that with the administration of the cave by the NPS, leaving graffiti was no longer encouraged. A Superintendent's Report notes, "The recent visitors to the caves have shown unusual thoughtfulness and understanding concerning defacing or marking up the interior, and no such offenses have been noted" (September 1938). Not everyone was courteous, though, and five arrests were made for defacing natural features in the caves. A different group was apprehended smoking marks on one of the cave formations and was made to clean up the mess (Jan/Feb 1939). Signatures are found in the cave through the 1950s, but in reduced numbers than in the early years.

The March 1964 Superintendent's Report stated, "The cave trail was thoroughly scrubbed to remove the dust and compacted dirt caused by natural seepage, normal trail use and by winter maintenance activities. Unnatural dust was carefully washed from many of the cave formations" (Jacobsen 1964b).

The primary maintenance in the cave has been the upkeep of the infrastructure, including the trails, stairs, platforms, and electrical systems (See sections 2.3 and 2.4 for more on trails and other infrastructure). This maintenance has been done by reinforcing and installing safer equipment and by maintaining these items in as clean a condition as possible.

A 1979 Superintendent's Annual Report notes that the "cave trail is inspected daily to insure against slippery spots and faulty lighting (Moore 1980). In 1984, the cave trail was inspected twice weekly and light bulbs replaced as needed and water accumulations removed from the trail (Hendricks 1985). There were also reports that the entire cave trail was washed and scrubbed in June 1973, June 1974, and fall 1982 (Robinson 1974, Moore 1975, Hendricks 1983). Beginning in 1998, a routine cleaning program was implemented in the cave, with the maintenance division sweeping trails and removing trash on an as-needed basis (Mills 1999).

At present, maintenance changes lightbulbs in the cave as needed.

Lint Camps
Lint camps began in 1997 to remove decades worth of lint that had fallen off people's clothing and drifted onto the cave surfaces (Figure 37). Lint is undesirable because it provides an artificial food source for cave biota, can change the deposition of speleothems, and mars the aesthetics of the cave (Horrocks and Ohms 2006). Lint cobwebs that draped from one stalactite to another in the Gothic Palace made Ronal Kerbo, the NPS national cave and karst program chief, to comment that Lehman Caves was the dirtiest cave he had ever seen. Scaffolding was erected in the Gothic Palace and cavers scampered up high to remove the offending lint.

Figure 37. Lint and debris are inadvertently brought into the cave by visitors. The lint accumulates on cave formations, providing an artificial food source, changing the cave geology by encouraging dissolution, and altering the aesthetic of the cave.

As of March 2017, over 13 additional lint camps have been held in the cave. They have cleaned nearly all the sections of passageway on the cave tour at least once (Figure 38). Because lint is continually being deposited as long as people enter the cave, lint will continue to need to be removed. Reducing the amount of lint that enters the cave would greatly assist in preserving the cave.

Figure 38. Annual lint and restoration camps are held to clean the cave. Volunteers come from several states.

Restoration
In 2003, wooden platforms from the Civil Defense Room were removed (Figure 39). Broken speleothems that had been stored there were transferred to the park museum. Restoration of the Talus Room section of the cave is covered in Section 2.4, Trails.

Figure 39. Flooring in the Civil Defense Passage of Lehman Caves was removed in 2003.

Much restoration is needed for past lighting systems. Many cables were applied with grout to speleothems, and removing the grout in the wrong manner can damage the speleothems (Figure 40). Numerous areas of the cave show damage due to the past lighting systems, and these should be restored.

Restoration of broken speleothems has taken place. Speleothems in the West Room and Talus Room appear to have been "fixed" by the crews who made the tour route in 1960-61. Oral history refers to "Merlinites," or speleothems that Merlin Terry, a park maintenance worker, fixed. Many of these fixes are rather crude, with grout applied liberally (Figure 40). In the early 2000s, Jim Werker and Val Hildreth-Werker came to the cave and taught park staff how to repair speleothems. Several speleothems were repaired using more current methods (Werker and Hildreth-Werker 2006). A map has been made of speleothems that have been repaired and those that need to be repaired.

Figure 40. Old lighting systems damaged cave formations and applied excessive grout that is now peeling away.

2.14 Administration of Lehman Caves

Soon after discovering the cave, Absalom Lehman reportedly built a shanty near the cave, 12 x 14 feet in size with a dirt floor and two windows. There was a barn for two horses and room for loose hay. In approximately 1889 this building burned down, and a log house 30 x 40 feet was constructed (Baker 1961).

In 1891 C. W. Rowland purchased Lehman's lower ranch for $3,000, just a few months before Lehman died from the flu. Lehman's "Cave Ranche," although it was never filed upon, was sold in November 1895 by estate executor W.N. McGill to C.W. Rowland for $700. This "homestead" of 7 acres did not include the caves, but did include the approach to it. (Trexler 1966, Unrau 1990). Rowland improved the road and advertised the caves (Baker 1961). However, he didn't pay taxes on time in 1895 and 1897, losing the cave to the county. He subsequently got the land back by paying the money due. C.W. Rowland died in 1905, and his family took care of the cave until 1911, when P.M. (Doc) Baker and Nettie Baker bought the property (Baker 1961, Trexler 1966).

On February 10, 1909, President William Howard Taft proclaimed the Nevada National Forest, which included much of the Snake Range. In October 1912 the cave and land surrounding the homestead were added to the national forest, which eventually became the Humboldt National Forest (Trexler 1966, Unrau 1990). A sign at the cave entrance informed visitors of federal laws prohibiting the destruction of natural beauties. However, because access was through Bakers' land, federal supervision was likely almost absent (Trexler 1966).

The Bakers weren't interested in running the cave, so they turned it over to their friend Ernest C. Adams. In 1919 Adams filed on 65 acres covering the cave and adjacent land under a June 11 Forest Entry. When the Homestead Entry patent came, Adams learned that the Government withheld the right to the cave, and he obtained claim to 47.46 acres (Baker 1961, Trexler 1966, Unrau 1990). In 1920, Adams sold his rights to Nathan Kiger, who soon went into partnership with Clarence T. Rhodes and his wife Beatrice. The Rhodes' did extensive advertising and improved on the grounds outside the cave (Baker 1961). In 1918, Kiger sold his interest to the Rhodes' (Baker 1961).
On February 3, 1922, President Warren G. Harding established Lehman Caves National Monument, encompassing 593 acres. This followed efforts by Cada C. Boak, a national director of the Grand Central Highway [U.S. Highway 50] Association. Boak had written, "The caves as a whole far surpass my expectations…they will rank with any of the better known caves in the United States." Boak forwarded his write-up and photographs taken in 1921 by E.W. Blair to the Director of the National Park Service, Stephen T. Mather. Mather thought making Lehman Caves into a National Monument was a good idea, but because the cave was within the Nevada National Forest, he directed the matter to Chief Forester W.B. Greeley of the USFS. After reviewing the report, Greeley approved the application, although reduced it from three square miles to one square mile. The Secretary of Agriculture approved the recommendation, and shortly thereafter the presidential proclamation was signed (Appendix A). The US Forest Service was in charge of supervising operations. They appointed C.T. Rhodes as official custodian. A grand dedication was planned for July 4, which was later delayed to August 6 (Figure 1). An estimated 500 people attended talks, music, flag raising, gun salute, cave tours, and Mrs. Rhodes' food (Trexler 1966).

Because the Forest Service didn't have money to fund a cave caretaker, they gave a permit to T. C. Rhodes which authorized him to act as a caretaker and guide and allowed him to charge for tours in lieu of a salary (Ely Record 1923). In the early
1920s, the Rhodes' built log cabins and a dance

hall with a hard wood floor (Baker 1961). Improvements in the cave included stairways that replaced ladders, cave floor excavation, and the construction of the "Panama Canal" (Trexler 1966).

In April 1923, Nevada legislators designated Lehman Caves and its surroundings as a state recreation ground and game refuge. White Pine County then proclaimed the whole Wheeler Peak area as a county wildlife preserve (Trexler 1966).

In July 1924, Nevada Governor James G. Scrugham visited the area. He proposed a new cave entrance, a bath house, and trails to scenic spots in the mountains. Lehman Caves was currently a national monument and the area in front of the cave private property. That didn't stop him from later that month suggesting the development of a state park. He even provided state funds to build a concrete swimming tank, with construction starting in August. In December, the state obtained the 200 ft. by 150 ft. strip of land near the cave entrance on which the tank had already been built (Trexler 1966).

In 1929, the state offered to return the land deeded to it by the Rhodes' and later gave them a ten-year lease on it (Trexler 1966). In January 1931, the Nevada legislature introduced a bill to sell the land to the Rhodes'. The Rhodes' were trying to sell the land to White Pine County, who purchased it soon after. The state assembly then passed a bill giving the land to the federal government, but because of "present economic conditions," it took two years to accomplish. The deed had the acreage wrong, and it took decades to clear up (Trexler 1966).

In 1933, President Roosevelt issued executive order number 6166, which assigned control over Lehman Caves National Monument to the NPS. Many people, including the White Pine County Commissioners, were not pleased. The USFS had promised many improvements, and they were not certain the Department of Interior would make good on these promises. The NPS did not race to make changes. The first report about the monument came in December 1933, when Landscape Architect Harlan B. Stephanson reported the poor condition of many of the buildings in the monument (Trexler 1966). The first "Park Ranger in Charge," Otto T.W. Nielson, was appointed to Lehman Caves on April 27, 1934. Nielson reported to the Superintendent of Zion National Park. Nielson had to deal with some boundary issues (Figure 41). In 1939, the administrative responsibility for Lehman Caves was transferred from Zion to Boulder Dam National Recreation Area. Regional boundaries were redrawn at this time, removing both areas from Region Four (San Francisco) to Region Three (Santa Fe). Daily radio communications were made until May 1953, when Lehman Caves was given full field area status. This was short-lived, being rescinded in November 1954, and then reinstated on January 1, 1958. Effective January 12, 1960, the monument was transferred back to Region Four (Trexler 1966).

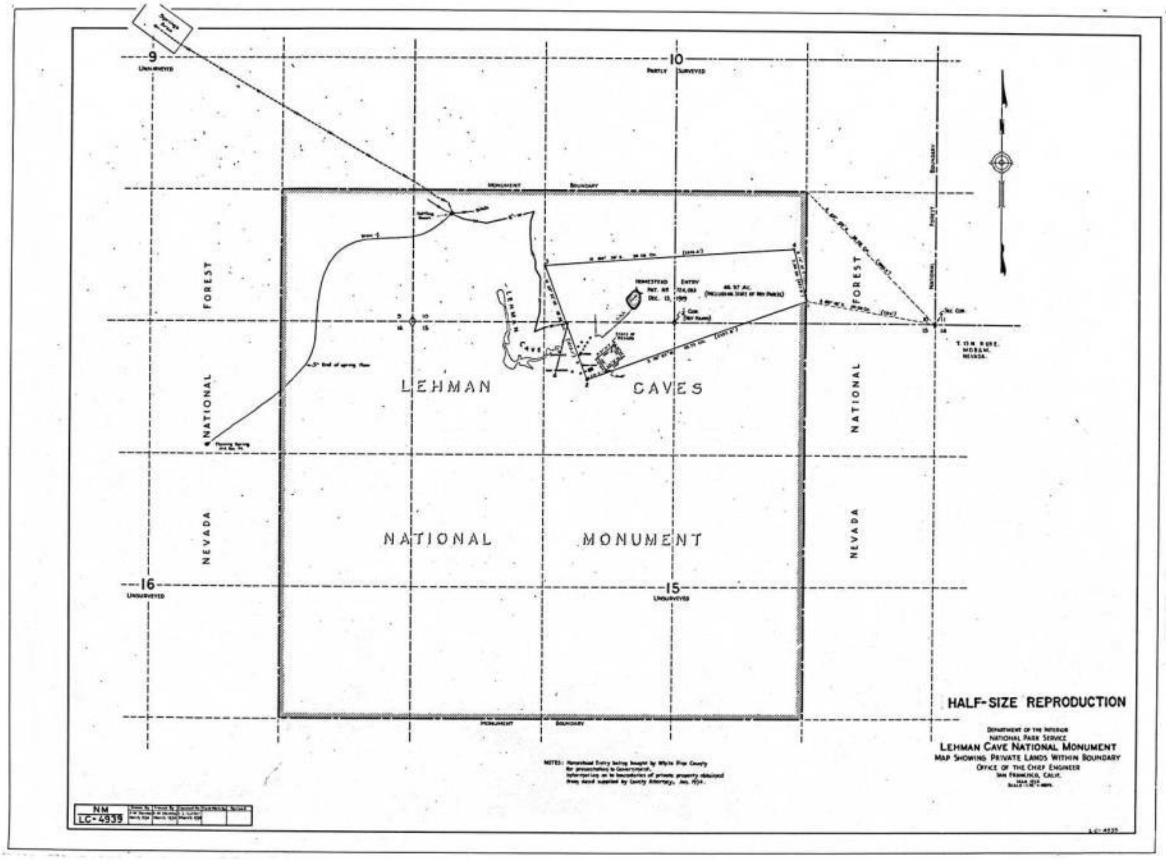

Figure 41. 1936 map of Lehman Caves National Monument and the private land adjacent to the cave.

After World War II, government employees were reduced from a seven-day work week to a five-day work week. By 1948, due to rising costs, the monument was on a five-day week, closed Friday and Saturday. Heavy snows and lack of funds caused the monument to be completely closed for several weeks in 1948, 1949, and 1950 (Trexler 1966). Government shutdowns also closed down Lehman Caves for several weekends in 1981-84, 1986-87, 1990; November 14-18, 1995; December 6, 1995 January 5, 1996; and October 1-16, 2013.

After decades of proposals, on October 27, 1986, Great Basin National Park was established, encompassing the Lehman Caves National Monument and greatly expanding its boundaries (Appendix B).Currently the cave is open every day of the year with the exception of New Year's, Thanksgiving, and Christmas Days.

2.15 Special Uses

Lehman Caves has had some additional uses that have not been listed above, such as use as a movie backdrop, a wedding chapel, a civil defense shelter, and more. These are described briefly below.

Photography

In 1928, Ely photographers John and Mary Walker took numerous photographs throughout the cave, with many of these photos used as postcards. In 2015, they were obtained from the Library of Congress. Dave Bunnell, a professional photographer, revisited the same areas to rephotograph them. A special exhibit comparing changes was on display during the National Speleological Society (NSS) Convention in Ely in July 2016, and then donated to the park (Figure 42).

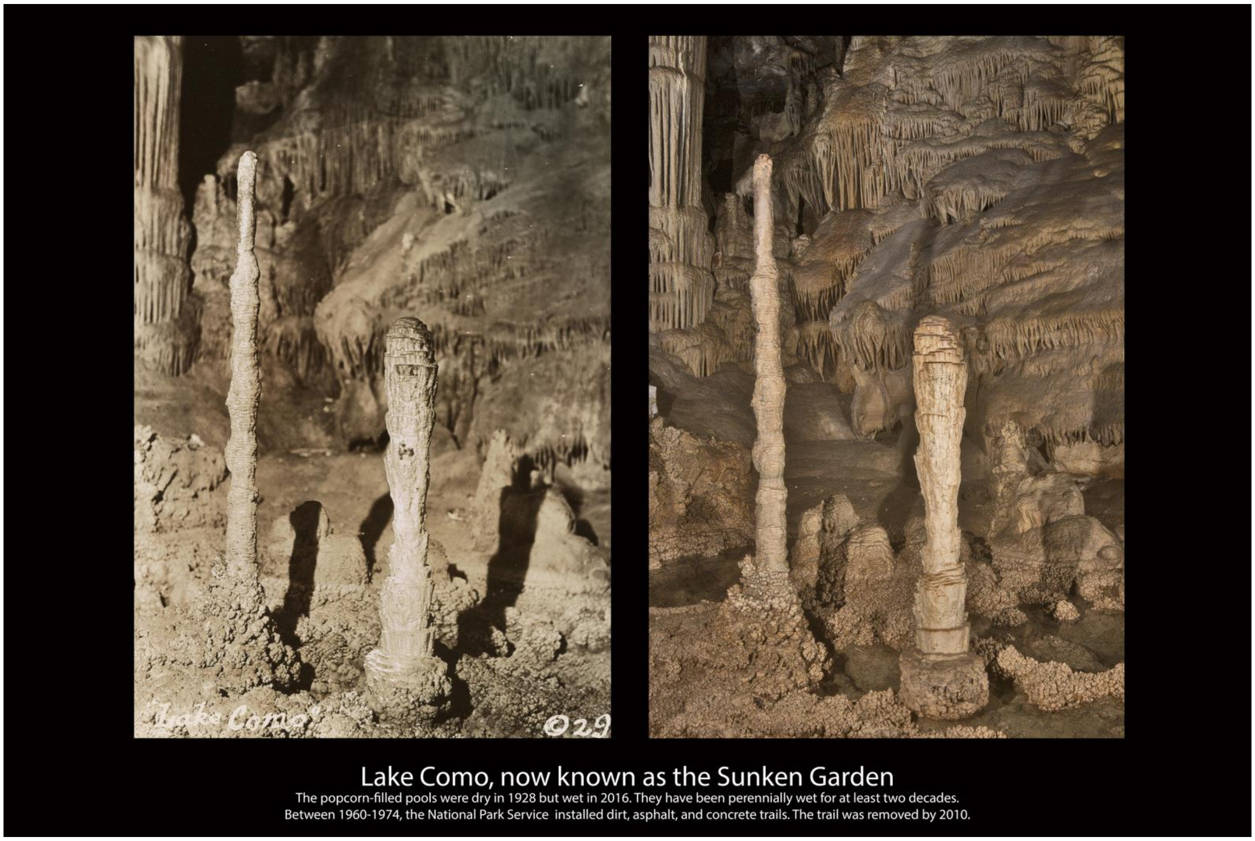

Figure 42. This is one of the areas photographed in 1928 by John and Mary Walker and then in 2016 by Dave Bunnell. The pools in the Sunken Garden were dry in 1928, but not in 2016 or for at least two decades before then. 1928 was the start of the great drought that caused the Dust Bowl.

Photography has continued to be popular in the cave and may be of increasing interest. Special use permits are given for after-hours photography tours. In 2015, 11 permits were issued, an all-time high. The average number of permits from 2007 to 2015 was 5.3 per year (P. Marques email 4 Feb 2016).

The cave was used as a movie backdrop for the 1967 feature *The Wizard of Mars*. Water was pumped into the Lodge Room to make the set look like astronauts were on the surface of Mars (Figure 43).

Weddings and Other Gatherings

Figure 43. Lehman Caves served as a backdrop for the 1967 movie *The Wizard of Mars*.

A few weddings have been held in the cave. The first reported wedding was October 1923, uniting Agnes Miller (Baker, NV) and Robert Wright (Colorado) with Judge McDonald of Ely officiating, performed in the Wedding Chapel. Additional weddings were held in 1925, 1928 or 29, 1947, and 1965 (Trexler 1966). Glen Dearden recalls his parents attending a wedding and his mother saying that the candle light used made it an especially beautiful ceremony (Dearden, pers. comm., 2016).

The Rhodes' promoted the caves as a meeting locale in the early 1920s, with the Lodge Room (perhaps then known as the Convention Room), as the main destination. The Knights of Pythias took advantage of this, as well as the Boy Scouts, Ely Elks, and Lions Club (Trexler 1966). The dance hall and cabins the Rhodes' built outside the cave also encouraged meetings and special events. In 1925, over a thousand people attended Flag Day at Lehman Caves, sponsored by the Ely Elks. Tours went into the cave Friday and Saturday nights with 40 people on each tour (The Ely Record 1925).

Civil Defense Shelter

The Army Corps of Engineers designated about 450 caves as civil defense shelters in the early 1960s, out of 10,000 known caves at the time. Of the designations, 115 were commercial or government-managed caves. Rations were brought into the selected caves, consisting of tinned crackers, 17.5 gallon water cans, sanitation kits, medical supplies, and radiation monitoring devices. Supplies were intended to last two weeks. The NSS, while originally supporting the idea of using caves as fallout shelters, changed their minds as they learned more about the conservation of caves. With many of the caves chosen inadequate due to various factors (subject to flash floods, too small, a stream cave, pit entrance, used as a trash dump, falling ceiling), the NSS spread information to end the use. The project dwindled when Congress rejected President Johnson's request for $460 million more for fallout shelters in 1964 and essentially ended with the growing war in Vietnam in 1965. Supplies were gnawed on by packrats, stolen by vandals, and, in gated caves, gathered dust until removed (Douglas 1996).

Lehman Caves was the only cave designated in the state of Nevada as a civil defense shelter. Fallout shelter signs were installed in front of the visitor center and on the cave door, but removed in June 1964, as they were reported to be highly obtrusive (Jacobsen 1964a). The cave was rated to have a shelter capacity of 3,330 spaces! While other fallout shelters were being discontinued, this program was just beginning. On January 19-20, 1966, White Pine County officials delivered the following supplies to the cave:

- 100 water drums, empty, without polyethylene bag liners; noted that most were rusted, and several severely dented
- 10 SK-IV sanitation kits (complete)
- 50 cartons of 28 lbs. each survival biscuits

- 2 cartons carbohydrate (candy) rations at 74 lbs. per carton
- One medical kit in unusable condition

Keith Trexler, the chief park naturalist who took receipt of these items, recommended that the capacity rating for Lehman Caves be reduced from 3,330 to 500-750 people based on the amount of space in the cave. Additional supplies, including shelter radiation kits, were supposed to be received soon. The items were stored in the Civil Defense Room, off the Rose Trellis Room (Figure 44). All Civil Defense supplies were removed from Lehman Caves as of October 1, 1979. These supplies consisted of rusting steel containers, cereal-based shelter rations, but no medical kits or shelter radiation kits (Moore letter 1979). Local school children tried to sell the discarded rations on the streets of Baker, but reported low sales for the poor-tasting leftovers (C. Baker, pers. comm., 2016).

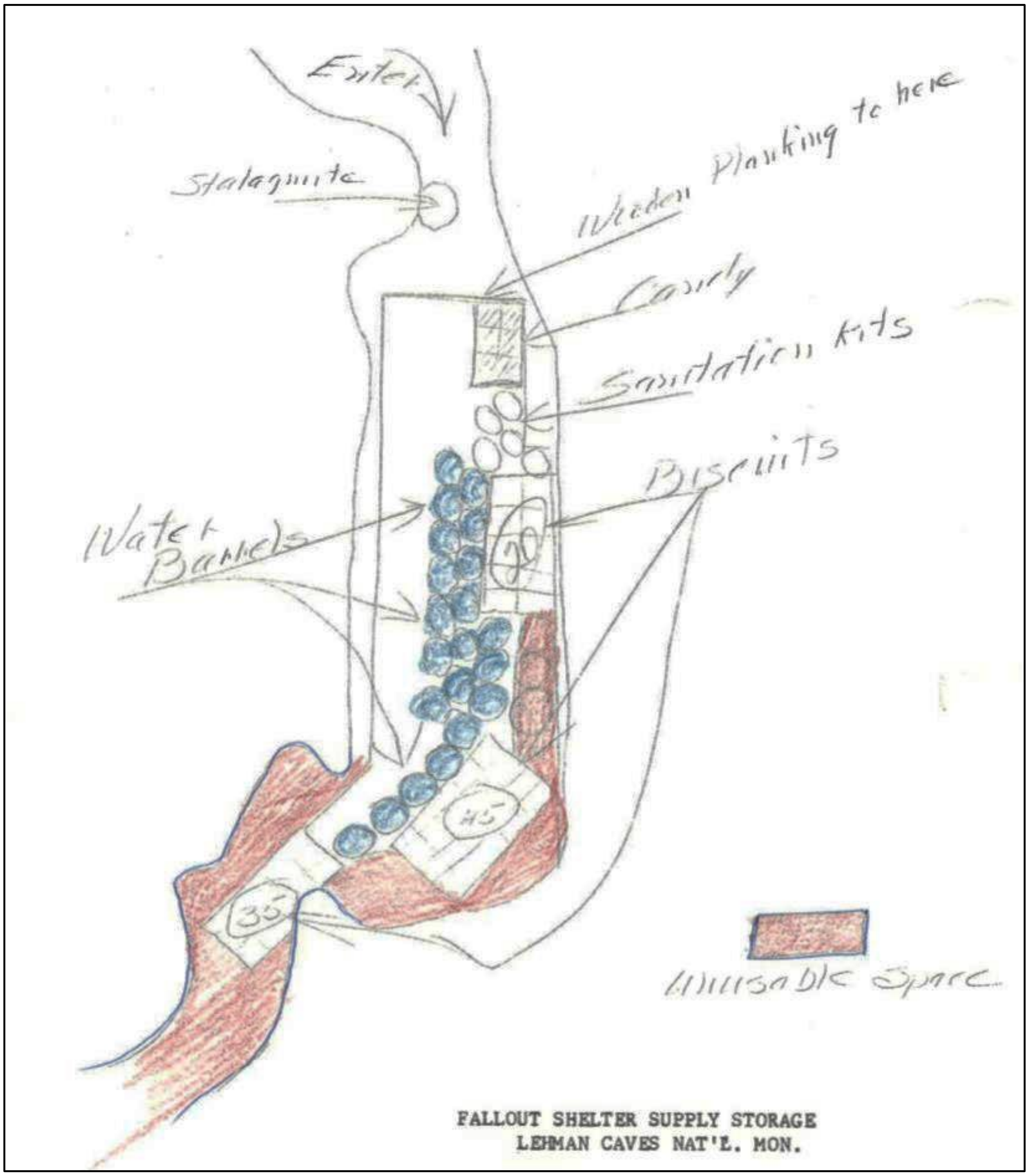

Figure 44. Fallout shelter supply storage in the Civil Defense Room, 1966.

Apparently some supplies were later put into the cave. Maintenance workers Brian Morrison and Glen Dearden recall taking out of the Civil Defense Room five to six, 25-gallon water barrels and several containers of crackers under the direction of Superintendent Al Hendricks. The crackers were stored in the basement of Residence 8 until about 2003.

2.16 Surface Activities

Tree roots seen in the cave are a reminder that the surface and subsurface connect in tangible ways. In addition, the rate of water dripping into the cave from above has been estimated to be between a few days and several weeks in various parts of the cave. What occurs on the surface above the cave has an impact on the cave below.

The only infrastructure above the currently known passages of Lehman Caves are the Nature Trail, the bat cupola above the natural entrance, and the Lehman Orchards Aqueduct. No known exotic plants have been found above the cave, thus herbicides have not been used there.

The dominant vegetation above the cave is pinyon pine (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*). The pinyon-juniper woodland is dense, and regular infestations of beetles and disease outbreaks have increased dead and down fuel. The risk for wildfire in the area is high due to this buildup of fuel and over a century of fire suppression.

2.17 Visitor Center

When the NPS took over in 1933, the buildings near the cave included a small lodge, eight cabins, information office, and a dance hall. In addition, outbuildings included an ice house and two stables. On the nearby state-owned land was a recreation and mess hall that included flush toilets, and nearby a small, shallow concrete swimming pool (Stephanson Jr., 1933 in Trexler 1966).

The small log lodge was used as a contact station over the years. Most of the other structures were gone from the monument by 1940, although one cabin, the Rhodes Cabin, was kept and is now on the National Register of Historic Places (Trexler 1966).

In 1955, the NPS released a long range action program called Mission 66, which was to be in place by 1966, the 50th Anniversary of the NPS. The program was designed to “assure the American people that their priceless heritage of national parks, monuments, and historic shrines would be developed in a manner in keeping with the greatness, yet fully protected for the enjoyment and inspiration of future generations.” What this meant for LCNM was the completion of four residences; moving the superintendent’s old house and two small cabins to the new residence area; construction of a visitor center, power plant, and utility building; building a new road to a 25-unit picnic area; upgrading the utilities system; and increased staffing. The Talus Room tour was also added during this time frame, regularly scheduled evening campfire programs began, and the Spelunker Tour was offered for the first time. Staffing increased from five personnel to thirteen. On June 8, 1963, a huge celebration was held, with more than 1,500 participating, and 1,016 touring the cave (Trexler 1966).

The new visitor center, built at a cost of $120,625, allowed more space for exhibits about the cave (Trexler 1966). In 1969, an addition to the south end of the Visitor Center allowed for an office and exhibit area for the Forest Service, as well as a combination café and curio shop. In 1970, a Forest Service residence was completed in the staff housing area at the monument (Unrau 1990).

In 1989, the Visitor Center exhibits shifted emphasis from Lehman Caves to the park in general (Superintendent’s Annual Report 1989).

In 2016, the Visitor Center contains an information desk, where visitors can buy or pick up previously bought cave tickets and receive information about the cave and park. The Western National Parks Association has a large selection of books and other merchandise covering about a third of the floor space. A few speleothems are in a case, and some information panels are on the wall, along with interactive computers. An exhibit about the Winchester rifle found in the park covers the west wall. A small theater shows the park movie and ranger minute videos.

2.18 Cave Concessions and Natural History Association

Although the federal government has managed Lehman Caves for decades, the assistance of outside entities has provided visitors with amenities and educational items that have contributed to their experience.

Park Concessions

On January 15, 1934, Ralph E. Kaufman from Baker asked to establish an auto service at the caves. This request was denied, pending a study of the visitation patterns at the cave to see what conveniences were necessary there. In 1935 an application for a tea room and campground were submitted, but also denied. The NPS said there was not enough demand for "lunch services and shelter accommodations," but allowed Mrs. Nielson, wife of the ranger in charge, "to furnish such services as there is demand for" (Trexler 1966).

The local press did not like these denials and accused the NPS of neglecting Lehman Caves. In addition, no food or lodging was available in Baker. In order to better accommodate visitors, the NPS planned a lunch room and overnight cabins. The lunch room was to have 24 seats, a curio, and a grocery department, as well as a bed and bath for the operator. The facility was constructed, but due to a shortage of housing, it was converted into a staff residence in the fall of 1941. The overnight cabins were also constructed but left vacant during World War II (Trexler 1966).

In 1947, there was another push for establishing a food and lodging concession, with backing from civic groups in Ely. However, it was difficult to find anyone willing to set up concessions either inside or outside the national monument. Finally, the superintendent's wife, Mrs. Marcella Wainwright, was convinced to use a portion of the old log lodge as a restaurant and gift shop. The Wheeler Lodge opened in May of 1948 and included breakfast, sandwich and dessert service, soft drinks, postcards, and gifts. Overnight accommodations cost $2.50 in the cabins that had been previously constructed. She operated the Wheeler Lodge until September 1951, when her husband retired.

In February 1952, the new superintendent's wife, Mrs. Olive Brown, signed a two-year contract. The old lodge did not pass sanitary inspections, so at first she had to prepare food in her own kitchen. No refrigerator was available, and all the drinking water had to be boiled before consumption. Numerous visitor complaints were made, and the lodge operated at a loss. The next winter, Mrs. Brown asked for improvements, but they apparently were not made, and the NPS rescinded the contract. No food or lodging for visitors was available at the monument or in Baker in 1953 or 1954.

Starting in 1955, the concessions were operated almost continuously from Easter to Labor Day, with some seasons extending later. Table 6 shows a summary of concession operations.

Table 6. Years and operators of the Concession at Lehman Caves.

Years	Operator	Name	Notes
1948-1951	Mrs. Marcella Wainwright	Wheeler Lodge	Breakfast, sandwich, and dessert service, gifts, overnight cabins
1952	Mrs. Olive Brown		Old lodge did not pass sanitary inspections
1953-54	No services		
1955-1956	Mrs. Blanche Yersin		
1957-1963	Mrs. Thelma Gregory Bullock		Reconditioned log lodge; three meals a day plus two overnight cabins
1963-1965	Mrs. Thelma Gregory Bullock		new Mission 66 facilities, coffee-gift shop but no overnight facilities due to low useage (Trexler 1966).
1965-1971	Unknown		In 1969, addition to south end of the Visitor Center that included a café and curio shop (Unrau 1990)
1972-1976	Shirley Robison		
1977-1979	Mr. and Mrs. Lewis DuMond of Carson City		
1980-1982	Lehman Caves Natural History Association	Lehman's Kitchen and Country Store	Lunch menu expanded, breakfast menu added, weekly Saturday night dinners
1983-1984	Joanne Dalton and Tonia Harvey	Lehman Country Kitchen	
1984-2008	Tonia Harvey	Lehman Caves Gift and Café	
2009-2011	Jane Murray and Nomi Sheppard	Lehman Caves Gift and Café	
2012-2016	Susan Geary	Lehman Caves Gift and Café	
2017-	Donnie and Christina Crouch	Great Basin Café	

Natural History Association/Cooperating Association

In 1963, the Lehman Caves Natural History Association was incorporated to operate primarily as a publication sales organization (Unrau 1990). On December 15, 1986 the name changed to the Great Basin Natural History Association. In 2005, the bookstore became part of the Western National Parks Association (WNPA), a cooperating association which runs bookstores in 71 National Park Service units. Since its arrival at Great Basin, WNPA has supported a variety of park functions, including funding of the park newspaper (*The Bristlecone*), park brochures, and site bulletins; sponsoring a speaker series; and supporting a variety of scientific research. Since 1938, WNPA has funded scientific research to help advance the management, preservation, and interpretation of our national parks. WNPA is committed to supporting meaningful inquiry in parks, helping shape the national park experience for every visitor. One of the key goals of WNPA's research program is interpretation—turning research findings into relevant narratives that engage, inform, and entertain to further enhance the visitor experience in our national parks.

3.0 Management Direction and Objectives

The National Park Service preserves unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations. The Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.

The primary goal of the Lehman Caves Management Plan is to manage the cave in a manner that will preserve and protect cave resources and processes while allowing for respectful recreation and scientific use. More specifically, the intent of this plan is to manage Lehman Caves to maintain its geological, scenic, educational, cultural, biological, hydrological, paleontological, and recreational resources in accordance with applicable laws, regulations, and current guidelines such as the FCRPA, 43 CFR Part 37, and National Park Service Management Policies.

Objectives

1. Provide high quality visitor experiences so that visitors to Lehman Caves safely enjoy and are satisfied with the availability, accessibility, diversity, and quality of park facilities, services, and appropriate recreational opportunities. Visitors would have the opportunity to visit the cave on guided tours for an educational and interpretive experience. Support cave and karst systems education and outreach.

2. Regulate or prohibit uses that would cause resource damage to cave systems. These uses may include land actions (e.g., surface disturbance above or near caves or projects that change the hydrologic systems connected to the cave), research (e.g., archeological or paleontological), and commercial uses.

3. Protect and preserve biodiversity. Cave life would have minimally hindered access to the cave by maintaining connectivity between the surface and sub-surface. Exotic species (e.g., algae) would be removed periodically. Staff would also work to protect the cave from white-nose syndrome and other potential diseases.

4. Manage the cultural resources and cultural landscape of Lehman Caves through documentation and preservation to allow for longevity, preservation, interpretation, and future research. In addition, research and record the ethnographic information for the cave.

5. Prioritize safety for both staff and visitors in and out of the cave. The cave would be a safe environment with access to necessary equipment, appropriate Job Hazard Analysis (JHA), and work-appropriate Standard Operating Procedures (SOPs). Each staff member would have a clear understanding of job duties, appropriate actions, SOPs, and where to receive more information to best serve park operations in the cave.

6. Design and utilize infrastructure that reduces maintenance, enhances longevity, and has minimal impact on the cave. Remove and repair past infrastructure damage.

7. Encourage, facilitate, and conduct high-quality scientific study of cave and karst resources.

8. Use partnerships and volunteer resources where feasible to augment park staff resources. Develop and foster communications, cooperation, and volunteerism with interested publics, Federal agencies, Native American Tribes, local governments, and academic institutions. Utilize partners and volunteer assistance for inventory, monitoring, surveys, maintenance, lint clean up, and restoration.

4.0 CAVE MANAGEMENT FOR LEHMAN CAVES

4.1 Safety

a. Park staff, volunteers, and researchers

The desired future condition for safety of all park staff, volunteers, and researchers in Lehman Caves is to have no incidents in the cave. In order to help achieve that goal, those that work in Lehman Caves will review the Caving and Cave Maintenance JHAs (Appendix G). This includes using proper PPE and basic knowledge of safe caving techniques. Park staff will be encouraged to attend the annual Lehman Caves Emergency Training to learn how to respond to an incident in the cave. Park staff also will be encouraged to have current CPR and first aid training. Park staff will avoid or mitigate known hazards.

Everyone entering the cave will inform a surface contact of where they are going and when they expect to return. For regularly scheduled tours, rangers will bring at least one additional source of light and be familiar with where the emergency kits are located (in 2017 they are located in the Gothic Palace, Lodge Room, and Grand Palace). All off-trail trips will have an assigned trip leader responsible for ensuring that all necessary personal protective equipment (PPE) is worn and that all trip members are capable of safely traveling the chosen route. For on-trail cave trips, all employees/VIPs will carry at least one portable radio per group, turned on and set to 'In Cave.'

b. Park visitors

The desired future condition for park visitor safety is to have no incidents in the cave. Before entering the cave, visitors will receive standard safety messages about low ceilings, steps, and dark places in the cave. Visitors will be encouraged to use hand rails. All park visitors will be escorted into the cave by an NPS employee or volunteer in park (VIP) with the ability to communicate by radio to the LCVC front desk. Visitors will be screened to ensure they are wearing the appropriate footwear and clothing. Visitors who have difficulty walking will be encouraged to take a first-room tour only. Visitors who have claustrophobia or otherwise feel uncomfortable upon entering the cave will be escorted out.

Park rangers will check their group periodically to screen for any problems, such as exhaustion, dizziness, or injuries. If any are encountered, they will proceed to Emergency Situations protocols (Appendix H).

In order to provide accessibility to the widest range of visitors and abilities there is only one age restriction. From March through October children under five are only allowed on the Lodge Room (60-minute) tour. Education programs for children in 5th grade or less will be limited to 60 minutes or less. Grades 6 through 12 will be at least 60 minutes but no more than 90 minutes depending on learning objectives and class time available. College level programs will be 90 minutes unless they request a 60-minute tour or ranger availability does not allow.

Some visitors require assistance to get through the cave. Infants can be carried in their parents' arms or with a front carrier only. Currently the park has two front carriers to loan to the public. Persons with canes are allowed to use them in the cave if they need them. These visitors are also informed that they cannot lean on the cave. If they need additional assistance they are encouraged to take a First Room Tour. A visitor with a walker or scooter can only attend a First Room tour. Hiking poles are not allowed as the tip can catch in the grated surface of the stairs.

Service dogs under control are allowed in the cave. Under Title II and Title III of the Americans with Disabilities Act, a service animal means any dog that is individually trained to do work or perform tasks for the benefit of an individual with a disability, including a physical, sensory, psychiatric, intellectual, or other mental disability. Tasks performed can include, among other things, pulling a wheelchair, retrieving dropped items, alerting a person to a sound, reminding a person to take medication, or pressing an elevator button. The work or tasks performed by a service animal must be directly related to the individual's disability. Emotional support animals, comfort animals, and therapy dogs are not service animals and are not allowed in the cave. Other species of animals, whether wild or domestic, trained or untrained, are not considered service animals either and are not allowed in the cave.

c. Communications

The desired future condition for communications is to effectively exchange information both within the cave and from the cave to the outside. Several options are possible and further planning is needed to move forward. Moving a radio repeater inside the cave may help with extending current radio coverage, which is currently spotty. Hard-wired telephones able to communicate with the LCVC would also work but require new wiring. These telephones could be located in the larger gathering rooms, such as the Gothic Palace, Lodge Room, Inscription Room, and Grand Palace. A guide would never be more than about a three minute walk from a phone. Ideally this phone system would include a message light on it, so that messages could be left for those away from the phones (e.g., biomonitoring trips in the Talus Room).

4.2 Infrastructure

a. Trails

The desired future condition for cave trails is to have a trail system safe for visitors and to reduce visitor impact to the cave. One way to do this is to improve the tread and add lint curbs. Some areas of the current cave trail are slippery when wet because the existing trail tread has been worn down or the grooves have filled in. The trails would be thoroughly cleaned, and if needed, additional trail tread added.

Lint curbs are currently used at other show caves (e.g., Kartchner Caverns, Mammoth Cave) and help to reduce the amount of lint that is spread onto cave surfaces. Rod Horrocks, cave specialist at Carlsbad Caverns, estimates that lint curbs there contain 80% of the lint left in the cave (personal communication 2017). Lint that settles next to the lint curb can easily be swept up or vacuumed (Jablonsky et al. 1993). Curbs would be 12-18 inches high (depending on the location) and could be constructed of cement or plastic boarding (Trex or equivalent).

b. Lighting

The desired future condition for cave lighting is to have a lighting system that is effective at illuminating the trails and cave features while minimizing growth of lampenflora. In addition, the lighting and electrical system would be protected from deterioration and minimize maintenance impacts on the natural floors.A new cave lighting system to replace the 1977-system would help to accomplish this. Any lights chosen would minimize lampenflora. Up-to-date controls would be installed for all systems, and all associated electrical equipment would be installed in a watertight raceway to minimize maintenance and protect cave features. Care would be taken to minimize impacts to cave features. Old cave lighting systems would be removed using the best practices possible. The new cave lighting system would be designed to minimize the need for off-trail maintenance.

c. Doors

The desired future condition for the cave doors help keep the cave climate as natural as possible. This may be accomplished at the cave tunnel entrance and exit by installing airtight doors that are resistant to rust, cracking, and bowing. These doors, most likely made of steel, are also more secure and more resistant to break-ins. The current system of double doors for each tunnel will be maintained to minimize cave climate modifications.

A cave door would be added to the entrance to the West Room from the Inscription Room, where the passage was blasted in 1960, to allow access. This door would require a key to enter, but would just require turning a handle to exit. It would restore natural air flow in this area.

d. Platforms & Stairs

The desired future condition for cave platforms and stairs is to have infrastructure that is safe and allows for natural cave processes to continue. The current platforms and stairs were built in 1998-2000 and are in excellent condition. The platform in the Sunken Garden would be expanded to improve visitor experience by allowing for interpretation of the room and a larger turn-around area. Other platforms could be added or modified as needed or desired as long as they meet the desired future condition.

In several areas, the trail acts as a dam, separating cave pools and flowstone that previously were hydrologically connected. These locations include the Cypress Swamp, King's Bathtub, and entrance to the Grand Palace. Ideally, a slightly elevated platform, made of fiberglass (like the stairs) and with a PVC backing to catch lint, would be installed in these locations. Stainless steel handrails may be needed to help those with balance issues.

e. Natural Entrance

The desired future condition of the natural entrance is to maintain a bat-friendly opening, not permit human entry, and allow for natural air exchange and nutrient input via occasional vegetative and animal matter (e.g., pinecones, rodents). The entrance will be inspected biennially by park staff to ensure the integrity of the current opening. If any deficiencies are found, they will be corrected.

f. Tunnels

The desired future condition of the cave tunnels is to keep the entrance and exit tunnels in safe, working condition. The supporting structure will be inspected biennially by Federal Highways and park staff to ensure a safe passage for visitors and park employees. The cosmetic gunnite that lines the tunnel would be repaired as needed, as well as the structural components. In addition, it is desired to improve the tunnel lighting consistent with cave lighting standards above.

g. Lint Abatement

The desired future condition for cave lint is to reduce the amount of lint deposited in the cave (Joblonsky et al. 1993). Grates would be installed just outside the cave entrance and exit doors to reduce the amount of lint entering the cave (the exit path would help for any tours that enter via the exit tunnel). An indoor-outdoor carpet would be installed in the entrance tunnel to help remove more debris from entering the cave. The carpet would be accessible-friendly and cleaned weekly. Lint curbs would be installed along the trail to reduce the amount of lint that is spread onto cave surfaces. Lint that settles next to the lint curb can easily be swept up or vacuumed monthly. Other methods of lint abatement will also be investigated, such as a blower to blow lint off people before they enter the cave.

h. Cave Cleaning

The desired future condition for cave cleaning is to effectively and efficiently reduce the amount of debris within the cave. Any visitation to the delicate cave environment will cause some degradation through the introduction of foreign materials. In Lehman Caves this includes: shoe rubber, lint, skin oils, hair, skin cells, gum, trash, and silt. These materials must be periodically removed to maintain more natural conditions in the cave. During any cleaning in the cave, no chemicals will be used that would be harmful to humans, the natural cave ecosystem, or to mineralogical systems. Maintenance staff are responsible for the weekly and monthly basic cleaning of the trail, and Natural Resource staff are responsible for the larger lint and restoration camps. If historic materials are discovered during cleaning activities, Cultural Resource staff will be consulted. Photographs will be taken and the items left in place unless prior arrangements with cultural resource staff have been made. If bats are present in the cleaning are, every effort will be made to minimize disturbance. In most cases, the cleaning can move to another area. See SOP #1 for more details.

i. Decontamination Program

The desired future condition of the decontamination program is to prevent the introduction of spores that cause white-nose syndrome (WNS) into Lehman Caves by humans. This will be achieved by screening and decontaminating visitors prior to entering the cave, using NPS and USFWS guidelines. The most current guidelines can be found at https://www.whitenosesyndrome.org/topics/decontamination. If there is a time when WNS has spread to Lehman Caves, we will then decontaminate visitors upon exiting the cave system, such as Mammoth Cave does, to help prevent further spread of WNS.

Installing permanent decontamination stations, such as those at Mammoth Cave and Lava Beds, will help with decon. These stations look like little bridges that visitors walk across to help decontaminate their footwear.

j. Holograms

Holograms could be used to provide a unique interpretive experience for visitors. Possible holograms could include Absalom Lehman welcoming visitors to the cave or pointing out a particular feature; a party in the Lodge Room with musical instruments; or an image that would pop out to provide a warning if someone got to close to a cave feature. The technical part of holograms would be integrated into the cave infrastructure to minimize impact to the cave. This feature will be evaluated in the future as for its desirability to the cave experience and technical capabilities of including along the cave route.

k. Communications

Communications is a part of infrastructure and safety, and is found in more detail in Section 4.1.c.

l. Security

The desired future condition for security in the cave is to prevent illegal access to the cave. This can be done through the installation of steel doors or through an Intrusion Detection System (IDS) that covers all known openings to the cave. The IDS would notify the GRBA 24-hour dispatch center electronically. The IDS would have cameras on all known cave openings, with real time video capabilities to display the live video to the GRBA 24-hour dispatch center. The cameras would be concealed to blend into the natural surroundings as much as possible to reduce impacts to wildlife and visitors and to prevent theft or damage. In addition, the cave locks would be re-keyed to ensure only those employees with a need to access the cave have keys to the cave. All staff would maintain accountability of cave keys. If a cave key is lost, the supervisor will be notified immediately. The supervisor will then notify the Property and Facility Managers.

4.3. Visitation, Interpretation and Education

a. Carrying Capacity

The desired future condition for carrying capacity for Lehman Caves is to determine the maximum number of people that can safely visit the cave and have a high quality experience without causing irreparable impacts to the cave.

i. Total Carrying Capacity
A User Capacity Study would be conducted so that the park has a scientific measure of visitor satisfaction with the cave and cave tours, as well as how many visitors and cave tours the cave can handle. Clemson University has done User Capacity Studies with other parks and might be a potential partner for GRBA. This information will help the park to evaluate visitor experiences and potential experiences with more than anecdotal information to make informed management decisions.

i. Tour Size
Current (2017) tour sizes of 20 people seem to work well. Tour sizes limited to ten people would be ideal for visitors, rangers, and the cave, as it would provide a better interpretive experience plus more protection of cave resources. However, tour sizes of ten would necessitate additional tours, more rangers needed, and potentially lights on longer during most days from March through October.

ii. Number of Tours per Day
   a. Currently (2017) the maximum number of tours, with 20 people on a tour, is 20, starting as early as 8:00 a.m. and with the last tour entering the cave at 5:00 p.m. Tour size could be smaller, such as 10 per tour, in the future if it is financially feasible or resource protection requires it. If fewer people are allowed per tour, than the maximum number of tours could be increased to still have 400 people per day entering the cave. The tours could start at 8:00 a.m. with the last tour entering the cave at 5:45 p.m. Having scheduled tours between these times allows for Special Use Permit tours to occur after the last tours and time for interpretive or resource management staff to conduct special tours. In addition, the cave is left in darkness for the majority of a 24-hour day. Number of tours per day may be advised by the User Capacity Study. If the number of tours per day is capped at 20, but tour size is limited to 10, the maximum number of people allowed in the cave would be 200, half of the current capacity. This would change the amount of revenue collected. If the maximum number of people is kept at 400 people as in 2017, and tour size is limited to 10, then up to 40 tours would be given a day, requiring many more rangers.

   b. During the winter at least one Grand Palace (90 minute) tour a day would be offered to the public. This number allows flexibility to add special tours and school group visits; for rangers to conduct projects; and for development of virtual, social media, and educational outreach to youth and the general public.

c. Spring and fall visitation is increasing and is expected to continue on that trend. Number of tours offered during these periods would be variable, depending on demand and staffing capacity.

d. Tours would continue to be offered 362 days a year, with the cave closed on Thanksgiving, Christmas, and New Year's Day.

b. Types of Tours

The desired future condition for tours of Lehman Caves is to expand beyond the standard 60-minute Lodge Room and 90-minute Grand Palace tours so that visitors will have additional options. GRBA should evaluate the interpretive programs offered on a regular basis to ensure that they are providing for both resource protection and visitor enjoyment. Providing special experiences helps to develop a stronger bond between visitors and park resources. If the public cares about park resources, they will help protect them more.

Trends in visitor age, needs, and interests will continue to change, so the park will need to re-evaluate regularly. In-depth visitor surveys, like those that used to be done by the Park Studies Unit at the University of Idaho, should be done regularly, ideally about every five years. These surveys will help the park obtain more specific information on what experiences visitors are seeking when they visit.

Below are some options for tours beyond the standard ones currently available.

i. *Candlelight/LED Tours*

Candlelight/LED tours provide the opportunity for visitors to see the cave as some of the first visitors did. Although candle lanterns may lend a more historic air to the tour, the spread of green mold in the cave necessitates an alternative. LED lanterns will be used instead, with additional experimentation to find the best "candle lantern" replacement lights to provide a more authentic experience.

Candlelight/LED tours target visitors who have already been on the regular cave tour and desire to see the cave in a new way. Tours may be offered during holiday weekends and at special events or anniversaries. Tours would follow the regular cave route and last about 60 or 90 minutes. In the future these tours could be offered on a daily basis.

ii. *Wild Cave Tours (West Room-Talus Room)*

With the restoration of the West Room and Talus Room and removal of the trail there, the opportunity exists for a new Wild Cave tour in Lehman Caves[2]. The tour would allow visitors to don helmets, headlamps, kneepads, and gloves to travel through the West Room and Talus Room. Tours would concentrate on how to cave safely while using minimum impact techniques. In addition, these tours would

[2] A Spelunker Tour was offered in Lehman Caves from 1965-1967 and in nearby Little Muddy Cave from 1978-1992.

provide more in-depth interpretation about subjects such as wild caving, cave conservation, cave geology, cave biology, and cave history.

Other NPS caves that provide Wild Cave Tours, such as Carlsbad Caverns, Jewel Cave, and Wind Cave, have had great success with these programs. These other caves also have very tight spots on their Wild Cave Tours, thus a West Room-Talus Room tour that does not have size restrictions would add to the overall offerings of NPS cave tours.

Wild Cave Tours would have a special fee higher than the regular cave tour to help generate revenue through Federal Lands Recreation Enhancement Act so project funds can be used to replace worn out equipment. Tours would be led by selected interpretive staff, trained by resource management staff. The wild tours would have a regular schedule such as on specific holiday weekends, or monthly on the second Saturday or another schedule visitors and staff can rely on that staffing levels allow. If tours become very popular and adequate fees are collected, then the program would be re-evaluated and a decision made if additional tours should be added and if partial salary should be covered by the funds generated from ticket sales for a term or Career Seasonal Permanent Employee.

iii. *Photography Tour*

Photographers are currently allowed into the cave via a Special Use Permit (SUP). A special cave tour for photographers could be offered for a fee less than the fees of a SUP, but higher than a standard cave tour. The tours would be 2.5 hours in length. It would allow up to two photographers per tour and five people on the tour total. The photographers could bring in a camera and a tripod along with one or two other people to carry additional flashes or lenses in pockets or pouches on the front of the person carrying the items. These tours could be offered weekly or monthly throughout the year. Tours would be restricted to the cave trail. Commercial filming and still photography with props, models, and/or other significant gear would require a Special Use Permit.

iv. *Educational Cave Tours*

Schools in Snake Valley and the rest of Millard and White Pine Counties, especially fourth graders, will receive annual communication from the park encouraging them to visit the park and cave. School groups from other areas will be accommodated when possible.

v. *Other Cave Tours*

Special Cave Tours would allow the public to see Lehman Caves differently and also be fun for staff to provide, augmenting staff morale. Some potential Special Cave Tours include:

- A midnight tour on New Year’s Eve
- Backwards tours, entering through the Exit Tunnel and exiting through the Entrance Tunnel (this could also be done throughout the winter months for a different cave experience without impacting other cave tours)
- Behind-the-Scenes tour to look at transformers in the cave and better understand how the trails, stairways, platforms, and electrical system work in the cave

- Living history tours with Ab Lehman or Mr. and Mrs. Rhodes or other historical characters
- Tours with special focus and an expert guide to explore subjects in more depth such as Tribal Tour, Cave Geology and Minerology, Cave Ecology, Effects of Humans on Caves, and Cave Exploration and Mapping.

c. Staffing

The desired future condition for staffing is to have enough qualified staff to provide quality cave tours on a timely basis. The current request is for the Interpretation Division to have 14 GS-05 seasonal park rangers, three permanent GS-05/07 park guides, a permanent GS-07/09 education specialist, and one intern. The intern provides opportunity for a local community member or college student to learn about becoming a ranger and prepare them to compete for ranger jobs in the future. Fourteen seasonals allows for staff to provide additional holiday weekend tours and support walkouts from the first room accessibility tours. Three Park Guides would work year round to provide cave tours and support for social media, multi-media, and education efforts to reach the public on cave biota, geology, and other concerns in and outside the cave.

If the desired future condition of tour size is limited to 10 people, then staffing needs would increase. This would require an additional 14 seasonal ranger staff and four permanent GS-05/07 Park Guides.

Other staff that would support the above listed staff would include a Supervisory VUA, Supervisory Park Ranger, Park Ranger-Interpretation, and Chief of Interpretation.

d. Training

The desired future condition for training is to provide formal training to all new interpretive staff annually. Training will include cave history, cave geology, cave biota, and cave conservation. For staff that miss the formal group training, the next best thing is allowing time for staff to participate in resource management activities in the cave and having time for questions with the resource experts. Hands-on experiences and getting to work with experts inspires staff and helps to develop areas of passion. That passion comes through to the visitors, often inspiring them to care about what the park cares about. In addition, a training manual will include recent articles about the cave so that staff will be able to share the most up-to-date knowledge with visitors. Videos of the cave, such as behind-the-scenes or tour-with-an-expert, would be produced so that staff can learn more about other facets of the cave. Tribes would be invited to share their perspective. Annual cave rescue training will be provided that stresses cave conservation during emergencies.

Job sharing amongst the divisions and the different work done in the cave will help increase understanding of everyone’s job to protect the cave and educate the public about the cave.

e. Virtual Cave Tours

The desired future condition for interpretation is to provide a way for visitors to experience the cave without physically entering the cave. With visitation to GRBA increasing and cave capacity staying level or even decreasing, a new way must be found to share Lehman Caves with visitors. One way is to use virtual cave tours. Virtual cave tours would enhance experiences for a variety of visitors, from those who are unable to access the entire cave due to physical or emotional limitations to those with limited time.

The virtual tours would contain multiple "stops" and be completed by park staff using a tablet to show captioned images to the public. First virtual tours could be made with Go-Pro cameras that the park currently owns and posted on the park's YouTube channel. As technology continues to improve and virtual reality devices become more dependable and user friendly, the program can be used with things like the Oculus Rift VR Headset. A virtual tour could also be placed on or linked to the park website and made downloadable for "homemade" virtual reality devices like Google Cardboard. Any of these virtual tours can be used for training as well.

The focus of Virtual Cave Tours will be the regular tour route as well as parts of the cave seldom visited, such as the Gypsum Annex. It would be possible to have many experts contribute to the Virtual Cave Tour so that the best knowledge is shared. In addition, it would be possible to have different-themed Virtual Cave Tours, such as historical, behind-the-scenes, and cave conservation.

f. Visitor Center Exhibits

The desired future condition for the Lehman Caves Visitor Center is for science-based and highly interactive exhibits. Visitor trends are showing that visitors do not read exhibits as much as they used to, but with great interactive exhibits they tend to stay longer. It would be ideal to include a cave replica or simulation in the visitor center. A collaborative interdisciplinary park team, park partners, stake holders and local tribes will participate in exhibit planning process. In 2016 this project was funded for $350,000.The visitor center exhibits would also be done in consultation with local tribes to provide the opportunity to tell their story. Visitor center exhibits will also be outside the visitor center to interpret the cave as well as other topics. These outside exhibits will help visitors who arrive after hours, as well as disperse visitors to other areas to help prevent crowding in the Visitor Center. These exhibits have yet to be funded.

g. Decontamination

The desired future condition of the decontamination program is to prevent the introduction of spores that cause white-nose syndrome (WNS) into Lehman Caves from humans. As white-nose syndrome (WNS) spreads, we want to prevent it from reaching Lehman Caves and other regional caves for as long as possible. The latest USFWS decontamination protocols will be followed (https://www.whitenosesyndrome.org/topics/decontamination.). Continuing current decontamination processes is important, where every person who buys a ticket is screened. Those who buy tickets through Recreation.gov are required to check-in with a ranger and the ranger provides WNS messaging as well as decontamination procedures, if needed.

An outdoor television will be installed outside the visitor center to play a WNS video informing visitors about the disease and its impact on bats and how visitors can help prevent the spread of the disease. The video will be updated as the park receives new information.

h. Cave Reservations

The desired future condition for cave reservations is to make them as streamlined as possible for both park staff and park visitors. Cave reservations have changed from a very labor intensive process where the park took reservations to an online system in the spring of 2016 with recreation.gov. After a year of using recreation.gov, the system will be evaluated for ease of the process, visitor satisfaction, and recreation fee revenue impacts. If the system proves to be satisfactory, it will be continued. If not, other options will be researched.

i. Social Media

The desired future condition of social media is to continue to use it to enhance park communications. It is a great tool to provide education and information to the public. In 2016 and 2017, social media posts about cave biota and videos of bats have been very popular with the public. As better techniques evolve for engaging the public in "conversation" through social media, the public can form connections to the cave and life within.

Social media also allows easy communication in both directions. The public can post stories of their experiences in the cave, photos, and family history with the cave online to share with the park and the rest of the public. Social media will continue to grow into new formats that will provide new and maybe unexpected ways to engage a public that isn't here.

Designated park interpretive staff will be assigned to use social media to share news and information about Lehman Caves. In addition, staff from other divisions may contribute.

j. Distance Learning

The desired future condition of distance learning is to increase the efforts to reach off-site visitors. Engaging with schools through distance learning where they can see images of the cave, talk with a cave specialist, or take a virtual tour will foster a new generation of cave scientists, educators, and stewards. This would be accomplished with an education specialist and park guide staff developing curriculum and using current technology platforms to live broadcast to schools both locally or anywhere in the US. The current NPS Junior Cave Scientist program may be used as well.

k. Visitation Reporting

The desired future condition of reporting is to have a complete record of cave visitors to assist with park management decision making. Currently, the visitation that is uploaded to Park Visitor Use Statistics (https://irma.nps.gov/Stats/) includes cave visitors, but this is not shown on the website. Adding these stats to the historical spreadsheet (graph of which is shown in Section 2.4) will allow for an easier way to follow the trend of cave visitation. The Visitor Use department keeps track of these statistics.

4.4 Biological Resources

a. Bats

Desired future conditions for bats in Lehman Caves include the following:

- Protect and maintain Lehman Caves as an important summer roost site for Townsend's big-eared bats and hibernacula for caverniculous bat species. Limit disturbance from cave tours (including being quiet under the natural entrance), recreational use, research, cave restoration/cleaning, and maintenance projects during critical life history periods. Train park staff how to minimize disturbance to bats. If impacts exceed a threshold (to be determined), then closures, alternate tour routes, or other mitigations will be implemented to prevent impacts to hibernating bats or critical habitat.

- Recognize the need to manage volant species at the landscape level, across administrative boundaries and between caves, mines or other roost sites. Establish or maintain partnerships with other parks, land and wildlife management agencies, and academic institutions to study bats across administrative boundaries.

- Monitor use of Lehman Caves as a summer roost site and hibernaculum by installing and maintaining permanent data logging stations at or near the natural entrance (e.g., PIT tag arrays, telemetry stations). Fill fundamental gaps in natural history information, demographic parameters and ecological data such as timing of use, mating, and parturition; spatial and temporal variation in roost selection by colonies or individual bats; abundance; survival; longevity; disease status and impacts of visitation.

- Share natural history information, bat studies, and monitoring efforts with visitors and park staff as it relates to Lehman Caves. Design visitor center exhibits highlighting the importance of bats to ecosystems and include white-nose syndrome messaging. Update signage at the natural entrance to include information on bat monitoring. Provide volunteer opportunities for the public and park staff during bat inventory and monitoring work. Resource management staff will participate in annual training for Interpretation staff to share knowledge and information on current bat work. Conduct outreach for schools and universities emphasizing the importance of bats to ecosystems, threats to bats, and management actions designed to mitigate threats. Incorporate social media as an outreach tool in sharing bat and conservation related information.

b. White-Nose Syndrome (WNS)

The desired future condition is to protect local bat populations from white-nose syndrome, monitor for its arrival, and inform park staff, partners and visitors how to prevent its spread.

Before entering Lehman Caves, park staff, partners, contractors, researchers and volunteers will follow the most current decontamination protocols outlined by the US Fish and Wildlife Service and USGS (www.whitenosesyndrome.org). Decontamination is highly recommended for these groups after exiting the cave. Equipment and clothing used in a confirmed or suspect WNS area will not be allowed. All visitors to Lehman Caves will be screened using current NPS guidelines (e.g. cave entry decision flow chart) before taking a guided cave tour; and if applicable, instructed to complete decontamination procedures before the tour begins. Other methods may be considered to prevent the spread of WNS to Lehman Caves including but not limited to closures, permanent decontamination stations or other infrastructure, the use of fungicides and/or other emerging technologies that reduce, exclude or eliminate *Pseudogymnoascus destructans* (Pd), the fungus that causes white-nose syndrome.

Every visitor touring Lehman Caves will be screened and informed about WNS, its impact on bats and ecosystems, and ways to prevent its spread. Training will be provided for park interpretation staff on the cause, spread, and effects of white-nose syndrome and how to screen visitors participating in guided cave tours. Messaging will be made available to park visitors on white-nose syndrome through educational materials and outreach efforts such as visitor center exhibits, posters, brochures, interpretive programs, website material, social media, and pre-tour screening.

Baseline information on bat hibernacula will be collected before the arrival of WNS. The park will conduct *Pseudogymnoascus destructans* surveillance with support from the USGS National Wildlife Health Center. Sample collection (e.g., swabs and soil samples) and submission will follow USGS protocols. If detected, bats and hibernacula will be monitored and tested following standard protocols. Climatic conditions in Lehman Caves and associated caves will be monitored to determine if conditions are suitable for the fungus.

c. Cave Invertebrates

The desired future condition for cave invertebrates is to have healthy and self-sustaining populations. In order to measure if this is the case, quarterly biomonitoring of cave invertebrates in Lehman Caves will continue as long as the Natural Resources Chief and/or cave specialist deem necessary. The program is currently set up as a long-term monitoring effort, using fourteen paired stations. The monitoring includes biological, hydrological, and climatological aspects (SOP #2).

The natural history of many cave invertebrates is unknown. Learning about their life spans, reproduction rates, and habitat requirements would allow the park to better protect these biota. Future studies of these organisms would be welcomed, as long as they meet NPS scientific research standards.

Because many cave organisms utilize the organic material, cave biologists caution that wood should be removed in stages to reduce the amount of cave biota attrition (Taylor et al. 2008).

d. Human-Wildlife Interactions

The desired future condition is to prevent negative human-wildlife interactions in and around Lehman Caves. Lehman Caves is a summer roost site and hibernacula for several bat species. Although less than 1% of bats are infected with rabies, there is the potential for contact between humans and rabies-positive bats. Visitors and staff should not come into contact with any bat. Rabies messaging will be posted at the Lehman Caves Visitor Center, and interpreters will provide a message about not touching bats. Rabies is almost 100% fatal in humans if left untreated. If contact occurs, park staff will ask for an EMS response and follow protocols established by the NPS Office of Public Health (SOP #3). Any sick, injured, or dead bat will be reported immediately to resource management staff. Only staff with a current rabies vaccination and training will handle or euthanize bats. Resource management staff will follow established protocols for collection, identification, euthanasia, and disease testing.

The area around Lehman Caves is a migration corridor for Great Basin rattlesnakes, the only venomous snake that occurs in the park. If left undisturbed, Great Basin rattlesnakes do not pose a threat to people. Resource management has instituted a short-distance relocation policy for rattlesnakes that are found in high visitor use areas or residential areas. All rattlesnakes found near Lehman Caves will be reported to the wildlife biologist to maintain public safety and the safety of the animal and allow for identification of marked individuals. Rattlesnakes that are found in or near Lehman Caves in high traffic areas will be moved by resource management staff or their trained designee following current, humane relocation protocols.

e. Animal Carcasses in Lehman Caves

Animal carcasses will be left in Lehman Caves to provide a natural food source for cave biota unless they pose a risk to the health and safety of humans or wildlife. Carcasses may be moved off trail by park staff wearing proper personal protective equipment (e.g., gloves).

4.5. Cultural Resources

The desired future condition for Lehman Caves cultural resources is to protect them throughout the cave. This includes protection and restricted access for the natural entrance area. This would comprise the previous excavation areas from the 1930s and 1960s and the area where Native American remains were interred behind a stone wall. The burial area is off-limits to everyone, including researchers and staff. Excess stone left from building the burial wall would be removed.

Soils above the entrance tunnel would be assessed and monitored. If needed, the soils would be stabilized to prevent collapse. Information presented to the public would include the Tribes' perspective gathered through consultation. The tribes request people be made aware the cave is sacred as a burial place and should be treated humbly and respectfully. Tours will be quiet as they pass under the natural entrance. Cultural sensitivity training for park staff by Shoshone representatives is recommended. Tribes would be given access to Lehman Caves for prayer and ceremony for the ones that have been repatriated back to the cave. This ceremony will be held privately. Consultation with tribes for ceremony is ongoing and a process will be developed as communication proceeds.

Historic resources of Lehman Caves would be fully documented, including trail segments, inscriptions, and tunnels. Historic artifacts would be left in place where practical. Cultural resource staff will assist in any cleaning and activity that may require removing artifacts. Any removal would be documented and artifacts preserved in the museum collection. A National Register of Historic Places nomination will be submitted. Any reinternment will follow the Native American Graves Protection and Repatriation Act (NAGPRA) process.

All activities and management actions within the cave are subject to individual evaluation and consultation requirements of Section 106 of the National Historic Preservation Act (NHPA). Overall the management plan benefits cultural resources through identification of future activities. This will allow for better response with Section 106 review as actions are implemented.

4.6 Geologic Resources Management

The desired future condition for geologic resources in Lehman Caves is to protect speleothems and other natural cave features from damage by visitors and park activities. In areas where they have been damaged, the goal is to restore them when feasible.

a. Photo Monitoring

Due to the delicate and essentially nonrenewable nature of caves and karst systems and the cumulative nature of impacts on cave resources, impacts from visitors and cave infrastructure should be monitored.

Fixed recoverable photo monitoring points will be established along the developed trails in Lehman Caves. These points will primarily be the same location as those taken in 1928. These locations were reshot in 2016. Other representative locations throughout the cave, where formations are easily accessible to visitors, where sensitive features exist, or where lint accumulates, may also be included. All photo monitoring should be documented on a standard form to increase repeatability (using maps, compasses, and similar equipment). Photos should be taken every ten years.

b. Restoration

The desired future condition for restoration is to make the cave as natural as possible while still allowing visitation. Many past activities and infrastructure projects in Lehman Caves have caused damage or impact to cave resources. Broken formations, graffiti, trail construction debris, electrical debris, cement, algae, lint, hair, trash, and altered microclimates are all a part of the recent history of many NPS caves. While some of this damage can never be repaired, it is possible to mitigate many of these impacts. In general, clean-up and restoration activities should be conducted in a cautious manner to insure that no additional damage is done to cave resources. Particular concerns include cave biota, natural airflow patterns, cultural features, speleothems, hydrological systems and natural sediments. Standard Operating Procedures (SOPs) for cave restoration and cleaning will be developed and implemented.

- **Cave Restoration**
  The historic development of Lehman Caves has left many undesirable materials in the cave. These include wood, cement, asphalt, electrical supplies, trail debris, and other materials. These materials should either be removed or replaced with more inert materials. Discarded non-native materials that are not part of cave facilities should be removed from the cave. If large amounts of wood have been left in the cave, they must be carefully examined for biota, including microbial life, before any decisions are made. Wood should be removed a little at a time so that biota has time to adapt. Cultural resources staff will also be needed for a determination on the potential historic nature of the materials.

  No gasoline-powered engines will be used in the cave. All cave restoration work will be overseen by the Natural Resources staff. All activities will be documented and photographed with before, during, and after photos.

- **Debris Removal**
  Only debris (rocks and sediment) brought from outside will be removed from the cave. Sediment and rocks/formations excavated from cave floors and redeposited elsewhere will stay in the cave. Special care must be taken not to excavate sediments that are still in their original place. If the material is being removed from the cave, it should be screened for broken speleothems, paleo artifacts, and historic artifacts. All speleothems should remain in the cave and restored if possible.

- **Speleothem Repair**
  Intentional vandalism and trail development have resulted in the breakage of thousands of speleothems in Lehman Caves. Some broken formations still remain in the area where they were broken and could be restored. They should be restored using non-toxic, long-lasting epoxies and stainless steel pins, following the most current standards. Any speleothem that is unrepairable should be returned to the area it originated from.

4.7 Paleontological Resources

The desired future condition for paleontological resources is to better understand what used to live in or near the cave through the study of bones, teeth, and other animal and plant remnants. Limited studies have been done in the cave. Research will be encouraged within stipulations.

4.8 Research and Collection

The desired future condition for cave research is to learn more about Lehman Caves with minimal impact to the cave. Any research and collection requests will be handled through the NPS Scientific Research and Permitting System, available online (https://irma.nps.gov/rprs/). Park staff will review applications, and if they meet park criteria, will be forwarded to the Park Superintendent or designee for approval. Cave specific criteria include that intact speleothems will not be broken; for biological studies, a limited number of biota may be taken; and for all in-cave research, minimum impact techniques will be used. All researchers will be accompanied in the cave by park personnel for their research.

4.9 Cave Climate

The desired future condition for cave climate is to better understand it and maintain natural conditions. Monitoring cave temperatures over the long term can inform managers and lead to studies to determine if climate change, visitation, development, or other factors are influencing cave climate. This information can also help cave biologists explain fluctuations in cave biota populations. Current climate studies done with dataloggers will be continued as long as is practical, with data summarized periodically. Additional cave climate research will be encouraged. Cave pools will not be filled artificially.

4.10 Partnerships and Volunteers

The NPS and GRBA encourage the use of volunteers. According to NPS policy (2006), the Service will continue to use its authority under the Volunteers in the Parks Act of 1969 to protect park resources and values; improve its service to the public; foster stronger ties with the public; and provide opportunities for the public to learn about and experience the parks. Pursuant to this statute, volunteers may be recruited without regard to civil service regulations; are covered for tort liability and work-injury compensation; and may be reimbursed for out-of-pocket expenses while participating in the program. However, volunteers will not be used for law enforcement work or in policymaking processes, or to displace NPS employees. Volunteers may perform hazardous duties only if they possess the necessary skills to perform the duties assigned to them. Volunteers will be accepted without regard to race, creed, religion, age, sex, color, national origin, disability, or sexual orientation. NPS housing may be used for volunteers. *(See Director's Order #7:Volunteers in Parks, and associated Reference Manual 7).*

Volunteers are a key part of the cave management program. For Lehman Caves, volunteers will continue to be used to provide interpretive and maintenance services, and to conduct resource management activities. This includes long-term formal volunteers who may work for the program for a few weeks to several months and informal volunteers who may work only a couple of hours a year. Many cave program volunteers come to the park several weekends per year to work on various projects including cave restoration, mapping, and research.

From the NSS-NPS MOU "*It is mutually agreed that the NPS and the NSS will cooperate in conducting studies and other cave related projects within the National Park System. These projects may include but are not limited to cave exploration, education, restoration, administration assistance, interpretation, mapping, inventories, research, monitoring, and the development of cave management documents. The NPS will develop project and site-specific operating procedures with NSS individuals, IO's and Grottos, and issue scientific research and collecting permits or special use permits, as appropriate. The NPS may use the results of NSS studies and projects in its development and application of cave management practices and procedures and in its interpretation for the public of the natural and historic features in units of the National Park System*."

4.11 After-hours tours, Off-trail trips & Exploration

After-hours tours by park staff will continue to be allowed, with the following rules:

- A Great Basin National Park employee may take close friends and relatives on a cave tour separate from a regularly scheduled tour, when the friends and relatives are visiting the employee in the local area.
- A tally of the number of people on the tour will be provided to the Cost of Collection supervisor for tracking purposes.

- The employee giving the tour must be familiar with the cave and have approval from their supervisor to give the tour.
- Doors must remain locked.
- Three sources of light must be taken into the cave for the tour.
- All ranger-led tour rules will apply; no touching of formations, no eating,
- drinking, smoking or chewing on gum.
- The employee-led tours will be allowed on the regular, paved tour route only.
- Use a surface contact. Surface contact will be responsible for calling Lake Mead Dispatch/Protection Division if the cave trip is overdue.
- Lights – Make sure the main disconnect is turned on before entering cave. Turn off all lights in cave after tour and turn off the main disconnect. Do not use cave lights if not familiar with them.
- Let the surface contact know when the group has exited the cave.

If rules are not followed, the supervisor may rescind this benefit.

Off-trail trips for maintenance functions will be done by maintenance staff. They will review the Cave Maintenance JHA periodically (Appendix G). Off-trail trips to other parts of the cave (e.g., Lost River Passage, Talus Room, Behman Annex) will be led by Resource Management staff with a designated purpose (e.g., biomonitoring, climate monitoring, hydrological monitoring, restoration, paleontological surveys). The Caving JHA will always be reviewed before such trips (Appendix G).

Exploration will only be allowed by written permission from the Chief of Science and Resource Management or designee. No speleothems will be intentionally broken to enter new passages.

4.12 Photography and Special Use Permits

Commercial filming and still photography with props, models, and other significant gear are currently allowed into the cave, usually after hours, via a Special Use Permit (SUP). These tours are provided on request as staffing allows. These tours are regulated by standard conditions provided in 36 CFR.and OMB form 10-114. In addition Great Basin National Park has added the following conditions:

1. All participants and equipment, for example, tripods and battery powered lighting systems, must be on established paved trails in the cave.

2. Permittee may film/record the following National Park Service employee, *Name*. The National Park Service selected *Name* to represent the park. Permission to use recordings, photographs, film, and other media of employees in conjunction with the named project is granted by this permit.

3. Permittee shall own all rights of every kind in and to all (photographs/film/recordings) made in the park and shall have right to use such material in any manner it desires without limitations or restriction of any kind. Permit does not grant any rights regarding the film, photography, or recording of individuals on National Park Service property. In addition, rights owned by other individuals or institutions are not impacted or changed by this permit.

4. No food or drink is allowed in the cave.

5. No smoking or tobacco products are allowed in the cave.

6. Clothing that may produce excess lint is not allowed in the cave.

7. No biodegradable substances, including liquid or solid human waste, may be left in the cave.

8. No touching or removing natural, historical, paleoanthropological, or archeological objects from the cave.

9. No marks or writing of any kind may be left on any cave wall or feature.

10. No carbide or carbide products may be brought into the cave.

11. Permittee(s) must comply with verbal/oral instructions of permit monitor. Failure to comply will result in revocation of approved permit and immediate escort from the cave.

4.13 Cave Map

The desired future condition for the cave map is to have an accurate, up-to-date map of the cave passages and features. The park is currently using a cave map completed by the Salt Lake Grotto in 1959. It is not a very detailed map. Two maps (as of 2017) are currently in progress to achieve the desired future condition. One is being completed by the Southern Nevada Grotto using a total station survey along the cave trail and standard compass/inclinometer/tape measure for off-trail sections. This survey will be very precise along the cave trail and help for future management actions along the trail. The final version is expected by the end of 2017. The other map was started in 1997 by Rod Horrocks and is a traditional cave map, with good detail of speleothems, cave floor, and other features throughout all cave passages. Profiles and cross sections are included. It is done at a scale of 1:20. Due to the amount of speleothems in the cave, this is a time-consuming map to complete, and additional funding will be necessary to finish it.

4.14 Emergency Situations

The desired future condition is to have minimal Emergency Situations in Lehman Caves. In order to achieve that, park staff will be trained how to prevent emergencies. In case emergencies do occur, park staff will know how to deal with them.

a. Medical Issues

The desired future condition for medical issues is to have as few possible in the cave, as the cave is a difficult place to deal with medical issues. Visitors should be made aware of what is involved with a cave tour, and if they are not comfortable with that environment, they should not enter the cave. If a park employee/VIP that becomes aware of a medical issue (e.g., dizziness, chest pain, shortness of breath) inside or immediately adjacent to Lehman Cave will contact the LCVC front desk immediately by radio or runner. The employee staffing the LCVC front desk will immediately contact Lake Mead Dispatch (700 on the radio or by phone 702-293-8998) and dial 9-911 and give the following information: Location, Chief complaint, Gender, Age (approx. is OK), Breathing/Pulse (Yes or No). Park and local Emergency Medical Services (EMS) personnel will be dispatched.

When EMS personnel arrive, the Front Desk will tell them any additional information that has been obtained. If necessary, the Lehman Caves Emergency Response (Appendix H) will be followed.

The park employee/VIP that is at the scene of the incident will remain calm and attend to the patient with the level of training that s/he is certified at. The patient should be kept warm and in a position of comfort. EMS kits at three locations in the cave (Gothic Palace, Lodge Room, and Grand Palace) may be used. The rest of the tour group should stay clear of the area. If anyone in the tour group has medical training, they may be able to assist to the first aid level.

b. Injuries to Visitors

The desired future condition for injuries is to have as few possible in the cave. Rangers will warn of low ceilings, as bumped heads appear to be one of the main injuries in the cave. If a visitor gets injured in the cave, first determine if the injury is Minor or Major (if in doubt declare Major). If minor ask visitor if they request EMS response, if yes see above, if no then no further action is required. If employee thinks that EMS may be required, even if visitor refuses, call for an EMS response. Transfer the responsibility to personnel with EMS training. If necessary, the Lehman Caves Emergency Response (Appendix H) will be followed.

c. Lost Person

The desired future condition is to have no lost people in the cave. Visitors on tours will not get lost unless they purposefully separate themselves from a tour. If a ranger is notified or realizes that a person is missing from their tour, they will notify LCVC front desk immediately. If there is a reporting party, that party will stay with the ranger until search and rescue personnel arrive to fill out a Lost Person Questionnaire. Another park employee will come to help escort the rest of the group out of the cave. The LCVC Front Desk personnel will call Lake Mead (LAKE) dispatch 702-293-8998, and the Lehman Caves Emergency Response (Appendix H) will be followed.

d. Fire

The desired future condition for fires is to have none in or near the cave. If an electrical fire in the cave occurs, stay calm, and evacuate the cave. The lights will likely be off, so keep your group calm and have them use their flashlights or cell phones to help get out of the cave. If a wildfire or building fire occurs in close proximity to the cave, evacuate the cave immediately, as the smoky air may infiltrate the cave and make breathing difficult. Keep the group together and calm and proceed to a safe area. Keep in communications with the Incident Commander or designated person.

e. Active Shooter

If an active shooter situation arises in the cave or Visitor Center, the basic principle to keep in mind is: Run, hide, fight.

f. Other

For any other emergency situations, contact LAKE dispatch 702-293-8998 for Visitor and Resource Protection (V&RP) staff to respond.

g. Resource damage

The desired future condition for Lehman Caves is to protect it with no damage to it. If a ranger sees resource damage happening on the tour, attempt to stop further damage from occurring. As soon as possible, contact LAKE dispatch for V&RP staff to respond. If you have any information on the person or persons that caused the damage, relay that information to LAKE dispatch and responding V&RP staff. Do not place yourself in any danger.

If resource damage is noticed that has already occurred and the perpetrators are not present, contact LAKE dispatch as soon as possible. Note the location, and if possible take a photo of it. Try to keep additional damage from occurring.

V & RP staff will follow the Federal Cave Resource Protection Act of 1988 (FCRPA) and ARPA and potentially NAGPRA for prosecuting those found to be causing resource damage in Lehman Caves. Penalties under FCRPA include imprisonment and fines.

4.15 Timeline for Implementation

The items included in Section 4 have been divided into three categories: Actions already in-place, Actions to start within the next four years (with current or proposed funding), and Actions to start after four years (no current or proposed funding) (Table 7).

Table 7. Timeline for implementation for action items identified in Section 4 of the Lehman Caves Management Plan. In parentheses are references to the sections above where the reader can find more information.

Category	Currently In Place or within Fiscal Year	FY2020-2024	FY2025 and beyond
Safety	• Read and follow JHAs (4.1.a) • Use proper PPE (4.1.a) • Conduct annual cave rescue training (4.1.a) • Offer CPR and first aid training (4.1.a) • Carry radio (4.1.a) • Share safety messages to visitors (4.1.b) • Clean nonslip surfaces (4.2.a)	• Install better communications (4.1.c) • Move cave repeater inside cave and wire to visitor center (4.1.c) • Improve trail lighting (4.2.b)	• Create fire break/thinning above the cave (5.0)
Infrastructure	• Replace cave tunnel doors (4.2.c) • Inspect cave entrance biennially (4.2.e) • Inspect tunnels biennially (4.2.f) • Install carpet in tunnel and clean weekly (4.2.g) • Hold annual lint camps (4.2.h) • Conduct annual algae cleaning (4.2.h) • Conduct annual cave pool cleaning (4.2.h) • Clean cave trail on limited basis (4.2.h) • Ensure cave key accountability (4.2.l)	• Thoroughly clean trails, focusing on tread (4.2.a) • Add additional tread to cave trails where needed (4.2.a) • Install lint curbs (4.2.a & 4.2.g) • Improve trail and feature lighting (4.2.b) • Remove old cave lighting systems (4.2.b) • Add West Room door to restore airflow (4.2.c) • Extend Sunken Garden platform (4.2.d) • Improve tunnel lighting (4.2.f) • Elevate Cypress Swamp-Grand Palace trail (4.2.d) • Elevate King's Bathtub trail (4.2.d) • Install grates outside tunnels (4.2.g) • Clean cave trail weekly/monthly (4.2.h) • Install permanent decon stations (4.2.i)	• Investigate holograms (4.2.j) • Install Intrusion Detection System (4.2.l)
Visitation, Interpretation, Education	• Conduct up to 20 tours per day (4.3.a) • Offer 30, 60, 90-minute tours (4.3.b) • Offer limited LED lantern tours (4.3.b) • Hold annual formal training (4.3.d) • Conduct WNS visitor screening and decon (4.3.g) • Update LCVC exhibits (4.3.f) • Allow cave reservations online (4.3.h) • Record all visitors who enter cave (4.3.k) • Use social media to share information about cave (4.3.i)	• Conduct a carrying capacity study (4.3.a) • Offer additional types of tours (4.3.b) • Add cave staff (4.3.c) • Invite tribes to share perspective for training (4.3.d) • Produce video of cave for training purposes (4.3.d) • Offer virtual cave tours (4.3.e) • Install outdoor TV for WNS message (4.3.g) • Conduct distance learning (4.3.j)	• Install additional exterior exhibits about the cave (4.3.f)

Biological Resources	• Limit disturbance to bats (4.4.a) • Maintain quiet under the natural entrance (4.4.a) • Maintain bat partnerships (4.4.a) • Monitor bat use (4.4.a) • Share information about biological resources (4.4.a) • Conduct WNS surveillance (4.4.b) • Conduct climate monitoring (4.4.b) • Conduct invertebrate monitoring (4.4.c) • Have human-wildlife protocols in place (4.4.d) • Leave animal carcasses in place (4.4.e)	• Design exhibits about bats (4.4.a) • Fill bat data gaps (4.4.a) • Discuss possible WNS closures (4.4.b) • Install permanent decontamination stations (4.2.i) • Encourage more biological research in cave (4.4.c)	
Cultural Resources	• Entrance area off limits (4.5) • Leave historic artifacts in place (4.5) • Tours will be quiet under the natural entrance (4.5)	• Assess soils above entrance tunnel (4.5) • Remove excess stone from entrance room (4.5) • Fully document historic resources (4.5) • Submit National Register of Historic Places application (4.5)	
Geologic Resources	• Develop SOPs for cave restoration (4.6.b) • Repair speleothems (4.6.b)	• Conduct photo monitoring (4.6.a) • Remove old trail debris from cave (4.6.b) • Encourage more paleontological research (4.7)	
Other	• Continue to allow scientific research in cave (4.8) • Monitor cave climate (4.9) • Continue partnerships with NSS and other organizations (4.10) • Allow after-hours tours on paved trail allowed (4.11) • Allow off-trail trips with guidelines (4.11) • Allow exploration, no speleothems broken (4.11) • Allow photography and special use permits (4.12) • Update cave map (4.13) • Coordinate with Visitor and Resource Protection for all emergency situations (4.14)	• Encourage more research in cave (4.8) • Seek highly detailed cave map with plan, profile, and cross sections (4.13)	

5.0 Surface Management

The only developments above Lehman Caves are the Mountain View Nature Trail and the bat cupola at the natural entrance. No other development (e.g., buildings, utility corridors, roads) will be allowed above Lehman Caves.

Best management practices for Integrated Pest Management will be followed as possible. Herbicides are not currently used above Lehman Caves. If non-native plants that can be treated with herbicides start growing above the cave, Resource Management will review the herbicide information and decide if it can be delivered in a targeted manner.

Fire retardant has been shown to add nutrients to cave systems, which can affect cave biota. No fire retardant or foam will be allowed uphill of Lehman Caves for 800 m, which is 450 m past the Prospect Mountain Quartzite-Pole Canyon Limestone contact (Figure 45). No retardant will be released between 114° 14’ 00’’ and 114° 13’10” W and 39°0’0” N and 39°0’30” N. The GRBA Fire Management Plan will be revised to reflect this new no-retardant area.

No water bucket drops will be allowed over the natural entrance or 30 m uphill to protect cultural resources in the natural entrance area.

This area is within the Wildand-Urban Interface and restricting fire retardant and bucket drops may have an impact on protecting the Lehman Caves Visitor Center. However, it should be remembered that the cave is millions of years old and can’t be replaced, while the visitor center is a non-historic building with a limited lifespan.

It is recommended that some thinning uphill of the cave be completed to help create a fire break.

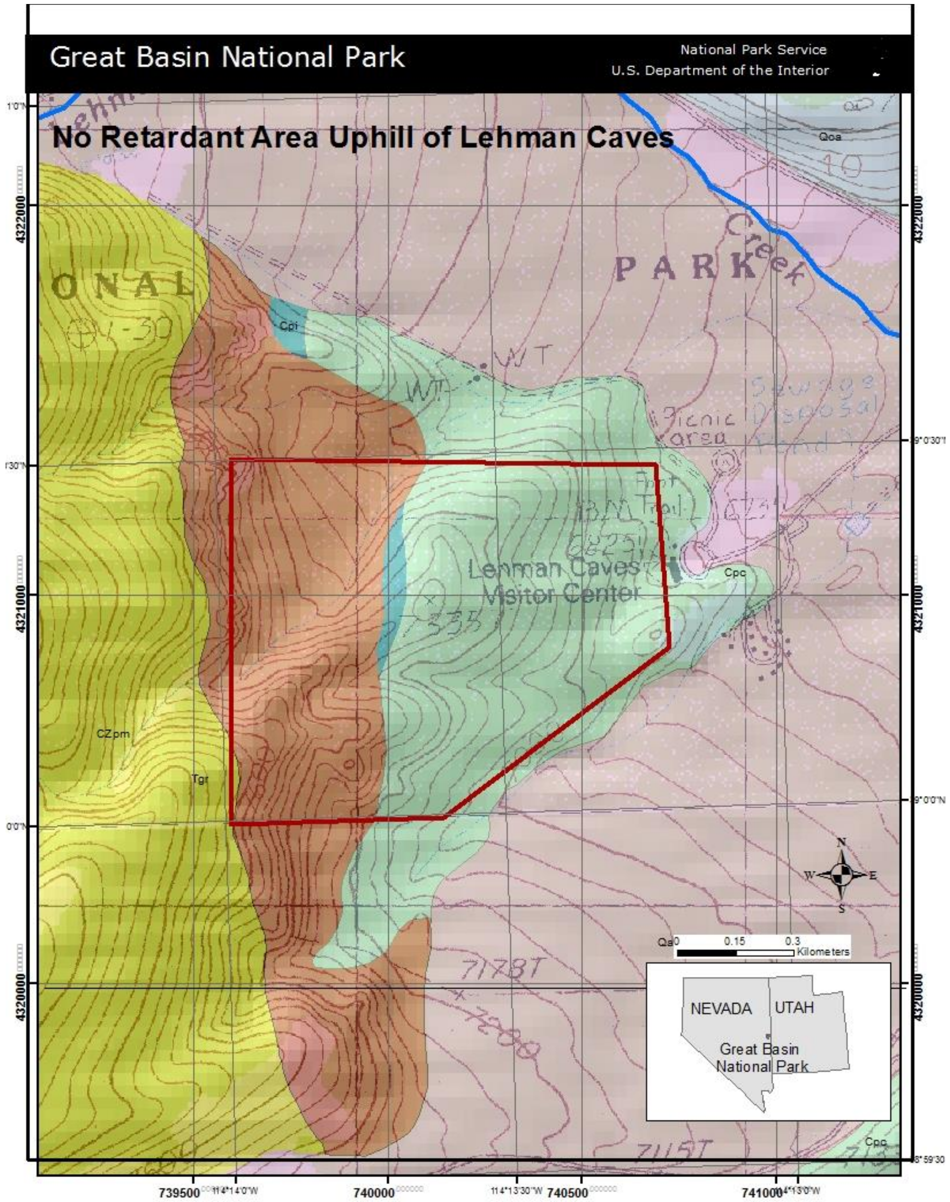

Figure 45. No fire retardant area near Lehman Caves is outlined in red to protect from runoff of fire retardant into the millions-of-years-old cave.

6.0 Adaptive Management

Cave management decisions will be based on the most current knowledge and science available. If new knowledge or research shows a different result than what is in this plan, the plan will be modified. Some areas of Chapter 4.0 (e.g., carrying capacity and bats) refer to studies that may be conducted to develop recommendations for cave management.

In addition, earthquakes, flash floods, wildfires, or other events may cause a need to adapt this plan given the circumstances.

Any member of the GRBA Management Team can call for an update of the plan at any time. Any updates will be approved by the Management Team.

7.0 Plan Updates

The Lehman Caves Management Plan will be updated every five years. The Chief of Resource Management is responsible for convening a meeting every five years to determine if and how the plan needs to be updated.

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Appendix A: Lehman Caves National Monument Proclamation

LEHMAN CAVES NATIONAL MONUMENT, PROCLAMATION (NO. 1618), JANUARY 24, 1922

BY THE PRESIDENT OF THE UNITED STATES OF AMERICA

A PROCLAMATION

[No. 1618—Jan. 24, 1922—42 Stat. 2260]

WHEREAS, certain natural caves, known as the Lehman Caves, which are situated upon partly surveyed lands within the Nevada National Forest in the State of Nevada, are of unusual scientific interest and importance, and it appears that the public interests will be promoted by reserving these caves with as much land as may be necessary for the proper protection thereof, as a National Monument.

NOW, THEREFORE, I, Warren G. Harding, President of the United States of America, by virtue of the power in me vested by section two of the Act of Congress approved June eight, nineteen hundred and six, entitled, "An Act for the preservation of American antiquities", do proclaim that there are hereby reserved from all forms of appropriation under the public land laws, subject to all prior valid adverse claims, and set apart as a National Monument, all tracts of land in the State of Nevada shown as the Lehman Caves National Monument on the diagram forming a part hereof.

The reservation made by this proclamation is not intended to prevent the use of the lands for National Forest purposes under the proclamation establishing the Nevada National Forest, and the two reservations shall both be effective on the land withdrawn but the National Monument hereby established shall be the dominant reservation and any use of the land which interferes with its preservation or protection as a National Monument is hereby forbidden.

Warning is hereby given to all unauthorized persons not to appropriate, injure, deface, remove, or destroy any feature of this National Monument, or to locate or settle on any of the lands reserved by this proclamation.

IN WITNESS WHEREOF, I have hereunto set my hand and caused the seal of the United States to be affixed.

DONE at the City of Washington this twenty-fourth day of January, in the year of our Lord one thousand nine hundred and twenty-two, [SEAL] and of the Independence of the United States of America the one hundred and forty-sixth.

WARREN G. HARDING.

By the President:
CHARLES E. HUGHES,
Secretary of State.

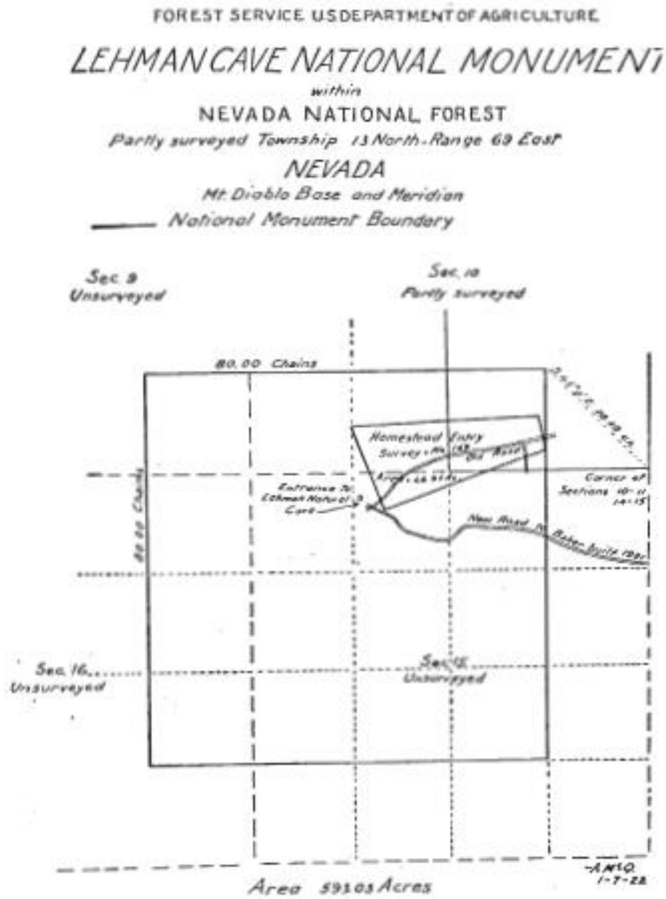

DIAGRAM FORMING A PART OF PROCLAMATION DATED JANUARY 24, 1922

Appendix B: Great Basin National Park Designation

Public Law 99-565
99th Congress

An Act

To establish a Great Basin National Park in the State of Nevada, and for other purposes.

Oct. 27, 1986
[S. 2506]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Great Basin National Park Act of 1986.

SHORT TITLE

SECTION 1. This Act may be known as the "Great Basin National Park Act of 1986". 16 USC 410mm note.

ESTABLISHMENT

SEC. 2. (a) In order to preserve for the benefit and inspiration of the people a representative segment of the Great Basin of the Western United States possessing outstanding resources and significant geological and scenic values, there is hereby established the Great Basin National Park (hereinafter in this Act referred to as the "park"). 16 USC 410mm.

(b) The park shall consist of approximately seventy-six thousand acres, as depicted on the map entitled "Boundary Map, Great Basin National Park, Nevada," numbered NA-GB 20,017, and dated October 1986. The map shall be on file and available for public inspection in the offices of the National Park Service, Department of the Interior, and the Office of the Superintendent, Great Basin National Park, Nevada. Public information.

(c) Within 6 months after the enactment of this Act, the Secretary of the Interior (hereinafter in this Act referred to as the "Secretary") shall file a legal description of the park designated under this section with the Committee on Interior and Insular Affairs of the United States House of Representatives and with the Committee on Energy and Natural Resources of the United States Senate. Such legal description shall have the same force and effect as if included in this Act, except that the Secretary may correct clerical and typographical errors in such legal description and in the map referred to in subsection (a). The legal description shall be on file and available for public inspection in the offices of the National Park Service, Department of the Interior. Public information.

(d)(1) The Lehman Caves National Monument, designated on January 24, 1922, by Presidential proclamation under the authority contained in the Act of June 8, 1906 (34 Stat. 225) is hereby abolished and the lands incorporated within the Great Basin National Park. Any reference in any law, map, regulation, document, record, or other paper of the United States to such national monument shall be deemed to be a reference to Great Basin National Park.

(2) Any funds available for purposes of the national monument shall be available for purposes of the park.

ADMINISTRATION

Conservation. Fish and fishing. Wildlife. 16 USC 410mm-1.

SEC. 3. (a) The Secretary shall administer the park in accordance with this Act and with the provisions of law generally applicable to units of the national park system, including the Act entitled "An Act to establish a National Park Service, and for other purposes," approved August 26, 1916 (39 Stat. 535; 16 U.S.C. 1-4). The Secretary shall protect, manage, and administer the park in such manner as to conserve and protect the scenery, the natural, geologic, historic, and archaeological resources of the park, including fish and wildlife and to provide for the public use and enjoyment of the same in such a manner as to perpetuate these qualities for future generations.

(b) The Secretary shall permit fishing on lands and waters under his jurisdiction within the park in accordance with the applicable laws of the United States and the State of Nevada, except that he may designate zones where, and periods when, no fishing may be permitted for reasons of public safety. Except in emergencies, any regulations prescribing such restrictions relating to fishing, shall be put into effect only after consultation with the appropriate State agency having jurisdiction over fishing activities.

(c) After notice and opportunity for public hearing, the Secretary shall prepare a management plan for the park. The Secretary shall submit such plan to the Committee on Interior and Insular Affairs of the United States House of Representatives and with the Committee on Energy and Natural Resources of the United States Senate within three years after the enactment of this Act. Such plan may be amended from time to time. The plan shall include, but not be limited to, provisions related to grazing within the park to the extent permitted under subsection (e) and provisions providing for the appropriate management of fish and wildlife and fishing within the park in accordance with subsection (b). Such provisions shall be adopted only after consultation with the appropriate State agency having jurisdiction over fish and wildlife.

(d) Subject to valid existing rights, Federal lands and interests therein, within the park, are withdrawn from disposition under the public lands laws and from entry or appropriation under the mining laws of the United States, from the operation of the mineral leasing laws of the United States, and from operation of the Geothermal Steam Act of 1970, as amended.

30 USC 1001 note.

(e) Subject to such limitations, conditions, or regulations as he may prescribe, the Secretary shall permit grazing on lands within the park to the same extent as was permitted on such lands as of July 1, 1985. Grazing within the park shall be administered by the National Park Service.

(f) At the request of the permittee, or at the initiative of the Secretary, negotiations may take place at any time with holders of valid existing grazing permits on land within the park, for an exchange of all or part of their grazing allotments for allotments outside the park. No such exchange shall take place if, in the opinion of the affected Federal land management agency, the exchange would result in overgrazing of Federal lands.

(g) Existing water-related range improvements inside the park may be maintained by the Secretary or the persons benefitting from them, subject to reasonable regulation by the Secretary.

(h) Nothing in this Act shall be construed to establish a new express or implied reservation to the United States of any water or water-related right with respect to the land described in section 2 of this Act: *Provided*, That the United States shall be entitled to only that express or implied reserved water right which may have been associated with the initial establishment and withdrawal of Humboldt National Forest and the Lehman Caves National Monument from the public domain with respect to the land described in section 2 of this Act. No provision of this Act shall be construed as authorizing the appropriation of water, except in accordance with the substantive and procedural law of the State of Nevada.

(i) In order to encourage unified and cost-effective interpretation of the Great Basin physiographic region, the Secretary is authorized and encouraged to enter into cooperative agreements with other Federal, State, and local public departments and agencies providing for the interpretation of the Great Basin physiographic region. Such agreements shall include, but not be limited to, authority for the Secretary to develop and operate interpretive facilities and programs on lands and waters outside of the boundaries of such park, with the concurrence of the owner or administrator thereof. State and local governments.

ACQUISITION OF LAND

SEC. 4. (a) The Secretary may acquire land or interests in land within the boundaries of the park by donation, purchase with donated or appropriated funds, or exchange, but no such lands or interests therein may be acquired without the consent of the owner thereof. Lands owned by the State of Nevada or any political subdivision thereof may be acquired only by donation or exchange. 16 USC 410mm-2.

(b) Lands and waters, and interests therein, within the boundaries of the park which were administered by the Forest Service, United States Department of Agriculture prior to the date of enactment of this Act are hereby transferred to the administrative jurisdiction of the Secretary to be administered in accordance with this Act. The boundaries of the Humboldt National Forest shall be adjusted accordingly.

AUTHORIZATION OF APPROPRIATIONS

SEC. 5. (a) Not more than $800,000 are authorized to be appropriated for development of the park. 16 USC 410mm-3.

(b) Not more than $200,000 are authorized to be appropriated for acquisition of lands and interests in land within the park.

Approved October 27, 1986.

LEGISLATIVE HISTORY—S. 2506:

SENATE REPORTS: No. 99-458 (Comm. on Energy and Natural Resources).
CONGRESSIONAL RECORD, Vol. 132 (1986):
Sept. 30, considered and passed Senate.
Oct. 6, considered and passed House, amended.
Oct. 9, Senate concurred in House amendments.

Appendix C: Lehman Caves Water Chemistry Data

From Prudic and Glancy 2009

Dissolved constituent	Sunken Garden Pool, 09-06-07, 10:30
Silica	45.0
Aluminum	<0.0016
Born	0.144
Iron	<0.006
Manganese	E0.0002
Strontium	1.03
Calcium	48
Magnesium	20.9
Sodium	25.4
Potassium	3.49
Carbonate	<1.0
Bicarbonate	E250
Sulfate	20
Chloride	14.5
Bromide	0.12
Fluoride	0.39
Nitrate as NO23	2.83
Dissolved solids	323
Dissolved inorganic carbon	E206
Alkalinity	E210
Hardness	210

Nutrient	Sunken Garden Pool, 09-06-07, 10:30
Ammonia as nitrogen (filtered)	<0.02
Nitrate + nitrite (filtered)	0.64
Nitrite as N (filtered)	E0.001
Total nutrient nitrogen as N (filtered)	0.94
Total nutrient nitrogen as N (unfiltered)	0.94
Phosphorus (filtered)	0.048
Orthophosphate as P (filtered)	0.052
Total phosphorus as P (unfiltered)	0.051

Appendix D: 2015 Lehman Caves Visitation Data

Visitor Statistics FY2015

	30 MIN TOURS				60 MIN TOURS				90 MIN TOURS				EDUCATIONAL/SCHOOL TOURS				Educational Programs		TOTAL VISITORS ON CAVE WALKS
Month	Avail	Went	Visitors	Hours	Avail	Went	Visitors	Hours	Avail	Went	Visitors	Hours	Given	Visitors	Hours	Fee Waivers	Times	Visitors	
Oct	124	4	8	8	62	70	956	1434	62	70	1185	2370	4	73	146	4	0	0	2222
Nov	39	3	6	6	3	14	139	208.5	42	42	525	1050	1	28	56	1	0	0	698
Dec	37	4	8	8	0	0	0	0	37	32	265	530	0	0	0	0	0	0	273
Jan	39	5	14	14	0	0	0	0	39	33	275	550	0	0	0	0	0	0	289
Feb	36	8	25	25	0	1	16	24	36	42	482	964	0	0	0	0	0	0	523
Mar	102	9	23	23	48	49	561	841.5	57	63	835	1670	0	0	0	0	0	0	1419
Apr	120	9	15	15	60	68	979	1468.5	60	84	1505	3010	1	25	50	1	0	0	2524
May	134	3	6	6	92	94	1181	1771.5	92	116	2174	4348	23	549	1098	23	0	0	3910
Jun	150	6	10	10	150	144	2246	3369	150	153	3064	6128	7	148	296	7	0	0	5468
Jul	155	8	19	19	155	162	2722	4083	155	189	3705	7410	2	36	72	2	0	0	6482
Aug	155	8	10	10	155	146	2074	3111	155	164	3013	6026	0	0	0	0	0	0	5097
Sep	127	9	17	17	81	92	1604	2406	81	131	2480	4960	2	50	75	2	0	0	4151
TOTALS	**1218**	**76**	**161**	**161**	**806**	**840**	**12478**	**18717**	**966**	**1119**	**19508**	**39016**	**40**	**909**	**1793**	**40**	**0**	**0**	33056

	Evening Programs				Ranger Led Hikes					Campground/Trail Roves								
	Lehman	#	Wheeler	#	Bistle		Ranger's		Casual	Bristle	Rove			GRBA For		Patio Talks		Astronomy
	CG	Given	CG	Given	Cone	Times	Choice	Times	Visitor Contacts	Times	Visitors		Times	Kids	Times	Visitors	Times	Viewing
Oct	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	0
Jan	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	0
Apr	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	0
May	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	484
Jun	0	0	0	3	14	0	0	0		8	339		12	67	13	107	0	0
Jul	0	0	0	7	40	0	0	0		7	260		19	163	12	333	0	0
Aug	0	0	0	2	28	0	0	0		3	189		15	125	13	133	0	1600
Sep	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	3897
TOTALS	**0**	**0**	**0**	**12**	**82**	**0**	**0**	**0**	**0**	**18**	**788**	**0**	**46**	**355**	**38**	**573**	**0**	**5981**
	AV Presentations LCVC				AV Presentations		Off Site Program		On Site Programs	Visitor Center		Park's	Total	Total	Total	Visitor Info Request		

	Park		Ranger		GBVC		Meetings		Programs		Hours of Oper		Total	Visitor	LCVC	GBVC	General		GBVC
	Film	Visitors	Minutes	Visitors	Shown	Visitors	Visitors	Times	Visitors	Times	LVCV	GBVC	Visits	Hours	Visits	Visits	Mail	E-Mail	Map Talks
Oct	160	648	140	560	83	291	0	0	0	0	279	136.5	7595	56768	8429	1161	4	3	38
Nov	108	394	96	325	0	0	0	0	0	0	246.5	0	3847	17653	3539	2054	13	0	0
Dec	68	209	52	171	0	0	0	0	0	0	246.5	0	2364	10834	2060	787	10	0	0
Jan	56	167	48	143	0	0	0	0	0	0	255	0	945	4062	586	992	28	57	0
Feb	85	272	74	236	0	0	0	0	0	0	238	0	2485	8960	1843	1304	25	44	0
Mar	146	644	139	607	0	0	0	0	0	0	263.5	0	2972	13861	2461	1716	32	24	0
Apr	156	675	141	562	0	0	0	0	0	0	285	126	7667	42259	5415	4860	22	22	0
May	189	941	169	781	118	383	0	0	0	0	268	254	21314	301893	21882	13470	8	12	0
Jun	173	835	160	752	123	368	0	0	0	0	255	285	14993	246149	18771	10203	13	4	61
Jul	148	797	142	782	114	413	0	0	0	0	263.5	294.5	21314	301893	21882	13470	8	4	50
Aug	133	642	126	618	108	365	0	0	0	0	263.5	294.5	20616	297545	15411	9027	3	0	61
Sep	147	587	137	563	172	531	0	0	0	0	258.5	273.5	20016	178680	19701	12687	6	0	54
TOTALS	**1569**	**6811**	**1424**	**6100**	**718**	**2351**	**0**	**0**	**0**	**0**	**3122**	**1664**	**126128**	**1480557**	**121980**	**71731**	**172**	**170**	**264**

Appendix E: Lehman Caves Fauna

Table 12. Fauna of Lehman Caves.
Records are all from the present study (Taylor et al. 2008) unless otherwise indicated.

Cyanobacteria
  Myxophyceae
    Anacystis montana (Stark 1969)
    Schizothrix calcicola (Stark 1969)
    Oscillatoria sp. (Stark 1969)
    Anabaena sp. (Stark 1969)
Eubacteria (Stark 1969)
Proteobacteria
  Betaproteobacteria
    Burkholderiales
        Leptothrix sp. (Desert Research Institute 1968)
    Rhodocyclates
      Rhodocyclaceae
        Zoogloea ramigera (Desert Research Institute 1968)
Amoebozoa
  Mycetozoa
    Dictyostelia
      Dictyosteliidae
        Dictyostelium sp. (Desert Research Institute 1968, Stark 1969)
  Myxomycoa
    Stemonitomycetes
      Stemonitidae
        Stemonitis sp. (Desert Research Institute 1968, Stark 1969)
unidentified fungus (Went, undated; Sheps 1972, Stark 1969)
Basidiomycota
  Agaricomycetes
    Agaricales
      Marasmiaceae
        Marasmius sp. (Desert Research Institute 1969)
Chytridiomycota (Desert Research Institute 1968, Stark 1969)

Bryophyta
  Bryopsida
    Dicranales
      Bruchiaceae
        Bruchia sp. (Sheps 1972)
    Hypnales
      Amblystegiaceae
        Campylium chrysophyllum (Sheps 1972)
    Funariales

Funariaceae
Physcomitrium sp. (Sheps 1972)
Hepatophyta
Jungermanniopsida
Jungermanniales
Metzgeriales
near *Metzgeria* sp. (Desert Research Institute 1968, Stark 1969)
Pteridophyta
Filicopsida
Polypodiales
Dryopteridaceae
Cystopteris fragilis (Stark 1969)
Aspleniaceae
Asplenium sp. (Stark 1969)
Chlorophyta
Chlorophyceae
Mugeotiopsis calospora (Stark 1969)
Chlorococcum humicola (Stark 1969)
Protococcum viridis (Stark 1969)
Nannochloris sp. (Stark 1969)
Roya anglica (Stark 1969)
Cosmarium sp. (Stark 1969)
Chlorella vulgaris (Stark 1969)
Coccomyxa dispar (Stark 1969)
Palmella miniata (Stark 1969)
Bacillariophyta
Bacillariophyceae
Naviculales
Naviculaceae
Navicula spp. (Stark 1969)
Centrales
Coscinodiscoideaee
Coscinodiscus sp. (Stark 1969)

Protozoa
Lobosa
Arcellinida
Difflugiidae
Curcubitella sp. (Desert Research Institute 1968)
Amoebida
Amoebidae
Amoeba sp. (Desert Research Institute 1968)
Vahlkampfidae
Vahlkampfia sp. (Desert Research Institute 1968)
Heliozoa

Actinophryidae

Actinosphaeridae

Actinosphaerium sp. (Desert Research Institute 1968)

Euglenozoa

Euglenida

Euglenales

Peranemataceae

Peranema sp. (Desert Research Institute 1968)

Ciliophora

Ciliatea

Peritrichida

Lagenophryidae

Lagenophrys nassa (Desert Research Institute 1968)

Litostomatea

Cyclotrichida

Mesodiniidae

Mesodinium acarus (Desert Research Institute 1968)

Haptorida

Enchelyidae

Rhopalophrya sp. (Desert Research Institute 1968)

Oligohymenophorea

Peniculida

Parameciidae

Paramecium sp. (Desert Research Institute 1968)

Sessilida

Vorticellidae

Vorticella sp. (Desert Research Institute 1968)

Oligotrichida

Strombidiida

Strombidiidae

Strombidium viridae (Desert Research Institute 1968)

Phyllopharyngea

Chlamydodontida

Chilodonellidae

Chilodonella sp. (Desert Research Institute 1968)

Spirotrichea

Euplotida

Euplotidae

Euplotes sp. (Desert Research Institute 1968)

Sporadotrichida

Oxytrichidae

Oxytricha sp. (Desert Research Institute 1968)

Urostylida

Urostylidae

Urostyla sp. (Desert Research Institute 1968)

Uncertain Placement (?Nematoda?)
Annelida
    Oligochaeta (Desert Research Institute 1968)
Arthropoda
    [undetermined arthropod fragments]
    Crustacea
        Isopoda
            Malacostraca
                Porcellionidae (2009)
    Arachnida
        Acari
            [undetermined Acari]
        Oribatida
            Oribatidae (Desert Research Institute 1968, Stark 1969)
            Rhagidiidae
        Pseudoscorpiones
            Neobisiidae
                Microcreagris grandis (present study, Muchmore 1969, Desert Research Institute 1968, Stark 1969, Schmitz 1986)
        Araneae
            [undetermined Araneae] (present study, Desert Research Institute 1968, Stark 1969)
            Agelenidae
                [undetermined Agelenidae]
                Hololena? sp.
            Araneidae
                Hypsosinga? sp.
            Dictynidae
            Pholcidae
                Physocyclus? sp.
    Symphyla
        Scutigerellidae?
            Hanseniella? sp.
    Diplopoda
        Polydesmida
            Macrosternodesmidae
                Nevadesmus ophimontis (Shear 2009)
    Hexapoda
        Collembola
            [undetermined Collembola]
            Arrhopalitidae
                undetermined (Desert Research Institute 1968 – see Krejca and Taylor 2003)
                Arrhopalites sp.
                Arrhopalites caecus
                Pygmarrhopalites shoshoneiensis Zeppellini

Entomobryidae
Entomobrya marginata (Stark 1969)
Entomobrya sp. 2
Hypogastruridae
Acherontiella sp.
Isotomidae
Folsomia sp.
Oncopoduridae
Oncopodura sp.
Onychiuridae
Tullberginae
Onychiurinae
Poduridae (Desert Research Institute 1968)
Tomoceridae
Tomocerus sp.
Microcoryphia
Orthoptera
Rhaphidiophoridae
Ceuthophilus hebardi
Psocoptera
Prionoglaridae
Speleketor sp.
Psyllipsocidae
Psyllipsocus sp. (Desert Research Institute 1968, Stark 1969)
Coleoptera
Cryptophagidae (present study, Desert Research Institute 1968)
Staphylinidae
Tenebrionidae
Hymenoptera
Formicidae
Lepidoptera
Tineidae
prob. *Amydria* sp. (Desert Research Institute 1968, Stark 1969)
Diptera
[undetermined Diptera]
Calliphoridae
Ceratopogonidae
Culicoides sp. (Desert Research Institute 1968, Stark 1969)
Heleomyzidae
undetermined Heleomyzidae
Pseudoleria sp. ((Desert Research Institute 1968)
Phoridae
Megaselia sp. (Desert Research Institute 1968, Stark 1969)

Megaselia necpleuralis Disney (Disney et al. 2011)
Psychodidae
Psychoda sp. (Desert Research Institute 1968, Stark 1969)
Sciaridae
undetermined Sciaridae
Bradysia sp. (Desert Research Institute 1968, Stark 1969)
Camptochoeta prolixa Vilkaama
Sphaeroceridae
Streblidae (Desert Research Institute 1968, Stark 1969)
Chordata
Aves
Galliformes
Phasianidae (Orr 1952 – see Krejca and Taylor 2003)
Mammalia
Rodentia
Erethizonitidae
cf. *Erethizon* sp. (Mead 1980 – see Krejca and Taylor 2003)
Cricetidae
Neotoma sp. (present study, Desert Research Institute 1968, Stark 1969)
Muridae
Peromyscus maniculatus (Desert Research Institute 1968, Stark 1969)
Reithrodontomys sp. (Mead 1980 – see Krejca and Taylor 2003)
Sciuridae
Tamias sp. (Mead 1980 – see Krejca and Taylor 2003)
Tamias dorsalis (Desert Research Institute 1968, Stark 1969)
Marmota cf. *flaviventris* (Mead 1980 – see Krejca and Taylor 2003)
Lagomorpha
Cf. *Sylvilagus* sp. (Mead 1980 – see Krejca and Taylor 2003)
Primates
Hominidae
Homo sapiens (Orr 1952)
Carnivora
Canidae
Canis latrans (Orr 1952)
Vulpes? sp. (Orr 1952)
Chiroptera
Vespertilionidae
Myotis evotis evotis Long-eared myotis
Myotis volans Long-legged myotis
Corynorhinus townsendii pallescens Townsend's big-eared bat
Lasionycteris noctivagans Silver-haired bat
Euderma maculatum Spotted bat

Appendix F: Annotated Bibliography of Research

Biology studies

Muchmore, W. B. 1962. A new cavernicolous pseudoscorpion belonging to the genus Microcreagris. Postilla 70:1-6.

Muchmore described a cave specimen collected by Monument custodian T. O. Thatcher in 1936 as a new species of pseudoscorpion, *Microcreagris grandis*. This species has been found in other caves in the southern Snake Range, but nowhere else to date.

Desert Research Institute. 1968. Final reports on the Lehman Caves studies to the Department of the Interior, National Park Service, Lehman Caves National Monument. The Laboratory of Desert Biology, Desert Research Institute, Reno, Nevada. 57 pp.

Stark studied organisms at varying distances from lights and included a list of biota found in the cave. Wheelers examined invertebrates and also included a list of biota. Ralston studied mammals in the cave. He set 40 Sherman live-traps in the cave on four trapping nights in June 1968 and caught three deer mice (*Peromyscus maniculatus*). The traps were set again for three nights in November 1968, and he caught eight cliff chipmunks (*Eutamias dorsalis*) and three deer mice.

Went, F. W. 1969. Fungi associated with stalactite growth. Science 166:385-386.

A fungus, *Cepahlosporim lamellaecola*, was found to be regularly associated with the active tip of stalactites; crystallization of $CaCO_3$ occurred on hyphae suspended from the stalactite wall in the terminal drop. Although 42 out of 46 cultures from stalactite tips produced *Cephalosporium*, of the 100 microorganisms developing on helictites, not a single one was that fungus.

Sheps, Lilian. 1972. The effects of photoperiod and some microenvironmental factors on plant growth in Lehman Cave, Nevada. Bulletin of the National Speleological Society, 34(1): 14-25.

Adding lights caused plants to grow in the cave. Those with a 12-hr photoperiod grew more than those with a 6-hr photoperiod or the intermittent cave lights. Plants also grew better in the cave than in the lab.

Taylor, S. J., J. K. Krejca, and M. E. Slay. 2008. Cave biota of Great Basin National Park, White Pine County, Nevada. Illinois Natural History Survey, Champaign, Illinois. Center for Biodiversity Technical Report 2008 (25) 398 p. Link

This cave bioinventory brought trained cave biologists to the park. They set up fifteen paired stations throughout Lehman Caves, with one station on-trail and one station off-trail. Bait was applied to a rock at the station, then the station was revisited 24 hours later to assess what had been attracted to within one-meter of the station. In addition, microhabitat data was collected during each assessment. This study was repeated by park staff monthly for the next year. Results showed that most specimens were found near the entrance, which is also the same area as highest visitation in the cave. The sampling periods with the highest number of specimens was September though January. White and grey springtails dominated the overall number of specimens counted. While grey springtails were more common closer to the entrance, white springtails increased in abundance when more than 200 meters from the nearest entrance, indicating they may be more cave adapted. There was no clear trend in proximity to trail except for the pseudoscorpion *Microcreagris grandis* and millipede *Nevadesmus ophimontis*, which were both notably more abundant far from the trail than near it.

Shear, W. A., S. J. Taylor, J. J. Wynne, J. K. Krejca. 2009. Cave millipeds of the United States. VIII. New genera and species of polydesmid millipeds from caves in the southwestern United States. Zootaxa 2151:47-65. Link

The millipede *Nevadesmus ophimontis* was found in Lehman Cave, along with several other park caves. It is a new genus of millipede. It was originally found on the side of the cave trail by the Queen's Bathtub.

Disney, R. H. L., S. J. Taylor, M. E. Slay & J. K. Krejca. 2011. New species of scuttle flies (Diptera: Phoridae) recorded from caves in Nevada, USA. Subterranean Biology 9: 73-84. Link

In 2010, a fly was collected under the natural entrance and it was discovered to be a new species, *Megaselia necpleuralis*.

Vilkamaa, Pekka, Heikki Hippa, and Steven Taylor. 2011. The genus *Camptochaeta* in Nearctic caves, with the description of *C. prolix* sp. n. (Diptera, Sciaridae). ZooKeys 135:69-75. Link

In 2006, flies from Lehman Caves as well as two nearby caves were examined and determined to be a new species, *Camptochaeta prolixa*.

Unpublished bat research

More bat research has been conducted in Lehman Caves recently. In 2014, exit counts documented up to 75 bats exiting the cave through the natural entrance. Thirty-four bats were captured with mist nets – two long-legged myotis and 32 Townsend's big-eared bats. Many of these bats were juveniles and lactating females, suggesting that Lehman Caves is being used as a maternity roost. Acoustic surveys revealed two additional species – hoary bat and Mexican free-tailed bat – foraging near the cave entrance (Horner and Hamilton 2014-The Midden).

In 2015, a PIT-Tag reader was installed at the cave entrance. This device records the numbers of any bats with PIT tags implanted. The information will allow park staff to better understand how long individual bats use the cave, preferred times of exit and entry, and seasonal use.

Geology studies

Curry, H. D. 1936. Geology of Lehman Caves National Monument. Park Files. Baker, NV. 20 p.

The first geology report of the cave was by Monument Custodian H. Donald Curry in 1936. He stated that, "Lehman Caves are limestone caverns…Tens of thousands of years ago..the first stage in their development began." He also mentions that in one of the larger chambers (probably the Inscription Room), large sandbars nearly fill the room and are now covered with a layer of dripstone. His description of speleothem formation is fairly accurate..

Moore, G. W. 1960. Summary report on the geology of Lehman Caves National Monument, Nevada. Unpublished USGS report to park. Menlo Park, California. 11 p.

The author noted that "The upper surface of the water (the water table) lay at the ceiling of the caves." He added, "The origin of the caves might best be considered as the extended steeping and slow solution of marble in slightly acid water over a period of tens of thousands of years." He goes on to add that after the cave passages were formed, a small stream entered the cave and deposited silt, sand, and gravel in various parts of the cave, with especially thick deposits in the Inscription Room. Moore notes that the limestone dips 20 degrees to the west, and since the cave is horizontal, the cave must be geologically very young, having formed within the last one to five million years. His description of speleothems contains more science, describing the chemical reaction that allows for calcite to form. He notes that the growth rate of stalactites broken 50 years ago appears to be an inch per hundred years (Moore 1960).

Bullock, K. C. 1960. Geology of the Talus Room, Lehman Caves. Park Files. Baker, NV. 8 p.

Bullock stated that the Talus Room measured 385 feet long, with a maximum width of 65 feet, and a maximum height of about 80 feet. The ceiling is composed of three high domes and one lower dome, separated by three low arches. He maps six main high-angle faults. He posits that rock fell in the Talus Room due to movement along one or more of the high-angle faults. He states, "The Talus Room can be regarded as being perfectly safe for visitors to the Lehman Caves."

Cloues, Philip. 1996. Trip report – Inspection of Lehman Cave Talus Room, Great Basin National Park (GRBA), April 10 &11, 1996. Geologic Resources Division, National Park Service, Denver, CO. 9 p.

This trip report summarizes previous documents about the unstable rock mass in the Talus Room. The rock mass known as the Roadmap showed signs of movement from 1978-81. Mine Safety and Health Administration inspectors in November 1981 said the danger was serious and "action should be taken immediately to either remove the hazardous material or attempt to stabilize the entire mass." As a mining engineer, Cloues states that the "structural control by faults, joints, and fractures moves the stability of the room closer to that of a mine..than a traditional solution cave system." He reiterates the options available for the Talus Room and his report includes Shafer's 1982 map of the room.

Hose, Louise. 2018a. The geologic story of Lehman Caves. Report for Great Basin National Park. Baker, NV. 13 p.

Hose, Louise. 2018b. Notes on the geology of Lehman Caves from a November 2017 Reconnaissance Trip – Part I Geologic Setting. Report for Great Basin National Park. Baker, NV. 13 p.

Hose, Louise. 2018c. Notes on the geology of Lehman Caves from a November 2017 Reconnaissance Trip – Part II Cave Geology. Report for Great Basin National Park. Baker, NV. 18 p.

Hose, Louise. 2018d. Notes on the geology of Lehman Caves from a November 2017 Reconnaissance Trip – Part III Thoughts on future work and needs. Report for Great Basin National Park. Baker, NV. 3 p

Hose visited Lehman Caves numerous times in 2017-18 to update and refine Lehman Cave's geologic story. She found more indications of a hypogenic origin of the cave and also looked into condensation corrosion, which appears to be affecting cave walls and speleothems in various locations throughout the cave.

Jasper, Jon. 2000. Paleo-hydrology and airflow studies of Lehman Caves, Nevada. Great Basin National Park files, Baker, NV. 21 p.

Jasper measured scallops at 20 locations throughout the cave and calculated water flow velocities. Direction of flow was also noted and resulted in a map showing water flowing from the Gypsum and Behman Annex areas out through the natural entrance and Lodge room areas. In addition, a flow route was noted from north of the Gothic Palace area out the Civil Defense passage. Airflow was measured in 13 locations in the cave, and the airflow path was mapped. The main path is through the natural entrance and towards the Talus Room. Additional airflow was encountered near the natural entrance exiting the cave and in the Behman Annex.

Shakun, J. D., S. J. Burns, P. U. Clark, H. Cheng, and R. L. Edwards. 2011. Milankovitch-paced Termination II in a Nevada speleothem? Geophysical Research Letters 38. L18701. Link

Using data from a stalagmite collected at Lehman Caves in 2004, the authors question the timing of the Termination II in Devil's Hole, Death Valley.

Cross, M., D. McGee, W. S. Broecker, J. Quade, J. D. Shakun, H. Cheng, Y. Lu, and R. L. Edwards. 2015. Great Basin hydrology, paleoclimate, and connections with the North Atlantic: A speleothem stable isotope and trace element record from Lehman Caves, NV. Quaternary Science Reviews 127: 186-198.

Stalagmite records from Lehman Caves cover the T-II period, which generally replicates Shakun's data. In addition, isotope results are given, and interpretations of large-scale temperature changes are given.

Steponaitis, E., A. Andrews, D. McGee, J. Quade, Y.Hsieh, W. S. Broecker, B. N. Shuman, S. J. Burns, and H. Cheng. 2015. Mid-Holocene drying of the US Great Basin recorded in Nevada speleothems. Quaternary Science Reviews 127: 174-185.

Looking at more recent history using stalagmites, the authors find that mid-Holocene drying that complements recent lake-level studies. They suggest that the reason for this drying has more to do than orbital controls.

Climate studies

Stark, N. 1969. Microecosystems in Lehman Cave, Nevada. National Speleological Society Bulletin, 31(3): 73-81.

Studies of light intensity, air temperature, relative humidity, soil moisture, and drying power of air were made at different distances from six light types. The organisms present were identified, and trophic levels were described for twelve microecosystems. Of the 200 light studied, 78% had algae, 21% had mosses, 75% had fungi, 21% had springtails, and 32% had various dead and live flies.

Desert Research Institute. 1968. Final reports on the Lehman Caves studies to the Department of the Interior, National Park Service, Lehman Caves National Monument. The Laboratory of Desert Biology, Desert Research Institute, Reno, Nevada. 57 pp.

Went studied mass air movements in the cave using a rich condensation nucleus recorder and a small particle counter. Hallett measured wind flow in the cave. He noted that blocking the natural entrance and opening the tunnel entrance may have led to a significant reduction in the humidity in the cave. Bamberg studied daily and seasonal variation in the environment of the cave, summarized below.

Bamberg, Samuel. 1973. Environments in Lehman Caves, Nevada. Bulletin of the National Speleological Society 35(2):35-47.

In 1968 and 1972, carbon dioxide concentrations of the air were monitored with an infrared gas analyzer in the Gothic Palace. In addition, air samples were collected throughout the caves in large plastic bags and analyzed for CO_2 content. CO_2 was generally highest in June-July at 1040 ppm and decreased to December to 390 ppm. The lowest concentrations were found near the entrance, with concentrations increasing towards the Talus Room. Air flow into the cave decreased the CO_2 concentrations. It was also noted that the cave dried out during this time, so less CO_2 would be released from water dripping off speleothems.

Quinn, Joyce A. 1988. Relationship between temperatures and radon levels in Lehman Caves, Nevada. The NSS Bulletin 50:59-63.

Quinn found that the error value was too great to determine a steady relationship between temperatures and radon levels in Lehman Caves.

Baker, G. M. 2011. Environmental Monitoring in Lehman and Model Caves, Great Basin National Park. Presentation at National Speleological Society annual meeting, Glenwood Springs, Colorado.

From 2006-2010, six temperature dataloggers were placed throughout Lehman Caves (Natural Entrance, Queen's Bathtub, Cypress Swamp, Talus Room, Behman Annex, and West Room) and monitored and analyzed. The dataloggers logged between five months (Behman Annex) and 43 months (Queen's Bathtub) of complete data.
Cave temperatures were found to be consistently warmer than the mean annual outside temperature by 1-4°C. No obvious differences were found in monthly mean temperatures at datalogger locations near vs. far from the tourist trail, nor between high season and low season months.

Shakun, J. D., S. J. Burns, P. U. Clark, H. Cheng, and R. L. Edwards. 2011. Milankovitch-paced Termination II in a Nevada speleothem? Geophysical Research Letters 38. L18701, doi:10.1029/2011GL048560

The brief speleothem record of Termination 11 from Lehman Caves appears to disagree with the nearby Devil’s Hole vein calcite record, as do other regional climate records during Termination 1.

Lachniet, M. S., R. F. Denniston, Y. Asmerom, and V. J. Polyak. 2014. Orbital control of western North America atmospheric circulation and climate over two glacial cycles. Nature Communications 5 (3805): 1-8.

A 175,000-year oxygen isotope record from precisely-date speleothems is presented that documents a previously unrecognized and highly sensitive link between Great Basin climate and orbital forcing. The data documents a strong precessional-scale Milankovitch forcing of southwestern paleoclimate. They state that the reappearance of large lakes in the Great Basin is unlikely until ca. 55,000 years into the future.

Cross, M., D. McGee, W. S. Broecker, J. Quade, J. D. Shakun, H. Cheng, Y. Lu, and R. L. Edwards. 2015. Great Basin hydrology, paleoclimate, and connections with the North Atlantic: A speleothem stable isotope and trace element record from Lehman Caves, NV. Quaternary Science Reviews 127: 186-198.

We present a record of speleothem stable isotope (d_{18}O, d_{13}C) and trace element (Mg/Ca, Sr/Ca) variations from Lehman Caves, Nevada for an interval of time (139e128 ka) that encompasses the penultimate glacial termination, Termination II (T-II). Our T-II d_{18}O record broadly replicates that of the Shakun et al. (2011) and Lachniet et al. (2014) records of this time, recording low values from 139 to 135 ka followed by an approximately 3.5‰ increase over an extended interval between 134 and 129 ka. our record broadly follows the marine termination, rising boreal summer insolation, and the rise in atmospheric CO_2.

Steponaitis, E., A. Andrews, D. McGee, J. Quade, Y.Hsieh, W. S. Broecker, B. N. Shuman, S. J. Burns, and H. Cheng. 2015. Mid-Holocene drying of the US Great Basin recorded in Nevada speleothems. Quaternary Science Reviews 127: 174-185.

Stable isotope and trace metal data from two Lehman Caves speloethems provide a well-dated record of hydroclimate between 16.4 ka and 3.8 ka, with a hiatus from 15.0 ka to 12.7 ka. Both Mg/Ca and δ^{13} indicate a wet period a the beginning of the record, followed by pronounced drying after 8.2 ka. The results suggest that Great Basin water balance in the early Holocene was driven by factors other than orbital changes.

Lachniet, Matthew S., and Chad M. Crotty. 2017. Lehman Caves are likely older than 2.2 million years. Report to park from Department of Geoscience, University of Nevada-Las Vegas.

Using Sigma 234 Uranium dating technique, they found that the oldest stalagmite in the cave to be at least 2.21 Million years old, meaning that the age of the cave is older than that.

Cultural studies

Wheeler, S. M. 1938. Archeological and Paleontological Studies at Lehman Caves National Monument, Nevada. Report to Superintendent. 23 p.

Small excavation and collect the bones that were being found during the tunnel construction. A total of 95 human bones were found.

Rozaire, C. 1964. The archeology at Lehman Caves National Monument. Nevada State Museum Report.

From September 22 to October 8, 1963, 19 pits were dug, covering about 30% of the soil surface of the room. The lowest deposits were fluvial and encompassed the animal bones (see section 2.10 Paleontology), as well as some human bones. A total of 65 pieces of human bones were found from throughout the deposits. Rozaire notes that it is interesting that none of the individuals who ended up in the cave had any artifactual associations

McManamon, Francis P. 1998. Notices. Federal Register 63(77):19940-19942.
In 1998, the bones removed from the cave were repatriated into the entrance area according to provisions of the Native American Graves Protection and Repatriation Act (NAGPRA), 43 CFR 10.9 (e). A detailed assessment of the human remains was made by NPS staff in consultation with the Confederated Tribes of the Goshute Reservation, Duckwater Shoshone Tribe of the Duckwater Reservation, Ely Shoshone Tribe of Nevada, Kaibab Band of Paiute Indians, and Skull Valley Band of Goshute Indians (Federal Register 1998). A wall was built around the remains, sealing them from disturbance.

Harwood, D. 2015. Sign in: The writing on the wall. The Midden. 15(1):6-7.

David Harwood has undertaken recording and researching the historic signatures in the cave. He has found about 2,000 signatures in the cave and recorded the medium with which they were made

Paleontological studies

Wheeler, S. M. 1938. Archeological and Paleontological Studies at Lehman Caves National Monument, Nevada. Report to Superintendent. 15 p.
Small excavation and collect the bones that were being found during the tunnel construction. A total of 219 animal bones were found.

Rozaire, C. 1964. The archeology at Lehman Caves National Monument. Nevada State Museum Report.

From September 22 to October 8, 1963, 19 pits were dug, covering about 30% of the soil surface of the room; 483 animal bones were found.

Santucci, V. L., A. L. Koch, and J. Kenworthy. 2004. Paleontological resource inventory and monitoring, Mojave Desert Network. National Park Service Technical Information Center (TIC), Denver, Colorado, USA. Document D-305.

This report summarizes what Wheeler (1938) and Rozaire (1964) found with regards to animal bones, with 219 and 483 respectively, encompassing more than 30 species.

Bell, G. L. 2015. Lehman Cave - Paleontological Assessment. Park files. Baker, NV. 2 p.

Throughout the length of the Lost River Passage, discrete but slightly scattered piles of small reddish rodent bones, mostly *Peromyscus* were found. The sediments in the tunnel are mostly clay with sandy particles and occasional clusters or associations of white chalky marmot bones. At one location they recovered a portion of a partially articulated marmot skull. At another location they recovered a thin flashing of travertine deposited on top of the sediment that also contained fragments of chalky white bone. The combination of soft white bone condition and a flashing of travertine capping the sediment strongly suggests that the bones in the sediment are very old and possibly of Pleistocene age.

Appendix G: Job Hazard Analyses (JHAs)

JOB HAZARD ANALYSIS - FORM 1.1

JOB HAZARD ANALYSIS (JHA)		Date: 11/19/15	☐ New JHA ☒ Revised JHA
Park Unit: Great Basin National Park	**Division:** Planning & Resources	**Branch:** Natural Resources	**Location:** Earth
JOB TITLE: Wild Cave Entry		**JHA Number: NRMCave-1**	**Page 1 of 5**
Job Performed By:	**Analysis By:** G. Baker/B. Roberts	**Supervisor:**	**Approved By:** Tod Williams
Required Standards & General Notes:	Call-in time established prior to the trip; Back travel country plan; Trip leaders must be trained and prepared for trip type. First aid kit located along travel route. Never enter a cave alone. Perform GAR to assess team skill level.		
Required PPE:	UIAA approved helmet, 3 light sources, knee-pads , elbow-pads, gloves, boots with good soles and ankle support, warm clothing, chemical heat pack, compact first aid kit, three forms of communication required.		
Tools & Equipment:	Side-mounted pack, adequate drinking water, adequate quick-energy food supply, extra batteries, watch, cave maps, compass, hand-line.		

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
Planning Cave Trip	Lack of leadership and communication. Failing to establish a reliable surface watch and reasonable call-in time. Planning a caving trip that will exceed the abilities of any team member. These abilities include physical condition, technical skills and psychological aspects.	1) One person for each trip will be designated as the trip leader. This person is responsible for providing leadership and clear communication concerning safety, minimizing impact to the cave resource and achieving the trip goals. Ensure that trip plans are within the range of all team members. 2) Discuss trip plans with team members and make sure each member understands the trip plans, is prepared to meet the challenges of the trip in terms of physical condition, technical skills and psychological aspects. 3) Establish a reliable surface contact person and reasonable call-in time. 4) Ensure designated surface watch and LE informed when conducting surveys in remote sections of cave and/or backcountry caves.

JOB HAZARD ANALYSIS - FORM 1.1

JHA—CONTINUATION SHEET	JHA number: NRMCave-1	Page 2 of 5
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**
Preparing Equipment	Not bringing proper equipment to achieve the planned objectives.	Trip members will make sure they have the proper personal equipment for the trip. Trip leader will supply protocol-specific checklist of necessary equipment.
	Equipment worn, broken or inoperable due to lack of proper maintenance.	Each trip member is responsible for regularly checking, cleaning and ensuring their caving equipment is in proper working order.
	Team member not knowing how to properly use caving equipment.	All team members will have the training and knowledge as to proper usage of each piece of equipment used for their specific trip.
Entering Cave	Entrance Zone Animals	While in the cave entrance area be alert for skunks, venomous snakes, spiders, and other wildlife. Avoid treading on accumulated guano or middens.
	Rock fall	Due to high fluctuation in temperature and moisture, some entrances areas can be prone to loose rocks. Move carefully and thoughtfully so as not to dislodge rocks.
Horizontal Caving (general)	Exposed climbs	Always use three points of body contact on cave surfaces to minimize risk of falling. Where feasible, use a hand-line or belay.
	Slippery surfaces / Falling	Wear good traction boats and a caving helmet with a chinstrap. Move in a controlled manner to avoid falling. When climbing, test all holds to ensure that they can withstand the force being placed upon them.
	Low/small areas	Trip leaders should ensure all members are able to negotiate low/small areas on caving route. Remain calm and think through what one must do to get passage is key. Never descend head-first through low/small areas that slope steeply downward.

JOB HAZARD ANALYSIS - FORM 1.1

JHA—CONTINUATION SHEET	JHA number: NRMCave-1	Page _3___ of __5__
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**
Horizontal Caving (general	Exertion / Exhaustion	Discuss length and duration of trip prior to heading into the cave. Team member need cave-specific physical conditioning. Push your endurance limit in gradual increments. Avoid overloading your pack; be creative to reduce weight and bulk. Prior to the trip, the trip leader should inquire about people with known physical conditions and treatment needs. Groups should avoid overexertion, and should stop at least every hour to eat and drink. Group speed should be tailored to the slowest member of the team. Should the trip become too much for one team member, the trip plan will be modified to assure the safety of all members. Perform a GAR prior to cave entry.
	Temperature related issues	Ensure team members are appropriately dressed for continued movement – a long-sleeved shirt and durable pants are usually sufficient and prevent overheating. Ensure team members have cold temperature clothing in their packs such as a balaclava and long-sleeved polypropylene shirt. Explain to team members about the colder temps while not moving and the necessity of wearing these items to prevent hypothermia. Keeping clothing dry.
	Dehydration	Team members will hydrated before entering the cave and carry sufficient water or electrolyte replacement drinks during the trip to maintain a proper hydration and avoid cramps.

JOB HAZARD ANALYSIS - FORM 1.1

JHA—CONTINUATION SHEET	JHA number: NRMCave-1	Page _4___ of __5__
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**
Horizontal Caving (general	Interior Rock Fall	Team members should stay aware of and locate themselves in areas where they will not be exposed to rockfall from other members above them. Should a team member accidentally dislodge a rock or drop equipment they will clearly yell "Rock!" to inform others of the impending danger. Team members below should be alert and step away (not look up). All team members will wear a caving helmet with a chinstrap when in an area with the potential for rockfall.
Wading	Total submersion	When possible, monitoring in cave streams and rivers should be performed during the dry season so that water levels and flooding potential are low (and visibility high). Check weather reports before performing monitoring in cave streams. Be aware of antecedent conditions: consider current soil saturation. If there is a high chance of heavy rain in the surrounding area the trip should be postponed. Always work in areas with adequate air space between the water surface and the cave ceiling. Know alternative exit routes.
	Hypothermia	When wading use neoprene socks and pants to keep warmed film of water in contact with skin. Chemical heaters that last for 8-10 hr are highly recommended to deal with hypothermia. A heat tab stove can be used to heat up water or a hot meal for energy and warmth. Performing physical exercise, e.g., hands and knees crawling, is a good way to warm someone up.

JOB HAZARD ANALYSIS - FORM 1.1

JHA—CONTINUATION SHEET	JHA number: NRMCave-1	Page _5___ of __5__
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**
Injuries	Minor	Self-rescue using compact first aid kit in pack or in caches.
	Major	When possible, at least one team member stays with injured party while other team member(s) goes for help. A SPOT device will expedite emergency assistance notification. Contact info of LE Ranger on duty should be known beforehand. Backcountry travel plan should be submitted prior to trip.
Overdue party	Potentially Lost	A surface watch will be established prior to embarking. This person should be briefed on what time to expect the team to return (or call-in) and whom to contact in the event the team does not exit on time. Location of the team, number of participants and travel route maps will be made available. If the team becomes lost, they will remain where they are and wait for the surface watch to notify search & rescue.
Emergency Evacuation Instructions	Team members are responsible for developing and discussing field emergency evacuation procedures (EEP) and alternatives in the event a team member becomes seriously ill, lost or injured.	Be prepared to provide the following: a. Nature of the accident or injury. b. Type of assistance needed. c. Location of accident or injury, best access route into the worksite (trail or road name/ number), Identifiable ground/air landmarks. d. Radio frequencies. e. Contact person. f. Local hazards to vehicles or aviation. g. Weather conditions. h. Topography. i. Number of individuals to be transported. j. Estimated weight of individuals for air evacuation.

JOB HAZARD ANALYSIS - FORM 1.1

JHA—CONTINUATION SHEET	JHA number: NRMCave-1	Page _5___ of __5__
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**
Air Quality	High CO2 levels, especially during the summer . This is due largely to the limited movement of fresh air . Changes in barometric pressure, prevailing winds, and temperature all help air turnover	Air Flow is the most important factor determining air quality in the cave. Local and regional weather patterns should be considered when planning. in LMC. Know the warning signs of overexposure to CO2 and an O2 deprived environment. Headaches, shortness of breath, nausea, drops in energy levels, and lethargy are all warning signs. It is important to have cave team members monitor each other for these signs. Exit cave immediately upon any team member experiencing the above signs. If the cave has a history of high CO2 levels, bring a hand held CO2/air quality monitoring device.

JOB HAZARD ANALYSIS – FORM 1.1

JOB HAZARD ANALYSIS (JHA)		Date: 8/06/2015	☐ New JHA ☐ Revised JHA
Park Unit: GRBA	Division: Maintenance	Branch:	Location: Park Wide
JOB TITLE: Rehab. Lehman Cave		JHA Number:	Page ______of ______
Job Performed By: Maintenance	Analysis By: Patrick Pollard	Supervisor: Glen Dearden	Approved By: Glen Dearden
Required Standards and General Notes:	Follow Lockout-tag-out procedures. Inform 764 and front desk of work being performed and of completion of work performed.		
Required Training:			
Required Personal Protective Equipment:	Eye protection, Gloves, minimum of two lights, voltage sensors meters and lockout-tag out kit.		
Tools and Equipment:	Hand tools, volt meters.		

Sequence of Job Steps	Potential Hazards/Injury Sources	Safe Action or Procedure
Identify and label all sources of hazardous energy. De-energize electrical circuits. Discharge capacitors. Lockout and tag-out all forms of hazardous energy including electrical breaker panels, control valves, etc. make sure that only one key exists for each of your assigned locks and that only you hold that key. Verify by test and/or observation that all energy sources are de-energized. Inspect repair work before removing your lock and activating the equipment. Make sure that only you and your co-workers are clear of danger points before re-energizing the system. Wear insulated gloves when testing an energized panel.	Shock and electrocution Slippery rocks and shifty rocks. Complete Darkness.	Follow lockout tag-out procedures. Climb and descend slowly, wear boots with good traction, look before you step and be aware of loose rocks. Always carry no fewer than two light sources. If all light sources fail, make radio contact with 764 or front desk.

Injury Source for the middle column: SB= Struck-By, SA = Struck-Against, CBY = Contacted-By, CI = Caught-In, CB = Caught-Between, CO = Caught On, FB = Fall-to-Below, CW = Contacted-With, O = Overexertion or Repetitive Motion, FS = Fall-to-Surface, BR = Bodily reaction, E = Exposure to Chemical, Noise, etc.

Appendix H: LEHMAN CAVE EMERGENCY PROCEDURES

Below are recommended procedures only. Every cave rescue will differ since actions depend on the situation!

1. Get report of incident. (Usually the Front Desk will receive this report as either a radio call or someone from a cave tour reporting it.)

-Find out what is wrong and where.

-Keep contact with the reporting party.

2. Contact LAKE dispatch. 702-293-8998 or on radio by 700. Give all known information.

3. Dispatch requests appropriate resources for incident. For example: "All SAR team members please respond to the VC Auditorium for a carryout."

4. IC role filled. The first person in charge (often Law Enforcement or Lead Interpreter) will be designated the Incident Commander until a more qualified person arrives. This person should be capable of organizing the completion of all below duties.

5. Entrance control established. Each person who enters or exits the cave is logged, along with all the gear taken into cave. The entrance control person will ideally be located right at the door to either the entrance or exit tunnel, and the other door will be secured.

6. Hasty team (or Initial Response Task Force (IRT)) enters cave. This properly equipped team (helmets, headlamps, leather gloves) should include an EMT and must remember to sign in with entrance control. This team's mission is to find and stabilize the patient and send a report including patient vitals to the surface. Ideally this team will have a map of the cave with them so that they can mark where they have searched.

7. All other people in cave evacuated. This includes other tours if they will hamper the rescue.

8. All actions documented. All radio communications, decisions made by the IC, gear requested, etc. should be documented. Forms for cave rescue are available from law enforcement, Ben, and Gretchen. Other SAR forms (or even blank paper) can be substituted as needed.

9. Additional equipment obtained. Equipment may include litters, blankets, medical supplies, headlamps, and helmets.

10. Additional Hasty Teams/IRTs sent into cave as needed.

11. Litter and litter team sent to patient.

12. Communication maintained between cave rescuers and surface personnel throughout rescue. This communication can be done via radios or runners. Every pertinent communication should be documented. Additional needs, such as an ambulance, should be requested as needed.

13. Entrance control logs all the rescuers as they exit cave and communicates to IC/Ops when everyone has exited cave. If someone has not exited the cave, then that person must be found before the operation ceases.

14. Debrief. After the patient has been transferred to the ambulance and all rescuers have exited the cave, the IC will call for a quick debrief. A more formal review may take place at a later date, but a debrief immediately following the incident is essential while everyone's memories are fresh.

15. Collect all documentation. All logs should be collected by the IC.

16. Get home safely. Keep in mind that often the most dangerous part of a rescue is afterwards when you are tired. Eat, drink, and rest as needed.

YOUR SAFETY IS OF THE UTMOST IMPORTANCE DURING ANY RESCUE!

WATCH OUT FOR YOURSELF.

WATCH OUT FOR YOUR FELLOW RESCUERS.

WATCH OUT FOR THE PATIENT

SOP1: Cave Cleaning

Version 1.0, March 20, 2017

Introduction

This SOP gives instructions for regular maintenance cleaning in Lehman Caves. People entering the cave inadvertently bring in dirt, dust, lint, and other debris, which is unnatural for the cave environment and cause alterations of cave processes as well as reduced visitor satisfaction.

Equipment

Standard caving gear (required for off trail, recommended for on trail):

- Helmet with mounted lights
- Boots
- Kneepads
- Gloves

Cleaning Equipment:

- Vacuum
- Broom/Dust pan
- Trash bags

Data recording:

- Cave map showing cave trail
- Pen/sharpie
- Camera

Timing and Location of the Cleaning

Cleaning will be divided into three categories: weekly, monthly, and annually. The weekly cleaning is expected to take one person one hour. The monthly cleaning is expected to take two people 6 hours. The annual cleaning will be conducted by lint camp volunteers overseen by park staff and time will vary from 1-3 days. The weekly and monthly cleaning will be overseen by maintenance staff, while the annual cleaning will be overseen by resource management staff with assistance from maintenance staff.

Weekly

- Vacuum carpets and floor in Entrance Tunnel.
- Sweep or vacuum outside Entrance Tunnel to remove debris that could be tracked into cave.
- Clean grates (when installed).

Monthly

- Vacuum sections of cave trail on a rotating basis, including stairs (Figure 1):
  - Entrance Tunnel to Lodge Room (months 1, 4, 7, 10)
  - Lodge Room to Exit (including all of Lodge Room) (months 2, 5, 8, 11)
  - Lodge Room to Sunken Gardens (months 3, 6, 9, 12)
- Pick up any visible trash along trail
- Wipe down handrails

Annually

- Clean out French drains (near Doghouse, two in Cypress Swamp, one in Grand Palace)
- Clean designated areas outside of the trail corridor
- Clean algae near cave lights
- Clean debris out of pools (best to clean obvious debris out of pools as soon as it's spotted)

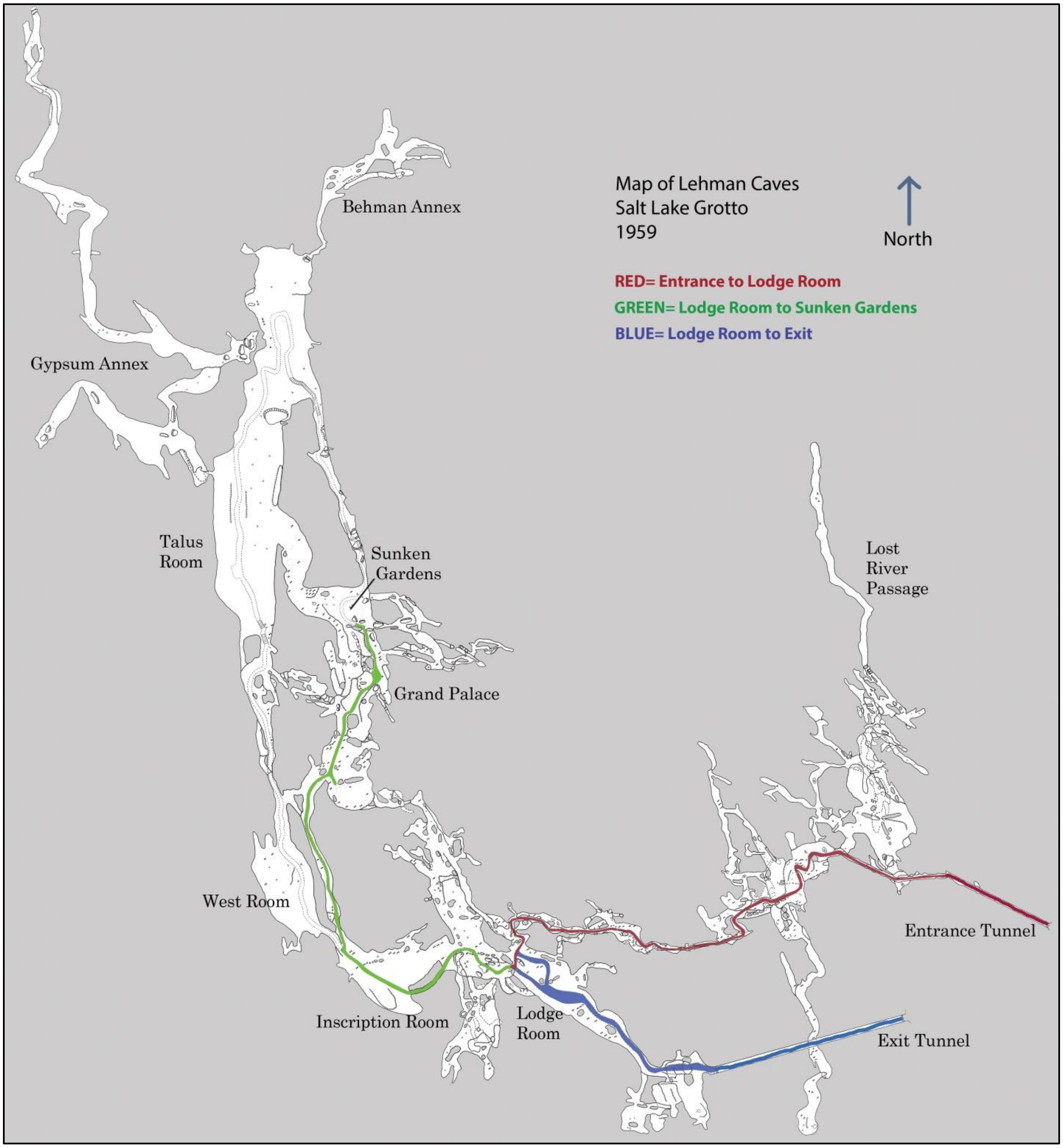

Figure 46. Map of Lehman Caves showing the three areas to be cycled through for cleaning: Entrance to Lodge Room in red, Lodge Room to Sunken Gardens in green, and Lodge Room to Exit in blue.

Safety
Safety briefings will occur before each monthly and annual cleaning trip, covering points in the caving JHA. These safety briefings will be documented.
All volunteers will sign volunteer agreements.

Conducting the Cleaning
The following steps describe the cleaning process. If bats are seen roosting in an area that is to be cleaned (most likely this would be the Entrance to Lodge Room area, but bats have been seen in many other places in the cave), then only quiet cleaning methods are to be used. Vacuuming should not be done when bats are present. Instead, come back another day, or move to another area and document the bats.

Weekly Cleaning

Step 1. Using a broom or vacuum, clean outside the entrance and exit tunnel doors to remove leaves, dust, and other debris. Clean out grates (when installed).

Step 2. Using a vacuum with a HEPA filter, clean the carpets and floor in the tunnels. Extension cords will be needed to reach throughout the tunnels. Empty filter upon completion and store vacuum.

Monthly Cleaning
Step 1. Check which section of cave is due to be cleaned. Bring in broom, vacuum, extension cord, light socket adapter, gloves to pick up trash if needed, and a small garbage bag.

Step 2. Unscrew a lightbulb and insert light socket adapter and plug in extension cord attached to vacuum.

Step 3. One person should sweep grooves in trail with the broom, the other person will vacuum along the trail.

Step 4. Empty vacuum and clean filter as needed. If visible trash is seen alongside the trail, pick it up, using gloves if necessary (e.g., with gum).

Step 5. For stairs, vacuum each step and the PVC tray under the stairs.

Step 6. When finished vacuuming, unplug vacuum cleaner and replace light bulb.

Step 6. Wipe down handrails with a moist cloth.

Step 7. Mark on map where you cleaned and any notes. Put it in the cave specialist's mailbox.

Annual Cleaning
Check for invertebrates in all areas to be cleaned. If they are seen, work around them so as not to impact them. If any historic objects are found, photograph them and leave them in place unless they pose a hazard. Notify the Cultural Resourses staff upon exiting the cave.

Step 1. Clean out French drains by taking the inner part of PVC out from the outer part. Remove cloth and replace. Remove any unnatural debris from drain. French drains are currently located near the Doghouse, two in the Cypress Swamp (by the Lake Room and towards the Grand Palace), and in the Grand Palace. Record which drains were cleaned and when.

Step 2. Clean lint outside the cave trail by using an array of brushes. Begin by gently brushing at the top of the area, brushing the lint and dust into a dust pan or bag. This is easiest to accomplish in dry areas of the cave. Remove lint from cave. Record where lint was cleaned.

Step 3. Clean algae near lights with a 10% bleach solution. Required PPE is nitrile gloves and safety glasses. Using a list of lights in the cave, proceed through the cave spraying the bleach solution on any visible algae at lights. Spray enough to cover the algae, but no so much that it starts running down cave formations. A particular patch of algae will only be cleaned after it has been carefully inspected for biota. Any biota found must be relocated outside the spray area. The diluted bleach solution will be dispensed in a hand-held spray bottle only (no tank sprayers). The diluted bleach solution will be lightly misted directly onto the algae so very little chlorine gas becomes airborne. A rag will be used to catch all bleach and algae runoff, so that no bleach runs onto other cave surfaces. Rags will be stored in plastic buckets during cleaning. Buckets will be held under ceilings being cleaned, especially over cave pools. Only small areas will be cleaned at a time to prevent buildup of chlorine gas. Record on the data sheet where algae has been treated.

Step 4. Clean cave pools by looking for unnatural debris in them and removing it. Generally forceps are a good tool to remove coins, bits of asphalt and wood, and other debris. Be careful not to fall in the pool.

Data Entry

Monthly and annual cleaning will be documented by marking on a cave map which areas of the cave were cleaned, any particularly dirty areas, and interesting items found. These marked maps will be put into the Cave Specialist’s mailbox. They will then be scanned and the data entered into an Excel spreadsheet. Scanned datasheets and spreadsheet will be kept in the RM Drive Cave folder.

SOP2: Cave Invertebrate Monitoring

Version 1.0

Introduction
This SOP gives step-by-step instructions for surveying invertebrates at established bait stations in Lehman Caves. These procedures are based on recommendations specific to Great Basin National Park (Taylor et al. 2008) and on monitoring protocols described by other entities (e.g., Krejca et al. 2010).

Equipment
Standard caving gear:

- Helmet with mounted lights
- Boots
- Kneepads
- Gloves
- Cave purse

Bait station equipment:

- Artificial substrate (flagging tape)
- Bait (peanut butter)
- Spreading implement (knife/spoon)
- Plastic bags for carrying bait and trash

Sampling Gear:

- Soil/air thermometer (e.g., Digital Pocket Thermometer)
- RH meter (e.g., Extech Presicion Psychrometer RH390)
- Water quality meter (e.g., Eutech PCS Testr35 multiparameter) meter)
- 10x hand lens
- Forceps, Paintbrush
- Small vials filled with 95% Ethanol
- Watch

Data recording:

- Field data sheet
- Meter data sheet
- Cave map showing stations
- Pencils/pens
- Camera

Timing and Location of the Survey

Surveys will occur every three months, at the end of January, April, July, and October. Fourteen paired stations, or 28 sites, have already been chosen in the cave (Figure 1). Site K has been discontinued and Site H has been switched by nearby site Z. Each of the remaining 14 sites is paired, with one on-trail and one nearby that is considered off-trail. The off-trail stations are given the double letter, for example AA.

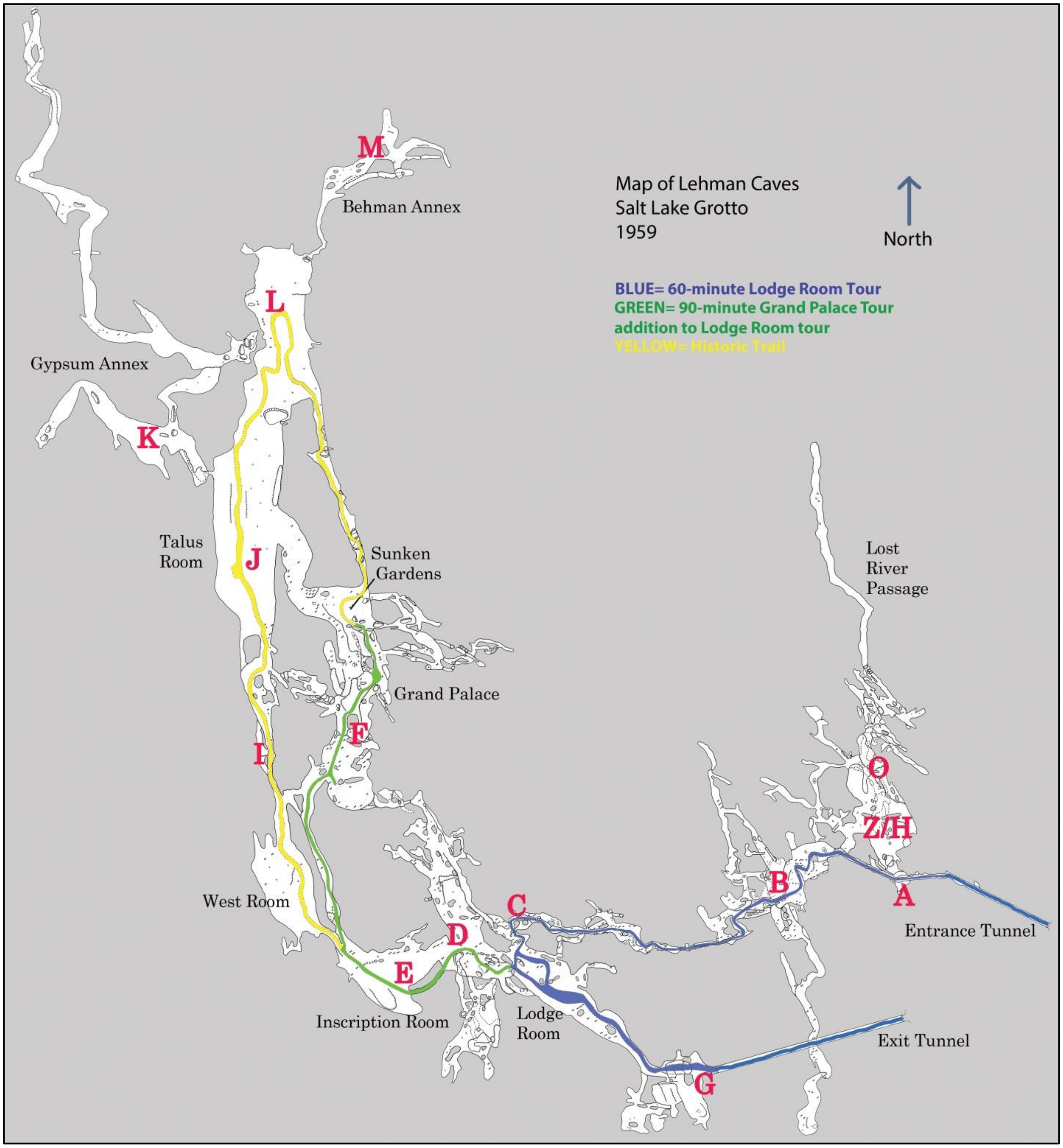

Figure 47. Map of Lehman Caves showing tour routes and cave invertebrate monitoring stations.

Safety

Safety briefings will occur before each invertebrate trip, covering points in the caving JHA. These safety briefings will be documented. While in the cave, if any member of the group does not feel comfortable at any time, they can decline going any further and will be escorted to the visitor center.

All volunteers will sign volunteer agreements.

Conducting the Survey

Field crews will enter the caves on day one of the survey to set out bait, and, if directed by the lead, conduct microhabitat data collection, water quality monitoring, and a pre-bait survey. On day two, the crew will return to do a post-bait survey, collect microhabitat and water quality data, and remove the bait. For some visits, the bait may be left for a longer period to collect additional data.
The following steps describe the sampling process.

Step 1. Upon reaching the station, put a small amount (pea-sized) of peanut butter on flagging tape about 3 inches long, fold it over, and put it under a rock.

Step 2. If directed by lead, conduct an invertebrate survey, looking around the center of the station (marked with flagging) in a radius of 1 meter. Look under rocks. Record any living organisms found, along with the microhabitat that they're found in (e.g., underside normal rock on normal soil). Use the classifications dry, normal, and wet to describe moisture level, with normal being the condition between dry and wet. Look for at least 3 minutes at each station, and record time searched. If the bait is missing, record that in the notes on the Field Data Sheet.

Step 3. If directed by lead, measure microhabitat data. Place the soil temperature thermometer 2 cm under the soil and record data when it has stabilized. Then turn the probe into the air and record air temperature. Meanwhile, place the RH meter nearby. Do not hold it in your hand or breathe near it. When the readings have stabilized, record relative humidity, wet bulb (in F), and dry bulb (in F). Record all readings on the Meter Data Sheet.

Step 4. If directed by lead, measure water quality if water is present at site. Use the multiparameter water quality meter and place it in about 10 cm of water, so the entire bottom part of the probe is submerged. When the readings have stabilized (about 3 minutes), record water temperature, conductivity, and pH. If the meter is not available, measure water temperature with the soil/air temperature meter, and take a vial of water back to the lab for analysis there. Record all readings on the Meter Data Sheet.

Step 5. On the second day, return to the cave and conduct steps 2-4. Remove the flagging with bait unless told not to.

Step 6. If any unusual invertebrates are observed, they may be collected under direction of the lead. Photographs are welcome.

Step 7. Any biota seen between stations can be recorded on the Field Data Sheet with a location description.

Data Entry

Following the survey trip, data will be entered into an Excel spreadsheet containing all previous data. The person entering the data will initial and date the datasheets to indicate they've been entered.

Original datasheets will be scanned and put into the RM Drive \CAVE RESOURCES\Cave Biota\data sheet scans

Literature Cited

Krejca, J. K., G. R. Myers, III, S. R. Mohren, and D. A. Sarr. 2010. DRAFT integrated cave entrance community and cave environment long-term monitoring protocol. Natural Resource Report NPS/KLM/NRR—2010/XXX. National Park Service, Fort Collins, Colorado.

Taylor, S. J., J. K. Krejca, and M. E. Slay. 2008. Cave biota of Great Basin National Park, White Pine County, Nevada. Illinois Natural History Survey, Champaign, Illinois. Center for Biodiversity Technical Report 2008 (25) 398 p. Link

SOP3: Contact with a Possible Rabies-infected Animal

Employee Message: Rabies positive bat from Lehman Caves

A bat from Lehman Caves recently tested positive for rabies. Although less than 1% of bats are infected with rabies, bats that are acting strangely or contact humans are ten times more likely to have rabies. Rabies is 100% preventable in humans with proper medical care, but it is almost always fatal if left untreated. Rabies is fatal in animals too, so any dead bats will be submitted to the NPS Wildlife Health Branch for diagnostic testing to help improve disease detection in the park.

Contact Resource Management staff as soon as possible if you or a park visitor observes a dead bat or witnesses a bat behaving strangely (e.g. aggressive behavior, lying on the ground or flying during the day near people). Rabies status can only be determined through laboratory testing.

If there was direct human contact with a bat, that person may have been exposed to rabies. Follow these steps:

Remember the 4 C's

1. Contact Resource Management staff to **C**ollect the bat/animal with which contact occurred. Only staff with a rabies vaccination or current titer should handle bats.
2. **C**lean the contacted area of skin thoroughly with soap and water and provide any basic first aid. Remain calm and reassuring to the visitor. Your professionalism will help ease their concerns. Contact Protection staff if needed.
3. **C**onsult your physician within 48 hours for medical care and to determine whether any post-exposure treatment is necessary. Circumstances may require post-exposure rabies vaccinations.
4. **C**ontact an NPS Public Health Officer. Provide the visitor with contact information to discuss contact and potential post-exposure prophylaxis recommendations:

    Dr. Danielle Buttke, One Health Coordinator, Office of Public Health and Wildlife Health Branch, National Park Service (970) 267-2118 or (970) 631-5084, Danielle_Buttke@nps.gov.

5. Inform supervisor and Resource Management staff of the incident.
6. If the animal was collected, Resource Management staff will submit the animal for rabies testing.

For more information:

http://www1.nrintra.nps.gov/BRMD/wildlifehealth/surveillance.cfm.

http://www.cdc.gov/rabies/exposure/

What Do I Do If I Come Into Contact With A Bat?

While the vast majority of bats in the park do not have rabies, there is a small chance that you may have contacted one with rabies. Rabies is preventable with medical treatment, but is almost always fatal if left untreated. Humans can get rabies by exposure to bat saliva through a bite or scratch.

If you had direct contact with a bat, you may have been exposed to rabies.

We advise you to take the following steps:

- ***Immediately*** clean the contacted area thoroughly with soap and water.
- ***Within 24-48 Hours*** Contact your physician to discuss any potential need for further post-exposure treatment. Indicate the kind of animal you contacted and any potential bites, scratches, or contact with saliva.

NPS Office of Public Health
Wildlife Health Branch

Turn over for additional helpful resources ☛

Additional Resources

The following resources can assist you and your physician in making decisions about the need for further follow-up or medical treatment:

Nevada Department of Health

Dr. Ihsan Azzam, M.D., MPH
Nevada State Epidemiologist
(775) 684-5911

Nevada Department of Agriculture

Dr. Anette Rink, DVM, PhD
Animal Disease and Food Safety Laboratory
(775) 353-3700 - arink@agri.nv.gov

U. S. Public Health Service

Dr. Danielle Buttke
NPS Office of Public Health
(970) 267-2118 - danielle_buttke@nps.gov

National Park Service
U.S. Department of the Interior

www.nature.nps.gov