Cave Resource Management Plan 1993

Timpanogos Cave National Monument

Table of Contents

CAVE MANAGEMENT PLAN

Timpanogos Cave National Monument

I. INTRODUCTION

A. Monument Overview

Timpanogos Cave National Monument, consisting of 250 acres, is located 35 miles southeast of Salt Lake City, Utah. The monument was established by Presidential Proclamation (Number 1640) on October 14, 1922 which stated, in part, "whereas, a natural cave, known as the Timpanogos Cave, which is situated upon surveyed lands within the Wasatch National Forest in the state of Utah, is 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."

Timpanogos Cave National Monument is located in the Wasatch Mountains, a narrow, up-faulted range extending nearly due north from central Utah into southern Idaho. Surrounded by the Uinta National Forest, the monument is situated within American Fork Canyon. The monument contains a section of the American Fork River, the associated flood plain, part of the north slope, and much of the very rugged, steep south wall from the canyon bottom up to the rim. The majority of the monument is on the north-facing slope of American Fork Canyon above 5,600 feet. The cave system itself is situated on this slope at 6,730 feet above sea level. Pre-Cambrian through Mississippian-aged rocks are exposed along the 1 ½ mile trail from the visitor center to the cave entrance (Baker and Crittenden, 1961).

Annual visitation to the monument is about 130,000. The caves are open from about mid-May to mid-September depending upon the weather and funding. Visitation to the caves is by guided tour only. Annually, 60,000 to 80,000 visitors go through the caves.

B. Purpose and Need for Plan

1. Purpose of Plan

This Cave Resource Management Plan was created to offer the maximum protection for the nonrenewable cave resources located within the monument, while at the same time allowing for public enjoyment of some of these delicate resources. This plan identifies the resource problems unique to Timpanogos Cave National Monument, establishes guidelines for monitoring of these resources, suggests appropriate actions, and directs interpretation of these resources as they relate to resource management. This plan is an appendix of the Resource Management Plan and an extension of the Monument's General Management Plan.

2. Legislative Authority & NPS Guidelines

There have been several acts and guidelines that refer to the management of natural resources and in some cases specifically to caves in the NPS, including:

a. The NPS Organic Act of 1916: Under this act the NPS is required to manage the resources in the monument to "...conserve the scenery and the natural and historic objects and the wildlife 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."

b. Federal Cave Resources Protection Act of 1988: The cave resource management goals of Timpanogos Cave National Monument are consistent with the purposes of this Act. The FCRP Act of 1988 recognized that caves are invaluable and an irreplaceable part of the nation's natural heritage. The Act has two stated purposes:

   i. To secure, protect, and preserve significant caves on Federal lands for the perpetual use, enjoyment, and benefit of all people; and

   ii. To foster increased cooperation and exchange of information between governmental authorities and those who utilize caves located on Federal lands for scientific, educational, or recreational purposes.

   The FCRP also exempts cave information from the Freedom of Information Act by establishing confidentiality of information. Finally, it establishes criminal penalties for violators of the act.

c. 43 CFR, Part 37 - Cave Management, Final Rule: This ruling implements the Federal Cave Resources Protection Act of 1988.

d. Natural Resources Inventory and Monitoring Guideline, NPS-75: Under this guideline, the National Park Service is required to use inventory and monitoring procedures to proactively manage natural resources, based upon knowledge gained from those surveys. This guideline is based upon NEPA's requirement that knowledge of resource conditions be used to direct and evaluate effects of management Decisions. It is also a requirement that "NPS employees know the nature and condition of the natural resources under their stewardship and have the means to detect and document changes in those resources, and understand the forces driving the changes, in order to fulfill the NPS mission of conserving parks unimpaired." (NPS75, p.1).

e. Natural Resources Management Guideline, NPS-77: Under this guideline, the NPS is required to manage the natural resources in such a way that they are maintained, restored, and perpetuated in order to preserve their inherent integrity. Visitors are to be allowed to enjoy these resources only when such actions don't threaten these resources or goals.

f. NPS Management Policies Handbook, 1988: One of the management policies of the NPS is that caves are to be "...managed to perpetuate their atmospheric, geologic, biological, ecological, and cultural resources in accordance with approved cave management plans... Natural drainage patterns, air flows, and plant and animal communities will be protected" (Chapter 4:20). It is a requirement that natural resources be managed to "maintain and perpetuate their inherent integrity." (Chapter 4:1).

C. General Goals of the Plan

There are four major goals of the cave management plan:

1. Increase Knowledge of the Cave System

This requires conducting hypothesis-driven research in several areas, including hydrology, structural geology, speleomorphology, biology, and mineralogy. It also calls for completion of a thorough inventory and detailed geologic map of the cave system. The entire cave system should be studied to provide a scientific basis for cave management, information for interpretation, contributions towards cave-related science in general, and to develop a source of cave resource management information for cooperating agencies.

A thorough survey and inventory of the cave system was completed in 1992, including many passages and even additional caves that were not included in earlier surveys. During this survey, the surveyed length of the cave system increased from 2,900 feet to 5,600 feet. At this time, the first detailed profile view of the cave system was also completed. Forty-two types of speleothems were identified during a detailed inventory of the caves, including possibly two new types.

Additional survey and inventory work is needed in the caves, the cave watershed, and the monument in general. These projects include studying the microbiological, insect, and mammal species using the caves. This would also involve completing a threatened and endangered species survey of the caves as well as the monument. The geology of the watershed needs to be looked at in order to help establish groundwater flow regimes. Finally, the monument should be thoroughly searched for additional karst features.

2. Establish Guidelines for Monitoring Cave Conditions

Research is currently underway to identify hydrologic and environmental characteristics of the cave system. An automated monitoring system has been installed to continue sampling throughout the cave system and to identify baseline conditions. This automated system is supplemented by manual measurements. Sampling sites, parameters, and objectives for long-term monitoring have been developed, along with sampling, downloading, storage, and analysis procedures.

3. Identify and Direct Cave Restoration Projects

The development of the cave, on-going maintenance work, and heavy yearly visitation have created significant impacts upon the cave system. Only an aggressive resource management program can mitigate previous damage and try to prevent future damage to the delicate cave system. This program involves restoring natural conditions as much as possible, reducing human impacts, and establishing a carrying capacity for the cave system.
Information from the monitoring system referred to above helps determine the effects from heavy visitor use. These effects can be mitigated in several ways so that continued visitation can be allowed. At the same time it is imperative that routine maintenance activities in the cave system follow strict guidelines. Protection of the cave system must be the guiding principle in all cases.

Natural cave climate has been partly restored by eliminating artificial airflow through the tunnels and installing bat gates on natural entrances. Some debris from earlier development has been removed from passages, but in many areas restoration would require major efforts. It would include removing blasting debris from tunnel construction that was dumped throughout the cave system, in some cases filling the floor as deep as 12-15 feet. Remnants of mining activity in Hansen Cave, the original lighting system, and graffiti are part of monument history and should remain in place.

A major component of resource mitigation in the cave system includes cleaning formations. Algal growth must be removed twice each season. Removing lint and dust is an ongoing project. The cave lighting system was updated to use lights of a wattage that does not promote algal growth. Shielding should be used to eliminate hot spots on the cave walls.

Cleaning agents have been tested in various parts of the cave system and safe methods are available for removing dust and smoke damage throughout Timpanogos Cave. This cleaning project was initiated during 1992.

Due to continued impact upon the delicate cave resources and unnecessary danger posed to maintenance employees, the lighting system was completely redesigned and is scheduled for replacement. This new system will be serviceable from the trail and is based on cave management principles. Removing all evidence of the current system and restoring these areas will be a major component of this project.

4. Provide Quality Interpretation for Visitors

Interpretation in the cave system should follow the guidelines identified in the current Statement for Interpretation. This calls for thematic interpretation, which is dynamic and creative, moving beyond the traditional fairylanding approach. Interpretation should be based on current thought and scientific facts learned from on-going research in the caves. Regulations and safety concerns must also continue as essential components of interpretive programs.

II. CAVE RESOURCES AND FACILITIES WITHIN THE MONUMENT

A. Natural Features

1. Definitions of Karst and Cave Resources

Karst can be defined either as a condition whereby the subsurface drainage is significant enough to affect surface drainage and/or where pronounced dissolution features are found on bedrock surfaces. Whether or not the karst is considered significant is the important question. If there is no surface drainage, or combinations of karst features are present, such as sinkholes, caves, springs, or surface karren, it is usually considered a significant karst. The surface expression of karst can be in the form of sinkholes, pits, karren, or springs while the subsurface expression is in the form of caves and subsurface drainage. Any related feature can be considered as a significant or insignificant karst feature or resource.

The Federal Cave Resources Protection Act of 1988 defines a cave as, "Any natural occurring void, cavity, recess, or system of interconnected passages which occurs beneath the surface of the earth or within a cliff or ledge (including any cave resource therein, but not including any vug, mine, tunnel, aqueduct, or other manmade excavation) and which is large enough to permit an individual to enter, whether or not the entrance is naturally formed or manmade. Such term shall include any natural pit, sinkhole, or other feature which is an extension of the entrance."

There are over 23 different types of caves known; however, Timpanogos Cave National Monument is likely to contain only three types: Solution, Frost Wedging, and Tectonic Caves.

2. The Timpanogos Cave System

This cave system consists of four caves (The Grotto, Hansen, Middle, and Timpanogos Cave) connected by two artificial tunnels. Although The Grotto, Hansen, and Middle Caves are geologically the same cave, no humanly-passable connection has yet been found between them. There is a little over a mile of surveyed cave passage between the three caves (5,600 feet), including 1,600 feet in Hansen Cave, 1,100 feet in Middle Cave, and 2,900 feet in Timpanogos Cave. There are seven natural entrances to the cave system, but three are currently plugged, another is gated with a door, and the remaining three have bat gates installed on them. There is a total of 185 feet of vertical relief in the whole cave system, with Soda Pop Pit being the low point and the Middle Cave Entrance being the high point. Each cave averages around 140 feet of vertical relief. The cave system is sub-horizontal, with the entrance and the exit being within 13-vertical feet of each other. The caves are a series of irregular-shaped rooms and linear passages structurally controlled by three major and numerous minor faults and steeply dipping bedding planes. The total distance through the caves along the developed tour route is about 1800 feet.

Cave temperatures average approximately 45-49 degrees F year round, but have been known to fluctuate between 31 and 52 degrees F near the entrances.

The caves are profusely decorated and are most known for their abundance of delicate helictites and anthodites. A total of 42 types of speleothems were identified during the 1991-1992 inventory of the cave system. While many common speleothems have been identified from the caves, many uncommon or rare forms have also been identified. There also appears to be a couple of new forms never before named or described within the caving literature. In summary, the cave system is unique among National Park Service caves because of an abundance of helictites and anthodites, unusual coloration, unusual speleogenesis (origin), new formation types, and a rich human history.

3. Other Cave Resources in the Monument

Additional cave resources within the monument include six small caves. Two of these, Golden Arrow and Hidden Mine, were discovered by miners in the 1920s. Two of the other caves, Root Canal and Lunch Bench, were discovered by cavers during a surface survey over the main cave system in 1991-1992. The Grotto, the current visitor waiting area, is technically a separate cave, since there is no humanly passable connection between it and Hansen Cave. Although the Grotto is currently a rockshelter, it is considered a cave because of its speleogens and associated cave passages that are currently filled. This cave is considered part of the developed cave system.

In addition to these four caves, a rock shelter located along the upper section of the old trail was named Mountain Goat Shelter. An unnamed speleological site is also located in the Tintic Quartzite. This slot cave was developed by frost wedging along a fault in the quartzite, but it doesn't enter total darkness. There are undoubtedly several other as of yet undiscovered caves within monument boundaries.

B. Human History

1. Hansen Cave

The first cave in the system was discovered in the fall of 1887 by a local resident, Martin Hansen, and named for him (Iorio, 1960). During the following winter, Hansen and several companions built a rough trail to the cave and installed a door over the entrance to control access. For about 3-4 years, Hansen conducted tours through the cave, charging a small fee for the guide service.

In 1891 Hansen stopped taking groups through the cave and did not return for a year or two. Reportedly unknown to him, a local group organized a mining operation in the cave during the winter of 1892-1893. Working with the Duke Onyx Company of Chicago Illinois, this mining operation seriously damaged two areas in Hansen Cave, significantly degrading the scenic value of the cave. Between 1893 and 1921, Hansen Cave was further damaged by souvenir hunters. Although the cave was not regularly shown after the monument was created in 1922 it was preserved until the tunnels were excavated in 1936-38. The tunnel blasting debris from the Hansen Tunnel was dumped in the entrance room in Hansen Cave, filling up 1 /3 of the room and further degrading the scenic value of the cave (Horrocks, 1994).

2. Timpanogos Cave

During the summer of 1913, two teenage boys, James W. Gough and Frank Johnson, discovered Timpanogos Cave while on an outing in American Fork Canyon. James's father, James C. Gough and a friend named John Hutchings, filed a mining claim on the cave, calling it the "Lone Star Lode Claim", on August 8, 1915. Shortly afterward, James moved to Idaho and little or no assessment work was completed on the claim. Before moving, James W. stashed a powder box inside and piled rocks over the cave opening (Horrocks, 1995).

Soon after Jim Gough moved back into the area, rumors about a "new cave" in American Fork Canyon circulated throughout Utah Valley. Vearl J. Manwill from Payson, Utah, arranged a trip to the area on August 14, 1921 to try and locate this rumored cave. Vearl found the sealed entrance to the cave that afternoon, and he explored the cave with other members of his party. Having witnessed the destruction to Hansen Cave, the club members discussed how this new cave could be preserved. Led by Dr. L.D. Pfouts, they formed the Payson Alpine Club to protect their discovery. Their ideas and knowledge of the cave set in motion the chain of events that culminated in the establishment of Timpanogos Cave National Monument in 1922 (Iorio, 1967).

3. Middle Cave

The third cave was discovered on October 15, 1921, by the son and grandson of Martin Hansen, George Heber Hansen and Wayne E. Hansen. Always on the lookout for another cave, these men spotted an opening in the south wall of the canyon while hunting on the opposite side. They explored to the edge of the pit that same afternoon and then returned a few days later with a large group and equipment to explore in more detail (Iorio, 1967).

4. Development for Visitor Use

Development of the caves for visitation started almost immediately after the re-discovery of Timpanogos Cave. The cave was quickly designated a "Public Service Site" and the mining claims were declared invalid. The first improvement involved using black powder to enlarge the entrance so a door could be installed. Unfortunately, much of the cave was stained black after the blasting. Trails were constructed both inside and outside the caves during the fall and winter of 1921-1922. Work was also started on an electric line. The U.S. Forest Service gave the Timpanogos Cave Outdoor Committee of American Fork a Special Use Permit to run operations. Guided trips through Timpanogos Cave started in the spring of 1922, with 10,000 people visiting the cave that first year. In 1924-25 the electrical lighting system was replaced.

The Monument was transferred to the National Park Service in 1934 and managed under the direction of the superintendent at Zion National Park. In those days of limited understanding of cave systems, projects such as expanding the trails in the caves, filling in pits, building the cave rest room, and' connecting the three caves with tunnels were seen as major "improvements." Work on the first tunnel, from Hansen to Middle Cave, started in

1936 but was not completed until February, 1937. A longer tunnel was completed between Middle Cave and Timpanogos Cave in August, 1938.

The spring of 1939 marked the beginning of one-way tours through the entire cave system. Visitors enjoyed other conveniences during their visit as well. Hansen Cave Lake was tapped as a drinking water source and a solid wooden door was placed over the entrance. Finally, the "Grotto" area was prepared as a waiting room (Iorio, 1960).

Development continued into the 1960's, with major changes in the lighting system in 1952 and installation of storage tanks for drinking water in Hansen Cave in 1959. Paving was also completed along the entire mountain trail in 1956 and then through the caves later.

While regulations against souvenir collecting and touching formations in the cave system were enforced through much of this development period, resource management received proportionately far less attention and funding than direct visitor services.
During this time period, many activities by the National Park Service actually caused serious impacts upon the cave system.

One of the worst was an experiment in the early 1970's to reduce the seasonal staff by offering self-guided tours. This was stopped once it was realized that significant vandalism was being done to the caves.

In recent years, several resource management projects have been undertaken. These include:

1985 - Wooden door placed in Timpanogos Tunnel to reduce chimney-effect winds.
1985 - Cave cleaning of algae and lint was started.
1989 - Barohygrothermographs installed in Middle and Timpanogos Caves to constantly record temperature and relative humidity.
1986 - Photomonitoring project was started.
1991 - Four air-lock doors installed in the tunnels to eliminate all chimney effect winds. Bat gates were installed on the natural entrance.
1991 - Automated cave monitoring system was installed to monitor temperature, relative humidity, and lake levels.
1992 - The caves were completely resurveyed and inventoried.
1993 - An artificial fill removal project was started in the Hansen Cave Entrance Room.

C. Current Use and Facilities

From 1946 until 1990, cave management was based mainly on trial and error and upon a few geology and mineralogy studies completed between 1952 and 1975. A resource management program was started in 1990 with a seasonal resources management specialist being hired in 1992.

Existing guidelines for visitor use are effective. Group size is limited to a maximum of 20, and hiking times are assigned in the ticket sales area to reduce congestion outside the Hansen Cave entrance. At the beginning of each interpretive program, rangers inform visitors of

various regulations, such as not touching, bumping, or leaning on cave walls and not eating, drinking, or smoking in the caves and the reason for those regulations, such as oil and water do not mix and touching will kill the formations. Interpreters also mention the various safety hazards, such as low ceilings, slippery surfaces, and steps. A volunteer from the B.A.T.S. (Behind A Tour Specialist) program is placed at the end of each tour. This person shuts all doors, makes sure no one is touching or vandalizing the cave, and handles all situations such as children that need to go out to the rest room or adults that are suffering from claustrophobia. If a BAT is not available, the interpreter chooses a responsible mature volunteer to bring up the rear to close doors and keep the tour participants together.

Visitors begin their cave tour between the "Grotto" waiting area and the entrance to Hansen Cave. The length of the developed cave trail is about 1,800 feet. Their tour finishes about an hour later at the Timpanogos Cave exit shelter. After the ranger reminds them not to run down the trail, they leave the ranger and continue around the exit trail about 1/4 mile to the junction with the main cave trail' for the hike back to the Visitor Center.

Because the cave system is smaller than some show caves in the United States, with no large rooms or large passageways, the rangers leading the tours must take special cave conservation steps. Additional challenges stem from the number of annual visitors, which ranges between 60,000-80,000, with a peak day involving about 1,400 visitors and an average day about 600.

Several facilities are operated at the cave system for visitor and employee convenience:

1. Public Water Source

The drinking fountain at the Grotto is fed from Hansen Cave Lake. Water is pumped, as needed, from the lake to two redwood storage tanks that hold 2,500 gallons each. The water is batch chlorinated by a certified person inside these two tanks and then pumped into a smaller galvanized tank.

Visitors are not allowed to fill canteens or other water containers at the drinking fountain since water supplies are limited.

2. Rest Rooms

This building is located just below the entrance to Hansen Cave and operates as a vault toilet system with no water available for visitors. The aerator is turned on at nights, to minimize the smell for visitors. Water from Middle Cave Lake is used each spring to clean out the vaults and then refill them part way.

3. Lighting System

Electric lines from the canyon bottom to the caves are overhead because of the rugged terrain. Utah Power & Light maintain this system. The main power drop into the cave

system is through the natural entrance to Middle Cave. There are two main banks of lights inside the caves, one in Hansen and Middle Caves and the other in Timpanogos Cave. Indirect, subtle lighting highlights the natural colors and features of the caves. During the operating season, the entire lighting system is used daily. Preliminary research has been conducted on light intensities. There are numerous serious resource management concerns with the current lighting system. These include employee safety, algae promotion, drying and cracking speleothems, and unintentional damage to the cave when lights are serviced. Employees have fallen from exposed ledges, been shocked with electrical current, nearly gotten stuck, and blinded when returning back through the cave. The old system was redesigned in 1994 by a cave lighting specialist, Neil Kell, from Australia. This system was designed to eliminate these problems by putting all lights along the trail. Money was received and purchase of the lights has begun. However, installation of the design has not yet started due to lack of additional funding.

4. Middle Cave Pump

A pump is located in a part of the Middle Cave Lake that the public does not see. This pump has a float attached to a switch. When the lake level rises to the point where it begins to threaten the walkway and the electrical system, the float activates the pump until the water decreases to a safe level. This pump may operate as often as once each day during the peak runoff in the spring. During the summer and fall it is rarely activated. Most water removed from the lake by this pump currently runs out over the cave trail and down the slope and is wasted. However, some water is used for cleaning the rest room vaults.

5. Grotto Waiting Area and Timpanogos Cave Exit Shelter

These structures are designed to protect people from rock fall in places where they spend time waiting at the beginning or end of the tour.

6. Employee Room

A small, enclosed room near the Grotto that is available for storage and as a dressing room for rangers between tours and during lunch.

7. Security System

An alarm system in the caves includes contacts on both outside doors and the upper door of the Timpanogos Cave tunnel. There is also a contact on the Employee Room door. The alarm system is turned on each evening when the cave doors are locked. A gate located in the second tunnel along the cave trail prevents access above the 1/4 way mark when the cave and cave trail is closed. This gate is opened by the first ranger up and then locked by the last ranger down the trail.

8. Air Lock Doors

Additional doors were installed in the tunnels in 1991 to provide an air lock between each cave.

During the off-season rangers visit the caves approximately once each month for research and monitoring. Maintenance personnel check on facilities, especially the operation of the pump in Middle Cave, several times during the winter. They also watch the lake levels, so that pumping can be initiated when spring run off is beginning.

III. GENERAL CAVE MANAGEMENT GUIDELINES

This section includes standard operating procedures for ongoing cave management projects and policies for visitor, research, interpretation, and maintenance use of the cave system.

Any person or group entering the Timpanogos Cave System must adhere to the guidelines and regulations included in this management plan. Any off trail use must follow the guidelines included on the Timpanogos Access Map. Individuals on these trips must wear a helmet, sturdy boots, have at least twolight sources (no carbide lamps are allowed), and not go into any highly decorated areas. No recreational caving is allowed within any currently known caves in the monument.

The Resource Management staff will document all activities within the cave system as well as past cave management projects. This will be done using professional photography, notes, written histories, and maps.

Problems and needs in cave management will be identified through research, inventory, and monitoring.

A. Opening & Closing Procedures

Standard opening and closing procedures for the grotto have been developed to facilitate a smooth transition between visitor seasons.

1. Opening Procedures (to do before each season begins):

   a. Scrub everything down with Clorox using mask and rubber gloves to mitigate possible viral threats from intense rodent use.
   b. Uncover radio, microwave, battery chargers, and chairs.
   c. Unstack chains and clean them.
   d. Put paper towels in vertical locker.
   e. Put perishable first aid equipment back into the First Aid and Resource Management cabinet.
   f. Hookup interpreters' battery chargers.
   g. Change alarm code.
   h. Sweep grotto using a mask.
   i. Put new information in enclosed bulletin board.

2. Closing Procedures (to do after each season ends):

   a. Make sure there is water in the cave radio battery.
   b. Cover the radio and microwave with plastic to protect them from dripping water (leave radio on because of the alarm system).
   c. Bring down interpreter's flashlights and battery chargers (except maintenance

charger - cover this one with plastic).
d. Clean out all', edible food from lockers and any personal items left by interpreters.
e. Clean out all uniforms from lockers.
f. Bring down perishable supplies from the first aid cabinet (oxygen bottle, wool blankets, and first aid kit).
g. Bring down first aid kits from cave to store in a dry place (from Grotto, Middle Cave stairs and Timpanogos Exit).
h. Stack chairs and cover them.
i. Turn heater off, remove from floor, unplug and cover it.
j. Remove trash from all garbage cans (leave nothing for rodents).
k. Clean everything off floors that could be damaged from spring snowmelt.
l. Remove all items sitting on top of shelves, especially below the ledge.

B. Visitation Policies

1. Visitor Regulations

These guidelines provide for visitor safety, enjoyment, and protection of the cave system. Regulations are given verbally at the time a ticket is purchased, printed on the ticket itself, and provided at the beginning of each cave tour. Specific regulations for visitors inside the caves include:

a. Touching formations or walls inside the caves is prohibited because of damage it causes (oil and water do not mix, it kills formation growth and stains formations).
b. Food, drinks, chewing gum, cigarettes, and other tobacco products must be kept outside the cave system (these introduce unnatural food sources in the caves).
c. Walking sticks, baby backpacks, and large backpacks are not allowed inside the caves. Visitors should carry small backpacks in front of them to prevent bumping them on cave surfaces.

Other rules that the rangers need to emphasize to visitors are:

a. Removing or vandalizing any formation or geologic feature in the caves is prohibited.
b. Marring or defacing any speleothem or wall in the caves is prohibited.
c. Travel off the established tour route into special tour access areas is limited to approved special tours in the company of a ranger with group sizes limited to five people total (special precautions need to be taken to protect the cave and not track silt back onto the trail).

2. Visitation Policies

No tour should have more than 20 people, as larger groups result in damage to cave resources. The 20-person limit for cave interpretive programs has been established through trial and error

during the past 50 years. Exceeding this limit or using a self-guiding system was found to detract from the interpretive experience and resulted in significant damage to the cave system, in terms of broken formations and graffiti.

a. Scheduling Cave Tours:

1. Tours should never be booked at the visitor center with more than 20 persons.
2. Educational groups should not be booked into large blocks of time, eliminating opportunities for visitors who show up at the monument looking for a tour.
3. Maximum visitation through the cave system should be limited to 20 people per tour with intervals of at least 10 minutes between tours. Tours must be scheduled so that visitors hike up or down the trail during daylight hours.

b. Special Tours:

1. All individuals on special tours should be provided with a hard hat when they leave established trails. To prevent inexperienced persons from inadvertently breaking stalactites by bumping them, no decorated areas should be entered. This regulation is an attempt to teach proper cave safety to visitors. It would be irresponsible for the monument to encourage unsafe caving practices.

2. All individuals on special tours must brush off their shoes before returning to the paved trail.

3. Off trail special tours should be restricted to the Tank Room of Hansen Cave and the less decorated part of the Lower Passage in Timpanogos Cave. No through trips of the Lower Passage will be allowed because of fragile formations near the Chimes Chamber. All off-trail tours will be restricted to flagged trails.

4. Special tours should not re-enact historic events that would give a poor cave conservation message. The monument should teach responsible caving practices and not encourage non-cavers to commit dangerous or illegal practices in other caves that do not have commercial lighting.

3. Volunteers / B.A.T.S.

The ranger should manage each group in such a way as to prevent thoughtless visitors from damaging the caves. One of the most important ways this can be done is to:

The most ideal situation is to have a volunteer from the B.A.T.S. (Behind A Tour Specialist) program trail every tour. If one is not available, the interpreter should choose a responsible person to be a trailer. This person should be responsible for closing all doors and making sure nobody falls behind.

C. Interpretive Program

There are several techniques that an interpreter can use to safeguard the caves during a tour.

1. Tour Concerns

a. Send the group ahead to the next stop so no one can linger behind with the first person being naturally watched by the remainder of the group.
b. Remind the group to stay within hearing distance so they will not miss anything covered on the tour.

Additional limitations to which interpreters must adhere:

a. Educational or youth groups should have at least two adults on each tour.
b. Interpreters should not encourage visitors to stop in the middle of the Middle Cave Faultline to look at the historic ladder, since this will result in visitors leaning against the wall.
c. Interpreters should not use the Coronary Bypass because this will cause silt to be tracked onto the trail and then through the cave.

2. Visitor Programs

Guidelines for cave interpretation are found in the latest Statement for Interpretation.

a. Interpretive topics

1. Geology / mineralogy
2. Hydrology
3. Human History
4. Natural History
5. Science and Resource Management vi. Speleology
6. Biospeleology

b. Interpretive methods: Standard NPS interpretive methods have been emphasized at the caves since 1990, calling for thematic interpretation, preparation of individual outlines, and regular audits by supervisors. Annual training for interpretive rangers includes the following:

Interpretive methods, emphasizing individual creativity and program development. New rangers should not learn how to do a cave interpretive program simply by "trailing" veterans several times.

Potential stopping points inside the caves and techniques used to protect cave resources.

General principles of speleology and geology. iv. Current resource management issues. Optional training may include:

Wild caving in a nearby cave.

Guest speakers from other resource management agencies. vii. Trips to Special Tour Access areas of the cave system. viii. Cave restoration and resource management techniques.

Individual interpretive programs should have an easily recognizable, simple, and relevant central theme based on the topic areas above. A tour guide or "fairylanding" approach should not be used since it limits visitor understanding of the unique features and processes present in the cave system. Recent research has shown that both public and private caves across the nation are emphasizing preservation and resource management, with the NPS being a leader in this trend. Visitor comments on these types of changes in interpretive methods at Timpanogos Cave have been overwhelmingly positive.

Interpreters should be encouraged to develop and conduct outreach programs in nearby communities. These programs could help educate the public about speleology, cave conservation, and volunteer programs at the monument.

3. Community Outreach

The monument has much to offer visitors. We are attempting to increase the NPS image and our cave safety message by community outreach programs. We are , however, severely hampered in this effort by our very small staff. This program should strive to educate the public about the various resources available at Timpanogos Cave National Monument. Although the caves should be the primary concern, other subjects should also be explored.

A small fraction of the people living along the Wasatch Front view caves as a non-renewable and delicate resource that must be protected, and even fewer are aware of the safety concerns involved with wild caving. The common perception is that a single flashlight, ball of twine, and a six pack are all one needs to explore a cave. Employees have observed that a very small fraction of the population living along the Wasatch Front even know that Timpanogos Cave National Monument is managed by the NPS. The common perception is that the U.S. Forest Service manages the cave system. The NPS should be a leader in disseminating cave conservation information. A sound safety message should be conveyed at the same time. Likewise the mission of the National Park Service should be expounded upon.

The goal of the community outreach program is to instill the perception that caves are a delicate, non-renewable resource. The goal should not be to generate interest in wild caving, since significant increase in the use of the limited cave resources in the area would result in their degradation.

The community outreach program should involve the following:

a. An updated school educational packet.
b. A cave resource management brochure.
c. Junior Ranger program.
d. Special speleology slide shows for community groups who visit the caves.
e. Radio, newspaper, and television features on cave conservation and protection. f. Cave publications for sale in the visitor center.
f. NSS pamphlets for individuals who show an interest in cave exploration.
g. Opportunities for volunteers to participate in closely supervised cave resource management projects.
h. Art contests with a cave-related theme.

4. Special Programs

Special tours and programs will be developed by the interpreters, working with the Chief Ranger and Resources Management Specialist (see the Special Cave Uses section). Such programs should provide the visitor with a unique interpretive experience. These programs may include, but are not limited to any of the following Ranger-led activities:

a. Historic Cave Tour
b. Candlelight Cave Tour
c. Cave Geology or Speleology Tour d. Five Senses Walk
d. Geology Tour of Cave Access Trail
e. Slide shows dealing with any of the above topics
f. Off Trail Cave Tour

All special tours in the cave system must follow the Timpanogos Cave Access map. Special tours are only allowed in the Tank Room in Hansen Cave and the north 3/4 of the Lower Passage in Timpanogos Cave. The highly decorated connection between the Chimes Chamber and the Lower Passage should not be entered. This will require groups to enter on the north end and retrace their steps. Any off-trail tours should stay within any flagged trails.

All special tours in the cave must address the following topics:

a. Resource management message that includes a cave conservation and safety message.

b. Rules for exploring a wild cave:

1. Each person should have a helmet, helmet mounted light, and two backup lights.
2. There must be a minimum of three individuals in the party and a maximum of five with a qualified guide that has been approved to lead special tours by the Chief Ranger.
3. Make sure someone knows where they are and when they expect to be back.

5. Exhibits and Signs

Interpretive displays should be maintained inside the Grotto waiting area safe from rockfall or snow buildup. This material not only prevents visitors from becoming bored while waiting for their tour to start; it also provides an extra opportunity for cave-related information and regulations to be presented to them. This should include information that the interpreters probably will not have time to cover.

No place name signs will be displayed inside the cave system. These are unnecessary and distracting. The cave map and the interpreters should provide this information.

D. Maintenance Activities in the Cave

1. Guidelines

The maintenance division is responsible for the upkeep and repair of cave trails, lighting, pumps, and electrical systems. No project will be started by any other division that effects the cave trail or related maintenance maintained system prior to consulting with the Facility Manager. All such projects will include funding for installation and repair of effected systems. Resource management personnel should conduct cave conservation and management training tours of the cave system for maintenance employees. The following issues will be emphasized:

a. Maintenance activities should be limited to Public Tour, Special Tour, and Maintenance Access areas only. When going to Hansen Cave Lake, travel must be limited to flagged trails.

b. Boots must be brushed off with a hand-held brush before returning to the paved trail to prevent silt from being tracked onto the trail where dripping water will turn it into mud that is then tracked through the caves by visitors.

c. Flowstone surfaces should not be walked upon, unless light-colored Aqua or water socks are worn.

d. All debris from maintenance activities must be removed from the cave system.

e. Tools, materials, and supplies used in maintenance activities should be stored outside the cave system.

f. The Resources Management Specialist must approve any chemical use inside the caves.

g. Water and dirt from cleaning trails should not be swept into side passages, but should be collected and removed from the caves.

h. Any changes in light bulbs must be with a comparable wattage bulb. Personnel

changing light bulbs in the Chimes Chamber must use designated routes and watch for the new stalagmites forming on the floor.

i. Pumping of cave lakes should be coordinated with resource management personnel. Pump meter readings should be recorded before each pumping event from the Hansen Cave Lake.

j. Artificial light housing should not be built to conceal lights or other foreign objects.

k. No internal combustion engines or blasting are allowed within the caves.

l. No additional cave fill, which is still in situ should be disturbed. Any digging should be carefully supervised by the resource management person except when emergency repairs are being conducted.

2. Cave Doors, Trails, and Gates

A near airtight seal should be maintained on the doors in the tunnels. Rubber matting that is not harmful to the caves should be maintained at entrances and on slick spots along the cave trail.

3. Monitoring Breakdown

It is extremely rare for breakdown to fall inside most caves. However, movement along one of the faults in the Timpanogos Cave System or alteration of natural conditions found in the caves may cause such a threat. The ceiling near the paved visitor trail should be periodically monitored for potential threats from breakdown. If a threat is found, the Resources Management Specialist should be contacted and appropriate action taken upon their advice.

E. Future Development

An inventory and mapping project in 1991 identified several new passages in the Timpanogos Cave system, but all of them are very inaccessible. The existing cave trail cannot be expanded without compromising the cave system itself, so the present carrying capacity and tour route will remain. Some special tours use part of the lower passage of Timpanogos Cave and this practice can continue without damaging the resource. In fact, the lower passage may be cleaned of powder scars from blasting as this cave management plan is implemented. Because tours through this passage are limited, no additional trail development will be necessary.

1. Cement Trail

The cement trail through the cave system may be replaced in the future if better technology becomes available. The concern with cement inside a cave is that calcium hydroxide in the cement is more soluble than calcite and thus mobilized and redeposited more quickly than most natural calcite. However, this does not yet appear to be a problem since the cave trail is generally at the bottom of passages in both Hansen and Middle Caves and also has silt and clay deposits beneath it.

2. The Grotto

The existing "Grotto" should be maintained as a waiting area with congestion controlled at the visitor center and trailhead. This area is the only rockfall protection currently provided at the start of the tour. This small shelter often fills up and visitors spill out onto the exposed areas before the entrance.

3. Drinking Water Storage Tanks

The existing water system should be eliminated so that water is no longer artificially removed from Hansen Lake and stored in the redwood tanks in the Tank Room. If these steps are taken, the tanks and pipe system should be removed and the cave restored (see project statement numbers TICA-N-030.012 & TICA-N-030.002).

4. Historic Rest Rooms

The historic rest rooms should be replaced. A better system needs to be researched. However, the historic nature of this comfort station should be preserved, perhaps having the building serve as storage for maintenance materials.

5. Cave Entrance

One of the natural cave entrances near the Exit Door does not have a bat gate on it. The entrance is currently blocked with a few rocks that could be dug open by vandals in a manner of minutes. This entrance should probably be rock-walled up with a small hole left for biota to come and go through.

6. Disturbance of Floors

No area with previously untouched cave fill should be excavated or covered with an artificial surface without meeting the following conditions:

a. Before any excavation is started, a professional paleontologist and cave

sedimentologist should analyze the deposits.

b. The entire deposit should never be completely removed. A good stratigraphic section should always be preserved for future scientific investigations or development of new methods of analysis.

7. New Caves or Passage

Any new cave found within the monument or any new passage found within a known monument cave is initially classified as a Scientific Tour Access area.

Leads (passages that may lead to new discoveries) in the caves may only be pushed after a written action plan is approved by the Superintendent. Such passages should only be entered by qualified cavers accompanied by the Resources Management Specialist. When digging in a lead that involves moving dirt or rocks for continued exploration, a representative sample of the fill should be left in place. Very limited rock expansion techniques may be used and only upon approval from the Superintendent. No internal combustion engines or explosives may be used within the caves.

Tasks to be completed when new passage is first entered by survey crew:

a. Detailed cave inventory (TICA Form #20).
b. Detailed survey including plan, profile, and cross sections (at scale of 4 meters to the inch on Rite in the Rain™ all weather paper).
c. Photographic documentation of floor and event.
d. Survey for signs of biota.
e. Flagging of trail if floor is delicate or highly decorated (used to limit traffic to a path that will cause the least damage).

These new caves/passages may be named by the discoverer, subject to approval by the Superintendent. As a matter of policy, caves and passages will not be named after living individuals. After these tasks have been completed, the discovery may be reclassified if deemed appropriate.

8. Cave Gates

Cave gates can introduce or impede airflow or organisms in a cave or cave passage. If a significant new cave or passage is found, a gate should be designed that addresses airflow and biological concerns. An interior gate should only be built within the Timpanogos Cave System if the new section was dug open or if it is very large, highly decorated, vulnerable, or hazardous.

F. Special Cave Uses

The 1992 cave resurvey was used to establish guidelines for off trail work and tours. An off trail Access Map has been implemented and should be followed by everyone entering the caves. The Off Trail Access Map should be updated if any new passages are discovered in the caves. If a new cave is discovered, a new off trail access map can be created if the cave is deemed sensitive due to delicate or unusual speleothems, features, biological organisms, or paleontological remains.

1. Off Trail Use

a. Any employees leaving the developed trail must sign the log sheet and have permission from the Chief Ranger or Resources Management Specialist.

b. All off-trail trips must follow the guidelines set forth on the Timpanogos Cave Access map. This map divides the cave system into the following four access areas:

1. Public Tour Access: Open to rangers, maintenance and other employees. Only open to visitors, scientists, or photographers when accompanied by an employee or approved volunteer tour leader.

2. Special Tour Access: Open to visitors only when on a ranger-led special tour, maintenance employees, and scientific or volunteer groups when accompanied by a ranger or Resources Management Specialist. Limit of five visitors on these tours.

3. Scientific Tour Access: Closed unless granted permission from the Chief Ranger, and accompanied by the Resources Management Specialist. Group size kept at 3 or fewer. If the floors of these areas are covered by flowstone, they should only be entered with light-soled water socks.

4. Limited Permit Access: These areas are closed to all off trail access except by special permit from the Superintendent. Group size kept at 3 or fewer. If the floors of these areas are covered by flowstone, they should only be entered with light-soled water socks.
5. All off-trail areas not visible to the public, and that receive trips, should have an approved flagged trail. No one is allowed to leave this trail without special permission from the Chief Ranger and the Resources Management Specialist.

No wild caving tours will be allowed in the main cave system or in any of the currently known caves within the monument.

2. Research

Any cave-related research must be approved by the Chief Ranger and Superintendent (See Research Section). All cave research must follow the Access Map and obey all rules and regulations pertaining to access, activities, and collecting.

3. Photography

a. Special photography trips must be approved by the Chief Ranger and must adhere to National Park Service permit guidelines as defined by the Superintendent.

b. Only professional photographers or experienced cave photographers may photograph off trail. The Resources Management Specialist must accompany photographers into passages classified as Special Tour or Scientific Tour Access areas. Photo trips aren't allowed in Limited Permit Access areas.

c. Copies of successful photographs should be made available to the monument. Payment for cost of materials and processing may be made based on the availability of funds within Resource Management and prior written agreement. Copyright of the photographs and reprint permission should be established before the trip is scheduled as part of a written volunteer agreement.

d. A special use fee applies to all commercial photographers. If overtime is required by accompanying employees or if resources are used, a fee can cover these expanses.

4. Media Coverage of Cave Features and Activities

a. Any news or feature reports on the cave system must be approved in advance by the monument Superintendent or designee.

b. Guidelines established in the Timpanogos Cave Access map must be followed during all media reporting.

c. Any articles produced should be reviewed for accuracy by the Chief Ranger or Resources Management Specialist before they are published.
d. If overtime is required by accompanying employees or if resources are used, a fee can be charged.

G. Cave Restoration

Previous development activities in the caves have created a pressing need for restoration work in light of current cave resource management information. A considerable amount of damage was caused during development of the caves, all in the name of improving the resource.

An ongoing project to control lint, dust, and exotic plant growth has been initiated in the Timpanogos Cave System. In addition, a cave restoration and cleaning project was started during 1992. The following standardized procedures have been created, after research and trial and error, to provide a safe working environment for employees and visitors and to create the absolute minimal adverse impact on the caves.

1. Personal Protection:

a. Safety Equipment: The following safety equipment will be worn by personnel involved with all levels of cave cleaning:

1. Coveralls
2. Hard Hat
3. Work Gloves

Personnel involved with HCL cleaning will wear the following additional safety equipment:

1. Goggles
2. Respirator
3. Rubber Gloves

b. Exposure Limitations: Spraying with Clorox will not exceed two (2) hours between breaks. HCL exposure is limited to no more than one (1) hour between breaks. Breaks must include at least 15 minutes outside the cave system.

c. Portable Eye-wash Stations: An eye-wash station will be filled with clean water and made ready for use at all times during cave cleaning and restoration.

d. Ventilation: When spraying, all cave doors must be opened to allow for the proper dissipation of chlorine or acid fumes. HCL and bleach should never be used at the same time, as they will create a toxic gas.

An employee or volunteer experiencing any ill effect from the fumes or contact with the bleach or hydrochloric acid will notify the group leader immediately.

2. Protection of the Caves:

a. Whenever any cleaning is done that involves bleach, HCI, or vinegar, special care should be taken to first check for cave life in the area. This is absolutely critical!

b. Dilution or mixing of chemical agents and the cleaning of equipment will be done outside the cave system.

c. Bleach or acid should not be used near lakes, unless something is used to soak it up as it runs off the walls.

d. Any spills or excessive run-off of bleach, vinegar, or acid must be cleaned up immediately. Caution must be maintained to prevent contamination of cave water sources. Spills must be reported to the group leader at once.

e. Corrosive material must be stored in non-breakable containers and kept in a location outside the caves.

3. Visitor Protection:

Following cleaning and prior to the first tour entering the caves, a survey will be made to determine the potential risk of residual fumes to cave visitors. A designated official will check for the following:

a. Irritation of skin or eyes
b. Breathing difficulties
c. Irritation to the mucous membranes
d. Other toxic effects

4. Cleaning and Restoration Projects:

a. Lint and Dirt Removal: The greatest concentrations of lint and dirt are in areas with the heaviest visitation, mainly along the tour route. Lint tends to accumulate below waist level and especially on or along the trails. Chapin tank sprayers provide a portable and effective way of removing lint and dust by applying a pressurized spray of water directly to the walls. After carefully washing the debris down to the cave floor it can then be collected in a bucket and carried out of the caves.

When cleaning walls, white vinegar (citric acid) can be used in conjunction with spraying down walls and flowstone. Several applications for 10-15 minutes each are recommended.

A team of no more that five individuals will be assigned to cleaning along the cave trail. They must be at least 16 year of age. If workers are unskilled, or have little or no caving experience, their activities should be closely supervised and limited to the developed cave trail. All team members must be NPS employees or registered NPS volunteers.

Delicate formations such as helictites, anthodites, and soda straw stalactites will only be cleaned by the most experienced of the cave cleaning crew.

When cleaning the cave trail, caution should be used when working near water sources,

such as along the bridge over Middle Cave Lake, or near Hidden Lake, Father Times Jewel Box, or Cavern of Sleep. Excess drainage from the trail into the lakes has been common in the past and must be eliminated.

Only cave water should be used for cave cleaning. Do not use river water or chlorinated water from the redwood tanks. Water for cave cleaning is currently being removed from Middle Cave Lake during heavy runoff in the spring. Only use the water adjacent to the bridge. Whenever water is removed, a beginning and ending lake level must be recorded and an exact total used reported to the Resources Management Specialist.

b. Control of Algae Growth: Algae growth is for the most part under control since establishing a twice- a-year program of spraying Clorox bleach in the areas of excessive growth. These areas are found mainly near moist areas near lights and by cave entrances. Two people with a Chapin tank sprayer and hand-held spray bottles can cover all areas of the cave system in a single evening.

   Clorox bleach is misted directly onto the growth area. Rinse only if residual algae remains intact 24 hours after spraying.

c. Airflow Restoration: When the Hansen and Timpanogos tunnels were drilled between 1937-39, unnatural airflow patterns were created. These chimney effect winds reduced the relative humidity and thus greatly increased the evaporation and drying out of the caves. The cave system is a active system, with relative humidity naturally averaging around 100%. The tunnels caused this percentage to drop as low as 77%. To solve this problem, an airlock consisting of two sealed doors was created for each tunnel. It is important that these seals be maintained, since a decrease in relative humidity of 0.5% can cause the evaporation rate to double, thus causing a significant impact to the moist conditions inside the caves.

d. Black Powder Cleaning: When the exit of Timpanogos Cave was blasted in 1921, black powder dynamite was used. The soot from this activity permanently blackened a significant portion of Timpanogos Cave. Several applications of diluted HCL can partially remove this type of stain.

e. Fill Removal: When the tunnels connecting the three caves were excavated between 1937-39, much of the waste rock was used to fill up pits in the floors or dumped into side passages. This material should be removed from the caves and the buried surfaces restored. It is imperative that the resource management person leading this project be familiar with speleological, archaeological, and paleontological principles.

f. Cement Removal: When the cave trail was paved, cement was splattered on many walls and formations. When the lighting system was put in place, cement was spread over cables that were in view of the public. These techniques were often used right on top of speleothems. To hide the light fixtures, artificial housing, consisting of rocks or

broken formations, was built around the lights. These structures were often placed right on speleothems. Much restoration work is required to repair this damage.

g. Moving Light Fixtures: Sometimes light fixtures were placed in highly decorated pockets. Whenever maintenance personnel changed a bulb, formations are accidentally broken or damaged. Other fixtures were placed on flowstone surfaces, forcing maintenance crews to walk on the flowstone. These fixtures need to be removed and the impacted surfaces restored. The lighting system has now been redesigned, with implementationto follow as soon as funding is received.

h. Formation Repair: In the early days, visitors were often allowed to take home souvenirs. However, not all formations that were damaged or broken were removed from the caves. Some of these formations could be repaired using hair dryers, 3M epoxy or dental epoxy, steel pegs, drill, and special supports.

5. Cleaning the Cave Mats. The following steps are recommended:

There are rubber mats covering the grates on the Middle Cave Bridge and stairs. These grooved mats catch a lot of lint and dirt and become slippery, posing a safety concern for monument visitors. These mats should be cleaned every two weeks during the peak visitor season (June 1 - September 6). This is an excellent project for a small group of closely supervised volunteers. The following procedure has been developed to clean these mats:

a. Roll up the three bridge mats and carry them outside. Unroll these down the paved trail just below the Hansen Cave Entrance.

b. Use a pocketknife or scissors to snip the three plastic ties holding each of the rubber mats to its step on the stairs (be certain not to drop these in the cave lake). Carry the mats outside and drape over the top of the rock wall, with the groves running vertically.

c. Meticulously clean a five-gallon plastic bucket outside the cave. Dip the clean bucket into the Middle Cave Lake, adjacent to the Middle Cave bridge. It will take about 10 gallons of water to clean the mats.

d. Pour the cave water into two tank sprayers and two hand-held spray bottles.

e. Using the sprayer and hand-held scrubbing brushes, start cleaning the mats at the uphill end. Work all dirt and gravel downward, cleaning the mat as you go.

f. Once clean, fold the mat in half and clean the back side, particularly any rust from the grating. Keep folding the mat in half until only a small section is dirty. Pick the mat up and finish cleaning it. Repeat this process for the other two long mats.

g. Using the hand-held spray bottles and brushes, clean the stair mats. Turn over and clean the backs too.

h. Unroll the clean mats on the bridge and attach the stair mats to the steps using plastic pull-through ties.

Materials Needed:

1. Five-gallon bucket.
2. Six hand-held scrub brushes.
3. Two tank sprayers.
4. Two hand-held spray bottles.

6. Cleaning the Cement Cave Trails

These trails catch a lot of lint and dirt and become slippery when water drips on them, posing a safety concern for monument visitors. These walkways should be cleaned once a month during the peak runoff season (April - June). This is an excellent project for a small group of closely supervised volunteers. The following procedure has been developed to clean these walkways:

1. Meticulously clean a five-gallon plastic bucket outside the cave. Dip the clean bucket into the Middle Cave Lake, adjacent to the Middle Cave bridge. It will take about 10 gallons of water to clean the walks from the entrance to the Middle Cave Lake.

2. Pour the cave water into a tank sprayer.

3. Use absorbent rags to form a dam a few feet below the top of the walk. The muddy slurry can be wrung into a couple of buckets positioned near the rag dams.

4. Using the sprayer and hand-held scrubbing brushes, start cleaning the walks at the uphill end. Using the scrub brushes, work all dirt and gravel downward, scrubbing the cement as you go.

5. Use a dustpan to pick up the heavier mud and gravel. Sop up the remaining slurry, being careful not to let any water run off the paved trail.

6. Continue to rinse off the trail until clean.

7. Dump the muddy slurry over the rock wall outside the caves.

Materials Needed:

1. One clean five-gallon bucket for water. Two others for slurry.
2. Six hand-held scrub brushes.
3. A tank sprayer.
4. A dust pan.

Note: Begin by sweeping grotto and Hansen Cave entry (use half-face respirator with HEPA filters, due to Hanta virus concerns).

7. Cleaning Cave Walls

a. Use tank sprayers to clean sections of walls and ceilings, gradually washing lint and dust to the floor. This residue will then need to be collected and taken outside for disposal.

b. Cleaning Algae: Put straight Clorox in tank sprayer and in spray bottles outside of the caves. Begin in Hansen Cave and gradually move thorough Middle and Timpanogos Caves treating areas of algae and moss contamination. Air lock doors can be opened to achieve necessary ventilation. Clorox should not be allowed to run or drip into cave lakes.

8. Use of Hydrochloric Acid (HCL)

Beginning in the summer of 1992, the process of removing imbedded dust and other debris was begun. This project requires the most experienced of workers and is limited to a group of four, over the age of 16, which are supervised by a trained individual designated by the Chief Ranger.

One team member applies the HCL spray to the formations. Only small areas are treated, let sit for a specified period of time, then wash it away with fresh cave water. This process will be repeated until optimum results can be achieved on cleaning. Use a small spray bottle and dilute solution (10% HCL) to start. Too strong of a solution will pit the formations.

Acid and water drainage from cleaning must be kept out of sensitive areas such as near cave lakes or the lower passage of Timpanogos Cave. Burlap can be used to soak up the acid/water mixture. It can be dried and then re-used.

There must be at least a one-week interval between using bleach and HCL to eliminate any danger of creating toxic fumes in the caves. Any work with HCL must be done in the evenings, after the last tour. Proper ventilation will also be utilized.

Dilute 1 qt HCL with 4-6 qts water to reduce fuming. All mixing of chemical agents will be done outside of the caves. Experiment with various dilution strengths to find best results.

Once treatment is done, rinse equipment and neutralize with 1 TBSP. baking soda outside the cave system. Caution: equipment must be rinsed thoroughly to remove any residual baking soda. This reduces the risk of introducing foreign substances into the cave system.

9. Care and Storage of Cleaning Equipment

a. All equipment must be thoroughly cleaned and flushed with clean water before storage.

b. All equipment will be stored in either the resource management locker or Rubbermaid storage containers.

c. An inventory of cleaning materials will be maintained at each storage location and in the Resource Management files.

d. The sprayer pump handles should be oiled periodically.

10. Documentation

Written documentation, maps, and when possible photographs and field notes will be taken to show the effects of cleaning and restoration on the cave formations. Exact amounts of cleaning solution will be recorded by the project supervisor and reported to the Resources Management Specialist. A list of names on each team and the area cleaned will also be reported to the Chief Ranger.

H. Monitoring

The following priorities have been established for monitoring in the cave system:

1. Hydrology

Water quantity should be monitored at sampling points identified by the hydrology study (see appendix H). Lake levels and pumping events will be monitored constantly. Flow rates (drip rates from stalactites) should be measured weekly at the six locations established for the hydrology study, at least between April and October. These points allow at least one monitoring point in each of the five major sections in the cave system. This monitoring should continue through the year 2000, if not beyond (see Cave Management Plan Appendix A-F).

A weather station was established in the cave watershed to provide temperature and precipitation data for the hydrology study. This station has been converted for long-term monitoring and should be maintained accordingly. Monthly trips for maintenance and data retrieval are required. Snow surveys have been conducted at this location for the cave hydrology study but can be discontinued as long as general precipitation data are being gathered (see Appendix G).

2. Temperature and Relative Humidity

These parameters will be monitored constantly at two locations in each cave. Background conditions should be identified and compared with data collected during the peak visitor season. A sampling location outside the Hansen Cave Entrance should be maintained to provide surface temperature and relative humidity (See Cave Management Plan Appendix E-F).

3. Photomonitoring

Work began on this project during the mid-1980s and should be completed, especially within Timpanogos Cave (see project statement # TICA-N-530.024). This project must be completed every ten years. Middle Cave is scheduled for the next photomonitoring in 1996. Both fixed photo points and video should be used. Photo points should be recoverable, using maps and field checking methods. All work should be documented on the photomonitoring form (TICA 60). Photos should be repeated precisely using maps, compass bearings, inclinations, and duplicate equipment.

Photographic monitoring, which was last carried out during 1988, should be continued. However, this project should not take priority over research for background conditions and implementation of a basic monitoring system.

4. Biological Populations

A survey of cave biota should be coordinated with a monument-wide Threatened and Endangered Species Survey. A graduate student is currently working on a biological inventory of the caves. Bat gates will be maintained on all natural entrances. Resource management or maintenance projects should never threaten cave life.

5. Barometric Pressure

This parameter should be monitored in each cave to provide an index of storm events and correlation with changes in airflow. Additional monitoring equipment should be added to the existing system to provide this capability.

The desiccant should be changed in each data logger once a month if packets are used or twice a month if reusable tins are used. The 12-volt batteries will probably have to be replaced every 3 to 5 years (first group was installed in 1991). Junction boxes should be opened

6. Radon

Most caves have been found to contain elevated radon levels. While they may not be sufficiently high to be a risk to the visiting public, they can be a risk to employees working in a cave for many years. Prolonged exposure to alpha radiation has been shown to cause an increase in the risk of developing lung cancer. The NPS recommends that an employee doesn't receive more than 3.5 WLM per year with a lifetime maximum of 105 WLM. The NPS requires that all caves be monitored for three years to determine the radon levels. Although an initial three-year test has been carried out, the recent completion of the airlock door project has almost eliminated the winds that once blew through the caves. Since the lack of air movement might have elevated the radon levels, additional testing is currently being conducted.

All monitoring data will be made part of permanent monument records. Information that is no

longer being used for research or cave management decisions will be cataloged into the archives.

I. Maintenance of Monitoring and Caving Equipment

1. Data Loggers

The desciccent should be cahnged in each datalogger once a month if packets are used or twice a month if reusable tins are used. The 12-volt batteries will probably have to be replaced every 3 to 5 years (first group was installed in 1991). Junction boxes should be opened yearly and yearly and desiccant packs replaced.

2. Ropes

All caving ropes should be 11-mm kernmantle static ropes. If these ropes receive moderate use, they should be cleaned whenever they get very dirty or after a couple of uses. The ropes should be washed in cool to warm water with detergent. Any type of detergent that does not have chlorine bleach in it is acceptable. Ropes should be washed in a bathtub and not in a commercial washer. One capful of fabric softener should be added to every 10 gallons of water used to clean the ropes. They should be hung up to dry in a basement. Ropes should never be left in direct sunlight for any length of time. They should never be stored on a cement surface and they should be thrown away after six to seven years of use. When in use, a rope pad should always be anchored wherever the rope touches a lip of rock.

3. Battery Chargers and Flashlights:

a. Battery Chargers: Periodically check the contacts for corrosion. Clean with water and baking soda solution if necessary.

b. Flashlights: Periodically check the contacts for corrosion. Clean with water and baking soda solution if necessary.

4. Hydrology Equipment

pH meter: The probe on the digital pH meter should be kept moistened at all times when it is not in use. Before it is used, the probe should be soaked for one hour in a storage solution. Any salt deposits should be removed with distilled water. The 9-volt battery should not be stored in the meter.

J. Cave Watershed and Water Quality

The health of the caves and the purity of the drinking water obtained from Hansen Lake are dependent upon the management of the cave watershed. The boundaries of the cave watershed have been outlined. The routes that water takes to the caves and the flow through time should be determined. Since the recharge for Hansen Cave Lake is likely conduit flow, contamination may be a serious concern. The Hansen Cave Lake should not be used as a drinking water source, although water is currently pumped from this lake and chlorinated for drinking purposes.

1. Pollution Threats.

Any potential pollution threats to this water should be identified and prevented. Some possible threats include livestock grazing, recreation, and decaying animal carcasses. These threats could introduce bacteria, including fecal coliform and fecal streptococcus. Other contaminants could include nitrates, *Giardia intestinalis*, or cryptosporidium.

2. Water Quality Monitoring

Water quality monitoring is required for any water supply used by the general public. The Hansen Cave Lake water should be tested daily from the 135-gallon chlorination tank.

3. Weather Station

To monitor the health of the water in the cave watershed and the rate of precipitation, a weather station has been installed near the rim of American Fork Canyon. This station and the upper section of the cave watershed are located just outside the boundaries of the National Monument on USFS lands. The station can be reached by driving west on the Timpanooke Road and hiking a mile and a half to the canyon rim. Winter access requires a combination of snowmobile/ski trip. Real time data from this station may be shared with avalanche control groups and interested meteorologists.
This station must be visited every other month to download data, change desiccant, and empty the rainbucket (see procedures in Cave Management Plan Appendix G).

We are currently in the process of installing a radio hookup between this station and the resource management office (see project statement # TICA-N-782.001).

K. Cooperation with Cave Resource Managers

1. Exchange with U.S. Forest Service and Bureau of Land Management:

The resource management staff should exchange ideas with cave managers from nearby Federal agencies. Assistance may be provided to the Uinta National Forest as they manage nearby caves. Timpanogos Cave should take an active role in representing the NPS in the proposed state-wide Cave Resource Management MOU, to be established between the Federal agencies managing cave resources in Utah. An equipment sharing, personnel, and GIS MOU was signed with the Pleasant Grove Ranger District of the USFS during 1995.

2. Exchange Between NPS Sites:

The monument should, budget allowing, participate fully in all cave resource management activities within the National Park Service. This will include attending cave restoration workshops and Cave Resource Management Symposia, and corresponding with other cave Resources Management Specialists via CaveNet (a NPS CC:Mail forum, initiated by TICA staff, accessed by all NPS sites with cave resources) and a proposed National Park Service Cave Resource Management Newsletter.

3. Cooperation With NSS and CRF:

The monument should keep up-to-date on cave conservation techniques advocated by organizations such as the National Speleological Society, the Cave Research Foundation, and the American Cave Conservation Association. The monument should subscribe to publications produced by these groups and attend cave restoration workshops and Cave Resource Management Symposia.

L. Geographic Information System

A cave Geographic Information System will be implemented as a fundamental informational tool for all cave management decisions. Currently, the monument does not possess the necessary hardware or software to implement this project. However, an existing MOU with the Pleasant Grove District of the USFS allows Timpanogos Cave use of their GIS AIM lab (See project statement # TICA-N-062.009).

1. Themes.

A cave GIS will have an individual level for each of the following themes:

1. Each of the 42 types of cave formations
2. Hydrology
3. Hazards

4. Cultural material
5. Graffiti and vandalism
6. Biological observations
7. Electrical systems
8. Stops along the cave tour route
9. Geological features
10. Monitoring equipment & wiring diagrams
11. Drip rate and lake level stage locations

2. Responsibilities

The Resources Management Specialist is responsible for maintaining the cave GIS information and for the following duties:

1. Entering new data
2. Correcting errors
3. Checking accuracy of data
4. Data Documentation
5. Backing up data
6. System security
7. Assigning log-ins to system users
8. Cave Inventory
9. Data sharing

M. Inventory

1. Cave Inventory

A thorough survey and inventory of the cave system was completed in 1992. Any additional inventory within the main cave system, or at any new cave within the monument, should use the Cave Inventory Form (TICA 20). All inventory sheets should be copied and the originals placed in the monument curatorial collection.

2. Geographic Information System

The 1991 inventory project provided essential information for cave management, information not collected during the 1974 survey of the caves. All inventory data should be entered in a cave GIS, with each type of data entered as a separate data layer. The Resources Management Specialist should update the GIS if any additional cave inventory is gathered within the monument (see L above).

N. Research

Because Timpanogos Cave National Monument was established for its scientific interest and significance, monument policy is to maintain an active research program, primarily to provide scientific data for resource management activities, planning, interpretation, and development within the monument. Projects related to cave management problems will be given priority. Research proposals will be reviewed by the Chief Ranger and the Resources Management Specialist and approved or disapproved by the Superintendent. Only institutions or individuals associated with institutions or other Federal agencies will be granted research privileges. Approved research projects are a privilege given to researchers whose proposals meet all TICA Research Project Certification Criteria (See Appendix J.

1. Research Topics

Priority topics for research in the cave system include the following:

a. Cave Hydrology: Water is essential to the natural life cycle of speleothems in the cave system. The hydrologic system from the cave watershed to the cave and beyond is complex and can be affected by many factors, including temperature, increased evaporation, pollution, flow routes, and flow through times. Each of these can have a significant effect on the natural deposition or dissolution of speleothems. Although significant progress has been made since 1989 in understanding the cave watershed, flow regimes, and water chemistry, several questions remain. Because a large database has now been compiled, research should be continued. This will require continued monitoring of environmental conditions, drip rates, water chemistry, and isotopic signatures.

b. Effects of heavy visitation: A “carrying capacity” has essentially been established for the caves with a maximum of 20 people per tour and at least 10 minutes on average between tours. Accommodating additional visitors requires risking damage to speleothems and compromising the interpretive experience and is strictly forbidden.

Research should be conducted on the effects of existing heavy visitation on the cave system. Particular issues include:

1. Changes in cave climate: Monitoring has shown that relative humidity in the caves decreases and temperature increases each day the caves are open to visitors. A similar change does not occur when rangers work in the caves during the off season, so apparently the lighting system is not causing these changes.

2. Carbon dioxide from visitors: Whether or not visitors affect air quality, such as carbon dioxide levels, is unknown. Increased drip rates and the presence of visitors in the spring and summer seasons undoubtedly raise the C02 levels in the caves. It is assumed that the air exchange with the surface keeps the C02 levels fairly low.

The actual air exchange rate and amounts should be determined by using airflow measurements and concentrations of gases coupled with models of air exchange.

c. Speleogenesis: Research in this area could provide much valuable information for cave interpretation and management. There are four areas of special interest:

    1. Cave Development: Study the cave geomorphology, sediment fill, wall rock, and speleothems to determine and document the probable cave development sequence and how it relates to current cave origin theories. Dating speleothems, cave fill, and any alterations using U/Th and paleomagnetic dating techniques to determine the approximate age of various events represented in the caves and possible ages of individual speleothems.

    2. which probably represent cyclic dry and wet periods, important information about speleothem growth rates could be obtained when coupled with U/Th dating. This information could be used to study paleoclimates of the area. Additionally, samples of already broken speleothems could be dissolved to recover clues to past climates.

    3. Paleoclimatological Study: By analyzing the rings in the speleothems,

    4. Cave Sediments: By dating the cave fill sediments using paleomagnetism, the minimum age of the caves could be determined, assuming that the caves are older than the last reversal, 750,000 years ago. By studying pebble imbrication, sediment deposition, and speleogens the paleoflow direction could be determined. Paleoclimatic data could also be obtained by looking for pollen in the fill. Additionally, some of the younger sediments could be analyzed for paleontological remains. An analysis of Pleistocene or Holocene mammal species in American Fork Canyon has never been attempted.

    5. Hydrologic System: By matching peaks in surface precipitation with peaks in speleothem drip rates, it will be possible to determine flow rates for the major sections of each cave. Actual flow-through paths can be determined by dye tracing.

d. Ecology: A survey of cave biota has never been completed. This survey could be done as part of a monument-wide Threatened and Endangered Species Survey and could include microbiological, invertebrates, and vertebrate species. Such a survey should determine the number and identification of obligate and facultative cave dwellers and accidentals. This would require pitfall trapping, microbiological testing, and visual surveys.

e. Air quality, Including Radon: A single previous three-year test indicated that radon is not a threat to people visiting the cave system. More testing is required to determine if radon is a threat to employees working in the cave for multiple seasons.

There is an increase in air pollution from industry (particularly Geneva Steel) and automobile traffic in Utah County, which may be both directly and indirectly affecting cave resources. Air quality both inside and outside the caves should be monitored. The USFS has installed an IMPROVE air quality station inside the monument in Swinging Bridge Canyon. This station samples the organic carbon, fine mass (ammonium sulfate), and trace elements of sodium, chlorine, bromine, selenium, lead, and zinc in the air. Data gathered over two to three years could be correlated with air quality in Utah Valley and may indicate whether or not air pollution is a threat to the cave system. Preliminary results from the cave hydrology study indicate that acidic deposition in the cave watershed is not a problem. Initial research would be best directed toward the effects of degraded air quality on the cave system.

Increased carbon dioxide levels in the atmosphere may also profoundly affect cave mineralogy, and monitoring in this area should be implemented when other air quality threats have been researched.

0. Enforcement of Regulations and Laws

The public will be made aware that the following laws are enforced at Timpanogos Cave National Monument. This information may be distributed through cave tickets, brochures, signs, or interpretive programs. All existing regulations and laws pertaining to caves will be enforced.

1. 43 CFR Cave Management, Final Rule (Federal Cave Resource Protection Act of 1988)

The FCRPA applies to all significant caves on federal lands and to all caves on NPS land. This act was passed, "to secure, protect, and preserve significant caves on Federal lands for the perpetual use, enjoyment, and benefit of all people..." The following acts are prohibited under the FCRPA and are subject to criminal prosecution:

a. Vandalism: "...any person who, without prior authorization from the Secretary knowingly destroys, disturbs, deface, mars, alters, removes or harms any significant cave or alters the free movement of any animal or plant life into or out of any significant cave located on Federal lands, or enters a significant cave with the intention of committing any act described in this paragraph..."

b. Selling: "...any person who possesses, consumes, sells, barters or exchanges, or offers for sale, barter or exchange, any cave resource from a significant cave with knowledge or reason to know that such resource was removed from a significant cave located on Federal lands..."

c. "...any person who counsels, procures, solicits, or employs any other person to violate any provisions of this subsection..."

2. The U.S. Code of Federal Regulations, Title 36: This document adds some additional regulations.

a. Disturbing natural, cultural, and archaeological resources. Section 2.1 (1).

b. Tossing rocks in caves. Section 2.1 (3).

c. Smoking in caves. Section 2.21 (b).

IV. IMPLEMENTATION STRATEGY AND SCHEDULE

All regulations and policies outlined in the Cave Management Plan have been or are currently being implemented. Project Statements that have to do with cave resources (the former "Action Plans") should be proposed for funding and implemented in order of priority as indicated in the Project Statement Number.

V. NPS STAFF RESPONSIBILITIES

A. Superintendent

The monument Superintendent is responsible for completing and implementing the monument Resource Management Plan and thus this Cave Management Plan as well. Actual duties may be delegated to monument staff as appropriate.

B. Chief of Interpretation and Resource Management (Chief Ranger)

The Chief Ranger is responsible for:

1. Updating and implementing the Resource Management Plan as delegated by the Superintendent.

2. Coordinating all cave-related interpretation, cave management projects, research, monitoring, and protection guidelines.

3. Enforcing laws and regulations relating to caves.

4. Seeking funding for cave resource management projects. - Preparing news releases on cave-related activities.

5. Supervising the Resources Management Specialist and the Physical Sciences Technician.

C. Chief of Maintenance

The Chief of Maintenance must coordinate with the Superintendent and Chief Ranger to ensure that maintenance projects in the caves are completed in compliance with the Cave Management Plan. These projects should also be prioritized as indicated in the Plan.

D. Resources Management Specialist

This individual is responsible for the following duties:

1. Gathering information on which resource management decisions must be based.

2. Assisting the Chief of Interpretation and Resource Management in updating the Cave Resource Management Plan annually or whenever needed.

3. Maintaining curatorial collections and write annual reports.

4. Initial review of research proposals and collecting permits.

5. Assisting the Chief Ranger in seeking funds for resource management projects.

6. Directing fieldwork on resource management projects.

7. Surveying and inventorying all caves within the monument.

8. Monitoring the caves using photomonitoring, atmospheric sensors and data loggers, and hydrologic sampling. Maintaining monitoring equipment.

9. Keeping in touch with other cave specialists in the NPS and offering assistance to other government agencies in the area seeking cave expertise.

10. Attending cave resource management and restoration workshops and symposia.

11. Providing special resource management and geology tours to professional individuals and educational groups.

12. Scheduling and directing volunteers working on cave restoration projects.

13. Maintaining all caving equipment.

14. Offering cave-related training for interpreters and helping update interpretive programs and materials.

15. Maintaining air-quality monitoring equipment.

16. Providing resource management and geology tours to visitors.

17. Maintaining, updating GIS systems and data.

This position requires knowledge and experience in resource management, speleology, cave restoration, and Geographic Information Systems.

E. Physical Sciences Technician and Work Group Leaders

These positions will be responsible for day-to-day monitoring and data gathering in the cave system, carrying out cave management projects, and for analyzing information as needed for management decisions. This will include entering drip rate data into the computer and creating monthly and year-to-date files. This position is extremely budget sensitive, and will not be filled every year unless TICA base budget is increased.

F. Interpretive Staff

Interpreters at the cave system will be responsible for following guidelines for visitation limits and visitor safety. They will also be responsible for interpreting resource management projects for visitors. The ranger supervising the fee collection/ticket sales operation will be responsible for appropriate scheduling.

G. Volunteer Assistants

Volunteers should be kept active in cave management projects depending upon qualifications and skills required. Cave conservation groups such as the National Speleological Society should be primary sources for volunteer recruitment. Any volunteers assisting with cave management projects must be appropriately trained before the project begins and then closely supervised once started.

The Chief Ranger or Resources Management Specialist must designate volunteer work group

leaders. All volunteers will be supervised by a monument employee or designated volunteer work group leader at all times. Volunteer groups of more than 4 people will not be allowed to leave the developed cave trail. Volunteers under age 16 will not be allowed to leave the developed trail unless accompanied by a member of the resource management team. All participants must be registered TICA VIP'S.

H. General Guidelines for Monument Personnel

As the caves are TICA's primary resource, it is imperative that there always be at least one person on staff with extensive experience in cave resource management, general speleology, and Geographic Information Systems. The person or persons with this expertise should work closely with other divisions and volunteer staff involved in projects affecting the cave and should be consulted as part of any cave management decision.

VI. METHODS FOR SEEKING FUNDING AND ASSISTANCE

A. National Park Service Funding

Individual action plans from the Cave Management Plan have been incorporated into the Resource Management Plan as Project Statements. They will be proposed for appropriate funding in this format, following the indicated priority order.

B. Research Funding

Various sources are available to fund research in the cave system, including the Cooperative Park Studies Unit, Southwest Parks and Monuments Association, and organizations such as the Cave Research Foundation. Proposals for the two or three highest priority research projects in the cave will be submitted each year.

C. University Research

The Geology Department at Brigham Young University has been instrumental in completing research in the cave system. This partnership should continue, since the university has both graduate students and professors who will contribute time. Essential work can be done through universities at much lower cost than if contracted out, including analysis of water samples, data analyses, and work with Geographic Information Systems.

A graduate student from the biology department at the University of Utah (U of U) is currently doing an inventory of biota in the caves. This new alliance with the U of U should be developed.

D. The National Speleological Society

The National Speleological Society has entered into a MOU with the National Park Service. The local grottos of the NSS, including Timpanogos, Salt Lake, and Wasatch Grottos, contributed thousands of hours of labor to cave management projects between 1991 and 1995. Many members have valuable cave management skills, such as surveying and mapping, installation and operation of air lock systems, gating, cleaning, and monitoring. These people are essential to fully implementing the Cave Management Plan during the next several years and this valuable partnership should continue.

VII. REVISION OF THE CAVE RESOURCE MANAGEMENT PLAN

The Cave Resource Management Plan should be updated as needed and at least once each year. The Chief, Interpretation and Resource Management, and Resources Management Specialist should work jointly on this project for review by the Superintendent.

VIII. GLOSSARY

Anthodite - Needle-like aragonite crystals that have the same composition as calcite.
Bat Gate - A specially designed gate that allows bats and other biota to enter a cave, but not humans.
Cave - Any natural cavity that is large enough to allow human access.
Cave Inventory - A list of features, biota, hazards, and cultural material found in a cave that are managed by using a GIS.
Cave Watershed - The natural surface recharge area for water that enters a cave.
Cave Resource Management Specialist - A manager of cave resources that inventories speleological resources, monitors natural conditions in a cave, supervises research, and mitigates any effects from cave use.
Cave System - A cave that has multiple entrances or a series of caves that are hydrologically related.
Data Logger - An computer that can be used to store electronic data obtained from a monitoring system or weather station.
Drip Rate - The rate that a stalactite is dripping at a particular time. Measured in ml/min.
Frost Wedging Cave - A shelter cave formed by the freezing and thawing action of ice breaking rock along a fault, joint, or bedding plane.
Geographic Information System - (GIS) A computer program that is used to analyze, manage, and store spatial information.
Helictite - An eccentric speleothem with a hollow central canal that defies gravity in its growth patterns.
Hydrology - The study of waters property, distribution, and movement, especially below the surface.
Karst - An area where the surface is affected by the subsurface. Usually an area of soluble rock that contains no surface streams and has numerous sinkholes and caves. Karen - A dissolution feature on a bedrock surface.
Rockshelter - A shallow speleological site that does not enter total darkness and is wider than deep.
Sinkhole - A surface depression created by the collapse of a cave roof or the dissolution of soluble rock.
Solution Cave - A cave dissolved out of soluble rock by acidic water. The most common type of cave.
Speleogen - An unusual cave feature formed by dissolution or mechanical erosion of bedrock.
Speleological Site - A feature that shows characteristics of a cave but is too short to be considered one.
Speleomorphology - The study of shapes, styles, and distribution of cave passages, speleogens, and speleothems.
Speleothem - A secondary mineral deposit found in a cave.
Structural Geology - The study of the structure of rocks.
Tectonic Cave - A cave formed by the mechanical movement of rock masses.

IX. CAVE-RELATED BIBLIOGRAPHY

Aley, Thomas, 1992. "Results from Dye Tracing at Timpanogos Cave National Monument." Unpublished manuscript.

Birk, Clyde, 1972. "Recollections of Tunnel Construction at Timpanogos Cave." Unpublished manuscript.

Baker, A. A., and M.D. Crittenden, Jr. 1961. "Geology of the Timpanogos Cave Quadrangle, Utah." U.S. Geological Survey Map GO-132.

Bullock, K.C. 1954. "Geologic Notes on Timpanogos Cave." Technical Note No. 14. Salt Lake Grotto, National Speleological Society, P. 1-6.

Bullock, K.C. 1954. *A Study of the Geology of the Timpanogos Caves, Utah.* (Unpublished Masters Thesis), Brigham Young University Research Studies, p. 66.

Bullock, K.C. 1962. "Geology of Timpanogos Cave National Monument." Special Report for the National Park Service, P. 1-9.

Green, Dale J. 1975. "Results of Detailed Mapping in Timpanogos Cave National Monument, Utah County, Utah." Technical Note #76, Salt Lake Grotto, National Speleological Society. Includes detailed cave map.

Iorio, Ralph M., 1960. "The History of Timpanogos Cave National Monument." Unpublished manuscript, no copyright obtained.

Iorio, Ralph M. 1970. Discovery and Exploration of the Timpanogos Caves of Utah. *The Journal of Spelean History*, Vol. 3, no. 4, pp. 69-83.

Horrocks, Rodney D. 1994. "The Story of Timpanogos Cave." *NSS News*, Vol. 52, no. 1, pp. 614.

Horrocks, Rodney D. and Tranel, Michael J. 1994. "Timpanogos Cave Resurvey Project." *NSS News*, Vol. 52, no. 1, pp. 15-27.

Horrocks, Rodney D. 1994. "Volunteers Help Remove Tunnel Blasting Debris From Timpanogos Cave System." *Highlights of Natural Resources Management*. Natural Resources Report, National Park Service. pp. 28-29.

Horrocks, Rodney D. 1995. Artificial Fill Removal Project, Timpanogos Cave National Monument. *NSS News*, Vol. 53, no. 4, pp. 102-107.

Horrocks, Rodney D. 1995. "Timpanogos Cave National Monument Hydrology Study Update." Unpublished manuscript. 3 pp.

Jensen, Thomas M. 1990. "Update on Park Hydrology Study." Unpublished manuscript.

Palmer, Art and Peg, 1990. “Comments on Factors Involved in the Origin of Timpanogos Cave.” Unpublished manuscript.

Perkins, R.F. 1955. “Structure and Stratigraphy of the Lower American Fork Canyon-Mahogany Mountain Area, Utah County, Utah.” *Brigham Young University Research Studies, Geology Series*, Vol. 2, No. 1. P. 38.

St. Clair, Larry L. 1976. “The Diatoms of Timpanogos Cave National Monument, Utah.” *American Journal of Botany*, Vol. 63, no. 1, pp. 49-59.

Tranel, Michael J. 1990. “Hydrology Study Proposal.” Unpublished manuscript.

Tranel, Michael J., Alan L. Mayo, and Thomas M. Jensen, 1992. “Preliminary Investigation of the Hydrogeology and Hydrogeochemistry at Timpanogos Cave National Monument, Utah, and its Implications for Cave Management.” *Proceedings of the National Cave Management Symposium*, 164-178.

Tranel, Michael J., and Horrocks, Rodney D. 1994. “Changing to Prevent Change, Building a Science and Resource Management Program at Timpanogos Cave National Monument.” *NSS News*, Vol. 52, no. 1, pp. 22-24.

White, William B. and James J. Van Gundy, 1974. “Reconnaissance Geology of Timpanogos Cave, Utah County, Utah.” *The NSS Bulletin*, 36(1):5-17.

X. APPENDIX

A. Drip Rate Instructions

These instructions are for measuring and recording the drip rates and lake levels for hydrologic monitoring in the Timpanogos Cave System. This information should be collected weekly from April through October and bi-weekly the rest of the year. Use the "Drip Rate & Lake Level" form (TICA 21) to record this information.

Hansen Cave:

- Take Hansen Lake Cave Single drip rate.
- Record Hansen Lake stage reading.
- Record Hansen Lake pump reading if a pumping event has occurred since last recording.

Middle Cave

- Record Pump Room meter if a pumping event has occurred since last recording. - Take Middle Lake Double drip rate.
- Take Middle Cave Column drip rate.
- Record Middle Lake stage reading.
- Take Big Room Fill drip rate (.001 if moist and not dripping).

Timpanogos Cave

- Record Hidden Lake stage reading. - Take Chimes Chamber drip rate. - Take Timpanogos Fault drip rate.

Office

- Using information gathered, calculate ml/min.
- Update drip rate and lake level computer file in Quattro Pro.
- Store the "Drip Rate and Lake Level" form in the proper file for hard copy backup.
- Periodically back up the computer file and store in archives.

B. Drip Rate Data Conversion

1. Convert data to ml/min or ml/day (Based on what Quattro Pro file asks for).

    a. To convert to ml/min take amount of sample, divide by the time (in minutes).

    Ex: If you collected 5.0 ml of water in 3 minutes, the rate of ml/min would be 1.67 ml/min.

    b. Another way of converting data to ml/day is to take the amount of sample collected and divide by the number of collection days. The results would be an average rate for that specific period of time.

    Ex: 550 ml were collected on Julian date 330. The previous collection date was

314, a difference of 16 days. 550/16 is 34.4 ml a day.

2. In addition to the drip rates and hydrochemistry data, monthly precipitation totals are being gathered and stored in Quattro Pro. These monthly readings were assigned a Julian or study day equal to the last day of each month. These days should be changed to the middle of each month to reflect a more accurate representation of precipitation rate related to cave flow rates.

C. Drip Rate Data Entry Instructions

The data from the drip rate sheets will be entered into Quattro Pro after each trip to the cave and later imported into SigmaPlot for data analysis (Bold face items are items that need to be selected from the menu).

Select item #4 - Quattro-Pro (QPRO) from the main menu - Using the mouse, select File
Select Open
Select DRIPRATE.WK1 from the directory
Use the "Day of Year (Julian) Calendar" to calculate the Julian date. - Enter weekly drip rate data at the bottom of each column
Calculate the project date by adding 365 (6) to the formula in the project date column on January 1 of each year.
When data entry is complete, select File
Select Save
Select Enter
Select Replace from File already exists:
Select File
Select Exit

D. Drip Rate Graphing Instructions

The Quattro-Pro file DRIPRATE.WK1 should be imported into SIGMAPLOT to produce graphs (Boldface items are items that need to be selected from the menu).

Select item #5 - SIGMAPLOT (PLOT50) from the main menu

E. PC 208 Software

As data are collected from the caves, they should be downloaded from the storage module and assigned a file name the same as the day the information was collected. For example, if data were collected on October 20, 1992, the file name would be 200092. The order in which the data were collected from the CR-1 Os will determine whether the computer will assign a file extension of 01, 02, or 03. To keep things in order, "01" has been reserved for Hansen Cave, "02" for Middle Cave, and "03" for Timpanogos Cave. Downloading must

occur in that order. A downloaded file from Hansen Cave on Oct. 20, 1992 would be, 20009201.DAT.

This means that each "DAT" file has an array ID number to correspond to the section of cave it came from. Hansen Cave uses the 100s for Array ID, Middle Cave 200s, and Timpanogos Cave 300s. Cave watershed data are the 400s. To reduce the accumulation of files, all "DAT" files are merged monthly for each location. These files are found in C:\RESMGMT\DATA, each with a "DAT" extension. Watershed data will be collected separately.

Once data are received into the PC208 software, using the SPLIT feature will allow you to arrange the data before putting them into a spreadsheet format. Refer to the Campbell Scientific manuals to assist you in organizing your data. Once in SPLIT, you can access specific array IDs or even average temperature and RH values.

Once the data are arranged the way you want, you must create an output file. The computer will assign each output file a "PRN" extension.

F. Retrieving Datalogger Data

Bold face items need to be selected or typed in.

1. Downloading Data Logger Data From the Caves

Data from the data loggers should be downloaded weekly. The storage module and keyboard with cable, which are located in the Resources Management Specialist's office, need to be taken up to the caves for the download procedure.

To download the data from the data loggers, connect the cable into the storage module and then connect the cable to the data logger for 1 minute, while keeping the door closed. It is important to download the data loggers in the following sequence:
Hansen Cave, Middle Cave and Timpanogos Cave, as the files will be labeled XXXXXXO1, XXXXXX02 and XXXXXX03.

2. Retrieving the data from the Storage Module

- Plug the storage module into the cable from the PC
- Select item "#3 - PC208 DATALOGGER (PC208)" from the MENU SCREEN - Select "(1R) STORAGE MODULE COMMUNICATIONS (SMCOM)"
- Select "1 - COMM PORT 1" from SERIAL PORT OPTIONS
- Select "A - COLLECT ALL DATA FILES" from the SMCOM OPTIONS - Type in root collection file name: "C:\PC208\WD\DAMOYR" from A ROOT COLLECTION FILE NAME (6 CHARACTERS MAX) Note: this is where the computer adds 01, 02 and 03 to the file name (DAMOYR01) to distinguish Hansen Cave, Middle Cave and Timpanogos Cave data.

- Select "C - FS CONVERTED TO COMMA DELINEATED ASCII ARRAYS"
- Select "Q - QUIT" from the SMCOM OPTIONS
- This completes the downloading of the data. Now we need to print and verify that the data are correct and we don't have any failures with the data loggers or sensors.

3. Verifying the Data

- Select "SPLIT (2R)"
- Complete the SPLIT SCREEN as in figure #1 to print out Hansen Cave data on the laser printer

Select "F2 = COMMANDS" Select "R = RUN"
When completed, press "ENTER"
Select "N" for SAVE PARAMETER FILE (Y/N)?
Complete the SPLIT SCREEN as in figure #2 to print out the Middle Cave data Select "F2 = COMMANDS"
Select "R = RUN"
When completed, press "ENTER"
Select "N" for SAVE PARAMETER FILE (Y/N)?
Complete the SPLIT SCREEN as in figure #3 to print out the Timpanogos Cave data
Select "F2 = COMMANDS" Select "R = RUN"
Select " Q = QUIT"
Select "N" for SAVE PARAMETER FILE (Y/N)?

Verify that the printed data are correct and pass the printout on to the Chief Ranger.

After the data have been printed, verified and passed on to the Chief Ranger, file this hardcopy in the appropriate file folder in the Resources Management Specialist file cabinet. The storage module can now be cleared.

FIGURE #1

Name(s) of input DATA FILE(s): C:\PC208\WD\DAMOYROLDAT Name of OUTPUT FILE to generate: C:\PC208\WD\TEST.PRN/P START reading in DAMOYROI .DAT:
STOP reading in DAMOYROI .DAT:
COPY from DAMOYROI.DAT:
SELECT element #(s) in DAMOYROI .DAT:
HEADING for report: HANSEN CAVE DATA DAMOYR

FIGURE #2

Name(s) of input DATA FILE(s): C:\PC208\WD\DAMOYRO2.DAT Name of OUTPUT FILE to generate: C:\PC208\WD\TEST.PRN/P START reading in DAMOYRO2.DAT:
STOP reading in DAMOYRO2.DAT:
COPY from DAMOYRO2.DAT:

SELECT element #(s) in DAMOYRO2.DAT:
HEADING for report: MIDDLE CAVE DATA DAMOYR

FIGURE #3

Name(s) of input DATA FILE(s): C:\PC208\WD\DAMOYRO3.DAT Name of OUTPUT FILE to generate: C:\PC208\WD\TEST.PRN/P START reading in DAMOYRO3.DAT:
STOP reading in DAMOYRO3.DAT:
COPY from DAMOYRO3.DAT:
SELECT element #(s) in DAMOYR03.DAT:
HEADING for report: TIMPANOGOS CAVE DATA DAMOYR:

4. Clearing the Storage Module (Only after double-checking that a computer file and a hard copy of each file exist)

- Select "(1R) STORAGE MODULE COMMUNICATIONS (SMCOM) " - Select "1-COMM PORT 1" from SERIAL PORT OPTIONS - Select "E - ERASE AND RESET STORAGE MODULE" - Select "YES" from ARE YOU SURE?
- After storage module has been cleared:
- Select "Q - QUIT" From SMCOM OPTIONS
- Unplug the storage module from the SC532 Interface

Retrieving the Data From the Storage Module

Plug the storage module into the cable from the PC
Select item "#3 - PC208 DATALOGGER (PC208)" from the MENU SCREEN - Select "(1R) SMCOM "
Select "1 - COMM PORT 1" from SERIAL PORT OPTIONS
Select "A - COLLECT ALL DATA FILES" from the SMCOM OPTIONS - Select "C - FS CONVERTED TO COMMA DELINEATED ASCII ARRAYS"
Select "C:\PC208\WD\DAMOYR" from A ROOT COLLECTION FILE NAME (6 CHARACTERS MAX) Note: this is where the 01 is added to the file name (DAMOYRO 1) and the file must be renamed to DAMOYRO4.DAT after quitting SMCOM prior to printing the data.
Select "Q - QUIT" from the SMCOM OPTIONS

Renaming The Cave Watershed Data File:

From the MENU SCREEN type " REN C:\PC208\WD\DAMOYROI.DAT C:\PC208\WD\DAMOYRO4.DAT"

This completes the downloading of the data. Now we need to print and verify that the data are correct and we don't have any failures with the data logger or sensors. (Note: use figure #4 for the printing of data)

FIGURE #4

Name(s) of input DATA FILE(s): C:\PC208\WD\DAMOYRO4.DAT Name of OUTPUT FILE to generate: C:\PC208\WD\TEST.PRN/P START reading in DAMOYRO3.DAT:
STOP reading in DAMOYRO3.DAT:
COPY from DAMOYRO3.DAT:
SELECT element #(s) in DAMOYRO3.DAT:
HEADING for report: CAVE WATERSHED DATA DAMOYR:

8. Creating Monthly Cave Data Files:

At the end of each month the weekly data files need to be consolidated into monthly data files. The procedure is:

From the MENU SCREEN, type "C:\"
Type "CD\RM\PC208\WD"
Type "COPY DAMOYROI.DAT+DAMOYROI.DAT+DAMOYROI.DAT+DAMOYROI.D AT C:\PC208\MD\MOYR01.DAT" (these are the dates of the downloaded Hansen Cave files)
Type "COPY DAMOYRO2.DAT+DAMOYRO2.DAT+DAMOYRO2.DAT+DAMOYRO2.D AT C:\PC208\MD\MOYRO2.DAT" (these are the dates of the downloaded Middle Cave files)
Type "COPY DAMOYRO3.DAT+DAMOYRO3.DAT+DAMOYRO3.DAT+DAMOYRO3.D AT C:\PC208\MD\MOYRO3.DAT" (these are the dates of the downloaded Timpanogos Cave files)
Type "COPY DAMOYRO4.DAT+DAMOYRO4.DAT+DAMOYRO4.DAT+DAMOYRO4.D AT C:\PC208\MD\MOYRO4.DAT" (these are the dates of the downloaded Cave Watershed files)

9. Creating Year to Date, Cave Data Files:

At the end of each month the monthly data files need to be consolidated into year to date data files. The procedure is:

- From the MENU SCREEN, type "C:\" Type "CD\PC208\YD"
- Type "COPY YDMOYROI.DAT+C:\PC208\MD\MOYROI.DAT(current month) YDMOYR01.DAT"
- Type "COPY YDMOYRO2.DAT+C:\PC208\MD\MOYRO2.DAT(current month) YDMOYRO2.DAT"
- Type "COPY YDMOYRO3.DAT+C:\PC208\MD\MOYRO3.DAT(current month)

YDMOYR03.DAT"

- Type "COPY YDMOYRO4.DAT+C:\PC208\MD\MOYRO4.DAT(current month) YDMOYRO4.DAT"

G. Weather Station Procedures

1. Downloading Data Logger Data From the Cave Watershed: Data from this data logger should be downloaded monthly. The storage module and keyboard with cable, which are located in the Resources Management Specialist's office, need to be taken up to the weather station for the download procedure.

2. Equipment: The following items might be needed for each trip to the Weather Station (shovels and some other equipment is stashed under a tree 30 feet to the east):

Snowshoes/skis/snowmobiles...

- Radios for each participant
- Avalanche beacons
- Seat Harness
- Locking Carabineers & webbing loop
- Key to unlock datalogger
- Camera
- Antifreeze (Environmentally safe brand)
- Mineral Oil
- Crescent wrench
- Desiccant
- Wiring diagram
- Storage module and blue cord
- Keypad and blue cord
- Screw driver, pliers, crescent wrench, & Swiss Army knife
- Sturdy plastic container for used antifreeze
- Duct Tape

3. To do each trip

- Check tower guy wires and tighten if necessary.
- Climb to datalogger and download datalogger to storage module by plugging in blue cord into 9 pin receptacle in data logger box. Leave plugged in for ten minutes, then unplug.
- Change desiccant (place two new packets inside datalogger and relock the box). - Wipe solar panel with a clean dry rag.
- Climb to top of weather station to check the rainbucket. Empty if it is within a few inches of the top.

4. To do each spring

Empty environmentally safe antifreeze from rainbucket and carry out in sturdy plastic containers.
Calibrate spring (0 = Empty, 6.0 = Half Full, 12.3 = Full).

5. Winterizing Station (before first snowfall)

- Climb to top of station, empty rainbucket, and fill to line on bucket with environmentally safe antifreeze (2 quarts). Pour a thin film of mineral oil into bucket.\

H. TICA Hydrology Study Update
By Rod Horrocks, TICA Resource Management Specialist
Oct. 3, 1995

Beginning on January 1, 1990 a comprehensive Cave Hydrology Project was started in the Timpanogos Cave System and watershed. This project was started as a joint venture by Michael Tranel, TICA Chief Ranger, and Dr. Alan Mayo, BYU professor of hydrogeology. The goals of this project were to:

1) Determine how management projects involving water affect the natural hydrological, mineralogical, and environmental systems present in the caves and cave watershed. Develop site-specific data and analysis essential for rational, scientifically supported management decisions.

2) Compile baseline data documenting the flow rates and flow paths, as well as water quality of water entering the caves, based on drip rates, geologic mapping, and chemistry. Identify potential threats to the system.

3) To complete a study of groundwater recharge mechanisms in a carbonate terrain.

4) To develop interpretive information on the cave system dynamics suitable for presentation to monument visitors.

Additionally, it was hoped that this project would aid in future management decisions involving cave drinking water, maximum visitation levels, the cave watershed, and the cave rest room leaching system.

Initial work involved sampling surface and cave water and looking at the solute and isotopic chemical signatures. On the surface the following sources were sampled: springs, snow in the cave watershed, and the American Fork River. Within the caves, dripping water and cave lakes were tested quarterly during the four-year project. Finally, drip rates were measured bi-weekly at eleven sites in the three caves. The second part of the project involved setting up a long-term atmospheric monitoring system in the caves. This system used data loggers to continuously record temperature, lake levels, and relative humidity.

Preliminary results, published one year into the project, indicated that each cave has a distinct flow regime, which affects the quantity and type of speleothems present. Because Hansen and Middle Caves are shallow sub-surface caves, they respond quickly to meteoric recharge events through conduit flow, while Timpanogos Cave is deeper below the surface and affected slower. The project was successful in developing a quantitative model of background water quality within the monument. It is felt that the duration of this project was sufficient to be a representative sample of water quality within the monument.

One of the most revealing discoveries of the project involved the cave drinking water supply at Hansen Cave Lake. Currently, water is pumped from this six-foot deep lake at the back of Hansen Cave to two large redwood storage tanks, where it is chlorinated and gravity fed to a drinking fountain. The lake is located 200 feet below the surface and is recharged by conduit flow from the Hansen Cave Fault. We learned that surface water reaches the cave lake eight hours after a meteoric event on the surface. This quick recharge rate raises the issue of water quality problems created by disturbances in the cave watershed. Giardia could theoretically be washed into the cave from animal droppings or death near the input point. The quick conduit flow-through time and chlorination would probably not be sufficient to kill any microorganisms and could possibly result in affects to human consumers. However, the fact that this has not happened since the drinking water supply was first utilized in 1939, indicates that the probability of this happening is low
Unfortunately, a preliminary dye trace was unable to determine what happens to the effluent released each fall from the vault in the cave rest room pit toilet. The possibility that undiscovered cave resources are being contaminated exists. Finally, monitoring lake levels in the caves has told us that the lakes do not fluctuate like the drip rates and that most, except Hansen's, respond slowly to surface recharge events.

When Mike Tranel moved to Denali National Park in Alaska, the Resource Management Specialist, Rodney D. Horrocks, assumed project management and reorganized the project and evaluated the results of up to that point. It was determined that, based on discrete hydrological systems, formation types, and structural geology, the caves can be divided into five distinct sections.

On January 1, 1994 we expanded the scope of the cave monitoring system to better document information specific to each of these five major sections. This expansion called for installation of a tipping bucket in each section of the caves to continuously record drip rate information. It also calls for the installation of an anemometer to record wind speed so that the source and type of winds blowing through the caves can be determined. It was determined that five of the eleven drip rate sites were providing duplicate information and one major section was not represented. As a result of this discovery, five of the drip rate points were dropped and one new point was added. We then developed a drip rate form to be used in the cave, basically one representative site per major cave section. This information was collected for the fourth and final year of the project and will be an on-going project.

By studying the structural geology and topographic map, we outlined the extent of the cave watershed. This exercise revealed that a third of the watershed lies outside monument boundaries and within the Uinta National Forest. The potential for contamination based on the USFS multiple use policy exists.

Although the Hydrology Project is being wrapped up, drip rates will be continued at least until the year 2000. By continuing this project, the effect of periods of drought or unusually wet conditions can be documented.

These results should be considered preliminary, as the final analysis is just starting in preparation of a scientific article for eventual publication.