Proceedings of

BAT GATE DESIGN: A TECHNICAL INTERACTIVE FORUM

Held at
Red Lion Hotel
Austin, Texas

March 4-6, 2002

BAT CONSERVATION INTERNATIONAL

SOUTHERN ILLINOIS UNIVERSITY
Carbondale

Edited by:
Kimery C. Vories
Dianne Throgmorton

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Addresses and Phone Numbers

FOREWORD

On December 15, 1998, the Office of Surface Mining (OSM) signed a Memorandum of Understanding with Bat Conservation International, Inc. in order to establish a framework for cooperative efforts between the two organizations to maintain and increase the conservation of bats and their habitats. Under this agreement, OSM will:

- Consider the conservation of bats and their habitats in the development and implementation of abandoned mine land (AML) reclamation standards and recommendations to States and Indian Tribes.
- Provide assistance in the development of AML programs to help manage bats and their habitats.
- For Federal Programs, monitor non-emergency AML shaft and portal areas for bat activity prior to reclamation.
- As appropriate, require the use of bat gates to seal the shafts of portals where bat habitation is known and would be endangered if sealed otherwise. OSM will encourage the States and Tribes to do the same.
- Promote the education of OSM staff, State agencies, and Indian Tribes as to: the beneficial aspects of conserving bats, tested methods to safeguard bat habitat and public health, and ways to mitigate for loss of bat roosts and habitat.

On March 1, 1999, OSM convened a multi-agency, multi-interest group, steering committee made up of people who have experience in this area in order to initiate planning for a technical interactive forum on the subject of Bat Conservation and Mining.

On November 14-16, 2000, the Office of Surface Mining and Bat Conservation International cosponsored a technical interactive forum on Bat Conservation and Mining. In mid 2001, OSM published the proceedings of this forum and has distributed them widely as part of its effort to improve technology transfer and education on this issue. OSM has also made the proceedings available on its technology transfer CD and at its Bat Conservation Website at www.mcrcc.osmre.gov/bats. One of the recommendations of the participants of that forum and the bat conservation steering committee was to develop a manual on bat gate design for both caves and mines.

On April 21, 2001, a multi-interest group bat gate design steering committee was formed under the co-sponsorship of the U.S. DOI Fish and Wildlife Service, Bat Conservation International, and the U.S. DOI Office of Surface Mining. The objective of the steering committee was to plan for and hold a technical interactive forum that would serve to develop, for distribution by the Fish and Wildlife Service, Bat Conservation International, and others, a manual on how to best protect important caves and underground mines used by bats through the use of gates and other bat friendly closure devices. This proceedings is the product of that effort.

STEERING COMMITTEE MEMBERS

BAT CONSERVATION INTERNATIONAL

Kimery C. Vories (Forum Chairperson)
Mid-Continent Region
USDOI Office of Surface Mining

Roy Powers
American Cave Conservation Association

Jim Kennedy
Bat Conservation International

Dave Dalton
Gating Consultant

Keith Dunlap
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Val Hildreth-Werker
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STEERING COMMITTEE RECOMMENDATIONS
BAT GATE DESIGN

The following are recommendations made by the Bat Conservation Steering Committee immediately following the end of the forum. The recommendations represent areas that have the potential for future efforts by the committee.

1. OSM should continue to encourage States to increase bat protection efforts.

2. OSM should provide technical assistance to States that want to develop bat closure monitoring databases.

3. OSM and others should consider sponsoring a future forum or workshop on the best methods for monitoring caves and mines for use by bats.

4. BCI, US Fish and Wildlife Service, or OSM should convert the proceedings into a true cookbook style handbook on bat gate design.

5. BCI, US Fish and Wildlife Service, or OSM should develop a method or system for reporting successes or failures of the various gate designs. Could be a web site or some other method.

6. BCI and US Fish and Wildlife Service should develop a standard bat monitoring survey form.

7. Need better information on the effects of bat gates on other cave species.

8. What is the impact of bat gates on cave or mine microclimate and what changes can we make to improve microclimate?

9. Need better data on how the airflow changes as a result of the use of bat gate closures.

10. Need better information on the most appropriate and effective use of Culvert Closures and their potential impacts on bat use.

11. Need to research the acoustic signatures of gates and culverts for bats to see if there is interference to the echolocation.

12. Need research and analysis of the airflow characteristics of all gate and culvert designs in a wind tunnel.

WHAT IS A TECHNICAL INTERACTIVE FORUM?

Kimery C. Vories
USDI Office of Surface Mining
Alton, Illinois

I would like to set the stage for what our expectations should be for this event. On November 14 -16, 2000, the Office of Surface Mining and Bat Conservation International cosponsored a technical interactive forum on Bat Conservation and Mining. One of the recommendations of the participants of that forum was to develop a manual on bat gate design. On April 21, 2001, a multi-interest group bat gate design steering committee was formed under the co -sponsorship of the U.S. DOI Fish and Wildlife Service, Bat Conservation International, and the U.S. DOI Office of Surface Mining. The objective of the steering committee was to plan for and hold a technical interactive forum that would serve to develop, for distribution by the Fish and Wildlife Service, Bat Conservation International, and others, a manual on how to best protect important caves and underground mines used by bats through the use of gates and other bat friendly closure devices.

The steering committee has worked hard to provide you with the opportunity for a free, frank, and open discussion on the state of the art in Bat Gate Design that is both professional and productive. Our rationale for the format of the technical interactive forum is that, unlike other professional symposia, we measure the success of the event on the ability of the participants to question, comment, challenge, and provide information in addition to that provided by the speakers. We anticipate that, by the end of the event, a consensus will emerge concerning the topics presented and discussed and that the final proceedings will truly represent the state of the art in Bat Gate Design.

Therefore, one of the main purposes of this event is to bring as much scientific light and technical experience as possible to bear on this topic. It has been my personal experience, that the most progress I have seen, toward making advances in technical fields like this, has come when we have been able to work as a team of professionals toward a consensus on:

- the facts related to the topic, and
- the state of the science in terms of our most workable options and alternatives.

During the course of these discussions, we have the opportunity to talk about technical, regional, and local issues, while examining new and existing methods for finding solutions, identifying problems, and resolving controversies. The forum gives us the opportunity to:

- share our experiences and expertise concerning the design of bat friendly closures that should protect bats and bat habitats in both caves and mines,
- outline our reasons for taking specific actions, and
- give a rational for why a particular closure design should or should not be used in the protection of bats and their habitats at caves and mines.

A basic assumption of the interactive forum is, that no person present, has all the answers or understands all of the issues. It is also assumed that some of these issues, solutions, and concerns may be very site, regional, or species specific.

The purpose of the forum is to:

- present you with the best possible ideas and knowledge, during each of the sessions, and
- promote the opportunity for questions and discussion, by you the participants.

Our purpose is to empower you the participants with better knowledge, new contacts, and new opportunities for problem solving and issue resolution.

The format of the forum strives to improve the efficiency of the discussion by providing:

- a copy of the abstract and biography for each speaker that you may want to read before hand in order to improve your familiarity with the subject mat ter and the background of the speaker;
- We are tape recording the talks and discussions for later inclusion in the post forum publication so that you do not have to worry about taking notes. For this reason, we will require that all participants speak into a microphone during the discussions;
- In order for us to make the most efficient use of time, and ensure that you the participants have the opportunity to provide questions and comments, we require our session chairpersons to strictly keep to the time schedule;
- In the post forum publication, issues raised during the discussions will be organized based on similar topic areas and will not identify individual names. All registrants will receive one cop y of this proceedings. This publication will be very similar to the proceedings of earlier forums conducted by OSM and are available for your viewing at the OSM bat conservation Website at: www.mcrcc.osmre.gov/bats

It is important to remember that there are four separate opportunities for you the participants to be heard:

- 5 minutes will be provided for questions at the end of each speaker =s talk;
- 20 minutes of participant discussion is provided at the end of each topic session. The chairperson will recognize each participant that wishes to speak and they will be requested to identify themselves and speak into one of the portable microphones so that everyone can hear the question;
- At the end of the forum, we will conduct an open discussion on where we should go from here;
- and finally, an orange forum evaluation form has been provided in your folder. This will help us to evaluate how well we did our job and recommend improvements for future forums or workshops. Please take the time to fill out the orange evaluation form as the forum progresses and provide any additional comments or ideas. These should be turned in at the registration desk at the end of the forum.

One of the reasons for providing refreshments during the breaks and lunch is to keep people from wandering off and missing the next session. In addition, the breaks and lunch provide a better atmosphere and opportunity for you to meet with and discuss concerns with the speakers or other participants. Please take advantage of the opportunity at break time to visit the exhibits and posters in the break area. Absracts of the posters are provided in your participant folder. When the meeting adjour ns today, all participants are invited to a social reception where refreshments will be provided.

Finally, the steering committee and I would like to thank all of the speakers who have been so gracious to help us with this effort and whose only reward has been the virtue of the effort. I would also like to thank each of you the participants, for your willingness to participate and work with us on this important effort. Thank you.

Session 1

Why Do We Protect Mines and Caves?

Session Chairperson:
Val Hildreth-Werker and Jim Werker
National Speleological Society
Hillsboro, New Mexico

Cave and Karst Resources
Ronal Kerbo, National Park Service, Denver, Colorado

Importance of Protecting Mines
J. Scott Altenbach and Richard E. Sherwin, Department of Biology, University of New Mexico, Albuquerque, New Mexico

Legal Issues Associated with Bat Gate Construction
Jim Nieland, U.S. Forest Service, Amboy, Washington and Len Meier, Office of Surface Mining, Alton, Illinois

Management and Protection Issues on Private Land
Heather Garland, The Nature Conservancy--Tennessee, Nashville, Tennessee

Consequences of Not Protecting the Resource
Mark Mesch, Utah Division of Oil, Gas, and Mining, Salt Lake City, Utah

CAVE AND KARST RESOURCES

Ronal C. Kerbo
Natural Resource Program Center
Geologic Resources Division
National Park Service
Denver, Colorado

Abstract

Cave and karst resources include the species and inorganic formations found within and associated with a cave, as well as the ground and surface water resources associated with a cave. These unique areas were created and are continually changed by a combination of specific geologic processes. Interference with these processes changes the fundamental characteristics of the cave environment, often resulting in species endangerment and cave resource destruction.

Defining Caves and Karst

The Federal Cave Resources Protection Act of 1988, 16 USC §§ 4301 -4310 (1994) (FCRPA), defines a cave as "any naturally occur ring void, cavity, recess, or system of interconnected passageways beneath the surface of the earth or within a cliff or ledge that is large enough to be traversed by people, whether or not the entrance is naturally formed or manmade." The term includes a ny natural pit, sinkhole, or other feature that is an extension of the entrance. There are at least 23 types of caves, including lava tubes, solution caves in limestone and gypsum, tectonic fractures (earth cracks), littoral (sea) caves, ice caves, and ta lus caves. The FCRPA definition does not establish quantitative parameters for identification of a cave. While a speleologist or caver may not need a definition of a cave, the National Park Service offers the following criteria to assist managers in defining a cave: it has a total passage length of at least 50 feet, contains areas of total darkness, and/or the length of the cave passage exceeds the width of the entrance.

In order to protect karstic as well as other types of caves, the environment in whic h they occur must be protected. This includes protection of soils, surface landforms, natural drainage patterns and hydrologic systems, and cave microclimate and ecosystems. Karst landforms and caves are a significant component of hydrological systems th roughout the nation. The United States contains caves that are among the longest in the world, contain unusual speleothems and mineralogy, and serve as important hibernacula and maternity sites for bats. Caves also provide habitat for many significant an d diverse cave adapted species. While often misunderstood and overlooked in integrated land management schemes, caves and karst present managers with unique conditions and challenges. Some of the most complex hydrological and ecological conditions are fo und in cave and karst systems.

Importance of Cave and Karst Systems

Cave and karst systems are important for two major reasons. First, the overwhelming majority of the nation's **freshwater resources** are groundwater and about 25% of the groundwater is located in cave and karst regions. The protection and management of these vital water resources is critical to public health and to sustainable economic development. As identified by the National Geographic Society, water resources are a critical concern as society enters the twenty-first century.

Second, caves are storehouses of **information on natural resources, human history, and evolution**. Therefore, many avenues of research can be pursued in caves. Recent studies indicate that caves contain valuable data that are relevant to global climate change, waste disposal, groundwater supply and contamination, petroleum recovery, and biomedical investigations. Caves also contain data that are pertinent to anthropologic, archaeologic, geologic, paleontologic, and mineralogic discoveries and resources. Many researchers have turned to caves as natural laboratories where **paleo-climatic evidence** has been naturally deposited over the eons and is awaiting discovery. For example, the recently discovered Lechuguilla Cave in New Mexico has excited scientists with the possibilities of gaining insight into global warming from analyses of materials found there.

Cave-dwelling organisms have specialized adaptations such as extreme longevity and enhanced sensory perceptions. The adaptations reveal much about the evolutionary responses to past environmental changes and may provide valuable clues to current climate change. Many caves act as natural traps for flora and fauna. New species of extinct animals such as a mountain goat and a bush oxen related to the present day muskox (*Ovibus moschatus*) have been discovered from paleontological excavations in caves. These discoveries add to the knowledge of paleo-fauna and are an aid to understanding changes in the global climate.

Other examples of climate information include pack rat middens in Grand Canyon caves that yielded pollen as old as 4000 years. This find was important because pollen characteristics provide data about climatic cycles. For example, researchers produced a regional paleo-climate record from samples of travertine deposits in a submerged cave system in Death Valley National Park, California. Cores from carefully selected speleothems in Carlsbad Caverns, New Mexico, also provided indications of paleomagnetics and paleoclimate conditions.

Caves have always been known as repositories of archeological materials. Some of the oldest evidence of human activity comes from caves. In the caves of Arizona's Grand Canyon and in the lava caves of El Malpais National Monument in New Mexico, archeological teams have excavated ancient pottery, discovered figurines made from twigs, and found evidence of the use of caves for habitation.

In the Slaughter Canyon Cave of Carlsbad Caverns National Park in New Mexico, recent studies led to the discovery of one of only three deep cave art sites in the United States.

In the Mammoth Cave area of Kentucky, anthropological studies revealed that people used the caves for thousands of years as shelter and for mining minerals used as medicines.

Historic and prehistoric cultural remains found in caves are extraordinarily diverse. According to Dr. Patricia Watson, they range from ancient torch smudges on cave ceilings to civil war age saltpeter vats used to make gunpowder. Dr. Watson states that "In spite of this diversity, the cultural resources have common attributes: (1) they are subtle, elusive, fragile, or all three; and (2) they provide unique and valuable information about the past. Without proper documentation and research of these hidden cultural remains in deep or shallow caves, valuable and important segments of the human history would be lost for all time."

Adversities and Threats to Cave and Karst Systems

Use of caves by humans can have significant detrimental effects o n caves. Biological resources are sometimes threatened. Especially vulnerable are bats, cave -adapted invertebrates, and sensitive flora growing near cave entrances. So little is known about many of these species that evaluation of population stability, adversities from current and past human activities, and probabilities for species survival cannot be assessed without further inventories and monitoring.

Because cave and karst systems are intimately tied to local and regional hydrological systems, pollution or disruption of these natural systems can harm water supplies and water quality. Inappropriately placed toxic waste repositories, landfills, oil and gas leaks from hydrocarbon development, and toxic or corrosive chemical spills can cause direct threats to cave and karst groundwater aquifers. Remediation can cost millions of dollars. Also, sediment loading caused by erosion from agricultural operations, deforestation, and fires can cause significant deterioration of water quality.

Management of Cave and Karst Systems

Without proper management, use of caves by humans can have significant detrimental impacts on cave resources. Biological resources that are being threatened include but are not limited to several species of **endangered bats, ferns and lichens, and microbial communities**. Especially vulnerable are **cave-adapted invertebrates**. So little is known about many of these species that evaluation of population stability, impacts from current and past human activities, and probabilities for species survival cannot be assessed without further inventory and monitoring studies.

WATER QUALITY AND QUANTITY

Because cave and karst systems are intimately tied to local and regional hydrological systems, threats to these natural systems, if allowed to go un mitigated, can have impacts on water supplies and water quality and consequently cave biota, mineral deposits, and speleothems. Direct threats to cave and karst groundwater aquifers can include:

interruption or diversion of natural hydrologic flow; land disturbances; runoff from roads, parking lots, lawns, and roofs; inappropriately placed toxic waste repositories; pollution/runoff from sewage and septic systems; livestock and poultry operations, and/or landfills; leaks from improperly maintained and monitored underground gasoline storage tanks; oil and gas leaks from hydrocarbon development; toxic and corrosive chemical spills; and improper use of pesticides, herbicides, and fertilizers. Any of these situations can cost millions to remediate and can have devastating impacts on karstic aquifers. The hydrologic nature of karst systems allows for easy infiltration and rapid transport of contaminants over large distances below the surface. Regional, rather than localized, aquifer contamination is one of the prevailing risk factors that distinguish karstic aquifers from porous and permeable aquifers. Additionally, erosion as a result of agricultural activities such as excessive tillage and overgrazing, as well as deforestation and fires, can result in significant deterioration of water quality from sediment loading.

REFERRED TECHNIQUES

Preferred means of cave protection are confidentiality of cave locations, ranger patrols, and use of interpretive media to help people appreciate caves and understand the fragility of cave resources. Interpretation is an extremely important management tool since it encourages voluntary compliance and cooperation in protecting these nonrenewable resources.

GATES

While gates are an important and necessary component of cave and karst management and protection they are an obtrusion on the aesthetic integrity of a cave entrance and are often deleterious to the ecology of a natural cave, especially if improperly designed. Poor gate designs may impede or obstruct airflow and the movement of bats and other organisms into and out of the cave. Even a *bat-friendly* gate is not as friendly as an ungated entrance, though it may offer protection from external threats. The use of gates to prohibit unauthorized entry is often unsuccessful against determined vandals. Gates should be used to protect caves only where the need is considered essential and a biologically neutral gate can be constructed. The entrance to many caves is so large that gates are not feasible. Interior gates may be used to restrict access to areas of significant hazards or areas that merit special resource protection. Before a gate is constructed, the appropriate specialists should be consulted to ensure mitigation of all environmental concerns, including: ecological, physical, cultural, aesthetic, and law enforcement issues.

Vision for the Future

For far too many years, those of us who are cave managers and cave users, from recreational cavers to research scientists, have focused almost exclusively on the hollow components of karstic systems. We have not been aggressive enough in developing strategies, guidelines, or policies to manage, protect, conserve, or interpret overall cave/karst systems. Based on the almost total destruction of the contents of some caves (both natural and cultural), it has been and remains important to conserve and protect the

contents of caves. It is imperative that managers are better informed about the role of karst in the ecosystem and develop policies to prevent the possibility of catas trophic impacts to these important systems. We can no longer afford to ignore karst processes. One of our best hopes for scientific based protection methods and management strategies will come from the National Cave and Karst Research Institute Act, PL 10 5-325, signed into law on October 30, 1998, establishing the National Cave and Karst Research Institute.

Ronal Kerbo is the national cave management coordinator for the National Park Service. He has been caving for over 35 years and is an Honorary Life Member and a Fellow of the National Speleological Society, a member of the Cave Research Foundation, an Honorary Director of the American Cave Conservation Association, and a member or honorary member of many other speleological associations.

IMPORTANCE OF PROTECTING MINES

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Abstract

Underground, abandoned mines bear striking similarities to caves with respect to the roosting habitat they provide for bats and some other types of wildlife. Their patchy distribution reflects the geological conditions required for mineralization that prompted their excavation. The geographic and climatological variation associated with their location and individual variations associated with their excavation provide the wide range of internal conditions that makes them habitat for so many kinds of bats. The importance of mines to bats is so well documented that further attempts here are unnecessary. As we learn more about the ways bats use mines, the scale of this importance increases. The similarities with caves end when we consider the potential hazards mines represent. Aggressive safeguarding programs that threaten their existence compound the complications of protecting them as bat habitat. Given that they were created without consideration of longevity beyond the extraction of resources, the abandonment of hazardous materials, and the geologic conditions existing where removal of ore has left underground voids, mines cannot be considered as worthy of protection for any recreational potential. However, the archaeological and historical resources that historic mines provide in parts of North America are locally highly significant and often totally ignored in the consideration given to their non-destructive safeguarding. Mines may provide time capsules from the late nineteenth and early twentieth centuries that have no equal. Those time capsules have seen wholesale obliteration along with bat habitat by destructive closure. Another resource in the eyes of geologists, mineralogists, and the mining community is the idea that historic mines provide human-accessible "windows into the world" that cannot be equaled by core drilling techniques and are not likely ever to be created again. The complicated balancing act pits public safety (more accurately fears of liability) and accelerated destructive safeguarding (where time is money) against protection with non-destructive closure that may require more time-consuming evaluation and may be more costly or less convenient. Critical in this balancing act is the role of the scientific community in providing accurate assessment of the biological needs of wildlife, the actual patterns of mine use, and a reasonable assessment of the impacts associated with alternative closure options. The desperation decision-making on the part of biologists, a necessity in the face of the aggressive, often uniformed, often-arrogant closure programs in the last decade must give way to an unbiased scientific approach to the impacts of alternative closure methods if non-destructive closure efforts are to continue with success.

Key Words: abandoned mine, mine reclamation, mine remediation, bat roost, wildlife management, bat gate, roost protection.

Introduction

Abandoned mines and caves are often viewed as similar resources. In fact, it is not uncommon for the public and even researchers to interchange the two terms. Abandoned mines and caves are analogous in that both represent subterranean habitat. As such, internal conditions may be similar as both provide some sort of buffer from ambient conditions and usually provide habitats not locally available on the surface (Humphrey, 1975; Kirbo –this volume; Sherwin, et al., 2000a; Sherwin, et al., 2000b, Sherwin, et al., 2002; Tuttle and Stevenson, 1978). Both caves and abandoned mines are available in all shapes and sizes, include a wide range of climatic conditions, and are widely distributed. Both resources are located in a broad range of geographic conditions across a wide-range of habitats (vegetative, elevation, etc). However, there are some subtle, yet fundamental differences between caves and abandoned mines that make a profound difference in how both resources are managed. The differences between both resources are mostly attributable to the greater instability observed in abandoned mines relative to caves. The geological and hydrological processes that cause the formation of caves generally occur over geological time scales, allowing sufficient time for weathering to stabilize cave features and form. Abandoned mines are created over short temporal periods using violent processes (drilling, blasting, etc.). Many hard rock mines were excavated in brecciated or faulted ground where mineralization subsequently occurred, further compounding the ephemeral nature of internal workings. Mine workings were created to access and remove ore-bearing rock. Internal workings were designed to last only for the period of ore extraction and were not intended to last for prolonged periods of time.

To help support fractured overburden, mine engineers often called for internal support in the form of timbers or pillars (load-bearing rock left in place). However, ground supports were often minimal since timber was expensive and required additional time to place ("men were cheaper than timber" – Crampton 1956). When pillars were used, they were often robbed during the final stages of ore extraction and timbers were often pirated by later mining activities. Even when supports were left in place, subsequent stabilization often causes overburden to settle (causing pillar failure) and high humidity causes timbers and other wooden supports to rot over time. This combination of faulty ground, violent ore extraction processes, and lack or failure of internal supports, leaves abandoned mines exhibiting varying degrees of internal instability. In many cases, insufficient time has passed for internal workings to settle into stable form. A single mine may include portions that range from extremely stable (haulage tunnels through country rock that undercut ore zones) to dangerously unstable, further complicating the diagnosis of underground conditions. In addition, different types of mines are often viewed as more or less stable than others. For example, coal mines and uranium mines typically undercut sedimentary material (i.e., sandstone) leaving a flat roof (back) that is likely to fail into a more stable arch configuration. In addition to varying structural integrity, abandoned mines include a host of dangerous conditions such as toxic or oxygen displacing gasses, old explosives, vertical hazards (often hidden), abandoned equipment and even dangerously high levels of radiation. While those with appropriate training and experience can avoid these hazards, abandoned mines present a serious threat to the general public and even to those skilled in cave exploration.

Those interested in abandoned mine exploration, artifact hunting, and similar recreational activities often

ignore the dangers associated with abandoned mines and many are drawn to these sites. Even those not actively seeking abandoned mines are not insulated from their dangers. Abandoned shafts or open stopes are often relatively inconspicuous and were often covered with timbers, sometimes in-turn covered with dirt and debris. As timbers begin to rot, structural integrity is lost, and additional weight (vehicle driving over, human walking across, heavy snow, etc) may cause failure. As a result of the risks associated with abandoned mines, they cannot be regarded as having recreation potential. Most abandoned mines are viewed as an attractive nuisance by land managers (Sherwin et al. 2000a).

Abandoned mines have been identified as a threat to the public and most States have initiated abandoned mine reclamation programs. These programs are intended to locate and secure abandoned mines (through portal closure) and eliminate associated hazards. While the level of organization and effectiveness of these programs varies, the net result is the annual loss of hundreds of abandoned mines each year. At least 32,738 openings have been closed since the initiation of formal reclamation programs (Meier and Garcia, 2001). In addition, unknown numbers of abandoned mines are also closed by private landowners to ameliorate issues of liability, or are lost to renewed mining activities in historically mined areas. In addition, mine workings often initially penetrated weathered, unconsolidated ground, and the lack of portal maintenance following abandonment has often allowed slope creep and portal failure. An unknown number of mines are closed annually as the result of natural weathering processes. Regardless of the cause of closure, the net result is annual loss of open abandoned mines in the landscape (mines are being lost without replacement since modern, underground mining is relatively uncommon).

The unstable nature of mines (relative to caves) represents a fundamental distinction that pervades every aspect of their management and represents a single point of divergence from which mines need to be distinguished as a separately managed resource. Those determining the appropriateness of protecting caves with bat gates must weigh the costs and benefits of restricting or eliminating access. The burden of proof is on them to demonstrate that the presence of sensitive resources (geological, hydrological, historical or biological) warrant the exclusion of the public from a given cave. Conversely, those who attempt to protect abandoned mines must provide supporting evidence that sensitive resources warrant the protection of individual mines from permanent closure. They must have sufficient evidence to offset the potential costs of allowing the persistence of potentially dangerous resources in the environment.

In addition, caves are generally closed on a site-by-site basis, and are not usually part of large-scale closure programs observed in abandoned mine reclamation. Caves often have a tradition of use, with varying amounts of information available regarding the types and sensitivity of resources maintained within. Those visiting caves are more than just "spelunkers." Visitors often include cavers for whom subterranean exploration and cave conservation is a passion. These cavers often maintain excellent field notes documenting the condition and extent of passages, relevant observations, and documentation of negative impacts to cave resources (both biotic and abiotic). Cavers often stand as a voice for the resource and many caves have been protected as a result of efforts from local individuals and caving grottos. When pre-closure data are not available, there is an added luxury of time (supposing that resources are not in imminent danger) to collect suitable data to determine the appropriateness of cave

protection. Projects that threaten abandoned mines are generally conceived and conducted over much shorter time periods. In most cases, the actual timeline of closure projects (location of workings through closure) is less than one year with most of these projects including dozens to hundreds of discrete mine workings. There is generally no information available regarding the extent and condition of subterranean workings, let alone the resources in those mines. In short, those managing abandoned mines often face the daunting task of locating, surveying and collecting data at dozens to hundreds of mine workings and then making sound management decisions for individual closures, often within a single season, with no available baseline data.

Resources Provided by Abandoned Mines

Cultural Resources. Much of the early history of the western United States was built upon the availability of natural resources. The location of mineral deposits and the resultant financial booms associated with extracting these resources were pivotal for the establishment of infrastructures upon which settlement was predicated (Hardesty 1987). Many mining techniques were developed or refined in the western United States, and miners were drawn from all over the world (particularly Europe and Mexico). Evidence of these booms, diverse settlements, and technological advances remain at mining camps (Hardesty 1987; Sagstetter and Sagstetter 1998).
Historical and archaeological resources from historical mining have been discussed most frequently in terms of those located on the surface (Hardesty 1987; E. Twitty 2002). In fact, surfaces associated with abandoned mines are routinely evaluated by archaeologists during mine closure and mine expansion projects following State Historic Preservation Office (SHPO) guidelines. However, artifact hunters, campers and explorers have permanently altered the historical integrity of many mining camps. As a result, the quality and quantity of surface feature documentation and protection during safeguarding projects varies dramatically depending on the remoteness of the site and the degree of climatic variability (surface features are subject to weathering). While pre-closure cultural surveys are conducted on all State and Federal lands, there has been little call for appropriately trained archaeologists and few have any training or familiarity with the history of mining. Archaeological reports identifying a steam dome from an uncommon and very old steam boiler as a "piston cylinder" and another which states flatly that gasoline hoisting replaced steam hoisting within a narrow time span (because of supposed greater efficiency of gasoline hoists), illustrate the lack of expertise of those conducting surveys (Altenbach, personal observation.).

Even though archaeological evaluations of surface features often leave much to be desired, underground evaluation is typically nonexistent. This is unfortunate because underground archaeological resources can be perfectly preserved in dry workings and surprisingly well preserved even in damp or wet conditions. Some mines are virtual time capsules with artifacts maintained in such pristine condition that one can imagine hearing the sounds of voices and machinery, and even smelling the sweat and powder smoke in the air. They can provide a detailed view of the chronology of the mining operation, as well as many details of the techniques and technology of historical mining. Many of these details including subtleties of hand drilling, blasting, timbering, haulage, development and hoisting, have been lost. These details have only been rediscovered through the exploration and study of internal conditions and artifacts (Altenbach,

1997). A wide variety of large and small machinery remaining in underground workings is otherwise known only from illustrations in old suppliers catalogs. The lack of concern over historically significant resources available in abandoned mines is perplexing. Perhaps the mines are not old enough to warrant concern from most archaeologists, however, most mines are old enough for protections mandated under the National Historic Preservation Act (1966, amended 1976 and 1980). The lack of concern regarding historical artifacts in underground workings is evinced by the fact that the authors have surveyed in excess of 10,000 abandoned mine workings, yet only a single reclamation manager in one State program (H. Milford, New Mexico Abandoned Mine Lands Bureau) has ever queried regarding the historical resources in the surveyed mines. Even cursory documentation of underground resources by surveying biologists would be more appropriate than the current program of disinterest. It has been suggested that permanent closure of mines affords the best protection for cultural resources. However, solid closures (backfill, wall installation) often increase internal humidity, accelerating the weathering process, causing the permanent loss of cultural resources. In addition, without even cursory documentation of sites that contain significant cultural resources, it is hard to imagine that they will be rediscovered. We propose that the discovery of significant historical resources in abandoned mine workings should be sufficient to warrant protection, or at least, documentation.

Unique Geological Resources. Another resource that is typically ignored during both pre-closure surveys and subsequent determination of closure or protection is the geologic and mineralogical information that is lost in destructive closure. Mine geologists view abandoned mines as "windows into the world" that offer detailed looks at the geological history of that particular area. The view afforded through abandoned mines is not possible by any other means (R. Evelethe, personal communication). Surface evaluation of geologic conditions is often limited by alteration due to weathering. Although core drilling can provide information about subsurface geological features, it necessarily takes a narrow and nearly linear sample of the underground, easily missing major localized features. In addition, some types of drilling destroy much of the macro-morphology of investigated formations and often causes dramatic surface disturbance. In areas where abandoned mines are present, they are often the first resource investigated during prospecting and evaluation phases of mining operations. In addition, allowing access to underground workings allows claim holders (or landowners) to advertise their property to larger mining interests. Many universities (particularly those with mining programs) use abandoned mines as laboratories for training and educational purposes. In some cases, abandoned mine workings follow fault caves or intersect cave features, in which case protection might be warranted under the Cave Resource Protection Act (1988 –vugs are exempted). In the current climate of severe and costly regulation, coupled with the high costs associated with creating underground workings, these windows are unlikely to be opened again. Therefore, we propose that abandoned mines that contain unique geological features may warrant protection from destructive closure.

Unique Biological Resources. The fact that bats use abandoned mines and that abandoned mines represent important roosting habitat for bats has been well documented (Altenbach and Pierson 1995; Altenbach et al. 2001; Ducummon 2001; McAney 1999; Sherwin et al. 2000a; 2000b; 2001; 2002; Tuttle and Taylor 1998; Twente 1960). Abandoned mines are known to be critical to many species of bats in at least portions of their range (see Sherwin and Altenbach, this issue). While the importance of abandoned mines to bats is becoming more widely accepted, closures still occur with little regard for the

biological importance of these resources. Some mining companies and even mine reclamation projects interpret regulations to consider only endangered species. At least one Federally funded reclamation program on Navajo Nation Lands has closed all of its coal mines and virtually all of its hard rock mines without biological evaluations of any kind (D. Martinez personal communication).

Published accounts of the proportion of abandoned mines used by bats and the degree of their dependence on them varies regionally, but run as high as 70 percent (Sherwin et al. 2000a; 2000b; 2002). In addition, determining biological significance is somewhat subjective and also varies regionally. For example, colony sizes considered to be significant for some species in the West might be considered insignificant for Eastern species with colony sizes that often number in the thousands (Tuttle and Taylor 1998; Altenbach and Pierson 1995; Sherwin et al. 2001). In some regions in New Mexico approximately 15 percent of surveyed abandoned mines have documented bat use significant enough to warrant protection from closures through the installation of bat-compatible closures (Altenbach in lit.). In regions of Nevada and Utah, proportions of mines identified as significant bat habitat vary from as low as 6% to over 50% (Sherwin et al. 2002). If these figures are applied to the tens of thousands of mines that have been closed over the last 15 years in which no biological surveys (or inadequate surveys) were conducted, it is clear that there has been substantial loss of roosting habitat. It is also possible that these same closures caused direct mortality through the entombment of roosting colonies (see Tuttle and Taylor 1998; Ducummon 2001).

So Where Were Bats Before Abandoned Mines?

Mining activities in the western United States began in earnest with the arrival of Anglo-European settlers in the 1850's and had become a major industry by the 1890's. By 1920, an estimated 600,000 subterranean roosts had been created as a result of these activities. Currently, approximately 350,000 abandoned mines remain open and accessible to bats (in the West). In many cases, mining operations were developed along fault zones that had caused the creation of natural caves. In fact, roughly one quarter of all mines surveyed by one of the authors (Sherwin - roughly 5,000 mines) show evidence of cave features. Assuming that all of these sites that intersected caves had cave openings to the surface prior to the onset of mining activities (an untestable assumption), and further assuming these surveyed mines are representative of the whole, the net result is an increase of roughly 275,000 potential subterranean roosts.

It is important to remember however, that the mining boom is also correlated with increases in human abundance, expansion of urban areas, and creation of other cave surrogates such as buildings and bridges. Many species that were likely more closely tied to caves prior to the 19th century did not make the move to mines, but moved instead to buildings and other anthropogenic features. It would appear that only a few species of bats have responded to abandoned mines in such a way that they could be accurately described as abandoned mine obligates throughout their ranges (in the western U.S. -- *C. townsendii*, and *Macrotus californicus*). Many other species appear to be dependent upon these resources in portions of their ranges (*Myotis thysanodes*, *ciliolabrum*, *californicus* and *A. pallidus*) during certain times of year. When attempting to infer the impacts of abandoned mines on bats, it is

important to clearly differentiate between mine/cave obligates and species that are more casual in their use of this resource.

When attempting to understand the relative importance of protecting abandoned mines for the long-term maintenance of roosting bats, one must first understand the historical patterns of roost/colony distribution. We propose three hypotheses that predict different ways in which cavernicolous species have responded to the creation and abandonment of subterranean mine workings.

The Displacement Hypothesis. A common argument has been made that abandoned mines represent refugia to which bats have been driven as a result of human disturbance at traditional cave roosts (Pierson and Rainey 1995; Altenbach and Pierson 1995; Sherwin et al. 2000a –Figure 1). While this theory has not been rigorously tested, anecdotal evidence is available that supports this idea. For example, in central New Mexico a large cave-based maternity colony of fringed myotis (*M. thysanodes*) has gradually dwindled from over 500 mature females in 1990, to none during the 2001 maternity season. During this same time period, visitation of the cave by humans increased dramatically (as evidenced by increasing observation of visitors and an exponential increase in the amount of trash in and around the cave). Coincident to the decline in bat use of this cave, an abandoned coal slope about 5 miles away saw a steady increase in use by this displaced colony (Altenbach in litt.).

While human disturbance likely drives selection at local scales, it is unlikely that this factor drives roost selection throughout a species range. This is supported by Sherwin et al. (2000a, 2000b, 2002) who found that human disturbance was not equally expressed across entire ranges, and that many highly disturbed colonies did not abandon caves and relocate to seemingly suitable and adjacent abandoned mines.

Roost Limited (Range Expansion) Hypothesis. This hypothesis assumes that the presence of roosts is the ultimate constraint regulating both the distributions and population sizes of cavernicolous species of bats. The availability of abandoned mines in the landscape has relaxed these constraints and species are now responding to newly created roosts through changes in patterns of distribution, range expansions, increased rates of dispersal, and population increases (Figure 2). This net increase in potential roosts has likely resulted in the establishment of populations in parts of specific ranges that did not exist prior to the 19th century. In fact, it is likely that cavernicolous species are now more evenly distributed within the boundaries of their ranges and it is likely that some species have even expanded the bounds of their ranges as a result of the creation of abandoned mines (i.e., *Macrotus californicus*).

However, this argument assumes that the ultimate constraint regulating the size of populations was the number of roosts (thereby invoking inter/intraspecific competition and other density dependent constraints as functional limits). This assumption has not yet been supported, as there does not appear to be any correlation between roost size and population/colony size.

The Spilled Milk Hypothesis. This hypothesis assumes that while the distributional patterns of cavernicolous species are regulated by the presence of roosts, the population sizes are governed by

some other ultimate constraint (i.e., availability of energy). Therefore, the creation of additional roosts (in the form of abandoned mines) has merely altered the surface environment (not necessarily improved it) and the bats have responded by altering spatial patterns of distribution. However, the ultimate constraints remain in place so population sizes have not increased. Therefore, if we now further modify the landscape (at a much shorter temporal scale than the original modification), we may end up with a net loss of individuals and a decrease in total population. This would be analogous to spilling milk from a cup, where the milk represents colonies of bats and the cup represents roosts. The cup functions as a constraint on the distribution of the milk, and by spilling the contents of the cup over the surface of the table, the distribution of the milk changes (reflected in an increased surface area), but the total volume of milk has remained the same. If the spilled milk is then wiped off the table the total volume of milk has now been reduced (Figure 3).

This hypothesis is supported in *C. townsendii* where colonies in mines are smaller and more evenly distributed that than those in caves. This suggests that populations aren't responding to the increased availability of roosts by increasing colony and population sizes, but rather are simply becoming more evenly distributed in the landscape. This is further supported by the fact that colonies in abandoned mines decrease in size as one moves further from portions of the range where caves exist (Sherwin et al. 2002).

Formally identifying these hypotheses is not an exercise in trivia, nor does it represent irrelevant ecological theory. Personal interpretation of which hypothesis is most true, necessarily dictates the degree of alarm associated with the loss of caves and appropriate management of abandoned mines. We propose that these hypotheses are not mutually exclusive and are likely evinced at different spatial and temporal scales. For example, the displacement hypothesis may function at local scales, but can fade in importance as one addresses landscape and distributional scales. Simplistic interpretations that abandoned mines simply represent refugia or that they could only have positive effects (through increased availability of roosts), are inappropriate.

What are the Responsibilities of Persons Conducting Mine Surveys and Making Recommendations for Non-Destructive Closures?

The fact that abandoned mines represent important roosting habitat for many species of bats, and that they are disappearing at a rapid rate makes it important that critical roosts be located and identified prior to closure. The time constraints imposed by mine closure projects make the management of abandoned mines particularly challenging. This is further compounded by the more complex patterns of use described for colonies roosting in abandoned mines relative to those roosting in caves (Sherwin et al, 2000a; 200b; 2002). In populations of *C. townsendii* studied throughout the Southwest and Great Basin, colonies roosting in abandoned mines were less spatially and temporally stable than those roosting in caves. In addition, a greater amount of survey intensity was required at abandoned mines (relative to caves) before patterns of use could be discerned (Sherwin et al., 2000a, 2000b). This further compounds the problems facing those who manage time-sensitive abandoned mine closure projects. Altenbach et al. (2001) suggest that observed complexity in the use of abandoned mines by

bats makes a cookbook approach inappropriate. Specific techniques for conducting roost surveys are discussed by Brown (this volume).

The requirements for pre-closure bat evaluation have grown along with the costs of bat-compatible closure methods. Agencies and private entities have quite reasonably started to demand more accountability on the part of those asking that a particular mine be protected. If a mining company or State mine reclamation program is going to invest in a bat-compatible closure on a mine or several mines, it is reasonable that they see justification for the significance of the bat use at the mine and the probability that the closure will have the desired effect in bat conservation. The responsibilities of the biologists surveying the mine for bat use and making recommendations about the gate design fall into several categories.

The first responsibility of those overseeing mine closure projects is to locate all openings that will be affected. Following the location of openings biological surveys must be initiated that maximize the probability of detecting bat use or, equally important, reliably determining that the mine is not used. The costs and benefits of external versus internal surveys are discussed at length by Altenbach and Milford (1995) and Altenbach, et al. (2001). Altenbach, et al. (2001) discusses the experience, equipment and training requirements for underground surveyors.

Reasonable recommendations about appropriate closure methods should not be made without at least cursory internal evaluation, as external surveys provide no power to resolve negative data. Sherwin et al. (2000a, 2000b, 2002) discuss the level of intensity that may be required to adequately resolve negative data. Managers must ensure that qualified persons, with adequate training in both mine survey and bat survey techniques conduct evaluations. Bad examples of survey techniques abound. For example, a biologist working for an environmental consulting firm in Arizona was observed evaluating shafts for bat use by dropping rocks down the shaft and then equating the lack of exiting bats as indicative of no actual use by bats. This type of disturbance to bats in lateral workings off of a shaft or even on the shaft rib would more likely drive bats deeper into the workings making any out-flight highly unlikely (see Altenbach, et. al. –2001- for an overview of shaft evaluation). This same consultant routinely misidentified roosting *A. pallidus* as *C. townsendii* during roost surveys in Nevada. Diagnostic features of both species make misidentification difficult, suggesting that this person did not even have a basic familiarity with bats. Yet this individual was making decisions regarding the permanent elimination of hundreds of potential abandoned mine roosts (Brown, personal communication). Many inexperienced surveyors have watched a mine entry at night, observed no activity and pronounced the mine "free of bats" while tens or even thousands of bats exited from a less conspicuous opening a short distance away. Subsequent surveys by competent surveyors in mine reclamation projects have repeatedly found significant bat use in mines declared bat-free by various biological consulting companies.

It is critical that surveying biologists understand the natural history of the species involved to determine the significance of observed use. Sherwin et al. (2000a, 2000b, 2001), illustrate that colonies of *C. townsendii* routinely move between roosts over the course of a single maternity season with colonies

often moving long distances between roosts. When roost fidelity is low, several individual mines may be critical to the long-term maintenance of colonies. However, a single survey, even in maternity season, could easily fail to identify mines that may be highly critical to this single activity. The use of mines for hibernation and for swarming species is detected readily by external survey if the survey is timed appropriately for the species involved in a particular geographic region. For most Western species, detection of hibernation is virtually impossible without internal evaluation during hibernation season. Use of mines as migratory stopovers and by others as cold sites by females during preparturition requires survey techniques tailored to detect the particular use.

Following adequate biological surveys, managers must determine which mines will be protected with bat gates. In cases where mines cannot be maintained (in the case of mine expansion, or inadequate portal integrity), suitable mitigation roosts need to be located and protected. This may involve expanding surveys beyond the immediate area of impact and often involves contact with additional mining companies of or private landowners.

Managers must ensure that bats have vacated roosts prior to site destruction. Techniques for excluding bats from roosts are discussed by Brown et al. (2001) and by Sherwin and Haymond (2002). Typically, exclusion activities should be conducted at all openings at which closures are intended.

Those mines at which gates will be installed need to be protected with appropriately designed and installed bat gates. Another striking difference between caves and abandoned mines involves the complexity and difficulties involved in installing gates over mine openings. Shaft collars were often stabilized with timber so that stacked muck could be used to provide a level area for the surface plant. Collar sets often fail following abandonment and shaft collars begin to slump as a result (Figure 4). A similar phenomenon occurs at adit portals where weathered, unconsolidated ground had to be penetrated and stabilized with timber before competent ground was reached. Even in competent ground, a mine portal was initially opened with blasting that was likely to fracture the rock and make it even more susceptible to weathering. Obviously, these conditions complicate the task of installing an adequate gate, often requiring collar or portal stabilization prior to gate installation. In many situations, preservation of a mine requires substantial stabilization of the entry and prevention of slope creep that will eventually close off a mine opening. In addition, historical structures are often associated with mine openings and must be considered during gate installation or closure. Specifics of addressing issues of instability and gate design are considered throughout these proceedings.

Conclusion

While abandoned mines are superficially very similar to caves, they are very different resources requiring different management strategies. The fundamental difference between caves and abandoned mines stems from the inherent dangers associated with abandoned mines. These dangers have resulted in the creation of State and Federal abandoned mine reclamation programs and privately funded closures, both aimed at ameliorating issues of liability. In addition, abandoned mines are disappearing as a result

of renewed mining in historically mined areas. As a result, abandoned mines are a threatened resource and it is important that sites that represent critical bat roosts be located and protected from closure.

We propose that no qualitative statement can be given regarding the impacts of the creation of abandoned mines on various species of bats. We have no baseline data regarding historical population densities; we do not truly know the historical distribution of caves (although this might be obtainable). And most importantly, we don't clearly understand the constraints limiting population sizes and whether or not these have been relieved through the creation of additional roosts. Furthermore cavernicolous bats suffer from reproductive constraints (one pup/year, 50% survival rates) such that it will likely take many generations before population numbers can change sufficiently to determine if these constraints have been lifted. What we do know is that the creation of abandoned mines has had a dramatic impact on the patterns of distribution of these species. We propose that humans have so altered the roosting landscape that the lack of baseline data makes it impossible to determine how the addition of roosts in the landscape has altered specific population trajectories. In order to truly manage this system, we need to begin conducting rigorous, manipulative experiments by which we can begin to understand what resources need to be left in place and what can be destroyed. Unfortunately, the path of least resistance is to conduct "survey science" and design protocols based solely on current management practices. However, this quickly becomes a "positive feedback loop" with the same individuals doing the surveys, collecting the data, interpreting the data, and designing the protocols. Without the application of appropriate research, designed studies and the testing of actual hypotheses, we will continue to manage this system based on hunches and best guesses. We suggest that sufficient data is not currently available to determine an "endpoint," but as long as we continue to manipulate the landscape at such vast scales, we have an obligation to mitigate these impacts.

On a more positive note, we are in the process of conducting a manipulative experiment on an unprecedented scale, and as we monitor the effects of these landscape level changes, we may be able to determine what effects the creation of new roosting opportunities has had. We will likely also be able to better understand the constraints limiting this system.

Literature Cited

Altenbach, J. S. 1997. Hand drilling, the record from western mines. Eureka, 24:2-7.

Altenbach, J. S., and H. E. Milford. 1995. Evaluation and management of bats in abandoned mines in New Mexico. Pp. 326-330 in D. Pate, ed. Proceedings of the 1993 National Cave Management Symposium, Carlsbad, New Mexico. American Cave Conservation Association, Horse Cave, Kentucky.

Altenbach, J. S., and E. D. Pierson. 1995. The importance of mines to bats: an overview. Pages 7-18, in B. R. Riddle, ed. Inactive mines as bat habitat: guidelines for research, survey, monitoring and mine management in Nevada. Biological Resources Research Center, University of Nevada, Reno, Nevada.

Altenbach, J. S., R. E. Sherwin, and P. E. Brown. 2001. Pre-mine closure bat survey and inventory techniques. Pp. 115-125, in K. Vories and D. Throgmorton, eds. Bat Conservation and Mining, a

Technical Interactive Forum. Office of Surface Mining, USDI, Alton, IL and Coal Research Center, SIU, Carbondale, Illinois.

Brown, P. E., J. S. Altenbach, and R. E. Sherwin. 2001. Evicting bats when gates won't work: unstable mines and renewed mining. Pp. 187 -192, in K. Vories and D. Throgmorton, eds. Bat Conservation and Mining, a Technical Interactive Forum. Office of Surface Min ing, USDI, Alton, IL and Coal Research Center, SIU, Carbondale, Illinois.

Crampton, F. 1956. Deep enough: a working stiff in the western mining camps. University of Oklahoma Press.

Ducummon, S. L. 2001. Ecological and economic importance of bats. Pp. 7-16, in K. Vories and D. Throgmorton, eds. Bat Conservation and Mining, a Technical Interactive Forum. Office of Surface Mining, USDI, Alton, IL and Coal Research Center, SIU, Carbondale, Illinois.

Hardesty, D. L. 1987. The archaeological significance of mining districts. Proceedings of the Workshops on Historic Mining Resources: defining the research questions for evaluation and preservation. South Dakota State Historic Preservation Society. South Dakota.

Humphrey, S. R. 1975. Nursery roosts and community diversity of Neararctic bats. Journal of Mammalogy, 56:321-346.

McAney, K. 1999. Mines as roosting sites for bats –their potential and protection. Biology and Environment: Proceedings of the Royal Irish Academy, 99B:63 -65.

Meier, L., and J. Garcia. 2001. Importance of mines for bat conservation. Pp. 17 -28, in K. Vories and D. Throgmorton, eds. Bat Conservation and Mining, a Technical Interactive Forum. Office of Surface Mining, USDI, Alton, IL and Coal Research Center, SIU, Carbondale, Il linois.

Sagstetter, B., and B. Stagstetter. 1998. The mining camps speak. Bench Mark Publishing of Colorado. Denver, Colorado.

Sherwin, R. E., and S. Haymond. Methods for excluding bats from roosts prior to site closure. Wildlife Society Bulletin. (In Review)

Sherwin, R. E., D. Stricklan, and D. S. Rogers. 2000a. Roosting affinities of Townsend's big -eared bat (*Corynorhinus townsendii*) in northern Utah. Journal of Mammalogy, 81:939 -947.

Sherwin, R. E., W. L. Gannon, J. S. Altenbach, and D. Strickl an. 2000b. Roost fidelity of Townsend's big-eared bat in Utah and Nevada. Transactions of the Western Section of the Wildlife Society, 36:15-20.

Sherwin, R. E., J. S. Altenbach, and P. E. Brown. 2001. Methods for determining local mine characteristics of importance to bats. Pp. 109-114, in K. Vories and D. Throgmorton, eds. Bat Conservation and Mining, a Technical Interactive Forum. Office of Surface Mining, USDI, Alton, IL and Coal Research Center, SIU, Carbondale, Illinois.

Sherwin, R. E., J. S. Altenbach, and W. L. Gannon. 2002. Inherent spatial and temporal variability in the use of roosts by Townsend's big-eared bat. Wildlife Society Bulletin, xx:xxx -xxx. (In Press).

Tuttle, M. D., Stevenson, D. E. 1978. Variation in the cave environment and its biological implications. Pp. 108-121, in Zuber et al eds. National Cave Management Symposium Proceedings, 1977. Adobe Press. Albuquerque, New Mexico.

Tuttle, M. D., and D. A. R. Taylor. 1998. Bats and mines. Bat Conservation International, Resou rces Publication Number 3. 41 pages.

Twente, J. W. 1960. Environmental problems involving the hibernation of bats in Utah. Proceedings

of the Utah Academy of Science, 37:67-71.
Twitty, E. 2002. Riches to Rust: a guide to mining in the old west. Western Reflections Publishing Co. Montrose, Colorado.

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Figure 1.
Hypothesis I. Displacement Hypothesis

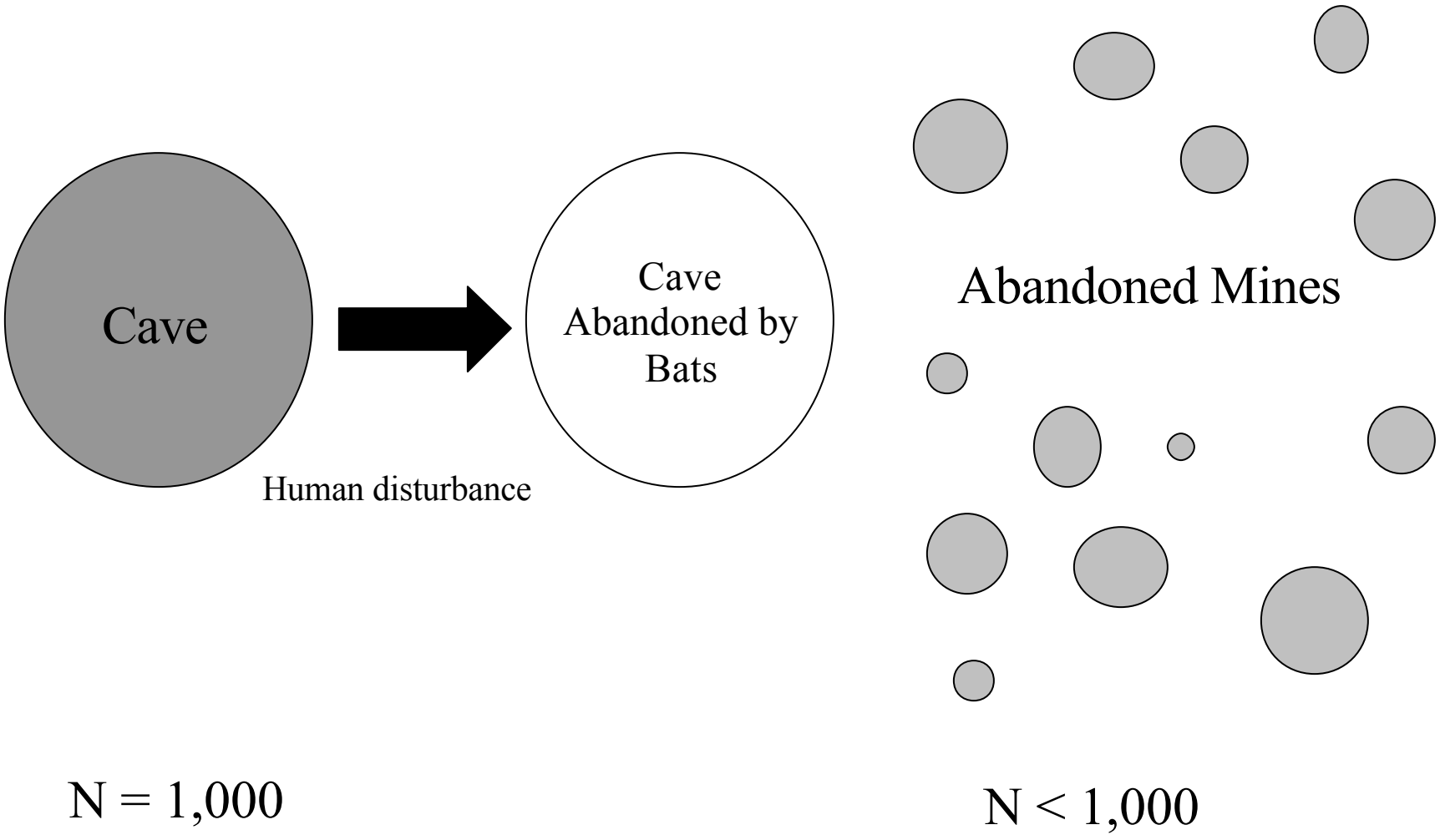
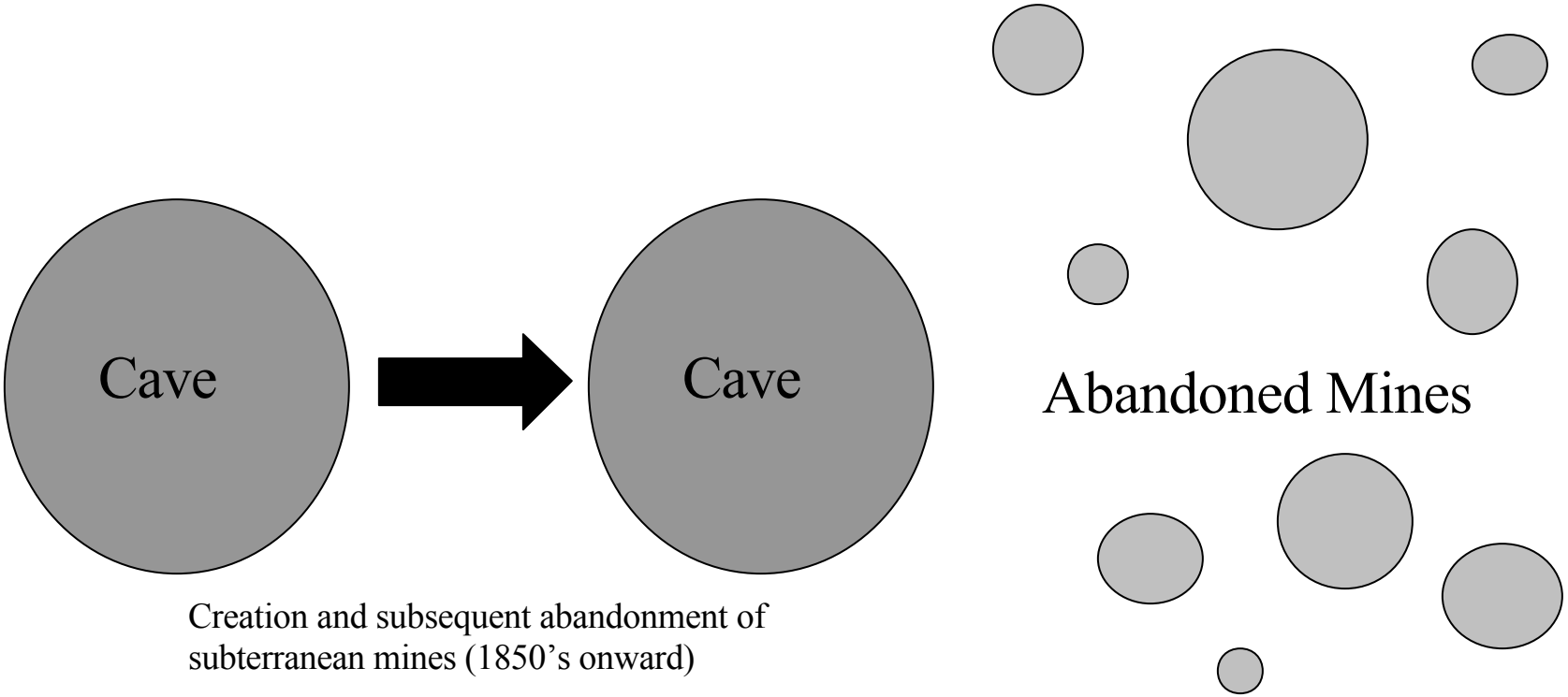


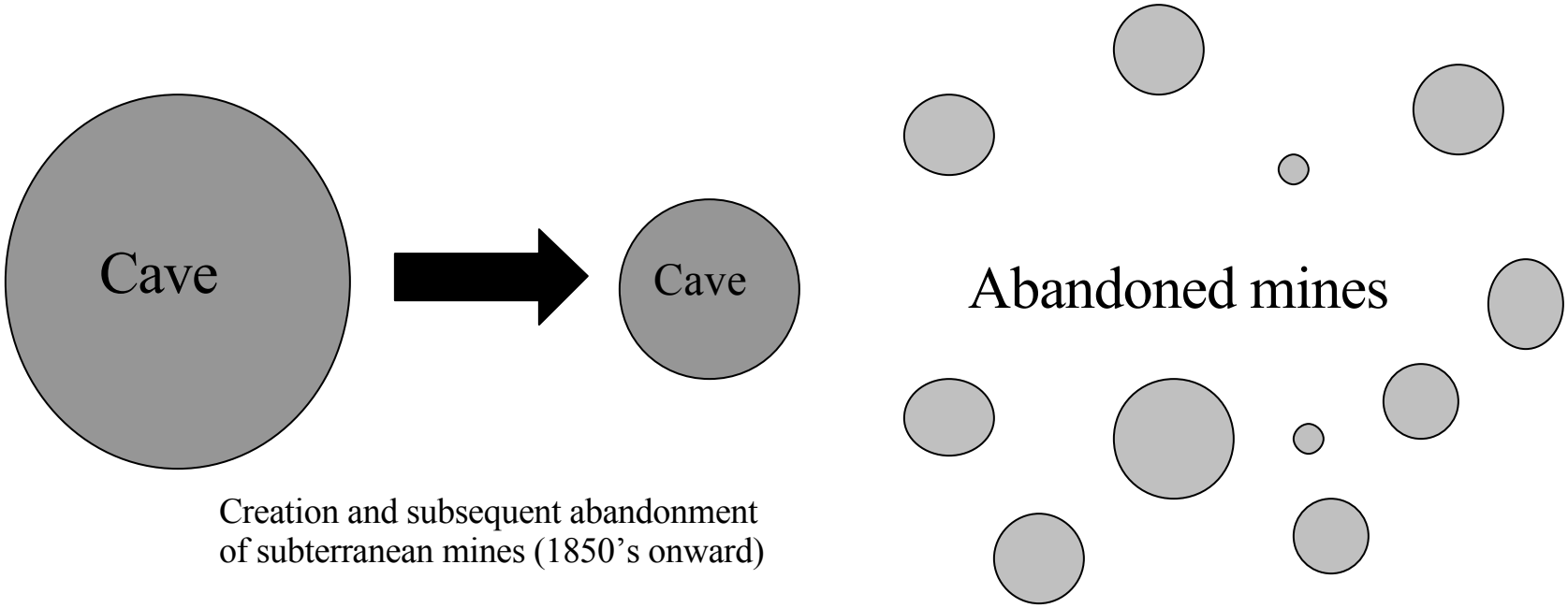
Figure 2.
Hypothesis II. Bats are Roost Limited



N = 1,000

N > 1,000

Figure 3.
Hypothesis III. Bats Are NOT Roost Limited



N=1,000

N=1,000

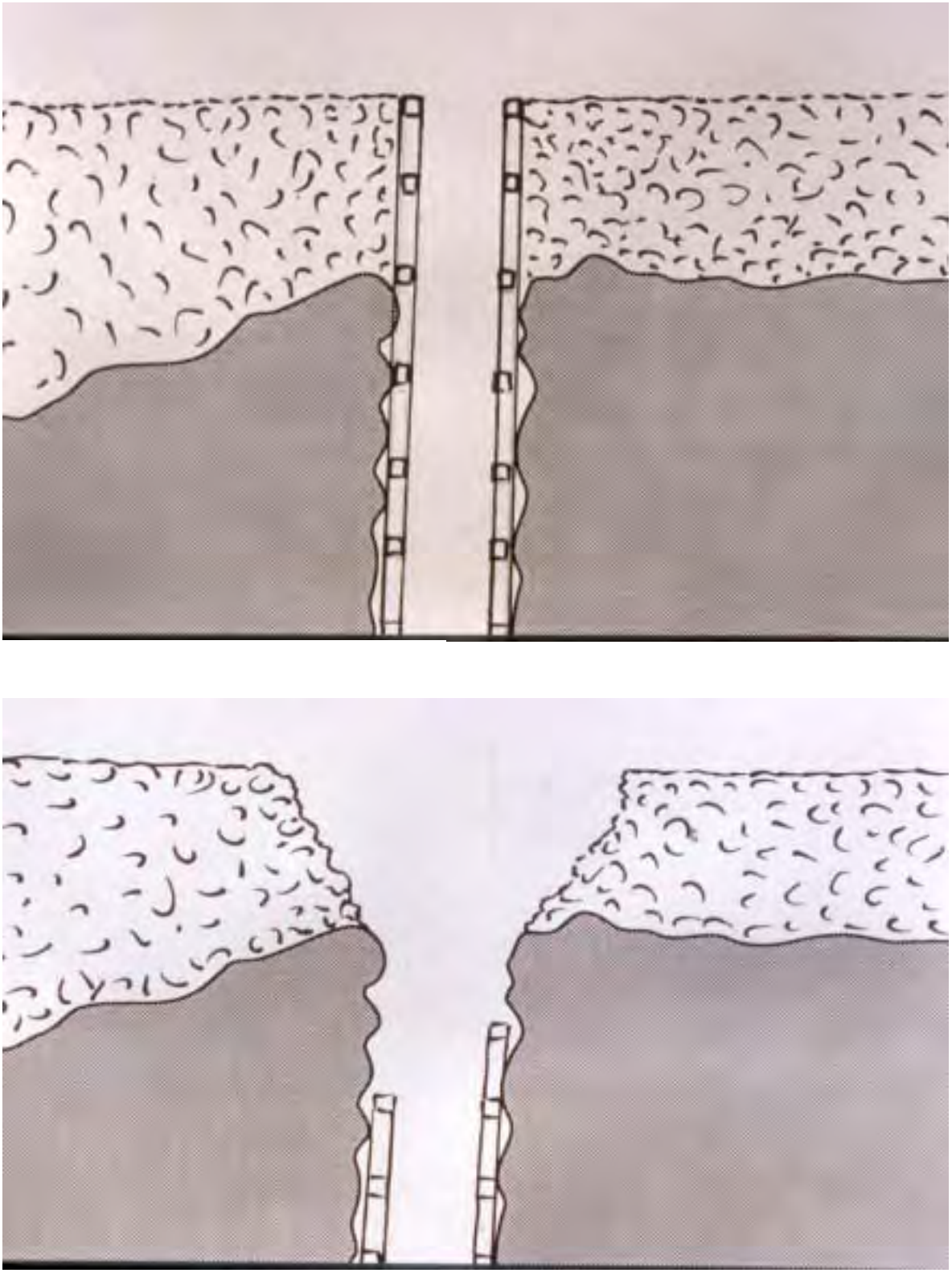


Figure 4. Profile of typical failure often observed at shaft collars subsequent to abandonment.

LEGAL ISSUES ASSOCIATED WITH BAT GATE CONSTRUCTION

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Abstract

Legal considerations are a part of any bat gating project. Legal considerations beg in with the project planning process, and depending on the legal jurisdiction, may continue long past the design life of the closure. Projects constructed on Federal lands or with Federal funds must comply with the National Environmental Policy Act and myr iad other laws. Projects built with State, local or private funds must also comply with certain environmental, zoning, or labor related statutes. Once bat gates are constructed, they may be compromised by natural weathering processes, vandalism, or land development activities. Government land managers, private landowners, and others involved with bat gate construction or management must consider the legal implications of long term monitoring and maintenance to avoid legal problems after a bat gate is con structed and the paint has dried. This paper provides an overview of the major legal considerations in developing a bat gate project and summarizes the experiences of several government agencies with regard to the legal implications of long -term gate maintenance.

Project Planning

Since most gates are constructed by governmental agencies, or in many cases at least on public lands, the project must comply with appropriate laws. The first is complying with the National Environmental Policy Act (NEPA) for Federal projects, or the State equivalent if the project is to take place on private land. Most States have "State environmental policy acts" usually referred to as SEPPA. There may also be local land use laws or building permits that may be required for either site grading or gate construction. A good place to check for requirements is at county building and planning departments for local requirements. On Federal projects you will also need to comply with other environmental laws such as the various ant iquities acts, the Endangered Species Act, the Federal Cave Resources Protection Act (reproduced in the Appendix), and any decisions from previous environmental impact statements that may cover your area of work. Agencies also must follow regulations, whi ch are the procedures by which they comply with laws. These also must be followed. For Federal agencies these are published in the Code of Federal Regulations. An example of the Forest Service 36 CFR Ch. II, Part 290-Cave Resource Management is reproduced in the Appendix. State laws are similarly reproduced and provide guidance for certain types of projects. It is the job of the planner to become acquainted with the laws that apply and assure these are met as a part of project planning and design.

Post Construction Protection Issues

Bat gates are constructed most commonly to protect vulnerable resources in a cave or mine or to prevent exposure of people to hazards within. More often than not, gates are constructed to fulfill both purposes. Bat gates are built to last many years and provide the desired levels of protection with minimal maintenance. However, even the latest designs and best materials do not always succeed in keeping vandals, cave robbers, or innocent explorers from attempting to breach some bat gates. Damaged gates present risks to the bats, cave resources, and the citizens we strive to protect. Damaged gates also present liability risks to the government agencies and private parties on whose lands the gates are constructed.

Land managers must be concerned about preventing, detecting, and repairing damage to bat gates for several reasons. First, construction of bat gates requires commitment of both funds and human resources. When gates are damaged by vandals, they must be repaired or replaced. Repairs can cut deeply into already limited maintenance budgets and reduce money available for other projects. Second, people who break into mines and caves often cause damage to cave formations and cultural or historic resources and may also disturb bat populations with disastrous results. Cave and abandoned mine resources are often non-renewable resources. Whether they are biological resources such as bats and cave salamanders or historic resources such as old mining equipment. Land management agencies are responsible for the protection of these resources. Loss or damage of these resources may be construed as failure of the agency to carry out its trust responsibilities to the public. Third, unauthorized access to caves and mines may lead to injury or death of people who enter. This exposure is not merely limited to the person that breaches the gate. Once a breach to the armor of the mine or cave is made, then other curious visitors may easily enter and suffer consequences never anticipated. In the following paragraphs, we will discuss some situations where bat gates or other closures were breached by vandals with tragic results. We will then discuss methods and strategies used by various agencies to: (1) reduce vandalism and unauthorized entry; (2) to aid in prosecution of vandals; and (3) reduce liability risk to gate builders and land managers.

Deterrents To Vandalism

Government agencies use a number of different methods to reduce vandalism. At Mammoth Cave National Park in Kentucky, park officials have found that public education, improved gate design and successful prosecution of vandals has reduced the incidence of vandalism and illegal entry to the many gated caves in the park (improved prosecution will be discussed later in this paper). Information brochures and signs at cave entrances educate the public on reasons why cave access is restricted and advise them of penalties for unauthorized entry to gated caves. Other agencies have observed similar results. The National Forest Service has also found that bat gate vandalism has been substantially reduced in recent years through a combination of increased public education, better gate designs, and better locks. Several agencies report that installation of concrete footers below bat gates has reduced the incidence of successful entry of gated mines and caves by vandals and cave robbers. It appears that digging under gate structures was a common method of breaching older bat gate designs. Many old bat gates constructed of simple rebar are now being replaced with newer designs and materials to better

withstand the cutting torches and hacksaws of vandals. In several Bureau of Land Management (BLM) districts, officials have identified and involved recreational user groups, such as caving clubs, early in the planning process for a cave closure thereby significantly reducing misunderstandings and vandalism as well. Caving organizations have proven to be important allies to gate monitoring and protection efforts.

Prosecution Of Vandals And Cave Robbers

Caves and mines on public lands contain resources that must be protected by land management agencies. They may contain biota, cultural, geologic, mineralogical, paleontologic, hydrologic, recreational, educational, or other resources. Caves on Federal lands must be protected as directed by the Federal Cave Resources Protection Act of 1988, and by associated regulations (see appendix A). Federal, State and local agencies responsible for protecting and managing these resources have been held responsible in situations where resources were damaged by vandals. At Mammoth Cave National Park, cave robbers dug under a bat gate at Crystal Cave and stole speleothems in 1995. Three young men were apprehended and convicted to sentences ranging from 22 to 33 months. The crime was "Destruction of Government Property." The judge felt so strongly about the offence that he added points to the sentence of one of the offenders for "damaging a non-renewable resource" associated with damaging and removing the speleothems. The records of these three men were not the only things damaged by the event. The National Park Service also received a considerable amount of negative coverage in the news media including accusations of failure to protect public resources.

Agencies have taken different approaches to improve the success of prosecution efforts. When the U.S. Forest Service closes a mine or cave, the Forest Supervisor can issue a Subpart B Order to prohibit public access to a mine, cave, or other area. Subpart B Orders, prepared under authority of Section 36 of the Code of Federal Regulations, are legally enforceable and can be issued quickly if necessary. A Closure Order may be permanent or the Closure Order may be in effect seasonally to protect bats at maternity or hibernation sites.

The Bureau of Land Management (BLM) has found that a different tool helps to promote successful prosecutions. BLM managers have found that a combination of early public involvement, barrier erection (such as a fence or bat gate), and publication of a closure notice in the Federal Register, provides the basis for successfully prosecuting vandals and others who break into gated caves and mines. BLM officials report that this approach has been effective in assuring successful prosecution when vandals are apprehended. The difficulty in apprehending vandals remains a major impediment to prosecution because of the remoteness of many BLM sites.

Liability Of Agencies And Landowners

Landowner and agency objectives for gating mines may be significantly different than for gating caves and exposure to liability may differ as well. Generally, mines are closed for two purposes, to protect the curious from the possibility of death or injury, and secondly, to protect bats and their habitat. Mines occasionally contain historic or cultural resources, but these are less common than in caves. Caves are generally gated to protect sensitive resources such as those outlined in the Federal Cave Resources

Protection Act. By in large, caves do not present the same hazards to exploration as do mines and are seldom gated due to safety concern. Cave exploration is recognized as a legitimate recreational use of Federal lands, both in regulations and in management policy. Many States have laws that protect landowners, including government agencies, from law suites stemming from recreational use of their lands. However, these laws differ from State to State and some States may lay at least a limited responsibility on landowners when hazard ous conditions are known to them. A review of your specific State law is suggested.

Discussions with mine reclamation professionals and reclamation program managers reveal that liability exposure (i.e. risk of being sued) is their greatest concern about building bat gates in lieu of solid closure methods on abandoned mines. This concern is demonstrated both in the failure of some agencies to perform bat assessments, except where endangered species are present, and in the aversion of many managers to building bat gates unless required by regulatory agencies. Failure of reclamation agencies to evaluate mines for use by bats results in destruction of important habitat and sometimes, destruction of thousands of bats (Tuttle and Taylor 1998). In most cases, t he concern over being sued is based on conjecture and fear rather than on the case history.

Homer Milford assessed the issue of agency liability and increased probability of a successful lawsuit in a paper written for the November 2000 forum "Bats Conser vation and Mining: A Technical Interactive Forum" in St. Louis, Missouri (Milford, 2000). In researching that paper, Milford and his collaborators reviewed case law dealing with bats, bat gates, and abandoned mines. They found no cases dealing with liability for bat gates and only one case dealing with abandoned mines. In that case, *Miller v. River Hills Development,* 831 S. W. 2d 756 (Mo. App. 1992), a private landowner was sued on behalf of a fourteen year old boy who fell into abandoned mine shaft afte r: (1) breaching a steel barricade and a fence; (2) ignored a sign warning of the danger; and (3) he knew of the danger. The Missouri Court of Appeals affirmed a lower court ruling that the landowner was not liable (Milford, 2000).

In another case, not cited by Milford, the Oklahoma Conservation Commission, was found negligent in a case where a boy entered a abandoned mine shaft and died of asphyxiation *Reif v. State ex rel. Oklahoma Conservation Commission* (1993). Numerous parties were named in the $21,000,000 lawsuit, however, the judge dismissed several defendants and two defendants settled out of court for $105,000. The Conservation Commission was found negligent because the Abandoned Mine Land (AML) Program did not find the mine shaft and fill it. The jury awarded $17,000 to the family of the boy for medical and funeral expenses. The boy was known to have entered the shaft several times before the incident. The judge found that the boy and the Conservation Commission were each 50 percent negligent and reduced the award by half for that reason. In the end, the Conservation Commission did not have to pay any of the jury award because of the previous $105,000 settlement by two other parties. This situation did not involve any bat gates or other acti ons by the Conservation Commission. Instead, it involved the failure of the Conservation Commission to be aware of the mine - shafts and to act upon them.

It appears that no Federal agency has been successfully sued in the United States in response to an injury or death as a result of a breached bat gate. Milford tells us that his review did not reveal any case in which someone was injured by breaching a bat compatible closure (Milford 2000). In further researching this paper, discussions between this author and the U.S. Forest Service (Trout Personal Communication 2002), National Park Service (Olson and Burghart, Personal Communication, 2002) and the Bureau of Land Management (Goodbar Personal Communication, 2002) did reveal instances where people have been injured or killed in connection with abandoned mines. Yet, none of these instances have resulted in a successful lawsuit against a government agency over the breach of a bat compatible closure and subsequent injury. It may be useful to review the known situations where people were injured to see if they reveal information relevant to the assessment of agency risk.

- The BLM has had two fatalities in recent years related to mines or caves. One occurred as four adults and a group of school children explored a cave that was wide open and had no access control. One of the adults was killed when a large rock broke loose and crushed him. The family sued but the judge found that BLM was not culpable, since the BLM: (1) did not know that the cave existed; (2) did not know that hazards existed; (3) had not issue a permit for the activity; and (4) had no management plan. The judge did not find BLM liable in this case.

- Another fatality occurred near Las Crusas, NM. Teenagers were playing near an old mine entrance that was covered by a cable net. The net was not securely fastened. One of the youngsters jumped out on the net and it collapsed. He fell into the mine and died. BLM was not found culpable in this case and the agency was not sued.

- Colorado has had three situations where people have been injured of killed after the State installed or modified a mine closure or steel door. None of these was designed specifically as a bat gate but the situations are similar. The agency was not successfully sued in these cases.

- On August 13, 1989, five teenage boys attempted to explore a mine where a solid steel door had been vandalized. Four boys entered the mine and one stayed outside. Three of the 4 died from lack of oxygen. The fourth climbed up on a ledge or pile of material and survived. The dead were aged 15, 16, and 17 years. The Colorado Inactive Mines Program had modified the door used for entry into the mine some years before. When the State originally inventoried the mine, staff found a thick steel door in place but the hasp was damaged beyond repair. Colorado determined that the door was adequate but it needed a good protected hasp and lock to keep it secure. Colorado modified the door, adding the hasp and lock. It is still not known who vandalized the new hasp. After the accident, Colorado welded the steel door closed to prevent future entry.

- In another situation near Grand Junction, Colorado, the State installed a culvert pipe and grate to prevent access to a sloping mine entry. Vandals tore the grate from the opening, apparently with a truck. Sometime later, two people entered the opening. Only one survived. The other, a 20 year-old male, died from asphyxiation.

- In a third situation, explorers entered a gated mine through a stope that opened up after the gate was installed. The gate was not actually breached. One of the explorers used a rope to rappel into the shaft only to find out that the rope did not reach the bottom. He fell to the bottom and had to be rescued.

Do these examples prove that there is no increased liability risk when choosing a bat gate over a solid closure? The answer is probably "no." As Milford reminds us, liability exposure differs from State to State based on State laws. Each agency's legal counsel must review the risk of tort liability and develop policy accordingly (Milford, 2000). We can only provide examples of what other agencies do to reduce liability exposure and, at the same time, operate a program to gate caves and mines when resource management considerations dictate that bat gates are the most appropriate solution.

As we discussed in the section entitled "Prosecution Of Vandals And Cave Robbers," the U.S. Forest Service and Bureau of Land Management take a two-stage approach to mine and cave closure with the multiple objectives of lowering risk of public injury and protecting natural and cultural resources. While the agencies differ in the procedural measures followed, the results are similar. Both agencies take positive steps to notify the public of closure actions and consider public comments. They also design and construct closure structures that are appropriate to the hazard risk. In addition, well before any of these actions are taken, both agencies use standard assessment forms, completed by field staff, to determine if and for what reason mines or caves should be closed to public access. These forms serve several purposes. They help guide managers in deciding what actions to take regarding a mine or cave. They also help support agency actions when meeting or answering questions by the public. And finally, they help support agency decisions should someone be injured in association with a closure.

A review of policies in two State Abandoned Mine Reclamation Programs revealed somewhat different approaches to the issue. The Utah Abandoned Mind Program was one of the first State reclamation programs to adopt a regular policy of gating abandoned mines used by bats. Utah has had a couple of instances where bat gates have been breached but none have resulted in injury or death. Utah has implemented a monitoring program to keep track of bat response to gates and to ensure that gates remain secure. This monitoring program has resulted in several revisions to gate designs, including improved materials, changed bar and stiffener spacing, and improved gate anchoring practices (Mesch Personal Communication, 2002). Utah does not normally consider replacing a bat gate with a solid closure when vandalism occurs. When a gate is damaged, it is replaced with another gate of the most recent design. The success of this monitoring and gate improvement program is demonstrated by the fact that the Utah AML Division has not had a bat gate breach using the latest gate design.

The Colorado Inactive Mines Program constructs many bat compatible closures on abandoned mine openings. The decision to construct a bat gate is based on many factors including the integrity of the mine opening and current or potential use by bats. Liability is not a major factor in deciding whether to use a bat gate or solid closure. The decision is based on what best suits the situation. However, Colorado does practice a "one strike and your out" policy on gates and other non-backfill type mine closures. If a gate or door is breached by vandals just one time, it is replaced by a backfill type closure. (This policy was not in place when the door was damaged in 1989.)

In Colorado, landowners are responsible, under State law, to close mines or otherwise protect the public from mine openings. For abandoned mines, this protection usually consists of a fence and sign unless the AML program is involved. However, the Colorado AML program feels that this "statutory responsibility of the landowner" provides an adequate level of protection to the State for implementation of a mine gating program.

These examples show how agencies have taken positive steps to address the issue of agency liability for bat gate construction while ensuring that both natural and human resources are protected. While they might not prove to be the right answer for all agencies and private landowners, they may serve as guides for development policies and practices unique to your situation.

Bat Gate Monitoring and the Relation to Liability Exposure

Once it has been determined that a bat gate is the method which will be employed to close a mine or cave, it is important that the structure be sound and robust. To be successful the gate must withstand attempts by vandals to force entry. If a gate is breached, and not repaired, the agency or landowner could be found liable if a third party injury occurs. Failure to properly maintain a gate, or any closure, can place the agency or landowner on precarious legal footing if an injury takes place.

Bat gates should be inspected on a regular basis as set fourth in a monitoring plan. The plan should specify the frequency of the inspections and a time frame for repairs if deficiencies are discovered. A monitoring program can reduce exposure to liability and increase the safety and integrity of new bat gates provided the monitoring program is followed and that follow up actions are taken as specified. If a monitoring program is followed and an injury were to take place due to an undiscovered breach that occurred between monitoring visits, it would be difficult to hold an agency or landowner at fault for not maintaining the closure. If, however, the monitoring plan is not followed, or there is no follow-up repair once the damage is known, the agency or landowner might be more likely to be found responsible for any injuries that occur.

Organizations that construct bat gates should consider developing partnerships with landowners, wildlife management agencies, caving clubs, or other organizations to conduct monitoring of bat gates. These partnerships can save gating agencies money, manpower, and possibly legal liability or embarrassment.

State wildlife agencies and caving organizations might be willing and able to provide both structural monitoring and bat population monitoring. Bat population information can be useful for evaluating the effectiveness of gates for bat access. Information on bat population increases or decreases can be invaluable during the early years after a gate is installed because it indicates whether bats are accepting the gates and whether predators or taking undue advantage of the gate structures. These types of partnerships can be the most useful because the organizations may have resources to understand the full range of issues at a mine or cave site.

Partnerships with landowners or organizations such as County Sheriff Departments can be effective for

ensuring early detection and repair of gate vandalism. These partnerships can be encouraged by advising parties that your organization will repair vandalized gates but you do not have the resources to perform the monitoring. Agreements that state, for example, that a landowner will monitor a site semi-annually and advise the State AML program of damages, can save the State program substantial monitoring costs. On the other side of the agreement, the State AML program might agree to repair vandal damage for a period of years when notified by the landowner. This type of agreement gives the landowner an incentive to monitor because it reduces his risk of liability and his cost of repairs. The State program benefits because the landowner performs the monitoring and advises the agency when repairs are needed. The State also benefits because a written agreement tells who is responsible for what action, in case an injury does occur. While landowners are ultimately responsible in most States for situations that occur on their land, such a written agreement may still provide additional protection to the agency that constructed the gate.

Local law enforcement agencies might also agree to monitor high activity sites on a regular basis if there is a history of problems with a cave or mine. The benefit for them is that when a breach is detected, they have someone to notify that will repair the damage and make the closure secure again. Again, the State AML agency gains by not having to worry over the monitoring activity.

There may be many other opportunities for bat gate monitoring partnerships. We have probably only scratched the surface here. However, the important consideration is that monitoring is essential for the long-term protection of the resources, protection of the public from injury, and protection of the agency from liability.

References

Milford, H.E. 2000. *Challenges in Protecting Bats.* Proceedings of Bat Conservation and Mining: A Technical Interactive Forum, November 14 to 16, 2000, St. Louis, MO. Southern Illinois University Press. Carbondale, IL.

Tuttle, M.D., and D.A.R. Taylor. 1998. *Bats and Mines*: *Resource Publication No. 3*. Bat Conservation International. Austin, TX. USA.

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Appendix

FEDERAL CAVE RESOURCES PROTECTION ACT OF 1988

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Public Law 100-691
100th Congress

An Act

To protect cave resources on Federal lands, and for other purposes.

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

SECTION 1. SHORT TITLE.

This Act may be referred to as the "Federal Cave Resources Protection Act of 1988".

SECT. 2. FINDINGS, PURPOSE, AND POLICY.

(a) Findings.--The congress finds and declares that--

(1) significant caves on Federal lands are an invaluable and irreplaceable part of the Nation's natural heritage; and

(2) in some instances, these significant caves are threatened due to improper use, increased recreational demand, urban spread, and a lack of specific statutory protection.

(b) Purposes.--The purposes of this Act are--

(1) to secure, protect, and preserve significant caves on Federal lands for the perpetual use, enjoyment, and benefit of all people; and

(2) 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.

(c) Policy.--It is the policy of the United States that Federal lands be managed in a manner which protects and maintains, to the extent practical, significant caves.

SEC. 3. DEFINITIONS.

For purposes of this Act:

(1) **CAVE**. -- The term "cave" means any naturally 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.

(2) **FEDERAL LANDS**. -- The term "Federal lands" means lands the fee title to which is owned by the United States and administered by the Secretary of Agriculture or the Secretary of the Interior.

(3) **INDIAN LANDS**. -- The term "Indian lands" means lands of Indian tribes or Indian individuals which are either held in trust by the United States for the benefit of an Indian tribe or subject to restriction against

alienation imposed by the United States.

(4) **INDIAN TRIBE**. -- The term "Indian tribe" means any Indian tribe, band, nation, or other organized group or community of Indians, including any Alaska Native village or regional or village corporation as defined in, or established pursuant to, the Alaska Native Claims settlement Act (43 U.S.C. 1601 et seq.).

(5) **CAVE RESOURCE**. -- The term "cave resource" includes any material or substance occurring naturally in caves on Federal lands, such as animal life, plant life, paleontological deposits, sediments, minerals, speleogens, and speleothems.

(6) **SECRETARY**.--The term "Secretary" means the Secretary of Agriculture or the Secretary of the Interior, as appropriate.

(7) **SPELEOTHEM**. -- The term "speleothem" means any natural mineral formation or deposit occurring in a cave or lava tube, including but not limited to any stalactite, stalagmite, helectite, cave flower, flowstone, concretion, drapery, rimstone, or formation of clay or mud.

(8) **SPELEOGEN**. -- The term "speleogen" means relief features on the walls, ceiling, and floor of any cave or lava tube which are part of the surrounding bedrock, including but not limited to anastomoses, scallops, meander niches, petromorphs and rock pendants in solution caves and similar features unique to volcanic caves.

SEC. 4. MANAGEMENT ACTIONS.

(a) Regulations.--Not later than nine months after the date of the enactment of this Act, the Secretary shall issue such regulations as he deems necessary to achieve the purposes of this Act. Regulations shall include, but not be limited to, criteria for the identification of significant caves. The Secretaries shall cooperate and consult with one another in preparation of the regulations. To the extent practical, regulations promulgated by the respective Secretaries should be similar.

(b) In General.--The Secretary shall take such actions as may be necessary to further the purposes of this Act. Those actions shall include (but not be limited to)--

(1) identification of significant caves on Federal Lands:

(A) The Secretary shall prepare an initial list of significant caves for lands under his jurisdiction not later than one year after the publication of final regulations using significance criteria defined in such regulations. Such a list shall be developed after consultation with appropriate private sector interests, including cavers.

(B) The initial list of significant caves shall be updated periodically, after consultation with appropriate private sector interests, including cavers. The Secretary shall prescribe by policy or regulation the requirements and process by which the initial list will be updated, including management measures to assure that caves under consideration for the list are protected during the period of consideration. Each cave recommended to the Secretary by interested groups for possible inclusion on the list of significant caves shall be considered by the Secretary according to the requirements prescribed pursuant to this paragraph, and shall be added to the list if the Secretary determines that the cave meets the criteria for significance as defined by the regulations.

(2) regulation or restriction of use of significant caves, as appropriate.

(3) entering into volunteer management agreements with parsons or scientific and recreational caving community; and

(4) appointment of appropriate advisory committees.

(C) PLANNING AND PUBLIC PARTICIPATION.--The Secretary shall--

(1) ensure that significant caves are considered in the preparation or implementation of any land management plan if the preparation or revision of the plan began after the enactment of this Act; and

(2) foster communication, cooperation, and exchange of information between land managers, those who utilize caves, and the pubic.

SEC. 5. CONFIDENTIALITY OF INFORMATION CONCERNING NATURE AND LOCATION OF SIGNIFICANT CAVES.

(a) In General.--Information concerning the specific location of any significant cave may not be made available to the public under section 552 of title 5, United States Code, unless the Secretary determines that disclosure of such information would further the purposes of this Act and would not create a substantial risk of harm, theft, or destruction of such cave.

(b)Exceptions.--Notwithstanding subsection (a), the Secretary may make available information regarding significant caves upon the written request by Federal and State governmental agencies or bona fide educational and research institutions. Any such written request shall, at a minimum--

(1) describe the specific site or area for which information is sought;

(2) explain the purpose for which such information is sought; and

(3) include assurances satisfactory to the Secretary that adequate measures are being taken to protect the confidentiality of such information and to ensure the protection of significant cave from destruction by vandalism and unauthorized use.

SECT. 6. COLLECTION AND REMOVAL FROM FEDERAL CAVES.

(a) PERMIT.-- The secretary is authorized to issue permits for the collection and removal of cave resources under such terms and conditions at the Secretary may impose, including the posting of bonds to insure compliance with the provisions of any permit:

(1) any permit issued pursuant to this section shall include information concerning the time, scope, location, and specific purpose of the proposed collection, removal or associated activity, and manner in which such collection, removal, or associated activity is to be performed must be provided.

(2) the secretary may issue a permit pursuant to this subsection only if he determines that the proposed collection or removal activities are consistent with the purposes of this Act and with other applicable provisions of law.

(b) REVOCATION OF PERMIT.--Any permit issued under this section shall be revoked by the Secretary upon determination by the Secretary that the permittee has violated any provision of this Act, or has failed to comply with any other condition upon which the permit was issued. Any such permit shall be revoked by the Secretary upon assessment of a civil penalty against the permittee pursuant to section 8 or upon the permittee's conviction under section 7 of this Act. The Secretary may refuse to issue a permit under this section to any person who has violated any provision of this Act or who has failed to comply with any condition of a prior permit.

(c) TRANSFERABILITY OF PERMITS.--Permits issued under this Act are not transferable.

(d) CAVE RESOURCES LOCATED ON INDIAN LANDS.--(1)(A) Upon application by an Indian tribe, the Secretary is authorized to delegate to the tribe all authority of the Secretary under this section with respect to issuing and enforcing permits for the collection or removal of any cave resource, or to carrying out activities associated with such collection or removal, from any cave resource located on affected Indian Lands.

(B) In the case of any permit issued by the Secretary for the collection or removal of any cave resource, or to carry out activities associated with such collection or removal, from any cave resource located on Indian lands (other than permits issued pursuant to subparagraph (A)), the permit may be issued only after obtaining the consent of the Indian or Indian tribe owning or having jurisdiction over such lands. The permit shall include such reasonable terms and conditions as may be requested by such Indian or Indian tribe.

(2) If the Secretary determines that issuance of a permit pursuant to this section may result in harm to, or destruction of, any religious or cultural site, the Secretary, prior to issuing such permit, shall notify any Indian tribe which may consider the site as having significant religious or cultural importance. Such notice shall not be deemed a disclosure to the public for purposes of section 5.

(3) A permit shall not be required under this section for the collection or removal of any cave resource located on Indian lands or activities associated with such collection, by the Indian or Indian tribe owning or having jurisdiction over such lands.

(e) EFFECT OF PERMIT.--No action specifically authorized by a permit under this section shall be treated as a violation of section 7.

SECT. 7. PROHIBITED ACTS AND CRIMINAL PENALTIES.

(a) PROHIBITED ACTS.--

(1) Any person who, without prior authorization from the Secretary knowingly destroys, disturbs, defaces, 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 shall be punished in accordance with subsection (b).

(2) 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 shall be punished in accordance with subsection (b).

(3) Any person who counsels, procures, solicits, or employs any other person to violate any provisions of this subsection shall be punished in accordance with section (b).

(4) Nothing in this section shall be deemed applicable to any person who was in lawful possession of a cave resource from a significant cave prior to the date of enactment of this Act.

(b) PUNISHMENT.--

The punishment for violating any provision of subsection (a) shall be imprisonment of not more than one year or a fine in accordance with the applicable provisions of title 18 of the United States Code, or both. In the case of a second or subsequent violation the punishment shall be imprisonment of not more than 3 years or a fine in accordance with the applicable provisions of title 18 of the United States Code, or both.

SECT. 8. CIVIL PENALTIES.

(a) ASSESSMENT.--(1) The secretary may issue an order assessing a civil penalty against any person who violates any prohibition contained in this Act, any regulation promulgated pursuant to this act, or any permit issued under this Act. Before issuing such an order, the Secretary shall provide such person written notice and the opportunity to request a hearing on the record within 30 days. Each violation shall be a separate offense, even if such violations occurred at the same time.

(2) The amount of such civil penalty shall be determined by the Secretary taking into account appropriate factors including (A) the seriousness of the violation; (B) the economic benefit (if any) resulting from the violation; (C) any history of such violations; and (D) such other matters as the Secretary deems appropriate. The maximum fine permissible under this section is $10,000.

(b) JUDICIAL REVIEW.-- Any person aggrieved by an assessment of a civil penalty under this section may file a petition for judicial review of such assessment with the United States District Court for the District of Columbia or for the district in which the violation occurred. Such a petition shall be filed within the 30-day period beginning on the date the order assessing the civil penalty was issued.

(c) COLLECTION.--If any person fails to pay an assessment of a civil penalty--

(1) within 30 days after the order was issued under subsection (a), or

(2) if the order was appealed within such 30-day period, within 10 days after court has entered a final judgment in favor of the Secretary under subsection (b),

the Secretary will notify the Attorney General and the Attorney General shall bring civil action in an appropriate United States district court to recover the amount of penalty assessed (plus costs, attorney's feet, and interest at currently prevailing rates from the date the order was issued or the date of such final judgment, as the case may be). In such an action, the validity, amount, and appropriateness of such penalty shall not be subject to review.

(d) SUBPOENAS.-- Title Secretary may issue subpoenas in connection with proceedings under this subsection compelling the attendance and testimony of witnesses and subpoenas duces tecum, and may request the Attorney General to bring an action to enforce any subpoena under this section. The district courts shall have jurisdiction to enforce such subpoenas and impose sanctions.

SECT. 9. MISCELLANEOUS PROVISIONS.

(a) AUTHORIZATION.-- There are authorized to be appropriated $100,000 to carry out the purposes of this Act.

(b) EFFECT ON LAND MANAGEMENT PLANS.--Nothing in this Act shall require the amendment or revision of any land management plan, the preparation of which began prior to the enactment of this Act.

(c) FUND.-- Any money collected by the United States as permit fees for collection and removal of cave resources; received by the United States as a result of the forfeiture of a bond or other security by a permittee who does not comply with the requirements of such permit issued under section 7; or collected by the United States by way of civil penalties or criminal fines or violations of this Act shall be placed in a special fund in the Treasury. Such moneys shall be available for obligation or expenditure (to the extent provided for in advance in appropriation Acts) as determined by the Secretary for the improved management, benefit, repair, or restoration of significant caves located on Federal lands.

(d) Nothing in this Act shall be deemed to affect the full operation of the mining and mineral leasing laws of the United States, or otherwise affect valid existing rights.

SEC. 10. SAVINGS PROVISIONS.

(a) WATER..-- Nothing in this Act shall be construed as authorizing the appropriation of water by any Federal, State, or local agency, Indian tribe, or any other entity or individual. Nor shall any provision of this Act--

(1) affect the rights or jurisdiction of the United States, the States, Indian tribes, or other entities over waters of any rivers or stream or over any ground water resource;

(2) alter, amend, repeal, interpret, modify, or be in conflict with any interstate compact made by the States; or

(3) alter or establish the respective rights of the States, the United States, Indian tribes, or any person with respect to any water or water-related right.

(b) FISH AND WILDLIFE.-- Nothing in this Act shall be construed as affecting the jurisdiction or responsibilities of the States with respect to fish and wildlife.

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Approved November 18, 1988.

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LEGISLATIVE HISTORY--H.R. 1975:

HOUSE REPORTS: No 100-534 (Comm. on Interior and Insular Affairs).
SENATE REPORTS: No. 100-559 (Comm. on Energy and Natural Resources).
CONGRESSIONAL RECORD, Vol. 134 (1988)

Mar. 28, considered and passed House.

Oct. 21, considered and passed Senate, amended. House concurred in Senate amendment.

Part 290-CAVE RESOURCES MANAGEMENT

Sec.
290.1 Purpose and scope.
290.2 Definitions.
290.3 Nomination, evaluation, and designation of significant caves.
290.4 Confidentiality of cave location information.
290.5 Collection of information.

AUTHORITY: 16 U.S.C. 4301-4309; 102 Stat. 4546.

SOURCE: 59 FR 31152, June 17, 1994, Unless otherwise noted.

§290.1 Purpose and Scope.

The rules of this part implement the requirement of the Federal Cave Resources Protection Act (16 U.S.C. 4301-4309), hereafter referred to as the "Act". The rules apply to cave management on National Forest System lands. These rules, in conjunction with rules in part 261 of this chapter, provide the basis for identifying and managing significant caves on National Forest System lands in accordance with the Act. National Forest System lands will be managed in a manner which, to the extent practical, protects and maintains significant cave resources in accordance with the policies outlined in the Forest Service Directive System and the management direction contained in the individual forest plans.

§290.2 Definitions

For the purposes of this part, the terms listed in this section have the following meaning:

Authorized officer means the Forest Service employee delegated the authority to perform the duties described in this part.

Cave means any naturally occurring void, cavity, recess, or system of interconnected passages beneath the surface of the earth or within a cliff or ledge and which is large enough to permit a person to enter, whether the entrance is excavated or naturally formed. Such term shall include any natural pit, sinkhole, or other opening which is an extension of the cave entrance or which is an integral part ofthe cave.

Cave resources mean any materials or substances occurring in caves including, but not limited to, biotic, cultural, mineralogic, paleontologic, geologic, and hydrologic resources.

National Forest System Lands means all national forest lands reserved or withdrawn from the public domain, acquired through purchase, exchange, or donation, national grasslands and land utilization projects, and other lands, waters, or interests administered by the Forest Service.

Secretary means the Secretary of Agriculture.

Significant cave means a cave located on National Forest System Lands that has been determined to meet the criteria in §290.3 (c) or (d) and has been designated in accordance with §290.3 (e).

§290.3 Nomination, Evaluation, and designation of significant caves.

(a) *Nominations for initial and subsequent listings.* The authorized officer will give governmental agencies and the public, including those who utilize caves for scientific, educational, or recreational purposes, the opportunity to nominate caves. The authorized officer shall give public notice, including a notice published in the FEDERAL REGISTER, calling for nominations for the initial listing and setting forth the procedures for preparing and submitting the nominations. Nominations for subsequent listing will be accepted from governmental agencies and the public by the Forest Supervisor where the cave is located as new cave discoveries are made. Caves nominated but not approved for designation may be renominated as additional documentation or new information becomes available.

(b) *Evaluation for initial and subsequent listings.* The evaluation of the nominations for significant caves will be carried out in consultation with individuals and organizations interested in the management and use of caves and cave resources, within the limits imposed by the confidentiality provisions of §290.3 (c) and (d).

(c) *Criteria for significant caves.* A significant cave on National Forest System lands shall possess one or more of the following features, characteristics, or values.

(1) Biota. The cave provides seasonal or yearlong habitat for organisms or animals, or contains species or subspecies of flora or fauna native to caves, or are sensitive to disturbance, or are found on State or Federal sensitive, threatened, or endangered species lists.

(2) *Cultural.* The cave contains historic properties or archaeological resources (as defined in Parts 800.2 and 296.3 of this chapter respectively, or in 16 U.S.C. 420, *et seq.*) or other features included in or eligible for inclusion on the National Register of Historic Places because of their research importance for history or prehistory, historical associations, or other historical or traditional significance.

(3) *Geologic/Mineralogic/Paleontologic.* The cave possesses one or more of the following features:

(i) Geologic or mineralogic features that are fragile, represent formation processes that are of scientific interest, or that are otherwise useful for study.

(ii) Deposits of sediments or features useful for evaluating past events.

(iii) Paleontologic resources with potential to contribute useful educational or scientific information.

(4) *Hydrologic.* The cave is a part of a hydrologic system or contains water which is important to humans, biota, or development of cave resources.

(5) *Recreational.* The cave provides or could provide recreational opportunities or scenic values.

(6) *Educational or scientific.* The cave offers opportunities for educational or scientific use; or, the cave is virtually in a pristine state, lacking evidence of contemporary human disturbance or impact; or, the length, volume, total depth, pit depth, height, or similar measurements are notable.

(d) *Specially designated areas.* All caves located within special management areas, such as Special Geologic Areas, Research Natural Areas, or National Monuments, that are designated wholly or in part due to cave resources found therein are determined to be significant.

(e) *Designation and documentation.* If the authorized officer determines that a cave nominated and evaluated under paragraphs (a) and (b) of this section meets one or more of the criteria in paragraph (c) of this section, the authorized officer shall designate the cave as significant. The authorized officer will notify the nominating party of the results of the evaluation and designation. Each forest will retain appropriate documentation for all significant caves located within its administrative boundaries. At a minimum, this documentation shall include a statement of finding signed and dated by the authorized officer and the information used to make the determination. This documentation will be retained as a permanent record in accordance with the confidentiality provision in §290.4.

(f) *Undiscovered Passages.* If a cave is determined to be significant, its entire extent on federal land, including passages not mapped or discovered at the time of determination, is deemed significant. This includes caves that extend from lands managed by any other Federal agency into National Forest System land, as well as caves initially believed to be separate for which interconnecting passages are discovered after significance is determined.

(g) *Decision Final.* The decision to designate or not designate a cave as significant is made at the sole discretion of the authorized officer based upon the criteria in paragraphs (c) and (d) of this section and is not subject to further administrative review of appeal under Parts 217 or 251.82 of this chapter.

§290.4 Confidentiality of cave location information.

(a) *Information disclosure.* No Forest Service employee shall disclose any information that could be used to determine the location of a significant cave or a cave nominated for designation, unless the authorized officer determines that disclosure will further the purposes of the Act and will not create a substantial risk of harm, theft, or destruction to cave resources.

(b) *Requesting confidential information.* Notwithstanding paragraph (a) of this section, the authorized officer may make confidential cave information available to Federal or State governmental agencies, bona fide educational or research institutes, or individuals or organizations assisting the land management agencies with cave management activities. To request confidential cave information, such entities shall make a written request to the authorized officer which includes the following:

(1) Name, address, and telephone number of the individual responsible for the security of the information received;

(2) A legal description of the area for which the information is sought;

(3) A statement of the purpose for which the information is sought; and,

(4) Written assurances that the requesting party will maintain the confidentiality of the information and protect the cave and its resources.

(c) Decision Final. The decision to permit or deny access to confidential cave information is made at the sole discretion of the authorized officer and is not subject to further administrative review or appeal under 5 U.S.C. 552 or parts 217 or 251.82 of this chapter.

§290.5 Collection of information.

The collection of information contained in this rule represents new information requirements as defined in 5 CFR 1320, Controlling Paperwork Burdens on the Public. In accordance with those rules and the Paperwork Reduction Act of 1980 as amended (44 U.S.C. 3507), the Forest Service has received approval by the Office of Management and Budget to collect cave nomination information under clearance number 0596-0123 and confidential information under 0596-00122. The information provided for the cave nomination will be used to determine which caves will be listed as "significant" and the information in the requests to obtain confidential cave information will be used to decide whether to grant access to this information. Response to the call for cave nominations is voluntary. No action may be taken against a person for refusing to supply the information requested. Response to the information requirements for obtaining confidential cave information is required to obtain a benefit in accordance with section 5 of the Federal Cave Resources Protection Act of 1988 (16 U.S.C. 4304).

MANAGEMENT AND PROTECTION ISSUES ON PRIVATE LAND

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Abstract

The protection of cave resources involves many facets of a community including Federal, State, local agencies, and private landowners. The Nature Conservancy of Tennessee, as a private, non-profit organization, has the unique opportunity to work closely with many private landowners of biologically significant caves. Often, building relationships with private landowners can be a delicate process requiring both patience and attention. This slide show presentation will attempt to describe our tools and methods for constructing valuable partnerships with private cave owners with the goal of protecting their resources. The presentation will provide several specific case studies that have resulted in the successful protection of a privately owned cave. In addition, an emphasis will be put on the need to cooperate with many other partners such as university experts, Federal and State agencies, and local caving grottos in order to gather information critical to protection decisions.

Tennessee Caves Initiative

In 1995, The Nature Conservancy of Tennessee hosted a meeting to discuss the status of biologically significant caves in the State. Present were representatives from more than twelve public and private agencies and organizations, including the National Speleological Society, the U.S. Fish and Wildlife Service, and local university experts. Essentially, the goal of this meeting was to develop a list of caves for which protection efforts were needed.

Known biologically rich caves were prioritized by the species present in the cave and the threats to the system. For example, a heavily visited cave containing a threatene d species would receive a higher rating than a cave containing the same species but being more remote in location and infrequently visited.

From this meeting, a list of the "Top 100" biologically significant Tennessee caves was created. Using this list as a starting point, the Tennessee Caves Initiative was formed to begin the task of bringing protection efforts to these important caves.

Most of the biologically significant cave systems in Tennessee are on privately owned land, presenting an array of unique challenges. The Nature Conservancy as an organization is well suited to this task, having accomplished many of our successes throughout the past 50 years with private landowners. These successes are mainly due to a long-standing policy of working only with willing landowners.

Steps Toward Protection

Initial Contact
The natural first step toward the protection of a cave is initiating contact with the landowner. While a letter or phone call is obvious methods, perhaps the best solution is enlisting the help of someone who already knows the person. Experience shows that landowners are much more comfortable when being introduced by someone with whom they are familiar. Neighbors, local cavers, or even other researchers can be invaluable in this capacity and ease a new relationship.

Site Visit
The first visit to a site is an excellent chance to ask questions of a landowner. At this time, one can learn what the person knows about the cave (historical or biological facts) and what kinds of problems they might have encountered while owning the cave. By talking with the landowner, one can also get a sense of their general interest in the cave and its worthiness or unworthiness to them and their family.

Provide Information
It is essential to provide landowners with information about caves in general and the specific species that reside in caves. The Nature Conservancy of Tennessee's Cave Program has developed several materials used for this purpose, including a cave pamphlet and a biannual newsletter. The cave pamphlet outlines the importance of caves as unique ecosystems, species that live in Tennessee's caves, and threats to cave systems. Our newsletter gives information about the Cave Program's activities and upcoming projects, and also gives the landowner information about The Nature Conservancy. In addition, books like "Bats of the United States" (Harvey, Altenbach, and Best, 1999), are appreciated by landowners and give them a chance to see photos and learn about bats that might be living in their cave.

Tools For Protection

Cooperative Management Agreement
Before any on the groundwork is started at a site, a Cooperative Management Agreement is developed between the landowner, The Nature Conservancy of Tennessee, and other partners such as the U.S. Fish and Wildlife Service, Tennessee Wildlife Resources Agency, or a local caving grotto. This is a non-legally binding document that outlines the protection targets at the cave, protection strategies and options for the site, and the responsibilities of the various partners. Partnerships are essential for cave conservation because they facilitate funding, exchange of ideas, law enforcement capabilities, research and data sharing, management help, and labor for large projects like cave gates. Partners may include local, State, and Federal agencies, caving organizations, local caving grottos, and local university experts.

Informational Signs and Periodic Clean-ups
Erecting informational signs at an important cave can be an effective tool in dissuading negative visitation. Such signs should go beyond the simple "no trespassing" statement

and include reasons for a closure period, including a description of the species residing in the cave that are the protection targets. Many people will respect a sign if they understand the reasons for limited access to a cave.

Conducting periodic clean-ups at a cave has several benefits. For caves with unrestricted access, periodic clean-ups are one way to gauge negative visitation to the site. In addition, these projects often provide an opportunity to involve partners and volunteer groups. Perhaps the most important reason for these projects is that they show a landowner a commitment to protecting their cave.

Sinkhole Fences and Cave Gates

When passive protection efforts fail in preventing vandalism and destruction of cave resources, more extreme methods are sometimes employed in the form of entrance barriers. While these projects are expensive, labor intensive, and occasionally unpopular, cave gates and sinkhole fences can be effective at controlling access at biologically important caves. It must be remembered, however, that such structures must be carefully and correctly designed to accomplish two goals: (1) to accommodate the species living in the cave; and (2) to prevent unauthorized and inappropriate entry.

Beyond access control, cave gate projects serve other important functions. These projects provide an opportunity to share management of an important cave with local caving grottos, thus enhancing valuable partnerships. Bringing together volunteers from many walks of life for such projects is another way to nurture partnerships. Often a local community will aid in the construction of a cave gate either through direct labor, donations of drinks and snacks, or by providing equipment such as bulldozers. Inclusion in such important projects can invoke a sense of pride in the community surrounding the cave, which in turn can help with the ongoing protection efforts. Cave gating projects also provide excellent opportunities to spread the message of cave conservation, both in a local community and throughout the State by inviting local and regional media.

Long-Term Protection

Long-term protection is the key to cave conservation. Although the Cooperative Management Agreement is an effective tool to begin protection efforts, it is not permanent. This puts caves at risk when a land ownership or family situation changes. Therefore, it is important that other methods be considered and utilized, if possible.

Conservation easements can offer an effective long-term protection solution. Since an easement will attach to a property deed, development and other restrictions may be passed along from landowner to landowner. One drawback to conservation easements is that since they generally restrict development and subdivision, they can slightly devalue property.

The best long-term solution is to deliver an important property into the hands of an organization or agency whose only goal is to protect the resource. Land donation does occur, but more often the only option is fundraising to acquire a property. Partnerships between private organizations and public agencies are critical to this process.

Fundraising is difficult, and for larger properties, raising acquisition dollars may be too challenging for a single organization. Therefore, finding partners willing to help is a necessity.

Cave Protection In Tennessee

The following case studies describe just a few of the projects in which The Nature Conservancy of Tennessee's Cave Program has been involved.

Holly Creek Cave Preserve
Hound Dog Drop Cave in Wayne County, Tennessee has been known for several years to be a summer roost site for the Federally endangered Gray Bat (*Myotis grisescens*) as well as a site for the Southern Cavefish (*Typhlichthys subterraneus*), a threatened species in Tennessee.

Conservationists discovered that the cave and surrounding property had recently been purchased by Forest Systems, Inc., a lumber company. The Nature Conservancy of Tennessee approached this company through a letter describing the cave and its importance. Forest Systems, Inc. responded and requested that TNC meet with them at the cave, as they were unaware of its location on the property.

After visiting the site and talking with a regional manager with the company, they decided that they would like to protect the site. They agreed that they would work with TNC's Cave Program to construct a management plan for the protection of the cave and its resources. However, their true wish was that this property be in the hands of someone more familiar with caves and their management. At this point, TNC contacted the Southeastern Cave Conservancy, Inc. (SCCi) and asked if there was any interest in acquiring this cave. Luckily, they were willing to take on the project.

Forest Systems, Inc. was unable to donate the property; but was willing to sell it at a reasonable price to the SCCi. Through a generous grant from the Wallace Research Foundation, The Nature Conservancy of Tennessee was able to fund the purchase of this cave. Along with Hound Dog Drop Cave, several other caves and about fifteen acres were purchased by the Southeastern Cave Conservancy, Inc. and named the Holly Creek Preserve.

As a result of the cooperative spirit between several concerned groups, this important cave can now receive the protection necessary for the survival of both rare species in the cave. In addition, there will now be opportunities to further study the cave and any fauna yet to be discovered there.

Caney Hollow Cave
Caney Hollow Cave in Franklin County, Tennessee is another Gray Bat (*Myotis grisescens*) summer roost site. This cave was included in the "Top 100" list, but The Nature Conservancy of Tennessee had not approached the landowners. A Cooperative Management Agreement had existed between the Tennessee Wildlife Resources Agency

and the previous landowners, but the old agreement lapsed when the property changed hands.

A biologist who was friends with the neighbors was able to talk to the landowners about the cave and advised a TNC staff member to pay them a visit. On the first site visit, TNC staff was able to visit the cave and spend some time with the landowners talking about their cave, the bats, and TNC's Cave Program. Information about caves and bats was left with them, as well as a draft copy of a Cooperative Management Agreement. Luckily, the landowners had a powerful conservation ethic and a good sense of the value of the cave and were happy to work with TNC to protect it.

In the following months, a Cooperative Management Agreement was signed and discussions about protection and problems at the cave continued. A TNC staff member was able to visit the landowners several more times and brought informational signs to erect at the various entrances to the cave. In the spring before the bats arrived, a small group of volunteers conducted a clean up of the cave.

During the summer, another biologist and a TNC staff member visited the landowners and brought them to the cave one evening to watch the emergence of more than four thousand bats from the cave. This was a wonderful chance to show them first hand what they were helping to protect. They were delighted and have since taken many of their friends to the cave on summer evenings to watch their bats. Their pride in the cave and the life within has blossomed into a deep concern for all caves and bats in Tennessee.

Another positive result of TNC's relationship with the landowners of this cave came in the form of a story on the Nashville Public Radio station. The story, heard by listeners throughout the State, revolved around the importance and protection of caves and bats in Tennessee, and featured an interview with the landowners of Caney Hollow Cave. Not only was this a chance to spotlight cave conservation, but also successful and cooperative partnerships between private landowners and conservation groups.

New Mammoth Cave

The Federally endangered Indiana Bat (*Myotis sodalis*) once numbered in the thousands at New Mammoth Cave in Campbell County, Tennessee. Unfortunately, this cave and the bats have suffered tremendous and sometimes malicious vandalism over the years, leaving the numbers only in the hundreds.

The Nature Conservancy of Tennessee and the U.S. Fish and Wildlife Service, along with other partners, first began a relationship with the landowner of this cave nearly ten years ago when the first of three gates was constructed at the entrance. When this gate was breached and more vandalism occurred, a second gate was built. Eventually, the newer gate was also breached and stood open for some time.

In the winter of 2001, the landowner was re-contacted by The Nature Conservancy of Tennessee after years of silence. This was due in part to staff changes at TNC and the fact that there was no one in the office whose time could be completely devoted to cave

issues. A TNC staff member spoke with the landowner about renewing our partnership with him and our commitment to the protection of New Mammoth Cave. Luckily, he was still very cooperative and interested in making another attempt to protect the bats. Plans were made to construct another gate, fashioned from much heavier steel and a more contemporary design, in the summer of 2001. Along with reinforcing the defense of the site, our other goal was to show to the landowner a recommitment to our partnership.

Through this project, the East Tennessee Grotto, who had provided much of the volunteer labor at the gating, stepped forward to offer their help in managing the cave. As well as easing the landowner's burden of managing access, a regular presence at the cave by grotto members will hopefully deter vandalism. It is our hope that this long-standing partnership with the landowner of this cave will continue for many more years.

Unnamed Cave, Bedford County

Unnamed Cave, Bedford County, Tennessee has been locally known for many years to be a remarkable place to see a beautiful cave. The landowners of Unnamed Cave have always been protective of the site because of its use as a household water source. However in the mid-1990's, they became protective of the cave for another reason; a Gray Bat maternity colony. Local cavers realized that they were witnessing something unique when they observed thousands of bats exiting the cave. When the identification of the colony was confirmed, the landowner of the cave was approached to discuss protection strategies.

In 1998, The Nature Conservancy of Tennessee formed a partnership in the form of a Cooperative Management Agreement with the landowners, State and Federal partners, and the cave survey team. At that time, it was agreed that a fence surrounding the sinkhole entrance should be constructed to protect the bats and the cave. Over several weekends, and with the help of many volunteers, the fence was constructed and has to date been quite effective at discouraging vandalism and disturbance.

Perhaps more interesting than the fencing projects itself were events taking place since that time. Until February 2002, it was thought that the protection of Unnamed Cave benefited only one rare species, but a recent trip of local cavers and TNC staff revealed the presence of another. On this trip, a unique salamander was observed and thought to be the rare Tennessee Cave Salamander, *Gyrinophilus palleucus*. The salamander was photographed and the pictures sent to experts on this species who have so far identified the animal as *Gyrinophilus palleucus*. What makes this find even more important is that the documentation of the species in this cave constitutes a new county record for the species and also fills in a locality gap on the range map, thus expanding the known range of the salamander.

No less important is the fact that a discovery of this magnitude serves to strengthen the partnership with the landowner and renew a dedication to the site. This exciting find gives the landowner a new sense of pride and one more reason to continue to protect the cave. This experience has reminded us that caves hold many mysteries yet to be discovered and that the protection of our Karst resources is of vital importance. In

addition, this highlights the importance of continued research and surveys at caves that are already protected.

Conclusion

Working with private landowners to protect important caves can be a long process of building trust and relationships and can lead to significant results. The Nature Conservancy of Tennessee's Cave Program has seen many successes over a decade of cave conservation. It should be noted, ho wever, that none of these successes would have been possible without the help and support the many partners and volunteers who bring a dedication to the protection of one of Tennessee's finest resources, its caves.

Acknowledgement

The Nature Conservancy of Tennessee's Cave Program exists because of generous grant support by the Wallace Research Foundation and the United States Fish and Wildlife Service.

Heather Garland is the Cave Program Coordinator for the Tennessee Chapter of The Nature Conservancy. Her interest in the conservation and protection of caves and their associated biota led her to The Nature Conservancy. Her responsibilities include: gathering and reviewing cave species data; organizing cave -related projects such as gates and clean-ups; communicating with partners interested in the protection of Tennessee caves; and contacting and building relationships with private cave landowners in the State. She is a graduate of Middle Tennessee State University with a degree in biology.

Figure 1. Cleanup: Volunteers Bill Ades (TNC) and Brooks Garland clean up trash at a protected cave in Stewart County, Tennessee.

Figure 2. Local caver Matt Hudson and bat researcher Steve Samoray at a cave on the TNC Jim Creek Preserve in Fentress County, Tennessee.

Figure 3. Volunteers and local Tennessee Wildlife Resource Agency officers unloading steel for the re-gating of New Mammoth Cave in Campbell County, Tennessee.

Figure 4. The New Mammoth Cave gate nearing completion

Figure 5. Tennessee Cave Salamander (*Gyrinophilus palleucus)* from Unnamed Cave, Bedford County, Tennessee.

CONSEQUENCES OF NOT PROTECTING THE RESOURCE

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Abstract

Caves provide extremely varied and valuable scientific, recreational, and scenic resources in their formations, life forms, and lo ose deposits. Without protection, these irreplaceable resources are threatened by careless and intentional vandalism. Similarly, abandoned mines provide valuable resources in the form of habitats for a variety of wildlife species as well as a cultural legacy of past mining history. The resources of abandoned mines, like caves, can be easily negatively affected by careless and intentional vandalism. Unlike caves, which developed slowly through natural processes over eons of time, abandoned mines are of relatively recent occurrence. They are artificial in nature and were developed by humans using earth fracturing explosives. Their aged disrepair, geo - technical instability, and unmaintained workings make them extremely hazardous and life-threatening to even the most experienced adventurer. Sealing caves and abandoned mines with gates: (1) allows continued access to the resource by authorized individuals and wildlife; (2) protects the fragile resources; (3) reduces human disturbance to the habitat; and (4) concurrently protects an unsuspecting and often unknowing public.

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Session 2

Project Planning

Session Chairperson:
Len Meier
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Alton, Illinois

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Jim Kennedy, Bat Conservation International, Austin, Texas

PERFORMING A NEEDS ASSESSMENT FOR POTENTIALLY GATING A CAVE OR MINE

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Mammoth Cave, Kentucky

Abstract

A needs assessment for a potential gating project can be boiled do wn to a central question: Does a given cave or mine need a gate or not, and if so, then what kind? In order to answer this composite question, a number of other questions must be addressed.

- Are there safety issues such as unstable rock or shafts deep enou gh to cause entrapment or injury?
- Are residential areas with children nearby (they can fit easily through the 5 3/4 inch bar spacing of a standard bat gate)?
- Is the entrance in an obvious location, near where people congregate, or marked on published maps?
- Conversely, is the opening obscure, remote, and hard to find even if you know where to look?
- What are the current human uses of this underground space? Are they appropriate?
- Who are the stakeholders (in the broader sense of the term)?
- What would be the impact on esthetics of the entrance if it were gated?
- Are there ways to minimize that impact?
- Does the cave or mine contain cultural resources worthy of special protection?
- What are the history and/or prehistory of this mine or cave?
- Did any events important to the nation's development occur here?
- Are resources related to a prior culture present?
- Does the cave or mine contain natural resources worthy of special protection?
- Did it at one time house any currently endangered or threatened species?
- Would gating a given entrance cause significant changes in microclimate, water or wildlife movement?
- What are the existing microclimatic conditions?
- Are these conditions suitable for species currently using or that formerly used this underground space?
- Has the entrance been modified to enhance human use?
- Is restoration of prior conditions needed?

Based upon the answers to these questions concerning safety plus cultural and natural resources, a determination of need for a gate on a mine or cave entrance can generally be determined. However, it is important to keep in mind that site -specific unanticipated factors may also need to be considered.

Considerations in Conducting a Needs Assessment

Welfare of People

Above all, human health and safety must be given priority when considering a gate for an entrance. If people are being injured or killed, then our chances of conserving natural and cultural resources will greatly diminish. One of the preferred designs is the Airflow Bat Gate designed by Roy Powers (Nieland 1998). It causes minimal changes to air flux, allows bats and other animals to pass, in most cases, and is reasonably resistant to forced entry. However, children and even small adults can pass between the bars. Most caving parties are composed of people too big to pass through, so this has not been a problem to date. In a situation where the entrance is near a neighborhood or recreational facility, then additional security measures will be needed. This could be in the form of a perimeter fence with signs warning of the danger analogous to those around electrical power substations. Determining the critical proximity is a matter of judgement. If the site is within the roving range of children, then take the extra steps. With increasing sprawl, currently gated entrances will need to be evaluated for adequate protection of both the people and resources in question.

Figure 1. Photos are examples of obvious and obscure entrances. The one on the left is on a bluff high above Green River in Mammoth Cave National Park. It is easily visible and is also an Indiana Bat hibernation site. The photo on the right is of a cave entrance that people with a map often fail to find. It is not gated.

Assuming an entrance is beyond the reach of unsupervised children, similar but slightly different criteria apply. If the mine or cave opening is in an obvious location, near where people congregate, or is marked on published maps, then inexperienced and poorly equipped people will be attracted to it (Olson 1999). These types of sites almost always require some kind of closure. On the other hand, if the opening is obscure, remote, and hard to find even if you know where to look, then gating it may simply draw attention, and establish a trail to it (see figure 1 for examples of both situations). Unless an initial approach by a curious individual would likely have dire consequences, you could allow obscurity to protect the resource and people from each other.

Current Human Use

It is important to learn if people are using a given underground space, and to determine if that use is appropriate. Recreation often accounts for most human use of caves or mines, but it is possible that a given site may be significant to Native Americans, or even to a group using the site for respiratory Speleotherapy. The treatment of respiratory ailments such as asthma by exposure to air in certain caves and mines is prevalent (and effective) in Europe, but is little known in the U.S. In any case, tactful inquiry with user groups and consideration of use compatibility with resource sensitivities is very important. Generally, people interested in a cave or mine will become allies with the managing agency in protecting resources if they are treated with respect.

If safety and/or resource factors indicate that a gate is advisable, consideration should be given to the potential impact on entrance esthetics if it were gated. So far as we know, esthetics is a purely human concern, but it is safe to say that entrances can be quite beautiful as indicated by the number of published photographs. Therefore, when conducting a needs assessment we must anticipate visual detriments and find ways to minimize them. This type of impact has two facets: (1) visual intrusion of the gate itself, and (2) damage caused during installation or replacement (see figures 2 and 3).

That potential visual impairment of a cave entrance can become controversial is illustrated by the example of Owl Cave in Mammoth Cave National Park (MCNP). The cave is an archaeological site in which plundering was ongoing and graffiti marred the walls, even out on precarious ledges high above the floor (see figure 2). With the resource damage and safety issues, the need for a gate was clearly indicated. Nonetheless, Joe Meiman (MCNP) and Chris Groves (Western Kentucky University) opposed gating the cave due to potential for diminishing the beautiful sunbeams that shine through the entrances in winter. I mention them specifically to emphasize that opposition on the basis of esthetics may come from unexpected sources, not just fringe groups unfamiliar with the issues. In this case, the cave was protected without diminishing the beauty of winter sunbeams via the use of flat "louvered" bars set at the incident angle of the sun at winter solstice (see figure 2).

Figure 2. View into Owl Cave on left. Graffiti on exposed ledges and artifact pilfering necessitated a gate. Impact to pretty sunbeams entering the cave was minimized by angling flat bars like venetian blinds. No bat use had been previously documented.

Nothing lasts forever, and this includes cave gates. Each time a gate is installed, some damage is done to cave walls, ceilings, and floors along with their associated resources (see figure 3). With corrosion, damage from forced entries, and research developing better designs, it becomes clear that it's time to put the old gate "out to pasture." More often than not, a replacement gate is sited in a new location, which then spreads the damage. Gaters are not malicious and are trying to protect people from themselves and the cave resources from the same people. Furthermore, the existing (not necessarily the original) gate may not be in the best location for movement of wildlife, and while the new structure is put in place, the old one provides some security. Still, damage to entrance walls is gradually increased by successive gate replacement, and the Historic Entrance of Mammoth Cave serves as an example. Therefore, to the degree possible gates should be designed with minimum impact removal and replacement in mind.

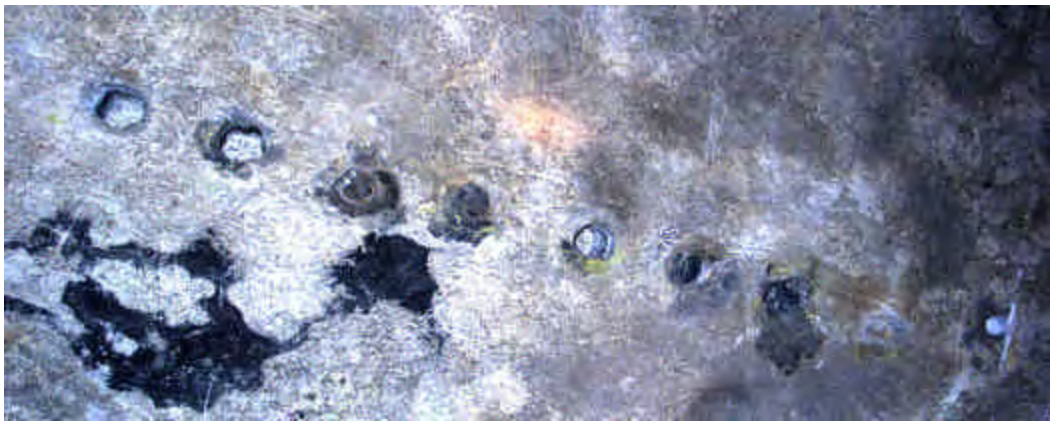

Figure 3. Holes drilled into the ceiling of Mammoth's Historic Entrance to accommodate bars of a previous gate.

Past Human Use

Mines in the U.S. are generally from historica l time periods, but there is always the potential for an aboriginal mining site nearby and so this possibility should be checked out. Be they in mines, caves, or even nearby, if there are resources related to a prior culture, prehistoric or otherwise, the n a specific plan for their documentation and protection should be developed and implemented (Simek et al 1999). In the historical realm, products from mining were often important to our nation's development (see figure 4). There may be relict equipment or historic structures worthy of special protection within and near the mine or cave. Historical researchers with academic credentials and organizations with interest in historic preservation may desire and deserve access to these resources. Again, these people should be regarded as allies unless otherwise demonstrated.

Figure 4. Wooden saltpeter-mining pipes made during the War of 1812 are shown at left above, and a box vat with hewn trough is shown on the right. The small white object is a temperature and relative humidity data logger deployed as part of an effort to stop condensation from developing and dripping onto the artifacts.

Natural Resources

A given cave or mine may contain biological, geological, or bio-geological resources worthy of special protection. Bio-geological resources include fossil and sub-fossil remains, and living geo-microbiological populations. On the biological end, endangered and threatened species such as bats come to mind (see figure 5). These of course are protected under the Endangered Species Act, but all native species inhabiting a cave or mine should be given consideration. Gates, partial gates, and fences around an entrance should not cause significant changes in microclimate, water or wildlife movement. Where security structures are needed, having them be environmentally neutral is important for geological as well as biological resources. Condensation of moisture or desiccation of areas formerly moist can cause the destruction of evaporite minerals or their deposition in places with negative consequences. Such shifts in moisture patterns greatly alter habitat conditions for cave life. Small terrestrial invertebrates adapted to humid cave conditions are particularly susceptible to desiccation (see figure 6). Finally, enhancement of air exchange through an entrance must be approached with great caution since increased influx of cold winter air can increase the rate of rock fall in the variable temperature zone, and this has implications for human safety (Olson 1996).

Figure 5. Endangered or threatened species of bats are a major consideration in determining the need for a gate on a mine or cave. The lumpy clumps in the ceiling of this dome are hibernating bats.

To the greatest extent possible, conduct a n inventory of biological, geological, and paleontological resources in concert with documenting existing microclimatic conditions. Then, via literature search and consultation with appropriate specialists, determine if these conditions are suitable for s pecies currently using or that formerly used this underground space. Cultural and natural resource evaluations go hand in hand. Historical research may indicate how and when the entrance was modified to enhance human use, and what species may have been p resent in the past. Lacking historical records, paleontological inventory (see figure 6) along with carbon 14 dating can provide information on what species were present at a given location and time period (Toomey et al 2001). From the foregoing, it can be determined whether restoration of prior conditions is needed. Bats are obviously a group of particular focus, and bio -assessment protocols for these species have been developed. The full spectrum of considerations for determining potential need for a gate (and, if so, then what kind) is more complex than one might expect. Hubbard's Cave in Tennessee is a case in point. It has both natural and cultural resource issues in addition to persistent illegal entry (Call and Powers 1999).

Figure 6. Though emphasis is rightly placed on the needs of bats, all biota should be considered. Cave crickets are a keystone species in cave ecosystems too (photo courtesy of Gary Berdeaux of Diamond Caverns). Dead bats talk or at least their remains can tell you what and when environmental conditions existed in the past at a given site.

Conclusion

Careful consideration of human health and safety issues, ongoing use by interested parties, plus cultural and natural resources can generally be used to determine whether or not a gate on a mine or cave entrance is needed. Any one of these values can lead to a positive gating decision, but it is probably just as common for multiple areas of concern to trigger that conclusion. In these cases, it is important to minimize personal or group bias in prioritizing values, and to figure out a solution that addresses all concerns. In every case, it is important to keep in mind that there may be factors unique to a given cave or mine that also need to be considered. If, after evaluation, a security structure is indicated, then it is appropriate to begin developing a project strategy. One final point I will add is to make sure that a chosen structure is secure. A gate or fence should be able to resist conventional or readily available hand tools. Put in a secure gate even if break-ins seem unlikely. Massive damage from illegal mining of speleothems in Floyd Collins Crystal Cave within Mammoth Cave National Park resulted from an inadequate gate.

Literature Cited

Call, G. and R. Powers 1999. Hubbard's Cave Revisited: Adaptive Cave Resource Management on a Private Nature Preserve. In: Proceedings of the 14 th National Cave and Karst Management Symposium, p. 19.

Nieland, J. 1998. Cave Gating Manual. American Cave Conservation Association, p. 3.

Olson, R. 1996. This Old Cave: The Ecological Restoration of the Historic Entrance Ecotone of Mammoth Cave, and Mitigation of Visitor Impact. In: Proceedings of the Fifth Annual Mammoth Cave National Park Science Conference. Mammoth Cave National Park, KY: National Park Service, p. 87-95.

Olson, R., Fry, J., Meiman, J., Ward, B., Hendrickson, S., and J. Bradybaugh. 1999. Cave Entrance Management: Principles and Practice at Mammoth Cave National Park. In: Proceedings of the 13th National Cave and Karst Management Symposium, p. 146.

Simek, J., Franklin, J., and A. Cressler. 1999. The Protection and Management of Prehistoric Cave Art in the Southeast. In: Proceedings of the 1999 National Cave and Karst Management Symposium, p. 184.

Toomey, R., Colburn, M., and R. Olson. 2001. Paleontological Evaluation of Past Bat use of Indiana Bat Roosts: A Significant Tool for Roost Restoration. In: Proceedings of the Indiana Bat Symposium, March 29-31, Lexington, KY, in preparation.

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DEVELOPING A PROJECT STRATEGY

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Introduction

As a land manager or owner with caves or abandoned mines on your property you have the opportunity to inventory your resources to determine whether or not the construction of gates would be advantageous. Depending on the types of caves or mines you may pursue different options as you develop a project strategy. I will review several strategies that I have used as a manager of public lands in southeastern California and southwestern Arizona during my tenure as a wildlife biologist with the Bureau of Land Management (BLM) and in my current position with the U.S. Fish and Wildlife Service (USFWS).

The construction of a bat gate can be very expensive and time-consuming. If a gate is determined to be necessary, a temporary gate may be installed to first evaluate the reaction of people and wildlife to your design. In this paper, I will describe three case histories that involve different project strategies in the protection of abandoned mines. The first involves the application of a temporary gate. I will also describe some of the options I have tried for getting the job done, such as using: agency staff, volunteers, employees and equipment from government agencies, and assistance from non-profit organizations such as Bat Conservation International, Inc (BCI).

Case Histories

The 3C Mine

Background: The 3C Mine is located in Imperial County in southeastern California on public land managed by the BLM. It is in an area open to mining and is located on the administrative boundary between BLM offices (Yuma and El Centro Field Offices). The 3C Mine first gained the attention of bat biologists when Dr. Denny Constantine noted that in the 1950s it was occupied in the large numbers of California leaf-nosed bats (*Macrotus californicus*)(Pat Brown, personal communication).

When Dr. Patricia Brown visited the 3C Mine in February, 1985, she discovered that the mining claimant was in the process of closing two of the three entrances to the mine (Pat Brown, personal communication). The claimant used a combination of used appliances, vehicles, bedsprings, and other refuse along with gravel and dirt to make the closure. Brown intervened, asking the claimant to stop. She entered the mine and observed over 1,000 *Macrotus*. She then contacting the BLM to ask for their assistance. The remaining entrance to the mine is an adit that trends southward and slopes down at approximately a 35 degree angle. The entrance to this adit is in unconsolidated alluvium and was

supported by a partially-broken series of collar-sets.

The mine is immediately south of the Imperial Long-term Visitor Area, which is a large, informal campground for winter visitors who bring primarily self-contained trailers and motor homes and spend up to seven months camped on BLM land. The mine is readily accessible by road. Both Dr. Brown and BLM employees noted people near the mine regularly. They were primarily prospecting using hand tools and small placer mining equipment. Most of the human activity takes place during the cooler winter months. This is, however, precisely the time that the mine is home to the largest number of bats. It was clear that easy access to the mine may be compromising the bats' security as well as posing a public safety hazard.

Monitoring: Since 1985, Brown has visited the 3C Mine at least annually, conducting both winter and summer exit counts. She determined that the mine was occupied regularly by up to 2,000 *Macrotus* in the winter months. During the summer, in addition to between 100 and 200 *Macrotus*, the mine also was home to a maternity colony of 300-500 Yuma myotis *(Myotis yumanensis*). The mine is not particularly attractive to humans, since the guano of the Yuma myotis smells strongly of ammonia and this smell carries to the entrance of the mine. On July 7, 1995, I entered the 3C Mine with Dr. Brown, and we located the Yuma myotis maternity roost and recorded an internal temperature of 89 degrees farenheit and 75 percent humidity.

Initial Gate Construction: In 1996, Imperial National Wildlife Refuge contracted Marion Vittetoe and David Dalton to construct a steel gate on the refuge's Eureka Mine that is also home to *Macrotus* and Yuma myotis. Out-flight monitoring at the Eureka Mine suggested that both species tolerated the new angle-steel gate well. However, bats had access to and used two alternative entrances to the mine, one with a partial chain-link closure, and one with a metal grate that allows bat access.

Response of Bats to Gating: To check tolerance of bats to a steel gate at the 3C Mine, in June 1997, Marion Vittetoe, David Dalton, Dr. Virginia Dalton, and I constructed a test gate of 3½@ polyvinyl chlorine (PVC) pipe. This size of pipe was used to roughly approximate angle steel bars. The bats' reaction to this gate was monitored immediately at that evening's out-flight using a tripod-mounted video camera as well as by night vision optics aided by infrared lighting. Approximately 560 Yuma myotis and 300 *Macrotus* successfully exited the mine over a 1½-hour period. The out-flight of bats was observed on the evening immediately prior to the construction of the PVC gate where a similar number of bats exited over a 1-hour period. The out-flight of bats was monitored on several successive evenings following the mock gate construction where between 800 and 1,000 bats were observed leaving the mine. *Macrotus* in particular were observed to pass through the mock gate several times, in a circling fashion, before finally exiting from the mine. The out-flight of bats took place more quickly during successive evenings, suggesting that the bats were becoming accustomed to the gate.

Final Gate Construction: Satisfied with the tolerance of the bats to a gate in the 3C Mine, an angle-steel gate (Tuttle and Taylor, 1995) was constructed in March, 1998, by Marion Vittetoe, David

Dalton, Bob and Ann Graf, Ben Watkins, Marsh McCoy, and Aaron Goodwillie. The timing of the angle-steel construction avoided the maternity and winter roosting seasons. The PVC mock gate was removed immediately prior to the construction of the steel gate. Assistance was provided by: (1) The U.S. Bureau of Reclamation who loaned a stake side truck; (2) El C entro BLM biologist Nancy Nicolai secured a $6,000 National Fish and Wildlife Foundation Grant; and (3) BCI provided $600 which was used towards the purchase of materials.

Marion Vittetoe designed the gate which was constructed of 4" angle steel bars re inforced with 1 2@ angle steel. The gate features two removeable bars for authorized mine access. The gate was constructed over a 4-day period. The total cost of the gate was about $6,100, not including the cost of the labor of agency employees. The co st of the contracted labor was approximately $4,800 with the materials totaling $1,300.

Entrance Stability: Although the innermost of the collar-sets were in good condition, the outermost collar-sets were deteriorating, leading to concerns that the adit may collapse in the future. In early 1999, the BLM once again contacted BCI requesting funds from the bats and mines program to help pay for the cost of the heavy, rough-cut lumber needed to reconstruct and extend the collar-sets. BCI generously provided $750 and the BLM paid the remaining $950. BLM :s David Tapscott used a BLM backhoe to expose the existing collar-sets and then reconstructed and extended the adit. The USFWS, Kofa National Wildlife Refuge provided a small bulldozer to re-contour the area. An existing dry water course, or wash, was realigned so that rainwater no longer drained into the adit. This measure should extend the life of the collar-sets.

Results: Dr. Brown monitored the out-flight of bats at the 3C Mine on February 15, 2002, an d counted approximately 3,500 bats. This suggests not only complete acceptance of the steel bat gate but about a 50 percent increase in the number of bats using the mine.

The Fortuna Mine

Background: From 1896 to 1904, the Fortuna Mine, a gold mine on t he west side of the Gila Mountains outside of Yuma, Arizona, provided enough employment for 80 to 100 men. Gold bullion worth approximately $2.5 million was obtained from the mine. The result was the establishment of a community known as La Fortuna. The mine features a 1,000 foot inclined main shaft with several levels (Wilson, 1933).

The area is currently on the portion of the Barry M. Goldwater Range (BGR) used by the Marine Corps Air Station, Yuma (MCAS). There are at least 100 adits and prospects in the immediate area. A road that can be negotiated by high-clearance vehicles leads from the eastern portion of Yuma to the Fortuna Mine area. A branch of the main road leads right to the main shaft of the Fortuna Mine. The shaft is approximately 75 feet across. The huge Fortuna head-frame that was constructed over the shaft is no longer present. A six-foot-high chain-link fence, roughly in the shape of a pentagon, was constructed by the Luke Air Force Base staff around 1980. The chain-link fence was built to prevent

vehicles and people from falling into the main shaft.
Bat Observations: In 1994, I observed an out-flight of bats from the mine with Dr. Virginia Dalton and Dave Dalton. We observed several hundred *Myotis* exiting the mine, spiraling up out of the shaft and then once clear of the shaft, flying at near ground level and then up and over the chain-link fence.

Fence Vandalism: The chain-link fence, we agreed, was a necessary safety feature of the area and was not posing an obstacle to the bats. The fence, however, was repeatedly vandalized by persons visiting the mine. Some of the main galvanized pipes supporting the chain-link fence were uprooted, presumably using a vehicle. The support posts were also shot repeatedly with a high-powered rifle to the point that they bent. The BLM theorized that the sort of persons responsible for the vandalism may be pacified in the future if they had a view down into the mine. A view down the shaft was not afforded by the original pentagon design.

Fence Maintenance: In February 1996, the chain-link fence was reconstructed using a new design - an alcove was constructed so that those visiting the mine could look directly down the main shaft. The MCAS maintenance crew assisted the BLM in the construction of the new fence. The BLM paid $350 for the materials used in reconstruction.

Result: The BLM and MCAS repaired the fence a second time in November 1999 because of repeated vandalism.

The Puzzler Mine
Background: The Puzzler Mine is an abandoned lead mine located in the foothills of the Castle Dome Mountains within the Kofa National Wildlife Refuge. Dr. J. Scott Altenbach of the University of New Mexico entered the mine on October 1, 1996. The Puzzler was one of 16 mines on the refuge he entered using his unique equipment that allows him to descend into open shafts guided by a cable. The mine contains a central shaft that extends over 200 feet deep and has at least seven levels. Most of the mine was found to have a temperature of 89.5 degrees farenheit. Of the mines he entered, he felt that this one had the highest priority for bat-compatible gating. He noted significant accumulations of guano on all levels in addition to debris such as batteries and beverage containers from humans entering the mine.

Monitoring: The Kofa refuge staff began monitoring the mine using exit counts and documented approximately 180 California leaf-nosed bats using the mine in the winter months. The warm internal temperatures are ideal for *Macrotus* in the winter. During the summer months, the bats apparently leave the mine for alternative roosts.

Gate Design & Construction: While measuring the shaft for a cupola-style gate, refuge employees encountered several people exiting from the mine carrying lead crystals they had collected. The Puzzler is a significant location of argentiferous galena and its presence has been documented in the *Mineral Record* (R. Kearns, personal communication). The refuge staff proceeded with the gate design and

construction at the Kofa NWR office. Steel was purchased locally and agency personnel were used for all labor. The gate was constructed with 2" square tubular bars. The bars were welded in place on the uprights in a parallel position rather than in a diamond -fashion. The entire gate was carried out to the refuge and placed over the shaft using a crane borrowed from the United States Border Patrol. A concrete foundation was constructed prior to the placement of the cupola gate. The bars on the top of the cupola were not welded in place at first to allow the bats to become accustomed to the gate in stages.

Result: While the roof was not yet in place, bats chose to exit out of the top of the structure. Since the roof was completed, bats exit out of the sides of the cupola, not the top. There has been no vandalism of the cupola gate.

Conclusion

The gating or fencing of these three mines represents a step in the right direction for the land managers in the region but in no way finishes the task in a region filled with abandoned mines. There will be more project strategies developed in the future. The BLM is currently considering closing the area surrounding and including the 3C Mine to mineral entry. This measure would prevent a mining claimant from filing a Notice of Intent and proceeding with a new mining effort. In the late 1990s, renewed mining in the nearby Cargo Muchacho Mountains changed an area with abandoned mine adits and tunnels inhabited by bats to an open pit gold mine.

The Military Lands Withdrawal Act (Public Law 106-65) transferred the natural resource management responsibility on the BGR from the BLM to the military (MCAS and Luke Air Force Base). MCAS and the Air Force are currently working on an Integrated Natural Resource Management Plan. The draft plan states that all abandoned mines will be off limits to unauthorized entry. It will be MCAS and the Air Force's responsibility to maintain the existing bat gates and protective fencing as well as to determine if additional bat gates on other abandoned mines within the BGR may be warranted. I learned from MCAS Natural Resource Management staff that the Fortuna Mine fence had once again been vandalized. The area may need closure from vehicles to prevent future damage.

There are literally hundreds of abandoned mines on the Kofa NWR. The refuge has benefitted not only by the inventory conducted by Dr. Altenbach, but also by exit counts provided by the Arizona Game and Fish Department (AGFD) Non-game Biologists (Snow, 1998) and our own refuge volunteers. AGFD biologist Linden Piest has established one long-term bat mist-netting location on the refuge. Decisions to construct more gates may become more urgent as the human population in the region increases and more and more people come to the desert to recreate and potentially, explore abandoned mines.

References Cited

Brown, Patricia. Brown-Berry Biological Consulting. Personal Communications.

Kearns, Ron L. Kofa National Wildlife Refuge Biologist. Personal Communications.

Snow, Tim K. 1998. Bat inventory of the Kofa National Wildlife Refuge. Tech. Rept. No. 134, Nongame and Endangered Wildlife Prog. Ariz. Game and Fish Dept. Phoenix, Ariz.

Tuttle, Merlin D. and Daniel A.R. Taylor. 1995. Bats and mines. Bat Conservation International, In c. Res. Publ. No. 3. 41pp.

Wilson, Eldred D. 1933. Geology and mineral deposits of southern Yuma County, Arizona. Univ. Ariz. Bull. No. 134. Arizona Bureau of Mines. 234pp.

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BIO-ASSESSMENT DETERMINING THE SUITABILITY OF MINES AND CAVES FOR BATS

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Abstract

A bio-assessment of a mine or cave should be performed prior to closure activities, and to prioritize sites for closure. Historic and/or current use by bats of caves and mines in the area can often be determined from museum records, literature review, and interviews with miners, geologists, cavers, and bat biologists. These sites should be surveyed at the appropriate season for current bat use. If no information on bat occupancy is available on the site that is being assessed for gating, then a survey of the mine/cave should be conducted during the season with the most potential for bat use (based on habitat, elevation, thermal characteristics, etc.). If no bats are discovered, surveys at other seasons should be conducted. Often, the period of bat residency in a mine or cave may be only a few weeks a year and it can be very important to the species at that time. The season of the survey, the bat species anticipated, and the characteristics of the mine or cave will dictate the type of survey techniques. Combinations of internal and external surveys (out-flight monitoring with night vision equipment, mist-netting, and acoustic recordings) are normally employed. The field survey results (the number and species of bats present and during what seasons) should be compared with other known sites in the same geographic area. Consultation with local bat biologists will help to place the importance or significance of the mine or cave in a regional context.

Introduction

Bio-assessment is the process by which we gather information about the life forms in a cave or mine. Typically, the biota and configuration of a cave system is better known than most mines, because caves are geologically older than mines and more people have been conducting research and mapping them for longer periods of time (Kerbo, this volume). The intrinsic value of caves has been recognized by the Federal government in the Cave Management Protection Act. Protecting mines and the animals that live in them is an uphill battle. Mines are viewed by most land managers as “unnatural” habitat. However, by living in a mine, bats and other animals define it as their natural habitat and it should be managed accordingly. The complex reasons that bats use mines and the importance of protecting mines has been adequately discussed by Altenbach and Sherwin (this volume).

Determining the suitability of mines and caves for bats and the seasonal use is necessary in deciding how to prioritize them for closure and in what season to close them. Since this is a bat gate design conference, bat-compatible closure is assumed. However, bio-assessments are necessary when mines need to be permanently closed (Brown *et al.* 2001). As has been demonstrated by Sherwin *et. al*. (2002), the importance of roosts for *Corynorhinus townsendii* can vary within and between years. Fidelity may vary between mine and cave roosts and can be influenced by external events such as fire and permanent mine closures in the area (Sherwin *et al*., 2000a, 2000b). The reason that bats use mines and which mines they use is a complex issue (Altenbach and Sherwin, this issue; Sherwin *et al*., 2001). The effort to attempt to simplify or model bat use of mines or caves often ends up in erroneous conclusions because so many variables cannot be measured or may not even be known. For example, the entry of people (other than the researchers) into mines that disturb bats is usually not known or quantifiable, yet it can have a major impact on where bats roost.

Pre-Surveys

Before commencing field surveys, a background check of the mines or caves slated for closure is advised and can help prioritize field efforts. Important resources in determining historic use by bats (or other wildlife) of caves and mines in the area are museum records, State heritage databases, published and "grey" literature, interviews with past and present miners, geologists, cavers, and bat biologists. The same people may also have knowledge of currently occupied roosts. Whenever possible, note the date when collections or observations were made. Other wildlife besides bats use mines and caves and they may influence what mines need closure (Brown *et al*., 1995). As an example, horizontal workings in the low deserts can shelter desert tortoises and gates may need to be designed to accommodate them. Non-biological criteria will also drive survey priorities. If human safety rather than bat roost protection is the primary concern, mines near roads, human habitation, and recreation areas will receive higher priority. Other environmental issues, such as acid mine drainage or radiation hazards, may direct survey efforts.

Aerial photographs and topographic maps can be useful in planning field surveys. The latter indicate different mine features (shafts, adits, prospects, open pits), and can provide a starting point for field surveys (Figure 1). In the author's experience, they are about 80 percent accurate---meaning that 20 percent of the time they indicate features that are not present, or mine features exist on the ground that are not mapped. One generalization is that mine features close together may connect and can indicate a complex mine with a higher probability of bats. A shaft located above an adit has the potential (if it connects) to exhaust warm air in the winter, drawing colder air in the lower adit and providing cooler temperatures for hibernating bats. Upper south to west -facing adits and stopes, have warm air drawn into them in the summer, as cold air flows out the lower portal, providing better conditions for a maternity colony (Tuttle and Stevenson, 1978). Mines and caves often share airflow characteristics, assuming that the configurations are known. Accurate internal maps may exist for most caves, but seldom for mines. Even when mine maps are located, they may no longer be accurate. Mines are inherently unstable, and

connections can collapse, or subsequent mine development may have enlarged the workings and/or filled them. Some mines are geothermally-heated or cold air traps, providing an array of temperatures that are not predictable from maps or surface surveys. For example, the mine depicted in Figure 1 in central Nevada has a lower geothermally-heated adit (1) with year-round temperatures of 33 degrees C (92 F) at the collapsed face (300 meters from the portal). Although it might have at one time, it no longer connects to the workings in the canyon to the northeast. In the warm season, the adit shelters a very large maternity colony of pallid bats (Antrozous pallidus) and a small maternity colony of Townsend's big-eared bats (Corynorhinus townsendii). In the winter, a few active Corynorhinus are found in the mine, presumably foraging over the adjacent hot springs. The main maternity colony uses the southwest facing adit (6) in the canyon above, while the north facing adit (number 4 connected to the shaft 5) contains hibernating clusters of Corynorhinus in the winter (P. Brown personal observation). Despite generalizations about temperatures and mine connections drawn from perusal of maps, field proofing is necessary. Aerial reconnaissance (especially in high-winged slow flying aircraft) with a GPS can be invaluable in locating mines, determining if they are still open, and what is the best road and/or hiking access.

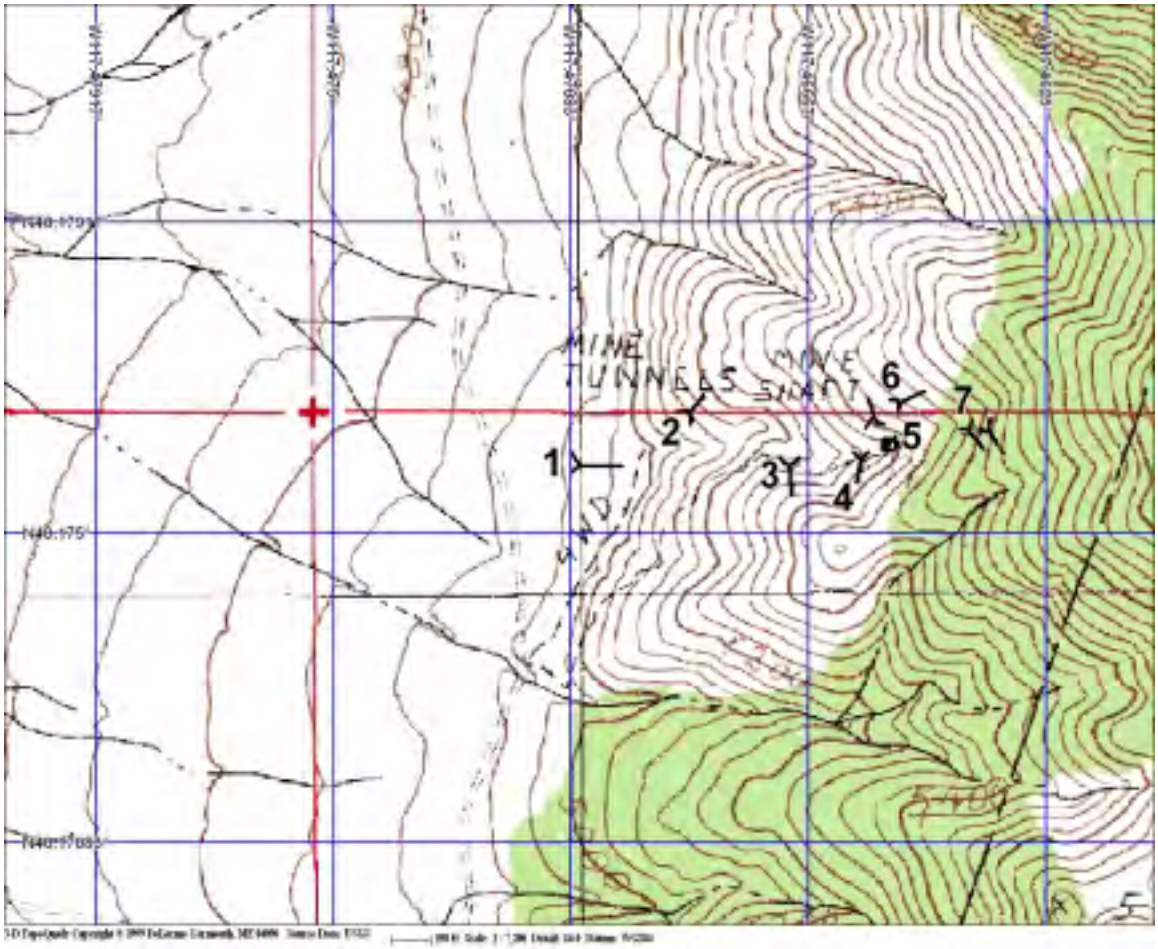

Figure 1. Topographic Map of Mine Site

Field Surveys

Basically, nothing can be substituted for thorough field surveys, as discussed by Altenbach *et al.* (2001). An average of 75 percent of the over 7,000 mine features we have surveyed in the arid Southwest over the past 30 years shelter bats or contain guano. About 10 percent are what might be called significant. The exact percentage will vary between mining districts and can be influenced by the number of mines and the foraging habitat surrounding them. In areas with fewer mines and/or caves, the percentage of occupied sites will probably be higher. In the arid West, mines located near riparian areas are more likely to shelter bats.

The initial field surveys should visit those sites at the appropriate season where the background research indicated bat use. Even if recent data is available, bat use should be verified close to closure. However, if no recent data on bat occupancy is available on the site that is being assessed for gating, then a survey of the mine/cave should be conducted during the season with the most potential for bat use (based on habitat, elevation, thermal characteristics, etc). If no bats are discovered, surveys at other seasons should be conducted. The time of occupancy may be brief but significant for a species.

Safety training is necessary for research around abandoned mines, even for initial diurnal mapping and external nocturnal surveys. Some agencies (i.e. Forest Service or Bureau of Land Management) offer classes on abandoned mine safety and may require certain paperwork before beginning a site survey. MSHA classes are for active surface and underground mine workers but they do offer some relevant training for abandoned mine hazards. The Colorado Department of Wildlife trains volunteers involved in external mine surveys in safety and survey protocols (Navo 1995).

On the surface, the position of mine openings first located on a map can be verified. The waste rock pile outside the mine can give an indication of the extent of the mine. A large "dump" generally means a large volume has been excavated (although subsequent collapses may have occurred), although the converse is not necessarily true. A small dump (or even the absence of a dump) does not mean a small mine working for a variety of reasons. The high grade ore might have been removed to the mill, the mine may be located in a wash or erosion channel, or the opening may have been dug from below and connect to extensive workings. Assuming that the mine portal or collar can be approached safely, airflow may be apparent, indicating that other openings to the mine or cave exist. The absence of airflow however does not indicate a lack of other openings as temperature difference between inside and outside the mine drives airflow. When the outside air temperature is higher than internal mine temperature, the cooler heavier internal air sinks drawing in warmer outside air at higher portals. The reverse occurs when outside air temperature drops below the internal mine temperature and the internal air now warmer than outside air will raise drawing in the denser, cooler outside air at the lower portals. As the internal and external air temperatures cross, airflow direction reverses causing some daytime periods with little or no flow. A good rule for all aspects of a survey is **absence of evidence is not evidence of absence**. This is especially true when underground entry to a mine is prohibited.

The decision on whether a mine or cave should be internally or externally evaluated is based primarily on: safety (the degree of training of the researcher), the proper equipment, and the stability of the mine. The steps to follow for deciding on an internal versus an external survey are described by Altenbach and his colleagues (Altenbach and Milford, 1995; Altenbach and Pierson 1995; Altenbach *et al*. 2001). The obvious advantage to internal surveys is that guano and/or bats can be viewed and possibly identified, temperatures can be taken, and airflow and mine connections determined. When conducting external surveys, it is important to watch all points of exodus. Without internal surveys, these may not be apparent. Hibernating bats don't exit a mine in winter, so internal surveys are the only means for determining the number and species of bats in residence. Care should be taken during winter surveys while bats are hibernating. Once hibernating bats are encountered, it's best to leave the mine rather than conduct an absolute count, and risk disturbing the bats. If internal surveys cannot be conducted in winter, hibernation use should be assumed and no closures installed at this season.

Some mines or caves are too hazardous and inaccessible for even the most skilled surveyors (i.e. Scott Altenbach). In this case, external surveys are the only option. Even with the ability to conduct internal surveys, external warm season surveys may still be desirable. Few mines can be totally surveyed internally due to the presence of large stopes, winzes, raises and crevices. Usually bats occupy the most hazardous areas in mines that are not accessible to predators (especially humans). For example, a mine in central Arizona slated for closure had little guano in the first 100 meters of the main drift when a winze was encountered that was impossible to safely traverse. At dusk over 30,000 Mexican free-tailed bats (*Tadarida brasiliensis*) erupted from the main portal and two stopes on the mountain above (P. Brown pers. obs.). Often bats and their guano can be totally hidden in a mine (**absence of evidence is not evidence of absence**). I have been surprised, occasionally, by the numbers of bats that have exited from mines where I had found relatively little internal bat sign even when a thorough internal evaluation was possible.

A variety of tools are available for external evaluation and monitoring that each has its own advantages (Altenbach et al. 2001; Herder this volume; Rainey 1995). The technology is rapidly changing and electronic equipment developed for other applications is being modified for use in bat surveys and monitoring. Survey protocols can be expected to change as new equipment becomes available (or more affordable). The more methods employed usually give a more complete picture of the number and species of bats present in a mine. Some species of bats (i.e. *Myotis* and *Tadarida*) begin exiting a mine at sunset and may be visible without special equipment. Other species (*Corynorhinus* and *Macrotus*) may exit after dark, in which case the use of night vision, thermal imaging (currently expensive), or infrared video cameras is necessary. White lights should not be used. There is some physiological evidence that red lights may be visible, at least to some bat species, such as California leaf-nosed bats (*Macrotus californicus)* (Schmidt *et al.*, 1998). When relying on external surveys, care should be taken by the observers to be quiet and as unobtrusive as possible, since bats may not exit if they sense a predator (human). Some species (*Corynorhinus*) appear to be more

sensitive to human presence than others. For this reason, remote sensing has advantages, especially the use of IR sensitive cameras (Sony Nightshot). The permanent tape record can be analyzed in the lab in slow motion, the cameras are relatively inexpensive (sometimes less than field assistants), and can be used to monitor multiple openings. Night vision equipment is especially useful for large open stopes, since a broader field of view and an active observer may be necessary to track bats.

Whereas the number of bats can be counted exiting a mine by direct observation or video-taping, species identification is difficult. Acoustic methods of detection (Anabat and/or Pettersson detectors) give better species identification (Herder this volume;) and can be used remotely at a mine, thereby eliminating observer bias. The disadvantages are that different species may use similar signals when exiting a mine. Some species are not easily detected either because they emit faint (low intensity) signals (i.e. *Corynorhinus*) or use vision instead of echolocation (*Antrozous* and *Macrotus*). Sometimes the communication sounds of these species are diagnostic. Acoustic records do not indicate the number of bats resident in a mine, since bats can be exiting, entering, circling or flying past. Coupling the output from a Pettersson detector with the IR camera can allow pairing of an acoustic signal with an exiting bat for better identification (Berry and Scewczak this volume). If absolute species identification or sex or reproductive condition is necessary, then the bats need to be captured in harp, hand or mist nets. Ideally, a normal out-flight is watched the night before capture is attempted in order to ascertain the number of bats, the flight pattern and the openings used for exit. Capture attempts definitely affect the normal exodus.

What is Significant?

For scientists, it is important to know how, when, why and how many bats species use mines and caves (Sherwin *et. al*., 2002). The decision of the land managers to install a bat compatible closure may not require this same degree of bio-assessment. Any bat use may be sufficient to warrant closure. The main consideration would be if the installation of a bat gate could have a negative effect on the resident bats (Sherwin and Altenbach, this volume). However, when funds are limited, only mines or caves with significant use may receive protection or be spared permanent closure methods. How is significant to be defined and who will do it?

Local bat biologists should be consulted to place the results of the bio-assessment in a regional context. In assigning priorities to gate, the following elements should be considered:

1. Is it a roost of a Threatened or Endangered species?
2. Is it a maternity colony of any bat species?
3. Does it shelter a large number of bats at any season?
4. Is it a complex site internally with the potential for many temperature regimes to satisfy bats at different seasons (especially if only a single survey was conducted)?
5. Is the bat use of a type that is not fully understood, and it requires more research?
6. What is the potential for long-term stability of this site?

7. Are other roosts available in the immediate vicinity for this species?

A positive response to questions one to five should be justification for a bat- compatible closure. However, the long-term stability of the site may be questionable or difficult to gate. Other roosts of the same species in more stable mines might be better to protect. Human safety and access issues also enter into the decision of what mines should be gated. Mines that are more accessible to people should receive priority for gating over a remote site that is difficult to reach.

Conclusion

All mines and caves should be considered as bat habitat until proven otherwise by appropriate surveys. With the right tools and training, surveys are not necessarily difficult. However, it may take multiple surveys at different seasons to understand how a mine is used by bats. Prioritizing mines and caves for gating may be driven by different motives. The reason to gate a cave is usually to protect biotic and abiotic features. Some mines have been gated with bat conservation as the primary motivation. More often, human safety and liability issues drive government agencies and private landowners to close mines. In these cases, a bat compatible gate is a better solution than back-filling, foaming or blasting, even if complete bio-assessments have not been completed. Occasionally, bat colonies do not accept gates, and gating may cause apparent declines in the population (Sherwin and Altenbach, this volume). Both pre- and post gating surveys are required to determine population trends caused by the installation of bat compatible closures.

Pragmatically, landowners and managers do not have the time, money, or expertise to perform multi-season, multi-year assessments on the thousands of mines that need closure, and then do the necessary post-closure monitoring of the site. Relatively few mines have been adequately surveyed and the sheer numbers are an overwhelming prospect. Permanent mine closures in the West for human safety and renewed mining are happening at a rate that exceeds the ability of qualified biologists to perform adequate bio-assessments. Without ESA, Threatened and Endangered bat species in the West (with the exception of *Leptonycteris*), the mandate and funding to provide sound scientific solutions to immediate mine management issues is absence. Are there band-aids, or easy solutions to this complex issue? The compromise is that mine closures (both bat-compatible and permanent) will proceed with limited bio-assessment, while relatively few mines will receive the attention outlined by Altenbach and his colleagues (Altenbach and Milford 1995; Altenbach and Pierson 1995; Altenbach *et al*. 2001).

Gating is done for people, not for bats. Bats are happy with the unimpeded entrance of the mine or cave they selected as roosting habitat. In an ideal world, people could be educated to stay out of mines and caves. In an ideal world, we would have total knowledge about the spatial and temporal use of mines by bats before management decisions are required.

Literature Cited

Altenbach, J. S., and H. E. Milford. 1995. Evaluation and management of bats in abandoned mines in New Mexico. Pp. 326-330 in D. Pate, ed. Proceedings of the 1993 National Cave Management Symposium, Carlsbad, New Mexico. American Cave Conservation Association, Horse Cave, Kentucky.

Altenbach, J. S., and E. D. Pierson. 1995. The importance of mines to bats: an overview. Pages 7-18, in B. R. Riddle, ed. Inactive mines as bat habitat: guidelines for research, survey, monitoring and mine management in Nevada. Biological Resources Research Center, University of Nevada, Reno, Nevada.

Altenbach, J. S., R. E. Sherwin, and P. E. Brown. 2001. Pre-mine closure bat survey and inventory techniques. Pp. 115-125, in K. Vories and D. Throgmorton, eds. Bat Conservation and Mining, a Technical Interactive Forum. Office of Surface Mining, USDI, Alton, IL and Coal Research Center, SIU, Carbondale, Illinois.

Brown, C., P.E. Brown, and R.D. Berry. 1995. Abandoned mines as habitat for bats and other wildlife species. *In* Riddle, B.R. (ed.). Inactive mines as bat habitat: guidelines for research, survey, monitoring, and mine management in Nevada. Biological Resources Research Center, University of Nevada, Reno. 148 pp.

Brown, P. E., J. S. Altenbach, and R. E. Sherwin. 2001. Evicting bats when gates won't work: unstable mines and renewed mining. Pp. 187-192, in K. Vories and D. Throgmorton, eds. Bat Conservation and Mining, a Technical Interactive Forum. Office of Surface Mining, USDI, Alton, IL and Coal Research Center, SIU, Carbondale, Illinois.

Navo, K. 1995. Guidelines for external surveys of mines for bat roosts. *In* Riddle, B.R. (ed.). Inactive mines as bat habitat: guidelines for research, survey, monitoring, and mine management in Nevada. Biological Resources Research Center, University of Nevada, Reno. 148 pp.

Rainey, W.E. 1995. Tools for low-disturbance monitoring of bat activity. *In* Riddle, B.R. (ed.). Inactive mines as bat habitat: guidelines for research, survey, monitoring, and mine management in Nevada. Biological Resources Research Center, University of Nevada, Reno. 148 pp.

Schmidt, U., K. Hessel, and A. Wiesemann. 1998. On some unexpected abilities of the visual system in Phyllostomid bats, [ABS]. 11th International Bat Research Conference. Pierenopolis, Brazil.

Sherwin, R. E., D. Stricklan, and D. S. Rogers. 2000a. Roosting affinities of Townsend's big-eared bat (*Corynorhinus townsendii*) in northern Utah. Journal of Mammalogy, 81:939-947.

Sherwin, R. E., W. L. Gannon, J. S. Altenbach, and D. Stricklan. 2000b. Roost fidelity of Townsend's big-eared bat in Utah and Nevada. Transactions of the Western Section of the Wildlife Society, 36:15-20.

Sherwin, R. E., J. S. Altenbach, and P. E. Brown. 2001. Methods for determining local mine characteristics of importance to bats. Pp. 109-114, in K. Vories and D. Throgmorton, eds. Bat Conservation and Mining, a Technical Interactive Forum. Office of Surface Mining, USDI, Alton, IL and Coal Research Center, SIU, Carbondale, Illinois.

Sherwin, R. E., J. S. Altenbach, and W. L. Gannon. 2002. Inherent spatial and temporal variability in the use of roosts by Townsend's big-eared bat. Wildlife Society Bulletin, xx:xxx-xxx. (In Press).

Tuttle, M. D., Stevenson, D. E. 1978. Variation in the cave environment and its biological implications. Pp. 108-121, in Zuber et al eds. National Cave Management Symposium Proceedings, 1977. Adobe Press. Albuquerque, New Mexico.

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She received her Ph.D. in Biology from UCLA in 1973, her research topic being the development of hearing and echolocation in pallid bats. She has continued this research interest at UCLA as a Research Associate, currently with an appointment in the Department of Physiological Sciences. From 1982-1992, she was also Director of the Maturango Museum, dedicated to interpretation of the cultural and natural history of the Mojave Desert. Since 1992, she has devoted her time to bat research and conservation, either through UCLA or her company, Brown-Berry Biological Consulting. She and colleague Dr. Robert Berry conduct bat surveys for government agencies and mining companies, and train students and personnel in bat survey techniques.

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DEVELOPING A CAVE OR MINE MANAGEMENT PLAN

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Introduction

This paper provides guidance on how to develop a cave or mine management plan. While the focus will be primarily related to cave and mine gating, the framework for writing a management plan presented should be applicable to any generalized need for a management plan. The first step in the process is deciding whether a management plan is required or recommended (It usually is!). Suggestions of items need to be included in the plan will be discussed and a recommended process for preparing a management plan is presented. The material is designed to reach a wide range of audiences with very different experiences in planning, resource-protection mandates, scope of work, and budgets. A brief overview of primary management concerns and ways to determine what your individual needs may be is provided. A management plan provides the means of sharing thoughts, logic process, and the making of decisions. While a management plan may not be required, having one is beneficial for justifying any management action (in this case gating) and clearly recording why decisions (to gate or not to gate) have been made.

What is a cave or mine management plan?

A management plan outlines how a cave or mine will be managed in the future. This document often includes background information on the history of the cave/mine, how it was managed in the past, and what aspects make this area important for management. The plan details exactly what will be done and why. A management plan establishes polices related to the cave or mine. The management plan provides an introduction to the resources and should highlight research deficiencies. A plan is important for documenting the logic and thought process that resulted in the management decision (e.g. gating an opening). Some plans are very "cookbook" in nature (e.g. the cave will be open for visitor access from September 1 to April 30), while others are more philosophical in nature (e.g. the cave will support a healthy population of a given species of bats). A management plan shares thoughts, explains the logic, and if well written and analyzed, makes the decision of how to manage a cave or mine easier. A management plan should clearly record what decisions have been made and justify the management action (e.g. gating).

Do you need a cave or mine management plan?

While many are hopeful a management plan is not needed or many believe writing a plan is a waste of time, management plans are extremely important. Writing a plan may seem like an onerous, thankless task, one that slows active conservation, preservation, or protection. However, management plans document the current conditions and explicitly

state the desired outcome of specified actions and the future conditions of the cave/mine. Management plans explain what led to the management action decision. Management plans create the measure of success by sharing the history of a project and allowing analysis of actions in the future. Below is a set of simple questions to determine if a management plan is needed for your situation.

- Is the cave or mine on Federal or State owned public land and administered by a government agency with authority over the cave/mine?
  If yes, then a management plan is almost certainly required. There are very few occasions in which a plan would not be required, and in those cases a plan is highly recommended. Caves, on Federal land, fall under the Federal Cave Resources Protection Act of 1988, which requires a management plan for all caves whether gated or not, whether visited or not.

- Are you a private agency/organization with extensive ties to the local community or a specialized user group that manages a cave/ mine?
  If yes, then a management plan is highly recommended to provide a record of the planning process and document how the cave/mine management action ties into the organizations mission statement and goals.

- Are you a private company with full authority over the cave/mine and surrounding land?
  If yes, then a management plan may not be necessary, but it is still recommended. At a minimum, your organization should document the process that resulted in the cave management decision (a gate project). This documentation allows future managers to understand the situation and why an action was taken. It establishes the context in which the decision was made. If there is a government nexus over the cave/mine to be managed, a management plan would most likely be required by the government agency for future actions pertinent to the cave/mine.

- Is the cave or mine under a cooperative agreement for management?
  If yes, then a management plan is most likely required. There are very few occasions in which a plan would not be required, and in those cases a plan is highly recommended. This is especially the case when dealing with multiple agencies or interested parties. Management plans are an excellent way to document the process that resulted in the management action (the gate or other management decisions). This documentation allows all interested parties to understand the situation and why an action was taken. The plan also allows cooperators to become stakeholders in the project that typically leads to a stronger commitment.

- Are you a private landowner with full authority over the cave/mine and surrounding land?
  If yes, then a management plan is probably not required or necessary (unless there is a government nexus over the cave/mine). However, it is still recommended to document the thought process that came to the decision of planning a gate project

(or other management decision). This documentation allows predecessors to understand the situation and why an action was taken.

A management plan shares thoughts and explains the logic. It should make the decision of how to manage a cave or mine easier, if it is well written and analyzed. Having a cave or mine management plan is always beneficial. A management plan justifies the management and clearly records what decisions have been made and why.

What Makes a Successful Cave Management Plan?

Before delving into the framework of a management plan and how to write one, it is important to consider what makes a cave or mine management plan (actually any management plan) successful. There are a few key points on this.

- Satisfies statutory requirements and internal agency guidance
  If the plan does not meet legislative and policy directives, it is doomed to fail. Without meeting these guidelines, a plan is more likely to be challenged in court. The managers are more likely to be scrutinized and are likely to lose public trust.

- Provides information on status and context of resources, caving activities, and its effects
  The plan should fully describe the resources it is intended to protect. An effective management plan is only as good as the data used to prepare it. Background information and historical perspective provide important baselines from which management decisions are made. This is a crucial part for fully disclosing the thought process.

- Builds cooperative relationships between special user groups and resource managers
  A plan is only successful if people follow it. Without public ownership of the solution, the plan will likely not succeed. This may be less important for private companies and individual owners, but can be an excellent means for improving public relations.

- Identifies minimum actions necessary to protect resources
  Typically, this recommends implementing a management action using an indirect means (e.g. educational outreach) first and escalates to more direct means (e.g. closures) as necessary. It is important to remember the first recommendation, satisfying statutory requirements. If policy or law requires immediate, direct action, do not hesitate to implement it but be sure to explain why the direct action was needed.

- Identifies management alternatives consistent with management approaches to other recreation groups
  This primarily relates to lands managed by government. Government agencies cannot manage with bias. If an agency prohibits a set of actions from one user

group it should be enforced on all. Differences in management actions need to be fully explained and justified.

Suggested Contents of a Cave or Mine Management Plan

Management plans need not be long documents. They should concisely outline the history, the issues, the resources, and the management actions for a mine or cave. A cave management plan may incorporate the following contents depending upon the scope and extent of the project. Some sections will be explained to assure that the recommended content is clear, others are obvious and need no further explanation. Considering all Federal agencies should follow the guideline established in the National Environmental Protection Act (NEPA), I am presenting the contents of a management plan that will meet the needs of NEPA as well as good management. I recommend this format to reduce workload by not writing the same information in two different documents. A well - written management plan should meet NEPA requirements. Suggested contents include:

- Introduction
- Purpose and Need
- Goals and Objectives
- Authorities, Policies, Guidelines for Resource and Recreation Management
- Description of Present Condition of Natural and Cultura l Resources
  - General Description
  - Affected Resources and Their Existing Conditions (vegetation, wildlife, geology, special species, cultural or historic resources)
- Description of cave/mine management, past and present
- Description of relevant management infra structure (trails, camping, waste disposal, parking)
- Description of Caving/Mining Activity
  - History
  - National and Regional Importance
  - Description of caving opportunities
  - Description of Use Patterns
  - Maps/location of cave or mine resources
- Description of othe r uses (such as mineral exploration)
- Description of management issues/ concerns
- Desired future resource conditions
- Management recommendations for policy, guidelines and action
- Summary of internal/public review process and procedures
- Glossary of Terms
- Literature Cited/Recommended Resources
- Contacts (interested parties/organizations)
- Appendices (as needed)

All of these suggested topics may not be relevant to a specific project. If the cave/mine is on private property and has always been on private property, there may be no caving

activity, thus a plan for this cave would probably not include management infrastructure, caving activity, or cave management. There may not be a need to discuss cultural values of a given cave or mine, or its place in history migh t be quite significant. This list is provided not to make the process of writing a management ominous, but rather to assist managers in assessing all the possibilities before beginning to write the plan. The first three sections – introduction, purpose and need, goals and objective -- are vital to your plan. They establish the framework from which everything else follows. If you do them well, the rest of the document should "write itself"; if you do them poorly, the remaining sections will flounder and lack cohesion.

The Introduction

There is only one chance for a first impression. The introduction needs to set a **positive** tone. If visitor-ship is high, consider referring to caving or mine exploration as a value to express your understanding of the vis itors' perspective. You may want to highlight the need to preserve a quality caving experience consistent with the protection of other resource values. Describe the unique character and history of the area and the general issues and concerns raised in sc oping. Refer to the importance of public input, flexibility of the final document to respond to changing conditions, use patterns, and statues or regulations.

Purpose and Need

This is the **sale pitch**. This section highlights management concerns; legislat ive and regulatory mandates; changes in resource conditions, visitation, administration, facilities, and public opinion that compel a management response; it answers why any management action is needed at all. It makes the case for an immediate action rat her than postponement. This section responds to and focuses on the changing conditions that may threaten values, not to be confused with goals and objectives. You should be able to compare this section to the actions implemented and understand why these actions were chosen over others. If you cannot clearly see the connection between the purpose and need to the implemented actions, perhaps your actions: (1) do not adequately meet the purpose and need; or (2) your purpose and need was not clearly explaine d. This section of a plan justifies what you want to do and why you must do it instead of another action.

Goals and Objectives

Goals are the over-arching **philosophies and grand schemes**. The typical primary goal of the management plan is to preserve and p rotect natural and cultural resources. A secondary goal should probably be to build a foundation of data as a basis of decision making. Additional goals may include providing for diverse recreational experiences, preserving caving/mining traditions, or e stablishing cooperative stewardship.

Objectives are the **steps that one can measure to see if you are achieving your goals**. Your first objective may be to clarify management concerns, needs and priorities. The next objective may be to analyze and describ e requirements for gating an opening. Objectives should provide a clear decision making frame work and action timetable. Objectives can outline the process to initiate or continue the planning process (i.e. Limits of Acceptable Change) or identify how and what resources will be monitored to assure

the goal of protecting the natural and cultural resources. It is important to be as explicit as possible with goals and objectives. These are the metrics others will use to measure the success of the plan.

The Meat of the Document: Everything else that remains

What parts you include in your management plan depend upon the specifics of your site. Another section in this manual covers a needs assessment for cave/mine protection to help you identify what topics mi ght be related to your particular project. Remember to include any mandates that relate to your cave or mine, these help define the scope of your project.

Unlike other resource issues, where resource protection issues often arise from surges in use (e.g. climbing), caves and mines are a unique and delicate ecosystem that can be impacted with low levels of use. Caving issues can be – lint, change in dust patterns due to hiking, tread of trails, vandalism, sensitive species (e.g. invertebrates, endemics, bats), water quality, air flow, smoke, human waste and garbage. You must carefully consider which issues relate to your cave/mine. Often this requires talking to a variety of specialists to make sure that something is not missed. Of course, you could ha ve a very simple, singular issue that does not require much outside consultation. Each cave/mine is unique. Which resources issues to be included in your specific plan cannot be addressed here, for this is beyond the scope of this technical manual. I hi ghly encourage you to seek the advice of local experts to assure that no pertinent issue related to your cave/mine is overlooked.

If your area has visitation, fully consider the implications that visitors have on your resources. Are there a maximum numbe r of people that the cave/mine can accommodate, at a single time or over the annual cycle? Does this maximum number allow for the desired condition of the cave/mine, or will it need to be reduced to provide necessary protection. I recommend implementing a "Limits of Acceptable Change" method for assessing and mitigating user impacts. LAC allows for explicit, tangible measurements, for example, amount of lint in a given area, the quality of trail tread, or the number of bats occupying the cave/mine at a given time. When you have concrete data to measure, the task of determining success when the plan is implement becomes much easier.

Guidelines for Preparing a Cave or Mine Management Plan

This section outlines a procedure for developing a cave management plan. Federal agencies first need to determine if NEPA is applicable to their action. In most cases, if not all, it is. NEPA is covered in another section of this manual and will not be discussed fully here. Preparing a cave or mine management plan ca n be broken down into 6 basic steps.

Initial Considerations

There are topics that need to be considered before the process of writing a cave or mine management plan begins. First, are there any special interest groups who might be interested in this project? Groups might include caving grottos, Federal and State agencies, Native American tribes, historical societies, special field units. Recognizing

that other might want to be involved (or may demand to be involved) in the planning process is something to consider from the beginning. Next, reflect on the current situation and what the future conditions might be. What are the mandates of your agency or the mission statement of your organization? They will have a direct bearing on this management plan. How much support do you have from the chain of command? Without "buy-in" from the management team, it will be difficult to present a plan to the public or other interested parties. How big is the cave or mine and how important of a resource it is? How does the cave/mine compare to other landuses and habitats in your unit? It is important to look at the issue from a board perspective now, for once the process begins it is easy to become myopic. Consider how you want to present the management plan. Some plans are difficult to read and understand although they shouldn't be. If you have a large public interest in this cave/mine, you might want to consider writing the document and a short briefing paper in lay-terminology. Finally, allow for plenty of time to compile the information, talk to interested parties, and prepare the management recommendations. It will take longer than anticipated.

Scoping

Once you have: (1) looked at the cave/mine issue from the broad perspective; (2) identified who you think will be interested in the project; and (3) a general direction for writing the plan, now is the time to begin to gather information and establish connections to interested parties. The first objective is to compile the background information on the cave/mine and the surrounding land. Be sure to include natural and cultural resource issues for the cave/mine in this initial task. Gather the legislative authorities, agency policies, and general guidelines for resource and recreation management related to this cave/mine. Begin a list of potential management issues related to your specific situation. With these basic background information elements in hand, it will be time to begin the scoping process. There are several elements to this process.

The first element in scoping is focusing on internal scoping. Talk to the people who directly manage the cave/mine to gather their ideas on what issues need to be addressed in the plan and which can probably be dropped from consideration. Next, if your agency has specialist in this field working at other units, contact them for additional perspectives. Contact other agencies or specialists outside your agency for their input and insight. With these addition points of information, expand the list of potential management issues begun in the initial phase.

If you work for a government agency, public scoping and outreach will be the next step. This is generally met by holding a series of public meetings. Interested agencies (State wildlife, USFWS, AML, etc.) should be contacted. For any cave on Federal lands, do not forget to contact and involve Native American tribes that used or have spiritual connections to the cave. An information packet is prepared on the history of the topic and the request for public input on issues to be addressed. These should be mailed to known interested parties (NSS, ACCA, local grottos, etc). Additionally, information should be provided at all visitor contact areas, the unit's webpage, and will hopefully be covered by local and regional media. Send out press releases and post in the Federal Register (if applicable) that public scoping meetings will be held and public comments

are desired. Public comments can be sent in writing or can be expressed at the public meetings. Scoping encourages public involvement and investment and helps define values, goals and strategies. **Public outreach is vital** for laying the groundwork for good relationships.

Scoping concludes with a summary of scoping results: (1) which issues were identified; (2) what areas need more research; and (3) what topics need further response. It is important for this document to summarize the management mandates of this cave/mine and whether the scoping comments are consistent with these mandates. If comments were not consistent with mandates, they can be dismissed from further consideration, but this should be documented and explained. This document should provide objective rational for decision making and should include reference to available data regarding resource conditions, visitor preferences, caving activities, and history. This will serve as the platform from which the management plan is written. Scoping identifies which issues need to be address and thus should be completed before the goals and objectives of the plan are determined and described.

Prepare the Draft Plan

The draft plan will include elements identified in the preceding section, Suggested Contents of a Cave or Mine Management Plan. The first three sections, the introduction, the purpose and need, and goals and objectives introduce the document and set the tone. It is important to get good reception from the beginning. It is vital to share portions of the document with interested groups to serve as a sounding board to make sure your intent is understood. All of the issues presented during scoping need to be identified or if they are no longer being considered, there should be a short explanation of that fact. Maps of the unit and where it is in relation to the larger landscape may be helpful to include. If the caves are on Federal lands, the Federal Cave Resources Protection Act of 1988, excludes cave maps from information that can be requested under the Freedom of Information Act (as amended in 1996). If your cave resources are not well known, do not include maps of cave locations or resources. However, if your caves are well known (or some of them are well known) including a map of well-known cave may help facilitate the public's understanding of your plan.

This is where the document can be come long and unruly or crisp and concise. Include all vital information, but weed out the minutia. The management plan is only valuable if it is used often and is easily accessible. Clear writing and topic heading are imperative. Don't sacrifice quality to maintain a timeline. Typically, the more effort placed in a draft plan, the fewer revisions and better received the final document will be.

Review and Revision of the Draft Plan

During the preparation of the draft, your agency and identified specialist should include an internal review of the draft plan. This internal review should be with a keen eye towards meeting legal requirements as well as basic grammar and flow of the document. NEPA requires a public review period if the management plan (or your agency) falls under its jurisdiction. However, I highly recommend a public review even if you don't fall under the jurisdiction of NEPA. Having the public review the plan strengthens the

document and improves public relations. Post the draft plan on the agency webpage and distribute it to interested parties. Send out press releases and post in the Federal Register (if applicable) that a draft management plan is available and public comments are desired. Set a minimum 60-day period for comments; show good faith that you truly want public involvement. If the management plan has a significant recreational use component, national and local grottos may be able to assist by promoting notice of the plan. Indicate how the public comments can be accepted: letter, email, and/or phone.

Revisions to the draft will incorporate feedback from the public and other resource management agencies during the review period. The resulting document will be the completed plan. On occasion, there may be the need for multiple drafts and multiple reviews before a final plan is accepted.

Implement the Plan

The plan only works if appropriate people, time, and money have been allocated for implementing the plan. It is important to ensure administrative resources have been provided, which is why having buy-in from upper management is a key point in the initial considerations. It is often best to have a single person designated as the contact person. It is imperative to monitor progress of implemented actions and of changes in use and the conditions of the resources. Is the management plan working? Are the goals and objectives being met? Are the cave or mine and the resources therein in better, the same, or worse condition? It is important to clearly define measurable features to show success or failure. When implementing the plan, it is imperative that these key features are measured and recorded over the long-term. You should be able to document resource improvement or at least resource stability when compared to the existing resource conditions prior to management actions.

Review the Plan

Review the management plan for its success and shortcomings. In the plan, clearly identify how the future review process and procedure will work. For example, I recommend annual internal review. Does the plan still meet the management goals? Are the management goals in line with current agency/organization mission statements and policies? Try to incorporate minor changes in protocols, as the needs become known. You will need to identify larger review process that includes your stakeholder. I recommend these larger reviews typically every 4 to 5 years. This may need to be more frequent if key factors change dramatically. I recommend stating in your plan that if there are large changes (e.g. a species that occupies the cave becomes listed); the review process would take place that year. On the other hand, you could approach review from a more "relaxed state;" internal reviews every 4-5 years and larger review only if major changes in management actions are needed. You need to decide what fits your situation best, but you must identify what the review process will be for two reasons. First, you will not be in this same job forever and you need to leave instructions (or at least guidance) to your replacement. Second, you need to keep interested parties informed and this will improve future working relations. If you have a very vocal constituent group, you may want to consider formalizing the relationship by developing a Memorandum of Understanding (MOU). The MOU defines the common interests the parties share and

defines the way they will work together to reach common goals. These documents should be brief (< 5 pages) and can cover a range of objectives from very broad partnerships and stewardships to very specific applications such a long-term monitoring.

Closing Thoughts

Hopefully, this section provided guidance on how to develop a cave or mine management plan. A management plan provides the means of sharing thoughts, logic process, and the making of decisions. While this was a brief overview of the items to include in a plan and a sketch of how the process can work, my goal was to give you something from which to work, to provide a good foundation from which to build your individual plan. A management plan can be a single page if all you are managing is an abandoned mine known to be bat habitat that needs a gate. A management plan can be a multi-page document that discusses a variety of resources (cultural and natural) and the nuances of visitors use patterns culminating in a delicate balancing act of conflicting agency mandates. Only you, and others closely tied to your specific site, can decide which is most like your situation. But no matter how simple or how difficult your management maybe, having a plan that outlines the "whats" and the "whys" will only help those that following in your place.

This section was written as if a management plan was being written for a single cave or mine. If you are in a situation of managing hundreds or thousands of mines (or ten's of caves), do not hesitate to write a single plan that addresses all features. The management plan can address the basic philosophy behind the management and can establish ranking criteria or requirements of a feature to bump it into a management scenario. For example, your plan could state, "Mines within 1 mile of a developed visitor zone will be assess for biological value. If the bio-assessment indicates low or no value, the mine will be closed for safety concerns, otherwise it will be gated to allow continued biological value." If you have a mine that is more than 1 mile from a developed zone, it would not be "managed." For caves/mines for which you have extensive knowledge, I recommend writing an individual chapter on how this feature may be managed. Quite often, the areas that we have the most knowledge have different management scenarios than ones of which we have little knowledge. Management plans are not to prevent you from doing conservation, but rather to justify and document what conservation efforts you are doing.

It may appear that the chapter is too heavily steeped in NEPA. For this I cannot apologize, but only encourage you to use NEPA. NEPA is not a stumbling block to the process of completing a plan, but rather it is the process. If the plan is based on legislative and executive mandates and was formed using the NEPA process, it is bound to succeed. Those plans that ignore their agency's authorities and policies and shun public involvement are almost certainly doomed to fail. While getting public involvement initially is difficult and time consuming, the final product is worth the additional effort. Only in the simplest of cave/mine with limited human access should be managed without a plan, for all others plans are important for documenting the past and looking forward into the future.

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Many of the ideas presented in this paper were inspired by Climbing Management: A guide to climbing issues and the production of a c limbing management plan, edited by Kath Pyke and published by The Access Fund (2001).

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BAT GATES AND NEPA COMPLIANCE

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Abstract

Bat gate projects that involve Federal fu nding, Federal lands, or that require an authorization from a Federal agency may be subject to the impact assessment and public participation requirements of The National Environmental Policy Act (NEPA). The purpose of the NEPA is to provide Federal decis ion-makers with information on the potential environmental consequences of a proposed project. NEPA assessments for bat gate projects will vary in size and complexity depending on the environmental resources present at the site, the scope of reclamation activities, the intensity of anticipated impacts, and agency documentation requirements. Project personnel involved in bat gate projects should understand the NEPA requirements that federal agencies must meet and be prepared to assist in information gather ing, document development, and implementation of final decisions. This paper presents a broad overview of the purpose of NEPA evaluations as well as some of the specific requirements that project planners should consider when conducting assessments. Info rmation is presented on the overall NEPA process, types of NEPA documents that may be required for bat gate projects, and the timing of evaluations.

Introduction

When Congress passed the National Environmental Policy Act in 1969, Federal agencies acquired a responsibility to assess the impacts of planned activities on the human environment. Signed into law on New Year's Day 1970, by President Nixon, the National Environmental Policy Act (NEPA) was the culmination of a decade of Congressional discussion s on how to address growing concerns over the quality of the environment. At its most basic element, NEPA requires that Federal agencies must review projects that have Federal participation and prepare a detailed statement on proposed federal actions that have significant impacts on the environment.

The NEPA is a rather short piece of legislation that contains two titles. Title I is the Congressional declaration of national environmental policy and Title II established the Council on Environmental Qualit y (CEQ). Each title is further broken down into sections that provide goals and objectives to Federal agencies, require input from State and local governments and the public, and provide the duties and responsibilities of the CEQ. Now, over 30 years sin ce its inception, formal regulations, agency policies, compliance handbooks, training courses, and other NEPA related tools guide project planners in their efforts to ensure that environmental values are considered in the development and execution of Feder al activities.

NEPA can best be described as a procedural law. The purpose of NEPA is to ensure that Federal decision-makers consider the potential environmental consequences of a planned action along with other goals such as agency objectives, or economic, political, and social benefits. NEPA does not mandate an outcome. Rather, NEPA directs Federal agencies to use a systematic interdisciplinary approach, which ensures the integrated use of natural and social sciences and the design arts, in planning and decision-making that affect the environment.

NEPA requires all Federal agencies to: (1) prepare in-depth studies of the impacts of and alternatives to proposed "major Federal actions;" (2) use the information contained in such studies in deciding whether to proceed with the actions; and (3) diligently attempt to involve the interested and affected public before any decision affecting the environment is made.

NEPA Implementation

Federal agencies must comply with NEPA requirements for a wide range of Federal "actions." Actions may include the award of funds, the issuance of permits, development of policies and plans, promulgation of regulations, and direct Federal construction efforts. Examples of such actions include Corps of Engineers Section 404 permits, Federal construction in National Parks, U. S. Forest Service timber harvest sales, new or revised Federal regulations on grazing, and the reclamation of abandoned mine lands on Federal lands or with Federal funds. The catalyst for NEPA implementation is Federal participation in the form of a decision, funding, or some other action. Not all Federal actions are subject to NEPA. Occasionally, Congress will exempt an action from NEPA requirements, such as when they provided Federal funds to "buy-out" families affected by the underground mine fire at Centralia, Pennsylvania. Agencies may also develop categories of actions that do not require further NEPA compliance. These "categorical exclusions" represent formal declarations by an agency that a particular type of routine activity will not result in significant impacts to the environment. However, many thousands of actions each year undergo evaluations to provide Federal decision-makers with information on the scope of impacts associated with a proposed activity and possible alternative solutions.

NEPA Requirements and Policies

As with most Federal laws, the National Environmental Policy Act is implemented through formal regulations, agency policies, and compliance handbooks. The NEPA regulations were developed by CEQ and are found at 40 CFR Parts 1500-1508 (Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act). The regulations contain the procedures to be followed, identify the types of assessment documents required, and define important terms commonly used in the process. Federal agencies must, at a minimum, comply with the CEQ NEPA regulations when conducting their programs.

To improve NEPA implementation in the field, most agencies have guidelines, handbooks, and policies. Generally, agency guidance implements the CEQ regulations through specific agency processes and example formats for environmental documents. In addition, many agencies have more streamlined processes, such as categorical exclusions that specifically address commonly performed activities. In general, persons preparing NEPA documents should follow the guidance applicable to the Federal "action" agency. For example, persons developing projects that will

address abandoned mine openings using funds from the U.S. Forest Service (USFS) should expect to be required to follow USFS NEPA guidance. Occasionally, more than one Federal agency may be involved in a particular action. In such cases, agencies can cooperate to produce a single environmental document that addresses the NEPA requirements of both agencies.

There are a number of additional resources to assist in preparing NEPA documents. In 1991, CEQ published answers to the forty most asked questions concerning the NEPA regul ations (46 Federal Register 18026, 1981, as modified in 1986). The CEQ "forty questions" Federal Register provides answers to questions like how many alternatives must be considered and to involve the public. The CEQ "forty questions" is an invaluable re source to gain insight into how certain NEPA requirements can be met. In addition, most agencies support Internet sites that provide agency requirements and example documents, as well as provide access to knowledgeable agency staff. Finally, there are a number of training courses available in NEPA compliance. A simple Internet search will yield courses by private consultants and Federal agencies. Project developers should contact the Federal agency that is sponsoring their work to determine if training opportunities are available.

The NEPA Process

People who are only casually familiar with NEPA usually identify the Environmental Impact Statement (EIS) as the vehicle for assessing project effects. While the EIS is the most publicly visible NEPA document, it represents just a very small portion of the NEPA evaluations performed in this country each year. Agencies like the Federal Office of Surface Mining (OSM) may prepare only one EIS each year while conducting hundreds of smaller assessments for t he abandoned mine lands reclamation program. An EIS is the appropriate NEPA document for projects with significant impacts because it provides for in -depth resource evaluation and has a detailed public participation process. An EIS may take one to two ye ars to complete and represents a substantial financial commitment on the part of an agency.

Unless an agency is certain that the proposed action will result in a significant impact(s) or agency guidelines specifically require that an EIS be prepared for the type of action, project impacts are first evaluated through the development of an Environmental Assessment (EA). The EA is a brief, but formal, document that assesses the intensity, context, and duration of impacts that a project may have on a range of environmental resources. The goal of the EA is to determine if significant impacts are expected, thus requiring the preparation of an EIS. Many agencies have a prescribed EA format and process that incorporates the results of consultation with other government agencies and the public. An EA will evaluate impacts to defined resources such as cultural/historic, floodplains, wildlife (including endangered species), air and water quality, and soils or other issues identified through an informal scoping pr ocess. If significant impacts are anticipated and the agency cannot mitigate those impacts to a lower level, then the agency must prepare an EIS. If no significant impacts are predicted, then the agency will prepare a Finding of No Significant Impact (FO NSI). As stated above, the vast majority of agency NEPA responsibilities are satisfied through the preparation of an EA.

Some agencies that routinely perform certain actions that do not result in significant impacts have formally declared those actions to be categorically excluded from further NEPA

considerations. For example, the Office of Surface Mining has a process for determining the types of abandoned mine lands reclamation projects that do not result in significant impacts and therefore, do not require the preparation of an EA. One such project is the placement of a bat gate over an abandoned mine opening when endangered species are not involved. Project planners should review any categorical exclusion that may be applicable before beginning the preparation of an EA. If a categorical exclusion applies to the proposed project, then the project planner should complete the necessary documentation.

The NEPA process does not end with the preparation of an EA or categorical exclusion. The office issuing the FONSI may need to make copies of NEPA documents available to the public for their inspection and, in some cases, Federal agencies may have to allow for a 30-day public comment period before the decision is final. In addition, project managers should conduct monitoring to improve future NEPA assessments and to ensure that the NEPA document continues to accurately describe site activities. CEQ's "forty questions" and agency NEPA manuals will provide the information needed to ensure that the public is adequately involved and that follow-up activities are conducted.

NEPA & Other Environmental Laws

Over the past 30 years, Federal, State, and local governments have put into place a full range of laws addressing environmental resources. While some of the most notable are those addressing air quality, endangered species, water quality and wetland protection, there are numerous environmental and resource related laws that operate on the local, State, and national level. Project managers developing projects with bat gates need to become familiar with the regulations and policies of a number of different agencies and political subdivisions. It is important to remember that the requirements of these environmental laws must be addressed regardless of whether a project is government sponsored and subject to NEPA. In general, each environmental law has separate implementation and/or compliance requirements that must be addressed by project managers.

Some Federal agencies approach the NEPA assessment process with the view that it is an "umbrella" review that assists in compliance other environmental laws. Under this approach, project planners concurrently assess impacts, develop mitigation plans, coordinate with affected agencies and the public, and begin any permitting activities. The outcome of this approach is a NEPA document that meets the needs of the agency and insures that all applicable environmental laws have been met.

As a final note, routine consultation with other agencies, environmental interests, and the public vastly improve the quality NEPA assessment document. Many times, issues raised by persons critical of a proposed project are resolved by providing a clear understanding of the agency mission and how the requirements of other environmental laws are being addressed.

Bat Gate Projects & NEPA Compliance

In general, where Federal funding or a Federal approval is involved in a bat gate project, project planners are required to assess the environmental impacts associated with the activity. Federal

funding may be in the form of a direct contract, cooperative agreement, or may pass through State programs in the form of grants. Examples of such funding include projects that rely on Federal Office of Surface Mining (OSM) funds t o the States to mitigate hazardous abandoned mine openings, and direct contracts between Federal agencies and the private organizations that will actually install a bat gate. In addition, even when private funds are used to install gates, NEPA compliance may be required. This usually occurs when gating actions take place on Federal lands and require the approval of agencies like the Bureau of Land Management (BLM), U.S. Forest Service (USFS), or National Park Service (NPS).

A major step in developing a n EA that deals with a project on public lands is writing the Proposed Action. The Proposed Action should succinctly describe all work that is anticipated including access routes and improvements, material and equipment needs, revegetation plans and any proposed mitigation.

Bat gate projects will likely include a range of related activities such as developing access to the project area and reclamation of adjoining abandoned mine areas. As a consequence, the Federal agency providing funding or otherwise authorizing the project must have a clear Proposed Action so that they can understand the scope of anticipated impacts for all of the associated activities. Once the Proposed Action has been tentatively developed, project planners should find agency NEPA manuals and sample document formats a valuable tool for organizing the assessment of the environmental resources found at or near the gating project site. In addition, a site visit with field representatives from other Federal, State, and local agencies will provide insight into the kinds of impacts or problems that should be addressed in the NEPA document. Project planners should pay particular attention to those agencies that have a regulatory or permitting role, as well as those agencies that possess specific knowledge of a resource or the project area. Information gained should be used to finalize the Proposed Action. Finally, project planners should meet with adjacent property owners and notify the public as soon as possible. The primary goal of t hese preliminary meetings is to identify issues that may arise as a result of the project. These issues may be internal to a Federal agency and/or concerns of the public.

Project planners should next determine the type of NEPA assessment document that w ill be most likely required for the gating project. If the gating activity is just one part of a larger project requiring an EIS, the planners may find that much of the information on resources and impacts is already being gathered and little additional a ssessment is required. If the project is more limited in scope and the assessment has not been initiated, project planners should work with the responsible Federal agency to determine whether the project can proceed under an existing categorical exclusion or if an EA is to be developed. If is appears that a categorical exclusion applies to the project, the planners should collect the necessary information and work with the federal agency to properly document exclusion eligibility.

Developing An Environmental Assessment

Gating projects will most likely meet NEPA responsibilities through the development of an environmental assessment (EA). As discussed above, the EA is a brief, but formal, document that assesses the intensity, context, and duration of i mpacts that a project may have on a range of environmental resources. As previously stated, the goal of the EA is to determine if significant

impacts are anticipated. In general, this means that project planners must be prepared to evaluate project impacts on water resources, air quality, cultural/historic resources, wetlands and floodplains, wildlife (including endangered species), agriculture, recreation, and any socio-economic or other issues that may be raised. Certain anticipated impacts may be mitigated in the Proposed Action. An anticipated impact to nesting birds for example, may be eliminated by adjusting the timing of the project to occur after the young have fledged. An impact to a cultural resource could be mitigated through avoidance, change of the proposed design, or may involve an agreement to perform additional inventory and documentation prior to conducting the proposed action.

In addition, planners need to assess the overall cumulative impacts of the project and the more recent environmental justice requirements. Assessing the cumulative impacts of a project has been the source of much discussion over the years. The sponsoring Federal agency will have guidelines for determining the scope of the review and other kinds of activities that must be considered. Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," was issued in February 1994. The order provides that "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." Executive Order provisions apply fully to Native American programs. Because many agencies have developed specific guidelines for meeting the Executive Order, project planners should work with the agency sponsoring the gating project to determine the scope of the analysis.

In general, an EA for a gating project will include the following:

- brief project summary of the project,
- statement of the need for the project,
- description of the area surrounding the project site,
- description of the proposed action, including any planned mitigation,
- description of additional alternatives to the proposed action,
- descriptions of resources values found in the project area,
- assessments of the effect of the proposed action on specific environmental resources,
- assessments of the effect that each alternatives might have on specific environmental resources,
- results of agency consultations and public involvement,
- administrative information on assessment preparation and preparers.

Project planners should keep records of all meetings with citizens and agency representatives. In addition, photographs and drawings will help record the condition of the area at the time of site review. Once the information is collected on the project area, environmental resources, potential impacts and issues, preparation of the EA can begin. At a minimum, the EA will inform the reader about the impacts that will occur under the preferred plan of action as well as those associated with taking no action. An assessment of the "No Action" alternative is specifically required by regulation. The EA should also discuss the potential impacts of any other alternative actions that were actually under consideration.

For example, an EA for a gating project would evaluate the activities of creating site access, disturbances that would occur during construction of the gate, and any conditions that would remain after construction is complete. The EA should discuss the impacts of these activities on environmental resources (air quality, noise, water quality, wildli fe, endangered species and others), and then provide a conclusion on overall impact intensity, context and duration. The EA should then present a similar evaluation relative to taking no action. Under the "No Action" alternative, construction related imp acts would not occur to bat populations or other site environmental resources, however, bats may continue to be affected by people exploring the abandoned mine. Any abandoned mine related dangers to the public will also persist at the site under the No Action alternative. Finally, if other alternatives were being considered, the EA would address the anticipated impacts of each.

The impact assessments in the EA should include any mitigation (efforts taken to reduce impacts). For example, assessments of impacts on water quality should consider the effects of site drainage control. In addition, if the local wildlife agency has identified possible impacts on nesting birds of prey if the gating project occurs within a specific season, the preferred alternative should reflect any changes in scheduling designed to eliminate the conflict. The EA should also note any permits that will be obtained and conditions they will impose. Once complete, the EA should provide the reader with an accurate description of t he Proposed Action, a description of the existing environmental conditions at the site and an understanding of the impacts anticipated as a result of proceeding with the gating project relative to taking no action at all.

Consultation

Consultation is one of the most powerful information collection and evaluation tools available to project planners. Information on site resources and areas of sensitivity in the community can be obtained from the agencies and citizens that have regulatory controls or know ledge about the site. Most agencies that sponsor a gating project will have established contacts in other government agencies as well as guidelines on public participation. Basic consultation consists of contacting specific persons (agency representative s, environmental groups, citizens, and educational facilities) in writing to determine any interest in or concerns about the project. Consultation with the US Fish and Wildlife Service and the State Historic Preservation Officer, at a minimum, is required to comply with the Endangered Species Act and the National Historic Preservation Act. Consultation with adjacent landowners and the local community, and other persons will likely reveal issues as well as their solutions. By identifying both concerns and their solution in the final document, the EA can serve as a record of how potential problems were addressed as part of the project development process. Agency representatives and citizens that provide assistance and information can be recorded in the adm inistrative information section of the EA.

Native American Consultation

The project planners need to assure that tribal governments, Native American communities, and individuals whose interests might be affected by the project have a real opportunity to fully participate in the decision making process. According to the 1992 Amendments to the National

Historic Preservation Act (NHPA), if a property of traditional religious and cultural importance to an Indian tribe is determined to be eligible for inclusion on the National Register; Federal agencies must under section 106 of the NHPA, consult with any Indian tribe that attaches religious and cultural significance to properties affected by the proposed project. Generally it is the public land managing agency such as the BLM or USFS that conducts this consultation process and then provides information to the project planners for inclusion in the environmental document, even if that agency is not writing the environmental document. This consultation usually involves sending a letter, requesting permission to attend a tribal council meeting, or using other contacts to explain the nature of the proposed project and solicit input. Traditional Native Americans may attach religious and cultural values to lands and resources on a very broad scale, such as recognizing a mountain or a view-shed as a sacred landscape. These concerns may be specific to the discrete location of the proposed project area; such as whether project activities may limit access to ceremonial places, or limit tribal members' ability to gather plants used for ceremonial purposes. Because many Native American issues and concern may be based on intangible values, or "sacredness," mitigation isn't always a feasible option in the same way that mitigation can be developed for impacts on other resource values. If necessary, the NHPA provides for formal agreements that outline the stipulations under which the project can proceed.

Timing of NEPA Activities

The timing of NEPA evaluations and the development of the NEPA document will vary according to the type of project. Evaluations for simple projects with few impacts and little or no controversy can be completed quickly. Projects that cover a large area or have complicated resource impact issues may require more development time to adequately resolve issues identified by citizens or other government agencies. It is important to start the evaluation and consultation process as soon as possible to ensure that the final NEPA document is completed in a timely manner. It is important to note here that applicability of any categorical exclusion should be determined early in the process to ensure that adequate time remains to develop an EA should it become necessary.

Perhaps the most important timing consideration is the completion of the final NEPA assessment document (categorical exclusion or EA). The document must be completed to allow time for the Federal agency to adequately assess the potential impacts as part of the decision making process. In all cases, the document must be completed prior to the Federal action (initiation of site construction, award of funds, issuance of permit). The document must be presented to the Federal action agency before there has been any irretrievable commitment of resources to ensure that there is an opportunity to make changes or additions to the document or to select a different plan of action. In most cases, this will mean completing the document before a final design or selection of a construction contractor.

Finally, Federal agencies must make a formal decision on the NEPA assessment document. The final decision will be in the form of a determination, a finding of no significant impact (FONSI), or a record of decision (ROD) (for categorical exclusions, environmental assessments, or environmental impact statements, respectively). In addition, Federal agencies may have to allow time for a public comment period, which can delay the final decision. In order to ensure that the

Federal agency has ample time for internal review and to finalize the NEPA process, project managers should work closely with agency representatives.

Important Points

Describing Impacts: Project planners will greatly improve the quality of the message to the federal decision maker if they use a consistent approach to describing impacts. An accepted method of discussing project effects on individual resources is to describe the positive and negative effects of the project, planned mitigation efforts, and conclude with a statem ent of the overall impact intensity, context, and duration. Some examples are:

- Intensity: negligible, minor, moderate. Major or significant impacts would require the development of an EIS.
- Context: site specific, community, local area, region, statewide , national.
- Duration: life of project, short-term, long-term.

Generally, project impacts in an EA are best described as negligible, minor, and moderate. Assessments that discover major, or significant, impacts will require the preparation of an EIS.

Consult with Experts & Public : Project planners involved in a bat gate project will likely have all the expertise needed to accurately describe impacts to bat habitat and populations. It is important that similar expertise be enlisted when describing the i mpacts of the proposed project on other environmental resources. If you invite the participation of people who are most interested in or most critical of the project, you will most likely improve the project design.

Describe Mitigation Plans : The NEPA document should include descriptions of any mitigation plans developed to address impacts to specific resources. The descriptions help the decision maker, consulting agencies, and interested citizens understand how identified issues have been addressed.

Permits & Authorizations : Depending on the type and location of a gating project, formal permits or other government authorizations may be required. Permits may be required for site access, drainage controls, or to authorize placement of the gate. While there is no NEPA requirement that the permits be formally obtained prior to the completion of environmental document, it is important that the document identify and discuss all permits that will be required. The document should also assess the effec ts that the permits on site resources.

Agency Resources: Project planners will find that a wide range of resources is available to assist them NEPA document development. First, copies of the NEPA manuals, NEPA guidance documents, and copies of any consultation agreements should be obtained from the agency sponsoring the gating project. In addition, the Internet site of the sponsoring agency may be able to provide electronic copies of the necessary forms. Finally, planners should request copies of previous environmental documents from the sponsoring federal agency to gain insight into preferred formats and how specific issues have been handled in the past.

Conclusion

Project planners developing bat gate projects using Federal funding or on Feder al lands where a Federal approval is involved should be prepared to participate in the NEPA compliance process. Participation may simply involve providing site related construction and environmental resource impact information to a Federal agency represen tative or it may require the development of the complete NEPA assessment document. By working closely with the Federal agency that sponsors or otherwise approves the project, planners can take advantage of established agency NEPA resources and ensure that the assessment documents are timely, accurate and acceptable to involved Federal agencies.

Project planners developing NEPA documents are encouraged to use a multidisciplinary approach to resource impact assessment. Planners should invite comments from government agencies and citizens who have an interest in the project area and gating activities, and they should solicit ideas for resolving any conflicts. Involvement of outside interests will improve the quality of the assessment and will facilitate com pliance with other environmental requirements. Finally, project planners are encouraged to use the NEPA assessment document as a record of the evaluation process. Information collected during site evaluations, as well as meetings with interested persons should be placed in the document and/or support file to serve as a record of the assessment and how identified issues were addressed. A complete and concise environmental assessment document will improve the quality of bat gate project and will provide the Federal decision maker with all the information needed to complete agency NEPA responsibilities.

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FUNDING A BAT GATE PROJECT: AN OVERVIEW OF PUBLIC AND PRIVATE SECTOR FINANCIAL RESOURCES FOR THE ENVIRONMENTAL PROFESSIONAL

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Abstract

Bat populations continue to decline from such key factors as habitat loss, environmental pollution and toxins, and agitation at key roost sites. Representing the most compromised of North America's terrestrial mammals, bats and the distinctive habitats which they depend upon, are subject to increasing levels of human disturbance. Caves and abandoned mines crucial to all aspects of chiropteran biology often require the construction of bat friendly gates to exclude vandals and trespassers. Obtaining the financial resources required to properly construct bat gates often involves coordination between individuals, foundations, corporations, and government agencies. Cultivating potential project funders can be an ongoing, time consuming process, but essential in today's budget conscious work atmosphere. Natural resource managers must remember that the amount of funds available from any one source will be limited, although the process of obtaining funding can be quicker and less bureaucratic than dealing with a public agency. There are many resources available that list potential funders and/or describe how to cultivate funders and develop effective proposals. An overview of these resources should allow the environmental professional to develop a financial strategy unique to their bat gate and/or mine stabilization initiative.

Principles & Methodology

In order to adequately protect natural resources and secure funding sources for such initiatives, resource managers must operate within the following framework:

- **$** Develop a protection strategy for the resource of concern (i.e. property acquisition, easement establishment, management)
- **$** Collect, organize, & comprehend all information necessary to understand the project and its players.
- **$** Understand the negotiation process and feel comfortable working within it - people skills.
- **$** Know when to seek assistance & how to effectively deploy others - you can't do it alone!

Establishing a Framework for Protecting Bat Habitat

Framework Approach

Answers to certain fundamental questions provide the framework for your initial approach to protecting bat habitat:

- **$** Is the resource available for sale? (private vs. public ownership)

- $ Are landowners willing to have their resource protect ed? (i.e. will a cave gate that restricts access be tolerated)
- $ What will it cost?
- $ Where will the money come from?
- $ Time-frame: how long do you have to negotiate a deal - how much longer can the resource last without protection?

Basic Protection Methods

- $ Own & manage the resource (outright fee simple acquisition)
- $ Own but others manage (develop appropriate management agreement)
- $ Resell to third party (acquire and resell to third party owner/manager)
- $ Limited development (development without sacrificing protection goal)
- $ Acquire partial interest (landowner retains certain rights)
- $ Conservation easement
- $ Use rights interest (mineral rights, rights conveyed through easements)
- $ Deferred interest (landowner sells/donates resource, but retains the right to live on the parcel in question)

Establishing Goals for Protection of Bat Habitat

The landowner component: ACornerstone@ of Success!

In the early stages of any conservation/protection project, it is crucial to find out everything you can about the landowner=s goals and constraints. This information will help guide you towards appropriate funding sources and determine the best way to pursue a positive working relationship. You must find a way to satisfy the landowner while achieving your protection goals.

Motivations Common to Most Landowners

- $ Economic return (cash, tax benefits, enhanced value on adjacent land)
- $ Timing (timing of payment may be as important as the amount -immediate cash)
- $ Flexibility & creativity (meet the landowner=s special needs while achieving your own conservation goal)

Community Support

Community support is essential for the success of your project. Be cognizant of community reaction to a specific project, this will help you to:

- $ Identify the best, most practical long-term protection strategy
- $ Identify sources of help and opposition (funding opportunities)
- $ Determine how to bring community elements together to promote the project
- $ Always be Aup-front@ and honest with landowners during the negotiation process
- $ Identify ways to use your project to strengthen your own program/agency - Apromote the positives@ to generate future opportunities (i.e. new project leads, new contacts, favorable publicity about bats and bat conservation)

Budget Development

In order to analyze the financial impact of your bat gate con servation project, examine the following factors:

- $ How much cash will be invested in the project? (i.e. consider adding a contingency factor of 10-20% to allow for cost overruns)
- $ Where will the money come from? What proportion originates from your own agency=s budget?
- $ What are the timing requirements of cash outlays - will there be major cash flow imbalances?
- $ Can payments be structured over a long period - can payments be refunded if necessary?
- $ What alternatives exist to making significant cash outlays?
- $ If things go wrong (worst case scenario); what is the maximum cash liability?

Establish Partnerships

Although it may seem commonplace to the environmental professional, it is essential to make the landowner your partner in the project. Demonstrate that you are there to help and that you seek mutually advantageous goals - regardless of whether your approach focuses on financial considerations or bat conservation goals.

Accept the Risks

Risk is integral to the business of conservation. In order to achieve your goals, be willing to put your resources and reputation Aon the line.@ Risks can be managed - the more you can accept risk, the more you will achieve for bat conservation.

General Principles of Negotiation - Negotiating Tips

- $ Assume everything is negotiable
- $ Be patient & persistent - take the time to Athink about it@
- $ Maintain your bargaining power - conceal your Alust@ for obtaining permission to construct a bat gate
- $ Ask for a gift - if you don=t ask, you aren=t likely to get one
- $ Know when to say Ano@ - always know your limits
- $ Speak in terms of Ahypotheticals@ - use such discussions to narrow down options (i.e. use phrases such as Awhat if@ and Aif we could@)
- $ Protect your interest - don=t be afraid to be Atough@
- $ Maintain flexibility - avoid ultimatums, if possible

Sources of Funding Your Bat Gate Project - an Overview

A corporation, foundation, Federal agency, State agency, local community group, and/or individual may be willing to provide partial or full funding for your bat conservation project - don=t rule anyone out!

To determine the best funding prospects, answer the following:

- $ Which foundations give to organizations or projects similar to yours?
- $ Which foundations cater to smaller, grassroots groups?
- $ What size are the grants - how much money is available ?

Resources & recommendations for wildlife and habitat funding - please contact:
The Foundation Center at 79 Fifth Avenue, New York, NY 10003 -3076 (Phone: 1-800-424-9836).
The Foundation Center publishes: *National Guide for Environmental Protection and Animal Welfare* & *The Grant Guide for Environmental Protection and Animal Welfare.*

Listing of useful text resources (Proposal Writing):

- $ Greening the Grassroots: The Wildlife Network, 401 San Miguel Way, Sacramento, California 95819. Phone: 916-457-0422 (published in 1996)
- $ Guide to Proposal Writing: Jane Greever & Patricia McNeill, The Foundation Center, 79 Fifth Avenue, New York, NY 10003-3076 (published in 1993)
- $ Winning Grants Step by Step: Mim Carlson, The Support Centers of America; Jo ssey Bass, Inc., 350 Sansome St., San Francisco, CA 94104. Phone: 800-605-2665 (published in 1995)
- $ Getting Funded, A Complete Guide to Proposal Writing: Mary S. Hall, Continuing Education Publications, Portland, Oregon. Phone: 800-547-8887 at Portland State University (published in 1988)
- $ Program Planning and Proposal Writing: Norton J. Kiritz, Grantsmanship Center, 1031 South Grand Avenue, Los Angeles, CA 90015 (published in 1980)

Listing of useful text resources (Fundraising):

- $ Environmental Grantmaking Foundations: Environmental Data Research Institute, 1655 Elmwood Avenue, Suite 255, Rochester, NY 14620-3426 (published in 1994; an alphabetical guide listing foundations with environmental interests)
- $ Fundraising for Social Change: Kim Klein, Chardon Press, PO Box 11607, Berkeley, CA 94701. Phone: 510-704-8714 (published in 1988)
- $ The Grass Roots Fundraising Book - How to Raise Money in Your Community: Joan Flanagan, Contemporary Books, Dept. SF, Two Prudential Plaza, Chicago, IL 60601 (published in 1992)
- $ Discover Total Resources - A Guide to Nonprofits: Mellon Bank, Community Affairs Center - Rm. 1830, One Mellon Bank Center, Pittsburgh PA 15258
- $ How to Shake Up the Money Tree - Creating Fund-Raising for Today=s Non-Profit Organizations: Thomas G. Dunn, Penguin Books (published in 1988)

Listing of useful Internet Resources:
The Foundation Center: http://fdncenter.org
National Wildlife Federation: http://www.nwf.org
Bat gate site: http://www.batgate.com
Environmental Conservation Hotlinks (Information Center for the Environment):
http://ice.ucdavis.edu/echo/governmental_agencies.html

Border Ecoweb: http://www.borderecoweb.sdsu.edu/Organi/usschool.html
Foundations with Specific Priorities (RESIST): http://www.resistinc.org/resources/ff_sect03.html Private U.S. Foundations: http://www.internet-prospector.org/found-us.html
International Grants & Funders: http://www.fundsnetservices.com/internat.htm
Foundation Online: http://www.fundsnetservices.com/foundb.htm
Grants for Environmental Projects: http://www.cyber-sierra.com/area9/envgrant.html
World Environmental Organization: http://www.world.org
Private Funding Foundations: http://www.mde.state.md.us/wetlands/f-form_1.html
The Progressive Directory: http://www.igc.org/
Meta-Index for Non-Profit Organizations: http://www.duke.edu/~ptav
National Center for Nonprofit Boards: gopher://gopher.igc.apc.org:7002/11/
Conservation Assistance Tools: http://www.sonoran.org
NOAA Restoration Center Funding: http://www.nmfs.noaa.gov/habitat/restoration/funding.html
Wildlife Forever: http://www.wildlifeforever.org
The Pew Charitable Trusts: http://www.pewtrusts.com
The Joyce Foundation: http://www.joycefdn.org
W.K. Kellogg Foundation: http://www.wkkf.org
Surdna: http://www.surdna.org
Charles Stewart Mott Foundation: http://www.mott.org
W. Alton Jones Foundation: http://www.wajones.org
Barbara Delano Foundation, Inc: http://www.bdfoundation.org
Turner Foundation: http://www.turnerfoundation.org/turner
U.S. Fish & Wild life Foundation: http://www.nfwf.org
Phillips Petroleum Company: http://www.phillips66.com
The Wilderness Society: http://www.wilderness.org

Conclusion

Project implementation, closing, celebrating & follow-up. The project design is fi nalized and all parties are in agreement. You are confident that funding is secured, so what =s next:

- $ Complete project and be sure to Afollow-up@
- $ As the project manager, you must: AFollow through with the follow up @
- $ Thank those who have helped - Recognize those who have helped and they will be more willing to help in the future
- $ Obtain media coverage, if possible - plan publicity in advance
- $ Celebrate - you=ve earned it! Showcase those who made the project happen. An opportunity to give credit Apublicly@ to the key players
- $ Evaluate - Critique your approach and consider what to do differently; compare original project budget to actual expenditures; determine ways to increase efficiency

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- $ The Wildlife Network & Earth Island Institute
- $ The Foundation Center, and
- $ Wildlife Forever.

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CAVE GATING PARTNERSHIPS:
SUCCESS THROUGH CAREFUL PLANNING AND COORDINATION

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Abstract

Prior planning prevents poor performance. This lesson certainly applies when faced with assembling diverse partners to plan, design, build, and monitor gates to protect bat roosts in caves and mines. The management challenge can be huge, but so can be the success story. At Hubbards Cave, located in the Cumberland Mountains of central Tennessee, there stands three successful bat gates. One is the largest of its kind in the world. They protect hibernating populations of 8 species of bats, including endangered Gray (*Myotis grisescens*), and Indiana Bats (*Myotis sodalis*). This monumental effort, spanning 14 years, required special innovation and the coordinated efforts of tens of diverse organizations and hundreds of dedicated volunteers. Successful gating partnerships first require background research to document the value of the site, its endangerment, and urgent need for protection. Lacking any of these three criteria, collaborative protection efforts will fall short. It also requires leadership and support from the site owner or manager. Without it, little progress will be made. It then requires an organization to champion the project, by facilitating partner involvement, securing necessary funds and handling countless other details. Often this leadership is provided by the organizations that have the biggest stake in a successful outcome, such as: the USDI Fish and Wildlife Service or other Federal or State land and wildlife agencies, because of their responsibility for managing wildlife and recovering endangered species; Bat Conservation International and The American Cave Conservation Association, because of their missions to protect bats and caves; or The Nature Conservancy, one of America=s largest land stewardship organizations. Now, with all these requirements met, the real work begins!

Planning

Prior Planning Prevents Poor Performance! That old principle certainly applies when you are attempting to bring together diverse partners to plan and build a mine or cave gate for bats.

Several key issues need to be addressed if you hope to have any chance of succeeding. Keep in mind, that planning a project like a bat gate does not follow a linear path. It jumps around and requires an ability to multi-task, bringing along a number of planning components at the same time.

Assessing Need:

The first issue to assess is whether or not there is an urgent need to gate. Is the no action alternative unacceptable? If the answers are yes to these questions, you can move forward. If not, you will never interest busy partners to get involved. A good example of urgent need to act was the Millie Hill Mine in

Michigan. In December of 1992, an amateur cave explorer called Bat Conservation International (BCI) to report finding a large number of hibernating bats in an abandoned Michigan mine scheduled to be permanently sealed within the next few months. This mine turned out to contain one of the largest bat hibernating populations known in the world. BCI went into immediate action, contacting the Michigan Department of Natural Resources (DNR) and local officials. Through extensive media coverage and well-attended public lectures, public opinion shifted in favor of saving the bats. Ultimately, local businesses, individuals from the community, and the DNR all rallied to protect the site, and today it is a popular State watchable wildlife site.

Scope of Work:
Next, you must assess and define the scope of the work to be done. Is it a single site or multiple site that must be addressed, as in the case of the Upper Peninsula of Michigan, where tens of old copper mines accommodate millions of hibernating bats from multiple States in the Great Lakes region.

Assess Importance of Site:
You must also assess the importance of the site, from the standpoint of number of species present, their endangerment, and their ecological and economic impacts. In Australia=s Cape York Peninsula, BCI assisted in gating Jack Gordon=s mine. Due to its close proximity to New Guinea, it offers a unique ecosystem, not found elsewhere on the continent and shelters 6 species of bats, 5 of which are rare and endangered. Obviously, protecting this site was an urgent priority. Another example is in Texas where BCI worked with Dr. Scott Altenbach and the National Park Service to gate the Mariscal Mine. This site was made a top priority because it contained at least 10,000 western big-eared bats, the largest known maternity colony for this species.

The next planning consideration is to understand specifically what the problem is that you will attempt to address with a gate. What is the threat to the bats that live there? Is it human disturbance or vandalism? Are there multiple problems that must be dealt with that are sometimes unrelated to gating issues? At Cueva de la Boca near Monterrey, Mexico there was a problem with human disturbance and vandalism, but those isues were secondary to two other larger problems: (1) a guano and phosphate mining operation that had to be terminated; and (2) a stone quarry on the opposite side of the valley facing the cave with almost hourly blasting. Until those issues were addressed, there was no need to consider gating.

Necessary pre-work must also include understanding what human modifications may have occurred that have changed the site from a once ideal bat roost to one that is now marginal or unacceptable. At Great Scott Cave in Missouri, simply plugging the small entrance, just to the right and above the main entrance, had a significant effect on the cave=s suitability for bats.

Environmental Monitoring:
A thorough understanding of seasonal airflow patterns and temperature regimes, in advance of gating is mandatory. This includes an understanding of the expected impacts of airflow and temperature following gating.

Experimental Gate Design:
Before finalizing a specific gate design it is sometimes necessary to experiment with several designs and monitor use and acceptance by the bat species that must pass through each night. At Fort Bowie in Arizona, it was unknown how the population of 4,000 cave myotis and their young would accept a bat-compatible gate. So an experimental, temporary gate was built in stages and monitored. The maternity colony adapted well, and in 1997 the permanent gate was installed by Dr. Scott Altenbach, in cooperation with BCI, The National Park Service, and Bureau of Land Management.

Logistic Feasability:
Another important planning consideration is the logistical feasibility of gating a site. At Stanton=s Cave in the bottom of the Grand Canyon, two 37-foot rafts made the 31 mile trip down the river, hauling 8,000 pounds of steel and other supplies. Each 200-pound steel bar had to then be carried by hand up the 160-foot vertical talus slope to the entrance. A second trip was required to haul arc welders, generators, acetylene bottles, and oxygen tanks. Under the direction of Bob Currie of the USDI Fish and Wildlife Service, the construction went off without a hitch, and only part of one piece of steel was left over.

Partnerships:
Assembling appropriate partners, to provide the many different skills and resources may be the most important planning challenge of all. In the case of sites on private lands, like Homestake=s California Mine, the site owner and manager must be enthusiastically supportive of the gating effort. It then requires an organization to champion the project, facilitate partner involvement, secure necessary funds, and handle countless other details. Often this leadership is provided by the organizations that have the biggest stake in a successful outcome such as the USDI Fish and Wildlife Service or Federal or State land and wildlife agencies because of their responsibility for managing wildlife and recovering endangered species. That was the case at Unimin=s Magazine mine where the Illinois DNR cooperated with the USDA Forest Service, Unimin mining company, and BCI to gate the largest known population of endangered Indiana bats in the State. Certain non-government organizations, such as BCI and The American Cave Conservation Association with their missions to protect bats and caves or The Nature Conservancy as America=s largest land stewardship organization, can play key roles facilitating partner involvement, providing technical expertise, and raising necessary funds.

Results:
Sometimes, when you=ve paid attention to all these key planning details, you end up with a major success story, like here at Hubbard=s Cave in Tennessee, where three successful bat gates (one the largest of its kind in the world) protect 8 species of bats. This monumental effort, spanning, 14 years, required special innovation and the coordinated efforts of tens of diverse organizations and hundreds of dedicated volunteers.

Steve Walker is currently the Executive Director of Bat Conservation International. He has also served as Associate Executive Director, Bat Conservation International; Director, Program for the Conservation of Migratory Bats, U.S. and Mexico; and the Steering Committee, North American Pollinator Protection Campaign. He has published several articles on Bat Conservation and given many lectures nationally

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TRAINING OPPORTUNITIES FOR CAVE AND MINE GATERS

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Abstract

The gating of caves and mines is an evolving science and few references are available. Much information previously published is now sadly out of date. The literature that is available focuses on bat-friendly gates to the exclusion of other designs. The most widely-accepted bat-friendly gate design is that developed by Roy Powers of the American Cave Conservation Association (ACCA). A recent version of that design is published by Bat Conservation International (BCI) in *Bats and Mines* along with much other useful information. The National Speleological Society is currently publishing the book *Cave Conservation and Restoration*, which will have a chapter on cave gating by this author. More intense, field-oriented training is available through a sporadic series of workshops sponsored by the U. S. Fish and Wildlife Service (USFWS), ACCA, BCI, and other partners. These combine classroom lectures with hands-on gate-building experience, and are taught by some of the country's leading gate builders. Other specialized training, such as abandoned mine safety training, is available from a variety of agencies and is considered mandatory for anyone working in or near abandoned mines.

This paper outlines available technical resources and training opportunities available for mine and cave protection and gate construction efforts. Examples are shown from gating workshops conducted over the past several years.

A Brief History of Gating Manuals

I cringe when I hear some of my caver friends tell me they just gated a cave. I dislike the undeniable fact that gating is a trend gaining momentum simply because it is the most effective method currently available for protecting fragile and irreplaceable resources. But I also worry that although the reasons were noble and intentions good, most people just don=t understand enough about gates and how they affect the cave and mine resources to design and build a good one. I should know. I have helped build several many years ago that I am less than proud of today.

Many, if not most, gates built on caves and mines are done so in response to some crisis situation. This mine is about to be backfilled. That cave is being visited by hordes of untrained explorers. That other one has just been discovered by pot hunters who are destroying the unique resources therein. And so on. Often, at least with caves, these gates are being built by volunteers using scrounged or donated materials. The main purpose is to control access. Little regard is given to the effects on wildlife,

microclimate, nutrient flow, and so on.

This does not have to be the case. There exists a cadre of experts whose backgrounds have helped them experiment, test, and refine gate designs over many years. Ga tes, particularly those intended to not negatively affect bat populations, have come a long way from their humble beginnings.

But it wasn=t always so. In the beginning, it was thought that any hole a bat could fit th rough would be adequate. So some sites, particularly show caves, often had solid stone walls built into the entrance, with a solid door with tiny cutouts. Not only was this difficult for bats to use, especially large colonies, but it changed airflow and the thermodynamics of the roost, usually rendering it totally unsuitable for bats. Other designs used grids of a variety of materials, often : or one-inch rebar. Still others took advantage of whatever materials were available, such as recycled jail bars, vertically oriented.

Knowledge about gates took a great leap forward in 1975 with the publication of the National Speleological Society (NSS) book *Cave Gating* by Hunt and Stitt. Concepts that were intuitive for some were finally formalized and made available to the masses. Over XXXX copies were printed and sold. However, the gate designs were primarily to solve access control problems. Rarely was mention made of the biological effects of those designs, and some w ere downright fanciful and impractical. But it was a start, and the book was revised in 1981 and is still being sold today.

A variety of papers were produced in succeeding years, mostly in the Proceedings of the National Cave Management Symposia (NCMS, or more recently, the National Cave and Karst Management Symposia, NCKMS) or in local caving publications. These are classic gray literature and, therefore, most of the papers remain obscure. One important early paper, however, deserves mention. In 1976, Merlin Tuttle of Bat Conservation International (BCI) presented a paper at the National Cave Management Symposium entitled AGating as a Means of Protecting Cave-dwelling Bats.@ This was the first paper to take an analytical approach to gate design and placement, discussing both good and bad features. In particular, he addressed some biological concerns, identifying key characteristics both suitable and unsuitable for bats. Th is paper has been reprinted several times, notably in the 1981 edition of *Cave Gating* and in BCI=s own training materials.

Most publications since that time have focused on the accomplishment of buildin g a gate or gates and few have examined the consequences of gating. Notable exceptions are White and Seginak =s experiments at Sauta Cave, Alabama, and Cave Mountain Cave, West Virginia, which looked at design preferences by bats. Their study showed that horizontal round or angle-iron bars were preferable to Afunnels,@ but round bars were more easily breached by vandals. MacGregor, in 1993, pu blished observations on population fluctuations before and after gating at 11 Kentucky caves, but under-emphasized uncorrected passage alterations (mostly entrance modifications) as a cause of continuing population declines. In 1993, Richter *et al.*, further showed how inadequate closures and entrance modifications negatively affected the microclimate of the hibernacula and caused significant population declines in their studies at Twin Domes and Wyandotte caves in Indiana. Ludlow and Gore made observations of entrance preferences of a large colony in Old Indian Cave, Florida, in 2000, concluding that although emergences increased at one entrance after a gate was removed, other factors such as

predator avoidance or passage congestion could account for that preference. An underlying issue is that the gates may have been poorly designed or situated in the first place, causing altered bat behavior that returned to normal after the gate was removed. And also in 2000, Martin *et al.* discussed the effective placement of horizontal bar angle-iron gates within the twilight zone (3-17m from the entrance) of 22 caves in eastern Oklahoma, which seem to be well accepted by small to medium nursery colonies of gray bats. Finally, Roebuck *et al.* published an engineering analysis on the effect of cave gates on airflow. Many other contributions, to numerous to name, were made to our current state of knowledge on gating effectiveness with the most important listed in the bibliography at the end of this paper.

To help spread the word about the latest bat-friendly closures, including fences and the now-standard horizontal bar angle-iron gate, Bat Conservation International produced *Bats and Mines* in 1994. More than 5000 copies were distributed free of charge, funded by the US DI Bureau of Land Management (BLM), USDI Fish and Wildlife Service (USFWS), USDI Natural Resources Conservation Service (NRCS), USDA Forest Service (USFS), National Fish and Wildlife Foundation (NFWF), and others. Although focusing on abandoned underground mines, most of the material contained was equally applicable to caves. Detailed drawings were included showing all components of a gate for both horizontal and vertical openings. A revised edition in 1998, with updated gate plans, also had a printing of 5000, and is still being distributed free to anyone needing gate plans.

A Brief History of Gating Workshops

In an effort to educate more cavers, biologists, and resource managers on the various types and applications of cave protection methods, including their pitfalls, a series of cave gating workshops were initiated. The first two were organized by Jim Nieland of the USFS and the ACCA. Two gates were built in September 1997 at Boulder Cave in Yakima County, Washington, to protect a maternity and hibernating colony of *Corynorhinus townsendii*. Instructors were Jim Nieland, Bob Currie (USFWS and ACCA), and Jim Kennedy (BCI). The Wenatchee National Forest helped provide additional funding and assistance. Twenty-two students participated during the two six-day workshops.

The workshops featured evening lectures on gate design and location, bat acceptance, logistics, construction techniques, safety, site restoration, and other aspects of gating theory. During the day, the students received first-hand experience in moving materials, cutting and welding steel, and the rest of the back-breaking labor that goes into building a gate. Each days instructors provided formal and informal discussions on gate placement, materials calculation, bat natural history, and other related topics. These activities were so well received that the sponsors (ACCA, USFWS, and BCI) decided to plan additional workshops as suitable sites and co-sponsors presented themselves. The group also laid the initial groundwork at that time for an updated cave gating handbook that eventually became the Bat Gate Design Forum in Austin in 2002 and the proceedings you are reading today.

The third cave gating workshop was held in June of 1998 and cosponsored by the National Park Service. The five-day event took place at Gregorys Cave in Blount County, Tennessee, a heavily-visited cave in Cades Cove in Great Smoky Mountains National Park. It was previously gated to protect the bats and other cave resources, but the gate became non-functional due to its poor location

at the steep entrance, where it trapped leaves and debris and blocked airflow into the cave. Roy Powers and Rosa Stiltner of the ACCA assisted the original three instructors in leading the group of 11 students in constructing a much-larger angle iron gate further inside the entrance and in the removal of the old rebar gate and accumulated debris.

Our fourth workshop was held during a cold and snowy October 1998 in Pendleton County, West Virginia. A large group of more than 15 students and the five instructors built new gates on both the horizontal and vertical entrances of Sinnett-Thorn Cave, a critical hibernacula for endangered *Corynorhinus townsendii virginianus*, the Virginia big-eared bat. Students had an opportunity to hike from entrance to entrance to learn what each team was doing during breaks in their own gate-building tasks. While the cupola-style gate at the upper (Thorn) entrance was larger and took more materials, working conditions were usually more pleasant than the cramped crawl ways of the horizontal Sinnett entrance. The existing old, poorly-placed rebar gates were removed after the new gates were completed, eliminating an ongoing predation problem by feral house cats. West Virginia Department of Natural Resources (WVDNR) was a partner in this project.

Most recently, we partnered with Missouri Department of Conservation (MCD) and Lake of the Ozarks State Park to place a large gate in the entrance of McDowell Cave in Miller County, Missouri. This gray bat maternity colony had a wide entrance, but needed a Achute@ designed into the gate to accommodate the bats while keeping out humans, including trespassers looting archeological artifacts in the cave mouth. Nieland, Currie, Kennedy, Powers, and Roy=s new assistant Kristen Bobo labored for five days in constant rain, heat, humidity, and mud with 14 students. Both of the last two workshops were greatly assisted by ACCA Executive Director David Foster, who handled registration, meals, and acted as an all-around gofer. More such workshops will be planned as we learn of willing partners and caves with demonstrated gating need near adequate facilities for lodging, meals, and lectures.

The Bat Gate Design Forum

The gating handbook we planned in 1997 was in limbo due to the work commitments of all the instructors, and the money provided for that publication from the Fish and Wildlife Service was due to run out. How could we get out the latest information on gating without having to write it all up ourselves? Bob Currie supplied the answer: hold a symposium similar to the successful Bats and Mines forum cosponsored by BCI and the UDSI Office of Surface Mining (OSM) in November 2000. Currie contacted OSM, who readily agreed. A steering committee was formed to represent interested agencies and organizations that met to develop the structure and topics of the symposium. Session chairs were selected, potential presenters contacted, date and location set, and the forum took place. We had more than 100 people attend a highly-specialized conference on one topic of cave management and, by association, abandoned mine management. The proceedings which you hold in your hand, ably compiled and edited by Kimery Vories of OSM, are far greater that the gating manual first discussed by Currie, Nieland, and Kennedy in 1997. This publication represents the current state of the art in gate design and construction.

Conclusion

We have come a long, long ways since the early days of cave protection with little thought to the biotic and abiotic consequences. But this publication is still not the final word in cave gating. Gating is an evolving science and just as the 1975 NSS booklet *Cave Gating* is now obsolete, we expect that much of the information presented in these proceedings will soon be obsolete as well. Stay informed, keep in touch with those on the cutting edge of gating and cave gate research, and do not rely solely on printed information. And if you learn of better techniques, don=t be afraid to modify or replace an old, substandard gate. And please share your findings with the rest of us!

Bibliography

Anon. 1985. Volunteers protect Tennessee bats. American Caves 1(2):8-9.

____. 1993. James Cave receives new gates for bats. Bats 11(3):4.

____. 1993. BCI helps protect Pennsylvania mine for bats. Bats 11(4):16-17.

____. 1995. New ACCA gates protect Kentucky and Tennessee caves. American Caves 8(1):10-11.

____. 1997. Gates, gates, and more gates! American Caves 10(1):6-7.

Bobo, Kristen, and James Greene. The gating of Wolf River Cave. NSS News 58(10):283, 286, 294.

Brady, John T. 1985. Cave management for the endangered Indiana bat (*Myotis sodalis*) and gray bat (*Myotis grisescens*). Pp. 86-95, *in* 1982 Cave Management Symposia Proceedings (Helen and Jer Thornton, eds.). American Cave Conservation Association, Richmond, Virginia. 119 pp.

Brown, Caroline B. 1996. Bat habitat in caves B What are the caver=s responsibilities? NSS News 54(2-3):52-53.

Burghardt, John E. 1997. Bat-compatible closures of abandoned underground mines in National Park System units. Pp. 184-195, *in* 1997 Proceedings of the American Society for Surface Mining and Reclamation. 787 pp.

Dutko, Rick. 1994. Protected at last, the Hibernia Mine. Bats 12(3):3-5.

Elliott, W. R. 1996. The evolution of cave gating. American Caves 9(2):9-15.

____. 2001. Project reports 2002: Missouri caves. American Caves 14(3):6-9.

____. 2001. Cave gating criteria. Unpublished document for the Missouri Department of Conservation. 5 pp.

Fletcher, Milford R. 1985. Endangered bat protection at Buffalo National River, Arkansas. Pp. 147-150, *in* Proceedings of the 1984 National Cave Management Symposium (James E. Vandyke, ed.). Missouri Speleology 25(1-4). 236 pp.

Forbis, Shelly, Valerie Haskins, and David G. Foster. 1996. Protecting the ancient history of Crumps Cave. Pp. 88-92, *in* 1995 National Cave Management Symposium Proceedings (G. Thomas Rea, ed.). National Cave Management Symposium Steering Committee, Indianapolis, Indiana. 318 pp.

Hathorn, Jim, and Jer Thornton. 1987. The common sense guide to cave gates. ACCA Cave Management Series 1(3):23-45. American Cave Conservation Association, Horse Cave, Kentucky.

____. 1993. Cave gates: design and construction considerations. Pp. 359-363, *in* 1991 National Cave Management Symposium Proceedings (D. L. Foster, D. G. Foster, M. Snow, and R.

Snow, eds.). American Cave Conservation Association, Horse Cave, Kentucky. 405 pp.
Hopper, Hillary Lambert. 1999. Cave gating: three success stories. American Caves 12(3):6 -9.
Hunt, Geoffrey, and Robert R. Stitt. 1975. Cave Gating (second edition 1981). National Speleological Society, Huntsville, Alabama. 60 pp.
Kennedy, Jim. 2002. On cave gating. *In press*. Cave Conservation and Restoration (Jim Werker and Val Hildreth-Werker, eds.). National Speleological Society, Huntsville, Alabama.
Ludlow, Mark E., and Jeffery A. Gore. 2000. Effects of a cave gate on emergence patterns of colonial bats. Wildlife Society Bulletin 28(1):191 -196.
MacGregor, John. 1993. Responses of winter populations of the federal endangered Indiana bat (*Myotis sodalis*) to cave gating in Kentucky. Pp. 364 -370, *in* 1991 National Cave Management Symposium Proceedings (Debra L. Foster, David G. Foster, Mary M. Snow, and Richard K. Snow, eds.). American Cave Conservation Association, Horse Cave, Kentucky. 405 pp.
Martin, Keith W., William L. Puckette, Steve L. Hensley, and David M. Leslie, Jr. 2000. Proceedings of the Oklahoma Academy of Science 80:133 -137.
Murphy, Mari. 1993. Restoring Coach Cave. Bats 11(3):3 -5.
Nieland, Jim. 1996. Washington=s Christmas Tree Cave gated B Bats protected. American Caves 9(2):16-17.
Powers, Roy D. 1985. General cave gate considerations. Pp. 77 -79, *in* 1982 National Cave Management Symposium Proceedings (Helen and Jer Thornton, eds.). American Cave Conservation Association, Richmond, Virginia. 119 pp.
____. 1993. Design improvements for gating bat caves. Pp. 356 -358, *in* 1991 National Cave Management Symposium Proceedings (Debra L. Foster, David G. Foster , Mary M. Snow, and Richard K. Snow, eds.). American Cave Conservation Association, Horse Cave, Kentucky. 405 pp.
____. 1996. A study of acoustical confusion. Pp. 274 -276, *in* 1995 National Cave Management Symposium Proceedings (G. Thomas Rea, ed.). National Cave Management Symposium Steering Committee, Indianapolis, Indiana. 318 pp.
Quinn, Michael, and Jim Petterson. 1997. A grand effort in the Grand Canyon. Bats 15(3):4 -7.
Richter, Andreas R., Stephen R. Humphrey, James B. Cope, and Virgil Brack, Jr. 1993. Modified cave entrances: thermal effect on body mass and resulting decline of endangered Indiana bats (*myotis sodalis*). Conservation Biology 7(2):407-415.
Roebuck, Brian E., Ahmad Vakili, and Lynn Roebuck. 2002. Cave gate airflow disturbance: a qualitative study. Pp. 169-175, *in* 1999 National Cave and Karst Management Symposium Proceedings (G. Thomas Rea, ed.). Southeastern Cave Conservancy, Chattanooga, Tennessee. 221 pp.
Roebucks, Lynn. 2000. Gating in Tennessee: a plethora of summer bat protection projects. American Caves 14(1):6-8.
Stihler, Craig W. 2000. Gates constructed to protect bats in West Virginia caves. American Caves 13(2):15-16.
Tuttle, Merlin D. 1977. Gating as a means of protecting cave -dwelling bats. Pp. 77-82, *in* 1976 National Cave Management Symposium Proceedings (Tom Aley and Doug Rhodes, eds.). Speleobooks, Albuquerque, New Mexico. 106 pp.

____ and Diane E. Stevenson. 1978. Variation in the cave environment and its biological implications. Pp. 108-121, *in* 1997 National Cave Management Symposium Proceedings (Ron Zuber, James Chester, Stephanie Gilbert, and Doug Rhodes, eds.). Adobe Press, Albuquerque, New Mexico. 140 pp.

____. 1985. Joint effort saves vital bat cave. Bats 2(4):3 -4.

____ and Daniel A. R. Taylor. 1994. Bats and Mines (second edition 1998). Resource Publication No. 3, Bat Conservation International, Austin, Texas. 50 pp.

Vories, K.D. and D. Throgmorton. 2000. (Eds.) Proceedings of Bat Conservation and Mining: A Technical Interactive Forum. November 14-16, 2000. St. Louis, Missouri. The U.S. DOI Office of Surface Mining and the Coal Research Center, Southern Illinois University, Carbondale, Illinois. 293 p.

White, Donald H. and John T. Seginak. 1987. Cave gate designs for use in protecting endangered bats. Wildlife Society Bulletin 15:445 -449.

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Session 3

Closure Design: Part 1

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Bat Roost Protection: Closure Design using Soft Closures
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Solid and Invertebrate Cave Gate Options
Mike Warton, Mike Warton & Associates, Cedar Park, Texas

Culvert Closure Design and Construction
Jim Langdon, Idaho Panhandle National Forest, Coeur d' Alene, Idaho

Protecting Cave Bat Populations with Flyover Barriers
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BAT ROOST PROTECTION:
CLOSURE DESIGN USING SOFT CLOSURES

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Abstract

Gates are quickly becoming a common method to prevent human disturbance in bat roosts, both in mines and natural cave s. However, the expense of a custom designed metal gate can be prohibitive for many non-profit groups or agencies. This is particularly true when it is uncertain how much traffic the site is actually experiencing. Therefore, it may be economical to cons ider less expensive methods to monitor and protect a site before immediately investing in a gate that may become a focus for vandalism and could require long -term maintenance. A first option includes educational signs used at the site, particularly when o nly a small area of the cave is off - limits to visitation. Pseudo-monitoring equipment or fake alarms can also be used to discourage visitation. Some sites have used volunteers to supervise caving activity in the area during the periods that the bats are in residence. If some funds are available, perimeter fencing around the entrance area has been successful in a number of bat roosts. Another, although expensive, choice might be installation of a commercial detector, now available on the market. These c an be incorporated with a remote signal (radio, cell phone, etc.) to alert the owner(s) when site security is jeopardized. Because different bat species respond differently to gates, it behooves us to consider other options before immediately considering a gate as our only alternative.

Introduction

It is generally agreed that the benefits of protecting bat roosts from natural catastrophe or human disturbance outweigh the costs. Agriculturists (ranchers, farmers) derive huge economic benefit from the efforts of our nocturnal insectivorous allies. Also, many sub -tropical desertland plants (Turner and Brown 1994) profit from bat-pollination in the American southwest. There is some evidence that past efforts to protect bat roosts, with metal gates or struc tural alteration to the cave, had a detrimental impact on bat roosts (Richter et al. 1992, Ludlow and Gore 2000). There is a general consensus within resource agencies to gate caves and mines, when monies are available, in an effort to protect the resourc e. However, a gate may not be the best and only alternative available for protection of bat roosts, particularly when the gate will potentially affect the flight path of bats. Any gate, no matter how well designed and built, impacts the bats' emergence patterns through the reduction of available cross-sectional area of the passage. This may not be entirely detrimental but even a 'bat -friendly' gate will constrain the bat flight to some degree. Once a gate is installed, it requires the bats to align thei r flight path to exit between the bars of the gate. Our decision to protect the site must include an evaluation of the bats' ability to successfully use the available flight window after gating. It may, therefore, be worth considering alternatives to gating, particularly when the budget is not sufficient to provide a properly designed bat-friendly gate.

We must first agree on the definition of '*soft closure*' within the context of bat-roost protection. The definition for this discussion of 'soft closure' will include any manmade change to a site that discourages human disturbance, but does not reduce the cross-sectional flight area available to the bats or affect the site's microclimate. Unfortunately soft closure is often perceived as not 100 percent effective, as determined individuals can still circumvent the soft closure obstacles. But, of course, the same is true for gates, which can themselves become attractive targets for determined vandals. We will present different 'soft closure' alternatives for bat-roost protection with a general comparison between benefits. Unfortunately, a cost analysis is impossible because the requirements for protection will be so different for each site. The ability of the site resource manager to pursue these soft closure options may depend on land ownership (whether public vs. private), as privately held land may more easily restrict access without public input. However, these soft closure options have been used in many situations throughout the United States and are well worth considering before automatically installing a metal gate.

Reasons for employing soft closure

When a cave or mine has a known bat colony (referred as 'roost-site' for our purposes) but only low-to-moderate visitation, it may be a reasonable site to initially incorporate soft closure techniques. If the soft closure methods are successful in protecting the roost, these will be potentially less expensive and will definitely be less intrusive to the bats. If a roost site is a maternity colony, the loss of maneuverability by pregnant females must be considered when initiating protection for the site. In addition, some bat species of do not adapt well to gates and a metal gate can have a long-term detrimental impact on the roost.

Budget restrictions of the group or agency attempting the resource protection may dictate the use of less expensive soft closure alternatives. A metal 'bat-friendly' gate may be beyond their financial resources and although attractive, a cheaper gate may greatly affect the bats' access to the roost. Large metal gates can be both expensive to build (plus maintain against vandalism) and often require extensive manpower for proper construction. Another constraint against metal gates for the protection of roost-sites can be the physical geometry of the cave or mine passage. Some passages are so large, that to adequately restrict human intrusion would require a massive gate structure. Worse yet, if you introduce a gate in a small passage, it becomes a very attractive spot for predators. As the bats are required to slow flight to exit the gate, a predator gains a benefit in the encounter. The risk of attracting predators can not be underestimated because the concentration of bats leaving a roost on a nightly basis can be very tempting to an animal in search of an easy meal.

Options for Soft Closure

One of the cheapest, and often effective, methods to discourage visitation to bat roosts is to reduce or eliminate vehicular access to the site. This will not work for all sites, given the myriad of legal access issues, but if you can reduce access by obstructing the roadway with a locked gate, then the longer cross-country hike will begin to 'weed-out' some of the less dedicated explorers. It is even better if you can permanently close the road by physical barrier such as installing boulders and scarifying the old roadway bed for a short distance.

A second low-cost alternative to consider when initiating protection of a site is to install educational signs at the entrance to inform visitors of the importance of bats and their vulnerability to human disturbance. It is particularly important to list the dates that the cave is closed to visitation on this educational sign (Fig 1). Trespassing can often be reduced if the explorers understand that the site is closed for an important reason but that they will have access at other times of the year. If your illegal entry is by a specific group (grottos, scout groups, locals) an educational program with a particular focus might be recommended. You are much further ahead if you can change your explorers from adversaries to allies in the protection of the site. At one roost site in southern New Mexico the educational sign has been installed inside the cave because the bats roost in a side passage off the main corridor. It is only that passage that is off-limits during the season the bats are in residence. This allows the rest of the cave to be visited throughout the year. However, extreme care must be taken that this situation is closely monitored because it is based on an honor system and disturbance may still occur. This alternative is a compromise that may only work when the explorers are as concerned about protecting the roost site as the resource manager.

A third alternative, which can be installed alone or in conjunction with other soft closure techniques, is the placement of alarm systems or pseudo-security devices. Past experience has shown that these devices can be effective at discouraging people, particularly when supplemented with an educational sign. It is surprising, but these devices have become the focus of vandalism, as it is believed that they are actually monitoring the site. Because the pseudo-security device is so inexpensive to construct (a medium sized box chained to the wall with a blinking LED and a soldered antenna can suffice), it can be effective in discouraging the more timid intruder or diverting attention from other, more expensive protection efforts.

Another technique to employ when protecting a roost-site is to involve volunteers in monitoring the site and discouraging illegal visitation by their presence. This method is particularly effective if the roost-site is used only during a specific time period (i.e. not a year-round bat roost). If the roost-site is on private land, these volunteers can include the landowner. In southern Arizona, a roost site used retirees who chose to spend some of their free time volunteering for worthwhile causes. Cave clubs (grottos) will often adopt a roost-site as a specific grotto project and thus allow the volunteer effort to be distributed among a number of people.

The last option is perhaps the most expensive soft-closure alternative, but it can provide the most permanent site protection. To keep out visitors, a perimeter fence can be constructed around the entrance area. Fences have been very successful in protecting roost sites without altering the site's microclimate or constraining the flight path of the bats. Also, a fence can be built by less-trained labor (no welding required) and can be built during any season, because it is not constructed in the actual passage used by bats. The effectiveness of the fence can be improved by installing barbed wire along the top (Fig 2). Also, rocks placed in concrete can be installed where necessary to tie the fence to the ground and eliminate access under the bottom of the fence (Fig 3). Another method to reduce explorers crawling under the fence is to run a secondary wire along the bottom (Fig 4). This makes it more difficult to pull up the fence to gain access to the site. At a number of sites in southern Arizona, the natural topography of the ground around the entrance allows the design of the perimeter fence to be even less intrusive to the bats' flight. The

slope of the land established the location of the fence such that the top of the fence is at the same elevation as the bottom of the entrance. This allows the bats total access at the entrance during emergence.

Options for Monitoring

It is important to initiate a monitoring program with most soft-closure alternatives to insure that they are effective in keeping out unauthorized visitors, especially in the beginning when people will attempt to circumvent the barrier. The cheapest and easiest monitoring method is to sweep the floor clear of footprints in a narrow portion of the site's passage. Subsequent monitoring visits to the cave or mine can then narrow the time of intrusion and concentrate efforts to catch trespassers on site.

Another inexpensive method to monitor a site will more closely evaluate the time of intrusion. A counter hidden in a narrow portion of the passage can be triggered by light from a headlamp or by breaking an infrared beam whenever a person passes. If the counter is attached to a data logger, the exact time of the intrusion can be determined. This helps concentrate the efforts of personnel protecting the site because it gives them a better idea when to visit the site and potentially catch intruders.

A more costly method to monitor the site is a motion detector or pressure pad hidden in the floor. Technology has reduced the cost of many of these systems but care must be taken when selecting this option. The equipment will need to be 'cave-proof' so that the circuitry is resistant to high humidity and potentially corrosive air. Generally, electronics will be sensitive to such adverse conditions and additional protection will be required (waterproof container or additional potting of electronics). This option may require frequent upkeep and would not be recommended unless volunteer personnel are interested in equipment maintenance.

The last monitoring technique can be the most expensive if the site is prone to vandalism. The installation of an infrared video camera can be very effective in discovering who and when the cave is visited. Similar equipment is often used by wildlife biologists at remote water holes to monitor animal use and could be triggered by the person's movement. However, this option is much more expensive, particularly if the camera is vandalized or stolen, and the power requirements for such equipment will be difficult at a remote site. In addition, to successfully catch any trespassers at the site, the motion detector, pressure pad or video camera must be linked to some form of communication system (pager, cell-phone, radio or satellite) to alert the resource manager at the time of intrusion. This adds to the expense but may be very useful in reinforcing the effectiveness of a soft closure alternative.

Review of Soft Closure Options

<u>Closure Efforts</u>

- Restrict access to site
- Education signs
- Pseudo-security
- Site Volunteers

- Perimeter Fence

Monitoring Efforts

- Monitor Tracks
- Infra-red counter
- Motion Detector
- Pressure Pad
- Video Camera

How do we decide what's best?

How do we decide which soft-closure alternative is the best solution for our situation? Unfortunately, there is no magic equation that spits out the exact answer when we provide our site constraints. However, an expensive metal gate should not necessarily be your first choice, particularly if you consider the other options available to you. As stated earlier, a critical factor in your decision for site protection will be your evaluation of the requirements for this particular bat roost and flight maneuverability of the bat species using the site. Gates may appear to be a 'quick fix' for your problems; however, gates can be expensive, vulnerable to vandalism and can therefore require long-term maintenance, for which you will rarely have funds allocated. You must also remember that doing nothing is not the same as soft closure. Soft closure is still a modification of the site in an effort to protect the roost without affecting the flight path of the bats or altering the microclimate of the roost in any way. Interesting enough, soft closure can provide information on the importance of a particular roost to the bats themselves. If a reduction in human disturbance brings about an increase in bat population, then additional protective measures may be warranted. This has been particularly true in southern Arizona. One site on the Fort Huachuca Military Reservation that had a visitation problem installed a very bat-unfriendly gate in the entrance for a few years, that is probably what finally drove the last bats away. Instead of gating two other historic (but abandoned) bat roosts, the first gate was removed and the three sites were fenced as described previously and supplemented with motion detectors tied to a communication system. The reduction in human disturbance was sufficient over 8 years that one site now has 8000+ *Myotis velifer* (Southwestern cave myotis) and 3000+ endangered *Leptonycteris curasoae* (lesser long-nosed bat) using the site each summer.

Last, but not least, remember that there are others wrestling with similar resource issues and problems. Our ability in this computer-age to network within non-profit groups and resource agencies allows us to learn how others have tackled comparable situations. The bottom line is that we all wish to protect bat roosts but we must keep in mind that although we feel that the metal gate that we have designed is the best solution and will be readily accepted by the animals, the bats have the final vote.

Literature Cited

Ludlow, M. E. and J.A. Gore. 2000. Effects of a cave gate on emergence patterns of colonial bats. Wildlife Society Bulletin 28(1):191-196.

Richter, A.R., S.R. Humphrey, J.B. Gore, and V. Brack, Jr. 1993. Modified cave entrances:

thermal effect on body mass and resulting decline of endangered Indiana bats (*Myotis sodalis*). Conservation Biology 7(2):407-415.

Turner, R.M. and D.E. Brown. 1994. Tropical and subtropical desertlands *in* Biotic communities: Southwestern United States and Northwestern Mexico. University of Utah Press, Sa lt Lake City. 342pp.

Debbie Buecher has worked on bat-related projects for 15 years throughout the United States. She has been technical assistant on a 12-year study of the endangered nectar bat (*Leptonycteris corosoe*) in two roosts at Fort Huachuca, Arizona. In 1997, she was principle investigator on a Bureau of Land Management project to monitor 4 cave myotis (*Myotis velifer*) roosts in the Guadalupe Mountains, New Mexico. She holds a B.S. degree in biology from the University of Arizona and is currently pursuing a Master's degree in Wildlife Ecology.

Bob Buecher is a registered professional engineer and land surveyor. He was Project Manager for the Pre-development Baseline Study for Kartchner Caverns, in southern Arizona. There he directed studies of the cave microclimate, geology, mineralogy, biology, hydrology, geophysics, and mapping of the cave. The cave has a maternity colony of cave myotis (*Myotis velifer*) and the study stressed low disturbance techniques to monitor the bat population. He has designed and built cave gates, motion sensors, and bat counters to be used in remote sites.

Bat Roost Protection: Closure Design using Soft Closures

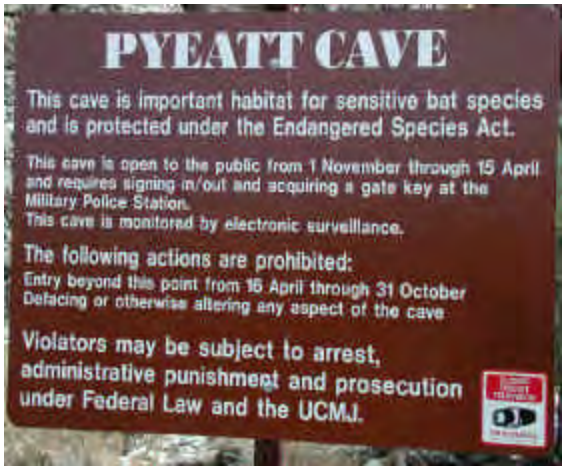

Figure 1. Note the Dates that the Site is Open for Exploration

Figure 2. Barbed Wire Discourages Climbing Over the Fence

Figure 3. Reinforce Spots Along the Fence where People might Crawl Underneath

Figure 4. Wire Along Bottom of Fence hampers Efforts to Crawl Underneath

CABLE NETS FOR BAT HABITAT PRESERVATION

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Abstract

Cable-supported structures have been used in architectural and engineering practice for long spans, such as suspension bridges, and to cover large areas with a minimum of support columns, such as sports arenas and aviaries. Similarly, in bat habitat preservation in underground mines and caves, use of cable nets is particularly well adapted to large span, usually vertical, openings. Nets also provide a solution at smaller vertical openings where equipment access is constrained because of steep slopes or other barriers. A critical design and construction requirement for cable nets is the necessity for solid anchorage, generally into competent rock around the opening. Depending on the species, type of use and size of colony, unrestricted passage for bats may not be important at very large cable nets, provided that the standard six-inch spacing of cables is used. Although bats need to slow to pass the net, predation becomes less likely as the size of the netted opening increases. Provision for bat passage can be made using framed openings in the net, a cupola structure suspended from cables or supported by beams or girders, or, where conditions allow, a standard vertical bat grate tied to the net.

An Introduction to Cable Net Enclosures

Cable net enclosures are one category of tension structures. The main elements of these structures carry loads only in tension and are highly economical in their use of materials. Suspension bridges and spider's webs are tension structures that most everyone is familiar with – both carry heavy loads with a minimum of material. In engineering language, tension structures have high strength-to-weight ratios.

For thousands of years, architects, engineers and builders have used cable-supported structures to span large distances and to carry substantial loads. Bamboo rope suspension bridges were built as early as 285 B.C. in China and iron chain-supported bridges shortly thereafter. Almost two millennia later, the Industrial Revolution led to the development of iron-wire and steel-wire cables. Wire rope suspension bridges of increasing span followed, with the Golden Gate Bridge designed in the 1940s containing a single span of 4,200 feet and the Akashi-Kaikyo Bridge designed in the 1990s with a clear span of 6,530 feet.

In this century, wire-rope cable net enclosures have been used to cover large areas with a minimum of supporting members, such as at sports arenas and aviaries. The most familiar large cable net enclosures constructed to date are the Munich Olympic Park Roof, completed in 1972 and covering more than 19 acres of stadium, swimming pool and arenas, and the Millennium Dome in Greenwich, London, with a diameter of over one thousand feet. Cable nets have also been used along highways below rock cuts where they absorb the high kinetic energy of tumbling boulders and slow or stop the boulders before they reach the roadway.

Cable Nets for Bat Habitat Preservation

In bat habitat preservation in underground mines and caves, the use of cable nets is particularly well adapted to large-span, vertical openings. With their high strength-to-weight ratios, they are often the most economical means to safeguard large openings with a minimum of materials. Cable nets also provide safeguarding solutions at both small and large vertical openings where steep slopes or lack of roads constrain construction access and at large horizontal openings (although at horizontal openings, the potential for vandalism needs to be carefully considered as discussed below). Being relatively lightweight, constructors can carry or drag the prefabricated cable net panels by foot to the work site. Since drills and compressors are required, however, a road must be close enough to stretch compressed air hoses to the work site (unless equipment is brought in by helicopter). Nets can also accommodate irregularly shaped openings more easily than most structural solutions.

In abandoned mine safeguarding practice, the most common size of cable used is 7 x 19 construction (number of strands times number of wires per strand) ¼-inch diameter galvanized aircraft cable with a nominal breaking strength of 7,000 pounds. A single length of cable is wrapped into a six-inch by six-inch grid patterned net. The grid is placed under an evenly distributed load and galvanized or stainless steel net clips are securely swaged with a hydraulic ram at all intersections. A perimeter cable of 7x19 5/16-inch diameter galvanized aircraft cable with a nominal strength of 9,800 pounds is strung through the outer loops of the net. Wire rope sizing should be reconsidered at very large openings, where significant rock fall is a possibility, or where minimization of vandalism is important.

Cable net manufacturers assemble cable net panels in any size from four feet to 15 feet wide and as long as 25 feet. The typical cable net is 24 feet by twelve feet (288 square feet). At large openings, several panels are sewn together at the job site with 5/16-inch cables and swaged to the panel perimeter cables with double sleeve connectors.

Design Considerations

The economy of materials provided by cable nets means that they offer very little or no reduction in the movement of sunlight, air, water, nutrients, and smaller vertebrates and invertebrates into and out of the underground void. This helps to preserve atmospheric and ecological conditions inside the cave or mine environment. For protection against human entry, the cables used in bat preservation and mine safeguarding are usually woven into a six-inch by six-inch grid. Bats passing through this size of opening would probably need to slow or stop to crawl through, increasing their susceptibility to predation. For nets over large openings, predation may be less of a concern and, in some instances; no special accommodation for bats may need to be made. However, at smaller cave or mine openings, at critical bat habitat, for large maternity colonies, and for less agile bat species, it is best to consider special provision for bat passage.

Uninhibited bat passage can be provided in several ways. The simplest method is to place a number of bat windows constructed of steel angle iron into the net. Windows used by the New Mexico Abandoned Mine Land Bureau (NMAMLB) have been approximately 5-3/4 inches wide by 18 inches long. Depending on the length of the window, two or more cables are cut for each rectangular frame, which is fastened to the net with u-bolts. Clearly there is a limit to the number of

cables that can be cut without reducing the strength of the net and to the number of bats that can use such openings.

To better allow for bat passage in two projects, the NMAMLB has used cable netting in conjunction with a standard vertical bat grate set at the horizontal entrances to the mines. Although I know of no examples, a bat cupola structure could be suspended from cables or supported by beams or girders over a large vertical opening and surrounded by cable nets. Special attention needs to be given to designing a long-lasting, vandal-resistant connection of the net to the grate or cupola. U-bolts connecting the perimeter cable to a steel member can be used provided that the bolts are protected from removal and vandalism.

All tension structures require solid anchorage to carry the applied loads. Competent rock, solid and relatively free from fractures, close to or at the surface around an opening provides the best condition for anchoring cable nets. The cable net panels are sized to overlap onto the rock around the opening for at least two or three feet. In abandoned mine practice, rock anchors are generally of the split-set type, three feet long, and spaced at no more than six feet on centers. The anchors are driven through six-inch square roof plates to secure the perimeter cable to the anchors at all net corners, at net seams, and at intermediate intervals of six feet maximum. The hollow center of each split-set anchor is sealed with concrete, grout, or epoxy to prevent moisture penetration along the anchor. To minimize vandalism to the perimeter cable and rock anchors and to reduce attempted entry under the perimeter of the net, the outer boundaries of cable netting are usually covered with rock or soil.

In sulfide-rich geological formations, I recommend that the rock bolt anchors consist of ½-inch to ¾-inch diameter steel rock bolts with expanding-shell anchorages or epoxy grout anchorages for corrosion protection. The anchor bolt should be epoxy-coated in either case. If the expanding-shell mechanical anchorage system is used, the drill hole should be filled with epoxy or cementitious grout after installation and tensioning of the rock bolt. Generally all anchorages should be founded at least three feet below ground surface or at least two feet into rock, whichever is greater.

In areas of less competent rock, a decision to use cable net should be very carefully considered. Longer anchors or closer spacing of anchors may suffice where the rock quality is not too poor. At very large openings or where there is less than ideal material, a qualified engineer should design the anchorages. I know of no case where cable net has been used in soft ground, but the required anchorage strengths might be able to be provided using rock bolts or soil anchors, or the netting could be attached to a concrete perimeter foundation. The design challenge here would be to stabilize the ground at the opening to avoid the collapse or erosion of material at the opening that could undermine the net and its anchors.

Despite the advantages of its high strength-to-weight ratio and the fact that at some sites they are the only feasible alternative to fencing, the potential disadvantages of cable netting are several:

- Without special and probably costly measures to stabilize the collar of an opening in weak or decomposed rock, competent or nearly competent rock is required to anchor the cable net as discussed above.

- With their economical use of materials, cable nets are more vulnerable to corrosion than structures with material to spare. At one recent cable net installation of the NMAMLB, corrosive soil conditions were not recognized until six months after installation when accelerated corrosion of a portion of the net was noticed. Wherever nets are to be used in a possibly corrosive environment, soil and rock samples should be tested to determine the levels of corrosiveness. Stainless steel or PVC-coated galvanized wire ropes can be used to increase corrosion resistance, but the cost of these materials is three to four times the cost of standard galvanized netting. In sulfide-bearing rock, anchors should be stainless steel or epoxy coated as discussed above.

- Cable net closures are vulnerable to vandalism. Bolt cutters can cut ¼-inch diameter cables and all cables are defenseless against cutting torches. Nets placed at adit or horizontal entries are very easily vandalized and I discourage their use at horizontal entries without special provision to address the potential of vandalism. Nets located over vertical openings appear to have much lower rates of vandalism; apparently, vandals would need climbing equipment at shafts and stope openings to make further progress. Heavier wire ropes can be used in areas where vandalism is expected or experienced, but increasing the cable diameter from 1/4-inch to 5/16-inch increases the material costs by 50 percent and the weight of the net by about 30 percent. The weight increase adds to the costs and difficulties in transporting nets to remote sites and in handling and placing them.

- At very large openings exposed to the wind, cable nets may flutter and special provision may need to be made to prevent the structure from flapping itself to destruction. Cable nets used for bat habitat preservation have been smaller with a higher percentage of open area compared with those used at sports arenas and aviaries, and they are usually protected from wind by being partially inside the mine or cave opening. For bat habitat preservation, wind flutter at nets has not been a problem to my knowledge, but should be borne in mind as a possibility by all cable net designers.

In the experience of NMAMLB at five projects constructed between 1992 and 1996, installed costs for ¼-inch galvanized cable nets ranged from $5 to $8 per square foot of net and for three-foot long rock anchors from $20 to $83 each. Installed costs in 1999 for the one project with 5/16-inch galvanized cable net was $15 per square foot of net and $250 for three-foot long rock anchors. Difficult access to the construction site and construction on a steep rock face were complicating factors in the 1999 project.

Construction and Maintenance Considerations

The equipment typically necessary to install cable netting includes an air compressor, rock drill, cable swaging tools, come-along pullers or winches, and other tools and equipment necessary to handle and place the cable net panels and rock anchors. Cable net, ¼-inch in diameter, weighs about 0.6 pounds per square foot. A typical panel of twelve feet by 24 feet will weigh about 175 pounds. For large, multiple-panel nets, small-diameter cables may need to first be strung across the opening to support the panels as they are moved into place. It is best to have personnel who have experience in drilling rock, working with wire ropes, placing rock anchors, handling of construction equipment and materials, and working around dangerous openings.

Cable net installations and rock anchors need to be checked regularly for corrosion and vandalism. Rock thrown or fallen onto the nets should be removed. Because of their susceptibility to corrosion, the expected life span of cable netting will depend on the regularity o f maintenance and on soil, rock and climatic conditions, but in general will not exceed 20 to 30 years.

Conclusions

Cable nets occupy a specialized, but important niche in cave and mine habitat preservation. Their disadvantages of corrosion susceptibility, the need for solid anchorage, and low vandal resistance are sometimes outweighed by their advantages of low weight, high strength, open construction, and ability to be installed at large and irregular openings and at steep and remote sites.

Bibliography

Currie, Robert R. 2000. An Evaluation of Alternative Methods for Constructing Bat Gates at Mine Closures. Pages 127-143 in *Proceedings of Bat Conservation and Mining: A Technical Interactive Forum*, St Louis, Mo., November 14-16, 2000. 293 pp.

Kretzmann, John A. 2000. New Mexico Experience with Bat Grates at Abandoned Mines. Pages 145-151 in *Proceedings of Bat Conservation and Mining: A Technical Interactive Forum*, St Louis, Mo., November 14-16, 2000. 293 pp.

Vandenberg, Maritz. 1998. Cable Nets: Detail in Building. Academy Editions, John Wiley & Sons, Chichester, Great Britain. 96 pp.

John Kretzmann worked as a design and project engineer in water resources for many years before beginning work in abandoned mine reclamation and safeguarding in 1990 for the New Mexico Energy, Minerals and Natural Resources Department. This work has included design for bat preservation at over eighty abandoned mine shafts, adits, and open stopes throughout New Mexico. He has a bachelor's degree in Civil Engineering from Valparaiso University.

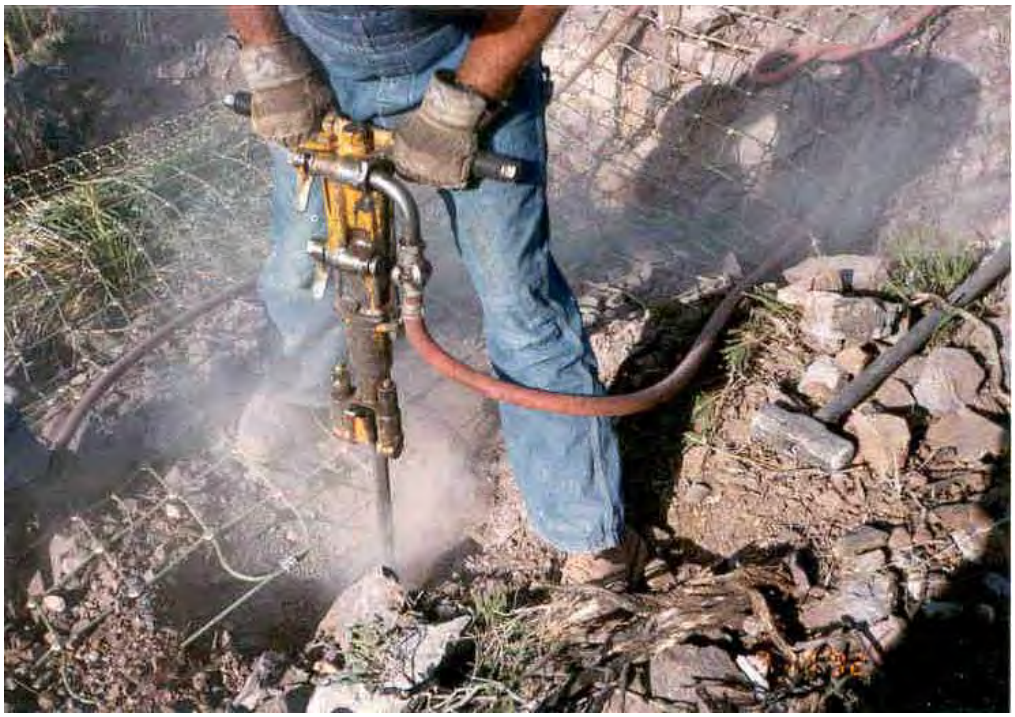

Figure 1. Drilling bedrock to anchor the perimeter cable of a cable net.

Figure 2. An installed split -set anchor prior to the hollow center of the anchor being filled with grout to prevent moisture penetration.

Figure 3. A multi-panel cable net installation over a large stope opening. The edges of the net have been covered with earth and rock to deter vandalism.

Figure 4. Cable net over a large stope opening with framed bat windows.
Note the steepness of the hillside.

Figure 5. Cable nets can easily accommodate irregular openings, as at this two panel net installation over an open stope. This net is at the far end of an abandoned underground mine in central New Mexico, that has bat use both for hibernation and mate rnity. Other entrances have bat-compatible grates.

Figure 6. Cable net over a shaft opening near to an adit, to the right, which is bat -grated for a large maternity colony of Townsend's big -eared bat in central New Mexico.

Figure 7: Cable net over a small stope opening on a remote, steep hillside.

Figure 8. Cable net attached to a concrete foundation. Although not designed to preserve bat habitat (rather to allow owner access to the underground workings), this pho tograph illustrates the use of a concrete ring wall to anchor cable net. The locking opening in the side of the foundation allows for human entry into the mine workings.

Figure 9. Angle - iron bat grate used in conjunction with a cable net at the horizontal entry trench into an open stope. This installation, with several others, serve a large colony of bats in an abandoned mine in southwestern New Mexico.

Figure 10. Cable net/angle iron bat grate combination at a large adit entry. This installation serves a maternity colony of Townsend's big -eared bat in north central New Mexico. Corrosive rock conditions at the left side of the net were not recognized until after net installation when accelerated corrosion of the galvanized net was noted. Repairs to the net will need to be made within the next few years.

SOLID AND INVERTEBRATE CAVE GATE OPTIONS

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Abstract

The gating of caves for the specific purpose of protection and preservation of endangered invertebrate species habitats in Central Texas is a new co ncept of environmental protection and need. In order for a cave gate to accomplish this, all of the cave's natural ecological functions and feature aspects that scientifically sustain such habitat must be studied, considered, and preserved accordingly. The desired effect and result of the gat is to protect and preserve these natural functions through a "transparency" in gate design, avoiding any significant impacts, as if, no gate were present at all. Such is an additional requirement of gating beyond st ructural integrity and qualities expected of gating in the past. A new type of gate design that now serves this purpose has evolved from a study process that has well considered the past and present technology of successes and failures of cave gating in t he past. Just as bat gates have been specifically designed for bat caves and habitats, presented here is the first gate designed specifically for cave invertebrates.

Cave Ecosystems

In every Cave, there are two ecosystems of important consideration. The first is one that exists at and within the cave's entrance area. The second is within the cave's interior reaches. These can be vastly different. I cannot stress enough the "critical" importance and values of environmental ecological study assessments being well understood and followed prior to the application of cave gating. These study results will identify the ecological aspects of each habitat regime and dictate the requirements needed for a cave gate that would preserve the habitat.

Cave Entrances

In Central Texas, the most common type of cave entrance occurs as a sinkhole, often found along rock joints. Entrance openings are usually positioned on semi -flat ground or along hillside slopes. The orientation of entrance openings is usually and ini tially vertical. Horizontal development within caves may occur at shallow depths. In this type of cave structure, the key position of a prospective cave gate is usually horizontal, with some degree of recess into the entrance. The concept of gate "trans parency" implies specifically that the gate is a non -solid covering that will not impede, block, or prevent the vertical fall of air, water, or natural organic materials from entering the cave similar to what occurs naturally. Thus, the transparent gate i s semi-open for these functions. In the cave entrance ecosystem, surface related and nocturnal invertebrate species may regularly pass through the gate in a manner not significantly altered by the presence of the gate. In Texas, endangered invertebrate s pecies are troglobitic in nature, never leave the cave environment, and never use or access the gate. They are critically dependent on

the gate's ability to allow un-impeded wash-in, or transport of organic food source materials to enter and replenish the cave. Up to seven common types of ground mammals also frequent Texas caves and have important natural roles in the cave ecosystem. Their points of access and egress through the cave gate are specific in location. The gate must facilitate their easiest points of access. The access portal design and size are set to an eight-inch diameter or square opening.

Gate Construction

Prior to gate construction, the cave's entrance may require certain preparations for acceptance of the gate. In welded construction where gates are custom built and fitted on site, we use commercially made welding blanket mats draped across the entrance opening in basket position in order to prevent contamination of the cave by slag and welding residues. The gate is a level horizontal grid cover constructed from 2-inch by 2-inch by 3/8-inch steel angle. The most important structural component is the supporting sub-structured arrangement of cross beams and drilled anchor points. Anchors are usually ¾-inch to 1-inch diameter rebar from 8-inches to 10-inches in length. Horizontal beam supports are built by welding together two pieces of angle iron to form a box-shaped beam that is solid welded to the point set anchors. Once the substructure is completed, the grid panel arrangement of bar angles may begin. The bar angles are placed on their edge sides, with angle peak pointed either to the left or to the right (all pointed in the same direction throughout the gate). By placing the angles on their edge side, the barrier thickness aspect of the gate panel becomes almost three inches thick, instead of the 3/8-inch thickness of the angle. Bar spacing throughout the gate and across the panel are set at 1-1/2 inches. The direction of airflow exchange to and from the cave's entrance, may determine the left or right pointing positions of angle peaks. The angle shape would be turned to such a position that "cups" and promotes the best airflow exchange. It should provide the level of airflow conductivity that is a substantial or prominent characteristic of the cave. In this construction, the location and position of the gate's access and egress door is pre-determined. The access door assembly is: (1) typically 30 inches square in size; (2) transparent in design; (3) a hinged door; and (4) contains a concealed lock mechanism and access point. The access door unit is the only gate component that is produced in the welding shop and then transported to the site for installation as needed.

After the access door is installed, the last stage of the construction is usually the placement of horizontal stiffeners across angle expanses. One-inch or 2-inch wide by 3/8-inch thick flat bar stock is used for the stiffeners. Stiffener spacing usually does not exceed a distance of five feet. Following the completion of all welding, the last stage of gate completion is to apply a protective metal coating with a high quality rust inhibitive paint. This is carefully hand brushed on instead of sprayed. Following gate completion, the under hanging blanket basket is removed and the site thoroughly cleaned of any foreign materials. Following construction of a gate, I generally include a detailed report of completion with photographs to the site owner(s).

In the many gates we have installed, the material of pre ference has been a "modified" grade of 2-inch by 2-inch by 3/8-inch steel angle, and flat bat. "Modified" steel adds additional carbon so that its yield strength is greater than 50,000 pounds.

Structural Integrity

The permanence of the protection method "specifically" factors in three very important aspects of structural integrity. These are:

- Drilled & dowelled anchors into solid stone walls and surfaces where possible.
- Tension and load bearing anchors that penetrates into non -solid walls and slopes of unconsolidated materials where feasible and possible.
- ALL solid welded connections in overall construction, that is always possible.

The locking access door component of the gate is one that contains a "weakest link" aspect in design. If it ever breached at this point it would facilitate easy and inexpensive repairs. The door hinges are the weak-link point, however, guard plates protect them. These gates offer a maximum level of durability and longevity, with very low maintenance care. With maintenance of protective coatings and lubrication, the best estimate as to the life span of the gate would be 100 years or more. The concealed lock box location in these gates prevents any direct attack. The lock box is designed to house 2-inch wide lock with 3/8-inch shackle. We use "Olympus" Brand locks, for their corrosion resistant brass bodies and tumblers. At only $10 each, they have proven to be very good locks. As the sky seems to be the limit on lock quality and cost, the Client may upgrade locks at any point desired.

It has been said, "There is no gate ever built that cannot be breached." This is still true today. One of the greatest areas of study in the development of our gates has been the aspects of breaching and vandalism. In almost a "forensics " style of review, it becomes useful to delve into the psychology and motivations of the potential perpetrator. I believe that the key ingredient of a successful surviving gate lies in a design ability that essentially beats the vandal at his own game. T his is accomplished by significantly to severely reducing the odds of extremity that they will resort to in a breach attempt. Our gates have been widely monitored by regular site visitations and inspections. There have been many cited breach attempts, ho wever, NONE have been successful without resorting to an uncommon extremity that could breach any gate. We do convey to our clients that such breaches seem limited to three possible modes of extremity. These are:

- An acetylene/Oxygen cutting torch rig
- Explosives, and
- Winching equipment where well in excess of 20,000 pounds of force is applied.

Environmental Impact on Gates

In addressing the concerns of potential environmental and ecological impacts of our gates once installed, we have relied heavily upon 1 4 years of site monitoring for species habitats performed by a world renowned cave invertebrate specialist, James Reddell. Mr. Reddell was the recipient of the prestigious NSS Science Award in 2001 in

acknowledgement of a lifetime devoted to cave inverteb rate research. His assessments of our gate's abilities for acceptances of all animals and invertebrates have been reflective of a good to high habitat quality.

Limitations on Construction

Construction limitations have been very few. Limitations are rel ative to the aspects of other material usages. It is always a nice situation when close vehicular access to of the cave entrance is possible during gating. However, like other gaters we are no strangers to toting heavy steel and equipment over long dista nce by foot to gate a cave. Welding far underground in a flowing stream passage and dressed in a wetsuit is not a regular occurrence but we have done it well and safely.

The skill level needed and equipment required is great. An expert knowledge and abi lity of welding and cutting is required. All workers, including highly experienced cavers, must be trained with some aspects of gating. Aside from general caving experience, background experience that includes some level of environmental karst is preferr ed.

Our options for access doors are limited to single types for invertebrate gates and bat gates. The typical door opening size for invertebrate gates is 28 inches square. For bat gates, a solid rectangular door is 18 inches by 24 inches and mounted ve rtically at the least possible point of bat flight interference. With bat gates, if the entrance is small, an above ground structure extending outward of the entrance may alternately be built. Bar spacing in all flight panels are set at 5 and ¾ inches. The weight of a completed above ground structure may well exceed 2,000 pounds.

Building Gates as a Business

From personal experience and perspective over the years, I would convey to you that "It is one thing to gate caves as an individual by single cont ract, grant, or sole purpose fund," but becomes entirely a different creature to do this as a business. For those who would contemplate it as a business, there are numerous hoops and hurdles to deal with. I would feel confident that your insurance carrie r <u>would</u> let you know their interpretation and response for coverage the very moment you mention the focus of your work. It will focus on, to them, one of the dirtiest four letter words in the English language "cave." The word mine is bad enough, but mines are man made and more acceptable, but cave? Forget it! It represents the "unknown," and means "High Risk!"

There will be many operational costs to bear as a business, and you will learn that if your prices for gating are not substantial, your business ma y not survive.

Construction Costs

Our base rate for cave gating services begins at $2,875.00 for small and uncomplicated entrances, and moves upwards perspectively with entrance size, complexity, materials and labor accordingly. Our cost structure does a llow us some range of flexibility to accommodate private landowners, but with limitations. In Central Texas, environmental

karst issues and concerns age well off the launch pad. It is predicted that by 2025, our present population in and around Austin wil l have doubled. Our measures of environmental protection are moving ahead at unprecedented paces as well.

References

Elliott, William R. 1996. The evolution of cave gating. American Caves, 9(2):9 -15.

Hunt, Geoffrey, and Robert R. Stitt. 2981. Caving gati ng: A handbook. Revised second edition. Huntsville, Alabama: National Speleological Society. 60 pp.

Warton, Mike. 1993. The "Environmental Kart Management" of Central Texas. National Cave Management Symposium, Carlsbad, New Mexico, October, 1993.

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PHOTOGRAPHIC DOCUMENTATION OF THE " MWA 101-P HORIZONTAL GRID PANEL CAVE GATE, WITH HINGED LOCKING ACCESS DOOR " CREATED BY MWA FOR PROTECTION OF ENDANGERED INVERTEBRATE SPECIES CAVE SITES IN THE CENTRAL TEXAS REGION.

MWA

1998 - 2000 PERIOD

Photo by: M. WARTON

VIEW OF RECESSED INSTALLATION OF THE MWA-101-P HORIZONTAL PANEL GRID CAVE GATE WITH HINGED LOCKING ACCESS DOOR. CONSTRUCTED OF 2X2X3/8" MODIFIED STEEL ANGLE. ALLOWS FOR ALL UNIMPEDED ECOLOGICAL FUNCTIONS OF THE NATURAL CAVE ENTRANCE.

MWA

1998 - 2000 PERIOD

Photo by: M. WARTON

THE MWA 101-P HORIZONTAL GRID PANEL GATE IS A "FLOATING" TYPE OF GATE THAT IS ANCHORED TO EXISTING STONE WALLS OF THE CAVE ENTRANCE, AND PROMOTES ALL ECOLOGICAL FUNCTIONS & UNALTERED INFLUX OF ALL NATURAL MATERIALS, RUNOFF, AIR EXCHANGE, ETC.

MWA

1998 - 2000 PERIOD

Photo by: M. WARTON

CLOSE UP VIEW OF GATE ACCESS DOOR THAT IS INSET INTO THE SURROUNDING HORIZONTAL PANEL. ALL CONNECTION POINTS ARE SOLID WELDED. NOTE, HOW NO ORGANIC MATERIALS ARE CAUGHT BY THE GATE & FREE TO ENTER BY DESIGN OF BAR SPACINGS

MWA

1998 - 2000 PERIOD

Photo by: M. WARTON

CLOSE UP DETAIL OF GROUND MAMMAL ACCESS POINT 8" CONFIGURATION FOR ACCESS. MAMMAL USE HAS BEEN OBSERVED WITH THIS GATE.

MWA – Gate Detail

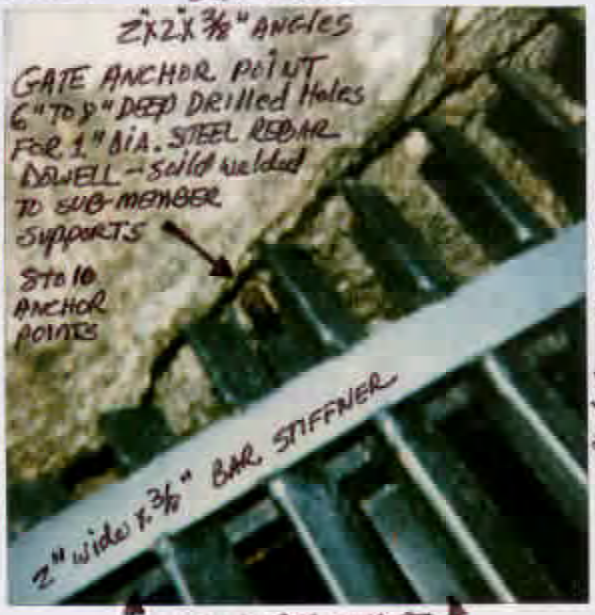
1998-2000 Period

Photo by: M. WARREN

1.6" WIRE BAR SPACINGS

ANGLES POSITIONED TO CUP AND PROMOTE AIR-FLOW EXCHANGES

MWA – Gate Detail



1998-2000 Period

Photo by: M. WARREN

SUB MEMBER SUPPORT

SUB MEMBER CROSS-BAR SUPPORT

MWA –

1998-2000 Period

Photo by: M. WARREN

GATE #2 VARIATION OF SAME GATE TYPE (101-P Horizontal Grid panel w/ Locking ACCESS DOOR. Angles are cupped in Direction of air-flow exchanges.

MWA

1998-2000 Period

Photo by: M. WARREN

GATE #2 VARIATION of SAME Gate TYPE (101-P) VIEW IS FROM OPPOSITE Angle. Influx of All Natural water intake & organics occurs unimpeded into Cave at All edges.

MWA

1998-2000 Period

Photo by: M. WARTON

SAME Gate, Detail of Ground Mammal access point. THIS ONE IS Highly USED BY RACOONS, AND has been observed.

MWA

1998-2000 Period

Photo by: M. WARTON

Close up view of Ground Mammal Access Point Evidencing High degree OF REGULAR USAGE. Surface of Rock has light COAT OF MUD left FROM RACOON PAWS.

MWA

1998-2000 Period

Photo by: M. WARTON

GATE #3 VARIATION OF SAME Gate TYPE (101-A) NOTE HOW INFLUX OF ORGANICS & WATER & AIR OCCUR Naturally around All edges of the Cave Gate.

MWA

1998-2000 Period

Photo by M. WARTON

GATE #3 - SAME / Close up of Ground Mamal Access Point. Semi-insulated & shadowy conditions BELOW the GATE Allow good environ FOR MOISTURE Affinity plants to GROW well, such AS FERNS.

MWA

1998 - 2000 Period

Photo by: M. Warren

Gate #4 - Same type - NOTE THE CONDITIONS BELOW THE GATE DOOR ALLOWS THESE FERNS TO FLOURISH IN THEIR NATURAL state/condition. THE Gate DOOR Presence Helps to promote THIS MOISTURE REGIME.

MWA

1998 - 2000 Period

Photo by: M. Warren

Gate #5 - SAME type - Variation (102-P)

IN THIS VIEW, NOTE HOW THE BAR EDGES EXTEND INTO & OVER LAP WALL EDGES COMPRISED OF soil & Rock fill (NON solid edge/wall)

MWA

1998 - 2000 Period

Photo by: M. Warren

Gate #5 - SAME type Variation (102-P) NOTE HOW EDGES of Angles EXTEND INTO & OVERLAP NON-solid wall edges.

MWA

1998 - 2000 Period

Photo by: M. Warren

Gate #6 - SAME TYPE Variation (101-P FOR linear entrance & RECESSED. Entrance walls Along Left side are NON-solid.

CULVERT CLOSURE DESIGN AND CONSTRUCTION

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Abstract

Culverts for closures and access control for mines and caves have become more common. This paper, based on the experience of the author, compares culverts to steel gates as a closure option. Material types, installation methods, and closures devices are introduced. Considerations for selecting a culvert include: safety, visual impacts, stability of the opening, costs, airflow and temperature changes, acceptance by wildlife, vandalism, and maintenance. Design and construction details for diameter, length, slope, closure devices, beveling, and drainage are discussed.

Introduction

Culverts are used for stabilizing mine entrances, controlling mine access, controlling cave access, creating artificial cave entrances, and stabilizing cave entrances. Culverts for mine closures have been uncommon until recently. Culverts are generally used when a mine entrance or portal is unstable and presents a working hazard when installing a conventional bat gate structure or where the portal is likely to collapse within a few years. A culvert is another tool or option that may be more appropriate than the standard bat gate structure.

Published information on the design and construction of culvert closures is sparse. Bats and Mines Resource Publication (Tuttle and Taylor, 1998) of Bat Conservation International (BCI) contains two pictures of the use of culverts as bat friendly closures and Appendix III contains a drawing showing how a cage assembly can be attached to a vertically placed culvert in a shaft. The "Handbook for the Remediation of Abandoned Mine Lands" (Robinson) mentions the use of culverts as part of a backfill closure and gives minimal details. The Neda Mine in Wisconsin was closed using culverts (Tuttle). The Vindicator Mine in Montana was closed with a culvert (Hargrave and others, 2000). The Mine Waste Cleanup Bureau of the Montana Department of Environmental Quality installed culvert gate systems in four mine portals in western Montana in 1996 (Hendricks, 1999). The National Park Service has installed several culverts for mine closures including the Mariscal Mercury Mine in Texas (Burghardt, 2000 and communication with Linda Dansby and others). A vertical culvert with a ladder was also placed to provide access as an alternate entrance to the Talache Mine in Idaho when the main portal was closed (personal experience). The New Mexico Mining and Minerals Division of the Energy, Minerals and Natural Resources Department has installed several culverts (communication with John Kretzmann). In 2001, the Stanislaus National Forest in California installed a 30-inch culvert in a near vertical shaft using foam for backfill (communication with Karren Nuni). The BCI website show culverts configured in an

attempt to create an artificial bat habitat at Solutia's (formerly Monsanto) Soda Springs Mine in southern Idaho (http://www.batcon.org/mines/mining.html). Indiana Karst Conservancy has installed culverts on the Hoosier National Forest (communication with Keith Dunlap) and the Indiana Department of Natural Resources has photos of culverts installed with heavy equipme nt on their web site at: (http://www.mcrcc.osmre.gov/Indianapolis/Bat%20Gate/553/index.htm).

Culverts have been used for stabilizing and controlling access to cave entrances for many years. Hathorn and Thornton, suggest a culvert sloped inward as an effective way to reduce breaching a cave closure device. Access and airflow to the Lechuguilla Cave in New Mexico are controlled through a 36-inch smooth-wall stainless steel culvert, with a ladder and air lock, which replaced a culvert installed in the mid 80's that was corroding (communication with Dale Pate of the National Park Service). An 18-inch culvert, steeply sloping inward, used to control access to the lower entrance of Papoose Cave on the Nez Perce National Forest in Idaho was installed about 1970 and still serves as an effective access control (personal experience and communication with Tom Miller and with the Salmon River Ranger District). Access control culverts i nstalled in the 1980's in the ARCO Tunnel and the Pot of Gold Caves in Southern Idaho have been removed recently (communication with Jim Hathorn). An artificial entrance to the Spring Valley Caverns in Minnesota (Ackerman) was recently constructed with th e use of a vertical culvert and a ladder. Artificial caves entrances on the Tonto National Forest in Arizona that were created by road construction were fitted with culverts and air locks to control access and air flow (communication with Jerry Trout). T he collapsing portal structure to an artificial entrance through a mine adit into the Fulford Cave on the White River National Forest in Colorado was stabilized with a 36 inch diameter culvert without access control in the late 1980's by the Colorado Cave Survey (communication with Bill Johnson).

A general lack of monitoring and scientifically rigorous data for bat use at culvert installations has lead to some conflicting opinions. The bat friendliness of culvert closures is in question by some. Bat Co nservation International does not necessarily endorse the use of culverts as being bat friendly. Culvert length and size may affect bat use. Hendricks found bats continued to use four mines in Montana after culvert closures. Kirk Navo (communication) fo und reduced bat use for culverts longer than 10 feet. Rick Sherwin (communication) found continued use at over 90 percent of those culverts he monitored. Barry Keller (communication) found no bat use at one site in North Idaho that had abundant use prior to closure. The little monitoring for the above closures is inconclusive at this time as to any of these factors.

Materials

Culvert materials include corrugated steel, stainless steel with smooth walls, corrugated aluminum, plastic (both corrugated a nd smooth wall), and concrete. Corrugated plastic is made from polyethylene. Corrugated steel is generally least expensive for diameters over 24 inches. Some biologists believe bats prefer smooth wall culverts to corrugated walls. Polyethylene liners have also been installed inside steel culverts to create a smooth

surface. Gunite (grout shot onto a surface) may be used to add a rock like texture to the inside of culverts. Aluminum and plastic are lighter and are used when the culverts are moved by hand. Stainless culverts have smooth walls (without corrugations) and have been used at Lechuguilla Cave and other locations. The Bat Conservation International, Bats and Mines Resource Publication Number 3 illustrates the use of a concrete culvert.

Corrugated steel culverts come in a variety of corrugation patterns and steel thicknesses (gage) and shapes. Generally the lighter gage and less expensive culverts will be adequate. An engineer should be involved in specifying for the application if there is any question. The author has exclusively used round culverts. Pipes arches, simple arches with foundations and other shapes may be worth considering for some applications.

Installation Methods

The basis of the remainder of this paper is mostly the author's experience since 1996 in North Idaho and Northeast Washington with the installation of 32 culvert closures on lands managed by the Idaho Panhandle National Forests, the Colville National Forest, the Okanogan National Forest, and the Idaho Department of Lands. Twenty-nine of these closures were nearly horizontal.

The steps of the installation are to excavate a foundation or bed, place the culvert in the bed, install the closure device and backfill. The bed may be level or sloped in or out depending on the purpose of the culvert. The culvert may be placed with the closure device pre-installed or the closure device may be installed after the culvert is placed.

Culverts may be prepared prior to placement by cutting holes for the closure bars and/or beveling the ends. The backfill should be blended to the surrounding topography and back-slopes or culvert ends. Compaction during backfill reduces future settling and helps stabilize the installation.

The closures installation may be by hand or with heavy equipment. Hand closures are best for remote sites or when the minimum disturbance is required. The author has installed culverts up to 54 inches by hand. Heavy equipment is economical and works well for moving culverts.

There are a number of ways to move culverts from the delivery point to the site. Excavators are effective for sites that are accessible and not far from the culvert delivery point. All terrain vehicles pulling a trailer loaded with a culvert and dragging them with a SUV can be more economical than an excavator. The author has effectively moved culverts with helicopters for eight remote installations. The bed needs to be completed prior to flying in the culvert.

A tracked excavator is the most versatile for most jobs and can be used in conjunction with access improvements and rehab work. An excavator has even been used to build an access road to a remote site and then to obliterate it in the same day.

Pre-assembly reduces field installation time for most sites. To reduce construction costs and avoid the need to have welding equipment at the installation site, weld and assemble the closure device off-site. For remote sites a culvert can be installed entirely with hand tools if the closure device is pre-assembled within the culvert and the entire assembly is flown in with a helicopter.

The author has placed only two culverts in vertical shafts. An excavator jammed the culverts into tapering solid material. Spaces between the culvert and the rock need to be small for this to work. In one case the culvert end was pre-shaped to fit the rock. The other culvert was fitted with a bracket to assure a good stable fit. Carefully estimating the culvert size and length helps to obtain a good fit. The author has used polyurethane foam to fill voids with solid material and then backfilled with native material. The use of other techniques, concrete collars, and the installation of cupolas to the culverts are beyond the scope of this paper.

Closure Devices

For most mines and caves, a culvert needs a closure device to control human entry. Several cave culverts have no closure devices. Closure devices can be installed internally within the culvert or internally underground beyond the culvert end, or externally outside the culvert. An internal device may be a conventional gate installed inside the mine or cave beyond the inside end of the culvert. In this case the purpose of the culvert is usually as a retaining structure. Airlocks are usually solid steel plates installed to reduce or prevent air exchange. A removable bar or a gate allows access. For some installations access is not needed.

The author prefers internal devices with round bars installed through holes that are precut through the culvert. The round bars vary in diameter depending on the design standard. Vertical plates can be added to maintain separation distances between the bars and to provide overall strength and integrity to the closure device and provide for a removable bar. Figures 1 and 2 illustrate the design currently used by the Idaho Panhandle National Forests for 54-inch diameter culverts with a removable bar for access. This design, constructed of managanal, is able to withstand approximately 2000 lbs of force in any direction. Figure 3 shows a typical closure used by the author. A similar design with smaller steel can be used for remote sites that are less likely to be vandalized. The closure device is placed inside the culvert about midway between the ends so that the top bar has a minimum of 24 inches of cover over it.

Other internal devices include a spider lock made from rebar used at Papoose Cave and internal angle iron gates and bars attached to frames. The New Mexico Mining and Minerals Division have installed octagonal frames from 3/8-inch plate that is bolted and grouted to the culvert (Figure 4). The bars that are attached to the frame can be angles, rectangular, or round.

A variety of external closure devices are possible. Figure 5 shows one used on the Idaho Panhandle. It consists of two vertical members with horizontal bars and is not anchored

(unattached) to the culvert but is supported by its frame in the fill below the culvert bed. The bed for the frame should be well compacted to avoid settlement. The bars may be angle iron or rectangular tubes. One or more of the bars may be removable. In Figure 6, a swinging gate is attached to a wooden portal structure. In Figure 7, the closure device is attached directly to the culvert with bolts.

The author prefers manganal steel round bars for most closures. Manganal work hardens when its surface is abraded or impacted. The surface becomes harder and is nearly impossible to cut with a hacksaw. It can be cut with a grinder and with power saws that are aggressive enough to cut into new metal beyond the work hardened surface with each pass of the tool.

Selection of a Culvert

For mine closures, the selection of a culvert over a conventional bate gate (steel structure) is generally a safety consideration. When the stability of the portal area is questionable, a culvert is a logical choice. Other considerations include security, maintenance, visual impacts, costs, environmental effects, and bat acceptance.

A culvert can be a bat friendly alternative to an earth plug. If the portal is unstable and/or working in the portal area is not safe, then a culvert closure is a reasonable alternative to constructing or reconstructing a portal structure. For most mines, a bat gate structure closure should be installed at a location as near the entrance as practicable in order to minimize the hazard of exposure to those who may enter the underground workings up to the closure. If the decision maker or manager is unwilling to accept some risk by having a portion of the underground workings accessible, then installing a culvert or constructing a portal structure may be the only alternatives that are bat friendly. Culverts cost less than portal structures and are generally more permanent than a bat gate structure that is installed beyond an unstable portal area.

The existence of a portal structure is a sign that a culvert closure may be a reasonable alternative. Portal structures were built to retain unstable material and to protect mine workers from falling rocks and material. Many portal structures were made from untreated wood and structural members may rot rapidly. A culvert serves as a replacement portal structure for stabilizing the portal. However the author has removed several portal structures and opted not to use culverts and installed a more conventional gate structure instead.

Another consideration is the visual impact of the closure. The author has installed two culverts within two hundred feet of Lake Pend O'Reille. The mine opening prior to culvert installation were somewhat hidden from the lake and did not draw attention. After culvert installation the sites were more visible. Attraction to the site can increase visitation, increase the chance of vandalism, and increase the chance of an accident or injury. This risk needs to be considered in the selection decision.

Construction costs of culvert closures vary. A typical 54 -inch diameter by 14 foot length culvert installed with an excavator by a contractor costs about $3000. Remote sites usually require a helicopter to move ma terials and installation equipment typically adding about $1000 to $1500 to the cost. The total project cost should not only include the construction, but also include planning, environmental documents, monitoring, contract preparation and administration, and overhead. For the author's projects, the percentage of the non-construction costs has increased significantly to about 50 percent of the total, as more people are involved in project planning, monitoring, and environmental documents. Intensive monit oring can easily exceed construction costs.

A change in airflow is more likely with a culvert than with a typical steel structure. The resulting change in airflow may affect temperatures and be detrimental to habitat.

Another selection criterion is ma intenance. How susceptible is the closure to vandalism and breaching? Culverts may be somewhat less susceptible to vandalism than conventional gates. Selecting an appropriate closure device may reduce vandalism and breaching. How will caving, and sloug hing effect the structure and what provisions should be made for corrosion that may shorten its life?

Details

Culvert diameters generally used for mine closures diameters are greater than 18 inches. The author does not consider diameters less than 36 in ches to be bat friendly. The culvert should be as large as possible and still fit within the opening. The smaller diameters may be used for ventilation or for an escape entrance for wildlife for an earth plug closure. The most common size used by the aut hor is 54 inches.

Matching the existing opening size and location reduces the chance of changing the airflow and internal temperatures. Sizing the culvert as large as practicable to fit into the excavated opening and constructing the bed so that the cent er of the culvert will be close to the centroid of the existing opening reduces the chance of adversely disrupting airflow. Generally adits that need culverts are: unstable, in the process of collapsing, and have a berm of material that has been caved at t he portal. Often this berm acts as a cold air dam and should not be completely removed. If the berm is removed to accommodate the culvert, consider should be given to sloping the culvert into the workings to create a cold air dam within the culvert to si mulate the existing cold air trap. Sloping the culvert inward also reduces the length of culvert required.

The length of culvert needed can be estimated by measuring at the site. This length includes the beveled portions. A rule of thumb for minimum le ngth is twice the diameter plus 3 feet. The length depends on: how the backfill is placed, the type of backfill material, the steepness of the slope above the site, and how well the culvert fits into the opening. A tight fitting culvert can be shorter.

Culverts that steeply slope inward with internal closure devices may be more difficult to breach. An inward slope traps cold air. An elevated bed traps cold air. If multiple

entrances are involved, then the slope of the culvert may be of less importance than the size of the culvert in maintaining airflow.

A beveled outside end provides a larger area for the culvert to move air and also conforms closely to the final back-slope without projecting into the air. Since less of the culvert is visible, people are less likely to notice it or be drawn to it. The bevel angle should match the back-slope angel and be 45 degrees or flatter unless a retaining structure is used. The bevel can be cut with a torch (for steel) or a chain saw (for polyethylene) at the same time that holes for the closure device are cut. The inside end of the culvert can also be beveled to obtain a better fit. Bevels may not be desirable for: steeply sloping installations, where retaining structures are used, or with some external closure devices.

Many adits have water dammed behind a sloughed portal area. Decisions about maintaining the water level and its biological value need to be made prior to excavating the bed. Provisions for wet installations include galvanizing for reduced corrosion and adding drainpipe. Drainpipe should be installed first on a constant grade below the bed and be long enough to accommodate the bed (typically at least 15 feet longer than the culvert). The author has used 4-inch diameter PVC and corrugated poly pipe as drainpipe.

Maintenance

Vandalism on culvert installations in North Idaho has been limited to one site on the cupola over a 54-inch vertical culvert at Bethlehem Mine shaft. The grating on the top of the cupola appears to have been vandalized and partially torn off with a pry bar. The vandalism was repaired by removing the grate and replacing it with 4 inch by 4 inch by 3/8-inch angle iron with both legs down and spaced 4 inches apart. No one has attempted to dig under or around culverts or attempted breach by digging down to the top bar. Breach by hand digging is difficult when the fill consists of a well-graded compacted mixture of dirt and rocks. Heavy equipment, torches, high force jacks and explosives will defeat the designs, but the designs are quite resistant to hack saws, car jacks, and hand winches.

Maintenance resulting from dirt and rock caving and sloughing and from corrosion will probably be a bigger long-term problem than vandalism at most sites. Most sites in North Idaho and Northeast Washington are humid and contain water on the floor at least part of the year. Corrosion can be accelerated in water or especially in a partially submerged environment. Steel culverts come galvanized. Care is needed to protect damaged surfaces, newly cut holes, and beveled cuts on steel culverts. Proper zinc repair can significantly prolong the long-term service life of steel culverts. Most Idaho Panhandle sites have zinc coated closure devices. Stainless steel, polymer coated, and bituminous coated culverts are also good solutions in corrosive environments.

Summary

Culvert use for mine closures has been uncommon until recently and references for design and construction are sparse. Culverts for cave access control and stabilization has occurred for many years. Bats appear to use culverts but monitoring is insufficient to draw final conclusions. Culvert materials include: corrugated steel, stainless steel with smooth walls, corrugated aluminum, plastic (both corrugated and smooth wa ll), and concrete. The most common material is corrugated steel. Installation includes: excavating a foundation or bed, placing the culvert and closure device, and backfilling. Excavation can be by hand or with heavy equipment. Materials can be moved w ith vehicles, heavy equipment, or helicopters. Closure devices include internal bars and external structures. Both may have removable bars for access. For mines, the most common use of culverts is for unstable portal areas that often were once supported by a portal structure. Considerations in selecting a culvert as an alternative to conventional steel closure structure include: safety, visual appearance, long -term stability, costs, acceptance by bats, and maintenance. A typical 54 -inch diameter by 14 foot length culvert installed with an excavator by a contractor costs about $3000. Caving and sloughing of dirt and rock and corrosion will probably be a bigger long -term maintenance problem than vandalism at most sites. Construction details are importa nt to reduce corrosion in humid environments.

References

Ackerman, J., *The Cave Farm - a Minnesota Karst Preserve.* NSS News, April 2001.

Burghardt, J.E., *Bat-compatible Closures of Abandon Underground Mines in the National Park System*, Office of Surfac e Mining Technical Interactive Forum: Bat Conservation and Mining (St. Louis, Missouri), November 2000.

Hathorn, J., Thornton, J., *A common Sense Guide to Cave Gates*, American Cave Conservation Association, Cave Management Series, Volume 1 Number 3, August 1986.

Hargrave, P.A., Metesh, J.J., and Oravetz, S, *Using Recharge Control to Reduce Mine Adit Discharges*: A Preliminary Investigation.2000.

Hendricks, P., *Effect of Gate Installation on Continued use by Bats of Four Abandon Mine Workings in western Montana,* A report to the Montana Department of Environmental Quality, Helena Montana. 1999.

Robinson, R.H. *Handbook for the Remediation of Abandon Mine Lands*, Prepared for the National Park Service 1992.

Tuttle, M., *Wisconsin Gains Key Bat Sanctuary*, Bats, Volume 14, No 4, Winter 1996.

Tuttle, M., and Taylor, D. A. R., *Bats and Mines*. Bat Conservation International Resource Publication Number 3., 50pp, 1998.

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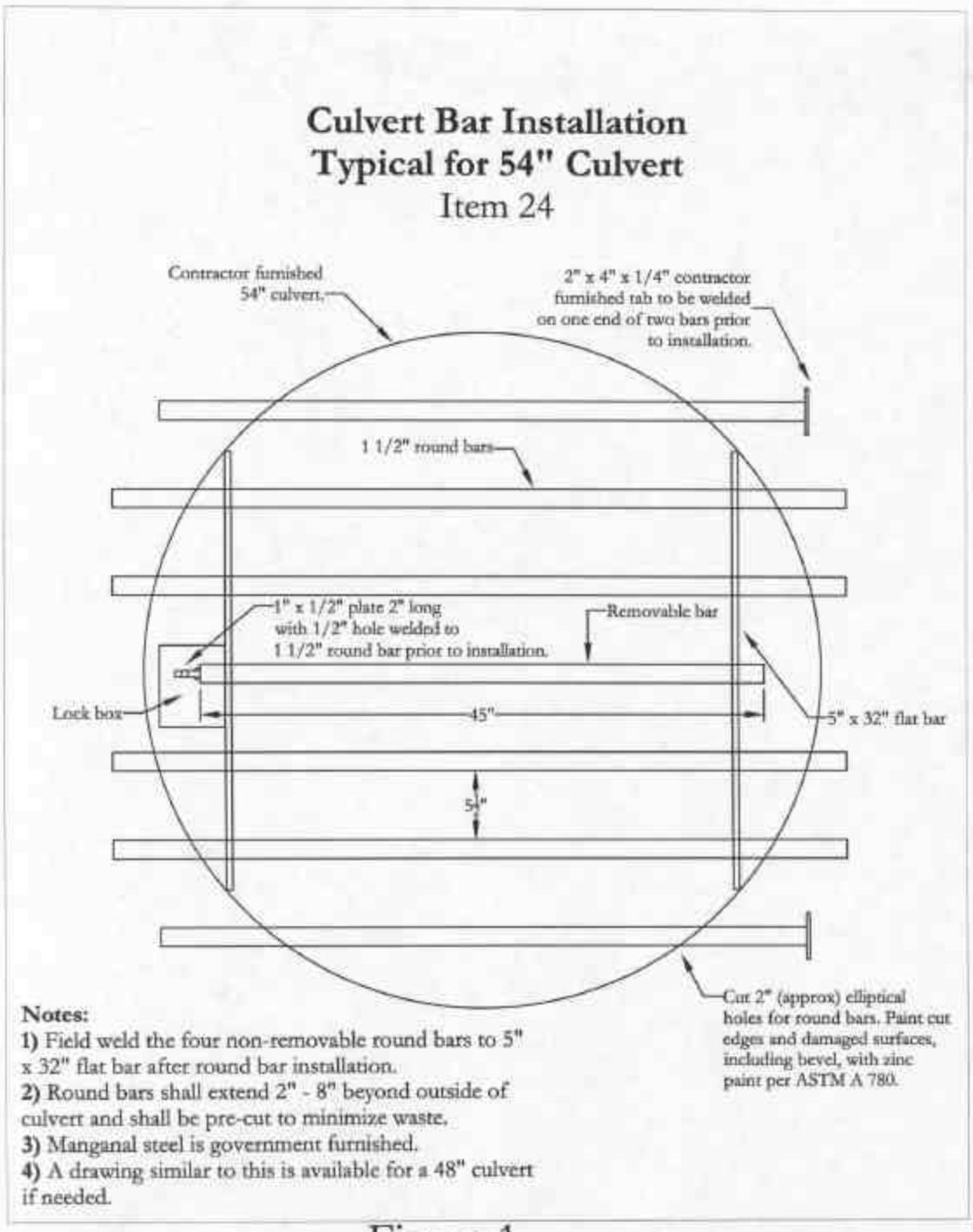

Figure 1. Culvert Bar Installation

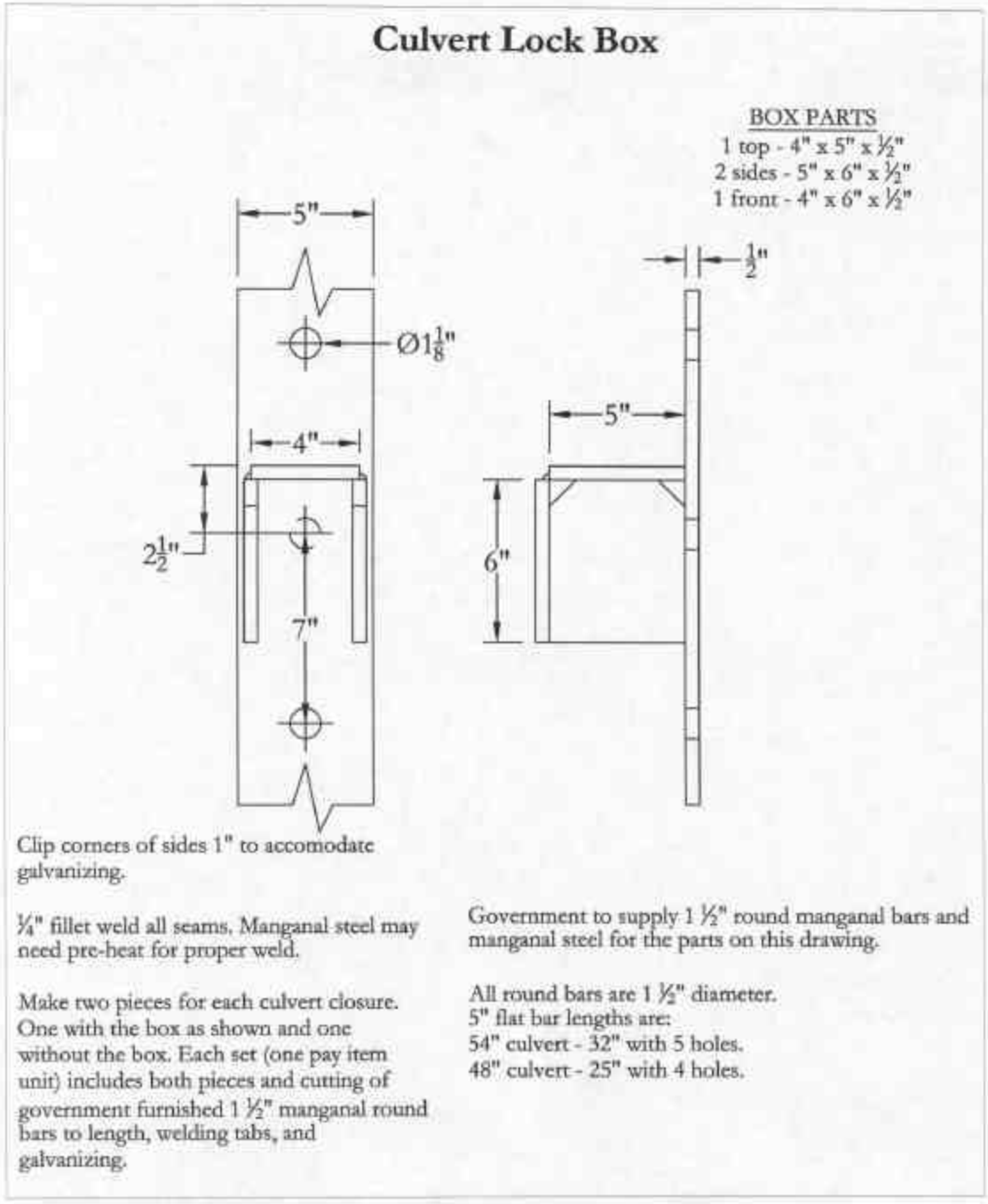

Figure 2

Figure 2. Culvert Lock Box

Figure 3. Typical Idaho Panhandle Internal Closure

Figure 4. Internal Hexagonal Frame with Rectangular Bars

Figure 5. External Frame Closure

Figure 6. External Gate Attached to a Wooden Portal

Figure 7. External Closure Attached Directly with Bolts

APPENDIX 1
JOB HAZARD ANALYSIS FORM

FS-6700-7 (3/98)

U.S. Department of Agriculture Forest Service	1. WORK PROJECT/ACTIVITY	2. LOCATION	3. UNIT
	Underground workings entry	Idaho Panhandle National Forests	IPNF SO
JOB HAZARD ANALYSIS (JHA) References-FSH 6709.11 and -12 (Instructions on Reverse)	4. NAME OF ANALYST	5. JOB TITLE	6. DATE PREPARED
	Jim Langdon	Civil Engineer	May 3, 1999

7. TASKS/PROCEDURES	8. HAZARDS	9. ABATEMENT ACTIONS Engineering Controls * Substitution * Administrative Controls * PPE
*Underground entry of abandoned mine workings for habitat assessments and gate measurements.	Portal Entry and all underground workings.	Workings deemed safe to enter and work in by qualified certified mineral examiner (CME). Notify dispatch or office before entering and upon leaving mine. Follow CME's lead throuout. *Personal Protective Equipment:* Hardhat, three light sources, proper footgear (mine boots w/ steel toe), safety glasses recommended, dust masks if conditions warrant.
Gate installations and closures	Bad air (O2 deficiency, high O2 conc., CO, CH4, NO2, and Radon	Qualified CME will be equipped with a multi-gas continuous monitor with visual displays of gas conc., warning lights, and audible alarms. All workers will immediately evacuate upon alarm or first sign of symptoms for bad air inhalation (i.e. headache, dizziness, slurred speech, nausea, etc.)
	Falling (winzes, inclines, raises & approaches)	Recognize, avoid, lead person points out & probe. For approaches, practice and stay fit.
	Explosives	Recognize and avoid. Suspected explosives will not be handled. All workers will be evacuated and certified blaster will be notified.
	Rotted timbers, chutes, posts, and collapse zones	Avoid if possible, Don't touch timbers and posts. Consider not going on. Know when to turn back.
	Pools of water	Lead to probe standing water. Know when to turn around. Wear mining boots of appropriate height.
	Disorientation	Remain in contact with party. Pay attention. Note landmarks.
	Hypothermia	Dress appropriately, bring extra clothes, use PPE.
	Wildlife	First aid kit, Maintain first aid skills. Don't disturb or handle bats without pre-rabies inoculations. Use rubber gloves if touching nests and droppings. Use respirator if dusty around nests and droppings.
	Poison plants	Recognize and avoid poison plants. Know first aid.
	HazMat and alien materials	Recognize, avoid, and report.
	Possible booby traps	Recognize, turnaround and leave.
	Heavy equipment	See JHA for working around heavy equipment.
	Injury from handling heavy steel parts	Know and practice proper lifting & carrying. Maintain safe working areas and distances around others. Use PPE (including gloves)
	Burns from hot metal	Be aware of hot metal. Cool with water. Use gloves. Know first aid.
	Dust, fumes and UV, & noise from hammers & welding & paint	Use hearing protection, ensure adequate ventilation, and use appropriate eye protection and respirators as needed.

10. LINE OFFICER SIGNATURE	11. TITLE	12. DATE

Previous edition is obsolete

(over)

FS-6700-7 (3/98)

U.S. Department of Agriculture Forest Service	1. WORK PROJECT/ACTIVITY **Underground Entry-Abandoned**	2. LOCATION **Your National Forest**	3. UNIT **Yours**
JOB HAZARD ANALYSIS (JHA) References-FSH 6709.11 and -12 (Instructions on Reverse)	4. NAME OF ANALYST **Ican Findem**	5. JOB TITLE **Certified Mineral Examiner**	6. DATE PREPARED **Current Date**

7. TASKS/PROCEDURES	8. HAZARDS	9. ABATEMENT ACTIONS Engineering Controls * Substitution * Administrative Controls * PPE
***Underground entry of abandoned mine workings**	**Portal Entry**	**Workings deemed safe to enter by qualified certified mineral examiner (CME). Three person team (at least one a qualified CME)-- One person will remain at entrance. Notify home office before entering and upon leaving mine. *Personal Protective Equipment:* Hardhat, MSHA approved lighting, proper footgear (muckers or work boots w/ steel toe), safety glasses recommended, dust masks if conditions warrant.**
	Bad air 1) O2 deficiency 2) High O2 conc. 3) CO 4) CH4 5) H2S 6) Radon	**Qualified CME will be equipped with a multi-gas continuous monitor with visual displays of gas conc., warning lights, and audible alarms. All workers will immediately evacuate upon alarm or first sign of symptoms for bad air inhalation (i.e. headache, dizziness, slurred speech, nausea, etc.)**
	Falling Hazards 1) Winzes 2) Raises	**Qualified CME is lead person, who will point out all underground openings to avoid.**
	Explosives	**Suspected explosives will not be handled. All workers will be immediately evacuated and certifed blaster will be notified.**
	Pools of water	**Qualifed CME will lead to probe standing water.**
	Disorientation	**Must remain in voice contact w/ qualified CME.**
	Wildlife	**First aid kit**
	HazMat	**Suspect hazmat will not be handled. Make note of any markings & notify safety officer.**
	Changes	**Qualified CME constantly checks for changing conditions (rock stability, airflow changes).**

10. LINE OFFICER SIGNATURE	11. TITLE	12. DATE

Previous edition is obsolete

(over)

FS-6700-7 (3/98)

U.S. Department of Agriculture Forest Service	1. WORK PROJECT/ACTIVITY **Poly Urathane Foam Installation**	2. LOCATION **IPNF**	3. UNIT **Ipnf**
JOB HAZARD ANALYSIS (JHA) References-FSH 6709.11 and -12 (Instructions on Reverse)	4. NAME OF ANALYST **Jim Langdon**	5. JOB TITLE **Civil Engineer**	6. DATE PREPARED **July 14, 1998**

7. TASKS/PROCEDURES	8. HAZARDS	9. ABATEMENT ACTIONS Engineering Controls * Substitution * Administrative Controls * PPE
Poly Urathane Foam Installation (Includes both separate components and after mixing)	**Depleted O2. Displaced with N2 and CO2 from cure.**	**Monitor O2 with meter. Provide ventilation or evacuate until O2 is adequate. Have a copy of the MSDS available on site.**
	Excessive MDI	**Wear MSHA/NIOSH respirator with correct cartridge while working in confined spaces.**
	Eye irritant	**Wear full closure protective glasses.** **Provide eye flush at site.**
	Skin irritant	**Wear protective clothing to protect skin and protect clothes from contamination. Protective clothing to include Tyvek suit, hard hat and long rubber gloves and booties.** **Use extra care during handling and installation to avoid spills on clothes, skin and protective gear.** **If skin contact occurs, wash thoroughly with soap and water.**
	Hazardous gases from combustion	**Reduce potential for combustion by installing after all cutting, welding and torching are completed and cooled down.** **Don't smoke in the area.** **Move up wind if a fire starts. See MSDS or JHA for fire fighting hazardous measures.**
	Ingestion	**Practice good hygiene. Never eat, drink or smoke in work areas.** **If ingested, give water or milk. Do not induce vomiting.** **Avoid punctures to the chemical component containers while mixing and placing.** **Collect all contaminated PPE and place in a plastic bag and dispose of properly.**

10. LINE OFFICER SIGNATURE	11. TITLE	12. DATE

Previous edition is obsolete

(over)

JHA Instructions (References-FSH 6709.11 and .12)

The JHA shall identify the location of the work project or activity, the name of employee(s) involved in the process, the date(s) of acknowledgment, and the name of the appropriate line officer approving the JHA. The line officer acknowledges that employees have read and understand the contents, have received the required training, and are qualified to perform the work project or activity.

Blocks 1, 2, 3, 4, 5, and 6: Self-explanatory.

Block 7: Identify all tasks and procedures associated with the work project or activity that have potential to cause injury or illness to personnel and damage to property or material. Include emergency evacuation procedures (EEP).

Block 8: Identify all known or suspect hazards associated with each respective task/procedure listed in block 7. For example:

a. Research past accidents/incidents.

b. Research the Health and Safety Code, FSH 6709.11 or other appropriate literature.

c. Discuss the work project/activity with participants.

d. Observe the work project/activity.

e. A combination of the above.

Block 9: Identify appropriate actions to reduce or eliminate the hazards identified in block 8. Abatement measures listed below are in the order of the preferred abatement method:

a. Engineering Controls (the most desirable method of abatement). For example, ergonomically designed tools, equipment, and furniture.

b. Substitution. For example, switching to high flash point, non-toxic solvents.

c. Administrative Controls. For example, limiting exposure by reducing the work schedule; establishing appropriate procedures and practices.

d. PPE (least desirable method of abatement). For example, using hearing protection when working with or close to portable machines (chain saws, rock drills, and portable water pumps).

e. A combination of the above.

Block 10: The JHA must be reviewed and approved by a line officer. Attach a copy of the JHA as justification for purchase orders when procuring PPE.

Blocks 11 and 12: Self-explanatory.

Emergency Evacuation Instructions (Reference FSH 6709.11)

Work supervisors and crew members are responsible for developing and discussing field emergency evacuation procedures (EEP) and alternatives in the event a person(s) becomes seriously ill or injured at the worksite.

Be prepared to provide the following information:

a. Nature of the accident or injury (avoid using victim's name).
b. Type of assistance needed, if any (ground, air, or water evacuation).
c. Location of accident or injury, best access route into the worksite (road name/number), identifiable ground/air landmarks.
d. Radio frequencies.
e. Contact person.
f. Local hazards to ground vehicles or aviation.
g. Weather conditions (wind speed & direction, visibility, temperature).
h. Topography.
i. Number of individuals to be transported.
j. Estimated weight of individuals for air/water evacuation.

The items listed above serve only as guidelines for the development of emergency evacuation procedures.

JHA and Emergency Evacuation Procedures Acknowledgment

We, the undersigned work leader and crew members, acknowledge participation in the development of this JHA (as applicable) and accompanying emergency evacuation procedures. We have thoroughly discussed and understand the provisions of each of these documents:

SIGNATURE DATE	SIGNATURE DATE

APPENDIX 2
UNDERGROUND ENTRY NOTIFICATION/AUTHORIZATION AND FINDING OF NECESSITY FOR ABANDONED MINE INVENTORY/REMEDIATION

1. Who is scheduled to go underground/purpose:
Jim Langdon Paul Mack, and Jim Robbins and Jay Price for preclosure assessments and contract closure inspections.

Attendant: **Jim Robbins** QSL (BLM safety lead)/QCME (Forest Service safety lead): **Jim Robbins**.

2. Name/Location of mine site(s) - see attached map(s):

Copper Camp adits and North Fork Adits. Maps are in original map package sent in May. Note that communicatons with dispatch from these locations is difficult. There may be delays between entry or exit times and communications with dispatch because we may need to relocate to communicate.

3. Scheduled date & time: August 21, 2001 late morning to evening.

4. Radio contact: Immediately prior to going underground dispatch will be contacted by radio (CDA frequency) or cell phone and advised of the number of people and expected time underground. When coming out from underground the dispatch will again be notified. As a backup, in the event that communication is not possible or unclear, the front desk will be notified by a phone call no later than **Two hours after late exit time** . to avoid unnecessary emergency agency contact.

5. Additional information:

6. In case there has been no communication to confirm that everyone has come out from underground, and the pre-arranged backup time has passed for a phone call, then first notify the District Ranger/Area Manager (or acting) prior to contacting the emergency agencies. There is good reason to suspect that persons going underground may have forgotten to call,or lost track of time, by the appointed deadline so: 1) first try to call them on the radio or phone and if no contact 2) send someone to the site to verify if there really is an emergency, not to go underground, but to see if their vehicle is still at the mine site and make a determination (i.e. caved portal, vehicle at site) before actually calling emergency personnel. If QSL/QCME failed to make communication confirmation: **mandatory next day bakery-fresh donut penalty for entire dispatch office - no excuses, no whining!**

7. In case of a **verified** emergency related to underground entry contact both:
   1. Sheriff's Office : 556-1114 Shoshone Co. or 664-1511 for Kootenai Co.
   2. Mine Rescue: 556-2225

SUBMITTAL/APPROVAL SIGNATURES CERTIFY COMPLIANCE W/BLM/FS POLICY

Submitted by:_____ Approved by:_____.
Date:_____ Staff Officer/District Ranger
Date:_____

PROTECTING CAVE BAT POPULATIONS WITH FLYOVER BARRIERS

D. Blake Sasse
Arkansas Game and Fish Commission
Little Rock, Arkansas

Abstract

Prevention of human disturbance to bats roosting in caves and mines is a primary management goal for cave bat populations. Angle-iron bat gates placed across cave passages have become the standard method of controlling unauthorized visitor access to these sites. However, these structures may not always be appropriate due to the physical dimensions of the passageway, construction costs, or the bat species using the cave. Flyover barriers are an alternative method of protecting bat caves that include chain link fences with barbed wire outriggers, vertical steel bar fences, and half gates. A mail survey of bat cave surveyors and managers was conducted in 2001 to determine the construction costs, maintenance needs, and effectiveness of flyover barriers in reducing human entry into the caves and in bat population recovery. Twenty-six chain link fences, seven vertical steel bar fences, and seven half gates have been used at 37 caves in nine States. Chain link fences were inexpensive to build but required more routine maintenance than vertical steel bar fences. The cost of half gates is also high, but is the only suitable option when a flyover barrier must be placed inside the cave. All three designs reduced disturbance and bat populations increased at caves where they had been placed.

Introduction

Several bat species that live in caves and mines have suffered population declines over the last 30 years. Often, this is due in part to both intentional and unintentional harm caused by humans entering these sites during periods when they are inhabited by bats (Pierson 1999). Efforts to restore populations of endangered species such as the Indiana bat (*Myotis sodalis*) and gray bat (*Myotis grisescens*) have focused on preventing human access to caves. A standard bat gate design consisting of horizontal angle-iron bars with 5 ¾" of space between bars has been developed that is greatly resistant to forcible entry by humans, causes minimal changes to cave microclimate, and allows bats to freely enter and exit these caves (White and Seginak 1987; Nieland 2001).

Standard bat gates provide the greatest degree of protection to caves, but may not be appropriate for use at some sites. Large horizontal entrances may require bat gates of such height or width that costs become prohibitive while gates placed at caves with entrances less than 5' in diameter may restrict airflow to such an extent that the internal microclimate of the cave is altered (Tuttle 1977). Bat gates can be adapted for use as cupolas over small vertical cave entrances or mineshafts, but may not be practical when the entrance is over 20' in width (Tuttle and Taylor 1998; Nieland 2001).

Certain species, such as the gray bat, Brazilian free-tailed bat (*Tadarida brasiliensis*), and Lesser long-nosed bats (*Leptonycteris curasoae*) may not fully accept standard bat gates that cover the entire passageway or entrance to a cave (White and Seginak 1987; Burghardt 2000, Currie 2000). At Blackwell Cave, Missouri, a gray bat summer colony abandoned the cave after a bat gate (round bar design) was built at the entrance, but returned after this gate was replaced with a flyover barrier (R.L. Clawson, Missouri Department of Conservation, Columbia, Missouri, personal communication, 2002). Placement of the standard bat gate in the dark zone of the cave, 10-56' from the entrance, has proven successful at gray bat summer caves in Oklahoma; however, at Colliers Cave, Alabama gray bats abandoned the portions of the cave behind an internal gate and populations declined until the gate was removed (Martin et al. 2000; Henry 1998). Another attempt to use this technique at Logan Cave, Arkansas, produced mixed results; emergence counts declined by about 50 percent in the three summers after an internal bat gate was built, but population estimates based on the size of guano piles in the cave have almost doubled (Harvey and Redman 2001; S.L. Hensley, U.S. Fish and Wildlife Service, Tulsa, Oklahoma, personal communication, 2002).

When it is not feasible or appropriate to install a standard bat gate, flyover barriers may be used as an alternative method of preventing unauthorized human access to caves. As the name implies, flyover barriers allow bats to enter or exit the cave by flying over the barrier that keeps humans out. Flyover barriers include chain link fences with barbed wire outriggers or vertical steel bar fences placed at or around cave entrances, and half gates placed inside cave passageways. Half gates are standard bat gates that block only the lower portion of a passageway, and allow bats to fly between the structure top and the ceiling (Nieland 2001).

Flyover Barrier Survey

A mail survey was sent to bat biologists and to State and Federal natural resource agencies in late 2001 to obtain information on sites protected by flyover barriers. Respondents were asked to describe the type of barrier used, construction costs, changes in patterns of unauthorized entry, and bat population response after barrier construction. Surveys were returned for barriers at 37 caves in nine States. Chain link fences have been used at 26 caves in Alabama, Arkansas, Indiana, Kentucky, Maryland, Missouri, Nevada, Tennessee, and West Virginia. Vertical steel bar fences are found at seven caves in Arkansas and half gates are in use at seven caves (three of these replaced chain link fences also included above) in Missouri. Recommendations for flyover barrier use are based on survey responses.

General Fence Considerations

Prior to the construction of chain link or vertical steel bar fences, observations should be made to determine the normal flight path used by bats so that the planned barrier will not obstruct these routes. Fences around vertical entrances should be set back from the cave a distance equal to at least twice the height of the fence. As bats cannot easily pass through fences, these designs should generally not be used inside horizontal cave

entrances and if a flyover barrier is necessary inside a cave, a half gate is much more desirable. Natural topography and vegetation should be used as a screen between the fence and areas used by the public in order to lower barrier visibility. Painting the fence to blend in with the site will also help avoid attracting undue attention to the cave. Vertical steel bar fences are more resistant to damage than chain link fences and should be used in remote areas where routine patrols are not feasible.

Chain Link Fences

Chain link fences provide the most inexpensive means to physically protect bat caves from human disturbance. Recently constructed fences in Kentucky and Nevada cost $15 and $17.50/linear foot while Ludlow and Gore (2000) reported a cost of $10/linear foot at a Florida cave. Fences should be at least 8-12' in height with an additional 1-2' of outward-facing barbed wire outriggers on the top. Though fences less than 8' in height or without barbed wire outriggers may prevent accidental entry into vertical shafts or sinkholes, they do not present a significant impediment to intentional cave entry and should not be used when bat protection is desired. The base of the fence should be set 6" below the surface in order to prevent people from crawling or digging underneath. Posts should be set in concrete, but doing so to the entire base of the fence may make repairs difficult (Tuttle 1977). If digging underneath the fence is a continuing problem, steel rods, at least 6" long, can be driven into the bottom of a shallow trench in front of the fence and then the trench filled with concrete. Additional hindrances to those trying to climb over these fences may include the addition of an inward-facing barbed wire outrigger, placing coiled barbed wire (e.g., concertina wire) at the base, or using a smaller chain link mesh size.

Managers of sites using chain link fences may expect 0-2 damage incidents each year due to vandalism and natural hazards. An inspection should be made and any required repairs performed prior to the arrival of bats at the cave. Regular patrols are necessary throughout the period of bat use in order to quickly find and repair any additional damage. The most common problems are usually falling trees or limbs destroying a fence section and vandals cutting holes in the chain link or barbed wire. One incident was reported in which the entire fence at Key Cave, Alabama, was stolen.

Nickajack Cave, Tennessee, is a unique site because the cave entrance is level with the surface of a reservoir. The chain link fence extends over both land and water and boaters often cut a hole in the fence so they could float into the cave. To combat this unusual form of vandalism a cable with floatation booms was placed approximately 30 yards in front of the fence and has prevented most boaters from attempting to access the site.

Survey respondents reported only two bat mortalities related to 20 chain link fences that had been in place a combined total of 311 years. One bat died after having its wing snagged by barbed wire and another was found tangled in the chain linking. In order to prevent such deaths, barbless wire was used atop the chain link fence at Coffin Cave, Missouri (LaVal and LaVal 1980). There were no mortalities reported for six other fences but incomplete survey responses make it impossible to state how long they have

been, or were, in use. While any endangered species death is important, proper fence placement can reduce such accidental mortality while also elimi nating the problem of predation experienced at standard bat gates (Tuttle 1977, White and Seginak 1987).

Chain link fencing is an effective conservation technique and has generally been successful at protecting bat caves. Human disturbance decrease d at 92% and remained unchanged at 8% of caves (N = 24) with these barriers. Bat populations increased at 81%, remained unchanged at 10%, and decreased at 10% of caves following installation of chain link fences (N = 21). There was insufficient informati on to evaluate human disturbance at two caves and bat populations at five caves. Of the two caves where bat colonies declined, one has an extraordinary amount of fence vandalism (approximately six incidents/year) and the second is used by the Indiana bat, a species that has continued to decline in spite of intensive cave protection efforts (Clawson 2000). Although not included in this study, chain link fences at five Florida caves successfully protect southeastern bat (*Myotis austroriparius*) and gray bat colonies and have proved less disruptive to bat emergence patterns than bat gates (Gore and Hovis 1994; Ludlow and Gore 2000).

Vertical Steel Bar Fences

Vertical steel bar fences were used at seven caves and have proven sturdier, though more expensive ($125-200/linear foot), than chain link fences. The current design calls for 1" thick steel bars spaced 6" apart (on-center), extending 10.5' above the surface, and with the top 1' 10" bent outwards at a 45 ° angle. The fence base should be within 4" of bedrock or be placed on a concrete footing 6" deep with 1" steel rods extending to bedrock or 6" below the base of the footing.

There has been one bat death associated with vertical steel bar fences. The fence at Bone Cave, Arkansas, extends in a "U" sh ape in front of the cave with the ends of the "U" inside the cave entrance. Soon after it was built a sunset emergence count was conducted at this gray bat maternity cave and approximately 60 (0.4%) of a colony of 14,870 bats attempted to fly back into the cave at a point where the fence intersects the inside wall of the cave. Twenty of these bats went through the fence without stopping and 20 turned around and flew away. However, the observer heard 20 bats apparently hit the fence while passing through it. After the count was complete, one dead bat was found on the ground underneath the fence. That portion of the fence was quickly modified so bars are horizontal and spaced 5 ¾" apart in order to prevent additional deaths. The top of the fence contacts the cave ceiling and prevents anyone from climbing over the top of this section of the fence. No further mortality has been noted since this change was made. This incident highlights the need to understand bat flight paths and incorporate this information into cave management planning prior to construction.

The National Park Service constructed vertical steel fences instead of standard cave gates at five gray bat caves on the Buffalo National River, Arkansas in 1982 -1983. This option was chosen in order to avoid restricting bat movements, eliminate the risk of predation at a bat gate, and to avoid changing airflow patterns within the cave (Fletcher 1985). Four

of these caves are transient or bachelor roosts and it has been difficult to evaluate the success of these efforts due to the unpredictable patterns of bat use at these locations. The other site, Cave Mountain Cave, has experienced a meteoric increase from 50 hibernating gray bats before construction to 234,850 in 2001 -02 (Harvey 1996; M.J. Harvey, Tennessee Technological University, Cookeville, Tennessee, personal communication, 2002). However, it is possible for people to bend the bars and climb over or through the 9'3" tall, ¾" thick bars used in these earlier fences. Two other fences, built with the improved design at gray bat maternity colonies by the Arkansas Game and Fish Commission in 2001 and 2002, have not been in place long enough to assess levels of effectiveness.

Half Gates

Half gates use the standard bat gate design (Nieland 200 1) but are topped by a horizontal 48" expanded-metal ledge or slanted outrigger bars to prevent people from climbing between the gate and the cave ceiling. These barriers are at least 9' tall and leave a space greater than 4' between the top of the gate a nd the cave ceiling and should only be used in passages that are in excess of 13' in height. Five of seven half gates reported from Missouri use this design while the other two, built in 1980 and 1985, use round metal bars instead of 4" angle iron. Ladde rs or tree limbs can be used to climb over short structures, and if possible, half gates should exceed 18' in height. Graphite grease can be spread over the expanded-metal ledge or outrigger bars to discourage human contact with that portion of the half g ate. Due to their similarity to the standard bat gate, design and construction guidelines can be found elsewhere in this volume and in Nieland (2001). Prices are comparable with standard gates; three half gates built in Missouri since 1996 cost $30-42/square foot.

Unauthorized human entry declined at six caves with half gates and bat populations increased at all seven caves. There was insufficient information to assess changes in human disturbance at one cave. Colonies protected with round bar h alf gates did increase in size, but the local bat surveyor recommends replacing them with the current design. White and Seginak (1987) reported that at Blowing Wind Cave, Alabama (not included in this survey), most of the gray bat maternity colony used an entrance blocked with a half gate rather than a passage with a standard bat gate. Presently 87 percent of this very large colony continue this pattern though approximately 30,000 bats use the standard bat gate (Keith Hudson, Alabama Department of Conservation and Natural Resources, Florence, Alabama, personal communication, 2002).

Acknowledgements

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Department of Natural Resources), Traci Wethington (Kentucky Department of Fish and Wildlife Resources), Bob Currie and Steve Hensley (U.S.D.I., Fish and Wildlife Service) , Roy Powers (American Cave Conservation Association), G.O. Graening and Dan Feller (The Nature Conservancy), Dana Limpert (Maryland Department of Natural Resources), Karen Tinkle (U.S.D.A., Forest Service), Laurel Moore (Arkansas Game and Fish Commission), and Chuck Bitting and Bryan Moore (U.S.D.I., National Park Service).

Literature Cited

Burghardt, J.E. 2000. Bat compatible closures of abandoned underground mines in National Park system units. IN Proceedings of bat conservation and mining: a technical interactive forum, St. Louis, Missouri, Nov. 14 -16, 2000. pg 79-98.

Clawson, R.L. 2000. Implementation of a recovery plan for the endangered Indiana bat. IN Proceedings of bat conservation and mining: a technical interactive forum, St. Louis, Missouri, Nov. 14-16, 2000. pg 239-250.

Currie, R.R. 2000. An overview of the response of bats to protection efforts. IN Proceedings of bat conservation and mining: a technical interactive forum, St. Louis, Missouri, Nov. 14-16, 2000. pg 173-186.

Fletcher, M.R. 1985. Endangered bat protection at Buffalo National River, Arkansas. Missouri Speleology 25(1-4): 147-150.

Gore, J.A., and J.A. Hovis. 1994. Southeastern myotis maternity cave survey. Florida Game and Fresh Water Fish Commission, No ngame Wildlife Program Final Performance Report, Tallahassee, FL. 33 pp.

Harvey, M.J. 1996. Status and management of endangered bats in Arkansas. Proceedings of the Southeastern Association of Fish and Wildlife Agencies: 50: 246-253.

Harvey, M.J., and R.K. Redman. 2001. Annual report to the Arkansas Game and Fish Commission: Endangered bats of Arkansas: distribution, status, and ecology (2000-2001). Cookeville, TN. 26 pp.

Henry, T.H. 1998. Population survey of the gray bat (*Myotis grisescens*) at select caves in the Tennessee River Valley 1997 - 1998 with results of surveys in the TVA Power Service Area. Tennessee Valley Authority Regional Natural Heritage Program Monitoring Report #001, Norris, TN. 36 pp.

LaVal, R.K., and M.L. LaVal. 198 0. Ecological studies and management of Missouri bats, with emphasis on cave -dwelling species. Terrestrial Series #8, Missouri Department of Conservation, Jefferson City, MO. 53 pp.

Ludlow, M.E., and J.A. Gore. 2000. Effects of a cave gate on emergen ce patterns of

colonial bats. Wildlife Society Bulletin 28(1): 191 -196.

Martin, K.W., W.L. Puckette, S.L. Hensley, D.M. Leslie, Jr. 2000. Internal cave gating as a means of protecting cave -dwelling bat populations in eastern Oklahoma. Proceedings of the Oklahoma Academy of Science 80: 133 -137.

Nieland, J. 2001. Cave Gating Manual. American Cave Conservation Association, Horse Cave, KY. 71 pp.

Pierson, E.D. 1999. Tall trees, deep holes, and scarred landscapes: conservation biology of North American bats. Pages 309-325 in Kunz, T.H., Racey, P., editors. Bat biology and conservation. Smithsonian Institution Press, Washington, D.C. 365 pp.

Tuttle, M.D. 1977. Gating as a means of protecting cave dwelling bats. Pages 77 -82 in Aley, T. and D. Rhodes, editors. National Cave Management Symposium Proceedings, Mountain View, Arkansas, 1976. Speleobooks, Albuquerque, NM. 106 pp.

Tuttle, M.D., and D.A.R. Taylor. 1998. Bats and mines. Resource Publication No. 3-revised. Bat Conservation International, Austin, TX. 50 pp.

White, D.H., and J.T. Seginak. Cave gate designs for use in protecting endangered bats. Wildlife Society Bulletin 15: 445 -449.

Blake Sasse became the Arkansas Game and Fish Commission's first Nongame Mammal Program Manager in 2001 and has been active in monitoring and management of endangered bats in Arkansas caves and mines. From 1996-2000 he participated in landscape scale wetland restoration projects in the Everglades as a wildlife biologist for the Florida Fish and Wildlife Conservation Commission. Blake holds a B.S. (University of Missouri, 1991) and M.S. (University of New Hampshire, 1995) degree in Wildlife Management where he studied forest bat roosting ecology.

Session 4

Closure Design: Part 2

Session Chairperson:
Keith Dunlap
Indiana Karst Conservancy
Indianapolis, Indiana

Ladder Bat Gates
Kirk Navo, Colorado Division of Wildlife, Monte Vista, Colorado and Paul Krabacher, Colorado Division of Minerals & Geology, Grand Junction, Colorado

Horizontal Bar Gates - An Overview
Dave Dalton, Gating Consultant, Tucson, Arizona

The Angle Iron Bat Gate
Roy Powers, American Cave Conservation Association, Duffield, Virginia

Rectangular Tube Gating
Marion Vittetoe, Gating Consultant, Tucson Arizona

Round Bar Manganal Steel "Jail Bar" Bat Gate
Louis Amodt and Mark Mesch, Utah Division of Oil, Gas, and Mining, Salt Lake City, Utah

Bat Cupola Design Considerations
John Kretzmann, New Mexico Mining and Minerals Division, Sante Fe, New Mexico

Characteristics of Materials Used in Cave and Mine Gates
Jim Werker, National Speleological Society, Hillsboro, New Mexico

The Problem of Bat Population and its Relation to Gate Area
Roy Powers, Jr., American Cave Conservation Association, Duffield Virginia

LADDER BAT GATES

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Colorado Division of Wildlife
Monte Vista, Colorado
and
Paul Krabacher
Colorado Division of Minerals & Geology
Grand Junction, Colorado

Abstract

One tool available to resource managers for the protection of bat roosts in mines that restricts human access and minimizes disturbance to roosting bats is the bat gate (Tuttle 1977, Powers 1991, Dalton and Dalton 1995). Standard angle iron gates are commonly used at caves and mines that harbor large colonies of bats (e.g. gray bats, Indiana bats). However, these gate designs can be expensive and difficult to justify with smaller colonies of bats or for species not currently considered to be endangered or declining. In some western States, evaluations of abandoned mines have documented widespread use by bats but typically consist of smaller colonies than those found in eastern States. Because of limited funding, resource managers are often in need of alternative gate designs that will allow more affordable conservation of bat roosts in abandoned mines in the West. In an effort to reduce the costs of gates and increase the number of mines potentially protected, modifications of the basic gate designs were developed and installed during mine reclamation activity in Colorado from 1990-2001.

The Ladder Gate Design

The Colorado Division of Minerals and Geology, Kressler Reclamation of Rockvale, Colorado, and Colorado Division of Wildlife developed an experimental ladder style gate (Fig. 1-3) for use at bat roosts in abandoned mines. Changes in this design from the traditional full gate design included limiting the amount of 6" by 24" passage to a central point in the mine portal (hence a "ladder") and using flat iron bars to replace the angle iron (Appendix 1).

The ladder gate design is similar to that reported in Pierson et al. (1991) and is designed to allow bat passage through the center of the gate with airflow only at the sides. The gating is composed of 1-1/4" by 3/16" bearing bars on 15/16" centers with cross bar resistance welded at right angles to the bearing bars and spaced 2" from center to center. Centered within the grating is the bat access segment, fabricated out of ¾" by 3" by 24" long steel bars welded to vertical 3" by ¼" angle iron. The steel bars are welded on 8" centers to provide a 6" by 24" spacing (minimum) the entire height of the mine opening. The entire gate is welded to steel anchors secured into the surrounding bedrock. In situations where the ribs (sides) of a mine were weathered or otherwise too unstable for anchoring the gate, mortared rock walls were keyed into the sides to provide a secure anchoring for the gate. These "wing walls" did not interfere with the airflow of the mine

due to the location of the face of the walls being at the excavated side of the adit, thus not constricting the opening of the mine.

These ladder designs can be placed on the end of culverts as an alternative method at unstable portals (Fig. 4 & 5). When portals are smaller, the ladder gate design can provide a means of anchoring a gate, resulting in more of a full gate appearance (Fig. 6). In cases where access is desired, a door can be placed in the ladder section of the gate (Fig. 7). Likewise, when greater risk to vandalism is a concern, the ladder portion can be composed of angle iron (Fig. 8) or steel bars (Fig. 9).

Post Gate Monitoring

Post gate monitoring on these gate designs indicates that they are accepted by numerous western species of bats (8) and appear to work well for most types of bat roosts (in prep). Summer and winter bat roosts in Colorado have demonstrated continued use of mines gated with the bat ladder design. However, bat colonies utilizing abandoned mines in Colorado, as in many western States, are not typically as large as roosts reported in eastern States. Colony sizes of approximately 100 *Corynorhinus townsendii* have been documented using the ladder style bat gate in Colorado. Issues to consider with the ladder design include the potential increased risk of predation at the gate. We recommend that the bat ladder is considered as an alternative gate design for situations where funds to pay for gates are a factor and summer bat colonies are not considered large. Additional study is required to evaluate ladder gate designs for use with larger colonies of bats.

Literature cited

Dalton, D.C., and V.M. Dalton. 1995. Closure methods including a recommended gate design. Pp. 130-135, IN Inactive mines as bat habitat: guidelines for research, survey, monitoring and mine management in Nevada. (B.R. Riddle, ed.). Biological Resources Research center, University of Nevada, Reno, 148 pp.

Pierson, E. D., and W. E. Rainey, and D. M. Koontz. 1991. Bats and mines: experimental mitigation for Townsend's big-eared bat at the Mclaughlin Mine in California. Pp 31-42, IN Issues and technology in the management of impacted wildlife. Proceedings, Thorne Ecological Institute, Snowmass, CO. April 8-10, 1991.

Powers, R.D. Jr. 1991. Design improvements for gating bat caves. Pp. 356-358, IN Proceedings of the National Cave Management Symposium. (Foster, D.L., D.G. Foster, M.M. Snow, and R.K. Snow, eds.) Bowling Green, Kentucky. October 23-26, 1991.

Tuttle, M. D. 1977. Gating as a means of protecting cave dwelling bats. Pp. 77-82, IN National Cave Management Symposium Proceedings (T. Aley and D. Rhodes, eds.). Speleobooks, Albuquerque, NM, 106 pp.

Kirk Navo is a wildlife biologist and project leader for the Colorado Division of Wildlife's (CDOW) Bats/Inactive Mines Project. He has been with the CDOW since 1983. He has worked with bats since 1977. The Bats/Inactive Mines Project is a cooperative partnership to protect bat habitat in abandoned mines. He is a past president of the Colorado Chapter of the Wildlife Society and is a member of the Colorado Bat Working Group and the leadership team of the Western Bat Working Group. He holds a B.S. in biology from Central College in Iowa and a M.S. in biology from Fort Hays State University in Kansas.

Paul Krabacher is an Inactive Mine Program Reclamation Specialist with t he State of Colorado, Department of Natural Resources, Division of Minerals & Geology for the last 18 years. He is responsible for overseeing the construction of over 75 bat grates throughout western Colorado. He was part of the design team for the first modified bat grates in Colorado first installed in 1990. He holds a B.S. degree in Biology from Colorado State University.

Figure 1. Ladder Style Gate

Figure 2. Ladder Style Gate

Figure 3. Ladder Style Gate

Figure 4. Ladder Gate in Culvert

Figure 5. Ladder Gate in Culvert

Figure 6. Ladder Gate in Portal

Figure 7. Door in Ladder Gate

Figure 8. Ladder Gate of Angle Iron

Figure 9. Ladder Gate with steel bars

HORIZONTAL BAR GATES – AN OVERVIEW

Dave Dalton
Gating Consultant
Tucson, Arizona

Abstract

Various techniques have been used to protect bats living in mines and caves from human intrusion. Strategies ranging from the simplest partial closures, such as warning signs and fences, to full closures, such as steel grates and doors, have been employed. Of all the full closure structures, the horizontal bar gate is by far the most commonly used. Horizontal bars are used instead of vertical bars to allow enough room for bats to fly through because more space is needed in the horizontal direction to accommodate a bat's wingspan. Typically, the space used between bars has been 5" to 6" vertically and a minimum of 24" horizontally. A variety of materials have been used for the bar material. Considerations in the selection of material are its resistance to anticipated forms of vandalism, cost of installation, cost of maintenance, restriction to bat access, and potential modification to the interior microclimate of the roosting area. Three of the more popular materials used are 1" round bar of Manganal steel, 2" – 3" rectangular tube, and 4" angle iron. Manganal steel, although vulnerable to gas cutting, is highly resistant to abrasive cutting. It is more expensive than other options and not readily available, but its ease of handling and installation minimizes installation costs. Rectangular tube is vulnerable to all types of cutting, but is readily available and relatively low cost. Because of its size and weight, its transport and handling costs are greater than Manganal. However, it is easier to install because of its cutting and welding characteristics. Angle iron is moderately resistant to abrasive cutting and can be made resistant to gas cutting, if T-bar inserts are used. The material is readily available and low in cost. Because of its high mass and material handling difficulties, it is the most expensive to install of the 3 types of bar. In summary, there is no one, good method for all circumstances. If risk of vandalism is low, rectangular tube can be a good cost-effective alternative. As example, it works well for vertical mine shafts, which people tend to avoid. If the site is remote, and anticipated vandalism would be from abrasive cutting, such as hacksaws, the increased cost of obtaining Manganal steel could be offset by the ease of installation. If the site is easily accessed and not easily monitored, T-bar stiffened angle iron would be resistant to more sophisticated forms of vandalism, such as gas or plasma cutting. Another option to high vandalism sites is a composite bar made of rectangular tube filled with reinforced concrete. When planning a gate, consider the availability of material, difficulty of site access, and the risk of vandalism. These factors will influence the cost and difficulty of building the gate and the ultimate effectiveness of the closure.

Introduction

Abandoned mines and caves have received closure structures for many years. In the case of mines, the closures were usually for safety reasons. If the mine had been economically worked out, the owners may wish to exclude any further human entry. In this case, the

most expedient method is to back fill the entrance with whatever rock and soil material was available on site. For caves, the motivation is usually for the preservation of some resource within the cave, with the intention of allowing controlled human access. For these situations, the choice has been to install some form of lockable barrier on the cave's entrance. Some of the methods used have been jailhouse cage doors, chain -link fence, and solid steel doors.

In several of these early cases, there was no consideration for wildlife access to these sites. All of the above structures are, generally speaki ng, incompatible with bat colonies (see Currie (2000) for examples). Bats require, at a minimum, spaces in the closure structure that will accommodate their fully extended wingspan in the horizontal dimension and the range of motion used in wing flapping in the vertical dimension. For most North American bats, this is generally accepted to be about 24" horizontal, and 6" vertical (Hunt and Stitt, 1981).

The risk of altering the microclimate of a bat roost, primarily by altering the airflow through the entrance, is another problem encountered. Even where the spaces in the gate are adequate to accommodate bat flight, the gate may restrict the airflow to the point where the roost site becomes unacceptable to bats.

Because of the wingspan space requirement for bats, designers of mine and cave gates have moved away from vertically oriented "jailhouse" bars, to horizontal mounting with wider spaced vertical columns to, in some designs, no vertical support columns at all. By increasing the stiffness of the bar material, the distance between vertical support columns can be increased without compromising the structural integrity of the gate. In some cases, if the entrance is small enough, and the material is stiff enough, the vertical columns can be eliminated e ntirely.

Three types of material are commonly used for horizontal bars. The first is solid 1" round Manganal steel that is used for jail bars. The second is 2" by 2" rectangular hollow tube steel and the third is 4" by 4" angle steel.

Note that there are many factors to consider beyond the choice of bar material. What species of bat uses the site and what does this species use the site for (hibernacula, maternity, night roost, etc.)? This must be understood prior to consideration of construction materials. It is not the intent of this paper to discuss these issues in detail. It is important to note that these issues are of equal or greater importance to the overall success of any roost protection plan than the factors discussed here.

When planning to install a gate on a cave or mine, several factors should influence the choice of bar material. These factors include the initial cost of the installation, the potential restriction to bat access, the possible modification to the microclimate of the bat roost within, the probability of, and in what form, vandalism may occur, and the cost of maintenance due to repairs necessitated by vandalism.

Horizontal Bar Types

MANGANAL STEEL
This material is typically used for jailhouse bars. It is an alloy of ab out 86% steel, 13% manganese, and 1% carbon and is harder than most hacksaw blades. In mine and cave gates, solid 1" diameter round bars of this material are used. Because of the round cross section and the reduced size over the other material types, ver tical supports are required at 2 ft. intervals to provide sufficient resistance to bending (Mark Mesch, personal communication).

RECTANGULAR TUBE
This material is standard light structural steel in the form of an extruded hollow tube of rectangular cross section. The most common size used for gates is 2" by 2" square tube with a ¼" wall thickness. This sized tube has sufficient stiffness to be used without vertical columns for gates up to 8 ft. wide.

ANGLE IRON
Angle iron is another common form of str uctural steel. For gates, the size used is 4" X 4" with a material thickness of 3/8". The heavier gage of this material allows unsupported spans of up to 10 ft. By installing 2 pieces if 1.5" angle inside the apex of the 4" angle, the stiffness is impro ved to a point where up to 20 ft. unsupported spans are possible.

Comparative Factors

COST OF INSTALLATION
The first factor to consider is the initial cost of installing the gate. Obviously, the size of the opening dictates how much material needs to be purchased. The material, along with all necessary tools, must be transported to the site. This transportation cost can be significant if the site cannot be accessed by motor vehicle. In these instances, additional cost is incurred hiring mules, helicop ter time, or laborers. The larger and heavier the material and the more difficult to install (requiring additional tools), the larger the transport cost in both time and money. Manganal steel is the lightest of all 3 types, which reduces the transportation costs. Additionally, it is easy to handle and place, which reduces actual installation time. However, the cost of the raw material is greater than the other 2 bar types. Being heavier, rectangular tube is more difficult to transport and handle. Howe ver, it is the cheapest material cost and is readily cut to size. Angle iron is the heaviest of all three types, making transport and handling more difficult. Any out of square cuts require compound angles to be calculated for a proper fit, which will sl ow down the installation process.

COST OF MAINTENANCE
Once a bat roost has been secured, the integrity of the closure must be maintained. The continuing maintenance cost must be considered when designing the closure structure, because the correct choice at the planning stage could ultimately reduce the overall cost. Ongoing cost is associated with environmental weathering and vandalism. In more

humid climates, steel structures will rust. If rusting is severe, large-scale repair, or complete replacement will be eventually needed. For these conditions, rust proofing may be a prudent step. Vandalism is usually the most significant maintenance cost. The necessity of making unplanned repair trips to the site, especially if the site is remote, can be far more costly than the initial installation cost. In addition, the bat colony is vulnerable as long as the gate remains breached.

RESISTANCE TO ANTICIPATED FORMS OF VANDALISM

The next factor to consider when selecting a gate material is the anticipated risk of vandalism. This factor will determine the level of effort necessary to protect the resident bat colony for the foreseeable future. When an installed gate is regularly breached, even if repaired promptly, the security of the bat colony within is not maintained. The colony could be severely affected from just one intrusion. Additionally, the need to repair damage due to vandalism on a regular basis pushes up maintenance costs, which, with time, will outweigh the initial savings of installing a less secure gate. If the risk of vandalism is low, then cheaper materials, along with simpler installation methods, can be used.

Vandalism can come in a variety of forms. For purposes of discussion, I will divide vandalism assaults into 3 types. The most common, Type I, is from either idle acts not specifically aimed at gaining entry, such as spray painting, or unplanned, spontaneous entry attempts. These attempts are usually done using on-hand materials at the site, such as rocks to break the locking mechanism, or tree branches to bend the bars. The next level, Type II, results from planned entry attempts with minimal equipment. Examples are hacksaws used to cut the bars or lock, or shovels and pry bars used to dig around, or under the gate. The highest level of vandalism, Type III, results from concerted efforts to gain entry at any cost. Methods used here can be power winches, gas powered cut-off saws, cutting torches, and even explosives. At present, there is no form of closure method that is completely effective against Type III vandalism, although different methods will require different times to breach a gate. Manganal is impervious to hacksaw attempts because its hardness is equal to or greater than most hacksaw blades. Although a determined effort at bending with a suitable lever could result in a breach, gates made of Manganal are generally able to deter vandalism Types I and II, but not Type III. Rectangular tube is quite resistant to bending, but can be cut with a hacksaw. This material is suitable to deter vandalism Type I, but will only slow down a Type II assault. Angle iron, although it can be cut with a hacksaw, makes this a time consuming task because of the bar size. Additionally, it can be made significantly more difficult to hacksaw cutting, as well as resistant to torch cutting, with the addition of T-bar stiffeners. Therefore, angle iron is an effective deterrent to Types I and II, and moderately effective against Type III vandalism.

POTENTIAL MODIFICATIONS OF THE INTERIOR MICROCLIMATAE OF THE ROOSTING AREA

Any gate structure placed in the entrance of a mine or cave will impede the movement of air into and out of it. This unavoidable modification of airflow may result in a sufficient modification to the interior microclimate such that it would become no longer suitable for

the resident bat colony. Determining the impact a particular gate design will have on the interior of the mine/cave a priori is virtually impossible. Therefore, the attempt has usually been to minimize the gat e's potential effect in all cases. A general guideline is that the lower the velocity of pre-gate air movement, and the larger the entrance, the smaller the effect the gate will have. A potentially more air-restrictive gate could be used in some circumstances (low air velocity, large entrance) with minimum risk of interior microclimate modification. In fact, Roebuck et al. (1999) found that for air velocities of less than 10 ft/sec, there is very little difference among bar shapes to the restriction of airflow. Because most cave/mine entrances fall in this category, bar type by itself is generally not a factor in microclimate modification. However, if the entrance is small, and air velocity is high, vertical column supports should be minimized or elimin ated from the design.

RESTRICTION TO BAT ACCESS

Any gate structure placed on the entry to a bat roost will restrict bat access to some degree. Bars with spaces large enough for a bat to fly through are not necessarily sufficient. If the resident bat col ony is large, any kind of obstruction in the entry way will cause a "traffic jam" condition during evening emergences. In these situations, the individuals must contend with locating a suitable space in the gate to fly through, while avoiding collisions with other individuals attempting the same maneuver (Powers, 1996). A larger cross sectional bar occupies more potential fly-through space, thus exacerbating this condition. The problem becomes worse as the size of the cave/mine opening becomes smaller. Roebuck et al. (1999) assumes that the ratio of area blocked by the gate structure to the area of the original opening, called solidity ratio by Hoerner (1965), must remain below 0.45 in order to minimize airflow restriction. The solidity ratio is adapted here as a measure of acoustic blockage affecting bat access. As used here, solidity ratio, instead of being a measure of the effective blockage of airflow, is changed to represent the effective blockage of bat sonar. As the portal gets smaller, the ver tical support members have more effect on the solidity ratio. For Manganal steel, although there are more vertical supports required, their small cross section does not significantly increase the solidity ratio in small openings. However, vertical suppor ts used for rectangular tube or angle iron are typically much larger, and therefore significantly increase the solidity ratio for small entrances. This problem can be avoided if these 2 bar types are installed in such a way that vertical supports can be e liminated.

Manganal, having the smallest cross section, presents the smallest solidity ratio of the three bar types. In a vertical space of 6.75 inches, there will be 1 bar of 1" and a free space of 5.75", giving a solidity ratio of about 0.15, depen ding on the number of vertical supports used. Rectangular tube gates have 1 2" bar for every 7.75 vertical inches, giving a solidity ratio of 0.26, without considering vertical supports. Angle iron gates have one bar of 3" vertical profile for every 8.75 vertical inches, giving a solidity ratio of 0.34, also excluding vertical supports. If vertical columns are added, this ratio increases. For example, an angle iron gate built on a 10 ft. wide entrance, using 2 6" wide vertical columns would have a solid ity ratio of 0.41. The same gate design used on a 4 ft. wide entrance would now have a solidity ratio of 0.51. Therefore, for small entrances, gates constructed of rectangular tube or angle iron should avoid the use of vertical columns.

Conclusions

Given the multitude of factors influencing the ultimate long-term success of a gate, there is no one, best solution for all situations. Risk of vandalism must be weighed against the potential impact the gate will have on the movement of bats through it. Initial cost must be balanced against ongoing long-term maintenance. Ultimately, some sites will be more costly than others. All of these conditions should be considered prior to settling on a particular design. In some situations, the wrong gate may be worse than no gate at all. The primary purpose of these gates is to provide long-term protection of the resident bat colony. If the commitment to long-term maintenance of the site cannot be assured, then a more maintenance free structure is needed. When developing a plan to close a site for the protection of bats, remember to be flexible, and also to be creative.

Literature Cited

Currie, Robert R., An Evaluation of Alternative Methods for Constructing Bat Gates at Mine Closures. IN Proceedings of Bat Conservation and Mining: A Technical Interactive Forum (K. C. Vories, ed.) November 14-16, 2000, St. Louis, Missouri. pg 127-144.

Hoerner, Sighard F., Fluid Dynamic Drag. 1965. Published by the author (Hoerner Fluid Dynamics, PO Box 342, Brick Town, NJ 08723).

Hunt, Geoffrey and Robert R. Stitt. 1981. Cave Gating-A Handbook. Revised 2nd Edition. National Speleological Society, Huntsville, Alabama. 60 pp.

Powers, R. D. Jr. 1996. A Study of Acoustical Confusion. Pp. 274-276, in 1995 National Cave Management Symposium Proceedings (G. T. Rea, ed.). National Cave Management Symposium Steering Committee, Indianapolis, IN. 318pp.

Roebuck, Brian, Ahmad Vakili and Lynn Roebuck, Cave Gate Airflow Disturbance – A Qualitative Study, in Proceedings of the National Cave and Karst Management Symposium, 1999.

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THE ANGLE IRON BAT GATE

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Abstract

This paper discusses the evolution of the American Cave Conservation Association (ACCA) angle iron gate types. Topics discussed include: air flow testing, materials, security, and advantages of these designs.

Brief History of Gate Installation

Many early gates installed in caves and mines caused more problems and damage to resources than they protected. Airflow disturbances changed temperature and humidity. Paints added pollution to the internal and external environments. In many cases, more resources were expended repairing these gates than during the actual construction. It was considered good economics to place the gates at the smallest cross-section area in order to reduce expense during construction. Some gates were designed with a weak point so vandals could gain entry with minimal damage to the gate.

During the construction of early gates, very little was known about air flow and the bats = usage of gate geometries. There were no design standards until 1 976 when Dr. Merlin Tuttle introduced a round bar gate with the spacing of horizontal bars at 6" and vertical bars at 24". The spacing of the vertical bars represents the maximum practical distance with round bar construction and the minimum for bat usag e. This design was a major improvement in bat gate design but, due to the nature of the materials involved, was difficult to construct and the strength of the gate was limited .

The first angle iron gate, installed in 1978, was designed to overcome the s trength problems of the earlier gates by using stronger materials. The strength of the angle iron allowed the distance between columns to be increased to 48". The 6" spacing of the horizontal bars however, still allowed, some small adults access. In or der to overcome this problem, the spacing was arbitrarily reduced to 5 3". A new philosophy on gating was also adopted with the introduction of the angle iron gate (Figure 1). The Aweak link@ was abandoned and the philosophy became Aif the resource was worth any protection, it was worth the best protection. @ This phil osophy has guided the development of design from then until today. It only takes one intrusion to severely damage or to totally destroy a resource.

The Earlier Designs

The first angle iron gates were constructed of 4" x 1/4" angle welded between 4" col umns spaced on 4 feet centers. The strength of the angle iron allowed a 4 foot span. The vertical columns were welded to a plate attached to a concrete foundation.

Problems with early designs

The welds of the horizontal bars to the vertica l columns were very weak without time - consuming reinforcing. The use of concrete is labor intensive and often requires excavation, forms, and the transportation of very heavy materials and equipment.

The excavation of the foundation at any archaeologic al site requires, at a minimum, a survey by an archaeologist and, in some cases, the archaeologist must be present during the entire excavation process. Several days could be lost installing the foundation and waiting for the concrete to set.

Another major problem with these first designs was closing the gap between the last column and the wall. This often required many odd pieces of metal welded to the gate and attached to the wall. This was labor intensive and often required as much time as the construction of the rest of the gate. The result of this patchwork often resulted in a sloppy looking gate.

Evolution of the modern design

As knowledge developed over the last 20 + years, the basic gate design changed to incorporate this new knowledge. Air flow studies show that the properly designed, properly placed and constructed angle iron gate does not affect the air flow significantly (Roebuck). When a weak point was discovered, the design was changed to eliminate the weak spot.

At the request of the U.S.Fish and Wildlife Service, the vertical spacing was increased to 5 : ". This increased spacing is a compromise between bat friendliness and restriction of human intrusion. Observation has determined that bats use this dimension better than the old spacing of 5 3 ", resulting in a more friendly bat gate. The first major change to the original design was to eliminate the concrete foundation by using a 6" angle iron as a sill and elevating the sill on steel footers above the floor. This change allowed the gate to be placed directly over resources with minimum disturbance. Using an angle for the sill allowed the vertical columns to be attached to the back or the sill. This allowed the columns to be aligned vertically with greater precision and less effort. It also allowed the horizontal bars to be attached with hangers to the front of the columns instead of between them. This type of construction also allowed a continuous bar from one wall to the other. This solved the closure problem of earlier gates. Also, since the span width is a function or the strength of the materials, the thickness of the 4" angle was increased to 3/8". This allowed spans greater than 4' and increased security by making sawing a bar more difficult.

It became apparent from the number of gate violations that the door was a weak point. The door was replaced by a removable bar which has over time proven to be much more secure than a door.

A U.S. Fish and Wildlife Service study by White and Sedgnick, testing various geometries using removable inserts, had proven the bats used the angle iron gate as well as the round bar gate validating the angle iron construction. An unpublished study by John Sedgnick (U.S. Fish and Wildlife Service) demonstrated gray bats were more sensitive to vertical columns than horizontal bars. Based on this

information, stiffeners made from smaller angles welded inside the 4" angle allowed an even greater span and greatly increased the bars ability to resist breaching by sawing (Figure 2).

Many gates were defeated by vandals digging beneath the gate. This problem was reduced by laying expanded metal and constructing the gate on top of the metal (Figure 3). This presents a difficult challenge for the vandal because now a long tunnel must be dug to get under the gate.

The resulting design is the basic modern angle iron bat gate of today. This design has been developed over 20 + years. Each feature of the design has been developed in order to: (1) eliminate weak points in its structure; (2) increase security; and (3) facilitate construction of the gate. The design is highly adaptive to fit most cave and mine geometries. This design meets a ll criteria for a bat friendly, secure gate. The criteria for bat friendly gates are:

- Vertical column spacing to be as long spanned as possible.
- Horizontal bar spacing also to be optimal for bat use and entry restriction.
- For the gate to be as secure as possible to prevent disturbance of the resource(s).
- That the gate must not alter the air flow or the affect the micro -climate of the cave or mine.

As an example of the refined design=s ease of construction, the Hubbard Gate (Tennessee) of older design, required over 100 volunteers working over 10,000 man hours to construct. The Gustafuson Gate (Arkansas) using newer design and construction techniques was constructed by five people in 475 man hours. This gate is only slightly smaller than the Hubbard Gate. In 1999, using the current design and techniques, the Schoolhouse Gate (West Virginia), that is the same size as the Hubbard gate was constructed in only five days.

Advantages of the angle iron design

5. No air flow constriction
6. Wide spans
7. Security
8. Adaptable to most site locations
9. Strength of materials allows very large construction
10. Uses no concrete
11. Can be placed directly over archaeological site
12. Ease of field construction

Variations of the design

Several variations of the angle iron bat gate design have been developed. The cupola design allows the construction over a vertical shaft (Figure 4). A bay window variation (Figure 5) allows the gate to be placed outside the cave or mine. This is done to increase bat usable surface area. A shielded variation allows species which have difficulty with regular gates to over -fly the top of a standard gate while supplying the same level of security (Figure 6). There is also a topless variation of the cupola for large vertical shafts. The last variation is the standard gate with a maternity chute for use when the conditions

are such that a shielded or fly -over gate cannot be used (Figure 7).

Availability of Plans

The most up to date plans and information are available from:

Bat Conservation International (BCI)
P.O. Box 162603
Austin, Tx. 78716
Ph. 512-327-9721

American Cave Conservation Association (ACCA)
P.O. 409
Horse Cave, Ky. 42749
Ph. 502-786-1466

It is always wise to consult with ACCA or BCI to make sure you have the latest information, plans and that the proper design and placement have been selected.

NOTE:
Remember that bat gates must be properly placed for many reasons and must be sized to the bat population and species.

Bibliography

Roebuck, B., Vakili, A.D., and Roebuck, L. 2002. Cave Gate Airflow Disturbance - A Qualitative Study. Published in 1999 National Cave and Karst Symposium, pages 169 -175.

White, D. H. and J.T. Seginak. 1987. Cave Gate Designs For Use In Protecting Endangered Bats. Published in The Wildlife Society Bulletin 15:445 -449, 1987.

Tuttle, Merlin D. 1977. Gating As a Means of Protecting Cave Dwelling Bats. Pages 77 -82 Published in the 1976 Cave Management Symposium, Aley, T. and Rhodes, D. (eds.), SpeleoBook, Albuquerque, NM.

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Figure 1. Big Bone Cave © 2002 Kristen Bobo

Figure 2. Haile Cave stiffners and hangers ©2002 David Pelren

Figure 3. Ohio mine expanded metal © 2001 Roy Powers

Figure 4. Little Bat Cave cupola © 2001 Kristen Bobo

Figure 5. Marcum Cave hybrid gate ©2000 Rob Robbins

Figure 6. Blackwell Cave fly - over gate © 2001 William Elliott

Figure 7. McDowell Cave standard gate with chute © 2001 William Elliott

RECTANGULAR TUBE GATING

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Abstract

There are several types of material that can be effectively used when constructing horizontal bar gates to protect bat roosts in mines and caves. Gates made of rectangular tube can be a cost effective option in certain circumstances. Where risk of vandalism is low or the opening size is relatively small, this type of bar may afford the most feasible solution. Rectangular tube is usually readily available from steel suppliers. It is less massive than 4" angle iron, making it easier to transport and handle. Construction methods are straightforward: it is readily cut with cut-off saws and is easily placed and welded. Because of its greater stiffness, longer unsupported spans can be used than with 1" round material. In entrances up to 10 ft. wide, no vertical columns are necessary. The bars are attached only at the ends to wall plating using a variety of timesaving fixturing and techniques. In this way, more cross sectional area of the opening is available for bat flight. If the risk of vandalism is especially high, this material can be made into, possibly, the most resistant of all bar types to all known forms of vandalism. In these cases, the tube can be hard faced and filled with quartz aggregate concrete, reinforced with standard rebar or Manganal steel. Proper application of hard facing imparts a similar resistance to hacksaw cutting as Manganal steel and the reinforced concrete fill thwarts attempts of gas cutting.

Introduction

There are several types of material that can be effectively used when constructing horizontal bar gates to protect bat roosts in mines and caves. Gates made of rectangular tube can be a cost effective option in certain circumstances. Where risk of vandalism is low, or the opening size is small, this type of bar may afford the most feasible option. Rectangular tube is usually readily available from steel suppliers. It is less massive than 4" angle iron, making it easier to transport and handle. Construction methods are straightforward: it is readily cut on cut-off saws and is easily placed and welded. Bars are fillet welded to vertical wall plates eliminating the need for vertical columns. The wall plates are attached to the wall with 1" cold rolled pins driven into the wall. The holes for the pins are drilled as the bars are being placed. A custom jig that fits on the top of a bar holds the rotary hammer drill and a hydraulic drive. The hydraulic drive is used to supply drilling pressure. The wall plates are made into U-channel columns by fitting custom cut facing plates to each edge. These facing plates are shaped to fit the contours of the wall and welded to the edge of the wall plate. A special feeler gage, adapted from a similar tool used on carpentry, greatly speeds up the process of marking these plates for contouring.

Primary equipment needed

The primary equipment needed for a gating project is as follows:

- *Primary equipment for the preparation site*: Generator, welder, grinders, cutting torch, metal cutting carbide cut-off saw, cutting table cutting stands, drill press. and cutting guides
- *Primary equipment for the gate site*: Generator, welders, spline rotary hammer drill, heavy duty ½" metal drill, drilling fixture for hammer drill and metal drill, hydraulic drive for the fixture, gauge plates, faceplate feeler gauge, and vacuum.
- *Primary equipment for power distribution*: For long runs we use an electric cable of 6/4 from the generator to an electric distribution box. Then 10/3 electric cables are used to the 240-volt welders and 120-volt electric equipment. We use 1/0 welding cables.

Secondary and support equipment

The following secondary and support equipment are needed at both the preparation and gate sites. Do not expect one set of equipment to take care of both sites. Too much time is wasted moving equipment between the two sites.

- *Secondary equipment*: Levels, tape measures, sledgehammers, slag removers, C clamps, vice grip clamps, squares, crescent and other wrenches of various sizes, trowels, and buckets.
- *Safety equipment* consists of first aid kits, hard hats, gas cutting and clear goggles, welding hoods, welding & work gloves, leather welding jacket, safety boots, dust masks, welding fume masks, and hearing protection.
- *Ventilation equipment* consists of manhole blowers and various lengths of hose for them.
- *Lighting equipment* can consist of Quartz Halogen work lights, floodlights with reflectors, and florescent lights. There also needs to be plenty of shorter electrical cords to supply these lights.
- *Fire suppression equipment* consists of, but is not limited to: Fire extinguishers, McClouds, Pulaskies, bladder bag sprayers, shovels and a 12 volt, 21 gallon, 100' hose, and wagon mounted tank sprayer.
- *Weather protection equipment*: Canopies and tarps are needed to protect people, equipment, and materials from the weather.

Backup and maintenance equipment, spare parts and supplies

Backup equipment is a must; too much time is wasted if something primary breaks down. Also I have learned from past experience that having spare parts and supplies for secondary and support equipment pays off.

- *Back up equipment* will consist of a welder, cutting torch, generator, hammer drill, extra pliers, screwdrivers, and wrenches of all sizes and types.
- *Maintenance equipment & supplies*: The following maintenance equipment & supplies are for generators and motor welders. Each machine will have the

following: a tool kit, air filters, oil filters where needed, oil, oil funnel, gasoline nozzle for gas cans, gas funnel, a set of manuals, hand cleaner, and paper towels.

- *Spare parts* can consist of, but not limited to: bulbs for lights, electrical tape, extra lens for gas cutting goggles and welding hoods, 4" and 9" grinding wheels, ear plugs, dust masks, welding fume masks, bolts, nuts, and washers of various sizes.

Cost Considerations

The cost of a non-enhanced 67"tall x 51" wide (24sq. ft.) opening that is readily accessible, constructed by a gating contractor would run approximately $4500.00. The cost of a gate can vary considerably due to a number of factors.

- *Distance of travel to site*: Most contractor/consultants will charge round trip mileage from their home base. The mileage is usually charged at 32 cents per mile per vehicle and usually there will be more than one vehicle and trailer, based on the size of job and crew they bring.
- *Size of gate & type of gate*: The cost of a gate will go up with the size of gate. A larger gate will require more material and time to construct. The type of gate also affects the cost. For example, a cupola could cost up to 6 times more than an adit gate.
- *Access into the mine or cave*: Providing continued access into the mine or cave after gate installation will add to the cost of the gate. The cost of installing a removable bar or swinging door will raise the cost as much as $800.00.
- *Remoteness of site*: If the gating site is accessible by a maintained road where a 2 x 4 vehicle could travel, then the materials and equipment can be delivered in a timely manner, without added cost. However, added cost will be incurred if four wheel drive vehicles, ATVs, boats, mules/horses, or helicopters are needed. Non-maintained roads usually require 4 wheel drive vehicles, and/or ATVs. Either of these adds to the transportation cost and the total time. If the site is located on a no road or wilderness area, the use of horses/mules and/or helicopters will again increase transportation cost and further increase time.
- *Optional enhancements for vandalism*: For sites subject to high levels of vandalism, additional security measures may be employed. The bars can be hard faced, or filled with reinforced concrete. These additional measures will add to the cost of the gate. Hard facing adds to the cost, because it requires special welding rods that normally are not used. Additionally, applying the Hard facing to the bars adds to the installation time. Concrete filling adds some to the cost of materials, because additional quartz aggregate concrete must be purchased, along with the reinforcing, be it standard rebar or Manganal steel. Also, larger bars are usually needed (typically 2" X 3") to allow sufficient room for the reinforcement and aggregate. However, the largest cost factor to concrete filling is the added time to filling the bars and allowing them to partially set, before installing.

Gating contractor vs. consultant utilization

Hiring a gating contractor can actually save overall project cost. An experienced contractor will have a trained crew who can install a gate in a minimum of time, with a

minimum of unexpected problems. The contractor comes with all necessary tools and support equipment, usually in good working order. Although a consultant can help minimize the risk of showing up on a remote site unprepared, a consultant cannot cover all unforeseen eventualities as well as a well equipped, experienced contractor. Also, because cost overruns are usually born by a contractor, the overall cost of a project undertaken by an inexperienced crew under the guidance of a consultant will usually cost more than originally budgeted.

Construction Planning

Site preparation and Setup

- *Prep Site:* For each gate, a location for the preparation of materials must be selected. This site is used for sill box construction, bar cutting and/or fabrication, and wall plate fabrication. It also provides general support for the gate site needs, such as power generation, equipment repair and maintenance, and safety management.
- *Picking a Prep Site:* Choose a spot outside of the mine/cave entrance, but as close as possible for easy communication and material movement with the Gate site. The site must also be easily accessible to transportation, so that equipment and supplies can be delivered here. In the best situations, the site can be within about 50 ft. of the gate site. For more inaccessible gate sites, the prep site may need to be as much as 1 mile away, requiring radio communication between the sites, with material moved by ATV, mule, or by foot. The site will usually have power generation (portable generators) and maintenance equipment, along with fire suppression equipment. The site will also be the location of the cut-off saw and cutting torch. Bulk gate materials (uncut steel and concrete) are stored at this site.

Gate Site

- *Picking a gate site in the adit:* The gate site should be a wider area in the adit passage. This is so that air flow and bat flyway is not restricted.
- *Setting up ventilation equipment and lighting:* Prior to beginning work on the site itself, some equipment must first be set up. Lighting racks and ventilation supports must be set up. Because welding fumes tend to rise, the ventilation exhaust must be set up near the ceiling. Power from the generators to the site can also be run up off of the floor in the ventilation supports, creating a less cluttered, safe working environment.
- *Prepping the Site:* Having chosen a good gate site, scale off any protrusions on the walls so you get the tallest height that you can for the wall plates without going to offsets. Next, start digging the sill box trench. It needs to be the width of the passage, 6 to 7 ½" deep and 12 to 16" long. The trench will be filled with concrete when the gate is finished. While the walls are being scaled and the trench dug, the sill box is being constructed at the prep site. After completion, the sill box is placed in the trench, leveled, and the wall plates are tack welded to it. They are placed vertically at the edge of the sill plate making sure the wall plates are plumbed vertical and perpendicular to the other wall plate. The wall plate is then welded to the sill plate.

- *Gate Fabrication:* After site preparation has been completed, then bar placement and wall plate pinning begins. The first bar is cut to fit and tack welded to the top of the sill plate, previously attached to the top of the sill box. The gauge plates are placed on the first bar. The second bar is then placed on the gauge plates and tack welded in place. Next, the wall plates and walls are drilled for the first pair of pins. These pins are then driven into the walls and tack welded in place. This process continues up, alternating placing bars with pin placement, until the top-most bar is in place. Note that pins are placed every second bar. Next, facing plates for the wall plates are measured and fitted. Next, all pins, bars and facing plates are fully welded. Finally, the sill box and trench are filled with concrete.

Construction and Material Details

- *Sill box:* The sill box is constructed of two lengths of 4" x 4" x 3/8" steel angle, with a 2" x 3/8" flat bar placed between them to form a U that is 10" wide. These three pieces of steel are butt-welded together, an end plate that is 10" x 4" x 3/8" is then welded to either end. At least three 9 ¼" lengths of rebar are equally spaced along the length of the box and welded in place inside the sill box keeping their top edge level with the sides of the sill box. A 6" x 3/8" flat bar (**sill plate)** is welded in place on top of the end plates and the rebar. (See drawing labeled end view of sill box.) Next, two rows of 1 ¼" holes are cut with the cutting torch in the bottom of the sill box. The holes are centered approximately 1 1/8" from the outside edge. These holes are placed 6 to 12" apart. [Note: if the probability of vandalism is high and the ground below the sill box is soft, place them 6" apart. If vandalism is low and the ground below the sill box is bedrock, place them 12" apart.]
- *Wall plates:* These are constructed from 6" x 3/8" flat bar. The intent is to run them vertically from floor to ceiling. Where this is not possible, the wall plate(s) will need to be stepped in to accommodate the changing shape of the walls. Try to keep the wall plates no more than 6" from the wall. This will keep the faceplates against the wall.
- *Bars:* The bars are usually 2" x 2" x ¼" tube steel. If the optional enhancements are used in the bars then the size of the bars should be increased to allow room for the concrete to flow around the rebar or Manganal steel rod.
- *Drilling holes:* A custom jig is then placed on top of the second bar. This jig holds and guides a ½" heavy duty drill with 1 1/16" hole saw while it drills a hole through the wall plate while being pushed by a hydraulic drive (Porta-power). The ½" drill is then replaced with a Bosh spline rotary hammer drill. It then drills a 1" hole into the rock wall of the adit. The custom jig is then turned 180 degrees and the process is repeated. This whole process of drilling holes is repeated every second bar.
- *Wall pins:* Wall pins are 1" dia. cold rolled steel rod, which can vary in length. One end is pointed to make driving them into the holes easier. The wall pins are driven past flush in the wall plates. This recesses the pins so that when they are fully welded the weld will be flush with the surface of the wall plates. They are tack welded until later.

- *Removable bar(s):* If there is a removable bar(s) it is placed approximately 3' above the first bar.
- *Locks on removable bar(s):* There are a number of ways of loc king removable bars. The locks that I am now using are McGARD fasteners Part # 117971 (5/8" – 11 x 2.00") and part # 110007 for the matching socket key. The fastener costs $18.00 each and the socket key costs $15.00 each. One problem with McGARD is that they require a $200.00 minimum order.
- *Lock detail:* Lock parts list for each lock (there will be two locks per bar)
  1 – 4" x 4" x 3/8" angle 5 ¾" long
  1 – 2" x 3/8" flat bar 3 ½" long
  2 – ½" x ½" square solid bar 3 ½" long
  1 - 1 7/8" pipe ¾" long
  1 – 5/8"x 11 nut

  I prefabricate most of the lock parts at my shop, that way there is less problem in assembling them in the field. First take the angle and place it so that one ear of the angle is horizontal, then place the flat bar on top of the angle orienting its long side front to back, leaving it a ¼" from the back of the angle and 1 5/16" from each side. Then tack weld the flat bar in place (it will be cut loose with the a 4" grinder later). A 5/8" hole is drilled through the angle and the flat bar. The hole is placed 1 ¾" from the back of the flat bar and 1" from each side. The flat bar is then cut loose from the angle. The 5/8" hole in the angle is then enlarged to ¾". Each ½" square bar is placed ¼" from the back of the angle and 1 5/16" from the right or left sides of the angle. Each square bar is then welded on the three outside edges (DO NOT WELD ALONG THE INSIDE EDGE AS THE 2" x 3 ½" FLAT BAR NEEDS TO FIT BETWEEN THE 2 SQUARE BARS WITH SOME SLOP). The next thing is take a 5/8" x 11 x 1 1/2" long bolt, place it through the hole drilled in the 2" x 3/8" x 3 ½" flat bar and screw the 5/8" x 11 nut down on top of the flat bar. Once this is done fillet weld the nut in place. (The next thing is done in the field with a ½" bench drill press.) The last things to do to the lock is when I get the length of the removable bar (2" x 2" x ¼" tube), I cut the bar short by 1/2". Then drill a 1 3/8" hole with the drill press (I use a hole saw). Locate the hole 1 ¾" from each end and 1" from each side. This ho le is drilled only through the first layer (DO NOT DRILL ALL THE WAY THROUGH THE TUBE). I then take the 2" x 3/8" x 3 ½" flat bar with the nut welded to it and place it so that the nut is inserted into the hole in the bar. Making sure the end of the bar, the end of the flat plate, both sides of the bar and the flat plate are flush. These two pieces are then clamped and welded together.
- *Faceplates:* A 6" x 3/8" flat bar the length of the wall plate is clamped to the front or back of the wall plate. The f aceplate feeler gauge is set for 6" and it is run along the contour of the wall. This transfers the contour of the wall to the faceplate. The faceplate is then removed and taken to the torch site where the contour line is cut with the torch. The faceplat e is then trial fitted to see if the wall or the plate needs to be fine -tuned. The faceplate is then clamped again to the wall plate and tack welded in place. Before the back faceplate is placed, a short length of rebar (approximately 5") is then laid ac ross a wall pin near to the

wall and slid forward until it touches the front faceplate. It is then welded to the faceplate and the wall pin. This prevents the faceplate from being driven inward at the wall side with a hammer thus gaining access to the wa ll pins. This should be done with at least 3 of the wall pins on each side.

- *Concrete:* Once the entire gate is completed, it is time to clean out the sill trench and sill box of all rocks and dirt. Wet down the entire sill box and sill trench and then begin pouring the concrete making sure the concrete flows into all of the box and trench. The concrete should cover the first bar that is welded to the sill plate.
- *Tack welds:* Tack welds are used instead of a full fillet weld to reduce the bowing in of the wall plates until the gate is complete. Once the gate is complete the tack welds are converted to full fillet welds.
- *Fillet welds:* Fillet welds are comprised of 3 welding passes completely around the bars.

Detailed Equipment descriptions

- *Metal cutting carbide cut off saw or abrasive cut off saw:* The cut of cutoff saws produce a cleaner cut than an Oxygen/Acetylene torch. The metal cutting carbide cut-off saw can cut steel up to four times as fast as a abrasive cut -off saw. However, one of its limitations is it can only be used on mild steel as its blade cannot cut harder material such as rebar and cold rolled rod. Therefore, the abrasive cut-off saw is used to cut rebar and cold rolled rod. With gas cutting you need to clean the edges of the steel so b ats won't injure them selves.
- *Heavy-duty ½" drill:* This tool is used for drilling wall pin holes through the wall plates. The drill is fitted with a 1 1/16" hole saw and is mounted on a custom fixture. The fixture has a hydraulic drive that provides dril ling pressure.
- *Rotary/hammer drill:* Bosh spline drive rotary hammer model # 11244E. This piece of equipment can chip, hammer, or drill according to what chisel, driver, or drill is inserted into the tool holder. The other ancillary parts for this drill include 1" x 9" and 1" x 22" drills, bull nose and flat blade chisels, and ¾" rebar driver. This type of drill is used in the hammer mode to scale the walls and dig the footer trench. When changed to the rotary hammer mode, it is used to drill holes.
- *Custom drilling fixture & hydraulic drive:* The Heavy-duty ½" drill, when attached to its drilling mount, is then mounted on this fixture and pushed by the hydraulic drive to drill correctly spaced holes for wall anchor pins through the wall plates. The rotary/hammer drill, when attached to its drilling mount, is then mounted on this fixture when it is time to drill holes in the walls for wall pins. This is done by placing the drill bit through the already drilled hole in the wall plate and is pushed by the hy draulic drive. The hydraulic drive can be a porta - power with its ancillary parts.
- *Portable welding equipment:* Electric welding equipment can include truck or trailer mounted welders if the gate site is vehicle accessible, or portable welders if the gate site is more remote. Portable electric welding equipment can be any welder that is under 250 pounds and capable of producing welding current of 100 - 150 amps. Four to 6 people can carry this size of welder into a work site. The portable welders could include welders that are powered by a portable generator.

I will only address portable welding equipment because that is what Dave Dalton and I own. Miller Maxstar 152, Millermatic 175, and Lincoln Weldanpower G3000LX. The Maxstar 152 welder with 230 VAC, 27.1 Amps input, 1 – 150 Amps output DC, weighs 31 pounds and has worked well for us. As with changing times, this model is no longer available. A new model the Maxstar 140 STR welder with 230 VAC, 20 Amps input, 1 – 140 Amps output DC, weighs 10 pounds and is comparable. Our newest welder is a Millermatic 175 wire feed with 230 VAC, 19.5 Amps input, 30 – 175 Amps out put DC, that weighs 73 pounds. Our backup welder is a gas motor driven Lincoln Weldanpower with 50 – 125 Amps output DC. 200 lbs with wh eel kit. It can provide 3000 watts of power when not welding. Power cables, welding cables for welders, and other ancillary tools for welding are also needed.

- *Portable generators*: Generators can include truck or trailer mounted generators if the gate s ite is vehicle accessible, or portable generators if the gate site is more remote. Portable generators can be anything that is under 250 pounds and capable of producing up to 10 kilowatts of current. Four to 6 people can carry this size of generator into a work site. I will only address portable generating equipment because that is what I own. We use a Wacker GS 8.5V portable generator for power to the mine site. This generator is capable of producing enough power to run a welder, lights, hammer drill, manhole blower, Grinder, etc. by itself. On the other hand this generator is not capable of running a prep site by itself. Usually our preparation site has a welder, two cutoff saws, a grinder, and lights. An example can be made at a preparation site t hat is using a metal cutting carbide cutoff saw (120 V / 15 Amps. and a Miller Maxstar 152 welder (240 V / 27.1 Amps). If the generator does not produce enough power for both machines, the welder could cause the cutoff saw to stall. The result is one or two teeth are broken on the cutoff saw blade resulting in the saw blade needing changed. This $150.00 blade is useless until it is repaired and sharpened. Hence the need for experienced operators. In the above example, you could do one of two things. Do not use the chop-saw while using the welder, which would waste time or have two generators that are both capable of running the welder. This would be the better choice because you now have a backup that could run the welder if the other one broke down.
- *Manhole blowers with hoses:* Ventilation is important when the gate site is more than 5' into a mine or cave. One way to ventilate a site is to use manhole blowers. Because most manhole blowers use 8" hoses, it is best to use two blowers. The way manhole blowers are usually used is to blow air into a manhole, however, in the case of a mine or cave gating, the hose would need to terminate behind the gate site to blow the fumes and dust out the entrance. With this method a person would be walking throug h the fumes and dust all the way to the gating site. For a gating site it is best to suck the welding fumes and dust away from the work site and expel them at least 10 feet away from the mine entrance. Doing it this way places the manhole blowers outside of the mine or cave, thus leaving more working area at the work site. The hoses for manhole blowers need to be long enough to get the fumes away from the entrance. The hoses usually come in 15

and 25-foot lengths which can be joined together by using adapters to make the hose any length needed.

- *Gage plates:* Custom made gage plates are used to get the correct spacing between the bars.
- *Faceplate feeler gage:* A custom-made feeler gage was designed to follow the contour of the walls and to scribe that contour onto the faceplate for gas cutting.
- *Steel grinders:* A 4" grinder is used to clean cuts made with cutting torch, weld burrs, and partial welds. When the 4" grinding wheel is changed for a wire brush wheel, it is used for cleaning slag from welds. It can also be used for cleaning the gate of weld dust and weld burrs. The 9" grinder is used in places where more metal needs to be removed and the cutting torch is not available.
- *Slag removers:* For removing the slag from welds can be a regular chipping hammer or a steel grinder with a wire brush instead of a grinding wheel. The wire brush works faster.
- *Oxygen/Acetylene cutting torch:* An Oxygen/Acetylene cutting torch is used for cutting contours in the faceplates, cutting holes in the sill box rebar anchors, and sharpening wall pins.
- *Wall pin sharpener:* Another custom fixture that is useful is a wall pin sharpener. This fixture is used with the Oxygen/Acetylene cutting torch. The torch is clamped in place in the fixture. The torch is then turned on and ignited. The flame is adjusted for cutting. A wall pin is inserted into the fixture and preheated. Then a bevel is cut on the end of the pin. This bevel makes it easier to drive the pin into the holes drilled into the wall.
- *Work lights:* Work lights are necessary to provide adequate illumination of the work site. They can be floodlights with reflectors, florescent lights, or quartz halogen work lights.
- *Vacuum:* A small vacuum is necessary to cut down on the dust in the gating site. It is used to catch drilling dust and, when used with a custom made nozzle, will clean out drill holes.

Contractor Observations

Contractors Crew Versus Volunteer & Agency Labor

A contractor has an experienced crew and can install a bat gate quicker. Usually volunteer & agency labor will be inexperienced in most aspects of gate installation, which means the gating consultant needs to train each person in the proper use of the equipment. This can waste a lot of time.

Contractors Versus Consultants & Agency equipment

The contractor knows from past experience what equipment is needed and brings it along for the job. The equipment will be in good shape and there will be spare parts.

The gating consultant's equipment is usually kept to a minimum so that only one vehicle is used. The consultant relies on the agency responsible for project to supply the equipment needed. From my past experience, Agency equipment has been broken or miss handled and time was spent repairing and finding new parts.

Marion Vittetoe was employed by Annamax Mining Company for 13 years, working on the large-scale mining operation, where he worked with heavy mining equipment. He has been active in the organized caving community since 1974, where he has had a significant influence on bat conservation through caving policies. During this time, he has influenced the gating practices of cavers in the West. He is a Gating Consultant with 15 years experience building bat compatible gates for a wide variety of clients including: Department of Defense, Bureau of Land Management, Forest Service in numerous States, National Park Service, US Fish and Wildlife Service, and Arizona Game and Fish Department.

Figure 1. Primary equipment for the preparation site. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

Figure 2. Primary equipment for the gate site. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

Figure 3. Primary equipment for power distribution. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

Figure 4. Secondary equipment (hand tools). (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

Figure 5. Safety equipment. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

Figure 6. Ventilation equipment. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

Figure 7. Lighting equipment. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

Figure 8. Fire suppression equipment. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

Figure 9. Weather equipment. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

Figure 10. Backup equipment. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

Figure 11. Maintenance equipment & supplies. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consult ants, Tucson, Arizona.)

Figure 12. Preparation site. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

Figure 13. Gate site. (Photograph credit Dave Dalton & Marion Vittetoe independent gating consultants, Tucson, Arizona.)

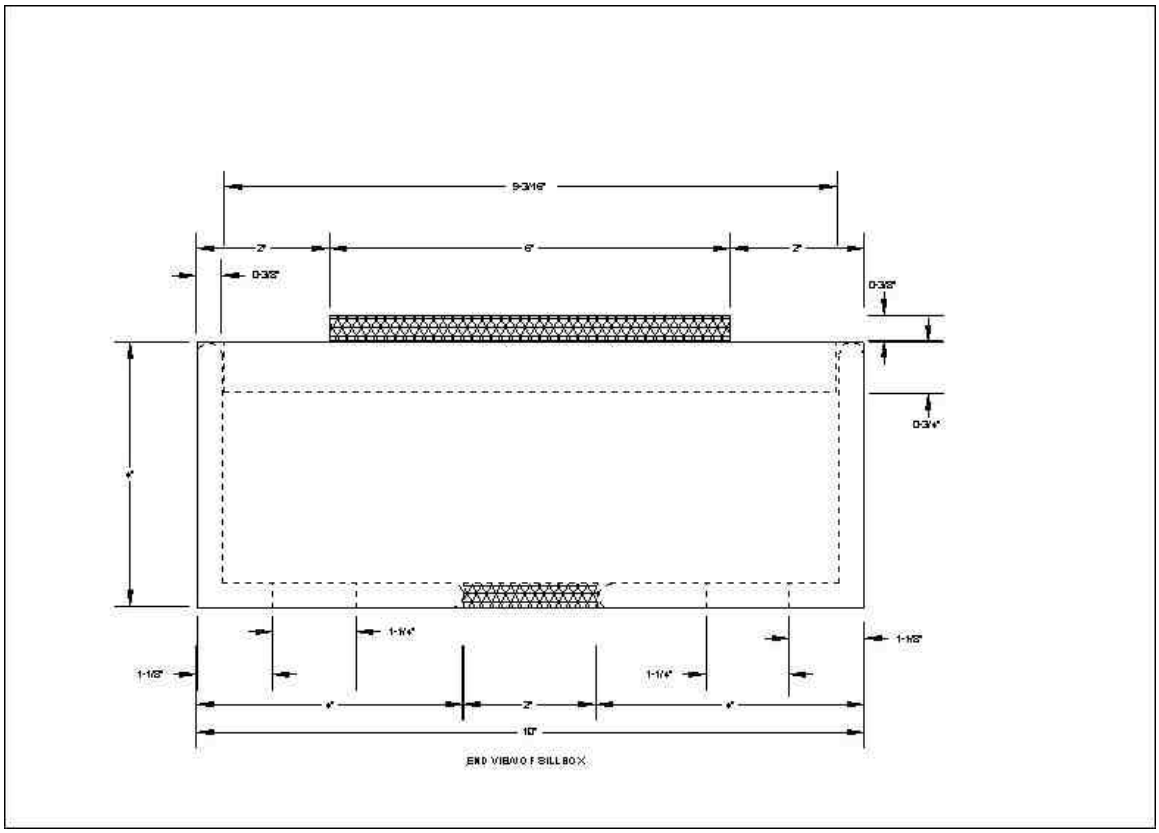

Figure 14. Sill box. Diagram by Marion Vittetoe independent gating consultant, Tucson, Arizona.

Figure 15. Drilling hole in wall plate. (Photograph credit Dave Dalton & Marion Vittetoe independent consultants, Tucson, Arizona.)

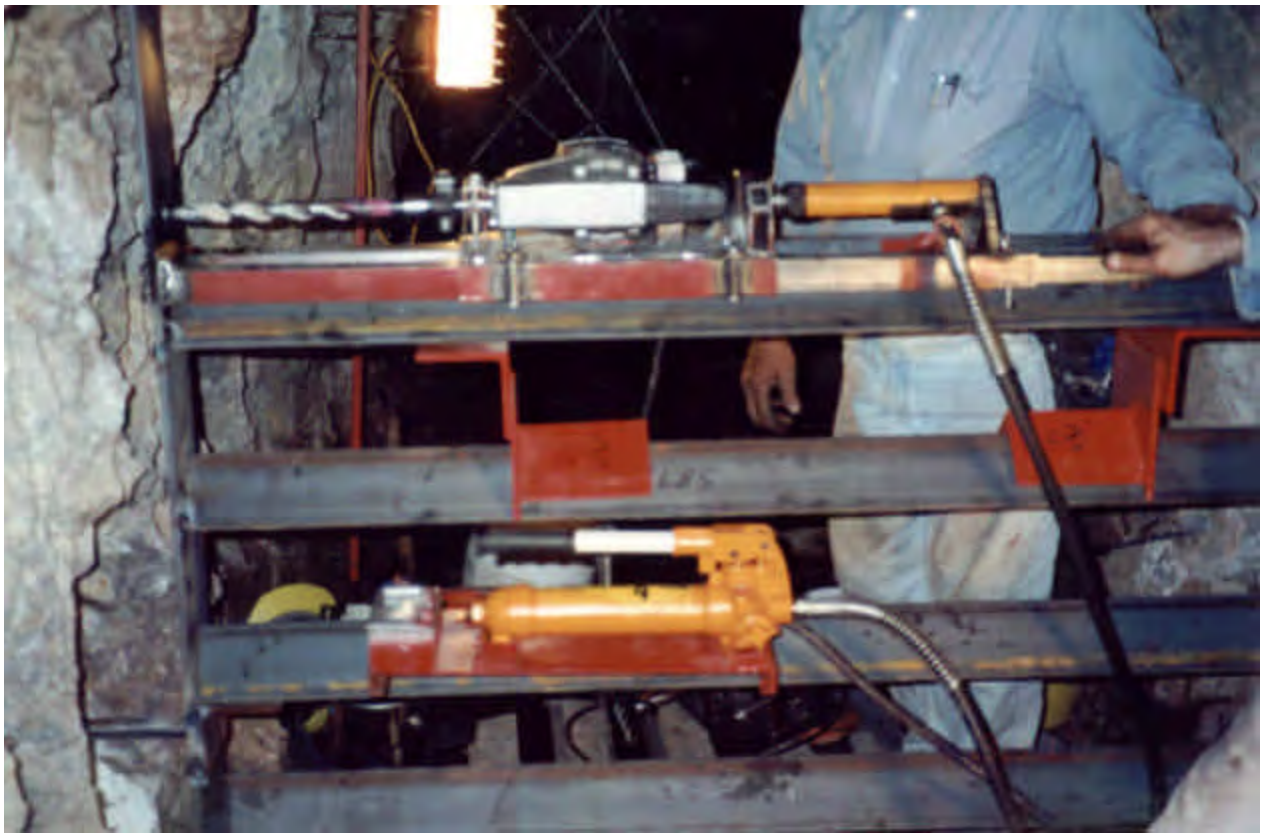

Figure 16. Drilling hole in wall. (Photograph credit Dave Dalton & Marion Vittetoe independent consultants, Tucson, Arizona.)

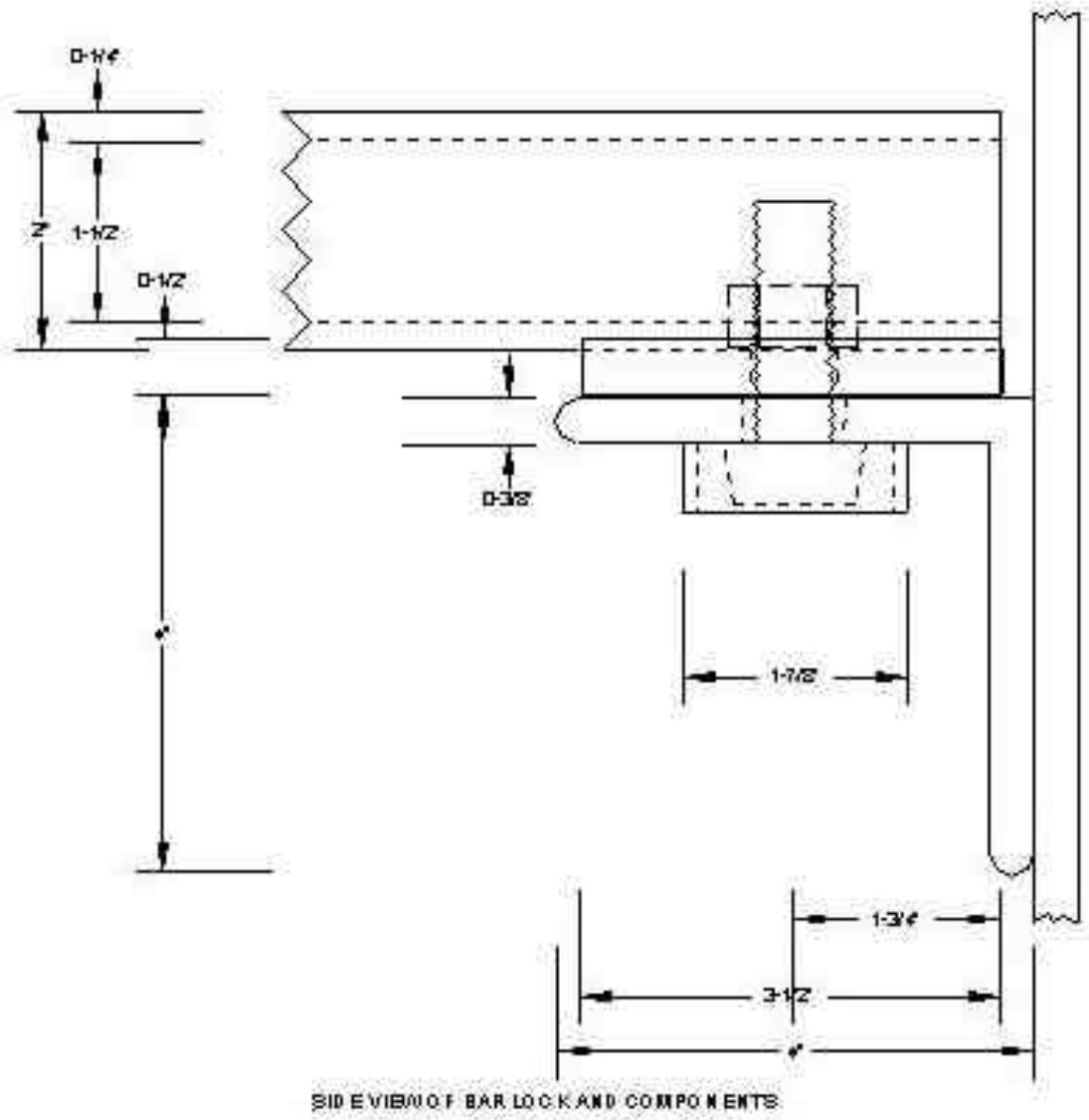

Figure 17. Rectangular tube lock diagram (side view) by Marion Vittetoe independent consultant, Tucson, Arizona.

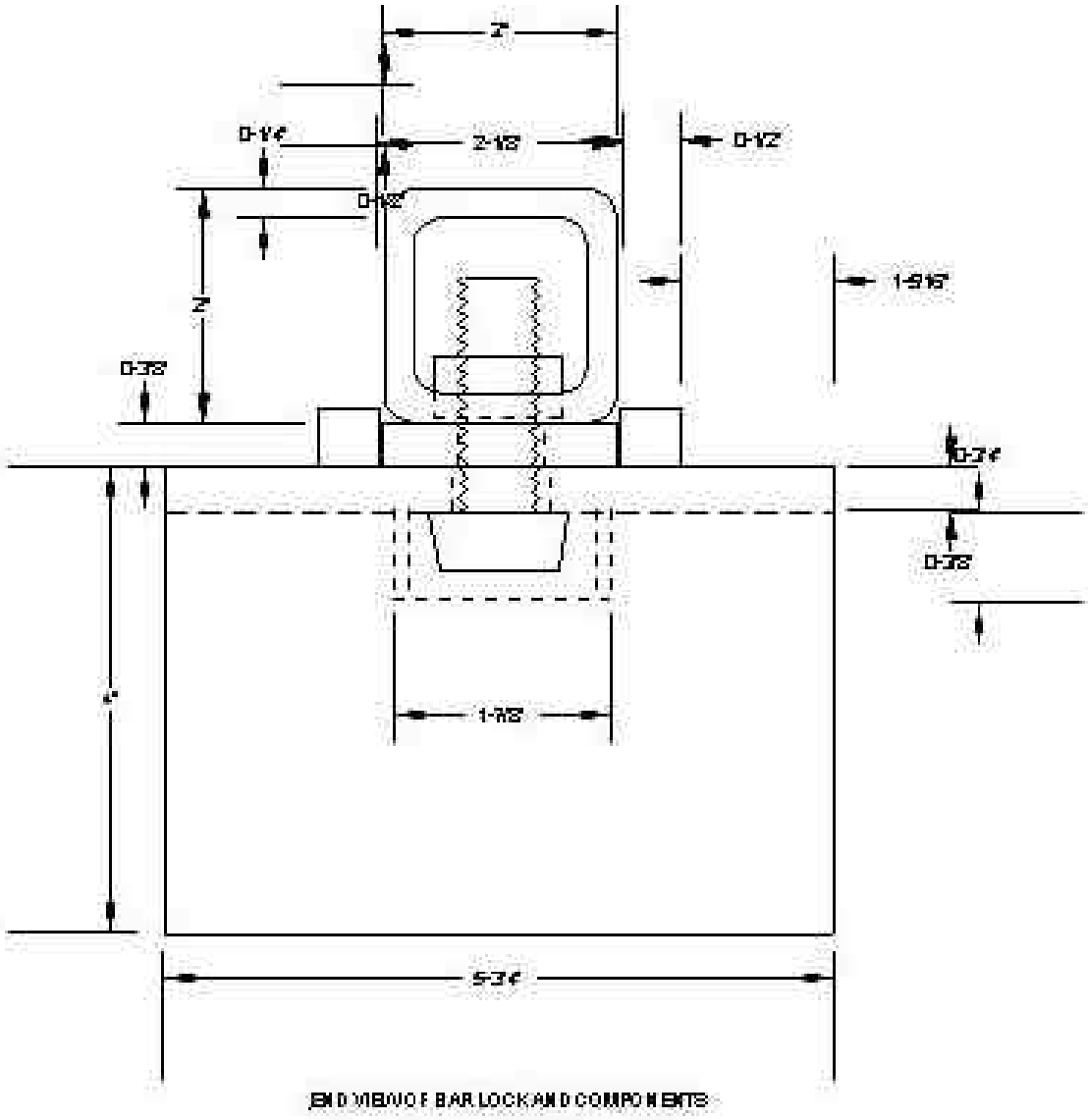

Figure 18. Rectangular tube lock diagram (end view) by Marion Vittetoe independent consultant, Tucson, Arizona.

Figure 19. Finished Rectangular tube gate. (Photograph credit Dave Dalton & Marion Vittetoe independent consultants, Tucson, Arizona.

ROUND BAR MANGANAL® STEEL "JAIL BAR" BAT GATE

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Abstract

Over the last 18 years, the Utah Abandoned Mine Reclamation Pro gram has utilized metal shaft and portal closures when physical constraints or the presence of sensitive bat species required an alternative closure method to backfilling. A variety of metal closures have been installed with the round bar Manganal® "jail bar" bat gate being optimal in meeting the duel goals of preventing human entry while allowing bats continued use of the mines. All types of metal closures are susceptible to vandalism and, as such, the design or creation of a secure closure is a dynamic process. Easily adaptable, the Manganal® gate design has proven its resistance to hacksaws, come -a-longs, and jacks. The gate design incorporates such features as ease of field fabrication and installation (thus minimizing the construction time under the brow), the labor involved, and disturbance to the area. Construction costs for Manganal® gates are comparable with mild steel closures due to reduced construction time and a smaller volume of materials required. In Utah, mine site access is often diffi cult and locations remote favoring small volumes of construction materials with comparatively light - weight. Maintenance repairs can usually be performed by a single individual.

Introduction

Over the last 18 years, the Utah Abandoned Mine Reclamation Program (UAMRP) has utilized a variety of metal shaft and portal closures when physical constraints such as equipment access, lack of or cost of fill materials, or the presence of sensitive bat species required an alternative closure method to backfilling or the construction of concrete block walls.

These metal closures have been met with a variety of success and, as a result, have evolved over the life of the Abandoned Mine Reclamation Program. When left undisturbed, most any closure works well with very little degradation occurring. But with the human factor and its associated vandalism, no closure is totally damage proof and, as a result, all of the closure designs utilizing metal have experienced vandalism of some kind.

Metal Closures

Since 1983, the AML program has used seven types of metal closures. Many were implemeted prior to any sensitivity to bat habitat issues and were developed based on other concerns such as continued air or water flow through the mine workings. The first such closure w as an A-frame style bird cage

closure constructed out of one-inch square tubing and 3/8-inch square bar stock (Figure 1). Although this design allowed bats continued use of the mine habitat that was not its design intent; airflow and movement of water from snow melt into the mines was its main goal. However susceptibility to collapse under moving snow loads and ease of vandalism eliminated the continued use of this type of closure (Figure 2).

The second design, again not specifically adapted for bats but usable by them, was the use of 3/8-inch round bar metal turned to form a cyclone fence design that laid flat at grade over an open shaft and was bolted into bedrock on the sides. This design was used when backfill material was not available or the shaft depth was too great making the economics of backfilling impractical. With this design bats could pass through the 5 by 5-inch openings, but off-site fabrication and difficulties with installation made this method too costly.

The third method used was to fabricate a 1-inch diameter rebar mesh on 5-inch centers cemented into a concrete grade beam around the perimeter of vertical openings (Figures 3 and 4). This method is currently still used for vertical openings and in some geological settings, such as sandstone, the rebar can be drilled and "pinned" directly into the bedrock below grade of the opening and epoxyed in place (Figure 5). Spot-welding at each cross member aids in stability and vandal resistance. To date, only one of these rebar type grates has suffered vandalism.

A forth method utilizing aircraft cable net has been used by the Utah AMRP on mines in the State within Nation Park Service boundaries. These cable nets consist of a single strand of aircraft cable woven and clamped at cross points creating 8 by 8 inch openings (Figures 6 and 7). One problem with the nets is they are easily breached by vandals if they are placed in areas that have easy access. Cable nets have also failed due to corrosion when in contact with acid soils.

Steel mesh doors have also been used in a limited number of mine openings. These closures leave a gap at the top of the gate that could be used as a flyway thus allowing some limited use by bats (Figure 8).

Bat Closures

In the early 1990's, when many abandoned mine programs developed an awareness of the critical relationship between bats and abandoned mines, Utah installed many of the angle iron bat gates. Many of these gates have been breached by vandals. They used hacksaws in order to gain entry into the mine workings. One area where the angle iron gate has been very successful is in Capitol Reef National Park. In 1993, eight angle gates were installed in adits that make up the Oyler mine complex (Figures 9 and 10). These gates remain in place today, vandalism free. It is likely this is a direct result of increase enforcement presence and frequent patrols typical in National Park Service administered lands.

The UAMRP continued to use the angle iron gate in other areas of the State undergoing mine land reclamation with less success. Vandals attacked gates installed in mines in the Wasatch Range, the highly visited mountains just east of Salt Lake City. Hacksaws were the preferred method used to gain entry at gated mines. Even though angle iron bars had the two inch stiffeners as per the design

specifications, vandals would manage to saw through a cross bar at the connecting point to the upright, then by constant torqing of the free end of the bar vandals would break the weld holding the bar to the upright thus freeing the entire bar from both uprights.

In order to test the angle iron design and potentially thwart future vandalism, UAMRP installed a gate in a heavily visited mine that had easy access. When the gate was vandalized using hacksaws, hard facing was welded along each edge of the bars and uprights. This thrust and parry between the vandals and the maintenance team continued until UAMRP realized, that in Utah, this was not a design that would deter vandals. Additionally, the cost of returning multiple times to a single site to perform maintenance was cost prohibitive and impractical. For isolated hardrock mines in the State of Utah, a new design was needed to accomplish the multiple goals of public safety and habitat protection.

Manganal® "jail bar" gate

In Utah, the round bar Manganal® bat gate has become the optimal design in meeting the duel goals of preventing human entry into dangerous abandoned mines while allowing bats continued use of the habitat those same mines provide. The design is based on the 1-inch diameter Manganal® "jail bar" type steel (Figures 11 and 12). The Manganal® steel is an alloy comprised of 12-14 percent manganese and iron. This alloy work hardens giving it the necessary strength and resistance to hacksaws and chisels that seem to be the prominent vandal tool in Utah. During fabrication, the steel is relatively easy to work with using standard grinding tools or oxy/acetylene cutting torches (Figure 13). This design allows for both bat use and small mammal use (Utah now has to accommodate Ringtail cats in its closure designs). The small bar diameter and use of flat strap Manganal® for the uprights rather than the more bulky 4 inch angle iron and 4 x 4 inch tubing minimizes interruption of air flow and, as in the angle iron gate, there is no interruption of water flow at the mine opening.

A total of 13 projects (Table 1) have been completed to date by the UAMRP for a total of just under $500,000. This gives an average closure cost of $2,700 each. Current costs are about $75.00/square foot installed. As with most new designs, fabrication of the first Manganal® gate was very costly, more than double the costs of subsequent gates. This is due to the continued refinement of field installation techniques, such as the sequencing the field fabrication and welding requirements on-site and within the portal opening. Although the actual cost of Manganal® steel is greater than mild steel, total constructions costs for Manganal® gates are comparable with mild steel closures due to reduced construction time and a smaller volume of materials required.

NUMBER OF SITES	PROJECT YEAR	PROJECT NAME	TOTAL COST OF CLOSURES	AVERAGE COST OF CLOSURES
1	1994	WASATCH	$8,080.00	$8,080.00
14	1994-95	SUMMIT AMERICAN FORK	$58,520.00	$4,180.00
50	1996-97	SILVER REEF	$143,006.00	$2,979.00
6	1997	SNAKE CREEK	$19,180.00	$3,197.00
21	1997	BULLION CANYON	$55,690.00	$2,652.00
2	1998	RIDGETOP	$4,500.00	$2,250.00
16	1998	WEST DIP	$32,235.00	$2,015.00
5	1998	WHITE RIM	$14,945.00	$2,989.00
6	1998	WHITEHORSE	$11,775.00	$1,963.00
14	1999	FIVE MILE PASS	$28,765.00	$2,055.00
11	1999-2000	SILVER KING	$30,985.00	$2,817.00
20	2000	JACOB CITY	$42,040.00	$2,102.00
11	2000	EAST REEF	$26,780.00	$2,435.00
177	1994-2000	TOTAL PROJECTS	$476,501.00	$2,700.00

Table 1. Gate Project Construction Costs

The bat gates are constructed of 25 mm (1") diameter solid manganese steel bar with two or more 12 mm x 10 cm (2" x 4") manganese steel strap vertical supports (Figure 13). All components are made of 12-14% manganese steel. The manganese steel gates have been known by the trade name Manganal®. The vertical supports have 25 mm (1") diameter holes cut on 1 6 cm (6-1/2") centers with the horizontal bars either electric welded or brazed to the vertical supports. The vertical supports are anchored to the roof of the adit by 25 mm (1") diameter 12 -14% manganese bars placed a minimum of 20 cm (8") and anchored with resin. The bases of the vertical supports are anchored to the floor of the adit by concrete grout (Figures 14 and 15).

The design and installation of a lock box to the vertical support allowed one of the bars to be removed allowing entry into the adit. This removable bar design was modified to allow for the removal of two bars in response to a request by search and rescue personnel to get rescue equipment into the workings if there was ever a need. The manganese steel may be rough cut off-site and cut to fit on-site utilizing a cutting torch. The 14 cm (5-1/2") spacing between bars allows bats to enter and exit freely while effectively restricting public access. Again, modifications of this design were deemed warranted in response to a change in the national building code standards for constructed gates in public areas and when concern over small children crawling between the lower bars of the closure was raised. This modification consists of reducing the spacing of the bars to 10 cm (4") on bars located below 1.2 m (48") from the floor of the adit. The spacing of 14 cm (5-1/2") is maintained above the 1.2 m (48") threshold. This allows for at least one and often many flyway spaces of 14 cm (5-1/2") in the average adit.

During fabrication, only two material components are needed, lengths of round bar and lengths of steel strap (Figure 16). Labor and time are reduced as only individual horizontal round bars and strap steel require cutting to finished length. Welding is only required to anchor the round bars to the strap steel and fabricate the lock box. For proper fit, the gate must be partially assembled on-site before installation within the opening (Figure 17). With subsequent installation projects, the contractors became fluent in the procedures required, thus further reducing the time spent under the brow of the mine, the most hazardous area during the construction process. Currently, time and labor required to install an average sized gate is two laborers and about one half day. Conversely, the mild steel angle iron gates require multiple components: 4 inch angle, 2 inch stiffeners, and 4 x 4 inch uprights. Numerous welds are needed to put the angle iron gate together.

Vandals have made numerous, direct attempts at damaging Manganal ® gates. These attempts have included trying to shoot off the lock box, spreading the bars with a variety of jacks, and hacksawing through the bars. None of these direct attempts at gaining entry to the mines through the gates have been successful. However, two indirect attempts have been successful in gaining access to the mine workings. In one case vandals dug into the sill (floor) of the mine and underneath the concrete footing holding the gate. In a second case, one rib (side) of the mine was literally mined-out allowing access around the gate and into the workings. In both of these cases the damage was easily solved. In the first case, the hole was filled with additional concrete and steel and the second case by merely welding additional pieces of Manganal® into the gap created by the "mining" activity. Maintenance of the Manganal® bat gates can be performed utilizing a minimum of labor due to a reduced amount of materials and equipment needed. Equipment usually consists of a cutting torch and a small electric welder.

In Utah, mine site access is often difficult and locations can be remote. In some instances, such as in National Park Service lands access may be restricted to foot traffic only, mines scheduled for closure may be miles from existing staging areas. Manganal® gates are excellent for these types of applications. The relatively small volumes of construction materials, (lengths of round bar and flat strap pieces), and their comparatively light weight makes getting into isolated areas easy. Portable

generators, welders, and gas cutting torches can also be easily mobilized into isolated areas. This was clearly demonstrated in the White Rim project in Canyonlands National Park. Mine sites were as far as two miles off existing a ccess roads. Park rules prevented any motorized or wheeled traffic off existing roads. All materials and equipment had to be carried in by foot (Figure 18) to construct 5 bat gates that comprised a total of 176 square feet of Manganal® steel.

Conclusion

The key benefits of the Manganal® design are: 1) the ease of installation; 2) a reduction of materials and less welding thus minimizing construction time under the brow; 3) its resistance to vandalism by hacksaws, come-a-longs, and jacks; 4) reduced labor in the transport of materials; and 5) reduced disturbance to the area around the closure.

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Figure 1. A-frame style bird cage closure

Figure 2. A-Frame collapse under moving snow loads and ease of vandalism

Figure 3. 1-inch diameter rebar mesh on 5-inch centers cemented into a concrete grade beam around the perimeter of vertical openings.

Figure 4. 1-inch diameter rebar mesh on 5-inch centers cemented into a concrete grade beam around the perimeter of vertical openings.

Figure 5. Rebar can be drilled and "pinned" directly into the bedrock below grade of the opening

Figure 6. Cable net.

Figure 7. Cable Net

Figure 8. Steel mesh door

Figure 9. Angle iron gate Oyler mine complex

Figure 10. Angle iron gate Oyler mine complex

Figure 10. Angle iron gate Oyler mine complex

Figure 11. 1-inch diameter Manganal® "jail bar" gate

Figure 12. 1-inch diameter Manganal® "jail bar" gate

Figure 13. Standard grinding tools or oxy/acetylene cutting torches for use with Manganal Steel

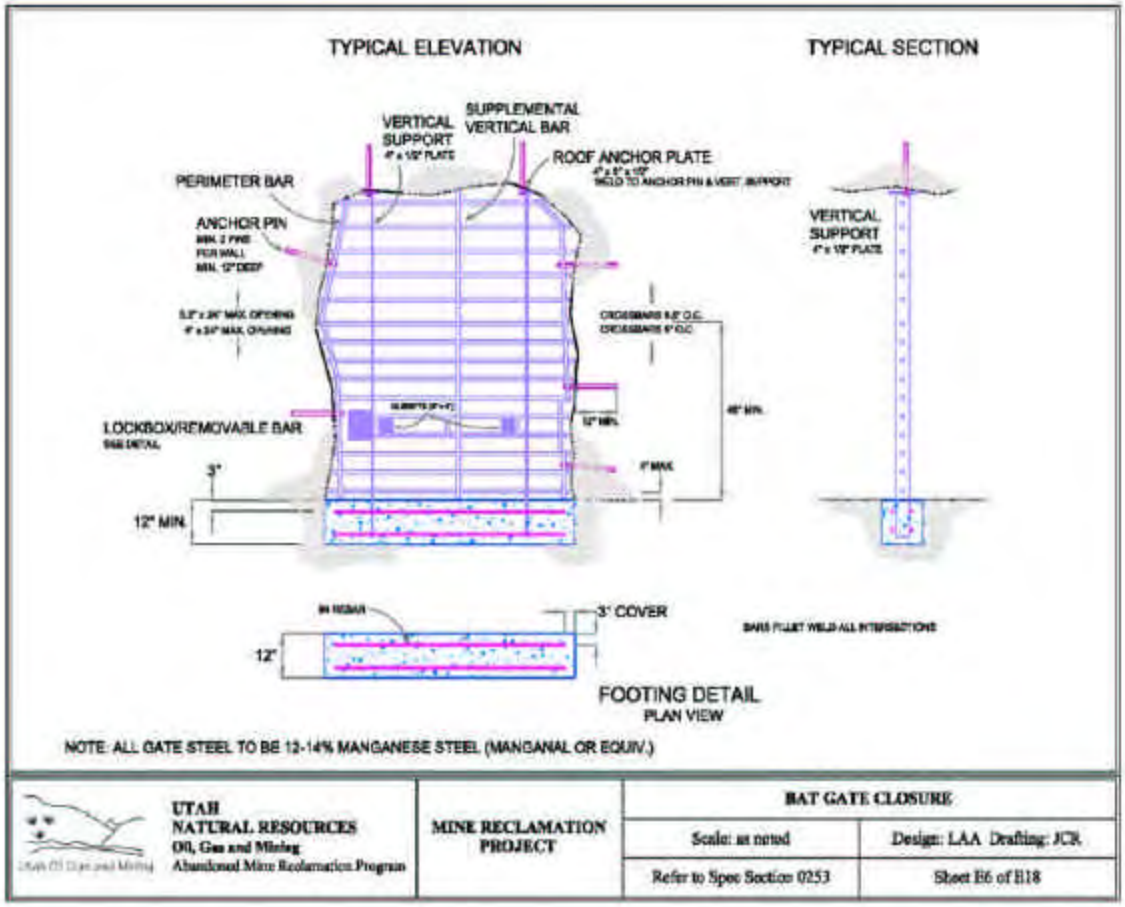

Figure 14. Bat Gate Design with Manganal Steel bars

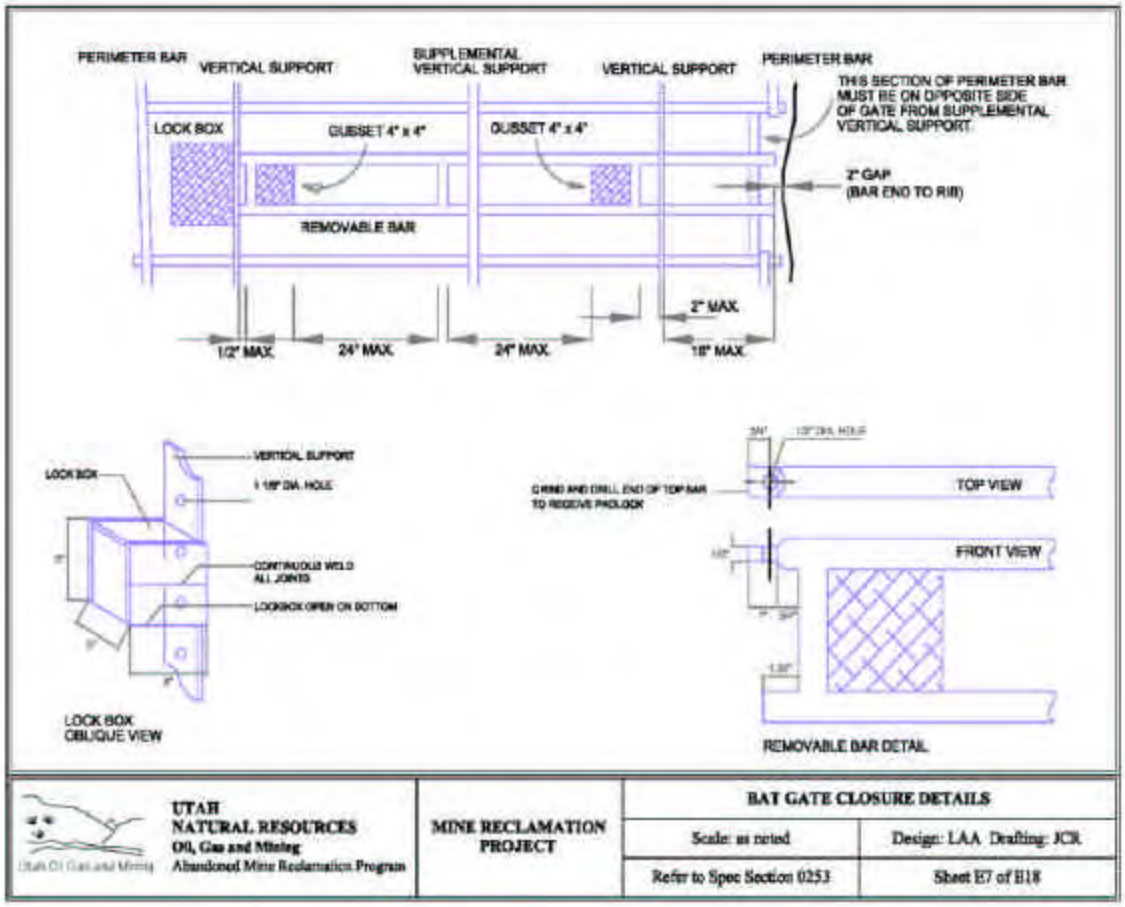

Figure 15. Manganal gate closure details.

Figure 16. Manganal steel lock box

Figure 17. Partially assembled gate before installation

Figure 18. Materials and equipment had to be carried in by foot

BAT CUPOLA DESIGN CONSIDERATIONS

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Abstract

Bat cupolas are constructed over vertical and nearly vertical mine and cave openings in order to provide access for bats while protecting the public from the usually extreme physical hazards of such openings. Provision of a proper foundation for a bat cupola is structurally the most important design consideration and is highly site specific. Options include concrete foundations and polyurethane foam plugs with vertical pipe risers. Rock conditions and the size of the opening are often the most important parameters in choosing a foundation design solution. Other factors such as: the presence of timbers in the opening, the need to preserve historic structures at or near the opening, accessibility by construction equipment, the location, size, type of use by and species of the resident bat population, the need to preserve airflow conditions in the underground mine or cave, and other factors may also play a role. Design guidelines for the bat cupola itself are less well defined than they are for grated closures in horizontal openings, but many of the same basic principles apply.

Introduction

Bat cupolas are three-dimensional structures, generally with four to six sides, constructed over vertical and near-vertical cave and mine openings to protect the underground habitat of bats and other species while safeguarding the public from the hazards of those caves and mines. However, flat single-sided structures can be used for vertical openings with small bat populations or at vertical openings infrequently used by bats but important for ventilation of underground habitat with multiple openings. I refer to these planar structures as horizontal bat grates or grated closures. Many of their design considerations are similar to those for bat cupolas and they could be considered a subset of cupola-type structures. Much of the following discussion is relevant to their design as well.

Although bat cupolas are most often constructed over vertical and nearly vertical openings, they may also have a place at inclined or horizontal openings where it is important to provide more space for the passage of large colonies of bats than could be provided with standard bat grates built inside the opening.

At vertical and steeply inclined openings, the first and most essential design consideration is to provide a secure and permanent foundation for the structure. The choice of the type of foundation is highly site specific and will depend on: the condition of the rock at the opening, the size of the opening, and construction accessibility to the work site. For large openings, the use of cable netting to span the opening should be considered. Where necessary for bat passage, standard bat grates or cupolas can be used in conjunction with cable netting.

Design guidelines for the cupola structure itself are less well defined than they are for standard bat grates. Being three-dimensional structures with only a few site-imposed constraints on their dimensions, cupolas display wide variations in height, shape, bar types and sizes, and other design details. As always, the primary design considerations for the cupola structure are to accommodate the needs of the resident bat population while providing public safety.

Options for Cupola Foundations

The ideal setting for the foundation of a bat cupola has: (1) strong, unfractured bedrock (what engineers and geologists refer to as "competent" rock) at or close to the surface; (2) a small- to medium-sized opening; and (3) a site with easy construction accessibility. In this case, a cast-in-place reinforced concrete footing would be my first choice. The footing would rest on bedrock with a minimum of twelve inches of rock between the inside of the footing and the edge of the opening. Where construction access is restricted, concrete may still be used if it can be pumped or carried to the site with a construction loader or helicopter. Of course, such extra handling will add to construction costs. The use of precast round, oval, and rectangular concrete pipes and box culverts placed vertically over the opening can also be considered.

In less competent rock or where competent bedrock is some distance below the surface, other options need to be considered including: riser pipes set on bedrock, polyurethane foam or concrete plugs with riser pipes, concrete "hollow-core" plugs, and concrete slabs. Riser pipes serve to stabilize weak, fractured or unsound rock or loose collar material and can provide a connection between deep competent rock and the surface. Because of its low weight and ready availability and strength, galvanized corrugated steel pipe is often used for risers at concrete and polyurethane foam (PUF) plugs.

Where competent bedrock is close to the surface, but deeper than one wants to excavate in order to form and construct a cast-in-place concrete footing, and where the bedrock is reasonably level or planar, a riser pipe can be placed on the bedrock surface around the opening. Backfill can then be placed around the riser pipe as required and either a concrete footing cast around the riser pipe or the cupola structure attached directly to the riser pipe, as discussed below. A variation on this solution is to position a cast-in-place concrete "hollow-core" plug, which is shaped like an inverted, truncated cone or wedge having a rectangular or circular opening closely matching the vertical opening in the rock below. One advantage of these approaches is that no reduction in cross-sectional area of the opening is required.

At less competent rock, a rigid PUF plug placed inside the vertical opening with a riser pipe held in place by the foam helps to stabilize the collar. Corrugated steel pipe is available with circular cross-sections as well as in pipe-arch and oval shapes that better fit rectangular openings. Unfortunately, even when the largest pipe or multiple pipes that fit into the opening are used, there is a significant reduction in cross-sectional area at the opening, often by 50 percent or more. Another disadvantage is that both experience and theoretical structural calculation of the effects of minimizing the thickness of the PUF

plug between the rock walls and apexes of the riser is limited and design of such closures needs to be approached conservatively and with caution. Concrete plugs, including the use of low-density cellular concrete (with unit weights down to twenty-five pounds per cubic foot), have been used for mine safeguarding. Although much more is known about the structural properties and behavior of concrete, it requires significantly stronger bottom formwork because of its weight, which can be difficult and hazardous to place in vertical cave and mine openings (especially those with poor rock conditions). Concrete has been placed in shafts using PUF plug forms and retrievable inflatable forms, greatly reducing the need for human entry into the opening.

Despite the lack of full knowledge of its structural behavior, PUF is a proven material for closure of abandoned mine openings. It is fairly easy to apply and has been used for at least 10 years in abandoned mine safeguarding without a reported failure of the foam itself; all reported failures have involved collapse of the surrounding material. Although PUF is a weak structural material, with compressive strengths around 25 pounds per square inch, it is extremely light (about two pounds per cubic foot in place) easing transportation of the material to remote sites and placement in vertical openings. Because of its low weight and rapid set, PUF can be placed with a minimum of formwork. Once expanded, PUF is also chemically inert to all but an uncommon industrial solvent. PUF is shipped to the job site as two liquid components, either in barrels or in pre-measured bags. Components in barrels are pumped through heated lines to the opening and mixed just before discharge through a special nozzle. Alternately, the components can be heated in the barrels, carefully measured in buckets, the two components mixed thoroughly, and poured into the opening. Bagged PUF is applied by breaking component bags inside an outer bag, thoroughly mixing the components, and throwing the bags with the expanding PUF into the opening.

The design of PUF plugs, especially those with large riser pipes, is currently not well defined and the structural behavior of the plugs and the fill material above them is subject to a large set of uncertainties. The best method for design of PUF plugs, of which I am aware, is in Finley A. Charney's paper, "Analysis of Polyurethane Mine Closures," in which he develops a theoretical design method for polyurethane foam using structural finite element analyses. More laboratory and field testing is required to better define the short- and long-term structural behavior of PUF plugs. As designers push the limits of what we do know, the good field record for PUF plugs may not last. Again, I recommend a cautious and conservative approach, especially in the design of large PUF plugs, PUF plugs with large riser pipes, and deeply placed PUF plugs. One way to reduce the uncertainties associated with PUF plugs with large riser pipes is to support the riser pipe from above using steel beams supported at the surface.

In deeply placed plugs, the characteristics of the backfill material, especially unit weight and free drainage, become more important. Designers may consider the use of lightweight aggregate fill, including scoria and expanded shale, to reduce the loads on and, therefore, the required depth of the PUF plug. At all installations of PUF plugs, it is important to provide drainage of subsurface water above the PUF plug to avoid adding hydrostatic pressure loadings to the plug. Two to three feet of soil cover is required to protect the foam from sunlight and fire.

Concrete slabs on shallow bedrock can also be used to support cupola structures. The use of PUF is ruled out in situations where the rock bridging over an underground void is competent but too thin for a PUF plug. If the rock is also too thin to safely carry the loads from a concrete footing, the use of a concrete slab either transfers loads to areas over thicker or more competent rock or spreads the loads over a sufficiently large area to reduce concern of collapse of the rock roof.

Corrosive and high sulfate soils and rock are sometimes found at mine and cave entrances. For additional life in corrosive environments, the use of polymer coated corrugated steel pipe can be considered or the portion of the pipe above a PUF plug could be coated with a ½-inch thick coating of the foam. Where soluble sulfate levels are above 0.20 percent, measures to protect concrete against sulfate attack and weakening should be considered. Such measures include the use of ASTM C150 Type V cement (sulfate-resistant) in the concrete mix, limiting the water-cement ratio in the mix to 0.45 or less, using a minimum of 600 to 650 pounds of cement per cubic yard, applying a waterproof coating (bituminous, epoxy or other organic coating) to the exposed faces of concrete, embedding the steel reinforcement more deeply at exposed surfaces (generally to provide at least three inches of cover), using a clean aggregate fill around the concrete, and providing good drainage to minimize exposure of the concrete to sulfate-laden waters.

The Cupola Structure

Design of the cupola structure itself involves similar considerations to those at standard bat grates:

- The cupola structure should be as safe as possible to construct and not present a danger to the public, while being durable and vandal-resistant in order to prohibit unauthorized entry and to protect internal habitat. It should safeguard the general public from the hazards of caves and abandoned mines, require minimum maintenance, and be easily repaired if breached or damaged.
- Requirements for overall dimensions and configuration of the cupola vary according to the size of bat colony, the type of bat use (maternity colony, hibernacula, day or night roost, etc.), the number and sizes of other nearby cave or mine openings available for bat passage, the proximity of the opening to the areas of the cave or mine being used by bats, the particular bat species involved, and the requirements of other cave- and mine-dwelling species. Cupola designers need to listen closely to the recommendations and biological understandings of bat biologists and cave ecologists.
- Avoidance of adverse impacts to airflow and, at some openings, to surface water drainage patterns helps to maintain internal cave or mine temperatures, moisture conditions, and other environmental conditions. Measures that block or significantly modify airflow, including the use of solid wall construction above the ground surface, need to be kept to a minimum.

- Protection of bats from predation is enhanced by reducing the number and sizes of vertical columns and other vertical obstructions, maximizing the number and sizes of horizontal bat fly-through areas, and properly selecting the dimensions and shape of the cupola structure.

Many shapes can be used for the cupola structure. These shapes include simple rectangular boxes, hexagonal shapes, and those with sloping tops. Sloping tops and sides have been used in cupola design to place the structure below the sight lines along a highway, to shed rocks thrown or naturally falling from an adjacent cliff face, to discourage people from climbing onto the top of a high structure, and to lower the weight of a cupola structure without reducing its height at a site with difficult construction access. Within the design considerations discussed above, cupola shapes and details can be chosen to be esthetically pleasing, especially where visitors will frequently see the structures in parks and open public lands.

Bat cupolas are generally constructed of steel, either mild or weathering steel, because of its strength and durability. Weathering steel has a higher strength than mild steel (50,000 pounds per square inch yield strength compared to 36,000), has sufficient corrosion resistance in most above-ground environments to remain uncoated, and, if uncoated, weathers to a soft rust color that blends into most landscapes. Mild steel structures generally require painting.

Cupolas have been built using angle-iron crossbars on the sides and sometimes the top of the cupola. These are similar in appearance to a multi-sided angle-iron bat grate. My preference is to use four-inch by four-inch weathering steel structural tubing for the corner columns, top perimeter beams, and major top crossbeams. I prefer four-inch by two-inch tubing for the horizontal crossbars, intermediate columns, short posts, and minor top crossbeams. The structural tubing has a standard quarter-inch wall thickness.

At a cast-in-place concrete foundation, attachment of the cupola to the substructure is most often accomplished by welding or bolting the cupola columns to a cast-in-place base plate. Alternately, the bottom of the cupola can be designed to rest on or over the top of a riser pipe with the weight of the cupola (and a few tack welds, construction epoxy, or drilled anchor bolts) holding the structure in place. Bolts need to be protected from unauthorized removal, generally by tack welding the nuts or bolt head, destroying of the exposed threads, or by making them inaccessible.

For protection against predation of bats by snakes, raccoons, cats, and coyotes at the cupola, the prime measure to be taken is to increase the width, length, and especially the height of the structure (which increases both the area any one predator needs to cover and the options available to bats for fly-through). Although no rules-of-thumb have been developed, the dimensions of the structure should reflect the maximum number of bats flying through the opening at any one time. This depends on the size of the bat colony, the type of use in the cave or mine, the species of bats, and other factors about which we may know little.

Cupolas can be designed to accommodate other creatures that use mi nes or caves, including birds and invertebrates. At several sites in southern New Mexico, where barn owl use of abandoned mine shafts for nesting is common, the New Mexico Abandoned Mind Land Bureau (NMAMLB) has experimented with designs to allow passage of the owls through the cupola structure.

Authorized entry through a cupola structure, for biologists, ecologists, cavers, and mineral claimants can be provided by means ranging from: a simple removable crossbar locked with locking bolts, a hinged or removable panel set into the top or side with locking bolts, or a protected padlock.

Experience, at least at abandoned mines in New Mexico, has shown that vandalism at vertical openings tends to be less than at horizontal openings, presumably because undergro und entry at those sites would require climbing equipment and significant effort. Nearby horizontal entries are the easier targets. Nonetheless, to minimize the costs and frustrations of repair and the dangers of breached closures, cupola structures should be designed to be resistant to pulling, prying, hammering, jacking, sawing, cutting, and other attempts at defacing and destroying. In areas with a high threat of vandalism, the structural tubing can be filled with concrete or grout to frustrate cuttin g with a torch or saw.

At the same time, the structures need to be safe for the general public. Since the standard 5 ¾ -inch vertical spacing for bat passage is wide enough for many children and a small percentage of adults to fit between the bars, the bottom bars can be spaced at no more than four -inches clear (following the requirements of the Uniform Building and International Building Codes), or heavy -duty expanded metal mesh or industrial bar grating can be installed around the base of the cupola. Bar grating and expanded metal mesh around the base of the cupola allows unrestricted airflow and, in the same way that plywood strengthens a wood frame structure, serves to reinforce the cupola against racking loads during handling and after completion.

Another public safety consideration is that structures over four feet high may present a hazard to those who climb onto the top. The Occupational Safety and Health Administration requires hand railing for walking and working surfaces four feet or more above the surrounding grade. One option at high bat cupolas is to avoid providing a "walking surface" by closing the top using crossbeams spaced for bat passage rather than using bar grating or sloping the top surface. Other options include providing railing around the top or constructing an overhanging top to make the top surface difficult to access. Any bar grating used on the top should be serrated to provide slip resistance.

Grating can be galvanized mild steel or weathering steel, although small quantiti es of weathering steel grating can be difficult to purchase. At some sites, NMAMLB has experienced vandalism of horizontal bar grating. Vandals have dented the grating by throwing large rocks onto it, in one case badly damaging the grating by dropping ro cks, possibly off an adjacent forty-foot high cliff, and prying it with bars. Nonetheless, horizontal bar grating can provide a stable working platform around a top lockable opening in the cupola and a safe platform for visitors to view the underground vo id.

Some abandoned mine shafts have significant amounts of timbers in them. The fire from burning timbers could not only compromise the integrity of the cupola structure and foundation, but is also likely to have severe impacts on bats and their undergro und habitat. Where timbers are present below a cupola structure, measures to minimize the chances of accidentally or deliberately set fires should be considered. These measures may include constructing a barrier to wildfire, avoiding the construction of a flat platform over the shaft opening (which would provide a place where campfires could be built or where vandals could find easy access), and constructing other measures to limit human access above the shaft.

Cost Information

A significant part of the installed costs of bat cupolas will depend on the foundation requirements, although, with its many joints, the cupola structure itself will involve a major expenditure for cutting and welding. The NMAMLB generally bids each complete cupola installation a s a lump sum item; structural component cost experience is therefore unavailable except for PUF. Over the last 10 years, costs for machine-applied and poured-in-place PUF have ranged from $150 to $250 per cubic yard, exclusive of the costs of formwork and riser pipes. Reinforced cast-in-place concrete including formwork is estimated to cost between $300 and $500 per cubic yard. Since 1992, total costs for cupola installations, including foundations, riser pipes where used and the cupola structures (but ex cluding the PUF plugs at some installations) have ranged from $5,500 to $20,500 at NMAMLB projects.

Conclusions

Foundation design is not only the most important structural component of cupola design – a foundation failure is costly to repair and may enda nger human life – it is often also the most difficult part of the design process, requiring understandings of: the geological and geochemical setting, the properties and behavior of rock and construction materials, and construction methods. Professional ju dgment is sometimes required, particularly where rock conditions are less than ideal and where full information is not available because of the difficulties of site inspection. It is well to consider seeking the advise of a structural engineer, geotechnic al engineer, or both in the design of all but the simplest of cupola foundations.

A wide range of options is available for the design of the aboveground cupola structure. Here, the prime considerations are to: provide for the needs of the resident bat po pulation and other protected species, minimize adverse impacts to the underground environment, and provide a safe and long -lasting structure.

I challenge designers also to make bat cupolas beautiful. Each cupola is a small monument to humankind's reawakening sense of responsibility for the fate of other species. Each cupola reminds us of our responsibility to care for the world and those with whom we share it and celebrates the beauties and mysteries of the cave, the mine, and the creatures that inhabi t them.

Bibliography

Anderson, Cara, Gabriel Gehrig, Jim Katzer, Vince Lombardi, Nathan Person and Mike Vair. 2000. Polyurethane Foam Closures of Abandoned Mine Shafts. Pages 429 -452 in *Proceedings, 22nd Annual National Association of Abandoned Mine Land Programs Conference*, Steamboat Springs, Colorado, September 24-27, 2000. 591 pp.

Boreck, Donna L. 1994. Use of Lightweight Foam Concrete for Sealing Abandoned Mine Shafts. Presented at the 1994 SME-AIME Annual Meeting, Albuquerque, NM, February 14-17, 1994. 11 pp.

Charney, F. A., G. M. Matheson and A. K. Sieben. 1992. Design Procedures for Rigid Polyurethane Foam Mine Closures. U.S. Bureau of Mines. 98 pp.

Charney, Finley A. No date. Analysis of Polyurethane Mine Closures. J. R. Harris & Company, Denver, Colorado. Prepared for the Colorado Mined Land Reclamation Board. 29 pp.

Currie, Robert R. 2000. An Evaluation of Alternative Methods for Constructing Bat Gates at Mine Closures. Pages 127-143 in *Proceedings of Bat Conservation and Mining: A Technical Interactive Forum*, St. Louis, Mo., November 14-16, 2000. 293 pp.

Kretzmann, John A. 2000. New Mexico Experience with Bat Grates at Abandoned Mines. Pages 145 - 151 in *Proceedings of Bat Conservation and Mining: A Technical Interactive Forum*, St. Louis, Mo., November 14-16, 2000. 293 pp.

Occupational Safety and Health Administration. Standards – 29 CFS, Subpart D, Walking-Working Surfaces, Standard No. 1910.23, Guarding floor and wall openings and holes.

Rushworth, Peter, David L. Bucknam and David H. Scriven . 1989. Shaft Closures using Polyurethane Foam. Pages 636-654 in *Proceedings: Symposium on Evolution of Abandoned Mine Land Technologies*, Riverton, Wyoming, June 14-16, 1989. 654pp.

Swenson, E. G. No date. Concrete in Sulphate Environments. CBD -136, Canadian Building Digest. 7 pp.

Tuttle, M. D. and D. A. R. Taylor. 1998. Bats and Mines. Bat Conservation International, Inc. Resources Publication No. 3, Revised Edition. Austin, Texas. 50 pp.

John Kretzmann worked as a design and project engineer in water r esources for many years before beginning work in abandoned mine reclamation and safeguarding in 1990 for the New Mexico Energy, Minerals and Natural Resources Department. This work has included design for bat preservation at

over eighty abandoned mine sha fts, adits, and open stopes throughout New Mexico. He has a bachelor's degree in Civil Engineering from Valparaiso University.

Figure 1. Formwork for a cast-in-place concrete foundation on bedrock around a shaft opening. Note the reinforcing steel inside the forms. The cylindrical shapes in the wall form to the right are 6-inch PVC pipes for drainage. The height of the compl eted walls will vary between 1-8 inches and 5-7 inches.

Figure 2. The completed concrete foundation with a pre-fabricated steel at cupola, at the upper left, waiting to be put in place. The threaded rods at the foundation corners and wall centers were used to hold steel base plates (hidden under a thin layer of concrete) during concrete placement. The cupola structure will be welded to the eight base plates. The shaft inside the foundation is 375 feet deep.

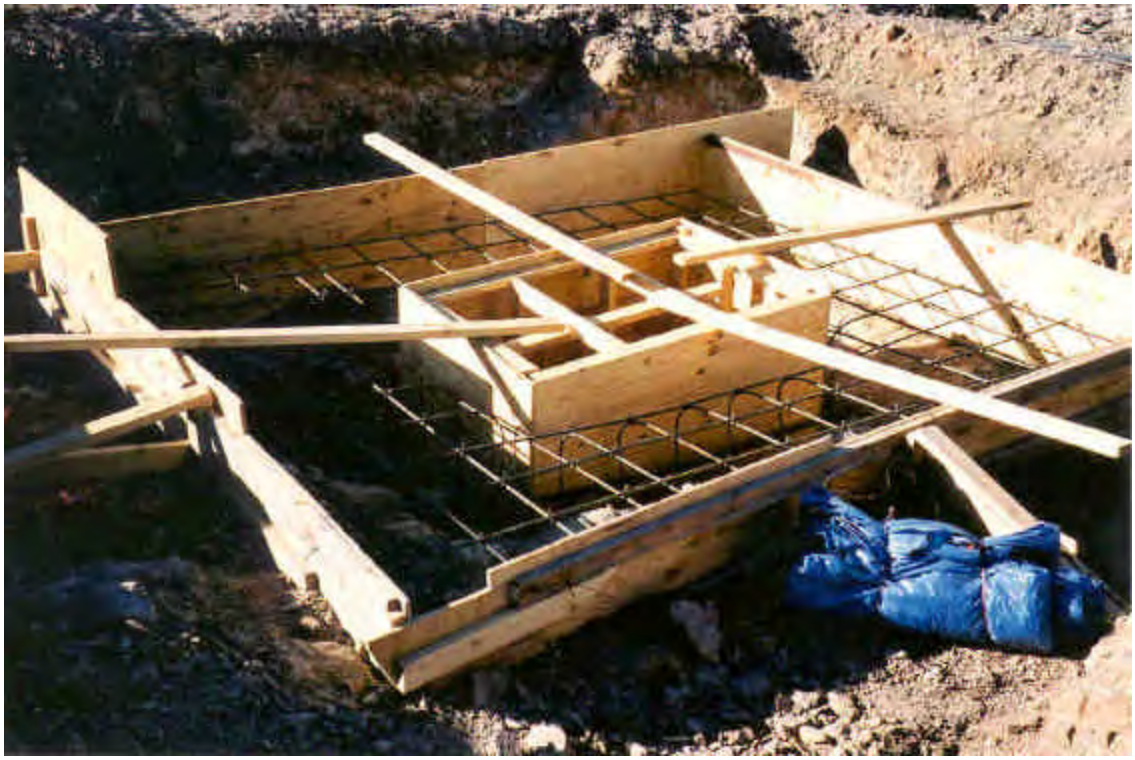

Figure 3: Formwork and reinforcing steel for a hollow -core cast-in-place concrete footing, which spreads loads over a wide area at highly fractured, weathered bedrock. The box in the center closely matches the size of the timber -cribbed shaft below.

Figure 4: A bat cupola, using angle -iron crossbars, attached to a pre-existing concrete collar at a deep shaft. Note the angle -iron bat grate in the adit portal behind the cupola.

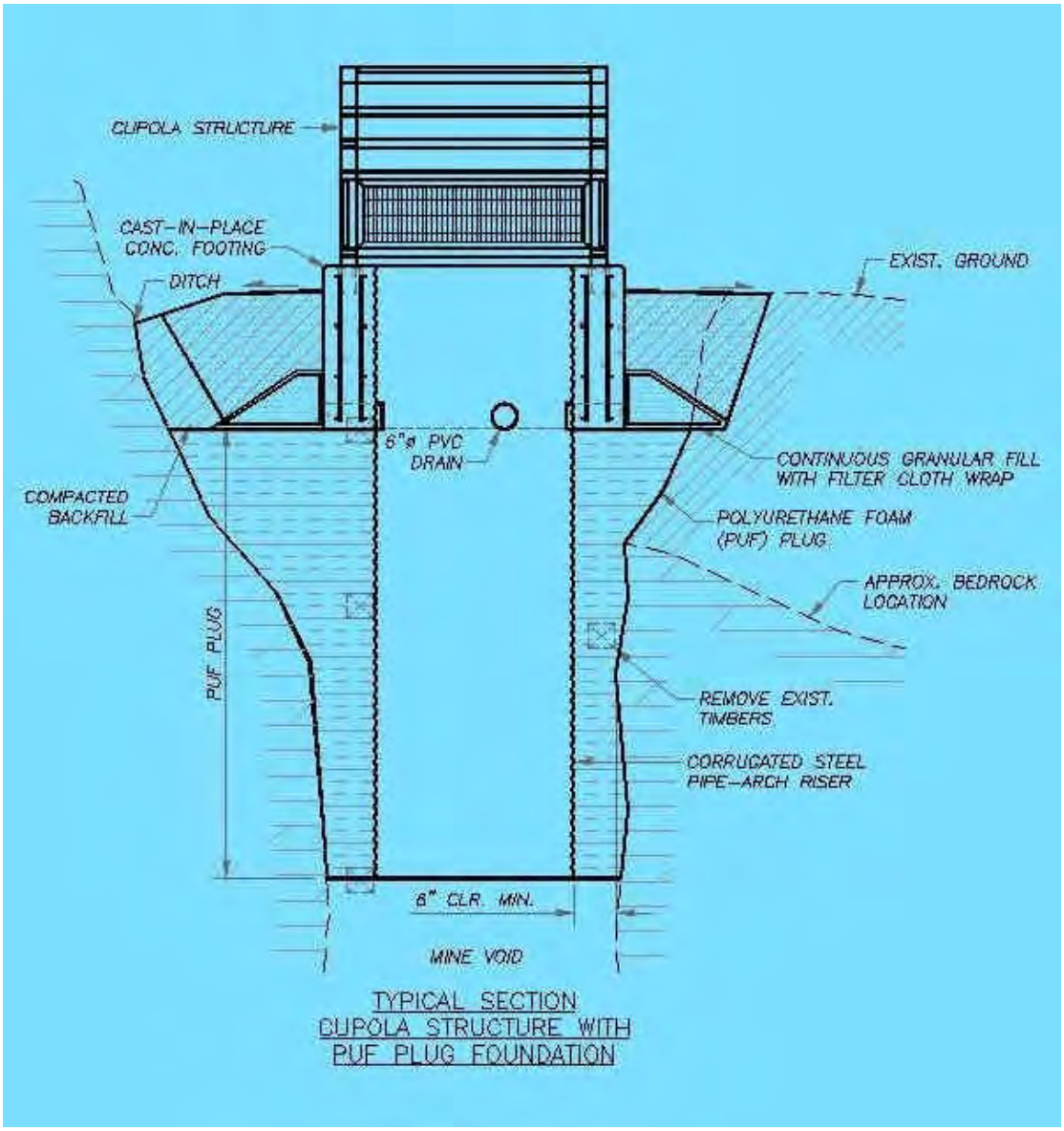

Figure 5: A typical section for a cupola structure with a polyurethane foam (PUF) plug foundation, riser pipe, and cast-in-place concrete footing. Note the provision for drainage of the ground above the PUF plug.

Figure 6: A PUF plug being formed around a corrugated steel pipe riser in a shaft opening.

Figure 7: A completed PUF plug with corrugated steel pipe -arch riser before construction of a cast-in-place concrete footing with drain pipes. The steel bea ms, which will be removed, supported a plywood work platform during placement of the riser pipe and foam.

Figure 8: A short cupola structure on a cast-in-place concrete foundation built with angle-iron crossbars. This structure is a secondary entry for bats at a mine complex, the primary entry being through a bat grate in a nearby adit.

Figure 9: A me dium height bat cupola with bar grating on the top and at the lower sides. Two sizes of steel structural members are used throughout – 4"x2" tubing crossbars and 4"x4" tubing columns and beams. This is the same structure shown in Figures 5 and 7.

Figure 10: Besides five -sided box shapes, many other shapes can be used for bat cupolas. This is a multi-sided "stealth" cupola designed to be out of the lines of sight along a highway. Expanded metal mesh covers the sides and top. (Photograph courtesy of Frontier Environmental Solutions, Ridgecrest, California)

Figure 11: A hexagonal cupola structure attached to a vertical precast concrete pipe placed over a shaft opening. (Photograph courtesy of Frontier Environmental Solutions, Ridgecrest, California)

Figure 12: An inside view of a bat cupola with steel bar grating at the top and lower sides. The octagonal openings are designed for barn owl use.

Figure 13: Detail of the barn owl openings that are about 10 -inches in diameter. Success of this design is currently unknown.

Figure 14: A removable cover in the top of a cupola to allow access for biological monitoring of the mine. The cover has four lifting rings and is locked in place with McGard security bolts. The biologist will descend and ascend the shaft in a specia l chair attached to a cable and winch.

Figure 15: Although not strictly a cupola structure, this flat bat grate over a shaft allows a secondary entry and exit for bats. The foundation consists of a deeply placed PUF plug with corrugated steel pipe-arch riser and lightweight aggregate fill above the plug. At the surface the installation has a stackable pre-cast concrete block ring wall and cast-in-place concrete collar into which the steel frame for the crossbars is anchored.

CHARACTERISTICS OF MATERIALS USED IN CAVE AND MINE GATES

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Abstract

Function and cost are important factors when selecting materials for constructing cave and mine closures. Characteristics of common construction materials, special materials for increased security, and common fini shes are factors in the design and planning process. Evaluation of longevity criteria and assessment of site environmental factors are vital to project planning. For each material commonly used in cave and mine gates, there are beneficial as well as dis advantageous characteristics—stainless steels, Manganal™, mild structural steels, concrete, aluminum, galvanized steel, plastic products, security inserts, paint, and other finishes. Specific knowledge about bat habitat and general common sense must dicta te design and material selection. Although many materials can offer enhanced protection, often the most cost-efficient and readily available material that provides reasonable life expectancy for cave and mine gates is standard structural steel.

Introduction

What materials are safe and cost-effective for long-term use in the harsh environments of caves and mines? Characteristics of common construction materials are described in this paper. Emphasis is placed on materials that are considered corrosion resistant, tough, and readily available. Other exotic materials, though their characteristics may be beneficial to the protection of underground habitats, tend to be expensive, less available, and sometimes require special installation procedures. Typically, gates for caves and mines are constructed of structural steels, concrete, Manganal™, or stainless steels. In addition to gates, there are cave and mine closure designs that call for cable netting or chain-link—these materials are described in other papers included in the proceedings for the 2002 Bat Gate Design Forum.

Before planning and designing gate structures, you should evaluate the material options and fabrication requirements. Gate-builders should add several useful reference manuals to their libraries: *Machinery's Handbook* (Industrial Press); Manual *of Steel Construction* (American Institute of Steel Construction, Inc.); Electrode *Pocket Guide* (Airco); and *Ryerson Steels Stock List and Data Book* and *Ryerson Special Metals Data Book* (Joseph T. Ryerson and Son, Inc.). Materials reference books are updated regularly and contain useful information for any construction project. For example, the *Machinery Handbook* has sections on types and properties of materials, welding s pecifications, and finishes. The strength of materials section in the *Machinery Handbook,* has simplified mathematical formulas to use in calculating material strengths for gate designs.

Stainless Steels

Chromium-nickel austenitic steels are commonly known as stainless steels. Both names refer to the same family of steel materials. The corrosion resistance and toughness of stainless steels make them highly suitable for cave and mine gates. The longevity of stainless is ten-fold that of mild steels. However, since stainless is more costly than other gating materials, it is currently used only when required by special site circumstances or gate designs.

Stainless steel life expectancy and corrosion-resistance far exceed the characteristics of other materials. However, since vandalism is a key issue for cave and mine closures, and since replacing stainless is expensive, it may be more cost effective to choose other materials for gate construction. In extreme cases, where the environment is too harsh for mild steels to survive, the site conditions may dictate that stainless be selected for its increased life expectancy. Any of the chromium-nickel austenitic steels offer good characteristics for cave and mine installations, however, there are important fabrication requirements for these stainless steel materials.

There are a number of weldable chromium-nickel austenitic steels on the market. If the project is fabricated in a controlled, clean welding shop, any of the weldable austenitic stainless steels will work well. Find complete listings of the characteristics of austenitic steels in the *Machinery's Handbook*. For austenitic stainless steels, welding requirements call for shielded gas metal arc welding processes to minimize the potential for carbide precipitation, e.g., tungsten inert gas (TIG), or metal inert gas (MIG).

Generally, stainless cannot be properly fabricated in the field unless special welding equipment is used to purge the welds with argon to minimize corrosion-inducing carbide precipitation. If welding must be done in the field at the gating site, chromium-nickel austenitic steel types 304L, 316L, or 321 are recommended. These steels are less vulnerable to the harmful carbide precipitation that enhances weld corrosion (rust) tendencies.

For field applications, an optional method of construction may be to pre-drill and countersink holes in a fabrication shop, transport the pieces to the site, then use bolts to assemble the pieces. Holes for the rivet-like bolting can be drilled in the shop. After installing stainless steel bolts with countersunk heads, flatten the heads with a hammer, and then grind the nuts to a cylindrical shape so they will not accept a wrench.

Manganal ä

High-manganese, austenitic, work hardening steel that is currently used in some cave and mine gates is available under the trade name Manganal ™. Typically, the chemical composition is manganese (12.00/14.00%) and carbon (1.00/1.25 %). Manganal™ bars, plates, and castings are used for high-impact industrial applications. Cost of high-manganese, austenitic, work hardening steel tends to run two to three times that of mild steel.

Manganal™ is used in extreme wear conditions a nd is hardened by impact, hammering, and abrasion. This surface characteristic is known as work hardening. In other steels (e.g., carburized or casehardened), the depth of hardness is fixed. When Manganal™ is subjected to wear, the surface toughens and the material remains ductile underneath.

Characteristics include high-strength, ductility, toughness, and substantial longevity. Corrosion resistance (e.g., rust and attack by acids) is about the same as ordinary steels. Manganal™ is extremely tough when work-hardened and may tolerate harsh environments. Functional mine rails made from this material are over 100 years old (Louis Arnodt, personal communication). Cave and mine gates constructed of Manganal™ can deter vandals using hacksaws, however power tools or cutting torches can breech the closures.

Continuous high temperature can cause high-manganese, austenitic steels to become brittle. In electric arc welding processes, no local area should remain at visible red heat for more than two or three minutes. If there is build up with multiple layers from weld passes, the welder may either skip weld, or weld intermittently to reduce localized heat.

Manganal™ is a good choice for field fabrication if the high cost is justif ied. Preferred applications tend to be in remote sites where minimal acidic conditions exist and where vandals cannot easily use power tools. Manganal™ is durable and has excellent longevity characteristics.

Structural Steels

The most common grade of structural steel (sometimes called mild steel) is ASTM A -36. The high-strength structural steels ASTM A-529 and A-440 have high carbon content for strength but they are no more durable than mild steels. Corrosion-resistant, high-strength steels have one advantage over the mild varieties in that they are more difficult to vandalize. Mild steels are easy to fabricate, readily available, and cost less than most other options. In some environments, the life expectancy is 50 to 100 years . Mild steel is available in a variety of structural shapes that are easily welded and fabricated in the field.

Aluminum

Aluminum will probably work for gates placed in dry, non -alkaline environments. However, aluminum is easy to vandalize because, generally, it is not as strong as steel. Aluminum can deteriorate rapidly and the degradation may introduce toxins into cave and mine habitats. For example, an aluminum ladder left in a cave located in the arid southwestern US literally deteriorated to a pile of scrap in les s than 20 years (Werker, unpublished data). Aluminum carabineers left in caves for varying time intervals rapidly show signs of pitting and corrosive deterioration (Storage, 1994).

When aluminum structures are exposed to the atmosphere, a thin, invisible oxide skin forms immediately and protects the surface from additional oxidation. This self-protecting characteristic gives aluminum its high resistance to corrosion unless it is exposed to some substance or condition that destroys the oxide coating. Alkalis are among the few substances that will attack the oxide skin —thus, alkaline conditions will cause aluminum to corrode. When aluminum is placed in direct contact with other metals, the presence of an electrolyte (i.e., moist conditions or high humidity) will cause galvanic corrosion of the aluminum at the contact points.

Depending on the site conditions, protective coatings may increase the life expectancy of aluminum. Chromate coating can be brushed on in the field, but anodizing must be done at a coating lab.

Because aluminum is especially susceptible to both vandalism and corrosion, it is usually a less desirable material for cave and mine applications.

Concrete

Concrete works well in most environments. It is resistant to chemical and corrosive attack and has extremely good longevity characteristics. Structures built with 3000psi concrete reinforced with rebar will deter vandals and will hold up for many decades in most environments. Cement is made of clay and limestone —thus, concrete is likely to add few if any toxic materials to cave and mine systems.

Culvert and Pipe

Culverts and pipes used for cave and mine closures can be made from a variety of materials. Several material types are addressed below. Be aware that culverts or pipes may not be the best option for protecting most bat colonies. Small diameter flyways can set the stage for easy predation of bats.

Galvanized Steel

Galvanized steel culvert has been used in roadway construction for decades and seems to function well. However, in caves and mines, galvanized culvert may deteriorate rapidly. For example, a galvanized culvert installed in Lechuguilla Cave in 1986 showed visible signs of degradation by 1994 and had severely deteriorated by the time it was replaced in the year 2000 (Werker, unpublished data).

As the zinc coating of galvanized steel degrades, it may generate harmful by-products. Welding galvanized material results in noxious fumes that can be hazardous to human health. The breakdown, out-gassing, and deterioration of galvanized steel culvert introduces by-products that may be especially toxic to bats. The by-products of deteriorating galvanized steel may adversely affect other cave or mine-dwelling animals and plants.

Plastics

Little is known about the degradation processes of plastics used in cave and mine environments. Polyvinyl chloride (PVC) used in water lines and air conduits tends to become brittle over time. PVC also out-gasses potentially harmful substances. Until studies further define the longevity and degradation characteristics of PVC and various plastics when used in subterranean environments, other construction materials are preferred for cave and mine use.

Finishes

Finishes applied to the surfaces of materials, intended to enhance longevity, may add contamination to cave and mine environments. Many paints and finishes, over time, will deteriorate (sometimes flaking onto the habitat floor). Out-gassing of these products may introduce potentially toxic materials to underground cave and mine systems. Research is needed to investigate the potential benefits and harms of various finishes when used on cave and mine gates.

Common Sense

Investigating the multitude of material choices, evalu ating their varying characteristics, and analyzing the cost, the potential for vandalism, and the inherent longevity of the materials can be an arduous task. First, evaluate the site, the habitat, and the purposes for the gate or soft closure. Simplify the goals, state the site objectives, and then allow common sense to dictate material choice and construction technique. In project planning, the priority is to be realistic about the habitat, the site requirements, and the budget.

References

Airco. No date. *Electrode Pocket Guide.* Airco Welding Products. Union, New Jersey. 161 pp.

American Institute of Steel Construction, Inc. 1973. *Manual of Steel Construction,* 7th Edition. New York. 999 pp.

Joseph T. Ryerson and Son, Inc. 1967. *Ryerson Special Metals Data Book*. Denver, Colorado. 288pp.

Joseph T. Ryerson and Son, Inc. 1987. *Ryerson Steels Stock List and Data Book*. Denver, Colorado. 432 pp.

Oberg, Erik, Franklin D. Jones, and Holbrook L. Horton. 1985. *Machinery's Handbook*, 22nd Revised Edition. Henry H. Ryffel and James H. Geronimo, eds. Industrial Press, Inc., New York. 2512 pp.

Storage, Bill. 1994. Techniques and Safety: Aging Carabiners. *NSS News*, 52(9):277-279.

Stulz-Sickles Steel Company. 2002. *FAQ About Manganol.* www.stulzsicklessteel.com/faq.html

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Jim Werker is a retired mechanical engineer with Sandia National Laboratories in Albuquerque. He worked in underground nuclear testing and research at the Nevada Test Site for two decades and applies that expertise to formation repair, environmental monitoring installations, and materials research for safe use in caves. He has 40-plus years caving experience. Jim and his wife, Val Hildreth-Werker, conduct restoration and conservation research in caves throughout the country and conservation/management workshops for land managers, cavers, and the public. They serve as the Conservation Division Co-Chairs of the National Speleological Society (NSS) and are currently editing a handbook on cave conservation, restoration, and repair techniques titled *Cave Conservation & Restoration,* scheduled to be published by the NSS.

Session 5

Construction Management

Session Chairperson:
Dr. Patricia Brown
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Bat Grate Construction/Contract Management
Paul Krabacher, Colorado Division of Minerals and Geology, Grand Junction, Colorado

Eastern Consultant Perspective
Kristen Bobo, American Cave Conservation Association, Duffield Virginia

Western Contractor Perspective
Ed Winchester, Frontier Environmental Services, Ridgecrest, California

Partner and Volunteer Logistics
Mark Stacy, Indiana DNR, Division of Reclamation, Jasonville, Indiana

Why Investigate Abandoned and Underground Mine Workings?
John Burghardt, National Park Service, Mining and Minerals Branch, Denver, Colorado

Bat Gate Construction, On-Site Coordination, and Work
Jim Nieland, U.S. Forest Service, Amboy, Washington

Personnel and Qualifications
Bob Hall, Bureau of Land Management, Kingman, Arizona

BAT GRATE CONSTRUCTION/CONTRACT MANAGEMENT

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Abstract

Working with contractors to insure a properly constructed bat closure should be a relatively easy task. Proper preparation is essential from detailing the initial site characteristics that comprise the bidding documents through proper construction oversight. Simple procedures can be followed and eventually will become routine that ensure the integrity of the grate throu gh construction check-points. After several closures, both the Project Manager and the Contractor will know what to expect. However, no matter how good the contractor is to work with, the competitive bidding process as mandated by the State of Colorado d oes not ensure a good contractor is able to return for future work.

Acquiring Contracts

Working with contractors and establishing a good relationship, how does it all begin? From the onset, it all begins on your desk or screen when the bidding document s are being put together. Specifications for bat grates are not rocket science. Usually State AML programs have had enough experience that specifications can be "cut and pasted" into any formatted document. Incorporating the 6" X 24" spacing into the ov erall grating using angle iron, manganal, tube steel or flat bar, or incorporating the spacing into a ladder style, corrugated steel pipe, or slot grate is easy. The construction materials utilizing angle iron or flat bar have been fairly standardized. Even the anchoring, which has typically been used with grating construction since the inception of most programs, is standardized. Where are the problems? Problems can occur when the specifications become unrealistic or just plain don't make any common se nse. How about the 72" diameter culvert fitting into the 60" hole? Or more commonly, anchor spacing on 12" centers in badly fractured rock. If the project manager has done his/her homework regarding site characterization, bid specifications should be ac curate.

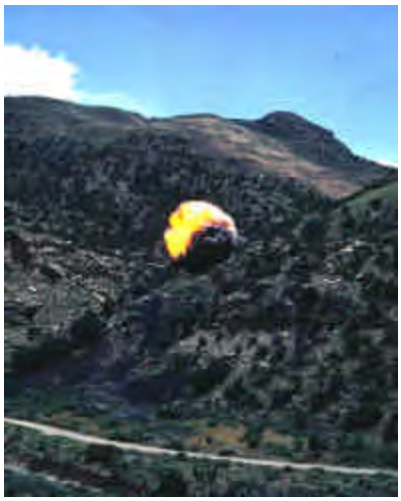
Another problem common to any construction is the inability to provide an accurate timeframe for completion in the bidding documents. Some contractors will take advantage of an inflated timeline by completing scheduled work at the last minute. More common, however, is an unrealistically short completion time. This immediately creates an uncomfortable relationship between the project manager and the contractor and has the potential to result in implementation of liquidated damages for going be yond the project completion time. When figuring out the time of completion for the bidding documents you need to be realistic. As usual, contractors will have their input at the pre-bid meeting with a predictable company representative always asking, "Ar e you sure the time for completion is long enough?"

Properly identifying construction inspection points within the bidding documents is crucial. Mandatory check-points are essential in establishing a good rapport with a contractor. Making the contractor aware that no construction can continue beyond a check-point not only ensures that construction specifications are met but also confirms that he/she knows the project manager means business. Once the location of a bat grate has been determined in the field, a common inspection check-point during bat grate construction is anchor depth verification. It only takes one time for a contractor to go beyond this inspection point when doing so will necessitate removal of completed work and/or creation of additional work to meet the inspection.

One of the easiest ways to ensure that a good, knowledgeable contractor will be bidding on your job is to stipulate within the bidding document that the contractor must have previous experience with grate construction. This requirement should be a mandatory statement in writing from the contractor stating the locations, completion dates, and possibly pictures with the bidding documents that they will be submitting. At the pre-bid meeting, contractors with previous experience will know what to expect and can provide insightful constructive criticism regarding the specifications as well. Typically those contractors with experience will become evident when it comes to critiquing specifications or the timeline. Many times their input results in changes incorporated into the bidding document through the Amendment from the pre-bid meeting. You may think you're the expert but who is the person who performs the drilling, anchoring, welding, and fabrication of these closures time and time again? Once the bid is opened and if a problematic contractor is awarded the bid, there is a chance that an increase in construction oversight may be in order.

Construction

Regardless of who is awarded the project, once the project is awarded, the grate location is shown and check-points are emphasized at a pre-construction meeting. With bid documents in hand, site rules are gone over as well as a materials check and sequencing method.



After construction start-up, quite often the project manager is presented with changed conditions. In grate construction, one of the more common occurrences is a rock condition that presents difficulty during anchor drilling. Unseen fractures can create unsafe working conditions that may require modification in drilling locations or even relocation of the grate. Changes in atmospheric conditions can also create unsafe working conditions especially in coal mines or mines with radioactivity. A mine feature that may be inhaling in the morning can easily change to an exhaling condition in the afternoon revealing dangerous radiological or even explosive gases. If changes result in additional materials or time for completion, the issuance of a change order is unavoidable. Keeping changed conditions that result in a change order up front with the

contractor maintains a healthy working relationship between the project manager and the contractor.

A contractor who takes pride in his/her work will automatically follow through with site cleanup once the grate has been constructed. There are those contractors, however, who don't expect anyone ever to visit the site again and have no regard for leaving pieces of grating and other trash for the bat biologists to trip on. At any rate, once the job has satisfactorily been completed, a salute is in order with the beverage of choice at the end of the workday. Once the opportunity arises, the conscientious contractor should be excited in being invited to attend the post construction monitoring for bat use.

On the Horizon

Keeping all the information up front and involving the contractor for suggestions initially shows contractors that they are part of a team. If the project is managed soundly, with good judgement and with a positive approach, contractors should be continually returning to bid. Insuring specifications are met leads to pride in workmanship from the contractor while a healthy bat habitat is maintained.

Paul Krabacher is an Inactive Mine Program Reclamation Specialist with the State of Colorado, Department of Natural Resources, Division of Minerals & Geology for the last 18 years. He is responsible for overseeing the construction of over 75 bat grates throughout western Colorado. He was part of the design team for the first modified bat grates in Colorado first installed in 1990. He holds a B.S. degree in Biology from Colorado State University.

EASTERN CONSULTANT PERSPECTIVE

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Abstract

This paper discusses the processes and methods of bat gate construction. Topics discussed include: assessment of site, assessment of resources, preparation of estimates, contracts/ agreement, materials required, equipment necessary and scheduling of the project. Also discussed are economics of the project and the responsibilities of the consultant.

Introduction

Roy Powers and I contract out our services, working with various agencies and volunteers.
In addition to gate consulting, we conduct other cave related projects such as in cave inventories and surveys.

Phases of a Gating Project

THE DESIGN PHASE

When we are contacted about a gate installation, all available information on the site is requested including: cross sections, sketches, photos, and site history. We then schedule a visit to evaluate the site. We observe rock composition and stability, inspect the resource to be protected, and check air flow and site accessibility. Based on the findings, we determine the gate placement as it is critical for optimal security and bat usage as well as ease of construction. We then determine the appropriate gate design site specific measurements while documenting and photographing the pre-project site conditions.

The gate design types are:

- The ACCA standard (Figure 1). This particular standard gate has additional bracing because of threats of vandalism.
- The ACCA standard with a chute (Figure 2). The chute is used where there is not sufficient height for a shielded gate, where we think the bats may have trouble using the gate and where there are large numbers of bats.
- The shielded gate with an open top using expanded metal (Figure 3).
- The cupola (Figure 4). We use cupolas on vertical entrances.
- The hybrid gate (Figure 5). This gate is a combination of a ACCA standard gate with a bay window and a chute. An open top may replace the chute on this design. This chute is inclined about 15 degrees upward in order to allow bats to gain altitude over the slope. Bay windows are installed in cases where sufficient height to overhang the slope with the chute cannot be attained. This allows the bats to gain greater altitude.

THE PROJECT PLANNING PHASE

Planning for a particular project is begun by developing a materials list and cost estimate. We try to group our projects in a geographical area to reduce costs and travel time. When scheduling, maternity sites receive top priority and are gated earl y in the spring or as late as possible after the young are flying. Funds for particular projects are often available only during a specific time frame, affecting project dates, so we schedule accordingly. We then negotiate a contract agreement. Some con tracts are as simple as a verbal agreement.

Equipment: We supply most of the equipment needed to construct a gate on site. The equipment we use is as follows:

- 5 kilowatt A.C. generator
- 150 amp Miller compact switching welder
- 2 sets of cutting torches as sembly
- 150 ft. of oxygen and acetylene hoses
- 1 Bosch electric hammer drill with chisel bit and various other bits
- 4@ grinder with cutting and grinding wheels
- laser level and line level
- 36@ level and an electronic level
- torpedo levels
- six spacing gauges
- eight 6@ modified ›c: clamps
- one 8@ ›c: clamp
- six snap clamps, vice grip type with feet
- wrenches for assebly of cutting torches
- set of allen wrenches
- extension cords and lights
- strikers, tape measures, combination squares, goggles, etc.
- two-way radios

The customer supplies the cutting gases, fuel for the generator, welding rods and the steel.

THE CONSTRUCTION PHASE

Site organization: The cutting station is located as close to the work face as possible. Materials are placed as close to, but not in front of, the cutting station.
Supervision of fabrication: Once everything is organized , construction begins. Roy keeps the operation moving, supervising the volunteers and overseeing the construction. I supervise at the gate, when Roy is not available, making s ure everything is properly placed before it is welded.

Figure 1. ACCA Standard Gate. Photo by Kristen Bobo

Figure 2. ACCA Standard Gate with chute. Photo by William Elliott

Figure 3. Shielded open top gate. Photo By William Elliott

Figure 4. The cupola gate. Photo by Kristen Bobo

Figure 5. Hybrid Gate, a Standard gate with a bay window and a chute.
Photo by Rob Robbins

WESTERN CONTRACTOR PERSPECTIVE

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Abstract

During this segment, what an agency must consider when deciding whether or not to gate an opening or what type of closure is desired will be discussed. It will include the types of customers, from those who are intensely involved in projects to those whose commitments do not allow them to participate as much as they would like. Other topics include contractor selection and design flexibility and view-shed friendly designs. Based on the experience of Frontier Environmental Services staff, helpful information will be suggested for those wishing to complete their first construction project when working with many different government agencies.

Introduction

Over the past two days you have been exposed to a variety of issues and designs in regards to the gating of mines and caves to protect the wildlife using them as habitat. During these presentations, you may have noticed there are several designs which may be appropriate to your site. Now you are the one to determine what is best for you and your project. Questions such as what type of materials, what type of structure and goals for the project are the ones to answer when contemplating a project. An even larger question is whether or not to do it in-house or contract it out. Over the next few minutes, we will discuss all of these questions.

Funding

When starting a project, money becomes an issue immediately. Generally, there are two scenarios for funding. The first is a mandate for construction to protect either the public or a species. The second is a plan submitted to protect an area that receives incremental funding. The differences here are funding methods. If an agency has issued a mandate to protect an area, it is usually the result of litigation or an attempt to head off litigation. In these cases, it seems as though a lump of money is thrown at the problem often before an in-depth study of exactly what is desired is conducted. These cases are more the exception than the rule. Commonly, a biologist, archeologist, or other party interested in an area develops a plan to protect an area. In some cases, the mines or caves in an area are but a small part of the overall project; in other cases they are the focal point. Figure 1 represents a mining area we are currently working on. Here the impetus was safety, but bat compatible gates are being installed because they satisfy both concerns at the same time. A great deal of work is being done to preserve the view-shed because this is the last head-frame standing in the area.

Planning

Developing an overall plan for a site is an involved process and it is usually best done as collaboration. If you have a lot of mining history that you wish to protect, it would be cost prohibitive to be done at one time. Break it down to a multi-phase project with priority placed on the sites most heavily visited or the most dangerous to the public. This incremental approach is an excellent one. It may be hard to get the entire funding amount in one shot. Budget difficulties will always be with us. If you break up a large project into multi year phases, you will find it more manageable. Once you get the project started, the management time required will decrease after the initial phase of the project. This will allow you to tackle a larger project when large sums of money are not available. The other way to speed up your project is to have a plan in case the fabled end of year fiscal monies are available. Usually in July or August you can find out if there are any funds available. If there are, you may be able to get these funds channeled to your project, if you are in a position to act quickly.

Materials

Once you have decided on a project. Next comes the decision on what types of materials to use. Is mild steel acceptable or is there a corrosive environment, which favors some other type of material? Does water flow through the area (Figure 2), or is it arid desert (Figure 3)? The environment of the project will be a substantial determinant but not the sole one.

Vandalism

What should really drive this stage of the project is the sophistication of past vandalism in the area. While it may not make sense, there are individuals who will believe that you are hiding something from them by gating an adit or shaft. While you and I may not understand this line of thinking, it is incumbent upon us to take steps to blunt their enthusiasm. Many factors come into play here. The biggest issue is the access to the area by vehicle. This concrete filled steel door (Figure 4) was found lying in front of the opening, after it was the subject of a vandal's attention. The closer a vehicle can get to the opening, the wider variety of tools they can bring to the site to vandalize or defeat your closure. The threat of vandalism needs to factor into the design and choice of materials for your project. If you have experienced a great deal of visitation to the area, or as Pat Brown would say, a "High Beer Can Index," you must take extra precautions. You must consider what tools you might expect a vandal would use on a structure. A hacksaw is easily thwarted, but tools such as an oxygen-acetylene cutting torch are much more difficult to defeat. Hardened steels and stainless steels are good choices in certain situations, but they can be overkill in others. I submit to you this is bat gate enemy #1 (Figure 5). If your law enforcement personnel see this tool in the possession of a "Visitor" they are up to no good. This tool will easily destroy all of the structures we have talked about here. Work with your contractor to come up with what they suggest and use your peer group who has already done similar projects. This group is an invaluable resource to you.

Eventually you will come to the realization that you cannot defend against every vandal. If you experience vandalism, work with your law enforcement personnel. You have invested a great

deal of time and money into the project; push them to prosecute, if at all possible. It is in the agency's best interest to prosecute whenever the opportunity presents itself, this will help in future litigation to show your agency's desire to protect the public.

When dealing with vandalism issues, a key factor is access to the site. If a vehicle can be driven right to the sight, the potential for vandalism is very high. If the closure is accessible by a trail that is a mile or so long, the vandalism threat is greatly reduced. Depending on your agency, you may be able to close roads to certain sites. This will mean they can't drive to the site and their enthusiasm to vandalize your closure will be blunted considerably. The more distance between your closure and the nearest vehicle, the less likely it is that van dalism will occur. It is a lot easier to defeat the use of a hacksaw than the use of a cutting torch. The use of berms around your site may also make it less visible. At this site (Figure 6). the engineer made great use of berms to hide the gate from vi ew. Spoils piles are generally easy ways to identify a mine site, so consider using vegetation to make the spoils less visible if possible.

Once a visitor, or vandal is present, signage becomes an issue. You must know from the beginning that your sign will either be stolen or shot. If you put it inside of the gate, it must be at arms length plus two feet to thwart the use of spray paint. Because of this, the text on the sign must be limited so as to be readable at that distance. Also, think about th e placement of signs as they can be detrimental to the opening if placed in the flyway. Figures 7 and 8 show great examples of where not to put the signs. We have seen a variety of signs used with varying degrees of success. Signs placed as a ruse such as warnings about potential gases can be particularly effective, but care must be used to prevent a public outcry at the warning of "Possible" gas problems. Another great sign is to dedicate the closure of the mine to a mythical person who died there. Ho pefully the mine has not claimed victims to warrant the sign, but it is a very effective ruse. The use of signs to discuss the benefits of the bats to society will also work, but there are a lot of pro's and con's to their usage.

We have been amazed at the amount of work a vandal or group of vandals will do to bypass a closure of a rehabbed trail. They will move boulders and think nothing of it, but they seem to respect the protectors put up for saplings. While they seem to have no regard for a rehab project, they seem to not bother what they perceive as seedlings. We can offer no sound reason for this, only anecdotal evidence.

The choice of materials is necessitated by the vandalism history in the area as well as the environment itself. Is water pr esent? How much snow is received each year? Is there airflow? Is that air temperature constant or does it change? In addition to that, what species is being protected and what type of roost is being protected? These questions affect not only the type of materials but also the type of design. An important factor here is to make the structure require minimal maintenance. In a lot of environments, the use of mild steel (Figure 9) is sufficient. Leaving the mild steel without applying a paint or other t ype of coating is advantageous because it develops a patina of rust that makes the structure look as if it has been there for many years rather than just a few. If a gate looks new, it is more likely to draw the attention of a vandal. The applications of coatings will serve to cause a recurring amount of work that can be problematic. However, the use of stainless (Figure 10), or weathering steels will require no recurring maintenance, but they can greatly increase costs compared to normal materials. One

drawback to stainless is its appearance. It is more likely to look newer longer and therefore make the potential vandal think it is a recent addition to the area and thus needs their attention.

Selection of Structure

Once you have decided on a choice of materials, next comes the type of structure itself. Is it an adit (Figure 11) or a shaft or decline (Figure 12)? Every opening has its special characteristics. Not all openings are the standard inverted horseshoe adit that is four feet wide and six feet tall. It might be a shaft six feet square or a decline that is sixteen by eighteen feet. How large does the structure need to be? The closure you would build for a colony of one hundred is likely to be different than what would be built for a colony of 100,000. This stage is a good spot for a reality check in your overall plan. Adit gates are quite simple as far as size, but cupolas are an entirely different story. It is important to give the bats a structure which is not detrimental. So often we have seen structures which have had to be redone due to bad theory or design. I realize this is a touchy subject, but placing the gate right at the portal is not doing the bat any favors. It makes it much more prone to predation. Our purpose is to protect the bats and the humans. With great criticism, I recommend an adit gate be placed about fifteen feet or so into the adit to reduce predation and give the gate a more stable site. The portal itself is generally so fractured that it would make a gate easier to defeat. I realize it is easier to check on later, but the effect on the species can be dramatic. A small carnivore could decimate any population, especially if the bat is at a disadvantage from the beginning by negotiating the gate at the surface. Move the gate back, give the species a break and preserve the view shed.

Generally, the cost of the materials is not the largest expense unless you are using an exotic metal that is substantially more expensive. The goal here is to build a structure that is so massive, the average person, vandals included, just looks at the sheer size of the gate in awe. A gate built with sub-standard materials is an invitation to be breached and possibly sued. In Figure 13, the shaft covering is anchored in place by only its weight, which as you can see is not enough to hold it down. Presently we have an excellent standard that provides a substantial structure (Figure 14). Use it! Resist the temptation to use lesser materials. The purpose of this forum is to examine different types of closures and it is up to you to decide which is best for your project.

Once you have a style of closure in mind, you must allow some flexibility for design changes and improvements. These will generally come from two sources, your contractor or a peer. Both are great sources of answers to questions you may have overlooked entirely. Talk to people who have built a dozen or two dozen or three dozen or more gates, they have invaluable experience. So, once you have thought out what you want to build, where you want to build it and what you want to build it with, don't rule out suggestions made which could be the product of a lot of experience.

A topic that is becoming more important is view shed. Some areas have protected view sheds that your project must integrate. This is a time for creative earthwork or creative closure design. As you may have seen in presentations in the last two days, the standard cupola shaft closure is not always going to fit in with a protected view shed. Figure 15 shows and opening where the park service demanded the closure be invisible to the road located nearby. Our stealth closure

(Figure 16) was the compromise for gating a shaft with a view shed issue that was going to kill the project. In that case, we were able to hide the structure behind the spoils pile. The structure we built looks quite small, but on the contrary it is quite roomy and preserved ground level airflow as well as providing a safe closure for the mine. This may not be an issue in the east where trees will obscure an area in a short period of time. Out west, however, it is a different story. Because of this, careful planning must be done to negate the impact to the view shed if it is an issue.

Project Management

Once you have determined what you want to build, you need to determine your level of involvement. Some of you will want to be hands on while others will prefer to keep a more supervisory role. It is important you know up front what role you intend to play. Your agency will dictate to some degree what you can and cannot do. If you desire the best results, you are the most important link in the chain. After attending this forum, you will have the most knowledge of gates and what to look for. I urge you to get qualified as being able to accept the work. If you choose to let someone else have this authority, it may cause you to do extra work to coordinate an extra person into the equation as well as losing some control over the project. You will know best whether or not your project is being built properly. The other downside to having another person in your office with authority over your project is less flexibility in the design process and on-site modifications during construction.

In any event, you have a significant amount of work to do in some cases. While different agencies handle these situations differently, you may have more hoops to navigate through than a croquet tournament. From personal experience, you must have a good relationship with the office that handles the mining claims if you are on public lands. Experience has shown that you must have some mechanism for them to notify you if someone tries to claim a particular site while you are doing a project there. If not, it can lead to incredibly tense situations that could end up in court. At the very least, your contractor will be quite upset and you may have a huge problem on your hands. While we are talking about public lands, keep in mind that some sites will still be open to claim. Sometimes volunteer groups may claim a site to protect a species, but in others, renewed mining may occur. At one site we were told the gate must allow entrance by a piece of equipment such as this Bobcat (Figure 17), this was a daunting challenge. The resulting gate (Figure 18) allows entrance by two thirds of the models of bobcats produced at the time of construction. If renewed mining is likely, consider designs that will allow the gate to be removed during periods of mining. You may be able to stipulate when mining can and cannot be done for the welfare of the wildlife. If that is the case, a removable gate will be a great compromise.

Now is a time for you to make sure the goals for the project are still in line with the realities of modern construction. Have you settled on a design which is effective yet affordable. It is easy to decide that you want a gate with exotic metals that will be the talk of conferences in the future. The problem is money. Once you have done all this work, estimated all the costs of construction and monitoring, is there money to do the job? I would highly recommend any person planning on leading a project attend a gating class or spend time on a peer's site to get a full understanding of everything entailed in the construction of a gate. It involves much more than showing up with

some steel, a welder, and a labor crew. The more you know, the better you will be able to develop appropriate cost estimates. You cannot ask a contractor for an estimate and then use this as your estimate for establishing the contract. Your contracting officer will kill the project and accuse you of collusion if you try that. It seems simple, but you would be surprised how often projects get mired in problems due to alleged improprieties on the part of the government official. Work up your estimates, consult your peers to see if they think you have a reasonable product, and then you may be able to start the contracting process. The most important piece of knowledge you can have is a good under standing of the contracting process. If you have this knowledge, your project will happen much smoother and reduce your workload during the project. Your knowledge of this process will be very important, as you are the initial and primary contact with yo ur contractors. You should have a firm grasp on the contracting process with your agency. Does your agency require an engineering approval of the proposed closure? If this is the case, talk to the engineer ahead of time to see if there are any questions they may have. This can save you a lot of time later when you are trying to get the contract going. Especially when trying to squeeze in a project with end of the year funds, the delays that can be experienced at the procurement level and the engineerin g review can mean your project will be put off due to weather. Your preparation beforehand is time well spent.

Do your homework. Your contractor will ask some general questions. These questions include how long your agency will take to pay and whethe r or not partial payments are allowed. If your project is likely to use a special service such as a helicopter or ferry, find out beforehand if your agency already has an existing contract that you can incorporate into your project. The use of a helicopter is sometimes necessary for a number of reasons, but it is quite likely the costs of the helicopter may be more than the rest of the project. Depending on the type of helicopter, it may run $2000 per hour with a three -hour minimum. Also, if you know of any specific requirements such as bonds or insurance amounts or the like, make sure you tell the prospective contractor so their bid can reflect the costs of those requirements.

You have done all your homework about the project, the designs and the mater ials. Now comes the biggest step, deciding whether to do the work in house or contract it out. We see a lot of agencies and private industry that do not have the time or manpower to have staff perform the construction. A common problem is an agency that has very little in the way of personnel resources and the work plan for the year is quite tight. I actually had a customer who would not come out to the site because his boss wanted him doing his job in the office. Of course, the tendency for agencies to let all qualified individuals go out when a fire is going means that a well planned work plan often does not get executed, further exacerbating the problem.

We also see a lot of customers who choose to have the project done by a contractor who specializes in this type of work. The feeling is that rather than have employees complete a project who may not be very enthusiastic about it and have a project that reflects that lack of enthusiasm, use a specialist. Doing it wrong the first time is not an opt ion. If you build a structure that is substandard, you and your agency may be liable if someone gets hurt. The use of standard designs will help insulate you, but giving into the use of lighter materials and bad concepts will only cause problems (Figure 19). It is much cheaper to do the project properly the first time. Some agencies use convict labor crews for all kinds of work. The use of these crews for gating mines is a problem waiting to happen unless you have provided them with all the

training necessary to work safely. A safety brief will not be adequate, they must be certified miners or their heirs will look to you and your agency's checkbook for answers about any accidents that occurred while on your project.

Another way of completing a project is to give more control to the contractor. This means you come up with the concept and then look at what the contractors propose. They may have a lot more experience in this type of work. If that is the case, their input may be quite valuable to your project. By using the experience of the contractor, you may be able to greatly reduce the time you may have to spend on design and engineering of the project. Also, if you choose to dictate in great detail the specifications of what you want built, make sure the documents agree with each other. To many times, we have seen RFQ's where the text and the illustrations do not agree. It is important that you take the time to insure the product you give to the contractors for their input is held to the same standards you expect of them.

Selection of a Contractor

The question now is what to look for in a prospective contractor. A prospective contractor should have the following minimum qualifications: attended a BCI approved gating class, State licensed contractor, MSHA certified contractor, certified surface/underground miner, and impeccable references. Every one of those items should be mandatory. A BCI approved gating class is essential, this assures you the contractor has been on site during construction and dealt with the issues which can happen during a remote site project. A State contractors license is preferred so that you know the company and if you have questions about them, the State contractors office can answer them. I realize that Federal agencies do not require contractor's licenses, but they can provide a lot of information about the contractor. A contractor who is serious about working on mine sites will have an MSHA number as well. This means they are responsible for any safety violations, not the property owner. In this day and age, safety has to be your primary concern. With that in mind, everybody working on the site should be a certified miner. You may believe this is overkill, but it is very necessary. Rather than hope the local MSHA district will not look at the gating activity as under their purview, it is better to err on the side of the safety. Basically, if you are working in a mine, drilling and digging, tasks that are part of the gating process, you had better be a certified miner. Aside from the credentials of training and experience, the contractor should be able to give you references. You should always check the references. These references are the key to your prospective contractors behavior. If you want to know what they are like once they have the contract or how their work was received, ask the references. While there are not a lot of contractors out there doing this type of work, do not settle for a contractor who does not meet your standards. Another source you may choose to contact is your State level contracting office. They may have had dealings with the contractor you are not aware of and be able to provide valuable information. Always be wary of a contractor who will not give you references or hesitates to do so. Make sure your contractor has some baseline knowledge of bats and their needs. This doesn't mean they have to be a biologist, but a working knowledge is a great asset and very desirable.

While working on a project, please make use of your peer group. People like Bob Currie, Bob Hall, Jim Nieland or Amy Fesnock can provide invaluable information about the planning and management of a project. Hopefully the publishing of these proceedings will provide a lot of

information and peace of mind for you, but you cannot compare that to the experiences of your peers.

Once you have selected a contractor and made it through the contract, now is a time for reflection. Ask some basic questions, did the project achieve all the goals you set for it? If you are not completely happy with some phase of the project, work to make sure it is corrected in future contracts. If you are not happy with the contractor, voice the concerns while on site. Waiting until you get a chance to see what was built a week or two later is not fair to you or the contractor.

Conclusion

You are the most important link in the chain. You are the one who knows what you want. With that in mind, ask for closures that are appropriate to the sites. Use materials that are suited for the environment as well as the level of anticipated vandalism. If you do the work in-house, use qualified personnel for the job, or use a qualified contractor. Manage the project effectively while always looking for ways to improve. Finally, when all is complete, select another project!

H. Sam Edwards M.S.E.E., P. E. is the safety officer for Frontier Environmental Solutions. He has a Masters Degree in Engineering from Purdue University. Since Frontier's inception in 1996, he has designed and built scores of bat compatible gates throughout the desert southwest and in the upper peninsula of Michigan. Paper presented by **Ed Winchester** of Frontier Environmental Solutions.

Figure 1. Mining area with bat gates, view -shed and head frame.

Figure 2. Mining area with flowing water.

Figure 3. Arid desert mining area.

Figure 4. Vandalized steel door.

Figure 5. Bat gate enemy #1

Figure 6. Use of berms to hide a gate.

Figure 7. Poor placement of sign in the bat flyway.

Figure 8. Poor placement of sign too close to gate and in the bat flyway.

Figure 9. Use of mild steel for a gate.

Figure 10. The use of Stainless steel for a gate.

Figure 11. Mine adit needing a closure device.

Figure 12. Shaft of Decline opening needing a closure structure.

Figure 13. Poor example of shaft closure structure.

Appendix III
Design A

These plans are provided courtesy of the American Cave Conservation Association and are revised annually. Contact the ACCA for current construction specifications or for consultation on special needs (see Appendix II)

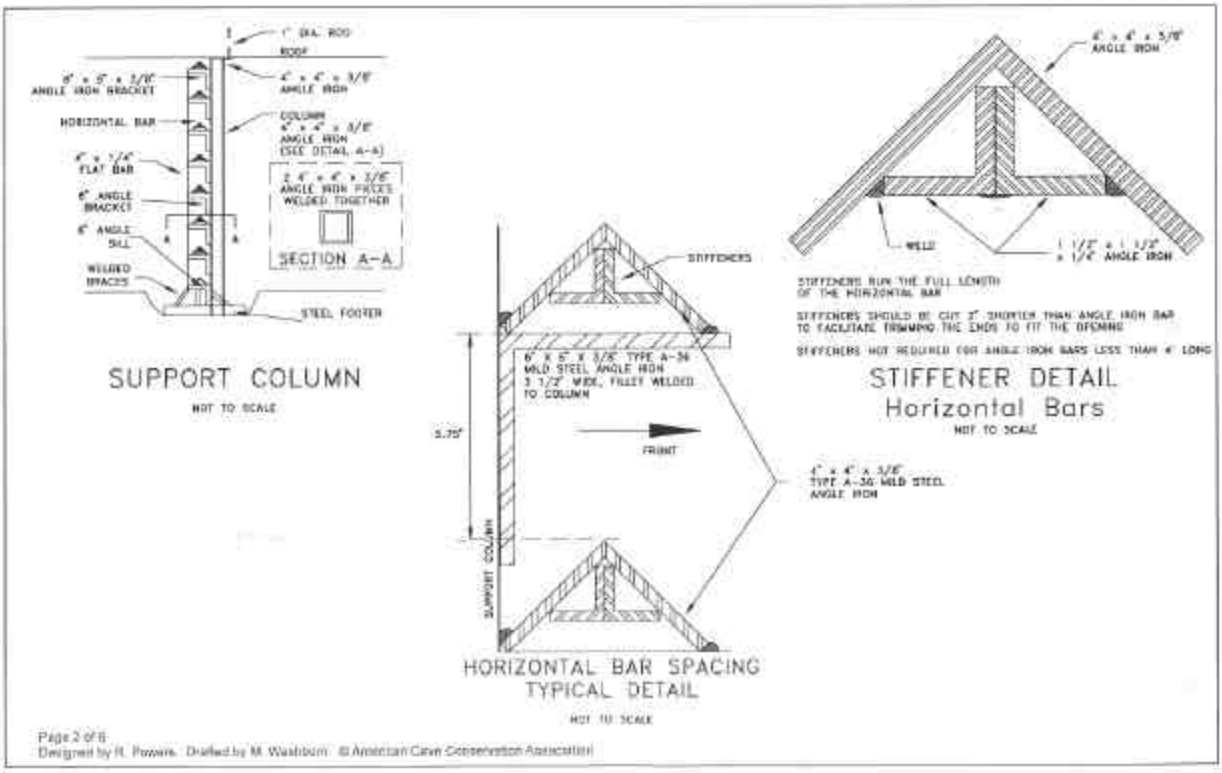

Figure 14. ACCA Bat Gate Design Specifications

Figure 15. Before condition of opening where the Park Service required that closure not be visible from the road.

Figure 16. Stealth bat closure created to minimize visibility.

Figure 17. Bobcat needing entry to mine through bat closure.

Figure 18. Bat closure designed to allow for two thirds of the models of bobcat to enter.

Figure 19. Poor example of closure that cut too many corners.

PARTNER AND VOLUNTEER LOGISTICS

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Abstract

The Indiana Division of Reclamation's Abandoned Mine Lands Program installs bat friendly closures at all sites that bats are using for the purpose of protecting the public from the safety hazards associated with open mines and to protect bat habitat. For several reasons, Indiana has chosen to utilize the services of volunteer organizations to facilitate and build angle iron bat gates. In the Indiana coal region, there are no local commercial contractors with bat gate building experience, and typical State contracting approval procedures can take months to obtain. Therefore, the State has entered into an agreement with the Indiana Karst Conservancy (IKC), a non-profit organization, to build its angle iron bat gates. By working with the IKC, the State benefits by acquiring a "contractor" with the proper experience and obtains the lowest possible "bid." Because this group is motivated mainly by conservation ethics, instead of monetary gain, they are willing to undertake the sometimes grueling task of building bat gates in remote areas, with only hand labor. Additionally, to facilitate contracting procedures, we also utilize the services of local Resource Conservation and Development (RC&D) Councils. These non-profit organizations, which undertake small reclamation projects funded by the Indiana AML program, complete all of the contracting and payment procedures for the bat gating projects. This effectively eliminates the sometimes-lengthy process of obtaining State contracts and making contract payments. Although there are some restrictions, working with these volunteer organizations has been a very productive, efficient and rewarding experience for the Indiana Division of Reclamation and has facilitated our goals of protecting the public and bat habitat.

Introduction

The Indiana Division of Reclamation's Abandoned Mine Lands (AML) Program began the development of its Bat Gating Program upon the discovery that Indiana Bats (*Myotis sodalis*) utilized an abandoned underground mine that was scheduled to be closed. Of course, we still had to address the safety issues of the open mine shaft, but now we also had to consider the critical habitat that was being used by an endangered species. We could no longer just fill the shaft with rock and concrete; we had to take another approach. The obvious solution was to utilize a bat gate. The very successful universal design developed by Roy Powers and the American Cave Conservation Association is extremely effective at keeping people out of the mine, but allowing bats to continue to utilize the habitat within. The only problem with this concept was that we had never built

one, nor had any idea of how to go about doing so. We had to start from scratch. In an attempt to properly design and install our first bat gates, a series of relationships developed with partners and volunteer organizations that pro ved to be both very effective and rewarding.

We built our first bat gates in Indiana in 1999 and have continued to build several every year since then. We now install gates at virtually every mine opening that is being utilized by bats, regardless of the presence or absence of endangered species. Bat habitat itself is becoming "endangered" and is often worthy of protection, even if no endangered species are currently present. Throughout this process, we have continued to utilize the services of the same volunteer organizations that we started with, a testament to their effectiveness.

Bat Conservation International

While trying to develop the Bat Gating Program for Indiana, I was fortunate enough to attend the American Society for Surface Mining and Rec lamation Conference in Austin, Texas. It was at this conference that I had the privilege of hearing a presentation by and meeting Sheryl Ducummon, the former Bats and Mines director with Bat Conservation International (BCI). This was to be the beginning of a very beneficial relationship for the Indiana Division of Reclamation as she essentially "took me under her wing" and helped me develop our own Bat Gating Program.

Ms. Ducummon not only gave me reams of information on bats and gates, including technical plans and specifications, but also spent many hours answering my numerous questions and queries about the subtle nuances of building bat gates. Shortly thereafter, she encouraged me to attend a BCI co-sponsored event, the Midwest Bat Conservation and Management Workshop. At this extremely beneficial workshop, Ms. Ducummon and others were able to teach me many of the finer details of bat gate designs and installation. I was finally starting to feel I might be able to build one.

And then, while on othe r business in the area, Ms. Ducummon accompanied by Roy Powers, graciously offered to come to Indiana and visit the actual sites where I wanted to build my first bat gates. Their personal consultations in the field were extremely helpful to the development of a plan on how to build the gates at these unique sites.

To anyone that is in the field of bats and/or bat gates, it may seem redundant to extol the virtues of Bat Conservation International. Everyone knows how valuable they have become to bat conservation worldwide. But BCI was extremely supportive, encouraging, and beneficial to the development of the Bat Gating Program in Indiana. I'm not sure I would have been able to develop a successful program without their initial assistance and guidance.

The Indiana Karst Conservancy

Now that I finally felt I knew *how* to build a bat gate, I had to figure out *who* was going to build it for me. I knew that none of the commercial contractors that our AML Program normally dealt with had any knowledge of bat gate construction. Most of them would have never guessed that bats inhabited mines, and even fewer could figure out why we wanted to protect them. To my knowledge, there were virtually no contractors that had any experience in building bat gates in the entire State. Of course, a good contractor can take a set of plans and specifications and should be able to construct just about anything. And, as one colleague of mine mentioned, "building a bat gate is not brain surgery." However, I still didn't want myself as an inexperienced Project Manager *and* an inexperienced contractor trying to build a gate to protect an endangered species. I felt that there was no room for error. I had to get it right the first time.

Another stumbling block with our commercial contractors was their apparent inability or at least reluctance for extensive manual labor. Most commercial contractors are short on laborers and heavy on equipment. One man on a bulldozer can do the work of fifty men with shovels. However, building bat gates is typically a very labor-intensive process and requires little if any large machinery, but lots of strong backs. We feared that getting one of our contractors to acquire enough men to build a bat gate would cause construction costs to skyrocket.

However, I did know that at least one bat gate had been built in Indiana at Wyandotte Cave in Harrison-Crawford State Forest. So I called our State Non-Game Wildlife Biologist to find out who had built it and to see if he had any suggestions on whom I might be able to get to perform this work. This is how I got in contact with Keith Dunlap of the Indiana Karst Conservancy (IKC). The IKC is a non-profit organization that is dedicated to the conservation and preservation of Indiana's unique karst features for their inherent geological, biological, and archaeological importance. The purposes of the IKC are the management, protection, and acquisition of karst areas in Indiana. The group is composed entirely of volunteers, essentially a bunch of cavers that are interested in protecting caves. And, much to my delight, they were building bat gates.

Under the supervision of Roy Powers, the IKC was involved with building the gate at Wyandotte Cave and other State properties as well as several others on private lands. Finally, I found a local organization that had gate building experience. However, working with a non-profit, volunteer organization required a few unique approaches from the State's point of view, but the benefits far outweighed the challenges.

One of the most obvious benefits of working with a non-profit is that you are very likely going to get the most work accomplished for the least amount of money. The best bang for your buck. Each IKC member volunteers his or her time to work on these projects. As a matter of fact, they may even absorb individual out of pocket expenses including travel, lodging, and food. And many of them bring and use their own personal tools. All this being evidence of their dedication to the cause. Also, because these projects are completed entirely with hand labor, there are no heavy equipment fees, no mobilization/demobilization costs, no dirt work costs, no revegetation costs. All of this contributing to relatively low project costs.

The fact that there is no heavy equipment used by the IKC brings up another benefit, low environmental impact. It is often a necessary evil to disturb an environmentally stable area in order to reclaim an adjacent AML site. However, when one of our bat gating projects is completed, there is virtually no disturbance to the environment other than a footpath through the woods. Even just moments after the throngs of people, vehicles, tools, and equipment leave the project site, it is barley noticeable that anyone has been there, other than the gate installed at the mine entrance.

There may however, be a few logistical problems working with a non-profit organization, but none have been too great to overcome. First of all, because of their volunteer status, these people all have "day jobs," which can make getting in contact with them possibly awkward, if not difficult. Because the organization probably doesn't have a business office with a secretary, you'll either have to contact somebody at work or at home. This may make you feel that you are infringing upon their professional or personal life. The best way to avoid this is to designate one contact person who doesn't mind an occasional phone call at work or home. And most of the correspondences can be taken care of through the use of email, being an efficient, non-invasive form of communication.

Along these same lines, the bat gating projects are going to have to be scheduled on a weekend because most of the volunteers are going to be at work during the week. And in order to get enough volunteers scheduled for the same weekend, it is often necessary to plan the projects months in advance. This is not necessarily a problem, just a fact that needs to be taken into consideration when planning the project. Just don't expect them to be on the job in two weeks of project notification. You need to conform to their schedule, not the other way around.

You'll also need to determine how many gates can be built in a two day time period, and not try to build too many. You want to get as many built as possible, but be sure to be able to get everything completed, because it may be quite some time before you can get the whole group together again. Foul weather can really wreak havoc on this whole process. You may have the organization scheduled for every free weekend that they have during a construction season, and if it rains, it's not like you can just wait until nicer weather. There's really no such thing as a rain day.

Another situation that needs to be considered is the fact the Indiana Division of Reclamation doesn't have the IKC sign a contract for these projects. This fact may cause concern for some. Typically, a contract is the document that spells out exactly what the contractor is expected to accomplish. And it is the "tool" that the Project Manager can use when the contractor doesn't do what he is expected to. Some Project Managers may feel uncomfortable not having that tool. But when working with a non-profit, volunteer organization, we felt it was neither appropriate, nor necessary to bind them to some legal contract. There was just going to have to be a certain amount of trust associated with working with this organization. To help stem any potential problems or misunderstandings, it is therefore very important that the Project Manager be on site during the entire gate building process to make final decisions and answer any questions.

I can honestly say that I have never had any reservations that the IKC would not complete a project as I had envisioned it, nor have I been disappointed.

A final issue that needs to be addressed is that of liability. Hopefully, nothing will ever happen that will cause this to become an issue, but if it should, you need to be covered. Fortunately for us, the IKC already had liability insurance for their own purposes, which our legal staff deemed adequate. All we need to do is ensure that we have an updated copy of the Certificate of Insurance on file prior to project construction.

One might ask why a volunteer conservation organization like the IKC would even be interested in building bat gates at abandoned coal mines. The obvious answer is that it is a fund raising project for them that allows them to support their karst conservation activities. In this way, both parties benefit. Finally, with the cooperation of the Indiana Karst Conservancy, I was able to build the first bat gates at abandoned mines in Indiana (see Attachment A).

The Resource Conservation and Development Councils

The Indiana Division of Reclamation has developed a partnership with local Resource Conservation and Development District (RC&D) councils through the Partners in Reclamation Program (see Attachment B). RC&D councils are non-profit organizations that help people care for, conserve, and develop natural, human, and economic resources in ways that will improve the area's environment, economy, and standard of living. The Partners in Reclamation Program allows the RC&D councils to work with local landowners that have AML problems and develop a reclamation plan that will be funded by our AML Program. We took advantage of this partnership by utilizing the services of area RC&D councils to compensate the IKC for their services.

Although the Indiana Division of Reclamation initiates, develops, and monitors all bat gating projects, technically, the IKC is working for the local RC&D, not the State of Indiana. The RC&D, through the Partners and Reclamation Program, is the organization that "cuts the check" for the IKC when each project is completed and approved. This is why the IKC is not under contract with the State of Indiana as mentioned above. The reasons we have chosen this route are twofold: The RC&D, being a private entity, can hire anybody they want to and they don't have to go through the State bidding or contracting processes. Although it is very likely that the IKC would offer the lowest bid and thereby be awarded the contract, by using this method, we are guaranteed to be able to obtain the "contractor" that we want. And we're also able to circumvent the time consuming and cumbersome bidding and contracting processes. This alone can shave up to five months off of our planning process for each project.

Conclusion

When I began to develop the Bat Gating Program for the Indiana Division of Reclamation, I never intended or imagined that I would be working solely with non-profit and volunteer organizations. However, I did seek to work with organizations that would

offer me the greatest experience in bat gate design, installation, and project administration in the most cost effective manner. It just so happened that Bat Conservation International, The Indiana Karst Conservancy, and area Resource Conservation and Development councils, all being non-profit organizations, were able to provide the necessary services that I was seeking. This is not to say that there are no commercial contractors available that can do this sort of work just as well. In the West, there are probably many that one can choose from that specialize in this type of work, but in the Midwest, we don't have that relative luxury. I consider myself very fortunate to have been able to work with these organizations.

There may be a few challenges working with volunteer organizations that require an innovative approach, but nothing that is insurmountable . Mostly, they are logistical problems that can be overcome rather easily with proper planning. The joy of working with volunteer organizations is that the people are motivated by their belief in a cause, not personal monetary gain. It is refreshing to witness their dedication.

Mark Stacy is an Environmental Specialist in the Indiana DNR, Division of Reclamation since 1985. He is responsible for developing and implementing the Bats and Mines program for the Indiana Division of Reclamation's Abandoned Mine Lands (AML) Program. He conducts initial bat surveys using bat detectors and assists in trapping and identifying bats at all AML sites with potential bat habitat. He also acts as Project Manager for all welded angle iron bat gate installations and as Assistant Project Manager for all gated culvert installations, utilizing "field engineering" techniques to complete these projects. He works with both volunteer organizations and commercial contractors to install these bat friendly closures. Mark received his BS Degree in Natural Resources and Environmental Sciences from Purdue University in 1984.

ATTACHMENT A
INDIANA DIVISION OF RECLAMATION
BAT GATING PROGRAM
AML SITE 17, TURKEY RUN STATE PARK

This gate was installed through a cooperative effort between the Division of Reclamation, Turkey Run State Park, the Indiana Karst Conservancy, and the Sycamore Trails RC&D.

BEFORE RECLAMATION

As thousands of State Park Visitors passed by this mine entrance every year, park personnel installed this chain link fence across the entrance in an attempt to keep people out. This was never entirely successful, as the fence was routinely breached. Unfortunately, the fence was effective at keeping bats out of the mine.

AFTER RECLAMATION

With the installation of this gate, park visitors are no longer at risk of injury from this abandoned coalmine. And, within six months of installation, bats had begun to utilize the habitat within. Today, the extreme public safety hazard has been eliminated and the bats are protected.

ATTACHMENT B

PARTNERS IN RECLAMATION

WHAT IT IS

The Indiana Department of Natural Resources and area Resource Conservation and Development (RC&D) Councils have joined together to provide an opportunity for local landowners. Funding is being made available on a competitive basis through the IDNR's Division of Reclamation for property owners to restore certain lands that have been adversely impacted by coal mining operations. Once the projects have been accepted by the county Soil and Water Conservation District (SWCD), the Division of Reclamation (DoR) will review the proposed project for compliance with all applicable regulations and fund up to eighty -five percent of the project cost through the RC&D. The RC&D can assist the property owner with contracting and other aspects of the project.

WHO IS IT FOR?

This program is designed to assist property owners who have been adversely impacted by abandoned coal mining operations. Examples of common mining related problem types that may be addressed are:

- -acidic water impacting land use,
- -barren or poorly vegetated mine spoil,
- -coal refuse including both coarse and fine refuse,
- -old mine haul roads,
- -highwalls or other steep embankments problems,
- -reduced stream flow capacity that results in periodic flooding of property,
- -mine subsidence or similar mine related ground displacement,
- -other mining related problems.

HOW IT WORKS

Problem Area Description

Property owners, or multiple owners working together if the problem(s) crosse s property lines, would be responsible for identification of the problem area and to develop a written description of the problem. This problem description should include a physical description of what the problem looks like, the location of the problem ar ea, and a complete list of all owners involved. The use of photographs, and plat or topographic maps is encouraged in order to fully illustrate the problem area. The owner may also develop a proposed plan of reclamation.

Project Proposal

This information should then be presented to the local SWCD board or a board member as an application package. If the SWCD board determines that the proposed project meets all guidelines of the program, and that sufficient information has been compiled for them to make a d etermination that the project has sufficient merit to request funding, the application package is then forwarded to the local RC&D Council for delivery to the IDNR Division of Reclamation.

The Division of Reclamation will make a determination on the elig ibility of the proposed project. DoR will also determine specific factors that need to be addressed in order to comply with all state and federal regulations, and may provide technical comments on the preliminary plan of reclamation. Once DoR determines th at the proposed project meets the criteria for this program, they will notify both the local RC&D as well as the SWCD that the project is eligible for funding.

Plan Development

The landowner is then responsible for developing a final plan of reclamation t hat includes all factors

developed in the preliminary review process. This final plan should be as simple as practical to ensure that it is both understandable as well as capable of being bid if required. Guidance from the RC&D, as well as DoR and/or NRCS staff should be sought to insure a proper plan of reclamation is developed. This final plan may include technical drawings for complex reclamation projects, as well as details on water treatment if required. Final slopes, grades and vegetation techniques s hould also be discussed.

Technical Assistance

Technical assistance in developing either the problem description or the proposed reclamation plan is available from a number of sources. The IDNR's Division of Reclamation, the Natural Resource Conservation Service (NRCS), or the IDNR's Division of Soil Conservation may be able to assist owners in certain aspects of preparing these documents. Private local engineers or mining professionals, county engineers, land contractors or other knowledgeable persons may be willing to assist owners as well.

PROJECT APPROVAL

Once the final reclamation plan is complete, the SWCD is responsible for review and approval. A final, not to exceed cost is attached to the proposal and it is then forwarded through the RC&D to the D oR. Upon receipt of the final plan, the DoR will review for adequacy and completeness. Those reclamation plans determined to be acceptable will be funded at the agreed upon cost.

RESPONSIBILITIES

Owner of Property:
-complete application for assistance t o reclaim property
-determine size and extent of reclamation activity required
-materially participate in reclamation either through cost share, cost savings or direct work involvement
-coordinate preliminary and final applications to the SWCD for assistan ce
-submit and abide by maintenance agreement on completed project site
Soil and Water Conservation District:
-review all preliminary and final applications for compliance with program guidelines
-determine technical competence of proposed project
-ensure owner compliance with terms of project and maintenance agreement
Resource Conservation and Development Council:
-coordinate all application, contractual and technical aspects of each project
-contract for services as required for reclamation projects
-handle all financial transfers between Division of Reclamation, contractors, owners, etc.
Department of Natural Resources, Division of Reclamation:
-provide technical and administrative guidance
-make final determination on eligibility of proposed project
-secure state and federal approvals for project
-provide requested funding for completion of reclamation project
-inspect completed project for adherence to reclamation plan
Natural Resource Conservation Service:
-provide technical support to owner and/or SWC D as requested
-assist in design and inspection of reclamation project as requested by owner

ABANDONED AND INACTIVE MINE SAFETY: UNDERGROUND MINE HAZARDS

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Abstract

Working in and around abandoned underground mines is a very dangerous business. Mines are often located along fault structures that are inherently unstable. The blasting used to develop a mine further destabilizes the overlying rock. Timbers, rock bolts, and other means of roof support, originally placed to stabilize "incompetent ground," tend to deteriorate and lose their effectiveness after the mine has been abandoned. Ventilation systems used to evacuate toxic gasses are no longer operational in abandoned mines, so there is a strong likelihood of encountering oxygen-deficient or toxic atmospheres. Abandoned explosives and hazardous substances are commonly encountered. Heavy equipment, deteriorating structures, and flooded areas present numerous hazards. Underground mine hazards and their avoidance will be addressed in detail in this session, including discussions on characteristics of gasses that may be encountered, radiation hazards at radioactive mine sites, and protocols for conducting underground work under the direction of a fully experienced and properly equipped abandoned mine specialist.

Introduction

Geologists often have reason to enter abandoned mines. Mineral examiners conduct underground inspections in assessing mineral resource values for mining claim validity and patent examinations. Exploration geologists inspect inactive mine workings to assess further development potential.

Wildlife biologists conduct surveys of underground mine workings to assess critical wildlife habitat. For instance, abandoned mines have become increasingly important to the survival of numerous sensitive and protected bat species since increased urban development, deforestation, and exploitation of caves threaten their natural habitat. Although external surveys can be used to gain useful information, underground surveys are best for assessing the importance of habitat provided by abandoned mines. Information from underground surveys is often essential in determining the most appropriate type of closure for a particular mine opening.

Cultural resource specialists are interested in abandoned mines and related artifacts that may be left underground.

Limited funding and time force abandoned mine land (AML) reclamation programs to prioritize closures. By entering abandoned underground workings, the true hazard level can be evaluated to determine which sites should be prioritized for closure. It is also often necessary to enter an abandoned mine in order to design and implement a suitable closure.

Because members of the public **will** enter abandoned mines, it is incumbent on land managers to

know what hazards are being left exposed to the public until appropriate closures can be constructed and to take whatever temporary measures are possible and necessary to minimize the hazard. In the event that a rescue may be required, it is good to have an idea of the extent and layout of underground workings before entering an abandoned mine.

Who is Qualified to Enter Abandoned Underground Mines?

The Mine Safety and Health Administration (MSHA) discourages entry into abandoned mines, except for rescue situations conducted by an authorized mine rescue team. MSHA is the agency in the Department of Labor that regulates and periodically inspects safety in active mining operations. Their official policy is that no one, despite experience, should be allowed to enter unventilated areas deeper than 100', unless they are trained and equipped as part of an emergency mine rescue team. MSHA, however, has no regulatory authority concerning abandoned mines.

It is the policy of the Office of Surface Mining Reclamation and Enforcement (OSM), as handed down to its State programs, to forbid entry of underground workings in excess of 25', or any deeper than is required to construct a suitable closure for each opening. All Federal funding for abandoned mine closure and reclamation is currently disbursed to 26 individual State and 3 Native American tribal programs through OSM. Outside of its own programs, however, OSM has no regulatory authority over the policies of other agencies or entities concerning abandoned mines.

Local State mine inspectors do have jurisdiction concerning abandoned mines. In many States it is against the law to enter abandoned mines. State mine inspectors may exercise their authority over Federal employees on Federal lands. Strictness of the laws and the level of enforcement varies from State to State.

Federal land management agencies are responsible for developing their own safety policies concerning abandoned mines. As much as possible, these policies should be consistent with MSHA, OSM, and State regulations. The USDA Forest Service (**USDAFS**) policy was most recently addressed in a memorandum dated April 6, 1999, from the Director of Minerals and Geology Management to all Regional Foresters. USDAFS requires "non-certified" employees to be accompanied by Federal or State mine inspectors or by certified mineral examiners who are qualified by their Regional Director for the Minerals Program. The US Bureau of Land Management (**BLM**) most recently addressed mine safety in a draft policy issued by the Director in an Instruction Memorandum dated April 18, 2001. BLM's plan is in conformance with their confined space policy as based on OSHA regulations at 29 CFR 1910.146, with modifications stipulated in the Instruction Memorandum. BLM's policy is also covered under BLM Manual Handbook 1112-2, §3.8 and §27.5. USDAFS and BLM both offer annual 1-week Mine Safety Workshops for all employees whose job requires them to work in and around abandoned mines.[1] These classes are open to other agencies and government contractors pending available space. To date, the National Park Service (**NPS**) has not established an underground mine entry policy,

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[1] See http://www.ntc.blm.gov/ (602-906-5604) and http://www.fs.fed.us/r1/minerals/NMTO/NMTO.htm (406-329-3626) for more information.

although it has worked closely with USDAFS and BLM in establishing AML policy and training NPS personnel for underground safety. **The NPS Geologic Resources Division does not sanction entry of abandoned underground mines by NPS personnel without underground AML training and experience unless they are accompanied and supervised by someone with that background.**

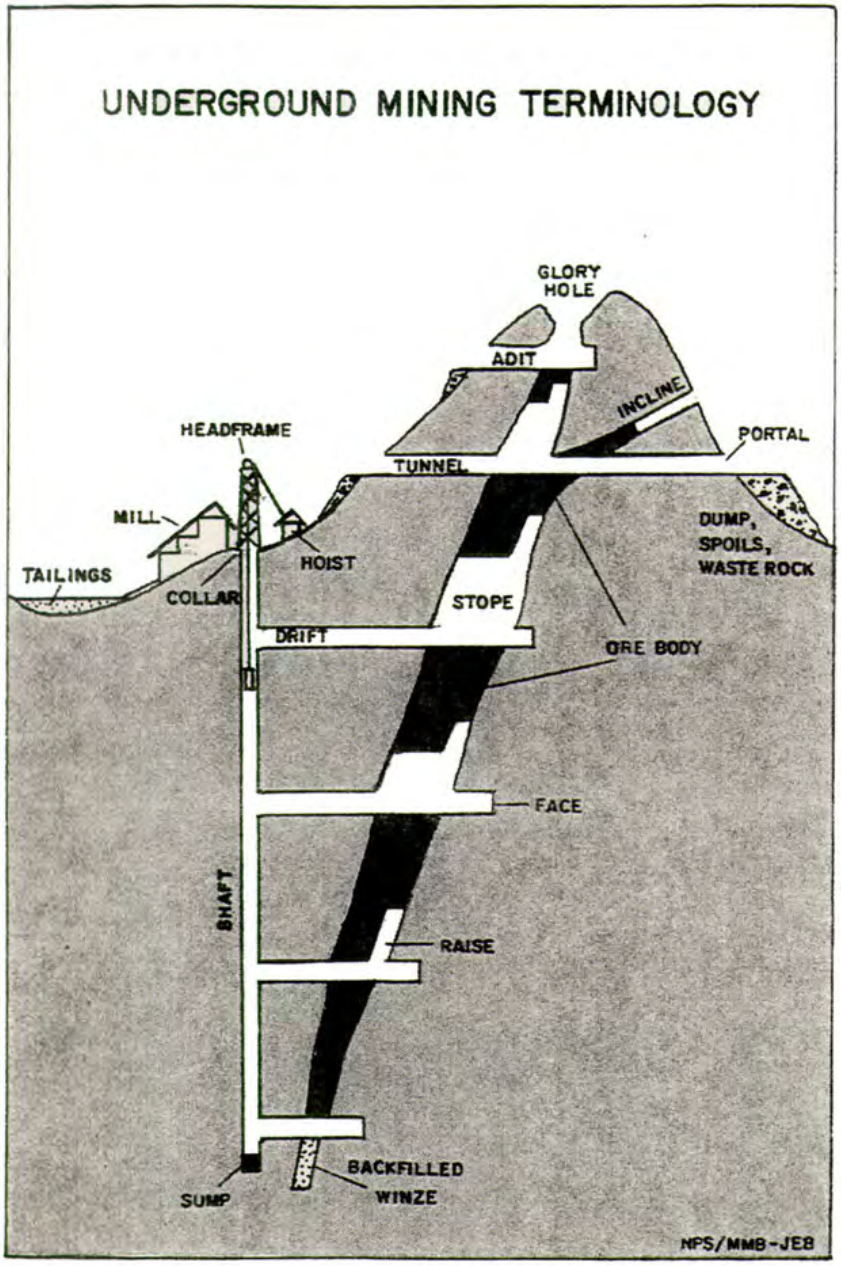

Figure 1. **MINING TERMINOLOGY**

Falling Hazards

SHAFTS, WINZES, RAISES: Shafts are vertical or declined openings exposed on the ground's surface, whereas winzes and raises are declined or inclined openings (respectively) underground inside of a mine. The area around the top of these openings is called the "collar." One of the primary dangers of vertical openings is when the collar has deteriorated through weathering and wear. Loose rock around a collar that slopes gradually into a shaft creates a slipping hazard that can draw its victim into the shaft. Inside a mine, raises and winzes often connect between different levels. An explorer with inadequate lighting could easily walk into a winze left open in the floor. Rotten boards or plywood may also conceal a winze or shaft and should never be trusted. Always check under any covering in a mined area that looks like it could conceal a vertical opening. Falls could result in a serious injury or death by the following means:

- Impact on the walls or at the bottom of the shaft during a fall
- The shaft may be a trap for contaminated or oxygen-deficient air, so that the victim who survives the fall may be asphyxiated.
- The shaft may be flooded at depth, which presents the possibility of drowning.
- The victim may be unable to climb out, especially if injured. When unaccompanied in a remote situation, a minor injury could be fatal.

GLORY HOLES: Many underground mines will follow a mineralized area upward near or to the ground's surface. When underground workings reach or collapse to the surface in this manner, a glory hole is the result. Quite often, the caved area underground is much larger than the hole at the surface, causing the glory hole to collapse and enlarge through time. If you are standing at the edge of a glory hole, chances are good that the ground you are standing on is undercut and subject to collapse.

STOPES: Underground stopes are large, often irregular mine openings where an entire zone of mineralization has been excavated. The larger the stope, the less stable it is. Stopes may reach the ground's surface (open stope) or may connect between levels in a mine. With inadequate lighting inside the mine, a person may fall into a stope to a lower level. Loose rock may fall from overhead stopes at any time.

COLLAPSE ZONES: Shallow underground mines are subject to subsidence or collapse at any time. Be particularly aware of surface depressions around mine sites. Avoid walking in these areas, and see if they may correlate to mapped underground workings in the area.

CAVE-INS: Unlike caves, mines are artificial, temporary openings designed to last as long as it takes to extract the ore. When a mine is abandoned, there is no longer a maintenance program to address deteriorating rock conditions and weakened ground supports. Caves are formed over thousands of years by relatively stable processes, whereas mines are created by blasting that destabilizes the rock left in place. Soft, stratified rock types, such as shale, tend to collapse easily, but often in small pieces. Harder, more massive rock types, such as granite, limestone, or sandstone collapse less frequently, but often more catastrophically in large blocks. Keep in mind that mines often follow fault zones, which are inherently unstable. Cave-ins may be the result of:

- **Unstable Rock - The first way to assess rock stability is to look at the floor of the mine.** If the floor is covered with loose rock, the mine is most likely unstable. If the floor is clean, rock conditions are most likely (but not necessarily) stable. Stratified or severely jointed rock types are most prone to collapse under the forces of gravity or from the force of "overburden" (pressure exerted by overlying rock). An area that is "taking weight" may make creaking and popping noises. Sometimes rock under stress can be seen to shoot off in splinters. Timbers under stress are also prone to splintering and emitting creaking noises. Other signs of weight stress are crushed timbers and bent steel support beams.
- **Decayed Timbers -** Through time, timbers that once supported the rock above will oxidize and rot. Although they may remain in-place and appear to provide support, they could be totally ineffective.
- **Ineffective Rock Bolts -** Rock bolts are used to stabilize weak areas in a mine. Sometimes an abandoned mine may have entire areas where numerous bolts are found dangling several feet below the roof. In these areas, the rock that these bolts once supported has since collapsed.
- **Unsafe Structures and Ladders -** Due to rotting and desiccation, wooden headframes, platforms, ladders, etc. become weak and unstable. They should not be trusted to support your weight.
- **Pools of Water** - Standing water may conceal flooded lower levels of a mine, boards with rusty nails, debris, etc. Upon entering an abandoned mine, inspectors should probe any standing water in front of them with a bar or stick before proceeding. Assume that mine water is toxic and unsuitable for drinking.
- **Highwalls and Steep Pit Walls –** These features are briefly mentioned in this discussion of underground mine hazards because surface and underground features are often both found at individual mine sites. A "highwall" is the vertical (or near-vertical) exposure of an open cut on its uphill side. Open pits typically have extremely steep walls on all sides that are usually "benched" with roadways to provide access to the bottom of the pit. Any steep rock wall exposed by blasting will tend toward instability through time, especially in a surface location where the rock is fully exposed to the forces of weathering. As with shaft collars, erosion near the edges may lead to a decayed, loose surface that increases the possibility of slipping and falling over the edge.

Explosives

It is not uncommon to find explosives in abandoned mines. **Under <u>no</u> circumstances should explosives be handled or touched by anyone other than a certified blaster.** When explosives are found, any distinguishing markings or characteristics should be noted, such as the form of the explosive and any printing on cases or on the explosives themselves. In particular, note any dates marked on explosives or their packaging, as age of an explosive is useful in determining its probable composition and stability. If there is any doubt whether the material in question is an explosive, assume that it is. The appropriate authorities should be notified and a certified blaster should be contacted to arrange for disposal.

Powder is the miner's term for explosives. Miners will often store their supply of explosives at the end of an inactive drift or in a small side room off of a main drift in the mine, called the **powder magazine**. Since explosives and blasting caps should be stored separately, there may also be a

separate **cap magazine**. Explosives are also often stored in a separate cache away from the rest of the mine.

Underground mine development is advanced by drilling specific patterns of holes in the **face** of a drift, loading these holes with explosives, blasting, and **mucking** (removing) the resulting broken rock. Each drill/blast/muck cycle is called a **round**. In a surface pit, the mine is advanced by drilling and blasting a series of vertical holes in a **bench**, accounting for the tiered, or stair-step appearance common to all open pit mines.

Explosives come in many varieties, some of which are listed below:

- **Stick Dynamite -** Dynamite is produced in various sizes, but basically looks like a paper-wrapped mixture of packed moist sawdust or powder. It may vary typically from 6 inches to 2 feet in length, from ½ to 1½ inches in diameter. It is usually packed in 50-pound cases. If the sticks appear wet or have clear golden beads of moisture on the surface, this is most likely nitroglycerine that has "bled" out of the dynamite. Bleeding occurs with age or when dynamite is heated. Nitroglycerine is the primary explosive component of dynamite and is highly unstable and dangerous when separated from the matrix of the dynamite stick.
- **Water Gels -** Water gels are similar in shape and packaging to stick dynamite, but have a plastic wrapper enclosing a jelly-like or creamy mixture in any variety of colors.
- **ANFO-Prill -** Prill typically comes in 50-pound bags and looks like fertilizer. It is often white but may come in a variety of colors depending on the manufacturer. The acronym, "ANFO" stands for its principle components Ammonium Nitrate and Fuel Oil. This combination makes for an extremely effective, yet economical blasting agent that is more stable than dynamite. It is the blasting agent of choice in many of today's larger mines. Rather than being placed in blast holes by hand, it is typically blown and compacted into drill holes using compressed air.
- **Boosters -** Boosters in underground mining typically look like plastic tubing that fits over the end of a blasting cap. In open pit mines where large-diameter holes (often 3 inches to 6 inches) are drilled and blasted, boosters may appear more like a molded plug wrapped in paper or encased in plastic with one or more holes through it to affix it to a detonator. The combination of a detonator connected to a booster is referred to as a **primer**. Boosters are typically used in conjunction with prill because ANFO requires more energy than dynamite to initiate detonation.
- **Detonator Cord -** "Det cord" is usually a brightly-colored, braided, hard nylon cord with a white powder core of pentaerythritetetranitrate (PETN). PETN is highly explosive, and consequently, det cord burns at rates of up to 20,000 feet per second. It is used to connect explosive charges together.
- **Detonators -** Detonators, or **blasting caps**, are metallic cylinders about the size of a small cigarette with attached wires (electric caps), plastic tubing, or cord (non-electric caps). Fresh caps will be marked, usually with a small paper tag bearing a number that refers to the delay time between ignition of the fuse and actual detonation of the cap. Caps are timed so that drill holes can be blasted in a sequence that optimizes the efficiency of breaking and moving the rock. Blasting caps may be found in a storage cache or, since they are easy to drop or misplace through carelessness, they can often be found laying about a mine site. The blasting agent in older caps was mercury fulminate. Today, the explosive charge in

caps is typically PETN. Blasting caps are powerful enough to blow off a hand, so they should be treated with the same respect as other explosives.

- **Fuse -** Fuse with a blasting cap on one end is used in "setting off" or initiating a non-electric blast. One of the more common fuses used is **blackwick**, which looks like a black waxy hollow-core cord. It burns at a rate of 1 foot per minute, so the length of a fuse determines the delay between "spitting" a round and the actual blast. If a miner needs 5 minutes after spitting a round to clear people out of the area of danger, he may, for instance, select an 8-foot fuse. After spitting the round at the face, he then clears the area (assisted by others if the mine has several branches that must be cleared) yelling, "Fire in the hole!" After clearing, he then posts himself as a guard at a safe distance from the blast, keeping others from entering the blast area. After the blast goes off, no one is allowed back into the blast area for 30 minutes. This allows any defective charges extra time to detonate (although this is not common) and allows time for the ventilation system to clear the air of gases generated by the blast.
- **Spitter -** A spitter is used to initiate burning of a fuse. It looks like a small cardboard tube with a pull-cord, similar to a "party-popper." The spitter tube fits over the end of a fuse, then its cord is pulled to initiate burning of the fuse. The charge in a spitter is very small, but could burn the skin if the cord is pulled when the end of the spitter is directed toward someone.
- **Misfires -** Misfires are explosive charges that for some reason did not detonate with the rest of a blast. Miners check for misfires after each blast, but may overlook them. One indication of a possible misfire is an irregularity in the typical profile of a drift. For instance, if a given mine typically has an arched roof, but there is a protrusion of rock in the arch of one round, this would be a likely place to find a misfire. This irregular protrusion may, however, just be a **bootleg** (a drill hole where explosives were not packed tightly, and when detonated, they simply blew out of the hole instead of breaking the surrounding rock). When entering a mine, an inspector watches the **ribs** (sides), **back** (roof, or ceiling), and **faces** (ends) of all drifts for irregularities and potential misfires. If wires, tubing, fuse cord, or dynamite can be seen protruding from a drill hole, it should be treated as a misfire. Misfires must be blasted in-place by a certified blaster. **No attempt should be made to touch a misfire or to remove it from the hole.**

Disorientation

In larger mines, it is easy to become disoriented. This can be quite unsettling and may lead to panic. In a panic situation, all of the other underground hazards become that much more dangerous. Some investigators will use “string line” measuring devices in mapping underground workings or simply to measure distance into the mine. Remnant string line is very handy for finding one’s way back out of a complex mine.

Wildlife

An abandoned mine may be home for many animals such as snakes, rodents, bats, or larger mammals. Animals that are normally reclusive and passive may become aggressive if backed into a corner of an abandoned mine by inquisitive intruders. Animal droppings can harbor diseases such as Hantavirus or Histoplasmosis. Every effort should be made to avoid disturbing wildlife

underground and to avoid stirring up dust in the area of animal droppings. A respirator should be used if dust is generated in an underground survey, particularly if animal droppings are present.

Encounters with wildlife may be equally detrimental to the wildlife. For instance, abandoned mines often provide critical habitat to bats that have an essential role in the ecosystem. Disturbing an underground **maternity roost** (a place where females bats give birth and nurture young) could cause adult bats to abandon their helpless young. Awakening bats in a **hibernaculum** (a place used for hibernation) could cause them to expend too much energy, leaving inadequate nutrition to sustain life through the remaining winter months when food sources such as insects are unavailable.

Hazardous Materials

Drums or other containers of unknown materials are often abandoned on a mine site or inside the mine itself. These containers should not be opened and should only be handled by a hazardous materials specialist. As with abandoned explosives, any distinguishing markings on containers should be noted and reported to the proper authorities.

Mine Gases

The composition of clean, dry air at sea level is 78.07% nitrogen, 20.95% oxygen, 0.93% argon, 0.03% carbon dioxide, and 0.01% other gases. Air composition can be altered in underground mines for a number of reasons. The most common mine gases, reasons for their generation, and the effects and symptoms of human exposure are summarized below:

- **Oxygen (O_2) -** Oxygen deficiency (**Anoxia**) may result from combustion, blasting, oxidization of organic material (e.g., mine timbers, coal), respiration in confined spaces, or replacement by other gases. Oxygen is highly flammable in high concentrations that are unlikely to be found underground except where leaky oxygen cylinders are stored.

Oxygen Content (% by Volume)	**Threshold Limit Values (TLVs)*, Effects, and Symptoms[2] (at Atmospheric Pressure)**
23.0 *	Upper permissible oxygen level
20.95	Typical ambient air conditions
19.5 *	Minimum permissible oxygen level
15 - 19	Decreased ability to work strenuously. May impair coordination and can induce early symptoms in persons with coronary, pulmonary, or circulatory problems.
12 - 15	Respiration increases in rate; pulse up; impaired coordination, perception, and judgement.
10 - 12	Respiration further increases in rate and depth; poor judgement; lips blue.
8 - 10	Mental failure; ashen face; blue lips; nausea; vomiting; fainting; unconsciousness.
6 - 8	8 minutes: 100% fatal 6 minutes: 50% fatal 4-5 minutes: recovery with treatment
4 - 6	Convulsions; coma in 40 seconds; respiration ceases; death.

*** The area should be evacuated at oxygen concentrations of 19.5% or less, or in concentrations above 23%.**

[2] Symptoms listed in this report vary with each individual's State of health and degree of physical activity.

- **Carbon Monoxide (CO) -** Carbon monoxide is an odorless, tasteless, and colorless gas that may build up in a confined space, usually as a result of combustion, blasting, or heating of flammable substances. It can also be produced by certain coals at room temperature. CO is slightly lighter than air, so it may tend to stratify toward the roof of a drift. CO inhibits the oxygen-carrying capacity of the blood by combining more readily with hemoglobin than oxygen. The rate at which CO combines with blood depends on the exposure time, CO concentration, and the activity of the exposed individual. CO builds up in the bloodstream with continuous exposure and may reside in the body for days or weeks after exposure, so the symptoms listed below are given as a function of concentration over time. In high concentrations of carbon monoxide, a person will collapse and become helpless with little or no warning.

ppm	%	TLV*, Effects, and Symptoms through Time
50 *	0.005	Permissible exposure level for 8 hours. Some agencies use the more conservative TLV of 35 ppm.
200	0.02	Slight headache and discomfort after 3 hours
400	0.04	Headache and discomfort after 2 hours
600	0.06	Headache and discomfort after 1 hour
1000-2000	0.1 – 0.2	Headache, discom fort, and slight heart palpitations after 30 minutes
1000-2000	0.1 – 0.2	Headache, discom fort, and tendency to stagger after 1.5 hours
1000-2000	0.1 – 0.2	Headache, discomfort, staggering, and nausea after 2 hours
2000-2500	0.2 – 0.25	Unconsciousness after 30 minutes
4000	0.4	Fatal in less than 1 hour

*** The area should be evacuated at carbon monoxide concentrations in excess of 50 ppm.**

- **Methane (CH_4) -** Methane is the most common flammable gas in mines, but other hydrocarbons such as ethane and propane may also be present in trace amounts. While hydrocarbon gases are most often associated with coalmines, they may also be found in mines adjacent to oil and gas fields or in strata that contain combustible materials. Methane is odorless, tasteless, and colorless and stratifies along the ceiling of a drift since it is much lighter than air. Although it is not toxic, it acts as an asphyxiant by diluting oxygen concentration in the air. Methane in air will ignite at a 5% concentration (by volume). This is termed the "lower explosive limit," or "100% **LEL**." Methane also has an upper explosive limit at 300% LEL (15% by volume in air). Above this level, methane has displaced so much oxygen that there is no longer adequate oxygen to support combustion. These properties of methane are diagramed below:

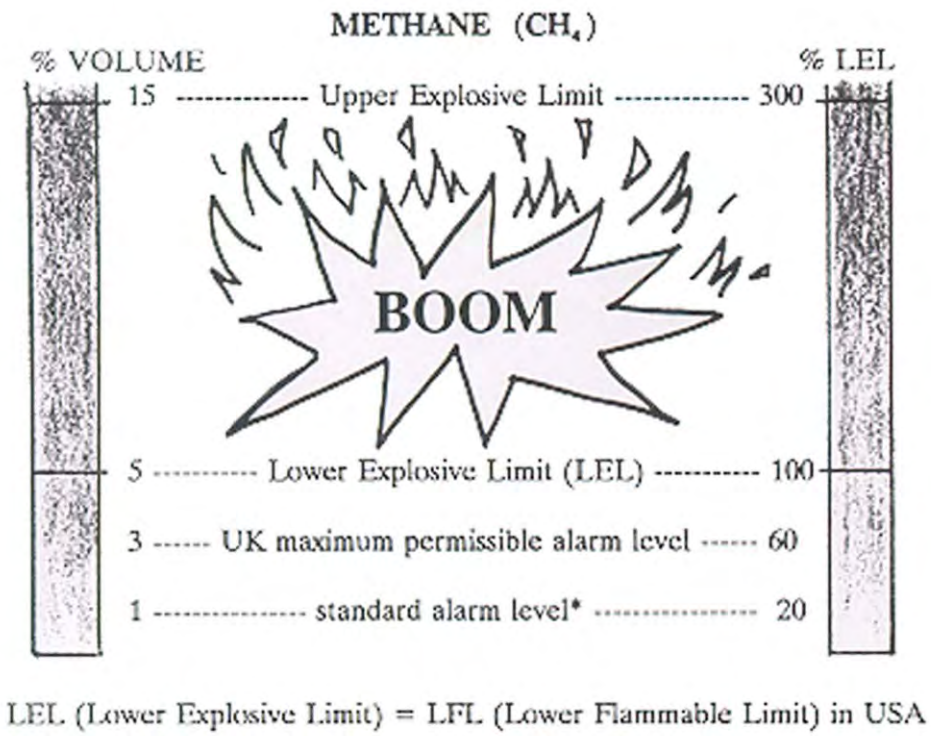

Figure 2. Upper and Lower Explosive Limits of Methane

*** The area should be evacuated at methane concentrations in excess of 20% LEL (1% by volume in air).**

- **Carbon Dioxide (CO_2) -** Carbon dioxide is produced through respiration, combustion, and blasting, and it can exude naturally from coal seams, carbonate strata, and other rock types. It is colorless, much heavier than air, and has a slight acid taste when present in high concentrations. While carbon dioxide is commonly present in the air (0.03%), it is hazardous in higher concentrations. The following chart demonstrates some of its effects:

ppm	%	TLV*, Effects, and Symptoms
5,000	0.5*	Breathing (ventilation) is deeper and faster than normal.
30,000	3	Ventilation doubles
100,000	10	Tolerable only for several minutes at low activity. (Note: Due to air displacement, 10% CO_2 concentration reduces oxygen content to 18.9%.)

In typical respiration, humans breathe air at 20.95% O_2 and 0.03% CO_2 and exhale 16% O_2 and 4% CO_2. In confined spaces, therefore, oxygen can quickly be replaced by carbon dioxide. Mining may intercept pressurized CO_2-bearing strata. Being much heavier than air, CO_2 stratifies along the floor of a drift and low-lying areas, displacing the air. This is one reason why extreme caution, proper instrumentation, and approved procedures should be used when descending into a mine. When entering a mine on a steady downgrade, a person may not be aware of elevated CO_2 until his mouth reaches the CO_2 level. By walking into the area, however, the person has mixed the stratified gas with the good air above. The resulting mixture may be incapable of supporting respiration, and the person may not be able to evacuate the mine.

*** The area should be evacuated at carbon dioxide concentrations in excess of 5,000 ppm (0.5%).**

- **Hydrogen Sulfide (H_2S) -** Hydrogen sulfide is a colorless, toxic, and flammable gas that can be formed when: blasting in sulfide ores, it may be formed in reducing environments such as areas of decaying timbers, or where a large animal falls down a shaft, dies, and decays. Hydrogen sulfide is common in varying concentrations in many hydrocarbon deposits. Although its foul odor (like rotten eggs) is easily detected at low concentrations, it is not detected at higher concentrations because it quickly desensitizes the olfactory nerves, leaving a person unaware of its presence. In high concentrations, a person may collapse with little or no warning. Hydrogen sulfide is heavier than air, so it tends to stratify in low areas.

ppm	% TLV	*, Effects, and Symptoms through Time
10*	0.0001*	Permissible exposure level for 8 hours
50 - 100	0.005 - 0.01	Mild eye and respiratory irritation after 1 hour
200 - 300	0.02 – 0.03	Marked eye and respiratory irritation after 1 hour
500 - 700	0.05 – 0.07	Unconscious and death after 30 minutes to 1 hour
> 1000	> 0.1	Unconscious and death within minutes

*** The area should be evacuated at hydrogen sulfide concentrations in excess of 10 ppm.**

- **Sulfur Dioxide (SO_2) –** Sulfur dioxide is a highly toxic, colorless, suffocating, and irritating gas that smells like sulfur. It is much heavier than air, so stratifies along the floor of a mine when present. Sulfur dioxide is produced by fires in the presence of iron pyrite and by blasting in certain sulfide ores. It is more likely to be encountered in wet sulfide mines since it is highly soluble in water. Sulfur dioxide is **extremely** irritating to the respiratory system and is not commonly a problem because it is so noxious that no one would attempt to enter an area of significant contamination.

*** The area should be evacuated at sulfur dioxide concentrations in excess of 5 ppm.**

- **Nitrogen (N) –** Nitrogen is the main dilutant of oxygen in air. In fact, it composes 78.08% of normal air by volume. Some rock types can generate nitrogen. It is colorless, odorless, tasteless gas that is slightly lighter than air. While nitrogen is not toxic, it is considered an asphyxiant because it replaces oxygen if introduced to air, producing an oxygen deficient atmosphere. Precautions for nitrogen are therefore the same as those for anoxia.

*** While nitrogen is not toxic, atmospheres in excess of 78.08% nitrogen are oxygen deficient.**

- **Nitrogen Dioxide (NO_2) –** Oxides of nitrogen are common in the emissions from diesel and gasoline engines, and can also be generated by electrical discharges and blasting. They are toxic because they form corrosive acids when mixed with moisture in the lungs. NO_2 is the most toxic oxide of nitrogen, and has a TLV of 5 ppm. It is reddish-brown and heavier than air, so tends to stratify low. Nitrogen oxide (NO) may occur with nitrogen dioxide, and has a TLV of 25 ppm. Oxides of nitrogen are not usually a problem in abandoned mines because their mode of generation is from operations typical only of active mines.

*** The area should be evacuated at nitrogen oxide levels in excess of 25 ppm and nitrogen dioxide concentrations in excess of 5 ppm.**

- **Hydrogen (H_2) –** Hydrogen is another gas that is possible, but unlikely to be encountered in an abandoned mine. It is typically only encountered after an explosion or fire, or near battery charging areas. Hydrogen is not toxic, but is considered an asphyxiant since it replaces air, leading to anoxic conditions. Because it is lighter than air, hydrogen stratifies toward the roof of a mine. It is colorless, odorless, and tasteless.

*** While hydrogen is not toxic, it can displace air in a closed environment, leading to anoxic conditions.**

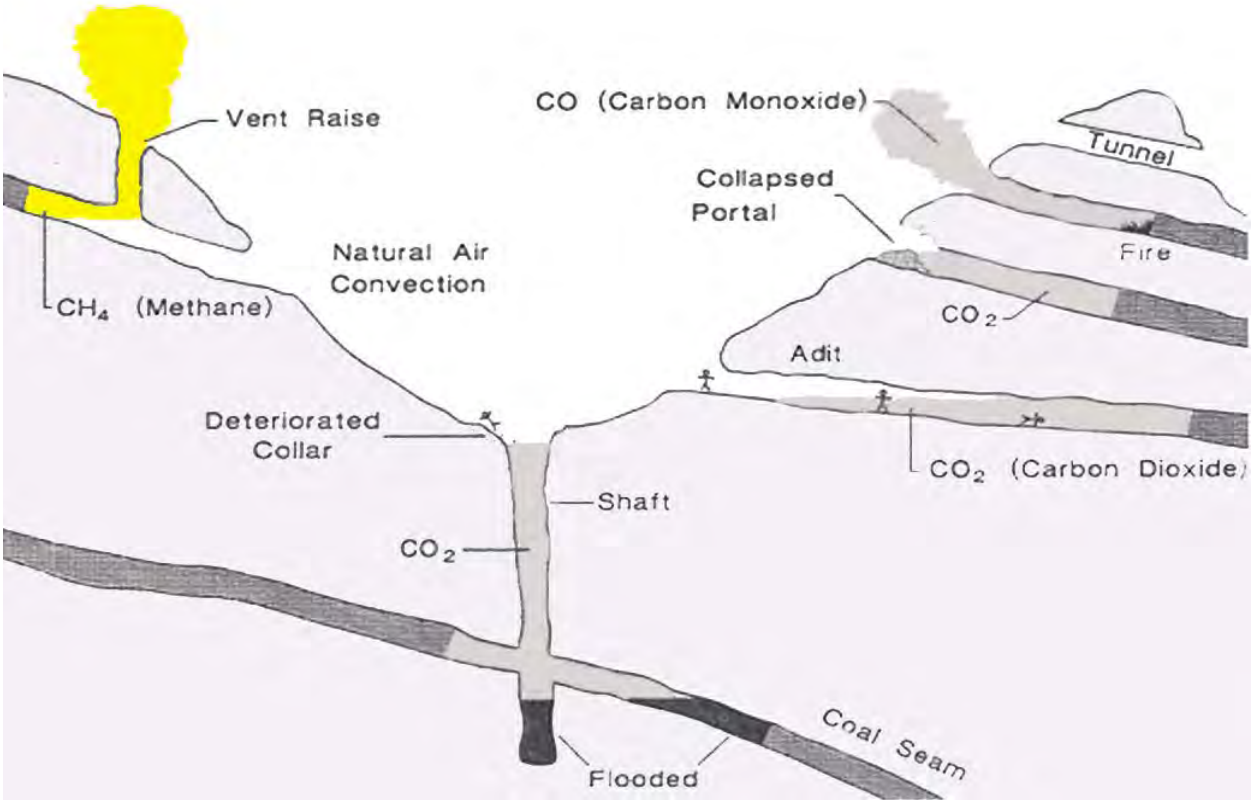

Figure 3. **Potential Underground Gas Hazards**

- **Radon gas (Rn-222) and its progeny -** Radioactive elements contain an unstable configuration of protons and neutrons in their nuclei. For instance, uranium-238 (U238) will decay through time to lead-206 (Pb206) in a defined sequence of steps, as depicted in the Uranium-238 Decay Series chart (Figure 6). The U238 decay series accounts for most of the radiation typically encountered in nature. When an atom of a certain element "throws off" an **alpha (α) particle** (composed of 2 neutrons and 2 protons, with an atomic mass of 4) from its nucleus, it becomes a new element (**daughter**, or **progeny** in the plural form) with an atomic mass of 4 less than the original element (**parent**). (Atomic mass is the total number of neutrons and protons in an atom's nucleus.) Discharge of an alpha particle in this manner is called "alpha radiation." When the atomic nucleus discharges a **beta (β) particle** (an electron thrown off by a neutron as it decays into a proton), the atom becomes a new element of the same atomic mass, but different atomic number. (The atomic number is the total number of protons in the nucleus.) Discharge of beta particles is called "beta radiation." **Gamma (γ) rays** (non-particulate energy rays) may accompany either of these processes. The rate of radioactive decay, or degree of activity, is constant for each element, and is measured by its **half life** (the time it takes for half of the atoms of an element in a sample to undergo radioactive decay).

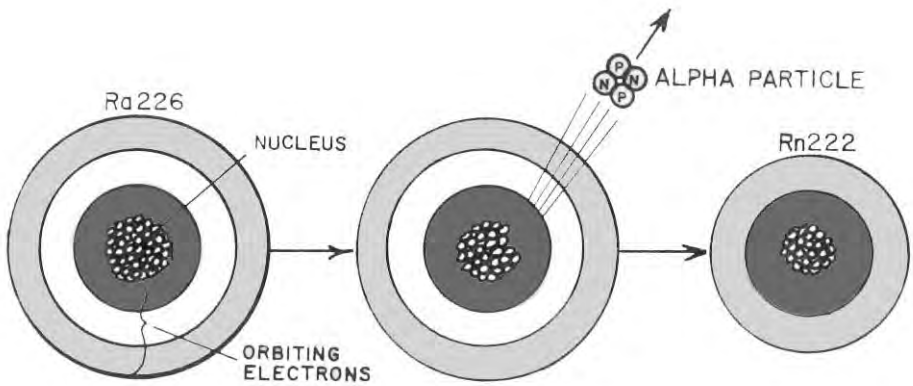

Figure 4. Conceptual Illustration - Alpha decay of Radium-226 to Radon-222

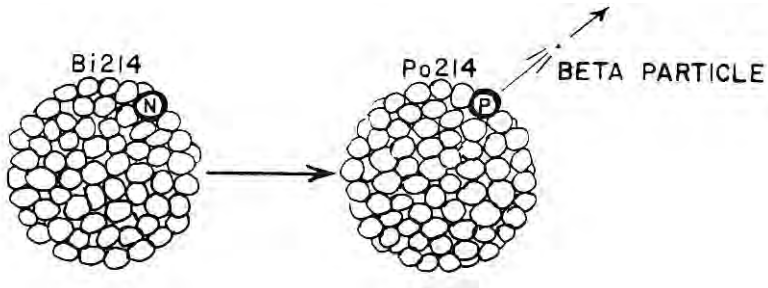

Figure 5. Conceptual Illustration - Beta decay of Bismuth-214 nucleus to Polonium-214 nucleus

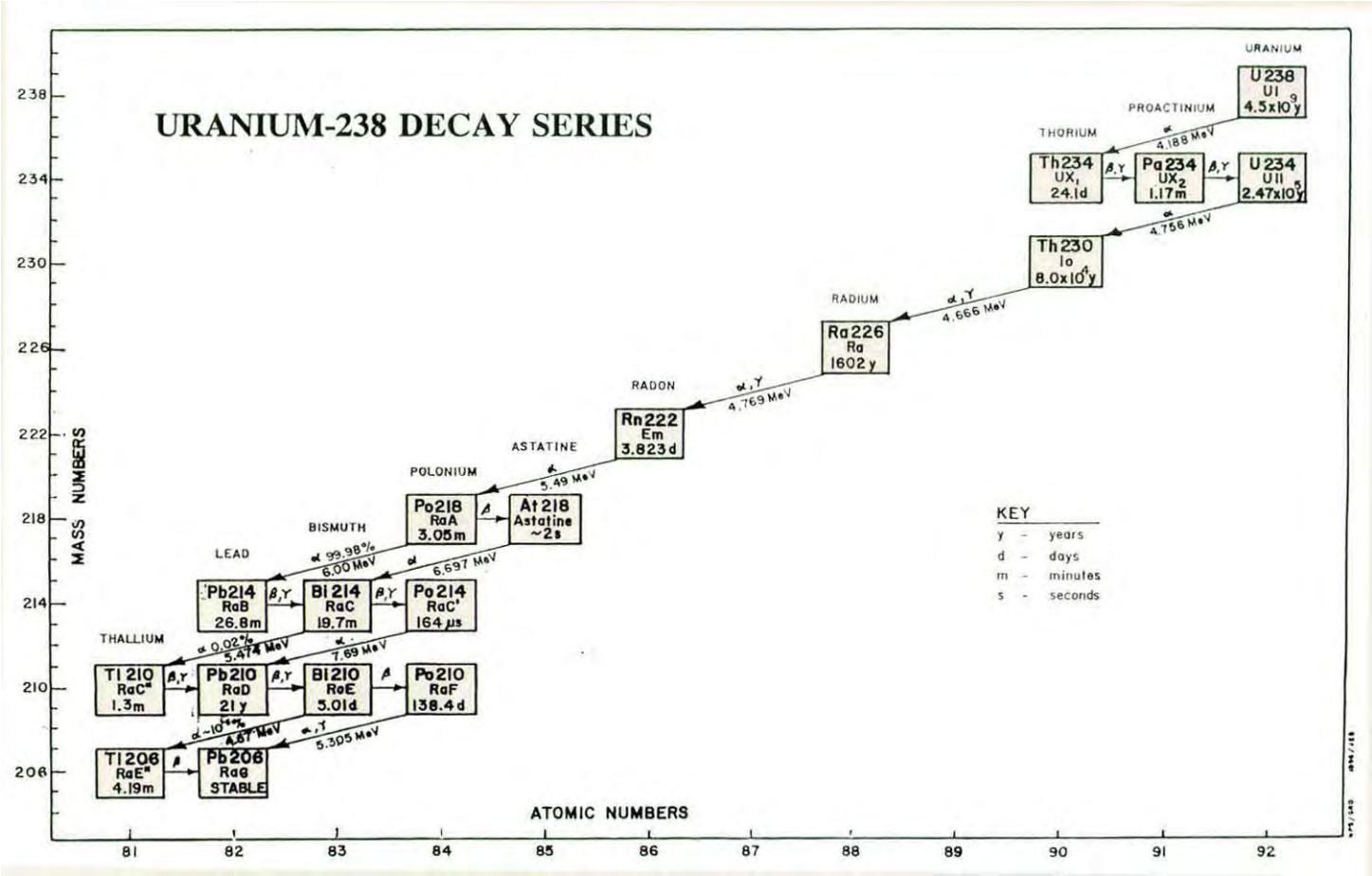

Figure 6. Uranium-238 Decay Series

The harmful effects of alpha, beta, and gamma radiation are primarily related to their ability to penetrate and alter living tissue. At a typical AML site, alpha and gamma radiation are of primary concern and beta radiation should not be a problem. Alpha particles are not highly penetrating, but because of their high mass and energy (on the atomic level), they can be highly damaging to tissue surfaces. Gamma radiation is less damaging at the surface but is highly penetrating and more apt to alter deeper tissues and vital organs.

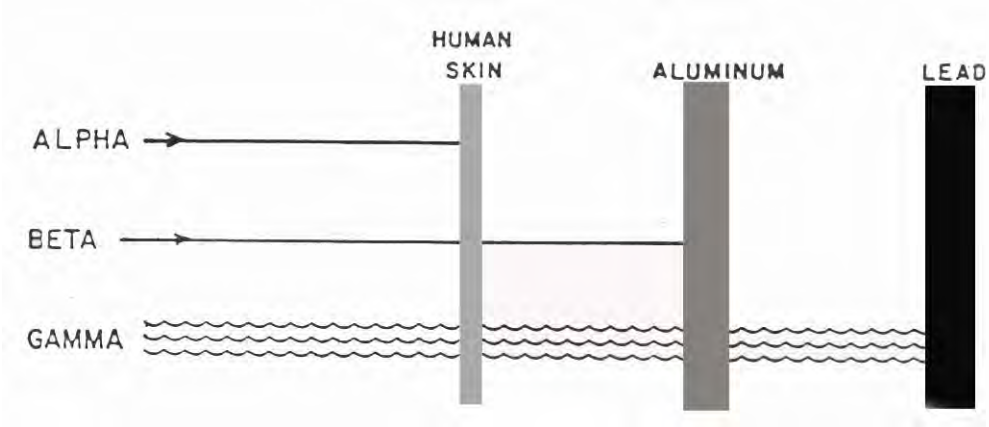

Figure 7. Conceptual Illustration - Penetrating powers of alpha, beta, and gamma radiation

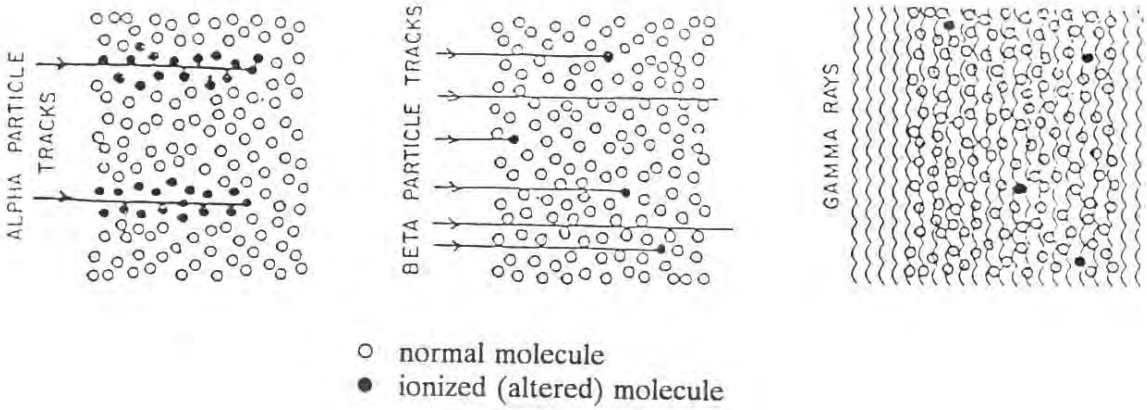

Figure 8. Conceptual Illustration - Ioniza tion potentials for alpha, beta, and gam ma radiation

The most dangerous alpha emitters in nature are the radon daughters, Polonium-218 [also called Radium A (RaA)] and Polonium-214 [Radium C′ (RaC′)]. There are two reasons for this: (1) RaA and RaC′ have relatively short half lives, which means that they are quite active, and (2) Radon daughters tend to get trapped in the delicate tissues of the lungs. The "trapping mechanism" is briefly described as follows. Radon is the only gas to occur in the U238 decay series at standard temperature and pressure, so at this point in the series, the

source of radiation becomes airborne. Radon daughters, because they are solids at standard temperature and pressure, have a high tendency for attaching to or "plating out" on dust particles and mist droplets in the air when they are formed. Dust and mist can get trapped in the lungs when inhaled, thereby trapping attached radionuclides. These radionuclides then continue to decompose inside the lungs, damaging cells of the lung tissue.

With extreme or continued low-level exposure to radon progeny, lung tissue is scarred in such a manner that it cannot take oxygen into the bloodstream, thereby reducing breathing efficiency. Damage from this process is generally believed to be irreversible and cumulative through one's lifetime, and may lead to cancer. Radon gas is not typically as harmful as radon daughters because it has no trapping mechanism, i.e., since radon is a gas, it does not have an affinity for dust and mist, and since it's halflife is 3.8 days, it is usually exhaled before decaying in the lungs.

While radon progeny are certain to be present to some degree in abandoned uranium mines, they are not limited to this occurrence. Radioactive elements may be associated with other mineralization episodes and occur in varying proportions throughout nature. Any confined airspace may host radiological activity.

Since radon progeny are airborne, they are controlled by dust suppression and dilution through increased ventilation. Personal protection is achieved through use of breathing apparatus. In AML situations, the primary radiological concern is damage to lung tissue. Human skin effectively stops alpha radiation. While skin cells may get damaged from alpha exposure, the effect is much less hazardous than typical sunburn damage and the damaged cells are replaced with new, healthy cells.

For occupational safety and health (the mining industry, predominantly), radon daughter concentrations are usually measured in **working levels (WL)** α. **Picocuries per liter (pCi/l)** is also a common unit of measure, where 1 WL ≈ 200 pCi/l in air. Occupational standards require that respirators be worn in radon daughter concentrations in excess of 1 WL. Concentrations in excess of 10 WL, where radon gas concentrations become more significant, require a supplied-air breathing apparatus. Miners, furthermore, are only allowed a cumulative exposure of 692 **working level hours** per year. (1 **WLH** is the equivalent of 1 WL exposure for 1 hour, 2 WL for 1/2 hour, etc.) In the absence of specific regulations for the general public, the USEPA typically recommends general public limits at 10% of occupational standards. By this line of reasoning individuals in the general public should be allowed a maximum cumulative exposure of 69.2 WLH per year. **Because of the compounding effects of smoking and radon daughter exposure on the risk of cancer, smoking is not permitted in mine workings exceeding 0.3 WL.**

Gamma radiation, as stated above, is unlike alpha radiation in that it is highly penetrating. Gamma radiation is essentially independent of air circulation. The major gamma emitters in nature are Radium-226, Lead-214 [also called Radium B (RaB)], and Bismuth-214

[Radium C (RaC)]. Gamma radiation intensity decreases with distance from the gamma-emitting source. Because of its high penetration power, personal protection from gamma radiation is virtually impossible except through complete avoidance. Workers who come into frequent contact with gamma radiation should wear "dosimeters," often referred as "radiation badges" or "TLDs" (thermoluminescent dosimeters, a type of dosimeter commonly used). These sensors record cumulative gamma activity through time and are periodically read and discarded or turned in to a laboratory for analysis. When cumulative exposure for a worker approaches a regulated limit, that individual must be re-assigned to other duties away from sources of exposure.

A standard unit of measure for gamma radiation exposure has been the **roentgen equivalent man (rem)**. Gamma exposures are typically given in **millirems (mrem** or **mR**, where 1 mrem = 1 x 10^{-3} rem) per hour, or **microrems (µrem** or **µR**, where 1 µrem = 1 x 10^{-3} mrem = 1 x 10^{-6} rem**)** per hour. More recently, the **sievert (Sv), millisievert** (**mSv**), **and microsievert** (**µSv**) are being used to express gamma radiation values, where 1 Sv = 100 rem.

There are no acute gamma exposure limitations specified for mines. This is because typical gamma exposures at a mine (or, for that matter, a mill tailings impoundment) rarely approach levels where acute exposure is imminently hazardous. Background radiation values in the southwest, with a few noteworthy exceptions, are typically about 20 µR/hr. Many radiological AML sites have gamma emissions falling in the range from 100 to 300 µR/hr. Gamma radiation in these ranges is not considered to be excessively high for short-term exposures. Values above this may be encountered at particularly "hot" sites, however, and are particularly characteristic of sites where natural material has been concentrated by some technological means. For instance, sites operating under a license from the Nuclear Regulatory Commission (such as a nuclear power plant) require evacuation at 2 mR/hr.

It is important to note that the **regulations typically limit minors and pregnant women to 10% of the normal adult worker exposures**, since gamma exposures can be particularly damaging to developing organs and tissues of the fetus and children. For this reason, work around radioactive AML sites for minors and pregnant employees is discouraged.

The current USEPA Radiation Protection Guidance (RPG) for Exposure of the General Public states that there should be no exposure of the general public to ionizing radiation unless it is justified by the expectation of a net societal benefit from the activity causing the exposure. The RPG goes on to state that a sustained effort should be made to ensure that doses to individuals and to populations are maintained As Low As Reasonably Achievable. ("**ALARA**" is a common term in industrial hygiene to emphasize this rule.) The combined radiation doses incurred in any single year from all sources of exposure covered under the RPG should not normally exceed an effective dose equivalent of 100 mrem for any individual. A source-specific limit of 10 mrem is recommended for individual sites.

There are three very basic principles for limiting exposure to ionizing radiation, thereby minimizing its effects: (1) **TIME**, (2) **DISTANCE**, and (3) **SHIELDING.**

Exposures are limited by minimizing the **time** of exposure, maximizing the **distance** between the receptor and the radiation source, and by **shielding** the receptor when exposure is unavoidable. As an additional precaution to minimize potential intake of radionuclides, **workers should not eat or smoke while at radioactive sites. Once off-site, it is important to wash off all dirt and dust and change out of dusty clothes before eating.**

The NPS Geologic Resources Division has instrumentation and expertise to monitor alpha and gamma emissions. Additionally, samples can be taken of soil and water around mines to check for **radium-226** (**Ra226**) levels. Ra226, a solid, is the direct "parent" of Ra222, and is therefore the best parameter on which to test soil and water contamination. Soil and water radiological pollution standards for mines and mills are therefore often based upon Ra226 concentration. GRD has been able to arrange for limited sample analysis through an informal agreement with the USEPA. These services are also available commercially but can be rather expensive.

For those interested, a detailed paper entitled Effective Management of Radiological Hazards at Abandoned Radioactive Mine and Mill Sites, is available by writing to National Park Service / GRD, Attn: John Burghardt, P.O. Box 25287, Denver, CO 80225-0287, or online at http://www2.nature.nps.gov/grd/distland/amlindex.htm#technicalreports.

Respirators should be worn in radon daughter concentrations in excess of 1 WL α.

The area should be evacuated at levels in excess of 10 WL α or 2 mR/hour γ.

Individual cumulative exposures should be limited to 69.2 WLH/year α and 100 mrem/year γ, and no more than 10 mrem/year γ from a particular site.

GAS	SYMBOL	SPECIFIC GRAVITY	EXPLOSIVE RANGE	HEALTH HAZARDS	SOLUBLE	COLOR	ODOR	TASTE	TLV*
AIR	**-**	1.000	-	-	-	- - -			-
OXYGEN	**O_2**	1.1054 highly	combustible, but not explosive	21% - normal 17 % - panting 15% - dizziness 9% - coma 6% - death	-	- - -			lower: 19.5% upper: 23%
CARBON MONOXIDE	**CO**	0.9672	flammable @ 12.5 – 74.2%	highly toxic	slight	- - -			50 ppm
METHANE	**CH_4**	0.5545	5 – 15%	asphyxiant	slight	-	"gassy"	-	20% LEL (=1% by volume)
CARBON DIOXIDE	**CO_2**	1.5291 -		increases breathing	soluble -		-	acidic	5,000 ppm (= 0.5%)
HYDROGEN SULPHIDE	**H_2S**	1.1906	4.3 – 45.5%	highly toxic	soluble	-	rotten eggs	sweet 10	ppm
RADON Rn		7.5260	-	radiation	high	- - -			1 WL – respirator 10 WL – supplied air
SULFUR DIOXIDE	**SO_2**	2.2638	-	highly toxic	high	-	sulfur	acidic, bitter	5 ppm
NITROGEN	**N_2**	0.9674	-	asphyxiant	slight	- - -			-
NITROGEN DIOXIDE	**NO_2**	1.5894 -		highly toxic	slight	reddish-brown [	blasting smoke	blasting smoke	5 ppm
HYDROGEN	**H_2**	0.0695	4.0 – 74.2%	asphyxiant	-	-	-	-	-

* Threshold Limit Value – Standard alarm level on gas monitoring equipment.
[Noticeable only at high concentrations. Essentially colorless in concentrations likely to be encountered.

Figure 9. **MINE GAS SUMMARY**

Change

A Major Reason for Caution - Abandoned mine sites are dynamic. Rock stability will deteriorate with time, so a portal or drift that may have been stable previously may now be a death trap. Heavy snow pack or a torrential spring storm may cause subsidence of a shallow mine feature, leaving a treacherous opening which may not have existed the last time a site was visited. Erosion may uncover new hazards such as abandoned explosives or openings that were not properly closed in the past. Perhaps the most dynamic aspect of change at AML sites is **airflow**, which is influenced by a mine's internal configuration, fluctuations in temperature, and changes in atmospheric pressure. Mines are said to "breathe," in that airflow at a given opening may be **static**, **incast**, or **outcast** under different atmospheric conditions. Because of these movements, a particular area may have good air on one site visit and bad air on the next visit. Air quality may even change in the course of an extended site visit. When conducting underground inspections, note the direction of airflow, especially at intersections where air from a different source may be encountered. Keep in mind that temperature and pressure changes may reverse airflow, bringing contaminated or oxygen-deficient air from different parts of a mine into an area that previously had good air. When conducting external surveys, avoid standing in air that is outcasting, or "exhaling" from an opening.

Rescue Situations

Many people have lost their lives in attempting to rescue someone else. If an accident occurs while conducting an underground survey, the survey team should carefully evaluate the area before attempting to help. If the victim cannot be safely rescued, the appropriate local authority should be contacted. Sheriff's departments may have rescue personnel or they may be linked to the State mine inspector's office and local active mines that have certified mine rescue teams. A **Job Hazard Analysis** (**JHA**) should include making prior contact with such groups and filing a survey plan with them, inclusive of scheduled check-in and check-out times from underground.

GUIDELINES FOR ABANDONED UNDERGROUND MINE RECONNAISSANCE

1. Underground exploration teams will realize that abandoned mines are unnatural, unstable, and temporary openings with a unique set of potential hazards. Caving experience is **no** substitute for underground mine experience.

2. Underground teams will be comprised of at least two people. If three or more people are present, one person will remain at the mine entrance. The exploration crew will check in with this person at predetermined time intervals.

3. At least one person on the team will be trained and experienced in underground mine safety and hazard recognition. This individual will lead the underground team and instruct inexperienced team members on potential hazards, underground mine safety procedures, and the use of safety equipment.

4. Safety equipment for **each individual** will include, but not be limited to:
   - **Hardhat**
   - **Steel-toed Footwear**
   - **Proper Lighting**, with at least one **backup lighting** source for **each person**.
   - **Eye Protection** - safety glasses are recommended; contact lenses are discouraged.
   - **Respirator**, which will be worn at all times in radon daughter concentrations in excess of 1 WL.

5. In addition to the above equipment, the **lead person** will be equipped with:
   - **Scaling Bar**
   - **Air Monitoring Equipment** (GRD uses a multi-gas detector which continuously monitors for oxygen, carbon monoxide, and explosive gasses. The meter has a visual display of gas concentrations, with warning lights and audible alarms that illuminate and sound when a threshold level of any of these gases is detected. GRD also uses monitoring equipment for alpha and gamma radiation.)

6. Inspectors must notify appropriate authorities before entering and upon leaving a mine. This can be done effectively by radio or cellular telephone.

7. Rock conditions will be checked with a scaling bar as the lead person enters the mine. Exploration will not continue if extensive barring down is required.

8. Underground teams will enter with the lead person in front and the rest of the survey crew following at a safe distance.

9. Underground teams will maintain voice contact with each other at all times.

10. If air detection equipment signals an alarm, or at the first sign of symptoms from bad air inhalation (i.e., headache, dizziness, slurred speech, nausea, etc.) in **any** team member, the symptoms will be mentioned verbally and the mine will be evacuated by **all** personnel **immediately**.

11. The survey crew will remain underground only long enough to complete the necessary work.

12. Unventilated shafts will not be entered.

13. Underground exploration will not proceed over caved areas.

14. Underground exploration teams will not proceed over rotten ladders or structures.

15. Standing pools of water on the floor will be probed for depth with a bar or pole before proceeding.

16. Suspected explosive or other hazardous materials will not be handled. Descriptive information will be recorded and the superintendent, chief safety officer, and regional blasting officer will be contacted to arrange for disposal.

QUIZ

For questions 1 & 2, prioritize from most to least often:

1. Accidents in active underground mines are caused by:

a. explosives
b. falling rock
c. falling / tripping hazards
d. contaminated or oxygen-deficient air
e. heavy equipment

2. Accidents in abandoned underground mines are caused by:

a. explosives
b. falling rock
c. falling / tripping hazards
d. contaminated or oxygen-deficient air
e. heavy equipment

Fill in the blank / multiple choice:

3. Looking in from outside, what is the first clue which indicates stability of rock in an underground mine?

_____

4. Investigation inside abandoned mines by park staff for the purpose of conducting a hazard assessment is condoned by:

a. the Mine Safety and Health Administration (MSHA).
b. the Office of Surface Mining Reclamation and Enforcement (OSMRE).
c. the Geologic Resources Division
d. none of the above.

5. Oxygen-deficient air tends to:

a. disseminate evenly throughout an enclosed area.
b. stratify along the ceiling of an enclosed area.
c. stratify along the floor of an enclosed area.
d. any of the above, depending on the relative density of the gas replacing the air.

6. Unstable rock at an abandoned mine's portal (entrance) is often its most dangerous feature because:

   a. it is directly exposed to the forces of weathering.
   b. it is unsupported on the external surface.
   c. blasting into the hillside might have destabilized overlying strata far overhead.
   d. all of the above.

7. Ambient air contains ____ % oxygen (by volume). An area should be evacuated at concentrations less than ____ %.

True / False:

8. A "shaft" is defined as any mine opening, horizontal or vertical, leading from the surface to underground workings.

9. Barring any unnatural circumstances, if the air was suitable for breathing going into an abandoned mine, you should have no trouble breathing on the way out.

10. A person with extensive caving experience is qualified to investigate an abandoned mine.

11. If an abandoned mine is well timbered, it should be safe to enter.

12. Nearby operating mines may have certified mine rescue teams which could help in the event that someone needed to be rescued from an abandoned mine in your park.

13. GRD can make certain adits safe so that parks can leave them open to visitors as interpretive sites.

14. From a safety perspective, list ways in which active and abandoned mines may differ:

ACTIVE MINES	**ABANDONED MINES**

KEY:

1. b, e, c, d (underground fires), a
2. c, b, d, a, e (educated guess; no hard data available)
3. loose rock on floor
4. d
5. d
6. d
7. 20.95; 19.5
8. F
9. F
10. F
11. F
12. T
13. F
14.

ACTIVE MINES	ABANDONED MINES
positive (forced) ventilation system	natural airflow only (potential for bad air)
periodic maintenance, ground support	no maintenance, left to deteriorate, collapse, flood, etc.
periodic inspections (MSHA)	no inspections
operating equipment	inoperative equipment (less hazardous, usually)
stable explosives	unstable explosives
experienced, equipped personnel	untrained, unequipped visitors
emergency medical facilities/staff on-site	no medical facilities/staff on-site
mine rescue team	no mine rescue team

John Burghardt received a B.S. in geology from Colorado State University in December 1976. He worked a total of 10 years as a miner, surveyor, and engineer for Amax, Inc. (now Phelps Dodge) at Henderson Mine: a 35,000 ton-per-day molybdenite mine 45 miles west of Denver. John joined the National Park Service in 1988 where he now serves as a geologist with primary responsibilities coordinating the mining claim validity program and the underground Abandoned Mine Land (AML) segment of the Disturbed Land Restoration Program. Collateral duties include providing mine safety instruction to federal and state agencies and participation in bat conservation initiatives, particularly as they relate to bat habitat in abandoned mines. John attained official recognition in 1993 from the Bureau of Land Management as a Certified Mineral Examiner, and is currently the NPS representative to the Bureau of Land Management's National Mineral Examiner Certification Panel, and to the Colorado Advisory Board of the Western States Bat Working Group.

BAT GATE CONSTRUCTION, ON-SITE COORDINATION, AND WORK

Jim Nieland
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Abstract

The key to project success is planning and logistics. The challenge is to have all material, personnel, and equipment come together, on th e work site, in a way that allows systematic and efficient assembly of the gate. The planner needs to take into consideration the size of the gate, the amount of materials needed for its construction, and make sure all materials are on site and ready befo re the start of construction. Similarly, all necessary tools should be on site and available when needed. The amount of labor needed must be estimated so adequate personnel will be available when needed. Transporting materials, equipment, and constructio n personnel to the work site can be challenging and may require advanced planning, particularly if aircraft or other unusual transportation is required. It may also be necessary to establish a field camp near the construction site to feed and shelter work ers, particularly if the work is taking place in a remote location.

On-site Coordination

On site coordination starts well before actual construction begins, with careful planning and coordination of all project elements. The most important objective is making sure that all personnel, supplies, and equipment are on site and available when work starts. This will assure systematic and efficient gate assembly. Failure to do this can delay work, create cost over runs, and potentially jeopardize the project.

The coordinator needs to take into consideration: gate size, the amount of materials needed for its construction, and make sure everything is ready at the start of the project. This requires pre-planning and often delivery of steel to the work site seve ral days ahead of time. Many projects have been delayed and the cost increased because equipment or supplies were not ready when needed.

Similarly, all necessary tools should be on site and available. The amount of labor needed must be estimated, so ade quate personnel will be available when work starts. Transporting materials, equipment and construction personnel to the work site can be challenging and may require advanced staging, particularly if aircraft or other unusual transportation is required. It may also be necessary to establish a field camp near the construction site to feed and shelter workers, particularly if the work takes place in a remote location. Remember, running to town or back to the shop is not always an option, be sure everything is on site, and you have necessary backup items.

It may also be necessary to establish a field camp near the construction site to feed and shelter workers, particularly if the work takes place in a remote location.

Once the day of construction arrives , it becomes important to establish a flow of materials and a routine for moving materials for gate assembly. The steel should be separated by size and stockpiled out of the way but near the construction location. A cutting station needs to be establishe d between the stockpile and work site, so material can be moved to a cutting stand, trimmed to size, then shifted to the gate for final assembly. On-site coordination becomes critical to make sure all operations are synchronized and personnel are kept busy. In larger projects, the goal is to keep two welders busy at all times. This means that steel must be cut, and made ready for assembly, at a fairly rapid rate.

Stiffeners are most conveniently added to gate bars at the cutting stand. The bar has already been cut to length and will be moved to gate as soon as welding is complete. Note clamps holding stiffeners in place, and the convenient working height for welding.

Steel is moved to the construction site with webbing strap handholds. The straps make it easy to maintain control of the steel, while permitting safe lifting technique. A 20-foot bar requires six to eight people to move.

Personnel need to be assigned the jobs of transport, measuring, cutting, and placement for welding. Welding may take place both at the cutting stand and at the gate, particularly if stiffeners are added to angle iron bars prior to assembly. Three to five persons can construct small gates, while large structures may require 15 - 18 people.

A large crew is required for large projects. This group built a gate 54 feet wide and 14 feet high in two-and-a-half days. The group is a combination of contractor, agency, and volunteer personnel.

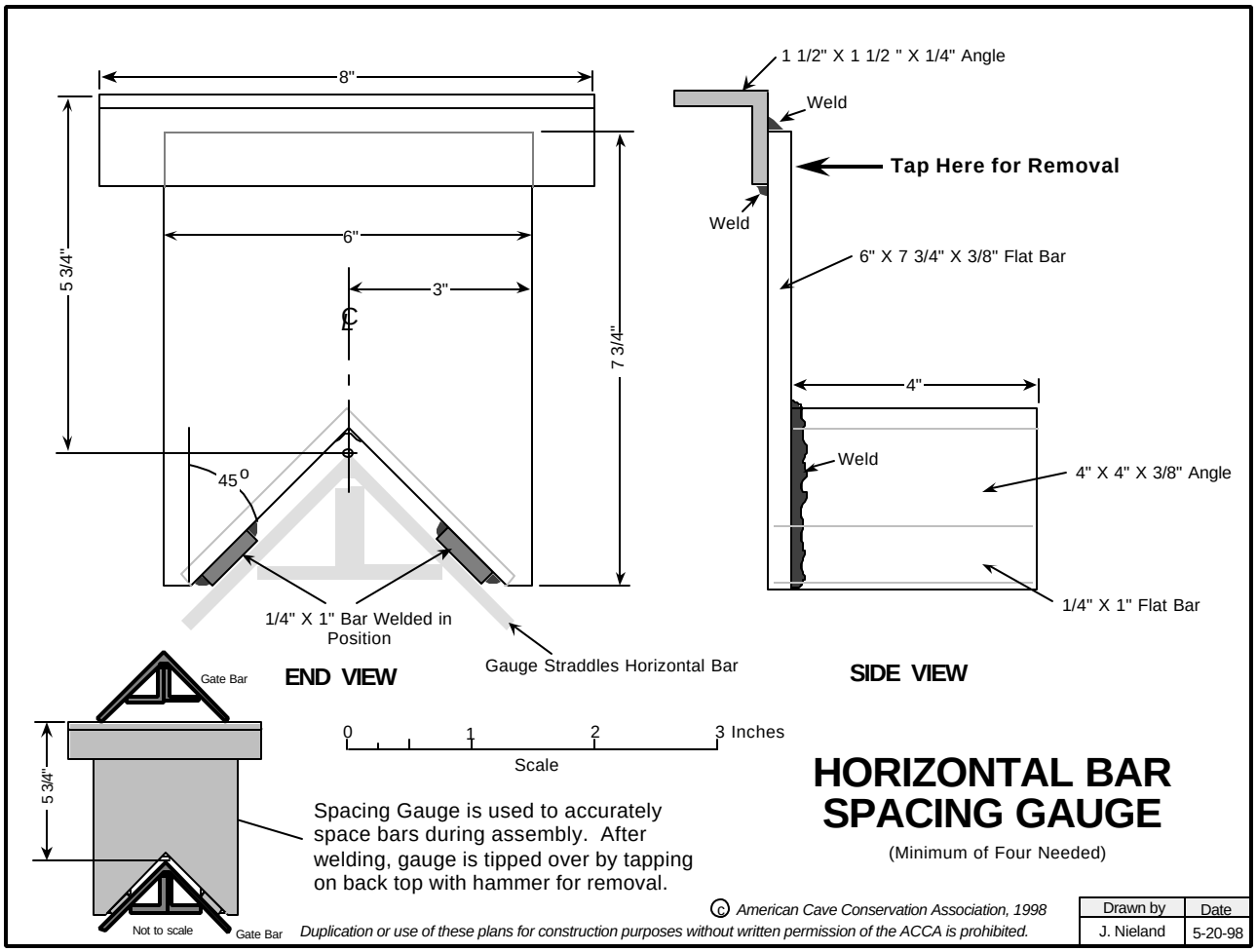
The construction coordinator needs to make sure all safety requirements are being followed, and to guard against injuries. The greatest hazards are usually lifting, poor footing, and being pinned by pieces of steel as they are moved. Personal protective

equipment should include approved hard hats, leather gloves, and wor k boots with traction soles.

Recommended Tool List

Below is a list of tools commonly used during a bat gating project.

- ❑ C-clamps (6 which open 6”, 2 which open 8”)
- ❑ Hammers (2) 3 lb. (1) 8 lb.
- ❑ Cutting torches (2, depending on size of project)
  - Strikers
  - Cutting goggles, or preferably face shields
  - Tip reamers
  - Rope to tie bottles in upright position, if trees are available.
  - Large adjustable wrench for hoses and regulators
  - Extra torch tips “0” or “1”
- ❑ Cutting gas bottles (2 acetylene 4 oxygen)
- ❑ Long hoses for torches (75’)
- ❑ Shovels (2)
- ❑ Short pry bar (1)
- ❑ Long rock bar for heavy prying (1)
- ❑ Scaling bar if loose hanging rock is present which needs to be removed (1)
- ❑ Extension cords, heavy duty, 12-3 stranded wire (two 100’ cords minimum)
- ❑ Soap Stone for marking metal.
- ❑ GFI breaker box to use with extension cords
- ❑ Halogen work lights on stands (2 minimum)
- ❑ Welding machines (2) 100-135 amp DC, or AC models with generators and extension cords
- ❑ 1/8” welding rod
- ❑ Welding hood
- ❑ Welding gloves (one pair for each person welding or cutting) (extra dry pairs if working in wet conditions)
- ❑ Chipping hammers for removing welding slag (2)
- ❑ Wire brushes for cleaning welds after chipping
- ❑ Long welding leads (100’ minimum, for each machine)
- ❑ Tape measures (4)
- ❑ Nylon string line (100’)
- ❑ Squares for marking steel (2)
- ❑ Soap stone for marking steel
- ❑ square for marking metal (2)
- ❑ One carpenters level, 24"
- ❑ Small magnetic levels (2)
- ❑ One small hydraulic jack
- ❑ Magnetic levels (2)
- ❑ 1” Nylon webbing carrying straps (8’ long tied in loop) (6-8)
- ❑ Pick (1)
- ❑ Gate bar spacing gauges (at least 6) *(See illustration)*
- ❑ Small hydraulic jack (1)
- ❑ Step ladder
- ❑ Staging planks for gates over 8 feet high (2 X 12 X 12’ long work well)
- ❑ Electric hand grinder for dressing for dressing sharp corners
- ❑ Electric rotary hammer/drill for pinning gate segments to cave or mine walls. Appropriate sized bits for drilling pin holes *(1/8 inch larger than pin size)*. If renting the rotary hammer, get the largest size available and <u>have at least two new bits.</u>
- ❑ C-clamps. At least six of which open 6" and two that open 8". More is better.
- ❑ Two shovels
- ❑ One Pick
- ❑ One long pry bar (sometimes called a rock bar).
- ❑ One eight-pound sledge hammer.
- ❑ One or two lightweight cable come-a-longs for pulling steel into position. Optional.
- ❑ Locks for the new gate
- ❑ McGuard button head bolts and nuts if installing removable bars



Bar spacing gauges are used to attain correct bar spacing during gate assembly. A total of six are usually used. (See photo below, left.)

Spacing gauges in use setting spacing of bar hangers.

Pre-cut bar hangers ready for instillation. Any parts that can be pre-manufactured will save time during gate construction.

Pre-Cutting Parts

Another way of speeding assembly is to pre-cut as many parts as possible. If special locking mechanisms are to be used, they can often be pre-fabricated, saving time during gate assembly. It is also highly recommended that all bar hangers (pieces of 6'x 6" x 3/8 angle) are pre-cut on a band saw to the length of 3 ½ inches. A favorite way to move and store these pieces is in 5 gallon plastic buckets that can be carried up to the gate and used as needed.

Seat ready to receive a removable bar. A nut is welded on the inside of the seat to accept the McGuard bolt. The removable bar sets over the seat where it is bolted in place as shown in the photo below.

McGuard button-head security bolts are often used when only occasional access to a mine or cave is required. They are simple and inexpensive to install, provide better security than padlocks, and are not affected by corrosion that can foul locks. The bolts are cone shaped and made of hardened steel which prevents breakage, or grasping with any tool except the special key-socket.

McGuard button head security bolt in place locking down a gate bar. The unique socket pattern matches the bolt head. Patterns are registered to the purchaser and are sold to no one except the registered owner.

Safety

Following safe working procedures is important to the effective construction of bat gates . Depending upon the location and environment in which the gate is to be constructed, a wide variation of safety concerns need to be addressed. Even under the best of circumstances, the possibility of injury accidents must be constantly guarded against.

At the onset of the project a "job hazard analysis" should be prepared. The analysis will itemize the different hazards found at the site, and expected during construction. Once the hazards are known, it is possible to develop procedures, or prescribe personal protective equipment to reduce the chance of injuries. When the construction crew arrives, a meeting should be held during which all the hazards are discussed, and the safety procedures to be followed.

Broadly hazards can be broken down into the following categories:

ENVIRONMENTAL HAZARDS

Site Stability is the first thing many people think about when working underground. Are there loose rocks, or is the ceiling going to collapse. Caves seldom have stability issues but mines frequently do. If there is any question of stability, a mining engineer or someone trained and familiar with assessing stability will be needed. Attempts to stabilize an area by barring down rocks, or other stabilization, should be done only under the supervision of an expert.

A clean working area is the next consideration. Work areas, and the path along which steel will be transported, must be free of loose objects and debris that could cause poor footing. Often material will have to be moved over or around large boulders, or other obstructions but good footing is a prerequisite. Water at the work site can also be a problem. In mine portals, it is common to find standing water where surface sloughing has created a dam. If a gate is to be constructed at or near the portal, the water should be pumped out or otherwise drained. Working in standing water is difficult and dangerous. Electrical lights will need to be set up to illuminate the work area. If there is water present, great care must be exercised to suspend the wires to avoid electrical shock.

Air quality in mines can be a problem, particularly through the accumulation of explosive gases or more commonly, reduced oxygen levels. Oxygen can be depleted through the oxidation of sulfide minerals or decomposition of woody materials. Carbon dioxide is heavier than air and accumulates in low areas, or behind barriers, such as debris piles, or descending tunnels. Air monitoring is mandatory for mine entry and must be conducted by a person who is certified to run the tests. Air quality can change over the course of a few hours or days depending upon atmospheric conditions and airflow in the mine.

Ventilation may be necessary to make sure the work area is safe, if any air quality problems are detected. Again, this is the work of experts, and will require continued monitoring during the project. Sometimes the air is good, but air movement is slight.

Welding produces a significant amount of smoke and fume, and while this is seldom health threatening, it can be annoying. In dry caves or mines, dust is often kicked up, requiring use of dust masks. Large electric fans are often employed to ventilate the work area. This low-tech approach is often very effective.

Weather can be a hindrance to construction, particularly if it is extreme. Cold weather can be guarded against by dressing appropriately. The most dangerous weather is when it is hot or during thunder storms. Hot weather dehydrates workers, causing a risk of heat stroke or heat exhaustion. This can be guarded against by pacing oneself and drinking liquids. Lightning is a special problem and can create dangerous conditions near mine or cave entrances. Cool humid air expelled from entrances has been reported to be an attraction for lightening. The gate under construction will conduct electricity. It takes little imagination to realize you don't want to be near the gate or the steel stockpile during an electrical storm! If a storm approaches, everyone should immediately leave the work site and wait inside vehicles until it passes. There are a number of publications (pamphlets) available providing recommendations for lightening avoidance that you may want to read. Most importantly, avoid high areas, caves, mines, lone trees, or waiting in a location where you are the highest object around. The metal exterior of a vehicle will conduct lightening around you to the ground, much like lightening protection systems ground building, providing a safe spot to wait out a storm.

Working in remote locations can present special safety issues. A worker injured in a remote location will be much more difficult to treat than if emergency medical treatment is readily available. Make sure you have a well stocked first-aid kit and persons trained to deal with emergency situations. Good communication is another factor to consider. If you are out of radio or cell phone contact, a satellite phone can be used if emergency assistance must be summoned.

CONSTRUCTION HAZARDS

Moving steel is dangerous if not done properly. Having secure footing was previously mentioned as a safety concern. Next, proper lifting technique must be used. Remember to always lift with legs and keep your back straight. Picking up pieces of steel by hand and trying to carry them around is dangerous and should be avoided. The best way to move a steel bar is with nylon webbing straps. A steel method has evolved using eight-foot length of one-inch tubular nylon webbing. The webbing is tied in a continuous loop that can then be wrapped around the steel to produce two handholds. One person stands on either side of the steel to be moved, reaches down with opposite hands, and grasps their lifting loop. This centers the steel between the two persons. The loop lengths can be adjusted to accommodate peoples respective heights, allowing easy lifting. A 20-foot length of four-inch angle iron weighs 196 pounds, if stiffeners are added, the weight rises to 290 pounds. A single length of six-inch angle weighs 298 pounds. The four-inch angle will require a minimum of six people to move, so on average no one lifts over 32 pounds. The heavier objects will require eight to ten persons to move.

When moving steel, the greatest hazard is being pinched, or pinned, between the steel and an immovable object such as a rock, tree, gate, or tunnel wall. All steel moving should be done slowly with control maintained at all times. One person needs to act as a "foreman" giving instructions to the other workers. This person should make sure all lifting straps are properly placed, coordinate lifting and movement of the steel. If anyone looses their footing or is about to be pinned, they should immediately yell "stop" with steel movement not resumed until they are able to regain footing or reposition themselves. The following are common commands from a foreman:

Ready..... Everyone responds "ready"(used anytime a change is to occur)
Lift..... Crew lifts slowly, using their legs, backs straight
Forward ..... Steel is moved slowly forward, kept within 12 inches of the ground
Stop ..... Crew stops motion (can be called by anyone, anytime)
Lower ..... Steel is set down

The work area will need to be well lighted and the best way is to use halogen work lights. These provide high quality illumination and can be purchased in single units, or mounted on stands. Both work well, but will require generators and extension cords to operate. Other electrical needs include power for operating grinders, rotary hammer -drills, and the welders. All electrical cords should be routed out of the way and placed where the y will not be damaged. If the area is wet, they should be suspended to prevent accidental shorting. All AC electrical lines should be protected using ground fault current interrupter (GFCI) breakers. These special breakers detect even small amounts of shorting and will instantly disconnect the circuit, preventing electrical shocks to the workers. These can be plugged into the current source, then the electrical cords plugged into them. All electrical cords should be a minimum of 12 -gauge, three-conductor wire with ground. Lighter gauge extension cords have no place on the construction site and should never be used.

The DC welding leads must be protected from damage and kept out of water, but do not present the same shock hazard as the AC circuits. Of more importance is making sure persons doing the welding always have dry gloves. Dry gloves provide electrical shock protection and should always be worn. The welders will not have to be reminded to wear dry gloves!

Generators should be set up away from the mine portal or cave entrance, preferably 50 -75 feet away. These machines make a lot of noise and produce carbon monoxide. Heavy extension cords guard against voltage loss, allowing the equipment to be somewhat remote from the site. DC welding l eads have been successfully run over 200 feet from the generator to the work site. Welding shops can help you select leads of a sufficient gauge to prevent voltage drop due to line loss. The benefit of having a quiet construction area cannot be over emphasized.

Cutting and welding operations require different safety precautions. Everyone should wear leather gloves and those using the equipment will want heavy, insulated, welders gloves. As previously mentioned, extra pairs should be available. Anyone cutting, or

grinding metal, or working near a person doing so, should wear safety glasses or face shields. Metal shards can easily become embedded in an eye, causing great pain, or even blindness. Full-face cutting shields with tinted lenses are suitable for both cutting and grinding and provide much more protection than goggles. They also tend not to fog up like safety glasses, making them more likely to be worn.

Welding requires special eye protection and dark lenses. Welding hoods come in a number of lens configurations, all of which work. Most welders find hoods with large lenses are easier to use since they provide a wider field of vision. Magnifying lenses can be placed in the hoods to compensate for the need to wear eyeglasses. Anyone working near the welding operation needs to guard against looking directly at the welding arc. The arc is exceptionally bright and produced large amounts of UV radiation. This radiation will cause eye damage. Before striking an arc, the welder should warn others they are about to start welding, so they have time to look away. Reflected light from the welding is usually not a problem if you are working on a segment of the gate some distance away. If you have been repeatedly "flashed" the symptoms will be the same as having your eyes "sunburned," they will be red and you will feel a gritty sensation and discomfort. By the next morning, the symptoms will usually have passed, but repeated exposures can cause lasting eye damage.

Field Cutting of Steel

Oxy-acetylene torches are used for field cutting of steel. Torches are portable, easily used, and can provide years of safe trouble free service if properly maintained and operated. Proper use can speed an operation by providing cleanly cut metal ready for assembly and welding.

A number of inherent hazards exist in the use of oxy-acetylene cutting torches. It is important that proper safety and operating procedures be understood before attempting to operate the equipment. A thorough understanding of use and safe procedures will add efficiency to your work.

Fire Safety

The work area must be fireproof. Fire safety while underground is not normally a problem, but must be considered if combustible materials are present. Mine shoring or packrat middens can be problems. If dry combustibles are present, but can't be moved, the area should be hosed down thoroughly before any cutting or welding takes place. On the surface, leaves, grass, and other organic debris should be removed from the area where cutting operations are to take place, particularly during dry weather. During cutting operations fire can be caused by direct contact of the torch flame with combustibles or by thrown globules of molten metal or sparks. During dry conditions, have water handy, and/or spray down the work area before the operation and afterwards. Special care should be taken to prevent fire.

The presence of pure oxygen serves to accelerate combustion and causes materials to burn with great intensity. Oil and grease in the presence of oxygen can ignite and burn violently.

Take special precaution to make sure clothing and cutting equipment is grease and oil free. Never use grease or oil to lubricate a torch.

These simple precautions can prevent most fires and minimize the risk of injury:

1. Inspect apparatus for oil, grease or damaged parts. Do not use if grease is present or if damage is evident.

2. Never use oil or grease around any oxy-acetylene apparatus. Even a trace of oil or grease can ignite and burn in the presence of oxygen .

3. Keep flames, heat, and sparks away from cylinders and hoses. Flying sparks can travel as much as 35 feet.

4. Use oxy-fuel equipment only with the gases for which it is intended.

5. Do not open an acetylene cylinder valve more than 3/4 of a turn, so the valve can be turned off quickly if necessary.

6. Never test for gas leaks with a flame. Use an approved leak-detector solution.

7. Upon completion of work, inspect the area for smoldering material or fires.

8. When not in use, or at the end of the day, close the valves on the acetylene and oxygen cylinders. Bleed gases out of hoses following procedure outlined in "Cutting Safety," below.

OXYGEN

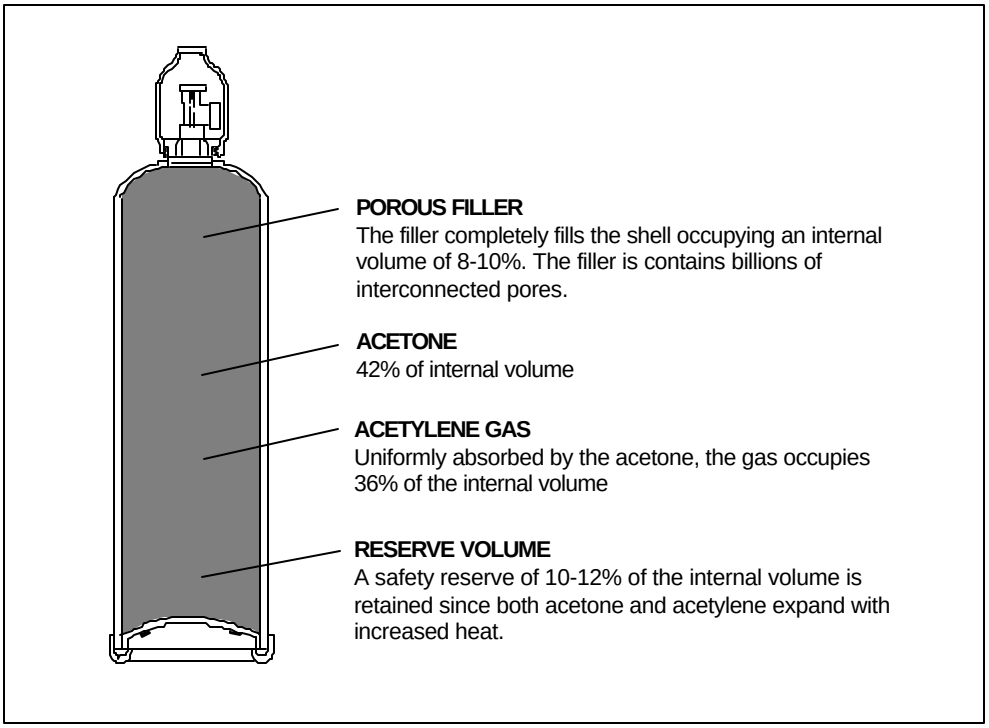
Oxygen is ordinarily supplied in 244 cubic foot cylinders. Smaller and larger sizes are available. Full oxygen cylinders are normally pressurized to over 2000 pounds per square inch. The content of the oxygen cylinder can be determined by reading the high pressure gauge on the regulator. A pressure reading of 1000 pounds, for example, would indicate that half the cubic feet of gas is remaining. Due to the high pressure with which oxygen is bottled, cylinders must always be handled with care. Cylinders should never be moved without their metal caps in place, and should always be placed in a secure position when in use. Oxygen should never be used as a substitute for compressed air, such as for dusting off clothing. Oxygen saturated clothing will burn explosively. The violent reaction of oil, grease, or other contaminants in the presence of oxygen cannot b e overstated.

ACETYLENE

Acetylene is a compound of carbon and hydrogen used for cutting ferrous metals, and in a variety of other welding and heat -treating operations. Acetylene is produced by the hydration of calcium carbide, or from petrochemical proce sses. Acetylene is compressed and stored under pressure in cylinders for transport. Acetylene becomes unstable when compressed in its gaseous state above 15 PSIG. Therefore, it cannot be stored in a hollow cylinder under high pressure the way oxygen is sto red. Acetylene cylinders are filled with a porous material creating, in effect, a solid as opposed to a hollow cylinder. To fill an acetylene cylinder, the

porous filling is first saturated with liquid acetone. When acetylene is pumped into the cylinder, it is absorbed by the liquid acetone, and is held in a stable state. A full acetylene cylinder is pressurized to 300 PSIG. By checking the pressure valve attached to the regulator, you will be able to tell how much gas is still in the cylinder.

Acetylene cylinders must be treated with great care, and maintained in an upright position during use. If a cylinder is transported on its side, the acetylene may separate from the acetone stabilizer. This is particularly true of partially full cylinders. If separation takes place, a potentially explosive situation may develop if gas is drawn from the cylinder before it again stabilizes. Most experts agree that a partially filled cylinder should be placed in an upright position 24 hours before it is used. If full cylinders must be transported on their side, it is important they be placed in an upright position as soon as they reach the work site.



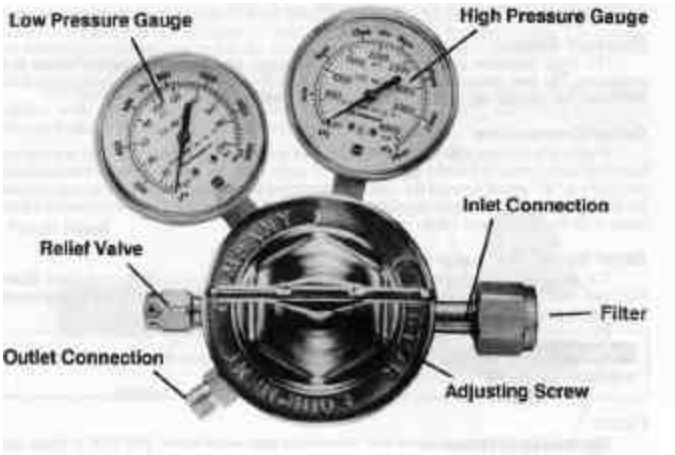
Acetylene is stored under relatively low pressure in cylinders containing a porous filler. Tanks should always be kept upright to prevent separation of acetylene gas from its acetone stabilizer. If transported on their side, it will take up to 24 hours for the contents to restabilize after the cylinder is returned to an upright position.

Once on site, the gas bottles should be placed in a convenient position near the cutting station, but out of the way of work. Because the cylinders are filled with high-pressure gas, it is imperative they be secure when the protective caps are removed. This means securely tying them to a tree or wedging them tightly between rocks. If a bottle were to topple and a valve break off, the cylinder would take off like an out of control rocket, crushing everything in its path.

Acetylene (left) and oxygen (right) cylinders in use during a gating project. Note that the cylinders are firmly wedged and held by stacked stones so they can't fall over.

REGULATORS

Oxygen and fuel pressure regulators are attached to the cylinders to reduce high cylinder pressure to suitable low working pressures.



Pressure regulators reduce the supply pressure, indicated by the high pressure gauge to suitable working pressure, indicated by the low pressure gauge. By turning the adjusting screw, proper working pressures can be achieved.

Regulators are connected to cylinders by their inlet connections. Special connections are provided for oxygen and different types of fuel. Generally, fuel connections have left - hand threads for acetylene while oxygen connect ions have right - hand threads. This makes it virtually impossible to accidentally connect an apparatus to the wrong cylinder.

The regulators contain a pressure adjusting screw, usually a tee - handle in center of the regulator. When the screw is turned clo ckwise, the regulator allows gases to flow through the regulator to the hoses and the torch.

Pressure gauges indicate the cylinder supply pressure entering the regulator. The low pressure gauge indicates the delivery pressure from the regulator to the h ose.

Regulators and gauges are fragile and must be treated with care to prevent damage. When transporting regulators they should be removed from their hoses and placed in a clean padded container. The T-handle should be screwed outward, releasing tensi on from the diaphragm.

HOSES

Hoses intended for oxy-acetylene torches are color-coded for gas identification. Oxygen hoses are green and fuel hoses are red. The hose walls are constructed of continuous layers of rubber or neoprene material over a bra ided inner section. Most hoses are flame retardant, they will burn, but will not support a flame if the heat source is removed. As with the regulators and gas cylinders, left and right -hand thread combinations prevent connection to improper cylinders or torch valves.

Hoses are often exposed to abuse when molten slag and sparks come into contact with the hose exterior. Falling metal can crush or cut into hoses, causing damage. The torch operator should take care to protect hoses from unnecessary abrasio n or damage by keeping them away from falling metal, sparks, or slag.

If cuts, burns, or worn areas are noticed on hoses they should be replaced. Over time, hoses may become cracked or coated with oil, grease, or dirt. This can conceal damaged areas, requiring frequent inspection. Hoses are relatively inexpensive and should be replaced if their integrity is in question.

During transport or storage, hose ends should be either screwed together or taped over to keep out dirt particles. Dirt passing into the torch can cause permanent damage to the apparatus.

Cutting Safety

If you experience a backfire or flashback (flame disappears and/or a shrill hissing sound when the flame is burning inside the cutting attachment), turn off the preheat oxygen control valve on the cutting attachment. Then turn off the oxygen control valve on the handle. Next turn off the torch handle fuel valve. Allow the cutting attachment to cool before attempting to re-light. If backfire and flashback occurs, have the apparatus checked by a repair technician before using again.

Following use of the torch, the fuel and oxygen lines should be drained of gases. First close the valves on the tanks, then open the oxygen valve on the torch handle 1/2 a turn. Close the oxygen valve, then repeat with the fuel valve in a similar manner. Allow about ten seconds for each 25 feet of hose.

While engaged in cutting operations, wear protective clothing and use goggles to shield the eyes from flame brilliance and spattering slag and metal. Make sure your clothing has no frayed spots that could be ignited by sparks. Leather boots should be high and well covered by pants legs to prevent slag from entering boot tops. Synthetic material used in boots such as nylon or Gortex should be avoided s ince hot metal will quickly melt through these fabrics causing damage to the boots and potential injury. Hands should be protected by wearing leather gloves.

Cutting Efficiency

Cutting steel with a torch takes practice and is best learned from someone experienced in its use. It is not difficult to do, but practice is required. From a cost and efficiency standpoint,

Tip Flow Chart

Metal Thickness	Tip Size	Cutting Oxygen		Pre-heat Oxygen PSIG	Acetylene		Speed IPM	Kerf Width
		Pressure PSIG	Flow SCFH		Pressure PSIG	Flow SCFH		
1/8"	000	20-25	20-25	3-5	3-5	6-11	20-30	.04
1/4"	00	20-25	30-35	3-5	3-5	6-11	20-28	.05
3/8"	0	25-30	55-60	3-5	3-5	6-11	18-26	.06
1/2"	0	30-35	60-65	3-6	3-5	9-16	16-22	.06
3/4"	1	30-35	80-85	4-7	3-5	8-13	15-20	.07
1"	2	35-40	140-160	4-8	3-6	10-18	13-18	.09
2"	3	40-45	210-240	5-10	4-8	14-24	10-12	.11
3"	4	40-50	280-320	5-10	5-11	18-28	10-12	.12
4"	5	45-55	390-450	6-12	6-13	22-30	6-9	.15
6"	6	45-55	500-600	6-15	8-14	25-35	4-7	.15
10"	7	45-55	700-850	6-20	10-15	25-35	3-5	.34
12"	8	45-55	900-1050	7-25	10-15	25-35	3-4	.41

selecting the right size cutting tip is important. Using too small a tip will make cutting difficult while too large a tip will use an unnecessary amount of gas. In the chart below compare the tip size with the thickness of metal to be cut. In bat gate construction, a No. 1 tip will suffice for nearly all cutting. Many experienced builders will use a No.0 tip that allows more precise cutting while saving gas. The chart also shows the optimum gas pressures to be used for cutting with different tip sizes. Pay close attention to the gas pressure since it is here that most cutting problems originate. The last t hing to remember is to turn off the torch when it is not in use. Frequently, persons new to cutting are seen standing around with a torch lit for long periods of time, wasting gas. Conservation of cutting gases not only reduces the cost of the project, i t may prevent a lengthy delay if they run out.

> ***Rule of Thumb:*** *Two oxygen cylinders will be used for every acetylene cylinder. Be sure to have twice as much oxygen on hand as acetylene.*

Cost Estimating

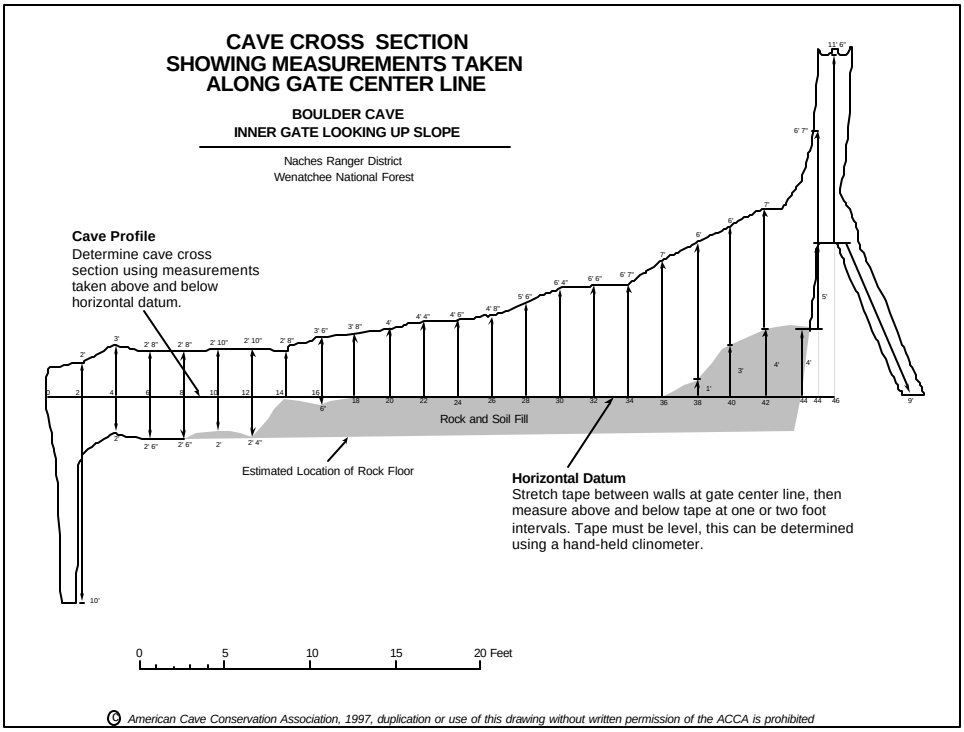
Estimating the cost of a bat gate project can be challenging. One of the first decisions is to decide who will be doing the actual construction. Then you will also need to know the material cost. Other factors come into play such as the site location and if there are unusual access or materials handling requirements.

The largest variable will be labor. Often volunteers have been used to assist in gate construction. Organizations such as the American Cave Conservation Association, Bat Conservation International, the National Speleological Society, The Nature Conservancy, and local wildlife and historical interest groups, have provided volunteers, donated money, food, and equipment. One should never underestimate what volunteers can accomplish. Volunteers often come with special skills and enthusiasm which is difficult to find anywhere else and will happily do jobs paid workers are reluctant to do.

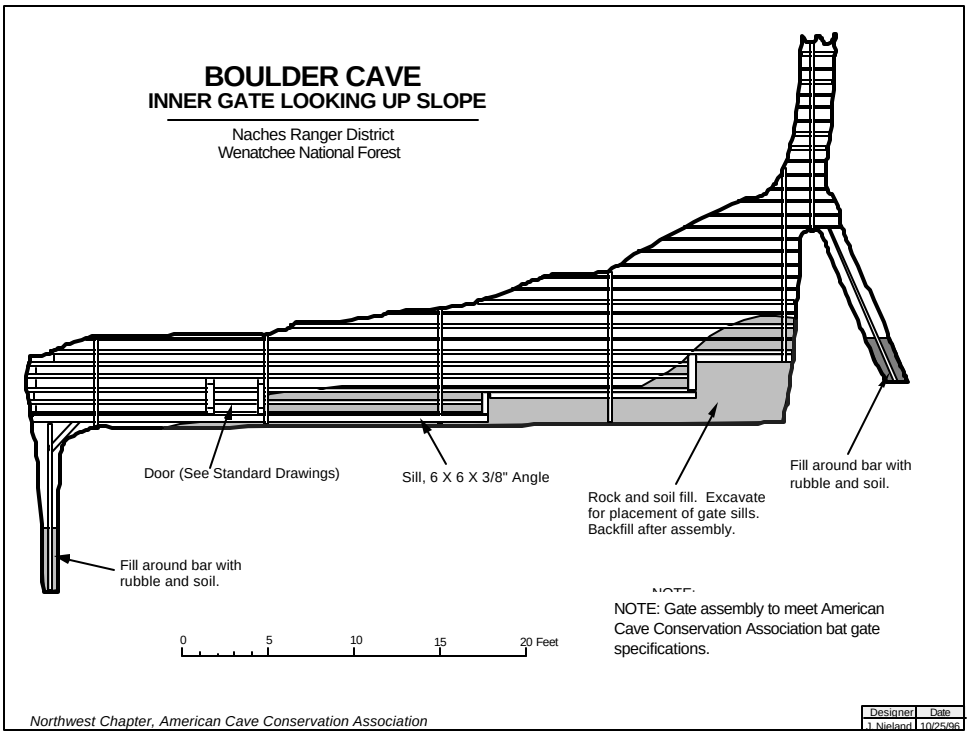
In some instances, volunteers may not be available or appropriate, particularly if unusual hazards exist or special skills are needed. In these cases, contracting, or force account work will be required.

When contracting is needed, one should expect cost to increase. Contracts require a higher level of engineering work to be performed and specifications developed for the contract. Costs for contract preparation, advertising, award, and administration must be added. The contractor does the work because it is their business, so additional expenses must be covered such as profit, risk, bonding, and any elevated labor costs. Federal contracts require Davis-Bacon wage rates to be paid that commonly increase labor cost.

Estimating material cost is usually fairly easy and starts when a gate site has been selected in the mine or cave. The first job is to measure the cross section of the passage, then design a gate to fit. Mines are usually easier since gates on portals usually close tunnels with simple cross sections. Below are two illustrations showing how a passage is measured for a cave gate.



Boulder Cave Washington, field measurements taken to determine cross-sectional profile.



Finished gate drawing ready for construction. Material quantities can be estimated from the drawing.

Once the profile has been drawn, it is possible to design and draw the components of the gate to fill the cross section. Once this has been completed, one can count and measure the pieces of steel needed for construction. When the exact quantity has been

determined, be sure to add 15% more material to your list. This is usually the amount extra you will need for unexpec ted occurrences.

In the Boulder Cave example above, the cross section is measured as in the first drawing above, then the cross section is converted to square feet of area. This can be used in estimating the total weight of steel needed to close the open ing and multiplied times the average price of steel per pound. Steel is normally sold at a per -pound cost, so this works fairly well, but is not as accurate as measuring and counting for each piece needed.

In the illustration below, the components of a " typical" angle iron gate to fill a 10 -foot square opening have been calculated. Pay close attention to the material sizes in the left column and the weight per lineal foot in the third column. You will find these of value when determining how much gate components weigh, as well as determining price.

Material Cost, 10' x 10' Angle Iron Gate, 2 vertical supports

Materials Needed

Sizes	**Pieces**	**Weight/ft**	**Lineal ft**	**Total Weight**	**Cost/lb** *Price varies*	**Cost**
4x4x3/8 angle	15	9.8	150	1470	$0.38	$558.60
6x6x3/8 angle	1	14.9	17	253.3	$0.50	$126.65
1 1/2x1 1/2x1/4 angle	28	2.34	140	327.6	$0.40	$131.04
1/4x4 flat bar	1	3.4	20	68	$0.42	$28.56
3/8x6 flat bar	1	7.65	10	76.5	$0.42	$32.13
1" round bar	1	2.67	10	26.7	$0.42	$11.21
			Total Weight/lbs	**2222.1**	**Total Cost**	**$888.19**

Steel weight per sq/ft of gate face in lbs.	**22.22**
Average material cost per sq/ft of gate face	**$8.88**

NOTE: Steel prices vary widely, depending on, location, and quantity purchased. The prices used above were obtained in Portland, Oregon in February 2002. They represent high-end prices without discounts.

The above figures are calculated for a 10-foot high, 10-foot wide gate segment, with a 6-inch angle sill and two vertical supports. To approximate the material cost for your own gate, multiply the cost per square foot, shown above, times the square footage of the opening you plan to close. To adapt the chart to your local purposes, obtain local steel prices and adjust the costs in the "Cost/lb" column.

In the calculations above, the average cost/lb of steel is $.40. The weight of steel per square foot of gate face is 22.22 lbs. while the square feet of a 10 X 10 gate is 100 square feet. From these calculations, it is easy to estimate material cost by using the formula: *Square Feet x 22.22 x Cost/lb of steel = Material cost (100 x 22.22 x $.40 = $888.).*

Below is a spreadsheet showing the costs that might be expected for the construction of the simple gate priced above, if built under contract. Cost of construction will vary

widely depending upon the labor source. Noted are many of the extra costs that add to total contract construction cost. You should especially notice that the cost of materials makes up only 18% of the project cost. If you are wor king on a limited budget, you will want to pay special attention to other areas for cost reduction.

Most projects utilize a combination of volunteer, force account, and contract work. A recent large project in Central Oregon was the gating of Stooky Ranch Cave. The project was a partnership between the BLM, USFS, Bat Conservation International, the American Cave Conservation Association, The Nature Conservancy of Oregon, members of the National Speleological Society, and the corporate landowner. Grant mo ney was provided by BCI, logistical and planning assistance from the Federal agencies, volunteer help from the ACCA and NSS, and a local steel fabricator hired to provide equipment and welding services. The construction site was remote, requiring voluntee rs and paid personnel to camp in the desert for three days. Some of the volunteers traveled over 200 miles to participate in the project.

Cost Estimate, 4" Angle Iron Bat Gate 10' X 10'

Steel (material cost)	Weight sq/ft	Cost/lb	Sq/ft of gate	**Cost**
	22.22	$0.40	100	$888.80
Transportation				$200.00
Labor	People	Hourly Rate	Total hours	
Welder	1	$30.00	12	$360.00
Helpers	2	$14.00	24	$336.00
Tools				$30.00
Welding Supplies				$35.00
Equipment Rental				$100.00
Motel / Food (one night stay, meals for two days)				$370.00
Contingency Cost (unforeseen needs)		Add 20%		$463.96
Contract (profit, risk, move in, move out, bonding, insurance)		Add 40%		$1,113.50
Contract preparation, Admin, Overhead, etc.		Add 25%		$974.32
			Total Cost	**$4,871.58**

Volunteer Construction Cost:	**$20.78**	**Per Square Foot**
Force Account Construction Cost:	**$27.84**	**Per Square Foot**
Contract Construction Cost:	**$48.72**	**Per Square Foot**

To the left is a rough comparison between force account, contract, and volunteer construction cost.

The project was well organized and successful, with construction completed in just 2 ½ days. Efficient project completion was possible due to the number of cooperators and the skill of the voluntee rs. A large number of volunteers had gained experience during previous bat gating projects. This knowledge and skill was invaluable during the project since they knew exactly what to do ahead of time and could immediately apply their skills when needed. They were also of great help in training other volunteers. The concept of developing a skill-base in local volunteers and workers is quite valuable and, over time, will add efficiency and lower construction costs.

Arc Welding

Bat gates are assembled thr ough arc welding. The best way to learn welding is to take a beginners course at a community collage or trade school, then to practice endlessly. In most libraries, you can find books describing beginning welding practices. The *Welders Handbook*, by Richa rd Finch, The Berkley Publishing Group, NY, 1997 is particularly popular and well suited to the beginner.

Welding of gates is most often done in the field with portable DC (direct current) arc welders. The most frequently used welders weigh under 150 pou nds and consist of a gasoline engine geared to a generator. Most welding is done within the range of 100 -135 amps, just within the range of small portable welders. Larger welders operate more efficiently but their greater weight (300 -400 lbs.) limits the ir use to sites with easy access.

AC welders, sometimes called "buzz boxes," are quite versatile and have the advantage of light weight. These small welders can be set up underground several hundred feet from the generators. AC welders require a power source, typically a 3000 watt AC generator. Heavy extension cords are used to carry 220V AC current from the generator to the welder. The high voltage cords must be treated with care since the shock potential is much greater than with straight DC welder s.

All welding machines are rated with a duty cycle, the percentage of time the arc welder can be used before it must rest. A machine rated with a duty cycle of 60% can be operated for six out of every 10 minutes. Exceeding the duty cycle can cause stre ss to the generator through over heating that will in turn decrease its rated output. This, at first, may seem like a hindrance, but it is seldom that a welder can carry an arc for more than a few minutes because of the necessity of moving to a more comfo rtable position, inserting a new welding rod into the holder, shifting to the next weld, or to take a rest.

Arc welding is accomplished by attaching the grounding lead from the welder to the metal to be welded, then placing an electrode (welding rod) in t he electrode holder attached to the end of the second lead. When the electrode is brought into contact with the grounded metal, an electrical circuit is closed with electricity passing through the electrode then back to the welding machine through the gro und lead. As the electrode is raised slightly from the metal surface, an arc is created. The arc both heats the grounded base metal and also begins to melt the filler metal in the center of the electrode. The filler metal is sprayed into the weld, addin g material to help fill gaps and bond the base metal pieces together.

An electrode consists of a center core of high strength metal covered with a flux coating. When an arc is struck, the flux is gradually burned away creating a gas shield within the arc and glassy solidified flux on the weld. This shield prevents contamination of the molten metal puddle by atmospheric gases which could weaken the weld. This solidified "slag" can be chipped away, exposing the weld beneath.

Welding Safety

Before you start to weld, you must be wearing appropriate protective equipment. The greatest hazard is from ultraviolet light (radiation) burns to the eyes and the skin. These burns are similar to sunburn except deeper and more serious due to its great intensity. Burns can be prevented by simply shielding the skin and eyes from the arc. Always wear long sleeved shirts and pants. The fabric should be natural fiber, avoid synthetics which will melt when hit by molten metal. The hands are protected with long, insulat ed, leather welding gloves. When welding, be sure to button the top button on you shirt to block spattering metal and to avoid UV burns to the neck and throat.

On your feet, you will want to wear high -topped leather boots. Your pants should not have a cuff and extend down over your boot tops to prevent hot metal or slag from finding its way inside. Never wear nylon tennis shoes when welding. Hot metal will melt its was straight through to your foot!

A welding helmet is used to protect the head and eye s from the arc. The hood is fitted with a window containing a colored lens in the front. The lenses can be purchased in various shades, with #10-#12 being best for most work. When working underground, the lighter #10 shade is most easy to use. Undergro und it is convenient to have a helmet with a large lens to maximize vision and help accommodate the inevitable condensation that collects on the inside. Keeping a clean handkerchief or other lens cleaner handy is a great help. Select a helmet light in we ight since you will be using it for long periods and lighter ones cause less fatigue.

When working around other people, be sure to warn them before you strike an arc, so they can turn away. The arc burns at approximately 10,000 degrees Farenheight and is roughly equivalent to looking directly at the sun. Severe eye burns or even loss of eyesight can result if an arc is watched for prolonged periods. The closer people are to the arc, the more serious the potential burns. Sunglasses provide inadequate pr otection for the light intensity of arc welding.

You will find that most portable welders have AC outlets to plug in extension cords to power grinders, drills, and electric lights. This is a big advantage since separate generators for this propose are no t needed.

Welding Rod

Selecting correct welding rod is very important to achieving satisfactory welds. For cave gates you will want to use 1/8 inch diameter electrode. The following rods are commonly used with good results:

E-6011--Easy to use, will b urn through dirt and rust, but generates a large amount of spatter which sticks to the base metal, near the weld, as little globules of metal. Some welders like this rod, so it is included in the list.

E-6013--Easy to use, metal must be cleaner than when using E-6011. This is often referred to as "farmers rod" due to its versatility and ability to burn through rust. E-6013 is the best overall rod to use for bat gate construction, particularly if wet conditions are expected.

E-7018--Produces strong, high quality, attractive welds, but is more difficult to use than E-6013. The base metal must be reasonably clean and dry. This rod works best on new steel. The rod is susceptible to moisture damage so must be kept dry and clean. Welding is enhanced by reversing the normal polarity of the welding leads so that the ground is negative. In dry settings, this is the rod of choice, and is a favorite of many steel fabricators.

All electrodes are stamped with a number. Lets look at **E-7018** rod as an example. The letter "E" means it is an electrode. The first two digits "70" indicate the tensile strength of the filler metal (70,000 PSI). The next digit is the position the rod can be used in "1" means all-position rod (2=flat position only). The last digit means the rod can be used with both AC and DC welders. Most rod can be used with DC welders, but there are limitations on AC welding.

Welding rod must be stored in a warm dry environment. Even small amounts of moisture can damage or destroy welding rod, including high humidity. The rod should be kept in sealed waterproof containers until used. New rod commonly comes sealed in 50 lb metal cans or in 5 lb packages wrapped and sealed in plastic. Once opened moisture can begin to penetrate the flux causing deterioration of the rod. For field use, plastic screw-top containers are a sensible way to transport and store rod. Only small quantities of rod are removed from their storage container at one time.

Working in caves and mines is a challenge for keeping welding rod clean and dry. Most welders like to use a leather rod-pouch attached to their waist to hold working-quantities of rod. These small pouches keep the rod from becoming dirty or damaged through rough handling.

Most DC welding is done with reverse polarity, with the electrode positive, allowing the electrode to becomes hotter than the base metal. This works particularly well when using E-6011 and E-6013 rod. When welding with E-7018 rod, reverse polarity (electrode negative) provides a steadier arc and allows smoother transfer of filler metal from the electrode to the work piece. As an experiment, try reversing the polarity and observe the difference in behavior.

Welding Technique

Your first step is to prepare the various cut pieces of steel for welding. These should be held in place with clamps so they won't shift out of alignment. Next attached the grounding clamp, from the ground lead, to the piece to be welded and insert a welding rod in the electrode holder. Be sure you are wearing gloves, long sleeved shirt or

coveralls, and high toped boots. Put on the welding helmet and make sure it fits properly, making any adjustments necessary for a snug fit. You are now ready to start welding.

The welding machine should be set at 100 - 130 amps. When using 1/8 inch welding rod, this is considered a "hot" setting, but it will make it easier to strike and maintain an arc while learning to weld. As you gain confidence, reduce the amperage and practice using an arch that is cooler. This will be very imp ortant later when you start making vertical welds.

The electrode (welding rod) should placed in the holder at 90 degrees to the handle. Other positions are possible but are usually only used for awkward welding. Hold the electrode about one - inch from the joint to be welded, then nod your head forward allowing the welding hood to drop into working position. Next, drag or scratch the rod across the metal at the joint allowing electricity to jump between the steel and welding rod creating an arc. As soon as an arc develops, the welding rod should be held close to the base metal, about 1/8 to 1/4 inch away, to maintain an arc.

Two welders are kept busy at all times during the assembly of a large bat gate.

It is normal, particularly while learning, to hav e the rod stick itself to the base metal. If this happens, quickly move the rod holder from side to side to break it off. If it doesn't detach within a few seconds, squeeze the handle on the rod holder releasing the rod. The rod will quickly become very hot if it isn't broken free, so use caution if grasping it with gloved hands.

With a little practice, you will learn to strike and maintain an arc. Next, you need to learn to run a bead. Butt welds, where two pieces of metal are butted together side by side, are the easiest place to learn. With the pieces placed in a horizontal position, start at one end

by striking an arc along the seam. Hold the rod in position momentarily then slowly move the arc back and forth across the joint in a figure -eight or circular pattern, or my favorite, a "U" shape. Move the rod no more than 1/8 inch past the seam on either side. You will notice two things taking place. First the arc will melt the base metal on either side of the seam as you move the rod back and fourt h. Secondly, as the rod arcs, the steel core melts, creating a small puddle of molten metal over the seam. Pay close attention to this small puddle, since it is the beginning of the metal bead that will form the weld. Holding the welding rod at about a 4 5 degree angle, slowly weave back and fourth across the seam, alternately melting one side then the other. Filler metal from the welding rod is added to the growing puddle that will elongate to form the weld as you advance. Try to maintain a uniform pudd le by advancing at a slow deliberate speed. It is much better to go too slowly, adding too much metal, than not enough.

Bar hangers being welded in place. The string line is used to check alignment of vertical support columns before the gate bars are attached. Vertical welds along the face of the hangers are the most difficult to make, requiring practice to perfect. Unwelded hangers can be seen clamped in place at the far side.

By holding the welding rod at a 45 degree angle away fr om the puddle, you will force metal to pile up and be added to the growing puddle. With a little practice you will be able to maintain the arc and produce more and more uniform beads. Your weld should advance at about 3 inches per minute. If you move mu ch faster, you will be depositing inadequate filler metal in the weld. Slower, and you will be placing excessive metal in the weld. With practice, you will develop a sense for the correct speed and appreciate a good looking bead.

As gate height increases, temporary scaffolding is used to provide a working platform. Note how the planks are clamped together to assure they won't move. Double planks provide extra strength.

Each weld will have three components, the base metal being welded, th e melted filler rod, and a layer of slag (melted flux from the welding rod). If for any reason you must stop welding, such as to place another rod in the holder, allow the weld to cool then use a chipping hammer to remove slag. Following chipping, use a wire brush to remove any remaining impurities. If any slag is left on the weld it will cause an inclusion resulting in a weak spot. After cleaning, you can resume welding.

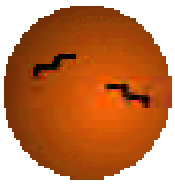
When welding two pieces together at right angles, the tendency is to overheat the piece being attached and under heat the base piece beneath. By directing the arc for a longer time on the base piece, it will be heated the most. Then, touch the arc to the piece being attached just long enough to cause it to melt. If the arc is held t oo long to the piece being attached, it will melt out or create an undercut just above the weld. This will weaken the weld and should be avoided.

When moving the rod along the joint, don't move too fast. Make sure the metal is being melted about half wa y through to the other side. When the other side of the joint is welded, there should be solid metal from one side to the other. This deep melting is referred to as "penetration." You want to make sure your welds penetrate the joint deeply for the most strength possible.

Once you have mastered welding horizontally, it will be time to work on vertical welds. To do this it is important to reduce the amperage of the welder so less heat is applied to the base metal. Reduce the amperage until you can just maintain an arc without sticking the rod. You will start your weld at the bottom and work vertically upward. Hold the rod so it is pointed upward at about a 30 -degree angle. This will cause the arc to push the filler metal into the weld and help hold it in position. The idea is to bridge between the two pieces of base metal with a bead, then stack up filler metal in layers as you go. As with horizontal welding, it is important to maintain a constant speed and stroke with the welding rod. You will want to move the weld along fast enough so metal doesn't run out

of the weld but slow enough to make sure a good bead is produced. Focus on the metal puddle and don't be distracted by flux running and dripping from the weld. You will want to pause at the end of each stroke just long enough to see the base metal start to melt. Then, quickly move the stroke to the other side, repeating the procedure. If you pause too long, the filler metal will run out of the weld, ruining the seam. If excessive melting occurs you are either moving the rod too slowly or the amperage needs to be reduced. Keep practicing until you gain control of the puddle. When the weld is completed, the flux can be chipped away exposing the weld beneath. With a little practice, you will learn to produce attractive strong vertical welds.

Jim Nieland is the Region-6 cave management specialist for the US Forest Service. He has a background in cave and bat resource management, including an active interest in caves of the northwest, which he has inventoried and surveyed since 1965. His experience includes drafting implementation regulations for the Federal Cave Resources Protection Act of 1988, and is currently working with a Bat Taxa Team, writing survey and management protocol for the Northwest Forest Plan. He is a frequent organizer and presenter at cave management seminars, most recently culminating in a series of five bat gating field sessions. He has a background in general contracting, leading to either the design or construction of 105 bat gates in the last four years. He serves as the secretary and a board of director of the American Cave Conservation Association. He was recipient last year of the National Speleological Society's cave conservation award.



PERSONNEL AND QUALIFICATIONS

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Abstract

Good contractors and good contract administration result in the construction of good bat gates. Establishing an effective, professional working relationship between agencies, agency administrators, and contractors is essential to this process. This paper explores the philosophy of recruiting, hiring, and retaining quality bat gate builders. It includes how to locate them, what to look for, and how to establish a successful working relationship before and after they are hired. Topics include: safety, volunteer and media management, innovation, training, and necessary paperwork.

Introduction

Those who construct bat gates are a special breed, with special interests and special skills. They can be difficult to locate and successfully recruit. With the ever-increasing public understanding of the important ecological roles bats play and the emphasis placed on public safety by landowners and land managers, bat gate builders are finding themselves plenty busy and in high demand. It is important that we utilize these skilled craftspeople, while looking for additional opportunities to train and recruit newly trained gate builders to take full advantage of future gating opportunities.

Locating & Recruiting Gate Builders

Prior to actually searching for a suitable contractor, several questions must be asked and answered. An assessment must be made as to why a bat gate is desired. Is it for public safety or bat habitat conservation or both? What kind of structure is most appropriate and what are the alternatives? When is the best time of year to build the gate considering weather conditions, availability of labor and materials. and the biology of the bats themselves? Is there an immediate need or emergency? Who are the potential partners and who should be aware of this project? Where should the gate be located? What are the constraints and limitations?

Once these questions are satisfactorily considered and answered, the search for gate builders can begin in earnest. When searching for gate builders, inquiries should be made of local State, Federal or local community organizations to see if there is any local experience with building bat gates. Are there already mines or caves in the area that have been gated? Who coordinated the project, when were they built, and who built them? Are any of these previous resources still available for additional projects?

If there is no local bat gating history or expertise, then it's time to widen the search. Does anyone have experience within the State? Check with geologists, cavers, or biologists that have Statewide responsibilities and see if they can provide any leads or contacts among their counterparts who may be able to provide helpful information.

Another source of information is the World Wide Web. A simple search for bat gates or bat gate builders gives the user a wealth of information from a variety of bat conservation organizations. There is plenty of information and examples on how to build a good bat gate as well as who to contact for help. In this day and age, this resource should never be overlooked.

Once these agencies have been contacted, referrals and references tracked down, and the Internet search has been completed, a list of names, addresses and phone numbers can be generated. These potential contractors can be contacted or sent notices of impending projects and their interest level determined.

Interviewing, Evaluation, and Selection

Once a list of potential contractors has been developed, it's time to start sizing up and comparing the various interested parties. There are many factors to be considered and, as is the nature of building bat gates in caves and abandoned mines, there are frequently special circumstances to be considered. The following suggestions are offered as critical considerations in selecting any gate builder.

SAFETY
What is the contractor's safety record? What emphasis do they put on safety? Is safety part of their proposal? Do they bring it up as a point of emphasis or only in response to the interviewer's questions? Are they willing, able, and comfortable providing safety training to agency reps, media, volunteers or others whom might want to get involved with the project? Are they certified and up to date in their own underground mine safety training?

Optimally, contractors will have a good safety record and will have their own safety program and safety officer in place. Worker safety and the safety of visitors to the worksite should be a top priority. Safety should be emphasized during every phase of the contract from pre-construction to post-construction.

HISTORY/EXPERIENCE/REFERENCES/QUALITY
Does this individual or company have a bat conservation related background? Have they built bat gates before? Where have they worked? In what type of landscape and at what time of year? Do they have examples of their work documented and available for review? What is the quality of their workmanship and materials? Do they have adequate, verifiable references?

Bat gate builders should have an established history of pro-conservation work. They should have thorough and up to date documentation of all their past related work experience and references that can be contacted for verification. Preferably, contractors should have experience working in similar climates and terrain as the proposed project.

FLEXIBILITY/CREATIVITY/INNOVATION

How rigid is the contractor in terms of construction designs and sp ecifications? Are they willing to make on the spot alterations or adjustments due to unforeseen complications or changing technology? What are the financial ramifications of such changes? Will creativity and innovation be encouraged? Are both parties a ble to incorporate flexibility and creativity into the contract?

Every situation is different. Every gating project presents it's own unique challenges. Problems will undoubtedly arise that have not been foreseen or predicted and reasonable adjustments or alterations to the gate plans should be routinely accommodated. Flexibility is critical on the part of both the gate builder and the contract administrator.

TRAINING OPPORTUNITIES

The building of bat gates is an art and requires special knowledge and skills. There remain thousands of caves and abandoned mines that could potentially be gated. Opportunities to train agency officials and other potential contractors are limited. Another consideration of hiring a bat gate contractor is their willingness to share their knowledge with others and train them in bat gate design and construction and the use of specialty tools and equipment. Although this is not necessarily a requirement in getting the job done, it is something to be considered in the big pictu re of bat conservation.

VOLUNTEERS, MEDIA, AGENCY

How willing is the contractor to utilizing willing volunteers or entertaining visits by the media or agency representatives? Some contractors may be justifiably uneasy or unwilling to use volunteers because of safety and liability concerns. They also may not be comfortable being interviewed by a reporter for a local radio or television station. Visits by agency representatives or managers may give the impression of an inspection or someone looking ove r the contractor's shoulder.

However, these are important opportunities to educate others and recruit new public interest in bat conservation. Publicity is an important tool in conservation that is often overlooked. As technical experts, resource specialists, and construction engineers, such as gate builders, often want to simply do their jobs and move on to the next project. What is sometimes overlooked is that public and agency support provides the direction, the capability, and the funding for init iating and continuing

this kind of work. The larger conservation organizations are often most effective in large part due to their publicity efforts and continued efforts at public outreach. These opportunities are often few and far between and each and every opportunity should be taken advantage of.

ATTITUDE AND GOALS

This is more of an observation than a question that the selecting official should be considering. When discussing the project, interviewing the contractor, or during the field review, obs erve the contractors demeanor and attitude towards the project. What kinds of questions are being asked? Does the potential contractor have a desirable attitude towards the project? Are their questions appropriate to the project? Are they second -guessing the project administrator? Are they going to be a good partner? Are they in it solely for financial gain or are they equally dedicated to the goals of bat conservation?

For a successful project that will lead to other worthwhile projects and opportun ities, agency administrators and bat gate contractors necessarily need to establish a strong cooperative working relationship. This benefits everyone, not to mention the public in terms of safety and bats in terms of conservation. Agency personnel shoul d feel comfortable stating goals and ideas and direction for the project, but contractors should also feel that they can propose additional ideas and suggestions. Respect, trust, and good communication by all parties will lead to a successful experience.

FIELD TRIP

Prior to selecting a contractor, a field trip to the project site(s) should be made. Preferably, to save time and money, only one field trip should be made. However, on these field trips, each potential contractor should be given the opportun ity to individually inspect the project site and ask questions of the agency representative. The field trip is also a first opportunity to observe potential contractor's commitment to safety in the field. Are they wearing proper clothing and safety equipment such as hardhats, gloves, and boots? Are all their representatives wearing safety gear? If they are truly committed and knowledgeable of safety standards and requirements, the agency representative should not have to worry or remind them of proper a ttire and equipment at the field site.

PAYMENTS AND HIDDEN COSTS

Even the most cooperative relationship can be undermined by poor performance when it comes to billing and payments. All parties must have a clear understanding of billing and payment procedures early in the process. Contractors must be clear in their bids of exactly what their bid covers and under what circumstances additional costs will be incurred. Contract administrators must be fair and forthcoming with proper billing and prompt paymen t procedures.

EQUAL TREATMENT

All potential contractors must be treated equally and given the same opportunities. Any information related to the project that is provided via the telephone, through the mail, in the office, in person, or on the project sit e should be available to every bidder or interested party. Contract administrators must consciously go out of their way to avoid even the slightest hint of favoritism or discrimination of any sort.

BASIS FOR AWARD

Technically, BLM Requests for Solicitations include the following standard language; *"Award will be made to the responsible firm whose quote is most advantageous to the Government, price and past performance being considered. Past performance information may be based on the Government's knowledge of, and previous experience with, the bidder, or other reasonable basis".*

Construction Phase

SAFETY

During construction, concerns for safety should be emphasized even more. This is when accidents occur, while on the job. Safety should be add ressed over and over again, when just the contractors are on the work site, and when other interested parties are present. Contractors should be especially cognizant of unexpected guests who just happen to come by the work site. If necessary, work should stop while an appropriate amount of time is invested in visiting, enlightening, and educating any curious visitors. Workers should not continue to work while trying to carry on a conversation or otherwise engage visitors. Safety of both workers and visi tors is always a higher priority than the actual job and is much more important than keeping to a rigorous time schedule.

TRAINING

If training of non-contracted personnel has been previously discussed and agreed to, such training needs to be scheduled and followed through. Training of agency personnel, volunteers, and others may include personal protective equipment, communications, hazard recognition, specialized tools and materials, basic safety and first aid, construction procedures, and actual work i ncluding cutting and welding steel. Anyone planning to visit the work site during construction should be encouraged to attend a training session or even required to do so. Contractors should allow interested, newly trained personnel to participate in th e actual construction of the gate. Although this may slow down a project, there can be major long -term benefits to bat conservation by developing additional support and expertise from local interested parties.

FLEXIBILITY

Inevitably, unforeseen circumstances or complications will arise once construction has started. A well-written contract, a good administrator, and a good contractor will be well prepared for this. An experienced contractor can be given some leeway in making these judgment calls. Early notification and communication with the agency's technical representative or contracting officer is critical. When it comes to construction contracts, no one likes surprises. Nonetheless, agency representatives should consider contractor experience and t imeliness when it comes to making changes to the gate design once construction has started. Is the change significant? Is it outside the parameters of the contract? Can it be handled over the phone? Can the agency's field representative handle the situation or is it significant enough to go through the contracting/procurement specialist? If flexibility is built into the contract up front, flexibility during the project should not be a serious problem.

Volunteers, Media, and Agency Representatives

Once construction on a bat gate has started, there is a certain rhythm that is established by the contractor. The presence of volunteers, local media, agency representatives, or other interested parties can be disruptive to the schedule and progress of t he project. Such visits, inspections, or other non-contractor participation should be carefully planned well ahead of time. Contractors and agency personnel should encourage and plan for such events and schedule them in such a way that they are worthwhile, informative, educational, helpful, and do not significantly slow the project down.

Location of Gate

Location of the bat gate is critical and may depend on a number of factors, including local bat species, accessibility, potential for vandalism, aspect , workspace, and material. Contractors and the agency's technical coordinator should already have visited the site and agreed on a general location for the gate

Attitude, Trust, Communication, and Cooperation

All of these factors are obviously related and interconnected. A positive outcome in any of these areas will trigger a positive outcome on the others. For example, a positive attitude will lead to trust and better communication and cooperation.

Reports, Paperwork, and Payments

A word about nobody's favorite subject…the paperwork involved before and after hiring a bat gate contractor. Every effort should be made to keep things as simple and straightforward as possible, with a minimum of effort on everyone's part as far as paper shuffling goes. However, the project should be well documented and supported by a logical paper trail. Contractors should have their reports and invoices submitted on time and complete. Any necessary reviews or billings should be processed by agency representatives in a timely fashion, as agreed to in the initial phases of the project. Paperwork takes time and is seen by some as a necessary evil. Others see it as important documentation to gain support for the next project. Whatever the point of view, if the paperwork is kept up to date and in good order, the process is easier on everyone, and the trust and cooperation between the involved parties is that much further enhanced.

Special Considerations and Problems

Bat gate builders and the people that hire them do develop a relationship. Recognizing the overall goal of bat conservation, this relationship will hopefully be a positive one that can be fruitful for years and generations to come. However, relationships can be strained when qualified contractors compete for the same job and their agency liaison is forced to choose only one of them. It is critical that this process and these personal relationships are kept professional, open, and honest. All parties should communicate and stay focused on the big picture of bat and bat habitat conservation and be aware of and avoid negative perceptions and situations.

Money flow can also cause problems. Payment and billing procedures must be established up front and adhered to. If problems develop, they must be dealt with quickly and effectively. No one likes working for free when they are supposed to be paid for their services. Also, contractors need to avoid financially surprising agencies that are usually on very tight budgets.

Agency representatives have varying capabilities as far as working in the field side by side with the contractors. This is simply the way it is. Some agency representatives or biologists will frequent

the work site, perhaps even making significant labor contributions to the project. While this is highly encouraged, this is not always feasible. Some agencies may not be able to afford the time for their specialists to participate in the field phase of these construction projects due to other pressing business and higher priorities, often beyond their control.

If several bat gates are being contemplated for a certain area, agencies should consider grouping these projects under one contract. There is usually a "bigger bang for the buck" and, to everyone's enjoyment, there is less paperwork overall. More work is accomplished for less time and money. This approach can also result in a larger pool of qualified contractors to bid on the job. A larger contract will usually draw in more competition from a farther distance.

Access can also create problems. Agencies may consider access limited, while an experienced contractor will try every conceivable way to successfully get tools and equipment right to the gate location. Access can be a delicate issue that all parties should discuss and agree to, preferably during the initial field trip prior to submission of bids.

SUMMARY

These are exciting and historic times for those of us interested in the conservation of wildlife and, in particular, bats! Collectively, we are making a significant difference. It doesn't matter if we are professional biologists, a local volunteer, a schoolteacher, in the construction industry, or at any other level of participation. We are all contributing in this worthwhile endeavor.

The successful long-term conservation of bats doesn't solely depend on the construction of bat gates or the preservation of caves and mines. It doesn't solely depend on our State, Federal, or local wildlife management agencies. It doesn't solely depend on conservation organizations. It doesn't solely depend on public education and other outreach efforts, or the publication of glossy posters and books and other bat related merchandise. It certainly does not depend solely on our elected politicians in State, Federal, or local governments. It depends on all of these groups and individuals, large and small, local or global, high profile or low, well funded or on a shoestring. Everyone should be appreciated, valued, and recognized for their positive contributions to bat conservation.

When it comes to the construction of bat gates, there can be significant differences in experience and knowledge between contractors and the agency personnel who employ them. There are plenty of opportunities for egos and territoriality to set in and undermine the worthwhile work that is to be accomplished. This obviously does not lead to a good outcome.

All parties involved in the construction of bat gates and indeed bat conservation in general, should first recognize the common ground they share in the bigger picture, to conserve bats and their habitat. Whether we are agency workers, contractors, or interested outsiders, we should all recognize the important role each individual person plays. We need to assist and support each other, be able to ask for help whenever we need it. This is a team game. We need qualified contractors and agency personnel who can effectively work together. The overall outcome of these and other bat conservation projects depends on all of us, not just the success or failure of each individual.

Bob Hall has worked as a wildlife biologist for the Bureau of Land Management for over 20 years. Much of his experience was specialized as an Endangered Species Research Coordinator working in his field office and throughout th e State of Arizona as a member of several interagency teams. Since 1995, Bob has been coordinating and conducting bat research and protecting important bat habitats in BLM's Kingman Field Office in northwestern Arizona. Projects have included species and habitat surveys in the Hualapai, Cerbat, and Black Mountains, underground assessments of abandoned mines, and protection of important bat habitats, including a precedent setting partnership in Arizona between the Arizona Department of Transportation, Bat Conservation International, and the Bureau of Land Management.

Session 6

Monitoring and Maintenance

Session Chairperson:
Robert Currie
U.S. Fish and Wildlife Service
Asheville, North Carolina

The Response of Bats to Gates
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Monitoring the Effectiveness of Bat Compatible Mine Gates
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THE RESPONSES OF BATS TO GATES

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Abstract

The use of bat gates to protect subterranean bat roosts has become an increasingly common management and conservation practice. While the exact number sites protected with bat gates is not known, at least 1,620 are in place throughout the United States. Despite the large number of gates currently in place and the casual acceptance of their use as a management tool, relatively little is known about how various species and colonies respond to their installation. The response of bats to gates can be an extremely complex problem and is often confounded by surface perturbations (concurrent mine closures), spatio-temporal scales, and anthropogenic factors. However, the sheer number of gates in place has produced a large number of anecdotal observations regarding the responses of various species/colonies across a wide geographic area. This voluminous amount of purely anecdotal observation makes it easy to overestimate the current state of our knowledge regarding the responses of bats to gates. In reality, very few studies have been conducted in a systematic manner, such that the actual impacts of gates can truly be evaluated. We propose that this paucity of scientifically rigorous data makes it too early to generate models that can accurately predict the responses of many species of bats to the installation of bat gates. The purpose of this presentation is to summarize our current knowledge regarding the responses of bats to gates. After clearly articulating the state of our current knowledge, we will identify the limits of our understanding, and attempt to dispel some commonly held beliefs regarding the responses of bats to gates.

Key Words: bat gate, abandoned mine, cave, roost, roost protection.

BACKGROUND

Of the 45 species of bats that roost in the continental United States and Canada, 21 are known to use caves and/or abandoned mines. While dependence on these roosts varies both spatially and temporally, many of these species are in fact, dependent upon these resources during at least part of the year in at least portions of their range (Pierson 1998; Sherwin et al. 2001). Bats are likely drawn to caves and mines for protection from ambient conditions and possibly from predators (Barbour and Davis 1969). Ironically, the protections afforded by roosting in these resources are often negated, as these same sites attract humans for recreation, research, and financial gain (American Society of Mammalogists 1992; Thomas 1995). This mutual attraction of both humans and bats to caves and mines has resulted in the expression of anthropogenic,

unidirectional pressures, often resulting in the reduction in the colony sizes of roosting bats and even the total abandonment of historically occupied roosts (McCracken 1989; Stebbings 1980). In short, the very resources that once afforded protection may now represent population sinks, with continued reliance on unprotected roosts resulting in the sustained reduction in size of roosting colonies. As a result of perceived population declines, protective measures have been initiated at many important subterranean roosts, with protection ranging from restriction of human access through seasonal closures to permanent exclusion of visitors through the installation of bat gates (American Society of Mammalogists 1992). In addition to the negative impacts on bats, the increasing use of caves and abandoned mines by humans has had devastating effects on unique cave features and on the historical integrity of abandoned mine sites (Altenbach and Sherwin this issue; Kirbo this issue). These impacts helped lead to the development of closure programs, which ultimately led to the development and refinement of the bat gate designs discussed throughout these proceedings.

While the exact number of bat gates currently in place is not known, at least 1,639 have been installed as a result of abandoned mine reclamation projects alone (Meier and Garcia 2001). This number does not reflect mines protected by private individuals and industry or any of caves at which bat gates have been installed. Therefore, this estimate likely greatly underestimates the number of gates in place. However, as the only reliable figure currently available, it is a valuable indicator of the scope of the use of bat gates to manage and protect bat roosts.

In preparation for this report we conducted various literature searches, each of which targeted different databases, using the Centennial Library of Science and Engineering located on the University of New Mexico campus. As a result of these searches we located 9,023 sources of information reporting some aspect of cave or abandoned mine gating projects. Literature was divided into two general categories including: (1) peer-reviewed studies published in scientific journals and, (2) gray literature, which included technical reports, popular media coverage, newspaper clippings, internet postings, etc. While the quality of the gray literature varied from important to trivial, it was universally difficult to locate and obtain. Due to the paucity of scientifically rigorous information available, we were most often forced to contact individuals in various States and institutions for information. These personal communications often led to contradictory and unverifiable observations regarding specific responses to gates. Based on the contradictory and unverified nature of these observations we chose to not use undocumented observations in our evaluation of the impacts of gates on colonies of bats.

In order to adequately test the effectiveness of bat gates we must adhere to basic principles of the scientific method. One of the primary problems with the information that is currently available is that single variables have rarely been isolated and tested. The lack of rigorous data collection and clear isolation and testing of bat gates as an independent variable makes it impossible to use this gray literature to infer specific responses to the installation of bat gates. Webster defines **an·ec·dot·al** as "Based on casual observations or indications rather than rigorous or scientific analysis." We chose to ignore these anecdotal accounts in the preparation of this manuscript. It is not our intention to trivialize past work and we sincerely applaud the efforts of those currently managing and protecting caves and mines. We also acknowledge the importance of the widespread observations currently available. However, management practices of this magnitude and scope cannot be responsibly managed using hearsay and untested observational data.

To illustrate the problem of failing to isolate gates as independent variables, we need look no further than abandoned mine reclamation programs. These projects are typically part of large-scale management programs. A single project will often involve the destruction of dozens to even hundreds of mine workings across landscape scales. Mitigation for such activities includes the protection of a subset of roosts with bat gates (while eliminating all others). Of the approximately 20,000 abandoned mines closed in the western United States, 1200 (6%) have been protected with bat gates. To attempt to measure population responses at remaining gated mines and then attribute observed changes to be a direct response to gates is inappropriate. Clearly, population responses reflect impacts of the entire management program of which the gates are only a small part. Therefore, confounding effects of concurrent mine closures make it impossible to attribute local responses (increases in colony size) solely to gate installation. When we fail to adhere to the basic principles of scientific investigation, we place ourselves in a tenuous situation, whereby important management decisions are often made based on hunches and hearsay. To further illustrate, there has been recent concern expressed regarding potential negative impacts of culvert/gate combinations on maternity colonies of *C. townsendii*. These concerns are based on anecdotal observations of colony abandonment at a single roost in Nevada that was gated to mitigate for the loss of dozens of mines in the landscape (Brown, personal communication). Management decisions are now being made based on this anecdotal account of negative impacts. However, Sherwin and Altenbach (in review) report that culvert/gate combinations are equally effective (as regular gates) and accepted by this species throughout New Mexico and Utah. Both researchers are reporting observational data collected without isolating gates as the only independent variable. As a result, there is insufficient data available for managers to make informed decisions. In fact, Sherwin and Altenbach (in review) continue to recommend culvert gate combinations, while Brown expresses concern over their use. Contradictory recommendations have even been made to the same management district of the Bureau of Land Management. A second example is the widely held assumption that gate installation increases rates of predation, as predators gain access to a larger proportion of available flight space. While this assumption makes intuitive sense, there is simply no rigorous data supporting the hypothesis that predation is greater at gated roosts relative to non-gated sites. Both of these examples illustrate the common problem that pervades the entire management practice of protecting roosts with bat gates…we simply don't have scientifically rigorous data, so we are managing based on hunches and best guesses.

While the quality and reliability of the data included in gray literature is questionable, some valuable information is available. We did learn that bat gates have been installed throughout the United States and that there have been many highly publicized accounts of gating successes. These accounts purport gate installations that have resulted in stabilization and even dramatic increases in the sizes of roosting colonies. Based on the abundance of this gray literature, it appears that the use of bat gates has become a widespread and even routine management practice and there is a general casual acceptance of their effectiveness.

Despite the abundance of gray literature and the scope of this management practice, we submit that there is currently insufficient data available to determine how various species of bats respond to gates. We propose that the current reliance on hearsay, hunches, and even gossip to formulate important management decisions reflects the all-to-common disconnect that exists between the research and management communities. Quite simply, the needs of managers have

outpaced production by researchers. In light of the lack of reliable information that currently exists, we have approached this presentation with several objectives: (1) to define the various scales and types of potential responses to gate installation, (2) determine what we currently know about how bats respond to gates, and (3) to establish a trajectory for necessary research

SCALE OF IMPACT

It is important to remember that the installation of a gate over a cave or mine portal may have ramifications that cascade far beyond the protected roost itself. In fact, manipulation of roost openings may have effects that pervade every aspect of a roosting colonies natural history and may even impact entire populations distributed across wide geographic areas. Much like casting a stone into a pond, the effects of gate installation ripple beyond the point of impact, potentially having landscape and community level effects. These effects could include changes in the total numbers of individuals across the landscape, changes in relative abundance of species and often include impacts upon nearby roosts. Due to the potential scale of these impacts, we are potentially conducting a management practice that is altering local and regional patterns of distribution for entire populations. As landscape relationships of individual populations change, communities are also impacted. The gray literature includes observations and assessment of impacts that ignore larger scales and concentrate on changes in numbers of roosting individuals as the sole gauge of gate success or failure.

This reliance on a single measure to assess the impacts of gate installation is quite troubling. In most cases, a single roosting colony does not represent the entire population, that likely includes many roosting colonies dispersed over broad geographic areas. The biological goal of installing a bat gate over a roost is to secure and maintain the *population* in the landscape, not simply to stabilize numbers in that particular colony. The alteration of roost attributes through gate installation often leads to a dramatic increase in the number of roosting bats at the protected roost. However, these dramatic increases in colony sizes of protected colonies represent dramatic reductions of colony sizes at nearby roosts. Through gate installation we may be dramatically altering patterns of distribution for entire populations. These changes in patterns of distribution may ultimately have negative effects on the persistence of populations in the environment. Therefore, it is possible that installation of a gate may result in an increase in colony size, but a decrease in total population size. Other questions that need to be addressed include: What are the long-term effects of concentrating an entire population at a single site? How do subsequent changes in community diversity alter trophic systems? Are we affecting density dependent relationships? Where do all of these bats come from when we have dramatic increases at gates sites over short temporal scales (Sherwin et al. 2001)?

Most obviously installation of a gate has direct impacts on that particular resource. The effect of installing a physical barrier (sometimes blocking 50% of the airspace) can impact navigation and internal abiotic conditions. Bats can respond to these changes in dramatic fashion. For example, alteration of internal abiotic conditions caused by inappropriately designed gates can effectively eliminate certain types of use. This would be most easily detected in cases of site abandonment or wholesale conversion in the type of use (for example, changes from maternity to bachelor use).

In most cases we tend to attribute colony increases as positive and colony decreases as negative. However, more subtle responses can also be exhibited that may have more pronounced effects upon the long-term maintenance of roosting bats. The ability to detect these responses is only as sensitive and exacting as the methods, intensity, and duration of data collection techniques employed. For example, changes in roosting colony size can be very subtle as colony sizes are often subject to temporal and spatial fluctuations (Sherwin et al. 2000a; 2000b; 2002; Mika and Sherwin in review). Gates can also result in changes in the specific ratios of roosting bats, as particular gate design/placement may exert differential pressures on various species. In addition, changes in internal patterns of distribution may be observed as a reduction in human visitation (see Speakman et al. 1991; Thomas 1995) that "allows" bats to roost in preferred locations where they were previously precluded. The ability of individuals to choose roost locations based solely on thermal conditions may have dramatic impacts upon reproductive success that may not be evinced (through increased population sizes) for many years.

Bat gates present a physical barrier that can have a dramatic effect upon flight behaviors of exiting bats. While changes in exiting behaviors may be trivial, there is a growing body of evidence suggesting that the timing, order, and patterns of nightly departures can have dramatic effects upon both reproductive success of females and survivorship of young (Lee and McCracken 2001; Lima 1998; Speakman et al. 1995; Speakman et al. 1999; Speakman and Tallach 1998). If gates impede the order and timing of nightly departures, it is possible that they apply selective pressures that can alter behavioral dynamics of colonies and affect energy budgets. These pressures may only be detectable across large temporal scales and may not be detectable for many years following gate installation.

Issues of temporal and spatial scale become important when addressing any of these potential impacts (what is the duration of concern). It is very possible to have positive results over short temporal scales at colonies that are ultimately doomed.

What do We Really Know about How Bats Respond to Gates?

There are documented cases of gates causing immediate site abandonment. It does appear that in most cases, abandonment was the direct result of poorly designed gates that either altered internal conditions or were too restrictive for flight. In many of these cases, the replacement of these closures with more appropriately designed gates resulted in increased use by bats (Currie in litt.). It is also apparent that some species (*C. townsendii*, *M. thysanodes*, *M. sodalis*) respond quickly and dramatically to gate installation through increases in numbers of roosting individuals. It is also apparent that gates have resulted in changes in exiting behaviors of colonies of *M. austroriparius* and *M. grisescens* (Ludlow and Gore 2000). There is available evidence to suggest that when faced with choices in gate design and material, some colonies of some species exhibit preferences for certain designs and materials over others (White and Seginak 1987). Lastly, we have available information that indicates long-term acceptance and continued use of bat gates by *C. townsendii*, *M. lucifugus*, *M. volans*, *M. thysanodes*, *M. ciliolabrum*, and *Myotis spp*. (Jewel Cave, SD; Choate and Anderson 1997) and by *C. townsendii*, *M. ciliolabrum*, and *M. velifer* (Torgac Cave, NM; Jagnow 1998).

Because of the physical barriers that gates impose, care should be taken when installing gates over openings through which large colonies must exit. Ludlow and Gore (2000) found that, *M.*

austroriparius and *M. grisescens* avoided a gated opening in deference to a non-gated opening. When the gate was removed, however, exit rates at the previously gated opening increased significantly. Additionally, Currie (2001) suggests that some species (*M. grisescens*, maternity; *T. brasiliensis*, any use) will not accept full gates and that alternate methods should be used to protect roosts occupied by these species.

So…where do we go from here?

The range of responses exhibited by bats to gates is wide-ranging; therefore this is not a simple question that can be easily answered. We must become more sensitive to the range of responses that might be exhibited and respond appropriately through the initiation of well-designed studies, followed by publication of results in refereed journals.

In order to accurately assess the impacts of a single bat gate on a roosting colony of bats it is imperative that adequate baseline data be collected. The types and end extent of data to be collected are dependent upon the hypotheses being investigated. For example, if one is interested in the effects of gate installation on internal climatic conditions, a suitable number of data loggers need to be placed and left for a long enough period of time to adequately resolve temporal variability (this will often require dozens of loggers per roost for many years). If one is interested in the numerical response of colonies following gate installation, adequate pre- and post-gate installation monitoring needs to be conducted to resolve natural fluctuations in colony size. In addition, researchers must determine if numerical or scalar responses are more appropriate (i.e. is a colony increasing from 100 to 200 individuals as significant as another going from 10,000 to 20,000 –both have doubled in size). Regardless of the questions of interest, they must be articulated *a priori* and basic rules of study design adhered to (see Dytham1999; Heath 1995; Jongman et al. 1995; Zar 1999). In addition, management objectives should be clearly defined prior to gate installation. Without stating objectives, it is difficult to determine if and when management objectives are met. Clearly, we must get away from the current practice of putting up a gate and "seeing what happens."

Literature Cited

American Society of Mammalogists. 1992. Guidelines for the protection of bat roosts. Journal of Mammalogists, 73:707-710.

Barbour, R. W., and W. H. Davis. 1969. Bats of America. The University Press of Kentucky, Lexington, Kentucky.

Choate, J. R., and J. M. Anderson. 1997. Bats of Jewel Cave National Monument, South Dakota. The Prairie Naturalist, 29:39-47.

Currie, R. R. 2001. An overview of the response of bats to protection efforts. Pp. 173-186, in K. Vories and D. Throgmorton, eds. Bat Conservation and Mining, a Technical Interactive Forum. Office of Surface Mining, USDI, Alton, IL and Coal Research Center, SIU, Carbondale, Illinois.

Dytham, C. 1999. Choosing and using statistics: a biologist's guide. Blackwell Science Ltd. Malden, MA.

Heath, D. 1995. An Introduction to Experimental Design and Statistics for Biology. UCL Press Ltd. London, England.

Jagnow, D. H. 1998. Bat usage and cave management of Torgac Cave, New Mexico. Journal of Cave and Karst Studies, 60:33-38.

Jongman, R. H. G., C. J. F. ter Braak, and O. F. R. Van Tongeren. 1995. Data analysis in community and landscape ecology. Cambridge University Press. New York, New York.

Lee, Y. F., and G. F. McCracken. 2001. Timing and variation in the emergence and return of Mexican free-tailed bats, *Tadarida brasiliensis mexicana*. Zoological Studies, 40:309-316.

Lima, S. L. 1998. Stress and decision-making under the risk of predation: recent developments from behavioral, reproductive and ecological perspectives. Advances in the St udy of Behavior, 27:215-290.

Ludlow, M. E., and J. A. Gore. 2000. Effects of a cave gate on emergence patterns of colonial bats. Wildlife Society Bulletin, 28:191-196.

McCracken, G. F. 1989. Cave conservation: special problems of bats. National Spe leological Society Bulletin, 51:47-51.

Meier, L., and J. Garcia. 2001. Importance of mines for bat conservation. Pp. 17 -28, in K. Vories and D. Throgmorton, eds. Bat Conservation and Mining, a Technical Interactive Forum. Office of Surface Mining, USDI , Alton,IL and Coal Research Center, SIU, Carbondale, Illinois.

Mika, M., and R. E. Sherwin. The effect of bat gate installation on population size and roosting habits of Townsend's big-eared bat (*Corynorhinus townsendii*). Wildlife Society Bulletin. In Review.

Pierson, E. D. 1998. Tall trees, deep holes, and scarred landscapes: conservation biology of North American bats. Pp. 309-325 in Bat Biology and Conservation (T. H. Kunz and P. A. Racey, eds.). Smithsonian Institution Press, Washington, D.C.

Sherwin, R. E., J. S. Altenbach, and P. E. Brown. 2001. Methods for determining local mine characteristics of importance to bats. Pp. 109-114, in K. Vories and D. Throgmorton, eds. Bat Conservation and Mining, a Technical Interactive Forum. Office of Su rface Mining, USDI, Alton,IL and Coal Research Center, SIU, Carbondale, Illinois.

Sherwin, R. E., D. Stricklan, and D. S. Rogers. 2000a. Roosting affinities of Townsend's big -eared bat (*Corynorhinus townsendii*) in northern Utah. Journal of Mammalogy, 81 :939-947.

Sherwin, R. E., W. L. Gannon, J. S. Altenbach, and D. Stricklan. 2000b. Roost fidelity of Townsend's big-eared bat in Utah and Nevada. Transactions of the Western Section of the Wildlife Society, 36:15-20.

Sherwin, R. E., J. S. Altenbach, and W. L. Gannon. 2002. Inherent spatial and temporal variation in the use of roosts by Townsend's big -eared bat (*Corynorhinus townsendii*). Wildlife Society Bulletin, xx:xxx-xxx. (In Press).

Sherwin, R. E., and J. S. Altenbach. Short term impacts of abando ned mine reclamation on the distribution of Townsend's big-eared bat (*Corynorhinus townsendii*). Journal of Wildlife Management. (In Review).

Speakman, J. R., N. Irwin, N. Tallach, and R. Stone. 1999. Effect of roost size on the emergence behaviour of pipistrelle bats. Animal Behaviour, 58:787-795.

Speakman, J. R., R. E. Stone, and J. E. Kerslake. 1995. Temporal patterns in the emergence behavior of pipistrelle bats, *Pipistrellus pipistrellus*, from maternity colonies are consistent with an antipredator response. Animal Behaviour, 50:1147-1156.

Speakman, J. R. and N. Tallach. 1998. Do emerging pipistrelle bats lose control of their timing due to 'crowd pressure'? Journal of Zoology, 246:445-448.

Speakman, J. R., P. I. Webb, and P. A. Racey. 1991. Effects of disturbance on the energy expenditure of hibernating bats. Journal of Applied Ecology, 28:1087-1104.

Stebbings, R. E. 1980. An outline global strategy for the conservation of bats. Pp. 173-178, in Proceedings of the Fifth International Bat Research Conference (D. E. Wilson and A. L. Gardner, eds). Texas Tech University Press, Lubbock, TX.

Thomas, D. W. 1995. Hibernating bats are sensitive to nontactile human disturbance. Journal of Mammalogy, 76:940-946.

White, D. H., and J. T. Seginak. 1987. Cave gate designs for use in protecting endangered bats. Wildlife Society Bulletin, 15:445-449.

Zar, J. H. 1999. Biostatistical Analysis. Prentice-Hall Inc. Upper Saddle River, New Jersey.

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MONITORING THE EFFECTIVENESS OF BAT COMPATIBLE MINE GATES

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Abstract

Abandoned underground mine workings pose serious threats to human safety. Many agencies have installed wildlife-passable gates at mine openings in an effort to mitigate these losses. Long-term monitoring studies have been initiated to determine if gates affect population numbers or alter behavior of animals using mines. Designing an effective monitoring program requires identification of the questions to be addressed, the scale, and the strengths and limitations of the methodologies used. This paper provides some recommendations for designing an external bat gate monitoring study, including a list of assumptions to be considered and questions to be addressed prior to selecting a methodology. Discussion of some of the more commonly used monitoring methodologies is also provided as well as advantages and disadvantages associated with each. Commonly used methodologies for biological monitoring include: exit counts, alone or enhanced using lights or night vision equipment; infrared event counters; video imaging; and acoustic detectors. Other methodologies being tested include thermal infrared video imaging, radar, and electronic transponders.

Introduction

Abandoned underground mine workings pose serious threats to human safety. To protect the public from the hazards of abandoned mines, public land managers have implemented large-scale closure efforts, often at significant expense. The most economically feasible mine closure methods include blasting, plugging, backfilling, and other permanent solutions.

Studies have shown that numerous wildlife species use these artificially created habitats including bats, mice, woodrats, skunks, ringtail cats, mountain lions, and a variety of birds and reptiles (Brown *et al.* 1995). Eighty percent of the mines in the Western U.S. show some evidence of bat activity (Tuttle and Taylor 1998). Permanent abandoned mine closure methods have not only resulted in destruction of roosting habitat but have also caused direct mortality of bats by entombing them within the sealed mine (Brown 1995, Brown and Berry 1991, Altenbach and Pierson 1995).

Many agencies have installed wildlife-passable gates at mine openings to mitigate the loss of animals and their habitat resulting from permanent closure. Gates allow animals to pass through openings too small for most humans, while maintaining air flow patterns crucial for internal habitat conditions. Unfortunately, many early gate designs impeded bats in flight, allowing predators to take bats easily (Tuttle 1977, Altenbach and Pierson 1995, Currie 2001). In some areas, bats have abandoned historic roosting areas despite the addition of bat compatible gates.

Currie (2001) suggests that bat compatible gates can be considered successful if the structure keeps people out, does not adversely affect mine microclimate, and the bat population remains stable or increases. For the most part, gates have effectively excluded 95 percent of the public from the dangers of abandoned underground mine workings (Currie 2001). However, few long-term monitoring studies have been conducted to determine if the gates impact bats or their behavior. To date, most studies have relied upon poor or biased study designs and failed to consider issues of scale (Altenbach et al., 2001; Sherwin et al., 2001).

Biological monitoring is important in identifying adverse affects to bats resulting from gate installation. Monitoring study results have been used to provide feedback for future modifications in gate design, select the most appropriate closure me thod at similar sites, predict bat response to gates, and to develop an index of bat population trends. In many cases, the decision to gate rather than fill a mine was based on the assumption that a resident bat population used the mine. Similarly, gates have been installed where bat colonies were not previously reported on the assumption that bats would locate and occupy the available habitat. Individuals and agencies financing bat gate installations want to know if the additional expense of gating is ju stified.

However, making accurate and meaningful determinations of whether a bat colony or population is increasing in number can be problematic (O ·Shea and Bogan 2000). Bats form colonies of different sex and age compositions throughout their annual cycle (Kunz and Kurta 1988, Altringham 1996, O ·Shea and Bogan 2000). Colonies may form specifically for reproductive activities such as parturition, rearing of young, courtship, or mating. In addition, colonies may form as resting aggregations during nightly foraging activities or migration (Kunz and Kurta 1988, Altringham 1996). Some species switch from one roost to another every few days during the warm season (Kunz 1988, Altrin gham 1996, Rabe et al. 1998, Herder and Jackson 2000, O·Shea and Bogan 2000). Individual bats may leave roosts through different portals on successive nights, or may remain in the roost if environmental conditions out side are inhospitable (Kunz and Kurta 1988, Herder and Jackson 2000). Very little is known of the basic natural history, distribution, and roosting preferences for many species (Kunz 1988, Herder and Jackson 2000, O·Shea and Bogan 2000). As a result, estimating the number of bats using a particular mine site is a complex problem that may not be resolvable by counting bats as they exit.

This paper provides some recommendations for designing an external bat gate monito ring study, including a list of assumptions to be considered and questions to be addressed prior to selecting a methodology. Discussion of some of the more commonly used monitoring methodologies is also provided as well as advantages and disadvantages ass ociated with each. These recommendations are offered primarily for warm season monitoring studies following gate installation. However, most of the methods are easily adapted to pre-gating situations at any time of year.

Considerations for Bat Gate Monitoring Studies

Many considerations are required in designing a bat gate monitoring study. In reviewing documentation of previous monitoring studies, several issues consistently arise associated with study design. These include:

- Lack of an adequate or well defined study plan including purpose, objectives, and assumptions
- Lack of pre-gating data as a baseline for comparison
- Changing study design or data collection methods between pre - and post-gating
- Reliance upon anecdotal observations rather than quantifiable measures
- Making invalid study assumptions
- Failing to address spatial or temporal issues
- Selecting methods that are not sensitive enough to detect changes in roost numbers
- Overestimating the significance of changes in bat numbers, and
- Not publishing information where it is accessible to others

The following are offered as suggestions to consider in designing a monitoring study and determining which methodology is best suited to the task. This is by no means an exhaustive review. Readers who intend to design a bat gate monitoring study are referred to text books on study design and sampling theory, and encouraged to consult with a statistician.

EXTERNAL VS. INTERNAL SURVEYS

Where possible external surveys are preferable due to the inherent dangers associated with entering abandoned mines and the potential for compromising the integrity of the closure. However, external surveys are limited by the inability to determine if all of the animals have exited. Pre-closure surveys should be conducted for at least one year, including both warm and cold season checks, to establish baseline use levels. For a more complete discussion of external versus internal surveys see Altenbach et al. (2001).

PRELIMINARY SITE EVALUATION

Several initial site visits may be necessary to determine baseline conditions and select the most appropriate method for monitoring. Altenbach et al. (2001) provide a thorough discussion of the elements of a preliminary site evaluation. The highest priority should be location of any and all human safety hazards present at the mine portal to minimize danger to observers. Hazardous areas should be flagged during daylight hours so that they can be avoided.

Determine the most appropriate location for counting bats during out flights. If possible, a determination of which bat species are using a particular mine should be made during the preliminary site evaluation. Specific habitat needs and adaptability of the species to gates is known for some species and could be extremely useful in determining the best approach for monitoring. A discussion of which North American bats use mines and the roost attributes they prefer is provided in Tuttle and Taylor (1998).

Preliminary site evaluation is the first opportunity to address issues of scale. Spatial scale issues include identifying suitable roost locations within the local area, if possible. The size of the area considered will vary by bat species, but a 25 km (15.5 mi) radius should provide an adequate range for most small to medium sized insectivorous bats. Clearly, increasing the size of the study area increases the scope and complexity of the effort involved. However, failure to consider roost switching to alternate sites may lead to erroneous conclusions about the effectiveness of the gate. An increase in colony size at a particular mine may be an indication that previously dispersed bats are using a roost due to the

increased protection afforded by the gate. However, it is equally likely that an increase in immigration is a result of closure or loss of a nearby roost.

Similarly, all potential exit points should be located for mines with multiple openings. Multiple exits will require additional equipment, labor, and time to effectively monitor. Counting bats at a gated mine portal is of little value if some unknown pro portion of the colony is exiting through another unmonitored opening.

The same concerns exist for temporal scale issues. A determination of the time of year the site is used and the type of roost is essential in developing an effective monitoring study. Exit surveys at the portal are of limited value if the site is only used as a hibernacula. Maternity colonies often relocate to a different roost once the young have learned to fly. Subsequent moves may occur with the onset of breeding activities or in preparation for migration or hibernation. As a result, observers may conclude that a gate has had an adverse affect on the bat colony. In addition, mines may be used by bats as day roosts, night roosts, or both. The methodology chosen to monitor a day roost may be different from that chosen for a night roost.

A hypothetical ideal site would include a solitary gated mine with one portal, far enough away from other roosts that roost switching could be considered rare or non-existent. Unfortunately, solitary mines with closed bat populations such as this are not common.

PREPARE A STUDY PLAN

The study plan should clearly identify the purpose of the monitoring study, define and document study objectives, and identify assumptions. The study plan should als o document what parameters are to be measured, the scope or extent of the study, how spatial and temporal scale issues are addressed, timing and duration of the study, the choice of method(s) used, and how success will be determined.

One of the most impor tant issues to be addressed in designing a bat gate monitoring study is establishing what questions the study will attempt to answer. Questions most commonly posed by such studies include:

- How many bats use the site?
- What time of year do bats use the site?
- What species of bats use the site?
- Has gating led to an increase or decrease in the number of bats using the site?
- How has or will gating affect bat behavior?
- Is there movement of animals between this and other adjacent areas?
- What parameters will be used to define gate success?
- Does the study need to use a method that is repeatable?
- How much time, money, and effort is available to answer these questions?

A list of the assumptions made is crucial to grasping the significance of the data collected. Common assumptions for bat gate monitoring studies include:

- Changes in numbers counted exiting the roost mean that the colony or population size has changed
- The methods chosen are sensitive enough to detect changes in colony or population size
- The methods chosen do not appreciably affect the bats or cause them to alter behavior
- All possible exit locations are monitored, and
- All bats exit every night

STUDY DESIGN

Bat species vary greatly in the way they select and use habitat, both within and outside of mines. These interspecific differences in roost requirements, breeding behavior, foraging strategy, echolocation, and flight morphology lead to differences in how bats use and behave in their environment. This in turn affects our ability to observe and count them. No technique currently exists to measure the absolute abundance of bats, except in extremely localized areas such as single roosts (Thomas and LaVal 1988). It is therefore impractical, and perhaps impossible, to obtain accurate absolute counts of bats at either the population or habitat level.

A number of factors influence the design and effectiveness of gate monitoring studies, including :

- Warm season monitoring will be limited in most cases to 5-6 months of the year when bats are present and active
- Cool season or hibernacula monitoring will be limited to two short periods of intensive monitoring during the fall and spring to establish the onset and termination of hibernation
- Only a small number of closely situated mine gates can be effectively attended, depending on the availability of personnel and equipment
- Repetition of sampling effort is desirable to increase precision. However, not all sampling periods will be suitable due to the constraints of weather
- Bat activity varies with ambient air temperature, humidity, moon phase, and availability of insect prey species, all of which change throughout the season

These factors require that an adequate number of observations (sample size) be made. Repeated observations at the same site(s) under the same or similar environmental conditions are necessary to produce an accurate count (Vonhoff 2002). The number of observations required for statistical significance in making relative abundance estimates will depend on the type of roost monitored, the methods employed, and the ability to hold these variables constant. Consult with a statistician to determine the optimum number of observations required for statistical significance.

Monitoring Methods

Because some members of a colony may remain within the roost during reproductive activities (Bogan 2000) or during periods of inclement weather (Thomas and LaVal 1988), nightly maximum counts

should be considered an estimate of relative abundance. No one technique will be ideally suited to detect and count all bat species in all locations.
Among the most common tools available for monitoring bat gates are exit counts, capture, acoustic surveys, infrared event counters, infrared video, and various combinations of these methods. Each method described has benefits and drawbacks associated with their use. There are also a variety of newer technologies available that are currently too expensive for most applications. However, the price of most of these technologies is expected to drop in the future. See Rainey (1995) for additional discussion of some of these methods.

The choice of monitoring method used will depend upon the physical layout of the site as determined in the preliminary site evaluation, the number of alternate roost sites within the study area, the species of bat present, the type of roost (whether day or night, maternity, bachelor, hibernacula, etc.), the season of use, and the manpower and financial capabilities of the observers. If time and funding allow, it is best to combine several methods to obtain presence/not detected and relative abundance data.

PORTAL SURVEYS/EXIT COUNTS

The most common technique used in counting bats at mine openings are portal surveys, also called exit or emergence counts. During a portal survey, one or more observers position themselves at fixed stations, silhouetting bats against the sky and count the animals as they exit. Portal surveys are typically begin at or before dusk and may continue until the out flight is complete or longer. Observers commonly using tally (lap) counters to record the number of exiting bats. Typically, each observer holds two tally counters, recording out flights with one and in flights with the other. In flights are subtracted from out flights after the survey is complete.

It is usually desirable to enhance visibility with red filtered lights or night vision equipment. White lights should be avoided as they may affect bat behavior. Observers should be positioned perpendicular to, but well outside of the flight path of bats as they exit the roost, preferably in front of a solid stationary object such as a rock wall. Observers should avoid sitting in the open where they would be silhouetted against the sky. Observer comfort is important as fatigue can introduce bias to the study results. For a more detailed description of portal surveys, readers are referred to Thomas and LaVal (1988), Navo (1995), and Rainey (1995).

Portal surveys are simple and relatively inexpensive, particularly where natural or red filtered lights are used. Night vision equipment increases the reliability of observations. Volunteer labor can be used to reduce costs (see Navo et al., 1995). Where sufficient personnel are available it may be desirable to have multiple observers make independent (double blind) counts to verify survey results. Observers are usually able to determine whether a bat passing through a gate is coming into or out of the mine. Experienced observers may be able to distinguish species visually. Portal surveys may be used pre- or post-gating.

Among the drawbacks to portal surveys is that they tend to be time and labor intensive and may have highly variable results. The number of exiting bats may vary with environmental conditions such as wind, rain, humidity, and moon phase. Bats may also remain in the roost during peak breeding activities.

Portal surveys provide no reliable method for determining species identification. No permanent record is available of visual observations other than the tally counters. Observers may loose count or be overwhelmed by out flights in excess of more than a few dozen at one time. Swirling or repeated out and in flights may confuse observers. Observer fatigue may result in missed bats or confusion between in flights and out flights. As equipment and personnel increase, so does the cost associated with portal surveys. Quality night vision equipment (generation 3 or better) start at over $1,000 U.S. for monoculars. Hands-free headset units are $3,000 U.S. or more. Observer presence may disturb bats, particularly if observers are noisy, using lights, moving about, or are positioned in less than ideal locations. Bats may also react to the presence of observers, possibly biasing counts.

CAPTURE

Capturing bats is the most common method for establishing which species are present in the study area. With bats in hand positive species identifications are possible. Additional information may also be obtained such as sex, age, and reproductive status of those species captured. The two most common devices used for bat capture are mist nets and harp traps. For a complete description of the use of these and other capture methods see Kunz and Kurta (1988).

- **Mist Nets**. Mist nets vary in size, typically measuring from 6 to 36 m in length and 2 - 3 m in height. Mist nets used for capturing bats typically are made of 50 or 70 denier/2 ply nylon with a mesh size of 36 mm. The nets are suspended from poles directly in the flight path of exiting bats. The bats fly into the mesh and becoming entangled in one of three or four baggy shelf panels. Mist nets typically cost between $50 and $150 U.S. depending upon size. Import restrictions sometimes limit the availability of mist nets.
- **Harp Traps**. Harp traps generally consist of two rectangular frames, with vertical strands of monofilament fishing line every 2.5 cm. The two frames are spaced 7 - 10 cm apart, face to face, with the monofilament lines on each frame offsetting each other. A collection bag is suspended below the frames. Bats generally pass through the first set of lines, but are unable to negotiate the offset between the frames and fall into the holding bag below. Harp traps typically cost between $400 and $1,500 U.S. Several references provide plans for building harp traps (Tuttle 1974, Tidemann and Woodside 1978).

Catching bats in mist nets and harp traps depends on careful placement of these capture devices. Wind, rain, bright moon, and other environmental factors may affect capture success. Duplicating exact net or trap placement is relatively easy at mine openings, though success may decrease if nets or traps are used in the same location on consecutive nights (Kunz and Brock 1975). Once placed, mist nets should be closely monitored. Harp traps do not require constant tending and so allow a larger number of mine portals to be surveyed during one sample period. Care should be taken to avoid capturing more bats than observers are prepared to handle.

Most capture devices are relatively inexpensive, highly portable and easy to use and set up. Mist nets provide a large collecting surface. Capturing animals provides a method for determining the species using a particular site, assuming the net only captures species exiting the mine and those animals are correctly identified. Using a net set at the mine portal, it is possible to determine whether the bat was

entering or exiting the site. Capture techniques are useful in both pre - and post-gating situations. Capturing bats is also the necessary precursor to application of radio telemetry or light tags.
There are numerous drawbacks to using capture techniques at mine openings. Among these, disturbance to the bats during capture and handling is the most troublesome. Bats may be killed as a result of excessive handling. Those that survive may relocate to another roost, sometimes abandoning their young in the process. All observers involved in capturing bats should be trained in use of the specific capture devices and in techniques for handling bats without injuring the animals. Observers handling bats should also receive rabies pre-exposure vaccinations. In order to assure proper identification of species in hand, observers should be trained in using taxonomic keys. Despite training, the potential for misidentification of bat species is high as distinguishing characteristics for some species are difficult to locate and identify.

Because of differences in their behavior, morphology, and/or flight patterns, some bat species are not easily captured (Vonhoff 2002). As a result, most capture techniques are biased towards the more easily captured species. Some species are adept at avoiding capture in mist nets or harp traps. Younger age class animals are more susceptible to capture than older age classes, leading observers to overestimate the proportion of juveniles in the colony.

Mist nets are time and labor intensive to use. Harp traps are expensive and have a relatively small capture area compared to mist nets. Neither method provides an indication of the proportion of the colony captured (or missed). Both capture methods are readily detected by bats and likely alter the behavior of the animals.

ACOUSTIC MONITORING

Bats rely on vocalizations for communication and orientation when orienting, commuting, and foraging (Fenton 1985, Altringham 1996). By emitting a series of discrete calls and listening for returning echoes, bats are able to navigate through their environment and locate prey items (Fenton 1970, Thomas and West 1989). Bats searching for prey emit a characteristic ›feeding buzz.‹ Because sounds produced are generally $\geq$ 20 kHz and are outside of the range of human hearing, an ultrasonic bat detector is required to monitor bat vocalizations.

Acoustic surveys are conducted by using one of the commercially available ultrasonic detectors to record and identify bat vocalizations. Bat detectors come in a wide variety of forms, but they can be distinguished on the basis of the circuitry used to transform the incoming signal; heterodyne, frequency division, and time-expansion (Pettersson 1993, Vonhoff 2002).

Heterodyne circuitry is used in so called tunable detectors. Observers can scan particular frequency ranges and sample for bat species that employ calls with different frequency components by simply tuning the detector. However, neither the duration nor the absolute frequency of the original signal is present in heterodyne signals, and thus is not suitable for further spectral analysis. These detectors are useful for measuring general bat activity where species identification is not required. Commonly used heterodyne detectors include the Mini, Mini-2, and Mini-3 detectors from UltraSound Advice (formerly QMC), the D100, D200, and D220 detectors from Pettersson Electronik AB, the BatBox III from

Stag Electronics, the Mk.2 detector from Magenta Electronics, and the SBR 1200 and 2000 made by Skye Instruments. Prices generally range from $150 to $250 U.S.

With frequency division detectors, the incoming signal is passed through a zero-crossing circuitry that isolates the dominant or loudest harmonic, divides the frequency by a user specified value, and provides output within the human audible range. The signal may then be recorded onto analog or digital tapes, or monitored in real-time using computer software. Information regarding the time and frequency characteristics of the dominant frequency are retained. This broadband system allows observers to monitor the entire range of frequencies simultaneously. This permits a greater sampling effort. Commercially available frequency division detectors include: S200 and U30 from UltraSound Advice, the D230, D940, and D980 units from Pettersson, and the Anabat II system made by Titley Electronics. Frequency division detectors range in cost from $350 to $950 U.S.

Time expansion detectors capture the incoming signal, including harmonics. The signal may then be recorded onto analog or digital tapes, or monitored in real-time using computer software. Commercial time-expansion detectors include the Portable UltraSound Processor (PUSP) from UltraSound Advice and the D240, D240x, D980 models from Pettersson. The higher information content of these time-expansion systems comes at a high cost. High-speed tape recorders and detectors with time-expansion systems typically range in cost from $1,000 - $6,000 U.S.

Advantages of conducting acoustic surveys include the potential for conducting remote, unmanned surveys, allowing automatic monitoring of bat calls while freeing the observer to perform other tasks. The output of heterodyne, countdown, and time-expansion systems may be recorded to analog compact cassette recorders, digital DAT, CD, or DVD recorders, or directly onto a computer using specialized software. This provides a permanent data record with a time/date stamp. These stored files are available for review at a more convenient time. One of the most debated issues with acoustic surveys is the capability of different units to produce a file that can be analyzed to determine the species of bat making the vocalization. While this is an acquired talent that requires extensive training and experience, it is possible to identify certain species and species. This is particularly true if a reference collection is established for the site from bats captured and released. Extensive discussions of this subject are provided by Pettersson 1993, Rainey 1995, Hayes and Hounihan 1994, Betts 1998, Weller et al. 1998, Barclay 1999, O'Farrell et al. 1999a, O'Farrell et al. 1999b, Vonhoff 2002). Call libraries are available for additional post-collection analysis (see http://sevilleta.unm.edu/~wgannon/batcall).

The cost of ultrasonic detectors and associated hardware and software can be a disadvantage in using these systems. No count data or estimate of abundance is possible from acoustic data. The observer cannot tell the difference between one bat making twenty separate calls and twenty bats making one call each. The equipment has a finite range, typically about 30 feet, for detecting calls. Bats that are closer will be picked up before, and sometimes at the exclusion, of those farther away. Bats that echolocate at higher amplitude will drown out bats that are vocalizing quietly. The detector cannot distinguish whether a bat was flying in or out of a particular mine gate, or if the bat was simply passing by and was not associated with the mine.

There is a steep learning curve associated with both operating the equipment and learning to identify bats to species. Some bat species which are readily identifiable in hand are difficult or impossible to separate using acoustic surveys. Most call libraries are composed of echolocation sounds made during foraging. But bats produce a variety of social and navigational sounds as well (Fenton 1970, Fenton 1985, Thomas and West 1989, Altringham 1996). At present, there are no keys to social sounds of bats. It is likely that bats use navigational rather than foraging signals while navigating through the bars of a bat gate. Foraging signals are probably not used until the bat is well clear of the gate structure. Bat calls detected near mine openings cannot be verified as coming from bats using the mine.

ELECTRONIC EVENT COUNTERS

Electronic event counters consist of a photo-electric beam, typically in the infrared spectrum, coupled with a time/event data logger to count bats (Kucera and Barrett 1993, Rainey 1995). These are essentially the same units that are used in retail stores to signal someone has entered. A wide variety of models are available for different applications. Passive infrared units emit a broad beam that is activated by both temperature and motion. Bats moving through the beam with a surface body temperature at least one degree above ambient temperature would be counted with a time/date stamp. Passive units may also be used to trigger a video camera. These units are effective at distances of 100 feet or more for larger animals. With bats, the useful distance is substantially reduced. However, mine openings typically offer restricted passageways where a passive unit might be effective.

Active infrared monitoring systems use a transmitter and receiver unit to transmit a narrow beam. Bats passing through the beam are counted with a time/date stamp. These units are typically oriented vertically just inside the mine gate. Larger gates may require more units. The sensitivity of these units may be adjusted to minimize the reset time between events. Infrared beams may be transmitted as far as 45 m (150 feet). The TM1550 developed by TrailMaster is specifically designed for monitoring bats and retails for approximately $360 U.S. Those with aptitude in electronics may wish to construct their own infrared photo-electric beams.

Active infrared event counters can be an effective tool for counting bats entering and exiting mines. Infrared event counter systems may be deployed in large numbers in remote settings, such as might be used in pre-gating situations. Battery life is typically three weeks or more depending upon the unit. Commercial units provide a time/date stamp, and have user selectable sensitivity and reset times. These units have rapid download and retrieval capabilities. Many commercial systems have an alarm or trigger mechanism, allowing the observer to activate a camera or other device when the beam is broken.

As with other methods for monitoring, electronic event counters have weaknesses which may bias count estimates. Commercial units cover a relatively small area and may be difficult to align. Sensitivity settings may not be appropriate for situation at a particular site. It is not possible to distinguish in flights from out flights using these units (though some manufacturers have multiple beam systems). Species identification is not possible with electronic event counters alone.

Electronic event counters typically underestimate numbers when bats overwhelm the counter by repeatedly breaking the infrared beam before the unit can reset. Underestimates also result from bats

avoiding the photo-electric beam. Electronic event counters are less effective with large colony sizes where hundreds of bats may exit at one time. Conversely, event counters overestimate the number of bats present when a single individual repeatedly triggers the counter, such as by circling the beam. The author has made numerous observations of bats circling the overhead receivers. These bats may be hearing ultrasonic noises from the event counters, may detect the infrared light, or may be reacting to the presence of a foreign object in an otherwise familiar environment. Bats may require an acclimation period where they require time to be accustomed to the presence of the device in their environment. These units will work either for pre- or post-gating surveys. However, without the gate in place, a restricted opening is required to ensure that bats will pass through rather than around the beam. In addition, the units are accessible and attractive to vandals.

INFRARED VIDEO

$ **Camcorders.** A wide variety of video camcorders are available commercially with the capability of taking still or video images in low light situations using infrared illumination. Digital or analog images are stored on tape media within the camcorder housing or may be transferred to a more conveniently located monitor/recorder system via audio/video cabling. Camcorders are widely available with many models and features to choose from. Most newer units offer digital recording capabilities and titling capabilities including time/date stamps. The cost of these units varies from $350 to $2,000 U.S. with most units in the $600 - $900 range. Nightshot camcorders are made by Sony, Sanyo, Phillips, Jensen, Toshiba, and a number of other manufacturers. Image quality ranges from fair to excellent depending on cost. Supplemental infrared lighting is also available. More sophisticated units offer remote control zoom, tilt, and pan. These camcorders should be mounted on a tripod. As a result, they often end up within the flight path of the bats as they exit, posing a potential disturbance bias. In addition, tape and battery life limitations may require an observer to change tapes and/or batteries every few hours, causing additional disturbance to the bats.

$ **Spy Cams**. A wide array of Aspy cams@ are available commercially including those known as bullet, box, pinhole, and lipstick cameras. These units consist of a small camera lens with cables attached for audio and video output and either AC or 12V DC power. Spy cams do not have recording capabilities. The signal must be transferred offsite to a monitor/recorder system. Spy cams typically do not include an audio output. Spy cams typically cost between $60 and $350 U.S. depending upon the size, shape, and configuration of the camera, the maximum resolution, whether color or black and white, and the number of infrared LEDs provided. Monitors can be as inexpensive as $50. The popularity of recreational vehicles has made DC powered TV/VCR combination units readily available for less than $200. With the addition of a quad or multiplexer unit, signals from numerous cameras can be viewed simultaneously in split screen format or one camera at a time.

Video cameras provide a means for verifying the accuracy of events recorded on infrared event counter and allow observers to monitor bats and their behavior as they fly through the gate. Video tape is a permanent storage method for recording data that allows unlimited review time with pause, rewind, and play back features. The smaller spy cams are ideal for less intrusive camera placement. Spy cams can be mounted on a small tripods and positioned on the ground, behind rocks, or on the rib of the mine for

camouflage. Because the recorder is located away from the mine portal, the observer can change tapes without disturbing the camera setup. Observers may control what video is recorded and what is not by viewing the monitor(s). Wireless transmitters are also available to send audio and video signals up to 400m from the site to reduce disturbance.

Camcorders can be expensive and bulky. Spy cams are comparatively less expensive, are smaller, and more easily camouflaged. Spy cams require additional equipment, and connections that may fail. Camcorders offer more options for trigger by remote devices, but startup time decreases their usefulness. Power up time for camcorders is generally 3-5 seconds, by which time most bats would likely have exited the field of view. Setting the camcorders in pause mode would substantially reduce the power up time, but would require almost as much battery life as recording mode. In addition, most camcorders will automatically power-down after a specified period of inactivity in pause mode. Many Nightshot camcorders offer a video out feature that allows you to cable the signal to another monitor/recorder setup. However, this makes the camcorder little more than a bulky, expensive, high-resolution spy cam.

Limitations of video systems include short tape and battery life and low resolution. Most video tapes are limited to two hours, though this can be extended to six on most systems by switching to a lower resolution, extended play mode. Most Nightshot camcorders offer optional extended life batteries. Battery life can also be extended by cabling a DC power source to a more remote battery. This increases setup time and the possibility of problems, but is desirable because it minimizes the effect of observer presence on exiting bats. Spy cams require far less power and can be run from 12V gel cell batteries or AC power. The availability of AC power at the site greatly increases setup options.

Another limitation of video systems is the field of view. Once a bat has left the camera's field of view, subsequent sightings should be considered different bats unless some unique identification is available. This problem does not occur with portal surveys as observers are free to track individuals in flight. Lighting can also be an issue. Experiment with placement of infrared lighting to prevent washed out or dimly let areas of interest.

Video systems all require an extensive analysis period where observers are required to review tapes to extract pertinent data. Review time is typically at least twice the length of the recordings, and often considerably more. One method for reducing tape review and analysis time requires an observer watch the monitor(s) and take notes in real time. Events of interest can be noted on the data sheets or with a time-event recorder. During review, the list of events can be used to identify what segments of the tape will require additional analysis.

COMBINING METHODOLOGIES

While none of the methods described provides an ideal solution for bat gate monitoring, most methods may be combined to take advantage of the strengths of each. For example, electronic event counters coupled with infrared video provide double counts which can be used to verify the accuracy of the methods used. Portal surveys may be conducted from a distance using spy cams to limit observer effects and disturbance. Using multiple cameras with overlapping fields of view should provide the most

effective coverage.

OTHER PROMISING METHODOLOGIES

Thermal infrared camcorders are now available commercially. These cameras record heat emanating from any object with a body temperature greater than the surrounding environment. Output from the camera appears as isothermic lines, each with its own color. Unfortunately, these devices are very expensive, with costs for even the lowest priced thermal imaging camera beginning at $13,000 U.S.

Passive transponder (PIT) tags are a tiny implantable device that must be attached to or inserted under the skin of the bat. Each tag has a unique identification code that is read by circular reader similar to a bar code wand. As the bat passes through the reader, the PIT tag is identified by the reader and recorded. PIT tags allow for positive identification of individual bats. Using PIT tags, observers should be able to determine when bats use a particular site from year to year. However, readers may not reliably detect bats on every pass, particularly if the bat is oriented in such a way as to block the reader with its body. At present, the largest affordable readers are approximately 0.3m in diameter. In the future, readers may be designed so as to be mounted on a bat compatible gate.

A variety of software programs have been and are being developed to enhance counts made from video applications. These software programs are available commercially, but can be very expensive (see http://www.noldus.com). Several universities are also in the process of developing computer software that will make automated counts of bat colonies from video tape.

Summary

Designing an effective monitoring program requires identification of the questions to be addressed, assumptions made, spatial and temporal scale, and the strengths and limitations of the methodologies used. Conduct pre-gate surveys where possible to document baseline conditions. Where possible, external surveys are preferable due to the inherent dangers associated with entering abandoned mines and the potential for compromising the integrity of the closure. Pre-closure surveys should be conducted for at least one year, including both warm and cold season checks, to establish baseline use levels.

Commonly used methodologies for biological monitoring include: exit counts, alone or enhanced using lights or night vision equipment; infrared event counters; video imaging; and acoustic detectors. Other methodologies being tested include thermal infrared video imaging, radar, and electronic transponders. Care should be taken to select a method with minimal disturbance to the animals being monitored. Table 1 includes a summary of advantages and disadvantages of using each of the methods discussed.

Portal surveys can be among the most cost effective means for biological monitoring, particularly if volunteers are available. However, underestimates may occur when animals are not observed or counted due to inadequate visibility, rapid exit of large numbers of animals, or observer fatigue. Under estimates may also result when observer presence disturbs exiting animals and/or causes a change of behavior. Even when the number of animals exiting is precisely counted, observers have no way of

verifying the accuracy of counts, of knowing if all animals present exited the site, or of determining which species were present.

Capturing bats as they exit is the most effective method for identifying species. However, this method can cause a great deal of stress to the bats and may lead to roo st abandonment and mortality.

Acoustic surveys provide a means for identifying species and may be used in remote, unmanned situations. However, identifying species can be problematic and requires training and experience. Some bats may not vocalize until they are away from the mine portal. It may not be possible to discriminate between vocalizations of bats using the mine and those of passing bats.

Battery-powered infrared event counters are effective for counting animals entering and exiting mines. However, event counters may underestimate numbers when multiple animals trigger the device before it has time to reset or when individuals avoided the beam entirely. Conversely, event counters may overestimate numbers when a single individual repeatedly t riggers the device, such as when bats circle the infrared beam. Remote devices are subject to vandalism, do not distinguish between out flights and in flights, and do not distinguish one species from another.

Infrared video cameras may be used to verify the accuracy of event counters and monitor animal behavior at the site. In some cases in may be possible to permanently mount infrared cameras within the mine to monitor roosts. Limitations of video systems include short tape and battery life and low resolution. Visual data stored on video tape serves as a permanent record which may be retrieved, analyzed, and edited at any time. However, reviewing video data can be very time -intensive without the use of costly electronic video editing tools. As with e vent counters, equipment left at the site may be subject to vandalism.

Literature Cited

Altenbach, J.S. and E.D. Pierson. 1995. The importance of mines to bats: an overview. *In* Riddle, B.R. (ed.). Inactive mines as bat habitat: guidelines for research, s urvey, monitoring, and mine management in Nevada. Biological Resources Research Center, University of Nevada, Reno. 148 pp.

Altenbach, J.S., R.E. Sherwin and P.E. Brown. 2001. Pre -mine closure bat survey and inventory techniques. *In* Vories, K.C. and D. Throgmorton (eds.). Bat conservation and mining: a technical interactive forum. U.S. Department of Interior, Office of Surface Mining, Alton, Illinois and Coal Research Center, Southern Illinois University, Carbondale, Illinois. 293 pp.

Altringham, J.D. 1996. Bats: biology and behavior. Oxford University Press Inc., New York. 262 pp.

Barclay, R. M. R. 1999. Bats are not birds B a cautionary note on using echolocation calls to identify bats: a comment. Journal of Mammal ogy 80:290-296.

Betts, B. J. 1998. Effects of interindividual variation in echolocation calls on identification of big brown and silver-haired bats. Journal of Wildlife Management 62:1003 -1010.

Bogan, M.A. 2000. Western bats and mining. *In* Vories, K.C. and D. Throgmorton (eds.). Bat conservation and mining: a technical interactive forum. U.S. Department of Interior, Office of

Surface Mining, Alton, Illinois and Coal Research Center, Southern Illinois University, Carbondale, Illinois. 293 pp.

Brown, P.E. 1995. Impacts of mining in historic districts and mitigation for impacts on bat populations. *In* Riddle, B.R. (ed.). Inactive mines as bat habitat: guidelines for research, survey, monitoring, and mine management in Nevada. Biological Resourc es Research Center, University of Nevada, Reno. 148 pp.

Brown, C., P.E. Brown, and R.D. Berry. 1995. Abandoned mines as habitat for bats and other wildlife species. *In* Riddle, B.R. (ed.). Inactive mines as bat habitat: guidelines for research, survey, monitoring, and mine management in Nevada. Biological Resources Research Center, University of Nevada, Reno. 148 pp.

Brown, P.E. and R.D. Berry. 1991. Bats: habitat, impacts and mitigation. *In* Issues and technology in the management of impacted wildlife. Pr oceedings, Thorne Ecological Institute, Snowmass, CO. April 8-10, 1991.

Currie, R.R. 2001. An overview of the response of bats to protection efforts. *In* Vories, K.C. and D. Throgmorton (eds.). Bat conservation and mining: a technical interactive forum. U.S. Department of Interior, Office of Surface Mining, Alton, Illinois and Coal Research Center, Southern Illinois University, Carbondale, Illinois. 293 pp.

Fenton, M. B. 1970. A technique for monitoring bat activity with results obtained from different environments in southern Ontario. Canadian Journal of Zoology 48:847 -851.

Fenton, M. B. 1985. Communication in the Chiroptera. Indiana University Press, Bloomington. 161 pp.

Herder, M.J. and J.G. Jackson. 2000. Roost preferences of long -legged myotis in northern Arizona. Transactions of the Western Section of the Wildlife Society 36:1 -7.

Kucera, T.E. and R.H. Barrett. 1993. The Trailmaster camera system for detecting wildlife. Wildlife Society Bulletin 21:505-508.

Kunz, T. H., and C. E. Brock. 1975. A co mparison of mist nets and ultrasonic detectors for monitoring flight activity of bats. Journal of Mammalogy 56:907 -911.

Kunz, T. H., and A. Kurta. 1988. Capture methods and holding devices. *In* T. H. Kunz (ed.). Ecological and Behavioral Methods for the S tudy of Bats. Smithsonian Institution Press, Washington, DC. 533 pp.

Navo, K. 1995. Guidelines for external surveys of mines for bat roosts. *In* Riddle, B.R. (ed.). Inactive mines as bat habitat: guidelines for research, survey, monitoring, and mine managem ent in Nevada. Biological Resources Research Center, University of Nevada, Reno. 148 pp.

Navo, K., J. Sheppard, and T. Ingersoll. 1995. Colorado=s bats/inactive mine project: the use of volunteers in bat conservation. *In* Riddle, B.R. (ed.). Inactive mines as bat habitat: guidelines for research, survey, monitoring, and mine management in Nevada. Biological Resources Research Center, University of Nevada, Reno. 148 pp.

O=Farrell, M. J., B. W. Miller, and W. L. Gannon. 1999a. Qualitative identification of free -flying bats using the Anabat detector. Journal of Mammalogy 80:11 -23.

O=Farrell, M. J., C. Corbel, W. L. Gannon, and B. W . Miller. 1999b. Confronting the Dogma: a reply. Journal of Mammalogy 80:297-302.

O=Shea, T.J. and M.A. Bogan (eds.). 2000. Interim report of the workshop on monitoring trends in

U.S. bat populations: problems and prospects. (Online Interim Report) U.S. Geological Survey, Midcontinent Ecological Science Center, Fort Collins, Colorado, 124pp. (Available at: http://www.mesc.usgs.gov/BPD/ireport.htm).

Pettersson, L. 1993. UltraSound detectors: different techniques, pur posed and methods. Pp. 11-20, *in* K. Kapteyn (ed.) Proceedings of the first European bat detector workshop. Netherlands Bat Research Foundation, Amsterdam.

Rabe, M.J., T.E. Morrell, H. Green, J.C. DeVos Jr., and C.R. Miller. 1998. Characteristics of ponderosa pine snag roosts used by reproductive bats in Northern Arizona. Journal of Wildlife Management 62:612-621.

Rainey, W.E. 1995. Tools for low-disturbance monitoring of bat activity. *In* Riddle, B.R. (ed.). Inactive mines as bat habitat: guidelines for research, survey, monitoring, and mine management in Nevada. Biological Resources Research Center, University of Nevada, Reno. 148 pp.

Sherwin, R.E., J.S. Altenbach, and P.E. Brown. 2001. Methods for determining local mine characteristics of importance to bats. *In* Vories, K.C. and D. Throgmorton (eds.). Bat conservation and mining: a technical interactive forum. U.S. Department of Interior, Office of Surface Mining, Alton, Illinois and Coal Research Center, Southern Illinois University, Carbondale, Illinois. 293 pp.

Thomas, D. W., and R. K. LaVal. 1988. Survey and census methods. Pp. 77 -89 IN T. H. Kunz (ed.). Ecological and Behavioral Methods for the Study of Bats. Smithsonian Institution Press, Washington, DC. 533 pp.

Thomas, D. W., and S. D. West. 1989. Sampling methods for bats. IN A. B. Carey, and L. F. Ruggiero (tech. eds.). Wildlife -Habitat Relationships: Sampling Procedures for Pacific Northwest Vertebrates. U.S. Department of Agriculture, Forest Service, Portland, OR. General Technical Report PNW-GTR-243.

Tidemann, C. R., and D. P. Woodside. 1978. A collapsible bat -trap and a comparison of results obtained with the trap and with mist nets. Australian Wildlife Research 5:355 -362.

Tuttle, M. D. 1974. An improved trap for bats. Journal of Mammalogy 55:475-477.

Tuttle, M.D. 1977. Gating as a means of protecting cave dwelling bats. *In* Aley, T. and D. Rhodes (eds.) National Cave Management Symposium Proceedings, Mountain View, Arkansas. Speleobooks, Albuquerque, New Mexico. 106 pp.

Tuttle, M.D. and D. A.R. Taylor. 1998. Bats and mines. Resource Publication No. 3, Bat Conservation International, Austin, TX.

Vonhoff, M. 2002. Handbook of inventory methods and standard protocols for surveying bats in Alberta. Alberta Environment, Fisheries and Wildlife Management Division, Edmonton, Alberta. 58 pp.

Weller, T. J., V. M. Seidman, and C. J. Zabel. 1998. Assessment of foraging activity using Anabat II: a cautionary note. Bat Research News 39:61-65.

Table 1. Comparison of Advantages and Disadvantages of Gate Monitoring Methods

	Portal Survey	**Capture**	**Acoustic**	**Event Counter**	**IR Video**
Disturb bats or change behavior	May	Yes	No	May	May
Species Identification	No	Yes	May	No	No
Reliability of Estimates	High	No Estimate	No Estimate	Mid-High	Mid-High
Unmanned Setup Possible	No	No	Yes	Yes	Yes
Distinguish In flights from Out flights	Yes	Yes	No	No	Yes
Use Volunteers	Yes	Yes	No	Yes	Yes
Cost	Low	Low-Mid	Mid	Mid	Mid-High
Other Consideration s	Night vision equipment improves survey, adds to cost	Reliability of species identification depends on training	Reliability of species identification depends on training and equipment	Over estimates and under estimates possible	Placement, lighting, battery and tape life issues

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PRE- AND POST-GATE MICROCLIMATE MONITORING

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Abstract

Changes in the physical configuration of a cave or mine, such as entrance size or number, can have profound effects on the interior microclimate. Good gates can protect the fauna and other resources of the site. Poorly designed and located gates can be horribly detrimental to the very things they are supposed to protect. When problems are identified, these poor gates are usually removed immediately and replaced with better designs. In the interim, the resource has been compromised, and bats (if present) may have abandoned the site altogether. While common sense during the design process will help one avoid many potential problems, a good set of baseline environmental data to compare with the post-gating data will clearly show if unacceptable alterations have been made. The wonders of modern technology now offer us lightweight, durable, and (relatively) inexpensive data loggers and other tools to record necessary data. We will cover a variety of monitoring devices and focus on the tools and methods used by the four-year Indiana Bat Hibernacula Temperature Monitoring Project. Examples of altered and restored cave microclimates will be given along with the broad findings of this project.

Existing Microclimate Data

The data we have on the microclimate conditions for roost sites is only representative of a point in time when the measurements were taken. We do not have good studies that would document microclimate conditions as they change over time. The data we do have is typically from a researcher who enters a cave to do a population count taking a thermometer with him and taking the temperature of ambient cave temperatures. We do not know the make of the temperature equipment (or calibration) or where in the cave the temperature was taken or at what height or distance from the walls. At best, you have a rough idea of possible microclimate conditions at the time of the measurement. This is not enough data for good management decisions.

The study of cave microclimates in the United States is in its infancy, and has mostly been limited to the observation of airflow at cave entrances. More in-depth studies have been performed in some European and Australian caves, but rarely to the point of developing a predictive model. How can we quantify the effect change *X* will have on the temperature of the cave? Is this a cave that is suitable for such things as endangered bats? Aren't all caves in a particular area the same temperature? These are the questions cave meteorology hopes to answer.

There have been a few good microclimate studies that have utilized thermocouple probes where data is recorded continuously and feed into computers. But more recently, the availability of small, sturdy, and relatively inexpensive data loggers has allowed us to place these at many locations and at multiple caves. Although not a product endorsement, our experience with the

inexpensive HOBO Pro data logger ($147 for quantities if 10-99 at Onset Computer Corp, http://www.onsetcomp.com) has proven to be fairly reliable in cave conditions and has given us information with good resolution. These data loggers have a large memory capacity (32,645 high resolution measurements) and have an accuracy of 0.2°C. One of the best features of these data loggers is that they may be downloaded and relaunched (at the same parameters as the original launching) while still in the hibernacula by an Onset device called a Shuttle. The shuttle stores data from 7 full HOBO Pros or more from partially full data loggers. The data is then uploaded to a computer later.

Microclimatic Factors

In order to understand the importance of having good microclimate data prior to making management decisions about cave gating, we need to understand a few basic principles about cave microclimate. Cold air is comparatively dense and will sink while warm air is comparatively light and will rise. If you know: (1) the configuration of the cave; (2) the temperature of the outside air compared to the inside air; and (3) where the cave entrances are located, you can begin to predict how and when air will move in the cave system and where warm or cold air traps may exist. Normally the microclimate of a cave will be the mean annual surface temperature of the surrounding area, but in reality it is much more complex. In order to begin understanding the basics of microclimate, one should first read Tuttle and Stevenson (1978), followed by as many of the other papers listed in the Reference section below as are available.

Large complex cave systems with multiple entrances, multiple levels, lots of vertical differences, and varying passages tend to be the most stable in terms of microclimate, but also contain the most microclimate diversity. These complex systems allow use by multiple species that are able to find their peculiar microclimate needs met in some area of the system. By contrast, the simplest caves that consist of a single entrance with a fairly limited void (on the order of tens or hundreds of meters) tends to have little thermal buffering and provide little to no microclimate diversity. The unfortunate thing for bats and other cave dwelling species is that the large complex caves that provide the best habitat for the most species are also the caves that are most likely to attract the most human activity. High levels of human activity encourage commercialization that usually results in cave modification such as: (1) increasing the size of entrances and passages; and (2) adding doors, steps, and walls which negatively affect the airflow and microclimate, resulting in increased adverse impacts on cave-dwelling species.

We can also use this knowledge at a cave site not currently occupied by bats to determine whether or not it is worth protecting, based on its potential usefulness as bat habitat. In other words, there are many caves that should be protected for bats because the habitat is still suitable, but which are not currently considered bat caves. This information also allows us to determine what changes to a cave environment, such as entrance enlargement or plugging of secondary entrances, may have led to its degradation as bat habitat. Note that this only addresses changes in physical parameters of the roost itself, not behavioral impacts like disturbance or exterior impacts like logging. In some cases, we may be able to determine the precise changes that caused the cave to be no longer suitable for bats and undo them.

NABCP Indiana Bat Habitat Study

The rest of this paper will focus on studies done by the North American Bat Conservation Partnership (NABCP) at Indiana bat hibernacula across the range of that species in the United States. The author and Bat Conservation International have coordinated this study. It came about with the release of the Revised Agency Draft of the Indiana Bat Recovery Plan in October 1996 (USFWS 1999). Although the conventional wisdom assumed that since the most important hibernation caves were gated, they were protected, and therefore decline of the species was attributable to some other cause. In actuality, this is not always the case, and in some instances installing bat gates may have the opposite result from that intended (Tuttle and Kennedy 2002). Many caves once utilized by Indiana bats have been modified by commercialization, saltpeter mining, or through recreational cave exploration where cavers have plugged an old entrance, created a new entrance, or enlarged a passage.

In 1998, BCI began a study of Indiana bat hibernacula at 15 sites in 7 States in order to see if we could obtain enough microclimate data (temperature and humidity) to characterize roosts, correlating roost temperatures with population fluctuations. We hoped to determine why the bats have stopped using some sites while continuing to use others, and why some populations declined while others remained stable or even increased. The study grew by 2002 to include more than 30 sites in 10 States. We have been able to clearly group hibernacula into three categories: (1) stable and ideal (temperature ranges between 3 and 6°C year-round); (2) stable and marginal (temperatures 7-10°C year-round); and (3) unstable, with wildly fluctuating temperatures largely dependent on the ambient temperature.

Some form of gate protected most sites. After several years, it became clear that several of the gates were contributing to the decline of the populations at those sites instead of the intended protection. This gave us the opportunity to begin small-scale restoration efforts to re-establish the prior conditions that once attracted bats.

One site we investigated was Great Scott Cave, Missouri, where the Indiana bat population declined by 80 percent in the mid 1980s due to a temperature increase in the cave. The timing of the decline in bat population seemed to coincide with the installation of a bat friendly gate. After we discussed this with Rick Clawson of the Missouri Department of Conservation (MDC), we learned that there was also an upper entrance to the cave. When MDC installed the bat gate in the main entrance they also cemented in the upper entrance to secure it from human entry. From our year-round temperature monitoring data we determined that the upper entrance was essential for the airflow in the cave, allowing warm air to flow out. MDC quickly removed the blocked upper entrance and installed a bat-friendly gate. Resulting air temperatures in the cave immediately dropped approximately 3°C, now well within the range useful for the bats. Bat counts are scheduled for this winter, so it will be interesting to see if the anticipated population increase begins to show.

Saltpetre Cave at Carter Caves State Resort Park in northeastern Kentucky is another example. When we originally visited the park to place data loggers in nearby Bat Cave, a Priority 1 Indiana bat hibernacula, we noticed the interpretive sign that mentioned the cave's cold temperatures.

We did not have much time, but our initial investigation of Saltpetre Cave showed extensive roost stains, mostly obscured by soot and graffiti. The cave has undergone extensive modifications as far back as the early 1800s from saltpeter mining and subsequent tourist development. We were able to place a few data loggers in the cave, which showed an unusually stable but slightly elevated temperature regime. But the extensive staining indicated a formerly large population that had abandoned the roost due to passage and entrance modifications. We contracted with Dr. Neville Michie, one of the world's leading cave microclimatologists, to study the cave climate in greater detail and make specific recommendations for mitigation. We spent an intense week each in the middle of winter (January) and in the middle of summer (July) measuring almost every conceivable aspect of the cave's meteorology in order to develop a geographic and temporal model of the airflow and temperatures in the cave. We also added seven more data loggers in other locations to the three we already had. Part of our work involved tracing air currents with chemical Asmoke@ and measuring air speed with custom-built microanemometers, which were configured to also calculate air volume. From this data, Michie was able to identify several actions that will correct the inadvertent changes to Saltpetre Cave's microclimate, without impacting the tourism or historic artifacts there. Actual work was delayed until a variety of State approvals were gained and is now scheduled for spring 2003. Combined with the winter closures, Saltpetre Cave will likely regain a large percentage of its former population, returning from a stable-marginal roost to a stable-ideal roost. Nearby Bat Cave, on the other hand, is an unstable-fluctuating roost, and is probably used by the bats only as a last refuge after being driven from Saltpetre. If our hypotheses are correct, we have been protecting the wrong cave all along.

We have been actively trying to restore other sites as well. At Coach Cave in central Kentucky, the Kentucky Department of Fish and Wildlife Resources built a rock-and-concrete Aair dam@ and the main entrance to re-create the original entrance sinkhole contour and slow the flow of cold air from the cave. While temperatures have already begun to drop in this 3.4 mile cave system, high humidity is still a problem. Condensation is seen directly on the roost stains and gypsum flowers, a type of speleothem. This is not normal, as Indiana bats do not use damp roosts, nor does gypsum form in a high-moisture environment (it is water-soluble). During the summer of 2002, an artificial upper entrance to the cave was sealed, hopefully preventing more of the warm moist air from entering the cave and condensing on the cool walls. Perhaps this will finally restore the cave to its natural, historic conditions. If not, we'll try something else. Coach Cave is the former home to over 100,000 Indiana bats, which totally abandoned the site as a result of the changes from the short-lived commercialization.

A similar project is being planned for Wyandotte Cave in Indiana, where excavation of the main entrance area for tourists has resulted in a slight increase in the otherwise stable and suitable cave temperatures.

Mammoth Cave, Kentucky, has a problem similar to Saltpetre Cave, but on a much larger scale (346.01 miles of passage and over 30 entrances, compared to 1.86 miles of passage and 6 entrances). Multiple changes from early saltpeter mining and development from tourism, including the excavation on several new entrances, have increased the temperature and humidity in this cave system. The National Park Service has already retrofitted the artificial entrances with

airlocks and experimented with various remedies for the natural entrances. However, the sheer size of the cave makes it more difficult to judge the effect of individual changes. New evidence discovered in the past few years (Toomey et. al 2002) give us hope that the cave may once again be home for the millions of bats that once roosted there every winter (Tuttle 1997).

Conclusion

In order to restore altered microclimates to hibernacula, one needs to know about the prior conditions. However, we rarely have this luxury, and must rely on circumstantial evidence, particularly at sites presently abandoned by bats. The key to intelligent tinkering, to paraphrase Aldo Leopold, is to not do anything drastic that you can't undo. Microclimate modeling is an important tool for roost characterization, which should lead to prioritization for protection or restoration. Remember that sites "with bats" are not necessarily the best sites "for bats."

Reference

de Freitas, C. R. and R. Littlejohn. 1987. Cave climate: assessment of heat and moisture exchange. International journal of climatology: a journal of the Royal Meteorological Society 7:553 - 569.

Forbes, J. 1998. Air temperature and relative humidity study: Torgac Cave, New Mexico. Journal of Cave and Karst Studies 60(1):27-32.

Gamble, D.W., J. T. Dogwiler, and J. Mylroie. 2000. Field assessment of the microclimatology of tropical flank margin caves. Climate Research 16:37-50.

Gates, J. E., G. A. Feldhamer, L. A. Griffith, and R. A. Raesly. 1984. Status of cave-dwelling bats in Maryland: importance of marginal habitats. Wildlife Society Bulletin 12162-169.

Halbert, E. and Michie, N. 1979. Meteorological behavior in the North Deep Creek, East Deep Creek and Eagles Nest Systems at Yarrangobilly, part II. Journal of the Sydney Speleological Society 16(12):336-341.

Hall, L. S. 1982. The effect of cave microclimate on winter roosting behavior in the bat, *Miniopterus schreibersii blepotis*. Australian Journal of Ecology 7:129-136.

Kuipers, B. and S. Daan. 1970. Internal migrations of hibernating bats B response to seasonal variation in cave microclimate. Bijdragen tot de Dierkunde 40(1):51-55.

Michie, N. A. 2000. Investigation of physical processes and bat requirements in bat caves. 2000 Australian Bat Society conference, Maitland, NSW.

Nepstad, J. and J. Pisarowicz. 1989. Wind Cave, South Dakota B temperature and humidity variations. National Speleological Society Bulletin 51(2):125-128.

Olson, R. 1996. This old cave B the ecological restoration of the Historic Entrance ecotone of Mammoth Cave, and mitigation of visitor impact. Pp. 87-95, *in* Proceedings of the fifth annual Mammoth Cave Science Conference, Mammoth Cave, Kentucky. National Park Service and Cave Research Foundation.

Pflitsch, A., J. Piasecki, and M. Kleeberger. 2001. Impact of tourists on the climate of static cave systems. Proceedings of the 15th International Congress of Biometeorology & International Conference on Urban Climatology, Sydney, Australia. Available at http//www.geographie.ruhr-uni-bochum.de/agklima/1pflitsch/cave1.htm

Pflitsch, A., J. Piasecki, and M. Kleeberger. 2001. Impact of tourists on air and rock

temperature in static cave systems. Proceedings of the 15th International Congress of Biometeorology & International Conference on Urban Climatology, Sydney, Australia. Available at http//www.geographie.ruhr-uni-bochum.de/agklima/1pflitsch/cave2.pdf

Postawa, T. 2000. A cave microclimate as modeled by external climatic conditions and its effect on a hibernating bat assemblage B a case of the Jaskinia Pod Sokila Góra cave. Pp. 199-218, *in* Proc. VIIIth EBRS, vol. 1, Approaches to Biogeography and Ecology of Bats (B. W. Woloszyn, ed.).

Raesly, R. L. and J. E. Gates. 1986. Winter habitat selection by north temperate cave bats. American Midland Naturalist 118(1):15-31.

Toomey, R. S., III, M. L. Colburn, and R. A. Olson. 2002. Paleontological evaluation of use of caves: a tool for restoration of roosts. *In* The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Tuttle, M. and D. E. Stevenson. 1978. Variation in the cave environment and its biological implications. Pp. 108-121, *in* 1997 National Cave Management Symposium Proceedings (R. Zuber, J. Chester, S. Gilbert, and D. Rhodes, eds.). Adobe Press, Albuquerque, New Mexico. 140 pp.

Tuttle, M. D. 1997. A Mammoth discovery. Bats 15(4):3-5.

Tuttle, M. D., and J. Kennedy. 2002. Thermal requirements during hibernation. *In* The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Twente, J. W., Jr. 1955. Some aspects of habitat selection and other behavior of cavern-dwelling bats. Ecology 36(4):706-732.

USFWS. 1999. Agency draft Indiana Bat (*Myotis sodalis*) revised recovery plan. Fort Snelling, Minnesota. 53 pp.

Wigley, T. M. L. 1969. Cave microclimate B a note on moisture. Helictite 7:43-49.

Worrell, D. J. 1971. Diurnal temperature variations within Rift Cave, Buckfastleigh [Devon]: a study in cave microclimate. Studies in Speleology 8:11 - 37.

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CLOSURE REPAIR AND MAINTENANCE

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Abstract

For abandoned mine safety programs to be successful on a long -term basis, they should include a plan for monitoring safety closures and conducting repairs when problems are encountered. Those closures installed to control human access to mines while allowing bat ingress and egress are particularly susceptible to vandalism and natural weathering. As such, the y should be periodically monitored for structural integrity and assurance that the original intent of the closure is still being met. A specific schedule of monitoring should be established for each closure installed, taking into account the accessibility of the site, the degree of hazard exposure if the closure is breached, and the resources available. Volunteers, landowners, and land management agencies should not be overlooked when assessing personnel resources.

A policy for addressing repairs discove red during monitoring activities should also be established. That policy will need to balance the resources available (time, money, people) to conduct repairs, the likelihood of the repairs being effective on a long -term basis, and the liability exposure of the landowner. Ideally, a closure should be expected to have a life span of several decades. Using materials designed to withstand natural weathering forces should be encouraged with no materials requiring periodic painting. Maintenance of closures s hould be addressed at the time of closure design.

Introduction

This isn't rocket science. Put in a closure, visit routinely to make sure it is intact, and fix if necessary. Any questions?

From our program's standpoint, we deal with installation of saf eguards at abandoned mines that have been shown to have some utility as bat habitat. We install the safeguards to primarily prevent entry of people into hazardous mine areas/situations but use bat friendly designs to accommodate bat ingress and egress at bat habitat sites. As such, our primary concern is maintaining the closure for safety purposes. If it is breached, bats will still be able to go in and out as usual but humans will now be exposed to the hazardous conditions. There is a need to assure th at the safeguard remains intact. That means someone must periodically visit the site to see if the closure is still functioning as intended. Therefore we need to establish a monitoring plan to include who will visit, when or how often, what types of info rmation will be reported, and how the information will be used and managed.

Who should Monitor

TheWho (not the rock group)? The most appropriate people to monitor sites are those who were responsible for the original installation. They are most familia r with the location and how to access it and often have built special relationships with the landowners. That original project manager is also most familiar with how the closure was installed and can most easily recognize any variation from that original condition. Another appropriate monitoring inspector is the landowner. Whether on public or

private land, they have a vested interest in seeing that the closure is still functional. They do have the ultimate liability. In Colorado, when we obtain permission to carry out the reclamation work, we have the landowner sign a written consent to allow the work to take place. That consent also reiterates a State statute reminding the landowner that it is his responsibility to safeguard the mine opening. We specifically state that the landowner is responsible for the continual upkeep of the closure. Our practice, however, is that we often repair closures that have been subject to vandalism or other problems. A third type of monitor is the volunteer. Our State Division of Wildlife enlists volunteers to help assess sites for bats before reclamation work is done and uses them to evaluate post-gate use by bats at some sites. They could also be enlisted for monitoring the physical conditions of the safeguards at other sites.

Monitoring Frequency

When or how often? A number of factors figure into the frequency of site monitoring. A specific schedule of monitoring should be established for each closure installed, taking into account the accessibility of the site, the degree of hazard exposure if the closure is breached, and the resources available. It is likely that the more accessible sites receive public visitation and are more susceptible to vandalism than remote sites. These should be monitored at least annually. If a site showed evidence of high visitation before closure, it will likely continue to be visited. Those earlier visitors may also be upset that "their" favorite mine is closed and may try to break in. Again, annual or more frequent visits are called for. Sometimes the very visible or accessible sites will require the least monitoring. These sites are those in people's backyards where access is controlled and trespassers are obvious. If access to the general area is controlled by gates or other barriers, there may be less need to monitor the site frequently. Constantly visited areas where there is a lot of public visibility sometimes helps control vandalism. Another factor is the condition of the material surrounding the closure. Gates installed in unweathered granite are more competently anchored than those installed in exposed, slaking coal, or shale and will be less likely to require inspection and maintenance due to natural weathering conditions. If staff people are to be used for monitoring, their availability in conjunction with other duties is a factor. The amount of time necessary to monitor each site factoring in remoteness and seasonal accessibility. Another consideration is the degree of hazard that would be encountered if the closure were breached.

Monitoring Information

What types of information will be reported? When monitoring a site, appropriate and adequate information should be collected and reported to satisfy everyone's needs. Among the information to be collected is: condition of the closure/gate (is it still functioning to keep people out of the mine while still allowing free ingress and egress of bats, does the gate show signs of deterioration of the materials used – corrosion primarily – or of the anchoring to the surrounding bedrock, has there been collapsing of the mine that effects the gate or the ability of bats to use it, are there signs of attempted or successful vandalism, was construction technique, materials, and design effective on a long-term basis), is there evidence of human visitation at the site, is the condition of the mine as can be seen from outside the closure the same as when it was installed (level of any water or drainage, roof falls, ventilation), location information should also be confirmed to assist in future monitoring of the opening (this might include the condition and location of trails and/or roads providing access, updated GPS location information, any new construction or buildings nearby, and updated narrative descriptions of how to locate the site), and the date of monitoring and name of the person which is often helpful later on.

Management of Monitoring Data

How will the information be used and managed? It is important to organize the information gathered in a systematic fashion. A database allowing periodic updating, querying, and reporting should be developed. This would allow for checking when a site was last monitored, if any problems were encountered, and, if so, whether they were fixed. Over time this could be used to evaluate the effectiveness of various closure designs and construction techniques.

A policy for addressing repairs discovered during monitoring activities should also be established. That policy will need to balance the resources available (time, money, people) to conduct repairs, the likelihood of the repairs being effective on a long-term basis, and the liability exposure of the landowner. If the closure program is affluent and has abundant staff who have time on their hands, then they may be able to afford to continually repair bat gates that are frequently vandalized. Programs with more limited resources will either look to other people to fund and carry out these repairs or make repairs that will not require further maintenance. The Colorado Inactive Mine Reclamation Program has a "one strike and you're out" policy with respect to all steel (grates, gates, doors) closures at abandoned coalmines. If one of these closures is breached, the opening is safeguarded with a non-removable, permanent, maintenance-free technique. This usually means backfilling the portal or shaft. We have established this policy because of our past experience with steel closures in abandoned coalmines and the tragic aftermath of having them breached. To date, none of them have involved bat gates.

Maintenance of closures should be addressed at the time of closure design as much as possible. Ideally, a closure should have a life span of several decades. Using materials designed to withstand vandalism and natural weathering forces should be encouraged with no materials requiring periodic painting or upkeep. Although there are some very tough materials and designs available (manganal steel, rectangular tubes, angle iron, etc.), there are also some very determined individuals who think closures are installed to protect the "treasure" within the mine. Never underestimate a vandal. If they want to breach a gate, they will find the equipment and a way.

Conclusion

Therefore, back to the beginning …….put in a closure, visit routinely to make sure it is intact, and fix if necessary. Any questions?

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POLICIES, MANAGEMENT, AND MONITORING: PROTECTION OF HABITAT UNSING BAT GATES

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Abstract

Bat gates are used to protect a wide variety of habitat "structures" including mines, caves, and cave-like features such as concrete tunnels and abandoned military bunkers. Laws intended to preserve cave resources, historic features, or wildlife may apply to these sites. Bat gates are used as a method of keeping people away from either sensitive resources or dangerous situations.

The Federal Cave Resources Protection Act of 1988 deems the location of caves on lands administered by the departments of Interior and Agriculture as confidential. Location information may not be made public unless the *"secretary"* determines that disclosure of the location would not *"create a substantial risk of harm, theft, or destruction of cave resources."* Other acts establish restrictions for location disclosure of cultural and historic sites, endangered species, and some paleontological resources. Generally, the locations of these sites are exempt from disclosure under the Freedom of Information Act.

Whenever possible, gated sites should not be shown on maps or discussed in publications that would draw public attention and interest. Some sensitive caves are gated: (1) to control entry; (2) allow entry only during certain times of the year, or (3) under special permit. Some mines: (1) pose a threat to the public; (2) may still be active, or (3) be under valid mineral claim. The manag ement of these sites may require special gates that can be easily opened during operations and then closed afterwards.

The location of all mines and caves should be inventoried and the locations recorded for future reference and monitoring. A number of i nventory strategies are currently being used which collect various geological and environmental data. This data is invaluable when determining priority for habitat protection or closures for public safety. GIS systems are now in common use by most agenci es and provide a convenient repository for this data. Making this information available to the public must take into account confidentiality provisions of Federal law.

Gates should be routinely monitored for evidence of forced entry. Many gates are located in remote areas, seldom patrolled by law enforcement, and in places where sophisticated electronic monitors are of little use. Each gate should be visited on a regular basis. If gates are found damaged, they should be repaired as soon as possible and reinforced if necessary. Regular monitoring and repair reduces agency or landowner liability if an accident were to take place and reduces the risk of resource damage.

Introduction

Bat gates are used to protect a wide variety of habitat "structures" including mines, caves, and cave-like features such as concrete tunnels and abandoned military bunkers. Laws intended to preserve cave resources, historic features, or wildlife may apply to these sites. Bat gates are used as a method of keeping people away from either sensitive resources or dangerous situations.

Determination of Significance

Federal agencies are required by the Federal Cave Resources Protection Act of 1988 to manage Federal lands in a manner which protects and maintains, to the extent practical, significant caves. Caves are deemed significant if they meet the criteria of having biological, cultural, geological/mineralogic/paleontologic, hydrologic, recreational, educational or scientific components. Virtually all Federal caves meet the criteria and are protected under the law.

Any cave located within a special management area, designated wholly or in part due to cave resources found therein, shall also be determined significant. This last category includes such areas as national monuments, special areas, research natural areas, or other areas of special interest. For the Department of Interior, any cave found within an area managed by the National Park Service, is automatically determined to be significant.

Significant caves are to be managed in a manner that protects and maintains their values, in accordance with the Act, the Code of Federal Regulations, and agency policy.

While cave protection laws apply only to natural caves, many wildlife protection laws apply to other habitats where bats are found. Federal laws provide penalties for harassment and vandalism of wildlife on public lands. Similar laws are found in many States, and apply to all lands within the jurisdiction. Since State laws vary, one should become aware of their state laws before engaging in the study or manage bat habitat. Some States require special permits or certification for the capture or handling of bats.

Purposes of the FCRPA

The Federal Cave Resources Protection Act has two purposes. The first is "to secure, protect, and preserve significant caves on Federal lands for the perpetual use, enjoyment and benefit of all people." For this to take place it is necessary to evaluate the resource values then determine long-term management goals. For example, caves with special resource values might be protected, while capable of withstanding recreational use might be developed for directed access or remain open for "wild caving."

The second purpose of the Act is "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 Act discusses the handling of confidential information concerning the nature and location of significant caves. In general, information concerning the specific location of any significant cave may not be made available to the public under Section 552 of Title 5, United States Code (Freedom of Information Act), unless the Secretary of Agriculture determines that disclosure of such information would further the purposes of the Act and would not create a substantial risk of harm, theft, or destruction of a significant cave. Other acts establish restrictions for location disclosure of cultural and historic sites, endangered species, and some palentological resources. Generally, the locations of these sites are also exempt from disclosure under the Freedom of Information Act.

No caves should be shown on maps or in publications unless they are developed for public access, and a determination has been made that disclosure of their locations is in compliance with FCRPA. Even though significant cave locations can't be disclosed to the public, there are generally few, if any restrictions, to visiting a significant cave. The exception is where caves have been gated, or access otherwise restricted for the protection of cave resources. Most National Park Service managed areas have restrictions on cave visitation, or require special entry permits.

Some sensitive caves are gated to control entry, allow human entry only during certain times of the year, or under special circumstances.

Some mines pose a threat to public safety, are still be active, or may be under valid mineral claims. The management of these sites may require special gates that can be easily opened during operations, and then closed afterwards.

The location of all mines and caves should be inventoried and the locations recorded for future reference and monitoring. A number of inventory strategies are currently being used which collect geophysical and environmental data. This data is invaluable when determining priority for habitat protection or closures for public safety. GIS systems are now in common use by most agencies and provide a convenient repository for this information. Making this data available to the public must take into account confidentiality provisions of Federal law.

Why Bats?

Man-made openings, such as tunnels and mines, frequently provide suitable bat habitat. In the United States, bats have been found inhabiting concrete bunkers built as military coastal fortifications, and even in concrete access tunnels of abandoned nuclear reactors. It is now recognized that bats will utilize nearly any man-made structure that approximates their natural habitats.

Temperature, humidity, and airflow control suitability of underground habitats. Air movement is the most important of these and has best been extensively studied in caves. The same principals of air flow, cold traps, and warm air accumulation apply to <u>all</u> underground habitats, and control their suitability for bats. When examining a site for bat suitability, this concept should be kept in mind.

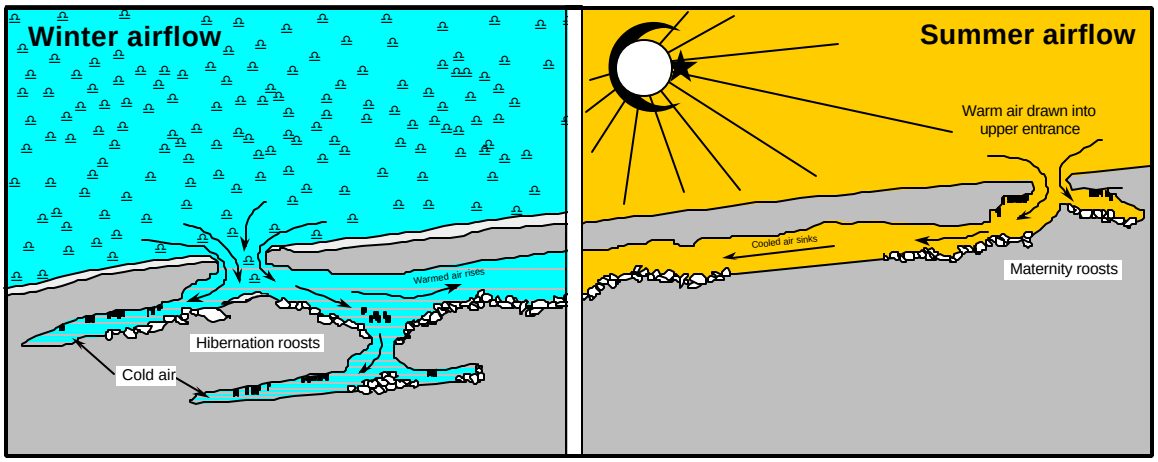
Natural processes which affect cave and mine microclimates are well documented . It should be noted however, that no two caves, or mines, are alike. Temperature, humidity, air movement, and passage configuration interact to create unique habitats. For this reason, it is important to inventory each cave or mine separately, analyze the conditions creating suitable habitat, and avoid generalizations of bat protection needs.

Roost Geomorphology and Bat Habitat

Bats have specific environmental needs for roosting, rearing young, and hibernation. By understanding how air moves through caves and mines at different seasons, it is possible to predict bat usage. Contrary to popular belief, underground temperatures are almost never stable. This is good for bats, since they have differing temperature and humidity needs at different times during their annual cycle.

Gravity, and differences in air density, cause strong air movement when a cave or mine has two or more entrances at different elevations. For example, consider a simple cave with an upslope and down slope entrance. On hot summer days, cool cave air, being more dense than warm outside air, settles toward the lower entrance. The cool air pours from the opening rustling leaves on nearby bushes and trees. Into the upper entrance is drawn warm outside air. As this air is pulled eve r deeper into the cave it is cooled by the walls, continuing the process.

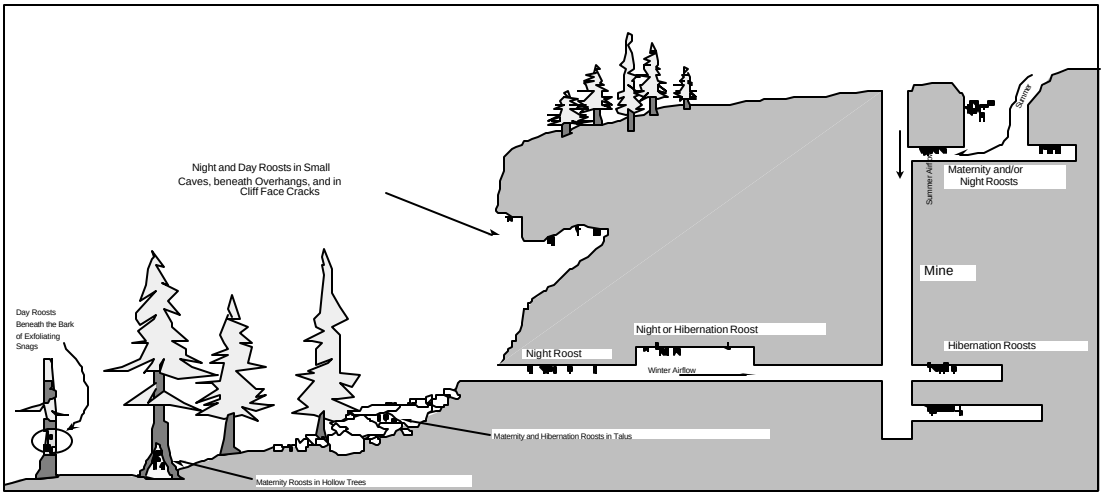
In the winter, when the underground air is warmer than that outside, it rises like smoke up a chimney. It rises as a warm moist column from the upper portal. This upward air movement is sometimes called a "chimney effect" and in the summer a "reverse chimney effect."



Other caves, particularly ones with large deep entrances, become cold traps in the winter. During cold weather, warm cave air is displaced by cold outside air t hat flows in along the floor. As the cold air accumulates, it cools the cave walls, and eventually causes the cave to assume the surface temperature. Caves with north or east -facing entrances are particularly prone to winter cooling. Once cold air has s ettled to a low point in a cave or

mine, it may take months of warm summer weather to gradually warm, if it does so at all. These cold caves are of particular importance to Townsend's big-eared bats for hibernation in the western United States.

Lava tubes with thin roofs are sometimes warmed by radiant energy from the sun, much like concrete bridge decks are warmed. These caves may provide suitable habitat maternity colonies. One of the largest *Coreorhinus* maternity colonies in Southwest Washington is found in a power line right-of-way clearing, where the sun strikes the ground during most daylight hours.



Typical Bat Roosts found in Mine and Forest Habitats

Air and Water Flow Dynamics

Alterations to the entrances, air flow dynamics, and water flow dynamics of caves can have serious implications on internal cave climate (Poulson 1975, Scharpf and Dobler 1985). Removal of vegetation in or around cave or mine entrances can alter ultraviolet light levels and change temperatures underground. More light may enter an entrance if vegetation is removed that can enlarge the twilight zone and decrease the dark zone, thus upsetting the balance between twilight and dark zone users (Scharpf and Dobler 1985).

Water often distributes organic material in caves and mines. Alterations in surface hydrology, particularly diversion of water underground, may alter atmospheric quality. Large accumulations of organic materials underground, combined with limited air movement, can cause increased levels of CO_2, which may affect the ability of bats to utilize certain habitats.

Monitoring mine temperature and humidity can be used to identify areas of suitable bat habitat.

Cave and Mine Entrance Zones

Cave and mine entrances are both sensitive and critical to underground ecosystems. Entrances are a focus of biological activity that contributes nutrients to deep cave organisms. The moderating effect of warm moist air creates microenvironments that promote growth and occupation by unusual plants and animals. It is common, for example, to find plants and animals inhabiting cave entrances that are otherwise hundreds of miles outside their normal range (Nieland, James R.). When contemplating activities for the protection of bats, it is important to remember that other resource values are involved.

Vegetation surrounding entrances helps maintain environmental conditions needed by many other animals besides bats. Shading and protection from strong winds, provided by trees, may be essential for maintaining temperature and humidity regimes necessar y for bats. Vegetation surrounding roost entrances may also provide protection form predation.

Surveys

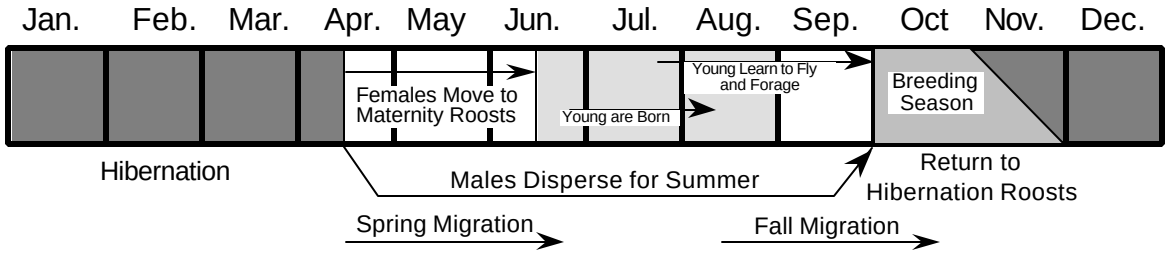
When surveying for bat use, protection of the colony is of utmost priority. Surveys must be done at the correct time of year and should emphasize non -invasive techniques. Most bat species are highly sensitive to disturbance, particularly at maternity sites. A single disturbance at a maternity site, if the females feel threatened, can cause abandonment of the roost and loss of that year's reproduction.

Looking for evidence of bat use at a mine portal

Guano is found where bats have been night roosting in the porta

Timing

Each potential roost site should be surveyed over a complete yearly cycle. Survey months are December-January for hibernation use, and mid-July to mid-August for maternity or day roosting. December and January surveys minimize disturbance because both sexes are in deep torpor and the reproductive activity is at a minimum. If weather is more mild than usual, entry into deep t orpor by males and some females may be delayed. It is not uncommon for low levels of activity to continue throughout the winter, particularly during warm spells, when the bats may briefly emerge from torpor. Summer surveys are designed to locate maternit y and male roost sites. In all cases, be certain to use recommended techniques to lessen disturbance and reduce the probability of abandonment of the roost site (Perkins, Mark J.).



Shown above is the yearly cycle followed by Townsend's big-eared bats in the Pacific Northwest.

Maternity Roosts

A maternity colony of bats consists of females (which may be pregnant or have young), and sometimes juveniles (May 15-September 15). The critical time for a maternity colony is after the birth of the young. For approximately 4-6 weeks, the young are non-volant and totally dependent on their mothers for nourishment. Disturbance at the roost can cause the females to abandon the roost, leaving the young to die of starvation. Disturbance can also cause young to detach from the ceiling and fall to the floor of the cave or mine. Once this occurs, the young are likely to die from starvation or predation. The female will not recover a young that has fallen (Noel, Debra C., 1993.

Hibernacula

A hibernaculum consists of a colony of bats that hibernate during the winter months. When bats hibernate, they lower their metabolism to a point that a minimum amount of energy from stored fat is required. If a disturbance causes a bat to flee, it must first increase its metabolism and body temperature. This utilizes stored fat that would otherwise be used for minimal metabolic functions. Some researchers estimate that as much as 10 percent of body fat may be consumed during each arousal. If 50-70 percent of total stored fat is needed for survival, it's apparent that hibernating bats can tolerate only a limited number of disturbances. It is common for bats to arouse from torpor, fly around briefly, then resume hibernation. These arousals may be initiated by fluctuations in temperature or humidity, or other biological triggers.

Surveys to determine bat use require special training and expertise. Please refer to the other papers presented as a part of this symposium for guidance.

Roost Protection

CAVE AND MINE GATES

Clearly, the single greatest threat to bats is human disturbance. This can come from recreational use, intentional harassment, or the closing of cave or mine entrances for safety or liability reasons.

Caves and mines are often perceived as a safety hazard or a liability risk. As a result, mining companies, agencies, or private landowners often seal a cave or mine by blasting, back filling, or gating (Belwood, 1991).

Many of these closure methods alter airflow, change underground temperature and humidity, and may block the ingress or egress of cave or mine dwelling animals (Tuttle and Stevenson, 1977). Incidents of adverse effects from cave or mine closures include the entombment of 20,000 little brown bats in New Jersey (they were later rescued), and an incident in Wisconsin in which approximately a quarter million little brown bats were nearly fumigated (Belwood, 1991).

The most acceptable method of restricting access is through the use of bat gates. Bat gates are usually constructed of horizontal angle iron bars and welded to support posts. Bars are spaced at (5 3/4 inches), wide enough for bat passage, but narrow enough to block humans. Building gates is expensive and can create unwanted impacts if improperly placed.

Gating is considered a serious undertaking and should only be done when less impacting alternatives are unworkable or have failed. (Alternative techniques include seasonal closures and signing, public education, limiting road access, and non-disclosure of cave locations.) The decision to gate a cave or mine should be made only after careful analysis and monitoring for bat use.

The survey plan should establish baseline levels of bat use of the site prior to habitat management. After the gate is installed, bat accept ance of the gate should be monitored over the next several seasons.

GATE PLACEMENT

Before placing a bat gate, the impact of gate construction on other values must be assessed. For example, it would be inappropriate to excavate for a gate if an archaeological site were to be disturbed or delicate formations or paleontological deposits would be damaged. In most cases adverse impacts can be mitigated, but only if a careful inventory is completed first.

A valid use of caves is for recreational use. The lev el of this activity is often based on a cave's location, ease of access, and how well it is known to the public. Discouraging recreational use of a popular cave is very difficult and gating such a site without prior public involvement may encourage force d entry attempts. Gating a popular cave is a serious undertaking and should be proposed only when it is biologically necessary.

Frequently only a portion of a large cave is used by bats. If recreational use is taking place in the cave, it may be possibl e to restrict access to a portion of the cave, leaving the remainder open to recreational use. Many caves are only used as maternity or hibernation sites. Outside these critical times, the bats may move to other locations. If this is the case, it may be possible to have the cave closed during critical times of the year but open for recreational use at other times. Seasonal closures may be a workable alternative and generate greater acceptance from the public.

The locations selected for placement of gate s will determine both their effectiveness and acceptance by bats. Gates should ideally be placed near the edge of the dark zone, in order to reduce the chances of predation. Gates should be placed in spots that don't restrict airflow. Constricted openin gs should be avoided, in favor of areas of larger cross section. The gate should not restrict airflow more than the smallest passage cross section in the vicinity.

When contemplating a gate, remember to consider other wildlife that may be using the mine beside bats. Most small animals can easily pass through the gate, but some larger animals may be blocked. Some mines and caves are used by desert tortoise, while other may provide habitat for cougars or bobcats. When larger animals are present, some fle xibility in locating the gate may be necessary.

Gates must be constructed to allow access to the cave or mine for monitoring. Current bat gate designs include an access doors or removable bars. The door opening is usually kept small but scaled to allow a stretcher to pass though in the event of an accident.

The American Cave Conservation Association bat gate designs have been used successfully in hundreds of locations to protect bat colonies. They features four - inch flange angle-iron bars spaced 5 3/4 inches apart and hung on vertical supports. The supports can be placed up to fifteen-feet apart, providing wide horizontal openings for bat passage. New design modifications include "half - gates" with open fly space over the top and unique "bat -chutes" (large windows which allow bats to fly through, but screened on the sides so people can't enter).

If the cave has a stream entering the entrance, or if the entrance is narrow and funnel shaped, debris could accumulate against the gate. The gate should be placed in a position that prevents twigs and leave from piling up and turning the gate into a barrier. Organic materials should be allowed to enter the cave in a natural manner, since they are important to deep-cave biota as a food source.

SIGNING

All gates should be accompanied by a sign explaining the reason the cave or mine closure, any seasonal use that may be allowed, and a source for further information. Every effort should be made to inform users of the importance of the closure, and solicit their cooperation.

Every effort should be made to inform users of the importance of the closure, and solicit their cooperation (Nieland, 1995).

CONSTRUCTION TIMING

Gate construction should be timed when bats are absent. Construction creates noise, fumes, and increased traffic, all of which can create disturbance. Welding creates clouds of fume that may disturb bats. If disturbing bats by fumes seems unavoidable, consider installing a temporary "air dam" across the passage using plastic sheeting held aga inst the ceiling with lengths of wood. At the end of the day, the screen can be dropped allowing normal evening bat passage.

MONITORING

Gates should be routinely monitored for evidence of forced entry. Many are located in remote areas, seldom patrolled by law enforcement, and where sophisticated electronic monitors are of little use. Each gate should be visited on a regular basis. If gates are found damaged, they should be repaired as soon as possible, and reinforced if necessary. Regular monitoring, and repair, reduces agency or landowner liability if an accident were to take place and reduces the risk

of resource damage. Signs should be checked for damage and replaced if worn or vandalized.

Vandals knocked this sign down at McDowell Cave in Missouri. Sometimes it is better to place the sign behind the gate where it is out of reach.

Monitoring of bat use is important to determining the effectiveness of gating. The least disturbing method is to conduct an exit count at the entrance to the roost. This method is only valid during the season when the bats are active and under acceptable weather conditions. All potential entrances to the roost must be observed simultaneously. The observers should be stationed so as not to block or disturb the bats up on their emergence (Kingsley et al, 1991).

Back-lighting the emergence with the western sky allows the bats to be silhouetted as they exit. If this is not possible, place a white sheet near the entrance to enhance visibility as the bats emerge. Night vi sion equipment with an infrared light source can also be used. White or red filtered lights should never be directed into the entrance. However, a low-intensity white light placed above the entrance and shining away from it may be used (Kingsley et al, 1 991).

In the summer, roost entrances should be monitored from a half hour prior to dusk until the emergence activity has waned.

Surface Activities

Logging, road building, mining, slash disposal, and water diversion may create adverse impacts to roost habitats. Surface activities may create changes in microclimate and affect suitability for bat occupation.

The following mitigations may help prevent damage to roost habitats:

- Limit use of heavy equipment above or in the vicinity of the roost or over the course of a cave or mine, if there is potential for damage.
- Retain of vegetation in the vicinity of a roost site to protect the entrance micro environment.
- Avoid alteration of entrances or their use as disposal sites for slash, spoils, or other refuse.
- Limit management activities near a roost site when the site is occupied by bats.
- Avoid diversion of surface drainage into mines or caves.
- Avoid blasting within 1/4 mile of roost sites when occupied by bats.

PHYSICAL DISTURBANCE

Caves share with other discrete habitats a vulnerability to trampling and physical disturbance and have a much lower human carrying capacity than most surface environments. Small passages suffer greater disturbance than large passages because a greater percentage of small passage area is affected. Besides bats, woodrats and pikas will abandon caves if disturbed. (Senger and Crawford 1984).

ROAD CONSTRUCTION

Roads can cause siltation when constructed near caves (Aley and Aley 1984). Roads have been constructed directly over lava tube caves with thin ceilings that are disruptive to cave inhabitants (Scharpf and Dobler 1985). A cave in San Juan County, Washington, was broken into during road construction. In addition to being directly damaged, the cave was then used for ditch drainage that introduced road oil and sediment into the cave (Nieland 1985). Similar instances have occurred on the Gifford Pinchot National Forest, the Modoc National Forest, and the Deschutes National Forest. Breaking through cave or mine roofs, can cause changes in temperature, airflow, and humidity that may adversely impact bats.

Road construction that poses no direct danger to caves or mines may, nevertheless, pose an inadvertent threat. Roads constructed for timber harvest and other reasons may make secluded caves more accessible to the public that may increase the chance for human disturbance (Scharpf and Dobler 1985).

CLIMATE

Any activity that affects the climatic quality of a cave or mine should be avoided. Removal of vegetation over a cave, in cave or mine entrances, or alteration of entrances can cause disturbance of internal climate and light levels (Poulson 1975, Tuttle and Stevenson 1977, Wauer 1980, Senger and Crawford 1984, Nieland 1985, Scharpf and Dobler 1985, U,S. For. Ser. 1986).

LOGGING

Logging is a common practice above and around caves in rural areas. Many logging related activities are potentially detrimental to roosting habitats. These

include the removal of vegetation above or around entrances, road building over a cave or entrance, or burning slash in cave or mine entrances (Nieland 1985a). Logging residue left in entrances may deplete oxygen concentrations, rendering habitat unusable. (Stringer et. al. 1991)

Slash burning around cave or mine entrances can be deadly to cave dwellers if the smoke is drawn into the cave (Tuttle and Stevenson 1977, Nieland 1985). Controlled burns can fill a cave with smoke and change surface vegetation and nutrient dynamics (Stringer et. al. 1991). There is evidence to indicate that bats inhabiting caves on U.S. Forest Service land were adversely affected when logging and broadcast burning were conducted in the vicinity of a cave (Nieland 1985).

Logging practices should not be conducted over caves or within 400 meters of any cave or mine before the site has been evaluated and appropriate mitigation measures developed. Protection measures may vary depending on size, aspect, and location of entrances. Logging can cause thin cave ceilings to collapse and may rob soil of nutrients or cause alterations in microclimate in and around caves. Activities that constitute logging include the removal of trees or vegetation, timber salvage, firewood cutting, and the burning or dumping of slash in or near cave entrances or above cave systems (Senger and Crawford 1984, Nieland 1985, Scharpf and Dobler 1985, Beck-stead 1992).

MINING

Mining can have devastating impact on bat colonies. Mining includes exploration for, and the removal or extraction of, minerals, fuels, rock, water, or other materials. Any alteration of existing air or water movement can have impacts on bat colonies. A careful analysis should be undertaken prior to conducting any mining operations or alterations on the surface near mine portals. These should be considered in determining mitigation measures to protect listed or otherwise protected wildlife species.

ROADS

Roads should be built to avoid passing over caves or coming near entrances. Roads should be designed to minimize erosion and to prevent alterations in microclimate or (see logging buffer above) the flow of water into or around caves (Wauer 1980, Aley and Aley 1984, Nieland 1985, U.S. For. Ser. 1986, Beckstead 1992). Other impacts may include compacted soils, paving, or any other activities that contribute to the alteration of water percolation above and into caves (U.S. For. Ser. 1986).

POLLUTANTS

Pesticides, herbicides, fertilizers, and other substances that are detrimental to either vertebrate or invertebrate animals should not be used in the vicinity of bat roosts, within a cave's watershed, or within the watershed of streams that serve cave systems (Nieland 1985, U.S. For. Ser. 1986, Beckstead 1992). Other pollution

sources that should be kept away from cave watersheds include sewage, septic tanks, and land fills (U.S. For. Ser. 1986).

Bats

Caves or mines that are used by bats require stringent protection. Since entering a cave or mine to determine bat use can, in itself, cause disturbance or abandonment, those suspected of bat use should be professionally surveyed for bat suitability and use.

The following recommendations involve eliminating disturbance during critical times and should be applied to caves with suspected or actual bats use. They are intended to complement other cave management recommendat ions (Poulson 1975, Brady 1981, Nieland 1985, Perkins 1985a, Perkins and Levesque 1987, Senger 1987, Sheffield et. ai. 1987, Ramey 1991, Beckstead 1992):

- *Caves that possess maternity colonies should be closed from 1 May through 30 August.*
- *Caves that possess hibernacula should be closed from November 15 through April 15.*
- *Cave closure for hibernacula and maternity colonies should include a closure buffer of 300 feet.*
- *Restrict access by removing or obliterating jeep and foot trails. Re-routing or closing roads is a useful and effective means of deterrence.*

Signs and Gates

Options for closing caves during critical times include the use of signs, fences, and gates (Brady 1981, Senger 1987), although gates should be considered a last resort (Senger and Crawford 1984) and used only when wildlife is threatened (Senger 1987).

Signs may be adequate to prevent disturbance. A sign might attract attention so it may be best to place it inside the entrance to the cave. The signs should be durable, vandal proof, and be placed so that airflow and egress or ingress is not impeded. The sign must be readable and obvious. Signs should include any accompanying legal consequences as a result of cave entry (Brady 1981).

Gates are an extreme form of deterrence and should be used as a last resort (Senger and Crawford 1984, Senger 1987). Successful gating is an exact science and improper gating has resulted in the prompt abandonment of bats (Brady 1981). Cave disturbance levels that dictate the use of gates are ser ious situations. Those considering gating as a management option or gating any cave that has bat use should contact Bat Conservation international, and the American Cave Conservation Association, for assistance, designs, and guidance with gating .

There are differing schools of opinion about whether to list bats as the reason for cave closures (Brady 1981, Nieland 1990). Levels of disturbance and whether disturbance appears malicious or accidental may influence those decisions. Contact Bat Conservation International and the American Cave Conservation Association for current guidelines on this issue.

Confidentiality

The Federal Cave Resources Protection Act establishes standards for the handling of confidential information concerning the nature and loca tion of significant caves. In general, information concerning the specific location of any significant cave may not be made available to the public under Section 552 of Title 5, United States Code (Freedom of Information Act), unless the Secretary of Agri culture or Interior determines that disclosure of such information would further the purposes of the Act and would not create a substantial risk of harm, theft, or destruction of a significant cave [cave resources].

Specific information concerning signi ficant caves will not be made available to the public. This information will be treated as confidential and secured in such a manner as to prevent access by non-authorized individuals. Regulations make it illegal for Federal employees to disclose the loc ations of significant caves. Information concerning significant caves may be made available only under the conditions noted in the preceding paragraph.

Similar rules for disclosure concerning mine locations do not exist, nor do these regulations apply to state, or privately owned lands. Biologists are, however, encouraged to safeguard location information to minimize the likelihood of encouraging recreational visitation.

Literature Cited

Aley, T. and C. Aley. 1984. Effects of land management on cave and water resources, Dry Medicine Lodge Creek Basin, Bighorn Mountains, Wyoming. Proc. 1984 Nat. Cave Management Symposium, Missouri Speleology. 25(1-4).

Beckstead, M. 1992. Draft--land management planning: statewide standards and guidelines. Washingt on Department of Wildlife, Olympia, WA.

Belwood, J. J. 1991. Bats and Mines: Abandoned does not always mean empty. Bats 9(3): 7-12.

Brady, J. T. 1981. Cave management for the endangered Indiana bat *Myotis sodalis* and gray bat *Myotis grisescens*. Pages 21-28 in K. A. West, ed. Proc. 2nd Eastern Cave Management Symposium. Southern Illinois University, Edwardsville.

Cooper, J. E. and T. L. Poulson. 1991. A guide for biological collecting in caves. National Speleological Society, Caving Information Se ries, edited by Jim and Libby Nieland.

Currie, Dr. Robert R. 1995. Endangered Species Specialist, U. S. Fish and Wildlife Service, Ashville, North Carolina. Personal Communication.

Halliday, William R. 1963. *Caves of Washington*. Washington Department of Conservation, Division of Mines and Geology, Information Circular No. 40. 71-77.

Nieland, James R., Nieland, Elizabeth, Benedict, Ellen. 1977. Special Management Considerations of Lava Caves. *National Cave Management Symposium Proceedings, Big Sky, Montana 1977.* Adobe Press. 85-91.

Nieland, James R. 1985. Cave Management Prescription. ACCA Cave Management Series 1(1): 36-41.

_____. 1985a. Three Sinks--Folgers and Deadhorse Caves, draft management recommendations. Unpublished report to Wind Rive r and Mount Adams Ranger Districts.

_____. 1990. Boulder cave recreation and cave management assessment. Unpublished report to Naches Ranger District, Yakima, WA.

_____. 1991. Cave management principals and responsibilities. Unpublished recreation seminar report.

_____. 1994. Cave Management Specialist, Region-6, USDA Forest Service. *Cave Management Plan, Mount St. Helens National Volcanic Monument.* 44 pp.

_____. 1995. Cave Management Specialist, Region-6, USDA Forest Service. *Cave Inventory, Classification, and Management, Gifford Pinchot National Forest.* 39 pp.

Noel, Debra C. 1993. Protocol for Monitoring Bat Colonies. Arizona Game and Fish Department. 4 pp.

Tuttle, Dr. Merlin D. and Stevenson, Diane E. . 1977. Variation in the Cave Environment and its Biological Implications. *National Cave Management Symposium Proceedings, Big Sky, Montana 1977.* Adobe Press. 108-121.

Kingsley, K. J., Y. Petryszyn, F. Reichenbacher. 1991. Protocol for conducting surveys for lesser long-nosed bats and other bats in inactive mines. ASR9101.FR, Part 2. ASARCO, Inc., Marana, AS. 22 pp.

Perkins, Mark J., and T. Schommer. Undated. Survey Protocol and an Interim Species Conservation Strategy for *Plecotus townsendii* in the Blue Mountains of Oregon and Washington. USDA Forest Service, Wallowa-Whitman National Forest. Baker City, Oregon. 22 pp.

Perkins, J. M. 1995. Final Report of the field inventory of *Plecotus Townsendii* for Washington Department of Game, Mount Adams Ranger District, and Wind River Ranger District. Unpublished report, Washington Department of Wildlife, Olympia, WA.

_____, and C. Levesque. 1987. Distribution, status, and habitat affinities of Townsend's bog-eared bat *(Plecotus townsendii)* in Oregon. Oregon Department of Fish and Wildlife, Tech. Report, Portland.

Poulson, T. L. 1975 Management of biological resources in caves. Pages 46 -52. National Cave Management Symposium Proceedings. Albuquerque, NM.

Protocols for Biological and Cultural Resource Surveys of Dangerous Abando ned mines in the State of Nevada. Undated prospectus from Arizona Game and

Fish Department. The Proteus Corporation, O'Farrell Biological Consulting, and Knight and Leavitt Associates, Inc. 4 pp.

Ramey, J. W. 1991. Cave resource management. Unpublished Report, Sylemore Ranger District, Ozark National Forest.

Scharpf, R. W. and F. C. Dobler. 1985. Caves, cliffs, and talus. Pages 188 -197. E. R. Brown, Editor. Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington. Part 1, Chapter Narratives. USDA Forest Service, Serial No. 62.

Senger, C. M., and R. L. Crawford. 1984. Biological inventory, Mount St. Helens Cave Basalt Flow Area. Unpublished final Report. Gifford Pinchot National Forest. St. Helens Ranger District, Amboy, WA.

Sheffield, S. R., J. H. Shaw, G. A. Heidt, and L. R. McClenaghan. 1987. Guides for the protection of bat roosts. Amer. Soc. Mammal., Albuquerque, NM.

Stringer, J. W., B. L. Slover, and T. Aley. 1991. Speleoforestry: Planning for an unseen resource. Journal of Forestry, 89:20-21.

USDA Forest Service. 1986. Interim directive No. 32. FSM 2356. Washington, DC.

Wauer, R. H. 1982. The management of caves within the National Park system. Pages 5-7, National Cave Management Symposium Proceedings, Carlsbad. Pigmy Dwarf Press, Oregon City, OR.

Jim Nieland is the Region-6 cave management specialist for the US Forest Service. He has a background in cave and bat resource management, including an active interest in caves of the northwest, which he has inventoried and surveyed since 1965. His experience includes drafting implementation regulations for the Federal Cave Resources Protection Act of 1988, and is currently working with a Bat Taxa Team, writing survey and management protocol for the Northwest Forest Plan. He is a frequent organizer and presenter at cave management seminars, most recently culminating in a series of five bat gating field sessions. He has a background in general contracting, leading to either the design or construction of 105 bat gates in the last four years. He serves as the secretary and a board of director of the American Cave Conservation Association. He was recipient last year of the National Speleological Society's cave conservation award.

Appendix

FEDERAL CAVE RESOURCES PROTECTION ACT OF 1988

.....

Public Law 100-691
100th Congress

An Act

To protect cave resources on Federal lands, and for other purposes.

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

SECTION 1. SHORT TITLE.

This Act may be referred to as the "Federal Cave Resources Protection Act of 1988".

SECT. 2. FINDINGS, PURPOSE, AND POLICY.

(a) Findings.--The congress finds and declares that--

(1) significant caves on Federal lands are an invaluable and irreplaceable part of the Nation's natural heritage; and

(2) in some instances, these significant caves are threatened due to improper use, increased recreational demand, urban spread, and a lack of specific statutory protection.

(b) Purposes.--The purposes of this Act are--

(1) to secure, protect, and preserve significant caves on Federal lands for the perpetual use, enjoyment, and benefit of all people; and

(2) 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.

(c) Policy.--It is the policy of the United States that Federal lands be managed in a manner which protects and maintains, to the extent practical, significant caves.

SEC. 3. DEFINITIONS.

For purposes of this Act:

(1) **CAVE**. -- The term "cave" means any naturally 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 man-made. Such term shall include any natural pit, sinkhole, or other feature which is an extension of the entrance.

(2) **FEDERAL LANDS**. -- The term "Federal lands" means lands the fee title to which is owned by the United States and administered by the Secretary of Agriculture or the Secretary of the Interior.

(3) **INDIAN LANDS**. -- The term "Indian lands" means lands of Indian tribes or Indian individuals which are either held in trust by the United States for the benefit of an Indian tribe or subject to restriction against alienation imposed by the United States.

(4) **INDIAN TRIBE**. -- The term "Indian tribe" means any Indian tribe, band, nation, or other organized group or community of Indians, including any Alaska Native village or regional or village corporation as defined in, or established pursuant to, the Alaska Native Claims settlement Act (43 U.S.C. 1601 et seq.).

(5) **CAVE RESOURCE**. -- The term "cave resource" includes any material or substance occurring naturally in caves on Federal lands, such as animal life, plant life, paleontological deposits, sediments, minerals, speleogens, and speleothems.

(6) **SECRETARY**.--The term "Secretary" means the Secretary of Agriculture or the Secretary of the Interior, as appropriate.

(7) **SPELEOTHEM**. -- The term "speleo-them" means any natural mineral formation or deposit occurring in a cave or lava tube, including but not limited to any stalactite, stalagmite, helectite, cave flower, flowstone, concretion, drapery, rimstone, or formation of clay or mud.

(8) **SPELEOGEN**. -- The term "speleo-gen" means relief features on the walls, ceiling, and floor of any cave or lava tube which are part of the surrounding bedrock, including but not limited to anastomoses, scallops, meander niches, petromorphs and rock pendants in solution caves and similar features unique to volcanic caves.

SEC. 4. MANAGEMENT ACTIONS.

(a) Regulations.--Not later than nine months after the date of the enactment of this Act, the Secretary shall issue such regulations as he deems necessary to achieve the purposes of this Act. Regulations shall include, but not be limited to, criteria for the identification of significant caves. The Secretaries shall cooperate and consult with one another in preparation of the regulations. To the extent practical, regulations promulgated by the respective Secretaries should be similar.

(b) In General.--The Secretary shall take such actions as may be necessary to further the purposes of this Act. Those actions shall include (but not be limited to)--

(1) identification of significant caves on Federal Lands:

(A) The Secretary shall prepare an initial list of significant caves for lands under his jurisdiction not later than one year after the publication of final regulations using significance criteria defined in such regulations. Such a list shall be developed after consultation with appropriate private sector interests, including cavers.

(B) The initial list of significant caves shall be updated periodically, after consultation with appropriate private sector interests, including cavers. The Secretary shall prescribe by policy or regulation the requirements and process by which the initial list will be updated, including management measures to assure that caves under consideration for the list are protected during the period of consideration. Each cave recommended to the Secretary by interested groups for possible inclusion on the list of significant caves shall be considered by the Secretary according to the requirements prescribed pursuant to this paragraph, and

shall be added to the list if the Secretary determines that the cave meets the criteria for significance as defined by the regulations.

(2) regulation or restriction of use of significant caves, as appropriate.

(3) entering into volunteer management agreements with parsons or scientific and recreational caving community; and

(4) appointment of appropriate advisory committees.

(C) PLANNING AND PUBLIC PARTICIPATION.--The Secretary shall--

(1) ensure that significant caves are considered in the preparation or implementation of any land management plan if the preparation or revision of the plan began after the enactment of this Act; and

(2) foster communication, cooperation, and exchange of information between land managers, those who utilize caves, and the pubic.

SEC. 5. CONFIDENTIALITY OF INFORMATION CONCERNING NATURE AND LOCATION OF SIGNIFICANT CAVES.

(a) In General.--Information concerning the specific location of any significant cave may not be made available to the public under section 552 of title 5, United States Code, unless the Secretary determines that disclosure of such information would further the purposes of this Act and would not create a substantial risk of harm, theft, or destruction of such cave.

(b)Exceptions.--Notwithstanding subsection (a), the Secretary may make available information regarding significant caves upon the written request by Federal and State governmental agencies or bona fide educational and research institutions. Any such written request shall, at a minimum--

(1) describe the specific site or area for which information is sought;

(2) explain the purpose for which such information is sought; and

(3) include assurances satisfactory to the Secretary that adequate measures are being taken to protect the confidentiality of such information and to ensure the protection of significant cave from destruction by vandalism and unauthorized use.

SECT. 6. COLLECTION AND REMOVAL FROM FEDERAL CAVES.

(a) PERMIT.-- The secretary is authorized to issue permits for the collection and removal of cave resources under such terms and conditions at the Secretary may impose, including the posting of bonds to insure compliance with the provisions of any permit:

(1) any permit issued pursuant to this section shall include information concerning the time, scope, location, and specific purpose of the proposed collection, removal or associated activity, and manner in which such collection, removal, or associated activity is to be performed must be provided.

(2) the secretary may issue a permit pursuant to this subsection only if he determines that the proposed collection or removal activities are consistent with the purposes of this Act and with other applicable provisions of law.

(b) REVOCATION OF PERMIT.--Any permit issued under this section shall be revoked by the Secretary upon determination by the Secretary that the permittee has violated any provision of this Act, or has failed to comply with any other condition upon which the permit was issued. Any such permit shall be revoked by the Secretary upon assessment of a civil penalty against the permittee pursuant to section 8 or upon the permittee's conviction under section 7 of this Act. The Secretary may refuse to issue a permit under this section to any person who has violated any provision of this Act or who has failed to comply with any condition of a prior permit.

(c) TRANSFERABILITY OF PERMITS.--Permits issued under this Act are not transferable.

(d) CAVE RESOURCES LOCATED ON INDIAN LANDS.--(1)(A) Upon application by an Indian tribe, the Secretary is authorized to delegate to the tribe all authority of the

Secretary under this section with respect to issuing and enforcing permits for the collection or removal of any cave resource, or to carrying out activities associated with such collection or removal, from any cave resource located on affected Indian Lands.

(B) In the case of any permit issued by the Secretary for the collection or removal of any cave resource, or to carry out activities associated with such collection or removal, from any cave resource located on Indian lands (other than permits issued pursuant to subparagraph (A)), the permit may be issued only after obtaining the consent of the Indian or Indian tribe owning or having jurisdiction over such lands. The permit shall include such reasonable terms and conditions as may be requested by such Indian or Indian tribe.

(2) If the Secretary determines that issuance of a permit pursuant to this section may result in harm to, or destruction of, any religious or cultural site, the Secretary, prior to issuing such permit, shall notify any Indian tribe which may consider the site as having significant religious or cultural importance. Such notice shall not be deemed a disclosure to the public for purposes of section 5.

(3) A permit shall not be required under this section for the collection or removal of any cave resource located on Indian lands or activities associated with such collection, by the Indian or Indian tribe owning or having jurisdiction over such lands.

(e) EFFECT OF PERMIT.--No action specifically authorized by a permit under this section shall be treated as a violation of section 7.

SECT. 7. PROHIBITED ACTS AND CRIMINAL PENALTIES.

(a) PROHIBITED ACTS.--

(1) Any person who, without prior authorization from the Secretary knowingly destroys, disturbs, defaces, 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 shall be punished in accordance with subsection (b).

(2) 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 shall be punished in accordance with subsection (b).

(3) Any person who counsels, procures, solicits, or employs any other person to violate any provisions of this subsection shall be punished in accordance with section (b).

(4) Nothing in this section shall be deemed applicable to any person who was in lawful possession of a cave resource from a significant cave prior to the date of enactment of this Act.

(b) PUNISHMENT.--

The punishment for violating any provision of subsection (a) shall be imprisonment of not more than one year or a fine in accordance with the applicable provisions of title 18 of the United States Code, or both. In the case of a second or subsequent violation the punishment shall be imprisonment of not more than 3 years or a fine in accordance with the applicable provisions of title 18 of the United States Code, or both.

SECT. 8. CIVIL PENALTIES.

(a) ASSESSMENT.--(1) The secretary may issue an order assessing a civil penalty against any person who violates any prohibition contained in this Act, any regulation promulgated pursuant to this act, or any permit issued under this Act. Before issuing such an order, the Secretary shall provide such person written notice and the opportunity to request a hearing on the record within 30 days. Each violation shall be a separate offense, even if such violations occurred at the same time.

(2) The amount of such civil penalty shall be determined by the Secretary taking into account appropriate factors including (A) the seriousness of the violation; (B) the economic benefit (if any) resulting from the violation; (C) any history of such violations;

and (D) such other matters as the Secretary deems appropriate. The maximum fine permissible under this section is $10,000.

(b) JUDICIAL REVIEW.-- Any person aggrieved by an assessment of a civil penalty under this section may file a petition for judicial review of such assessment with the United States District Court for the District of Columbia or for the district in which the violation occurred. Such a petition shall be filed within the 30-day period beginning on the date the order assessing the civil penalty was issued.

(c) COLLECTION.--If any person fails to pay an assessment of a civil penalty--

(1) within 30 days after the order was issued under subsection (a), or

(2) if the order was appealed within such 30-day period, within 10 days after court has entered a final judgment in favor of the Secretary under subsection (b),

the Secretary will notify the Attorney General and the Attorney General shall bring civil action in an appropriate United States district court to recover the amount of penalty assessed (plus costs, attorney's feet, and interest at currently prevailing rates from the date the order was issued or the date of such final judgment, as the case may be). In such an action, the validity, amount, and appropriateness of such penalty shall not be subject to review.

(d) SUBPOENAS.-- Title Secretary may issue subpoenas in connection with proceedings under this subsection compelling the attendance and testimony of witnesses and subpoenas duces tecum, and may request the Attorney General to bring an action to enforce any subpoena under this section. The district courts shall have jurisdiction to enforce such subpoenas and impose sanctions.

SECT. 9. MISCELLANEOUS PROVISIONS.

(a) AUTHORIZATION.-- There are authorized to be appropriated $100,000 to carry out the purposes of this Act.

(b) EFFECT ON LAND MANAGEMENT PLANS.--Nothing in this Act shall require the amendment or revision of any land management plan, the preparation of which began prior to the enactment of this Act.

(c) FUND.-- Any money collected by the United States as permit fees for collection and removal of cave resources; received by the United States as a result of the forfeiture of a bond or other security by a permittee who does not comply with the requirements of such permit issued under section 7; or collected by the United States by way of civil penalties or criminal fines or violations of this Act shall be placed in a special fund in the Treasury. Such moneys shall be available for obligation or expenditure (to the extent provided for in advance in appropriation Acts) as determined by the Secretary for the improved management, benefit, repair, or restoration of significant caves located on Federal lands.

(d) Nothing in this Act shall be deemed to affect the full operation of the mining and mineral leasing laws of the United States, or otherwise affect valid existing rights.

SEC. 10. SAVINGS PROVISIONS.

(a) WATER..-- Nothing in this Act shall be construed as authorizing the appropriation of water by any Federal, State, or local agency, Indian tribe, or any other entity or individual. Nor shall any provision of this Act--

(1) affect the rights or jurisdiction of the United States, the States, Indian tribes, or other entities over waters of any rivers or stream or over any ground water resource;

(2) alter, amend, repeal, interpret, modify, or be in conflict with any interstate compact made by the States; or

(3) alter or establish the respective rights of the States, the United States, Indian tribes, or any person with respect to any water or water-related right.

(b) FISH AND WILDLIFE.-- Nothing in this Act shall be construed as affecting the jurisdiction or responsibilities of the States with respect to fish and wildlife.

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Approved November 18, 1988.

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LEGISLATIVE HISTORY--H.R. 1975:

HOUSE REPORTS: No 100-534 (Comm. on Interior and Insular Affairs).
SENATE REPORTS: No. 100-559 (Comm. on Energy and Natural Resources).
CONGRESSIONAL RECORD, Vol. 134 (1988)
Mar. 28, considered and passed House.
Oct. 21, considered and passed Senate, amended. House concurred in Senate amendment.

Part 290-CAVE RESOURCES MANAGEMENT

Sec.
290.1 Purpose and scope.
290.2 Definitions.
290.3 Nomination, evaluation, and designation of significant caves.
290.4 Confidentiality of cave location information.
290.5 Collection of information.

AUTHORITY: 16 U.S.C. 4301-4309; 102 Stat. 4546.

SOURCE: 59 FR 31152, June 17, 1994, Unless otherwise noted.

§290.1 Purpose and Scope.

The rules of this part implement the requirement of the Federal Cave Resources Protection Act (16 U.S.C. 4301-4309), hereafter referred to as the "Act". The rules apply to cave management on National Forest System lands. These rules, in conjunction with rules in part 261 of this chapter, provide the basis for identifying and managing significant caves on National Forest System lands in accordance with the Act. National Forest System lands will be managed in a manner which, to the extent practical, protects and maintains significant cave resources in accordance with the policies outlined in the Forest Service Directive System and the management direction contained in the individual forest plans.

§290.2 Definitions

For the purposes of this part, the terms listed in this section have the following meaning:

Authorized officer means the Forest Service employee delegated the authority to perform the duties described in this part.

Cave means any naturally occurring void, cavity, recess, or system of interconnected passages beneath the surface of the earth or within a cliff or ledge and which is large enough to permit a person to enter, whether the entrance is excavated or naturally formed. Such term shall include any natural pit, sinkhole, or other opening which is an extension of the cave entrance or which is an integral part of the cave.

Cave resources mean any materials or substances occurring in caves including, but not limited to, biotic, cultural, mineralogic, paleontologic, geologic, and hydrologic resources.

National Forest System Lands means all national forest lands reserved or withdrawn from the public domain, acquired through purchase, exchange, or donation, national grasslands and land utilization projects, and other lands, waters, or interests administered by the Forest Servic e.

Secretary means the Secretary of Agriculture.

Significant cave means a cave located on National Forest System Lands that has been determined to meet the criteria in §290.3 (c) or (d) and has been designated in accordance with §290.3 (e).

§290.3 Nomination, Evaluation, and designation of significant caves.

(a) *Nominations for initial and subsequent listings.* The authorized officer will give governmental agencies and the public, including those who utilize caves for scientific, educational, or rec reational purposes, the opportunity to nominate caves. The authorized officer shall give public notice, including a notice published in the FEDERAL REGISTER, calling for nominations for the initial listing and setting forth the procedures for preparing an d submitting the nominations. Nominations for subsequent listing will be accepted from governmental agencies and the public by the Forest Supervisor where the cave is located as new cave discoveries are made. Caves nominated but not approved for designat ion may be renominated as additional documentation or new information becomes available.

(b) *Evaluation for initial and subsequent listings.* The evaluation of the nominations for significant caves will be carried out in consultation with individuals an d organizations interested in the management and use of caves and cave resources, within the limits imposed by the confidentiality provisions of §290.3 (c) and (d).

(c) *Criteria for significant caves.* A significant cave on National Forest System lands shall possess one or more of the following features, characteristics, or values.

(1) Biota. The cave provides seasonal or yearlong habitat for organisms or animals, or contains species or sub -species of flora or fauna native to caves, or are sensitive to disturbance, or are found on State or Federal sensitive, threatened, or endangered species lists.

(2) *Cultural.* The cave contains historic properties or archaeological resources (as defined in Parts 800.2 and 296.3 of this chapter respectively, or in 16 U.S.C. 420, *et seq.*) or other features included in or eligible for inclusion on the National

Register of Historic Places because of their research importance for history or prehistory, historical associations, or other historical or traditional signifi cance.

(3) *Geologic/Mineralogic/Paleontologic.* The cave possesses one or more of the following features:

(i) Geologic or mineralogic features that are fragile, represent formation processes that are of scientific interest, or that are otherwise usefu l for study.

(ii) Deposits of sediments or features useful for evaluating past events.

(iii) Paleontologic resources with potential to contribute useful educational or scientific information.

(4) *Hydrologic.* The cave is a part of a hydrologic syst em or contains water which is important to humans, biota, or development of cave resources.

(5) *Recreational.* The cave provides or could provide recreational opportunities or scenic values.

(6) *Educational or scientific.* The cave offers opportuniti es for educational or scientific use; or, the cave is virtually in a pristine state, lacking evidence of contemporary human disturbance or impact; or, the length, volume, total depth, pit depth, height, or similar measurements are notable.

(d) *Specially designated areas.* All caves located within special management areas, such as Special Geologic Areas, Research Natural Areas, or National Monuments, that are designated wholly or in part due to cave resources found therein are determined to be significant .

(e) *Designation and documentation.* If the authorized officer determines that a cave nominated and evaluated under paragraphs (a) and (b) of this section meets one or more of the criteria in paragraph (c) of this section, the authorized officer shall designate the cave as significant. The authorized officer will notify the nominating party of the results of the evaluation and designation. Each forest will retain appropriate documentation for all significant caves located within its administrative bou ndaries. At a minimum, this documentation shall include a statement of finding signed and dated by the authorized officer and the information used to make the determination. This documentation will be retained as a permanent record in accordance with the confidentiality provision in §290.4.

(f) *Undiscovered Passages.* If a cave is determined to be significant, its entire extent on federal land, including passages not mapped or discovered at the time of determination, is deemed significant. This includ es caves that extend from lands managed by any other Federal agency into National Forest System land, as well as

caves initially believed to be separate for which interconnecting passages are discovered after significance is determined.

(g) *Decision Final.* The decision to designate or not designate a cave as significant is made at the sole discretion of the authorized officer based upon the criteria in paragraphs (c) and (d) of this section and is not subject to further administrative review of appeal under Parts 217 or 251.82 of this chapter.

§290.4 Confidentiality of cave location information.

(a) *Information disclosure.* No Forest Service employee shall disclose any information that could be used to determine the location of a significant cave or a cave nominated for designation, unless the authorized officer determines that disclosure will further the purposes of the Act and will not create a substantial risk of harm, theft, or destruction to cave resources.

(b) *Requesting confidential information.* Notwithstanding paragraph (a) of this section, the authorized officer may make confidential cave information available to Federal or State governmental agencies, bona fide educational or research institutes, or individuals or organizations assisting the land management agencies with cave management activities. To request confidential cave information, such entities shall make a written request to the authorized officer which includes the following:

(1) Name, address, and telephone number of the individual responsible for the security of the information received;

(2) A legal description of the area for which the information is sought;

(3) A statement of the purpose for which the information is sought; and,

(4) Written assurances that the requesting party will maintain the confidentiality of the information and protect the cave and its resources.

(c) Decision Final. The decision to permit or deny access to confidential cave information is made at the sole discretion of the authorized officer and is not subject to further administrative review or appeal under 5 U.S.C. 552 or parts 217 or 251.82 of this chapter.

§290.5 Collection of information.

The collection of information contained in this rule represents new information requirements as defined in 5 CFR 1320, Controlling Paperwork Burdens on the Public. In accordance with those rules and the Paperwork Reduction Act of 1980 as amended (44 U.S.C. 3507), the Forest Service has received approval by the Office of Management and Budget to collect cave nomination information under

clearance number 0596 -0123 and confidential information under 0596 -00122. The information provided for the cave nomination will be used to determine which caves will be listed as "significant" and the information in the requests to obtain confidential cave information will be used to decide whether to grant access to this information. Response to the call for cave nominations is voluntary. No action may be taken against a person for refusing to supply the informati on requested. Response to the information requirements for obtaining confidential cave information is required to obtain a benefit in accordance with section 5 of the Federal Cave Resources Protection Act of 1988 (16 U.S.C. 4304).

DEMONSTRATION OF A BAT GATE DATABASE

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Abstract

Abandoned mines provide valuable and important habitat for a number of bat species throughout the United States. Many States that have abandoned mine reclamation programs are gating mines to preserve bat habitat. There is a need to collect and store data on the roost types, use, and the mine environment. Electronic data storage/retrieval is not only an effective method for tracking these gated mines and the resource they provide, but the information may be of value to the scientific community, bat working groups, and government agencies in decision making. Trends in bats use of mines may be revealed. Utah Abandoned Mine Reclamation Program developed a "bat gate database" (BGDB) using an interactive, geographically -referenced computer software package called ArcView™ GIS. This is a powerful tool for querying large sets of data, especially when spatial data e.g., GPS mine site points, are linked to a relational database. The database houses raw seasonal bat survey data and mine characterization data. Users can easily view, query and analyze the potential relationships between the geography, distribution, and roosting characteristics of various species of bats in Utah. A variety of queries of the existing data will be performed. "Hotlinks" that provide digital photos of the mine and surrounding habitat will be viewed.

Introduction

Abandoned mines provide valuable and important habitat for a number of bat species throughout the United States. Many States that have abandoned mine reclamation programs, such as Utah, are reclaiming abandoned mines in order to eliminate the safety hazards posed to the public. In the west, estimates of abandoned hardrock mines number in the hundreds of thousands. Although a relatively recent addition to the landscape, bats are utilizing the habitat provided by these mines. Bat biologists suggest that approximately 70 percent of these abandoned hardrock mines show some evidence of bat use. This use of abandoned mines by bats necessitates biological sensitivity during mine closure projects. This is usually accomplished through some type of survey, and where bat use is suspected, closures that allow continued use may be installed. With hundreds of thousands of mines docked for closure the potential exists to acquire a huge data set of the various biotic and abiotic factors associated with bats and mines.

Data Collection

Towards that end, the Utah Abandoned Mine Reclamation Program has developed a computerized tracking system aimed at managing the accumulation of data generated from these mine surveys and the resulting mine closures. In Utah, the AMRP conducts internal mine surveys in order to identify bat habitat. A warm season survey is conducted to identify maternity roosts, day roosts and night roosts. Cold season surveys are used to identify mines being used as hibernation sites. The data collected includes: where bats are located within the mine and the temperature at that location; the species identification; the number of bats found; and bat sign such as guano and insect parts. Microclimatic conditions are recorded throughout the mine such as temperature and relative humidity and air flow direction at the opening. Mine characteristics such as elevation and aspect of the mine opening, length and complexity of the workings, and dimensions of the mine opening. GPS points and digital photos are also collected at each location. The survey form below may be completed by hand or electronically during the survey.

Bat Survey Form

Tag Number_____

Project Name_____

Survey Date_____

Investigator_____

Elevation (ft)_____

Hillslope Aspect (e.g., NW)_____

Temperature (°C) at opening_____
at working face_____

Relative Humidity (%) at opening_____
at working face_____

Direction of Air Flow
? Into mine
? Out of mine
? No air movement

Number of Entrances into Mine
_____vertical openings
_____horizontal openings

Number of Levels_____

Complexity of Mine Workings
? High (>2 openings)
? Medium (1-2 openings)
? Low (1 opening only)

Total Length of Mine Workings_____ (m)

Visitation
? High (recent campfire, fresh tire tracks, garbage)
? Medium
? Low (No tire tracks, garbage, or fire rings)

Habitat/Vegetation Community Type
_____
_____
_____
_____
_____

Guano
? Large (discs >1 ft^2)
? Medium (discs <1 ft^2)
? Small (isolated droppings)
? None observed

Arthropod Parts
? Flying insects
? Ground dwelling arthropods (e.g., scorpions, centipedes)
? Other (list)_____
? None observed

Bats Observed
Species and Number (e.g., Coto0005)
_____
_____
_____
_____

Use Type
? Day Roost
Species and Number (e.g., Coto0001)
? Maternity
Species and Number (e.g., Coto0001

Geographic Information Systems

Electronic data storage and retrieval is an effective method for tracking the use of abandoned mines by bats and may be far reaching in terms of discovering trends that may be used to identify patterns or predict bat use of mines yet to be surveyed. Having a standardized format for this data increases its ability to be used as information sources for the scientific community, bat working groups, and in decision making by government agencies. However, merely storage and retrieving electronic data limits the uses of the data. Alternatively, to be able to easily view, query and analyze the ever increasing amount of bat and mine survey data in the context of a spatial format that can be linke d to any layer that can be conceived of in a Geographic Information System (GIS) unleashes an incredibly powerful analytical tool.

Database and ArcViewÔ

To meet these needs, the Utah Abandoned Mine Reclamation Program constructed a "bat gate database" (BGDB) using an interactive, geographically-referenced computer software package called ArcView™ GIS. ArcView™ has a graphical user interface and acts as a powerful tool for querying large data sets especially when spatial data (e.g., GPS mine site points) are linked to a relational database. The BGDB utilizes Microsoft Access™ as the relational database component that houses the raw tabular bat survey data and the AMRP-related mine site data. The various Access ™ tables are related through a primary key (a 12-digit tag number) that is a unique number assigned to all mine openings according to township, range and section. In this way, users can easily view, query and analyze the potential relationship between the geography, distribution, vegetation types and coverage, water bodies, and roosting characteristics of various species of bats in Utah.

What's in the Database

The database contains the following fields: **Tag number** (a unique number assigned to each mine; the first digit is the quadrant in the Salt Lake base meridian, the second and third are the township, the fourth and fifth are the range, the sixth and seventh are the section, the letters HO stand for horizontal opening, VO is vertical opening, IO is inclined opening, SH is subsidence hole, the la st three digits represent the mine number in that particular section), **Monument Number** (a sequential, unique number engraved on a metal cap that is welded to the bat gate or set in concrete on -site for easy field identification of the mine), **AMRP Number** (a number assigned to the project by the Abandoned Mine Reclamation Program), **County** (the name of the county where the mine is located), **Project Name** (the name of the AMRP project that was responsible for closing this mine), **Mine Name** (the name of the mine itself or the mining claim on which it is located), **Closure Type** (e.g., bat gate, shaft grate, etc.; in the ArcView project, use hotlinks to photos to see what these bat-compatible closures look like), **Closure Cost** (the total cost of actual work to close t he mine), **Closure Date** (the day, month and year when the bat-compatible closure was installed in the mine) **, Project Manager** (the staff member who was responsible for closing the mine as part of an AMRP project), **Photo**

Gate Detail (the pathname for ArcView to locate the close-up photo of a particular bat-compatible closure), **Photo Gate Overview** (pathname for an overview photo of the entire mine site showing the surrounding area), **Photo Bat** (a pathname for a photo of the actual bats found in the mine), **Investigator** (the name of the individual who surveyed and collected information on bats in the mine), **Elevation (ft)** (the elevation of the mine site), **Aspect** (the azimuth of the mine opening or the direction in which the mine opening faces; this is usually the same as the hillslope aspect), **Date Winter** (date of the cold season bat survey), **Date Summer** (date of the warm season bat survey), **Season of Use** (season in which bats are using the mine, summer winter or both), **Bats Winter** (the species abbreviation and number of individuals of that species found in the mine during the cool season survey, e.g., Coto0090 = ninety Townsend's big-eared bats), **Maternity** (species abbreviation and number of bats using the mine as a maternity colony), **Guano** (the presence of bat guano on the floor of the mine; L stands for Large amounts of guano that covers the much of the floor, M=medium, S=small, isolated patches of guano), **Day Roost** (species abbreviation and number that utilize the mine as a day roost), **Insect Parts** (yes if flying insect parts were found in the mine, GDA for ground dwelling arthropod parts), **Air Flow Direction** (air flow into or out of the mine during the summer and winter surveys), **Sum Temp Brow C** (temperature measured in degrees Celsius just under the brow of the mine during the warm season or summer bat survey), **Sum Temp Face C** (temperature measured at the working face, usually the back of the adit or bottom of the shaft), **Sum Humidity Brow** (% humidity measured just under the brow), **Sum Humidity Face** (% humidity measured at the working face), **Win Temp Brow C** (temperature measured just under the brow during the cool season bat survey), **Win Temp Face C**, **Win Humidity Face**, **Win Humidity Brow**, **Visitation** (estimated amount of public visitation to the mine site based on presence of tire tracks, garbage in and near the mine, campfires, etc.), **Vegetative Habitat** (vegetation type—this data has not been collected until this year and so is not included in the database yet), **Length or Height (ft)** (the height of the adit or incline or length of the shaft opening measured in feet), **Width (ft)** (width of the mine opening), **Depth of Workings (ft)** (the total linear footage of the underground workings), **Complexity** (High, Med or Low based on the number of openings to the mine and the number of levels in the mine), and **Comments**.

Database Queries

Within ArcView™, it is possible to use the "query builder" to search for complex relationships within the database for various scientific or decision-making purposes. For example, the user might query for all mines located in Fishlake National Forest above 6000 feet that serve as hibernacula for Townsend's Big-eared bats. A query is limited in complexity only by the imagination or curiosity of the questioner. The database currently consists of tables containing 40 field headings with over 400 lines per heading. The results of the query are highlighted on a topographic base map. Users may zoom into these selected mine sites on the topographic base map and, using ArcView's ™ "hotlink tool," view digital photos of the bat gate and the surrounding vegetative community. Alternatively, the AMRP might require information on the cost of all shaft grate closures installed in mines during fiscal year 1997. This can be quickly and easily calculated using a customized query button, designed especially for such institutional needs. Data

queries are relatively quick and easy ways of identifying potential trends in bat use of abandoned mines as habitat.

The Utah AMRP recognizes that many abandoned mines are now being used as bat habitat; and as such, must be protected. In order to protect bat habitat, bat surveys must continue to be conducted so that information derived from them can continue to aid in management decisions as well as have scientific and institutional relevance. The BGDB is an effective way to present and spatially analyze this bat survey data. Future improvements include expanding the BGDB to include any post-bat gate monitoring data and database deployment via a secure web site that serves information to those individuals and groups with proper clearances.

Mark Mesch is a reclamation biologist with the Utah Abandoned Mine Reclamation Program since 1988 and currently administers that program. Previously he was a field biologist with the Ecology Center at Utah State University comparing the recovery of surface mined lands with Mt. Saint Helens.

Leonard V. (Len) Meier is a Physical Scientist with the Office of Surface Mining, Mid Continent Regional Coordinating Center. He is responsible for abandoned mine land program policy, abandoned mine reclamation project management, technical assistance and training for the OSM Mid-Continent Region. He holds a M.S. in Conservation Biology from the University of Missouri and a B.S. in Agriculture from Southwest Missouri State University.

POSTER PRESENTATIONS

A Field Recording Technique to Passively Collect and Time Tag Echolocation Calls from Free Flying Bats Using a Time Expansion Bat Detector and a Digital 8 Video Camcorder

Robert Berry, Brown-Berry Biological Consulting, Bishop, California and Joe Szewczak, White Mountain Research Station, Bishop, California

Many bat biologists use the Anabat 6 software for passive monitoring of bat activity using a frequency division bat detector (Anabat II) connected to a laptop computer. Advances in computing technology and availability of full frequency spectrum analysis software (Sonobat) have sparked new interest in a more complete analysis of echolocation signals. A new technique is available to passively record echolocation calls in the field using an automatically resetting time expansion bat detector (Pettersson D240x) with a Sony Digital 8 NightShot camcorder. A stereo cable connects the bat detector output to the camcorder microphone input jack. The camcorder automatically time tags every frame of video/audio data and stores the audio in a standard format 32kHz WAVE file. The camera's automatic gain control adjusts the sound level for maximum resolution in a 12 bit format. Sony's DV (i-link) connection to a VAIO laptop allows direct downloading of the wave file with zero distortion. Automatic time-tagging of both Anabat II files and time expansion files allows the investigator to correlate the identical echolocation calls from both systems provided the bat detectors are co-located. The researcher can rapidly scan Anabat files to select which time expansion calls should receive full Sonobat analysis. The technique is particularly well suited for passive recording of mine roost outflights where a visual as well as audio recording is desired.

Interior Stabilization of The Unimin Specialty Minerals Corporation Magazine Mine:A Novel Indiana Bat *(Myotis Sodalis)* Hibernaculum in Southern Illinois

Joseph A. Kath, Illinois Department of Natural Resources, Division of Natural Heritage, Springfield, Illinois

Bats continue to rank among the world's most endangered wildlife despite extensive conservation efforts. Preserving these mammals and the ecosystems which rely on their existence is a prodigious task. Effective education, research, and conservation initiatives at the local, community, and corporate levels are essential to the long-term understanding and survival of these often neglected animals. Recent efforts at the UNIMIN Corporation's "Magazine Mine" to directly protect resources critical to bat reproduction and hibernation have both strengthened and promoted a conservation ethic benefitting not only bats, but the fragile Shawnee National Forest ecosystem as a whole. Magazine Mine currently supports at least 14,500 wintering Indiana bats (*Myotis sodalis*) and is the largest winter hibernacula of Indiana bats ever documented within the State of Illinois. Because this mine has been abandoned for more than 20 years, immediate and permanent stabilization at the main entrance was needed in order to prevent catastrophic collapse and eventual closure. Such a collapse at this Federal Priority II hibernacula would not only exterminate the large numbers of Indiana bats hibernating within this mine, but permanently prohibit use of this mine by successive generations of *Myotis sodalis*. Stabilization efforts of the 80 m long "Magazine Mine" entrance using specially engineered steel arches were completed during summer 2001 and cost approximately $110,000.

The Bat Protection Strategy for U.S. Borax's Abandoned Mines

Michael H. Rauschkolb, U.S. Borax Inc., Valencia, California

Background

In 1882, the twenty-mule team wagons began hauling ore from borate mines in the California desert. Each underground mine had an operating life of 10 to 20 ye ars. When all of the ore was extracted from a mine, the miners removed many of the mine timbers for use in the next mine. Then they boarded up the mine entrances and left for the next bonanza. Over time, bottle hunters and other explorers have re-opened many of the shafts and adits. Three years ago, U.S. Borax began a program to permanently close the company's historic mines.

Pre-Closure Wildlife Studies

Pre-closure wildlife studies were conducted to determine the extent of wildlife utilization of these mines. The pre-closure surveys involved internal mine surveys and night vision monitoring of mine openings. Outside of the mines, echolocation signals were recorded onto a laptop computer. Signals were detected for a number of bat species, including pallid bats (*Antrozous pallidus*), western pipistrelles (*Pipistrellus hesperus*), California myotis (*Myotis californicus*) and Townsend's big-eared bats (*Corynorhinus townsendii*).

In general the mine openings were in very poor condition due to the weak nat ure of the bedrock and the removal of many of the mine support timbers (Figure 1). Most of the mines were determined to be unsafe and were closed after exclusion of the bats (Brown et al 2000).

However several mines were identified that contained good habitat for bats. U.S. Borax joined with Dr. Patricia Brown and Bat Conservation International to protect two habitat sites for desert dwelling bats including a maternity colony of *Corynorhinus townsendii* at the Gerstley mine. Frontier Environmental Services designed and installed two bat gates and three air grates at Gerstley. The gated openings provide safe access and continued good airflow, while at the same time permitting open pit mining to occur adjacent to the closed underground mine.

Figure1 - Broken mine timber in abandoned borate mine.

The bedrock at both the Lila C and Gerstley locations is structurally weak, consisting of clay, shale, volcanic ash and limestone, that are highly weathered and fractured. This situation made it almost impossible to securely anchor bat gates to the walls of the various openings. Borax developed an innovative method for installing secure and stable bat gates in areas of weak and faulted bedrock (Cremeens and Rauschkolb 2002). We place six-foot diameter cement sewer pipe in front of each opening (Figure 2) and install the gates inside or at the end of these pipes. The areas around shafts and adits are re-contoured to prevent erosional damage.

Figure 2 - First joint of cement pipe being installed at the m ine portal.

The decision to place bat gates on particular openings was based on several factors including airflow, access, size and stability of the opening, visibility from roads and evidence of bat use (Figure 3).

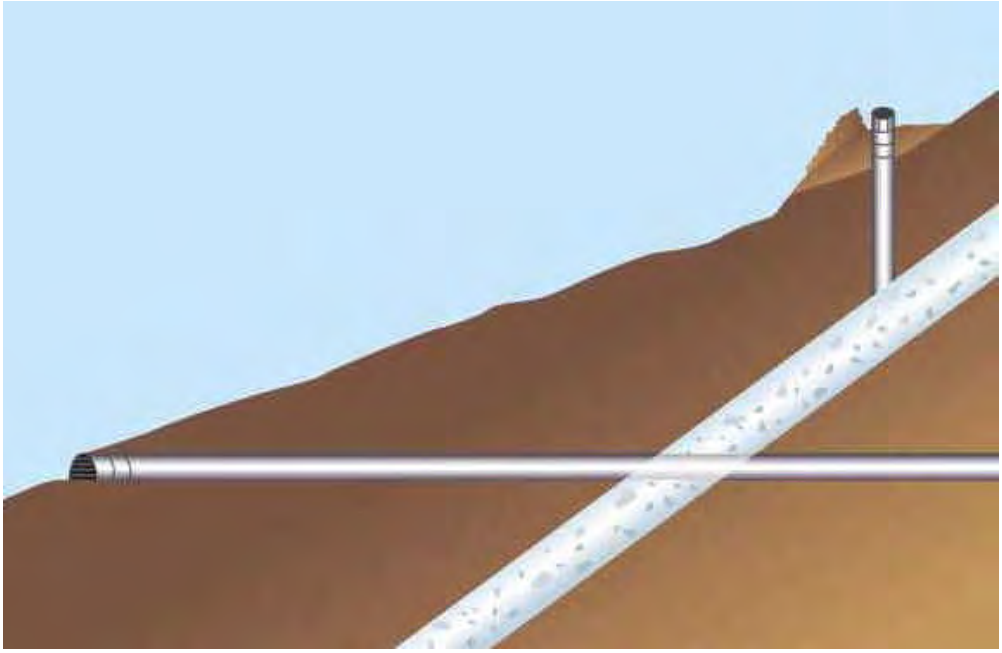

Figure 3. Relationship of Mine shaft to gate location.

Figure 4 - Bat cupola being installed at the Lila C mine. Man -made berm on left.

Figure 4 shows a bat gate and bat cupola that have been installed at the south end of the Lila C mine. The adit and shaft connect to the mined -out vein of borate ore. The vertically placed concrete pipes created a stable base for the cupola.

Figure 5 - Bat gate installed inside cement pipe at the Lila C mine.

In cases where the mine opening is larger than the cement pipe, rock -filled steel mesh gabions are placed around the pipe to close the remainder of the opening. After sealing the bedrock/pipe interface, we backfill around the pipe. Storm water diversion channels are placed around the opening. We also build berms of native rock in front of those sites that might be visible from nearby roads. The pipe/gate structures are stronger and more stable than bedrock -anchored gates. Hopefully they will be able withstand minor earthquakes and trespassers attempts to bypass the gates.

Borax is committed to developing an effective bat conservation program. In addition to the activities described above, we are working to develop a volunteer -based long-term monitoring program for the gated bat habitat.

Literature Cited

Brown, P.E., J.S. Altenbach and R.E. Sherwin. 2000. Evicting Bats When Gates Won't work: Unstable Mines and Renewed Mining. **In** K.C. Vories and D. Throgmorton. Proceedings of Bat Conservation and Mining: A Technical Interactive Forum. Airport Hilton, St. Louis, Missouri, November 14-16, 2000. p.187-192

Cremeens, J.A. and M.H. Rauschkolb. 2002. Closure of Remote Historic Underground Mines in Desert Environments. Preprint 02-057. 2002 Society for Mining, Metallurgy and Exploration, Inc. (SME) Annual Meeting, Phoenix, Arizona. 1 2pp.

Michael H. Rauschkolb is the Principal Land Agent with U.S. Borax Inc. He has been employed there since 1984. He received his B.S. and M.S. degrees in Geology from the University of Arizona. Rauschkolb is a Fellow of the Society of Economic Geol ogists, a Certified Professional Landman and is a member of the Board of Directors of the Death Valley Natural History Association.

WHERE DO WE GO FROM HERE?

PARTICIPANT RECOMMENDATIONS

1. Bat Conservation International needs to endorse Bat Gate Designs other than angle iron gates.

2. There is a great need in the West for additional Gate Designs that address regional differences.

3. Develop a national standard for bat gate design.

4. Develop an actual cave and mine gating handbook.

5. More technology transfer on surveillance and alarm systems .

6. Need to have a similar forum directed more to speleological interests.

7. Develop better guidelines or protocols for monitoring mine gates and would suggest a forum similar in format to this one as a means to that end.

8. More information on the weathering and corrosion of materials in a mine or cave environment.

9. Find a way to get this type of information to managers and decision makers who would fund or direct resources to these efforts.

10. Create an Internet based source, or list serve, of people working in the field.

SURVEY RESULTS
BAT GATE DESIGN: A TECHNICAL INTERACTIVE FORUM
PARTICIPANT COMMENTS AND RECOMMENDATIONS

CATEGORY OF PARTICIPANTS	# OF REGISTRANTS	# OF REGISTRANTS
TOTAL REGISTRATION	95	
TOTAL COMPLETING THE SURVEY	31	100
LEVEL OF SATISFACTION WITH THE FORUM		
EXTREMELY SATISFIED	22	71
VERY SATISFIED	9	29
SATISFIED	0	0
DISSATISFIED	0	0
VERY DISSATISFIED	0	0

COMPLIMENTS:

1. Great Forum! I really enjoyed it and learned quite a lot. Things ran quite smoothly.
2. This is one of the best conferences/forums I have attended. Very well done.
3. Generally an excellent session. Very informative with impressive speakers.
4. Excellent job by the session moderators of keeping the conference on time. The last session on monitoring and maintenance was excellent!
5. Excellent session. I was very impressed at how well prepared the speakers were.
6. Well done!
7. This was an excellent forum!
8. Great format! More interactive than the Bats and Mining Forum.
9. Excellent forum as is!! Excellent presenters. I don=t usually rank talks this high but I just liked it that much.
10. Good Format! Well organized!
11. I really enjoyed the forum, an excellent array of topics, great atmosphere and speakers!
12. Great overall! Amazing how far mine land managers have come with bat gates!
13. Everyone that I have called, agrees with me that the Austin Bat Gate Design Forum was the best workshop they have ever attended!

WHERE DID THE PARTICIPANTS COME FROM
AND WHO DID THEY REPRESENT?

PARTICIPANT AFFILIATION	# OF REGISTRANTS	% OF REGISTRANTS

State Mining Agency	17	18
State Wildlife/Conservation Agency	13	14
Bureau of Land Management	10	11
Caving Association	8	9
Consultant	8	**9**
National Park Service	7	**7**
Forest Service	7	**7**
Office of Surface Mining	7	**7**
International Conservation Organization	6	6
U.S Fish & Wildlife Agency	6	6
University	3	3
Mining	1	1
Real Estate	1	1

REGIONAL REPRESENTATION	# OF REGISTRANTS	% OF REGISTRANTS
WEST	50	53
MID-CONTINENT	35	37
EAST	9	10

PARTICIPANT RATING ON USEFULNESS OF TALKS
4.0=EXCELLENT
3.0=GOOD

2.0=FAIR
1.0=POOR

SESSION 1 WHY DO WE PROTECT MINES AND CAVES?

PRESENTER	AVERAGE RATING	RATING RANGE
Ronal Kerbo	**3.5**	**4-2**
Rick Sherwin	**3.9**	**4-3**
Robert Currie	**3.3**	**4-1**
Jim Nieland/Len Meier	**3.1**	**4-2**
Heather Garland	**3.3**	**4-2**
Mark Mesch	**3.5**	**4-2**

SESSION 2 PROJECT PLANNING

PRESENTER	AVERAGE RATING	RATING RANGE
Rick Olson	**3.4**	**4-2**
Susanna Henry	**3.0**	**4-2**
Pat Brown	**3.7**	**4-2**
Amy Fesnock	**3.6**	**4-2**
Fred Sherfy	**3.2**	**4-2**
Josheph Kath	**2.8**	**4-1**
Steve Walker	**3.0**	**4-2**
Jim Kennedy	**3.3**	**4-2**

SESSION 3 CLOSURE DESIGN: PART 1

PRESENTER	AVERAGE RATING	RATING RANGE
Robert Currie	**3.3**	**4-2**
Debbie Buecher	**3.7**	**4-3**
John Kretzmann	**3.3**	**4-2**
Mike Warton	**2.4**	**4-1**
Jim Langdon	**2.7**	**4-1**
Blake Sasse	**3.7**	**4-3**

SESSION 4 CLOSURE DESIGN: PART 2

PRESENTER	AVERAGE RATING	RATING RANGE
Paul Krabacher/Kirk Navo	**3.5**	**4-3**
Dave Dalton	**3.5**	**4-3**
Roy Powers	**3.3**	**4-2**
Marion Vittetoe	**3.0**	**4-1**
Mark Mesch	**3.6**	**4-2**
John Kretzmann	**3.7**	**4-2**
Jim Werker	**2.5**	**4-1**
Roy Powers	**3.3**	**4-2**

SESSION 5 CONSTRUCTION MANAGEMENT

PRESENTER	AVERAGE RATING	RATING RANGE
Paul Krabacher	**3.6**	**4-2**
Kristen Bobo	**2.9**	**4-2**
Sam Edwards	**3.6**	**4-2**
Mark Stacy	**3.6**	**4-3**
John Burghardt	**3.7**	**4-3**
Jim Nieland	**3.5**	**4-2**
Bob Hall	**3.6**	**4-3**

SESSION 6 MONITORING AND MAINTENANCE

PRESENTER	AVERAGE RATING	RATING RANGE
Rick Sherwin	**3.9**	**4-3**
Mike Herder	**3.5**	**4-2**
Jim Kennedy	**3.3**	**4-2**
Paul Krabacher/Bucknam	**3.1**	**4-1**
Jim Nieland	**3.5**	**4-1**
Mark Mesch	**3.6**	**4-2**

SUGGESTIONS FOR IMPROVEMENT

MONITORING OF BAT RESPONSE TO GATING

- $ Need more information on standardizing research methods for monitoring.
- $ Need a forum on Monitoring and evaluation of bat acceptance of gates.
- $ Need to get monitoring results published.
- $ Need a forum on monitoring protocals with results of pre - and post-gate monitoring.
- $ Future forum on monitoring bats with hands on activities.
- $ Need a workshop on monitoring of pre - and post-gate effects on bats.
- $ Need more information on gating effects on bat populations and bats in forested habitats.

VANDALISM

- $ Need a cost analysis of increasing cost as it is related to increasing vandalism.
- $ Need more information on the law enforcement aspect of protection from vandalism.

FIELD TRIP

- $ Have the field trip in the middle rather than the end.
- $ Would have liked a field trip to BCI and Congress Street Bridge during Bat Flight.

AGENCY COOPERATION

- $ Need to bring out the short comings of having abandoned mine reclamation driving the gating process because it limits our ability to manage species. As long as mining reclamation continues at this accelerated pace, biologists and land managers will continue to be hampered and limited in their ability to collect valuable biological data on the impact of gated on bats. The bottom line is that bat conservation remains a secondary benefit to abandoned mine reclamation.
- $ Future forums should advocate better cooperation between Federal reclamation agencies and State wildlife agencies.

$ Need to better protect bat habitat on private land through land acquisition and on public land by mineral withdrawals.

FORUM FORMAT

$ Need to have breakout groups for specific topics.

$ Need to have a follow-up forum similar to this another 3 -5 years.

$ Some of the topics had too much overlap. By day 3, half of the information was repetitive.

$ Need to reduce the amount of overlap between presentations.

$ There should have been more emphasis on design.

$ Some of the speaker presentations could have been improved.

$ We need more biological study results and less speculation.

GATING MANUAL

$ I am not convinced that the proceedings will function as a Agate manual.@ There is a lot of good information but I don=t think it will be enough for a Anovice@ to construct a gate.

$ BCI needs to endorse more than one bat gate design.

GENERAL

$ Needed a talk on how to identify abandoned mines with a high potential for bats but with no bats present prior to decision on gating.

$ Need a similar forum specifically for bats in the Western U.S.

$ I would have liked to know where to obtain information signs for bat gates, Anabat systems and bat detectors.

$ I would like to know more about cave invertebrate species needs .

APPENDIX 1: RECORDED DISCUSSIONS

Edited by
Kimery C. Vories
USDI Office of Surface Mining
Alton, Illinois

The following are the edited discussions that took place at the end of each speaker presentation and at the end of each topic session. The actual comments have been edited to translate the verbal discussion into a format that more effectively and efficien tly communicates the information exchange into a written format. The organization of the discussion follows the same progression as that which took place at the forum. A topical outline has been developed to aid in accessing the information brought out i n the discussions.

The topic of each question is shown in alphabetical order in **bold.** The individual spe aker questions are listed in outline format under the appropriate topic session and presentation title. Questions during the twenty minute interactive discussion are listed at the end of the session in the following format:

SESSION # AND TOPIC AREA
1. Presentation Title
   - **Subject of Question or Comment**

SESSION # INTERACTIVE DISCUSSION
Subject of Question or Comment

OUTLINE OF DISCUSSION TOPICS

SESSION 1: WHY DO WE PROTECT MINES AND CAVES?

1. Importance of Protecting Caves
2. Importance of Protecting Mines
   - **Importance of Mines to Bats in Eastern U.S.**
   - **Injuries in Mines**
   - **Other Biological Resources in Mines**
3. History of Protection Efforts
4. Legal Issues Associated with Bat Gate Construction
   - **Electronic Surveillance**
   - **Looting of Archeologic Resources**
5. Management and Protection Issues on Private Land
6. Consequences of Not Protecting the Resource
   - **Accidents and Education**

SESSION 1 INTERACTIVE DISCUSSION
Cave Ownership

Federal Cave Resources Protection Act
Mines as Unnatural Habitat
Need for New Federal Mine Protection Law
Other Biological Resources in Mines
Protection of Cultural/Historical Resources
Rate of Mine Closure
State Laws for Protection of Caves
Tools for Electronic Surveillance

SESSION 2: PROJECT PLANNING

1. Performing a Needs Assessment
2. Developing a Project Strategy
   - **Bat Response to Gating**
   - **Depth of Mine Shafts**
   - **Mine Use by Big Horn Sheep**
3. Bio-assessment - Determining the Suitability of Mines and Caves for Bats
   - **Cost of thermal and infra red cameras**
4. Developing a Cave or Mine Management Plan
5. National Environmental Policy Act (NEPA) Compliance
   - **Categorical Exclusions**
   - **Categorical Exclusion Documentation**
   - **Environmental Assessments for Ongoing Projects**
6. Funding a Bat Gate Project
7. Cave Gating Partnerships: Success through Careful Planning and Coordination
8. Training Opportunities for Cave and Mine Gaters

SESSION 2 INTERACTIVE DISCUSSION
Habitat Value of Underground Resource
Importance of Developing Relationships that will Protect Habitat
Importance of Hands on Workshops
Importance of Monitoring for the Biological Assessment
Revegetation around Gated Closures
Seasonal Windows for Work without Monitoring
Species Specific Tolerance of Bat Gates
Temporary Closures

SESSION 3: CLOSURE DESIGN: PART 1

1. Overview of Closure Strategies
2. Bat Roost Protection: Closure Design using Soft Closures
   - **Fake Surveillance Equipment**
   - **Radiation Hazard Signs**

- **$ Real Security Systems**

3. Cable Nets for Bat Habitat Preservation
   - **$ Barn Own Response to Cable Nets**
   - **$ Commercial Availability of Cable Nets**
   - **$ Corrosion of Cable Nets**
   - **$ Maternity Colony Avoidance of Cable Nets**
   - **$ Welding Cable Nets**
4. Solid and Invertebrate Door Gate Option
   - **$ Paint Effectiveness**
   - **$ Tourist Gate 800 Feet into Cave**
4. Culvert Closure Design and Construction
   - **$ Benefit of Bat Gate Inside a Culvert**
   - **$ Merit of Using a Cupola at the end of a Culvert**
6. Flyover Barriers as a Method for Cave Bat Protection
   - **$ Alternative to Chain Link Fence**
   - **$ Rope Access at Cave Entrance**

SESSION 3 INTERACTIVE DISCUSSION

Air Flow Data
Concrete versus Steel Culverts
Life Expectancy of Culverts
Manganal Steel Comparison
Windows in Cable Nets

SESSION 4: CLOSURE DESIGN: PART 2

1. Ladder Gate Design
2. Bat Gate Option Overview
3. Angle Iron Gate
   - **$ Benefits of Angle Iron in Time Savings**
   - **$ Removable Bar**
4. Rectangular Tube Gate
   - **$ Length of Welding Leads**
   - **$ Pin Spacing**
   - **$ Stretcher Access with Removable Bars**
   - **$ Type of Steel**
5. Round Bar Manganal Steel AJail Bar@ Bat Gate
   - **$ Bat Response to Manganal Gates**
   - **$ Cost of Manganal Gates**
   - **$ Suitability of Manganal Gate for Large Openings**
6. Bat Cupola Design Considerations

7. Material Selection
   - **$ Finish & Paint to Extend the Life of Steel**
   - **$ Stainless Steel Recommendations**

8. The Problem of Bat Population and its Relation to Gate Area.
   - ***$ Bat Behavior based on Memory***
   - **$ Bat Mortality due to a Bat Gate**

SESSION 4 INTERACTIVE DISCUSSION
Bar Spacing in Gate

SESSION 5: CONSTRUCTION MANAGEMENT

1. Contract Management
   - **$ Unnecessary Insurance Costs**
2. Eastern Consultant Perspective
3. Western Consultant Perspective
   - **$ ACAA Copyrighted Bat Gate Design**
   - **$ Cost of Dummy Video Cameras**
   - **$ MSHA Applicability**
4. Partner and Volunteer Logistics
   - **$ Administrative Fee**
   - **$ Bat Gates at Mines with No Bats**
   - **$ Determining Project Cost**
   - **$ Estimated Cost Exceeded**
   - **$ Types of Mines**
5. Safety Issues
   - **$ Prying Rocks at Mine Entrance**
6. On-Site Coordination and Work
7. Personnel and Qualifications

SESSION 5 INTERACTIVE DISCUSSION
Chicken Wire Exclusions
Large Contractor Bidding
Mines where a gate should not be installed
Transportation of Steel & Equipment

SESSION 6: MONITORING AND MAINTENANCE

1. Bat Response to Gates
2. Pre- & Post-Gate Biological Monitoring
   - **$ Bullet Camera Range**

- **$ Counting Software Development**

6. Pre- & Post-Gate Microclimate Monitoring
   - **$ Climate and Temperature Changes in Missouri Caves**

4. Closure Repair and Maintenance
   - **$ Funding for Post Gate Monitoring**
   - **$ High Carbon Dioxide Levels in Mines**
   - **$ Identification of Closures in the Field**
   - **$ Public Notification on Closure Damage**
5. Human Access: Policies, Management, & Monitoring
   - **$ Applicability of the Federal Cave Resource Protection Act**
   - **$ Limiting Visits to Hibernation Colonies**
   - **$ Monitoring Recreational Use of Caves**
6. Demonstration of Gate Monitoring Database
   - **$ Data Analysis**
   - **$ Import and Export of Data**
   - **$ Limiting Access to the Public**
   - **$ Public Availability of Data**

SESSION 6 INTERACTIVE DISCUSSION

Conflict over Release of Locations to Public
Modification of Mines to Improve Bat Habitat
Power of GIS to Link Related Geographic Data
Vandalism by Fire

DISCUSSION BY SESSION

SESSION 1: WHY DO WE PROTECT MINES AND CAVES?

1. Importance of Protecting Caves Ronal Kerbo, National Park Service, Denver, Colorado

No Questions

2. Importance of Protecting Mines Rick Sherwin/Scott Altenbach, University of New Mexico, Albuquerque, New Mexico

Comment: **(Importance of Mines to Bats in Eastern U.S.)** In Eastern North America where we can document dramatic losses of bats from caves, loss of mines can be very important. For example, 10s of millions of bats once lived in Mammoth Cave and Wyondot Cave and migrated from as much as 500 kilometers away. Although bats only require a small number of cave, they require 100 percent of the caves that cave explorers like. This is because the big hibernating sites need a very large volume and complexity in order to meet the bat needs which also makes them interesting to people. This has resulted in the commercialization of most of the caves of any size in Eastern North America and may never again be available to bats. Currently the only option we have to protect these bats is to protect key mine resources. It is not that unusual in Eastern North America to have large populations of bats in the 10s of thousands to be threatened with being buried during mine closure. One of the best examples of a recovering Indiana Bat colony is in a mine recently protected in Illinois. It has miles of the most ideal temperature regimes for bat colonies in North America and one day may become the equivalent of Mammoth Cave in terms of housing large bat populations.

Question: **(Injuries in Mines)**Are people who explore mines being rescued, injured, killed?

Answer: Yes. It is surprising that it does not happen more. Every year there are deaths and injuries from mine exploration that we know of and I am sure many more that we aren't reported. Most of the people getting into the mines are trespassing or entering without permission. I have been in situations where it was extremely difficult for me to gain access to a mine and I was completely equipped with all of the appropriate climbing and safety gear and find and empty six pack of beer and other evidence of inappropriate use.

Question: **(Other Biological Resources in Mines)** We have heard about biological resources other than bats in caves. Are there other biological resources besides bats in mines?

Answer: Virtually anything that you will find in caves you will find in mines. The problem is the time scale. You will get turkey vultures, bobcats, big horn sheep, desert tortoises, and mountain lions. Currently, the only inventories being done on mines are for bats. You should be designing the gates, however, for the types of wildlife that are using the mine. We haven't developed a good gate for big horn sheep.

3. History of Protection Efforts Robert Currie, U.S. DOI Fish & Wildlife Service, Asheville, North Carolina

No questions

4. Legal Issues Associated with Bat Gate Construction Jim Nieland, U.S. Forest Service, Amboy, Washington and Len Meier, Office of Surface Mining, Alton, Illinois

Question: **(Electronic Surveillance)** We are investigating electronic surveillance as a way to decrease looting. We had to have a three day stake out by agents of a cave where looting went on prior to catching the looters. Have other had experience with different types of surveillance?

Answer: I use a passive low tech way to detect human activity at a site. I place a new dollar bill in a area that pack rats are not likely to bother (pack rats may be attracted to salt in used dollar bills). If it is still there on my next trip I assume no human activity.

Answer: Video cameras with motion sensors have been used to video tape intruders so that you have actual evidence and because alarms may require such lengthy response times that the intruder is gone by the time agents arrive on the scene.

Comment: **(Looting of Archeologic Resources)** We build a lot of bat gates in Missouri and have a problem with archeologic looting in the larger cave entrances. We find a significant connection between the archeologic looting and disturbance of bats. Because of recent cave gates that were installed to prohibit looting there has been increased use of these caves by gray bats.

5. Management and Protection Issues on Private Land Heather Garland, The Nature Conservancy-Tennessee, Nashville, Tennessee

No questions

6. Consequences of Not Protecting the Resource Mark Mesch, Utah Division of Oil, Gas, and Mining, Salt Lake City, Utah

Question: **(Accidents and Education)** In the case of the boy on the ATV who fell down the shaft, do you that having a fence around the shaft would have prevented the accident?

Answer: I think that for the accidental injury where someone does not see a mine opening and accidentally drive into it that fences can prevent that type of injury. If, however, someone is interested in looking at the mine feature they will attempt to get as close to the mine opening as they can and they will crawl under a fence or climb over it to get close to the mine opening. I can not stress enough the positive role that education plays in being able to prevent accidental injuries associated with mine openings. This education may involve etiquette in caves, safety around abandoned mines, or the value of the wildlife that inhabit caves and mines. The State of Utah sends out a work booklet on an annual basis to every fourth grade child in the State that talks about the cultural and biological values of mines and caves and the importance of safety issues related to th em.

SESSION 1 INTERACTIVE DISCUSSION

Comment: **(Cave Ownership)** Concerning cave ownership, we need better information on management when there are multiple entrances, effects to water quality from agriculture, and multiple ownership of different cave components. A State may own an entrance yet not own the watershed or all of the cave passages or other openings and yet they are permitting people to enter a cave they don=t where they don=t have complete control.

Question: **(Federal Cave Resources Protection Act)** If an abandoned mine intersects a cave and the cave does not open to the surface, does that cave warrant protection under the national cave act.

Answer: The Federal Cave Resources Protection Act exempts AVUGS@ from consideration. The question then is the definition of a AVUG.@ VUG is a Cornish word meaning a cave or cavern. If it is an active mine it would not be protected. The same applies to drilling an oil or gas well. So the answer is no it is not protected especially if it is on Federal lands. This act only applies to lands owned by the Department of Agriculture and the Department of Interior. The act is concerned with making sure that mining is not inhibited by interference with underground voids or caves.

Question: Is there any size limit to AVUGs?@

Answer: There is no size limit. It could be 50 miles long and it is still a AVUG.@

Comment: **(Mines as Unnatural Habitat)** As a public lands manager, I would find it difficult to promote the protection of bat habitat in mines because they are not natural bat habitat.

Comment: I think the statement that mines are an unnatural habitat is not a valid st atement. If an animal uses a habitat it is habitat. Habitat may be man made but it is not unnatural any more than a reservoir is unnatural habitat for birds, fish, and other wildlife. The idea that a man made habitat is unnatural and we should make the animals go back to where they came from is not valid because we need to protect the wildlife species and the resources they use for habitat.

Question: **(Need for New Federal Mine Protection Law)** Is there a need for Federal laws that protect abandoned mines like we have laws for the protection of caves?

Comment: Concerning the need for additional Federal mine laws, even though Fish and Wildlife handles habitat issues, and State SHPOs for cultural resources, ultimately in all of the coal mining States the Office of Surface Mining has oversight. It is my opinion that if big law suits are ever filled in this area they will be brought against OSM because they are the funding source for mine closures.

Answer: Many of the State programs are usin g Federal Coal dollars to protect abandoned mines and as such must go through the National Environmental Protection Act process that requires a lot of background information including biological and archeological evidence. Because most of the mine dwelling bat species in Utah are not Federally protected, there is no legal requirement at either the State or Federal level that requires us to protect the bats in the process of closing mines for public safety.

Comment: **(Other Biological Resources in Mines)** In eastern Nevada in the winter, thousands of rosy finches roost in abandoned mines particularly in shafts. People need to be careful about closures of these shafts as you may destroy the entire population from adjacent mountain areas. I know of cases where we have lost thousands of these birds in mine expansion projects.

Comment: **(Protection of Cultural/Historical Resources)** You might be able to protect the mines from a cultural perspective of the historic value of the mine with the added benefit of protecting the bats while you protect the historic value it would make a much more defendable position. The historic values could include examples of different mining methods, the people or mining companies involved, different mining eras, different regional or mineralogical values. This may make them eligible for listing on the National Historic Registry.

Answer: There is an imp ortant disconnect between the historical value of surface features and underground features. I have surveyed over 7,000 individual abandoned mines prior to closure and I have never been asked about historical or cultural resources underground. Two weeks ago I was at the 1,000 foot level of an abandoned mine and all of the carbide lamps were still hanging there including personal items and equipment. I can=t touch this stuff or bring it out because it is protected but no one wants to house it and now the mine is closed and the resources gone. Once I took a carbide lamp to the historical preservation office and they sent their archeologist with me back to the mine to replace it and close the mine. They did not want to deal with the issue.

Comment: Concerning underground cultural resources, I have heard the Office of Historic Preservation say that leaving artifacts underground or even intentionally burying them is actually preserving them in place and are not lost.

Comment: One problem you have is that as soon as you close a mine the humidity rises and you start to loss things though decay. In addition, without even a brief documentation or inventory of these resources prior to closure, the chances of anyone ever c oming back to recover and interpret the artifacts when the mine is only one of hundreds of thousands of abandoned mines makes that possibility

from remote to impossible. It is my recommendation that who every is surveying the biological resources make some sort of record of any cultural or historical evidence that they find. I make it a point to video tape every mine I survey. At least with this record anyone who might want to come back would know which mine they wanted to reopen and investigate.

Question: **(Rate of Mine Closure)** Concerning the rate of mine closures, how can we take more time and do a better job?

Answer: If the underground survey is being conducted because of a possible mine expansion, then time is money. If there is not a legal constra int like the presence of an endangered species they the economics will dictate that the closure take place quickly.

Answer: Concerning the Abandoned Mine Program, it is important to place these closures in perspective with the amount of a bandoned mines that need to be closed in order to protect the public. In Utah there are 20,000 mines, in Nevada 200,000, Arizona 100,000, Colorado 25,000, New Mexico 70,000. There are hundreds of thousands of these mines. In Utah we have been working night and day for 20 years trying to close these mines and have only closed about 25 percent of them. The reason it takes so long is that there is a lot more involved than filling holes with dirt. The amount of time and work it takes to conduct investigati ons, evaluate the evidence, and design a mine closure. The actual construction takes place very quickly by comparison. There are years of time spent prior to construction evaluating a closure. At our current rate of closure in Utah of 5,000 closures in 20 years, we won=t finish mine closures for a long time. If you look at States that don =t have funded mine closure programs like Idaho, California, Nevada, and Arizona they are no t able to do even a fraction of the closures that are possible in the coal mining States.

Comment: **(State Laws for Protection of Caves)** In Virginia, we have had two incidents where an oil or gas well drilled through a heavily trafficked cave and it was ca sed and abandoned. We were able to enforce the Virginia Cave law and make them go back and open up the cave and reseal the holes. Many of the States have State Cave protection laws.

Comment: **(Tools for Electronic Surveillance)** People interested in avail able electronic surveillance tools can go to the Department of Defense and go through the DRMO who have a lot of electronic sensors developed for war time surveillance. They can be obtained fairly cheaply. Some of them with battery packs have a range of 20 miles. If you can build a tower, they can be reach to your office and be down loaded into your computer. You can inspect this type of surveillance all along our border with Mexico operated by the border patrol.

SESSION 2: PROJECT PLANNING

1. <u>Performing a Needs Assessment</u> Rick Olson, National Park Service, Mammoth Cave, Kentucky

No Questions

2. Developing a Project Strategy Susanna Henry, Kofa National Wildlife Refuge, Yuma, Arizona

Comment: **(Bat Response to Gating)** Just three weeks ago we surveyed the 3C mine at the Refuge and recorded an out-flight of 3,100 leaf nosed bats. By installing the bat gate, the numbers of bats using the mine have steadily increased.

Question: **(Depth of Mine Shafts)** How deep are these mines?

Answer: In 1996, we investigated 16 shaft mines on the Refuge and several reached depths of several hundred to a thousand feet deep. The depth depends entirely upon the type of ore being mined and the economics of recovery. The mining was very active around the turn of the century.
Question: **(Mine Use by Big Horn Sheep)** Concerning Big Horn Sheep, how far into the mine do we need to install the gate?

Answer: I would look for the sheep beds and for other evidence such as droppings on how far back the sheep are going. You may not be able to include all of the area they are using as I have found evidence of sheep up to 400 feet inside the mine in what appears to be total darkness. You also have to consider many other factors but an effort should be made to accommodate the sheep.

3. Bio-assessment - Determining the Suitability of Mines and Caves for Bats Dr. Patricia Brown, University of California at Los Angeles, Bishop, California

Question: **(Cost of thermal and infra red cameras)** How expensive are the thermal imaging and infra red cameras?

Answer: I do know that Rick Sherwin just purchased a thermal image camera for $40,000. The cheap thermal imaging cameras start around $12,000 (these allow you to record and do subjective differentiation on color) and they go up to $100,000 and more. Cameras starting at around $35,000 are necessary if you are going to do any analysis of temperatures after the event. We pay around $600 for an infra red camera with an additional $50 to $100 for a light source.

4. Developing a Cave or Mine Management Plan Amy Fesnock, Pinnacles National Monument, National Park Service, Paicines, California

No Questions

5. National Environmental Policy Act (NEPA) Compliance Fred Sherfy, Office of Surface Mining, Harrisburg, Pennsylvania

Question: **(Categorical Exclusions)** On my forest there is a district that is going to close 25 mine sites and the ranger wants to do a Categorical Exclusion from NEPA. What do you think?

Answer: You need to document that decision. The standard answer is, if your agency has a process for

a Categorical Exclusion that would extend to those 25 sites, then the agency has already made the decision and published that this would not have significant impacts to the environment. I know that in the Department of Interior we could not do that. The Department of Interior does not allow categorical exclusions when a project would have a high degree of public controversy. I don ‐t know what the situation is in the F orest Service.

Comment: I have closed mines at BLM using Categorical Exclusions because the two Exclusions used by BLM include threats to human safety and wildlife roosts. I always check with the area miners and if there is no interest in the mine openi ng then I determine that there is a low degree of public interest. I think that a Categorical Exclusion is very appropriate for our situation in the BLM.

Comment: We have done almost 100 closures on our forests with Categorical Exclusions.
Question: **(Categorical Exclusion Documentation)** Do you have a documentation process in the Forest Service to arrive at a categorical exclusion?

Answer: We have been very inconsistent. Some districts have not documented anything and others have a fairly formal process and in some cases we have done Environmental Assessments.

Question: **(Environmental Assessments for Ongoing Projects)** Concerning Environmental Assessments where an agency has an ongoing activity like OSM ‐s EIS 11 that is now 20 years old, does that ever get re-authorized or amended?

Answer: Yes is does, but it is a matter of priorities. After 20 years, the EA on abandoned mine lands project is working so well that OSM is not really inclined to devote th e resources just to do another programmatic EIS. But I am not saying it would not have value.

6. Funding a Bat Gate Project Joseph Kath, Illinois DNR, Division of Natural Heritage, Springfield, Illinois

No Questions

7. Cave Gating Partnerships: Success through Careful Planning and Coordination Steve Walker, Bat Conservation International, Austin, Texas

No Questions

8. Training Opportunities for Cave and Mine Gaters Jim Kennedy, Bat Conservation International, Austin, Texas

No Questions

SESSION 2 INTERACTIVE DISCUSSION

Comment: **(Habitat Value of Underground Resource)** Let me point out that the mine Joe Kath talked about in Illinois, where he has a very rapidly growing population of Indiana Bats, had almost no bats when the project began. You need to be able t o recognize what makes good bat habitat. I know of caves that we have protected that had no bats at the beginning of the project and now have 300,000 bats. Many times we are spending funds on protecting underground resources without knowing the potential for use of those resources by bats.

Comment: **(Importance of Developing Relationships that will Protect Habitat)** I am working on a gating project for a species of bat at BLM where we can not protect the mother lode of the species that is on private land but we are doing what we can on adjacent BLM land. Success is not always measured in increased numbers of bats that use a site, but sometimes it is measured in improved working relationships and partnerships that ultimately result in improved bat protect ion projects and efforts.

Comment: **(Importance of Hands on Workshops)** Concerning workshops on bat gate installation, I think that gating manu als are good, but these hands on workshops are like the laboratory portion of the class. I participated in one in the Great Smokies National Park and it was outstanding. These hands on workshops need to be part of the training for people involved in inst allation of bat gates.

Comment: At the last workshop, one of the participants commented that the most important thing he learned at the workshop was that he did not want to attempt it on his own which is what he was preparing for prior to the workshop.

Comment: Concerning the usefulness of gating workshops, a new gate was recently installed at Hubbard=s Cave in Tennessee where it took about a week to install a very large bat gate that was similar in size to a gate tha t had been installed in the early 1980's in about 6 weeks. Roy Powers attributed most of the shorter construction time to the fact that most of the volunteers had been to these gating workshops and had experience working on gate installation on the second installation while very few were experienced on the first installation.

Question: **(Importance of Monitoring for the Biological Assessment)** Is it possible to do a biological assessment without doing monitoring?

Answer: It is certainly the most desirable thing to do monitoring so that you will have real information to base your decision on. Although expediency dictates that we do not always have the opportunity to do monitoring it should be our goal to do monitoring in order to have good information guidi ng our closure decision making process.

Question: If the object of our biological assessment is to come to a determination of no significant impact on sensitive species and we are going to install a bat friendly closure, can =t we conclude no significant impact without doing monitoring.

Answer: If you don=t know what species of bat uses the mine, when and how the bats are using the

mine, and the size of the colony, it would be hard to determine how the bats are going to respond to a specific closure.

Comment: Since we are not able to always monitor prior to doing a biological assessment, sometimes our biological assessment is just wrong. If we don=t do monitoring we will just keep perpetuating our mistakes. We need to keep trying to do as much monitoring as possible.

Comment: In my program, I need to compete for funds with other projects. In order to remain competitive, I have so show that my projects are getting results. In order to show results, I need to monitor to show that the installation of bat gates actually results in increased use by bats.

Comment: A lot of us who are doing biological assessments for bat friendly closures do not have a primary job assignment of benefitting wildlife. Our primary job is to clear an area for timber sales or mining projects. I think that the greatest good you can do with the funds and time that are available is what you should do.

Comment: Concerning monitoring from the perspective of the National Park Service, we are certainly not doing our jobs if we don=t monitor for bat activity. I remember a gate at a lava tube with ice in it that was gated because of the sacred nature of the cave to the HOPI tribe and putting ceremonial objects in them that they didn=t want stolen. I recommended that they monitor it prior to installation of the gate for at least a year in order to assure that we would not impact the accumulation of ice in the cave. The monitoring was just as important for the protection of cultural features as it is for bats. You need to do it right the first time.

Question: **(Revegetation around Gated Closures)** Does anyone know about the desirability of reestablishing vegetation in arid areas around mines openings that have been reworked and closure devices installed?

Answer: In New Mexico we have revegetated around mine openings both with seeded species and with cuttings of Ocotillo.

Comment: You need to be careful with what you plant around these openings. I believe that Ocotillo is pretty spiny when it grows up. My experience in Texas is that we have had large spiny plants grown up around cave entrances that eventually became major bat mortality problems when they hit flying bats when the wind would blow and actually cause the abandonment of the site.

Comment: In the Mojave desert, we have had the best result with revegetation when we make a moon scape by roughing up the surface as much as possible around the old mine opening. We even bring in some large rocks to add shade to some of the area. We also try to create as many traps for rainfall as possible. With only one or two rainfall events per year we need to collect water. We have also found that in desert areas we need to find seeds from plants that are growing near that site with the same type of microclimate. If you are seeding a south facing slope you need to collect seed from a south facing slope and the same elevation and soil type. The only way we have been able to establish Creasote

plants is to collect seed from the site and take them to the local Junior College Nursery and have them grow small seedlings that we can drill and replant. In our area, it may take 20 years for the vegetation to fully develop like a natural area.

Question: **(Seasonal Windows for Work without Monitoring)** When we don=t have the resources for monitoring, and we need to close a mine due to vandalism, is there any guidelines for what time of year we should do our work when we don=t know if the bats are using the mine for maternity site or hibernation, or just roosting?

Answer: Although you need to know the elevation and latitude of the mine to give you an idea of when a mine is being used, usually there is a window of time in the spring before the maternity season really gets going and a window in the fall. Although some times we find that there is use at some of these sites in the fall for swarming. In general, the bigger and more complex the mine site is in terms of numbers of openings and openings at different elevations the more likely the mine will be useful for bat and for more seasons of the year. If you go to an upper mine entrance on a cold winter day and there is steam coming out of it there has to be another intake entrance. This would also apply if you are at a lower entrance and can detect that there is cold are flowing into it there is a good chance that the mine has another entrance. In the heat of the summer this process should reverse. If you are looking for bats in such a site, they will be closest to the entrance with the warm area during the summer and near the entrance where cold air is coming in during the winter.

Comment: **(Species Specific Tolerance of Bat Gates)** At the Bat Conservation and Mining Forum, there was a short paper with a table that summarizes what we know about which species will tolerate gates and which species will not. There are still a lot of species where we do not know how they will respond.

Question: **(Temporary Closures)** Concerning the use of temporary closure structures, please explain when and why you should do a temporary closure prior to installation of a permanent closure?

Answer: When we installed a temporary plastic gate at the 3C mine, we were concerned because of the large number of California Leaf Nosed bats. We were willing to tear it down right away if it had any negative effect on use by the bats the very first night it was installed. We found that on the first night the bats took 90 minutes to exit the gate where it had only take an hour before we installed the plastic gate. In that case, we knew that the bat species would tolerate the gate but we didn=t know what the effect would be on a colony of such a large size.

Comment: Concerning temporary gates, in a recent bat gate installation where we were concerned about acceptance of the gate by the bats, Scott Altenbach added gate bars over a period of time rather than all at once to allow the bats time to adjust to the gradually smaller spaces available to fly through.

SESSION 3: CLOSURE DESIGN: PART 1

1. <u>Overview of Closure Strategies</u> Robert Currie, U.S. DOI Fish & Wildlife Service, Ashville,

North Carolina

No Questions

2. Bat Roost Protection: Closure Design using Soft Closure s Debbie and Bob Buecher, National Speleological Society, Tucson, Arizona

Question: **(Fake Surveillance Equipment)** Where did you obtain your fake video camera to discourage vandalism?

Answer: It was installed by the Fort so they may have obtained it from the Border Patrol. Because of the availability of this type of equipment and the use of cell phones, it may soon be possible to actually have working video monitoring that is affordable. The problem would still be that at remote sites you do not have the many hours it would take just to get to the site in order to catch a vandal.

Comment: In Texas, we found that just by leaving some pocket change at the entrance to a cave or mine we can tell if someone has been there.

Comment: These systems may be useful when there is a history of vandalism, but I think that signs and alarm systems may actually bring more unwelcome attention to those sites that are not already well known.

Question: **(Radiation Hazard Signs)** Has anyone used radia tion signs or biohazard signs as a means to discourage unauthorized use or vandalism?

Answer: We have recently discussed this in Illinois and our attorneys have instructed us that we can not legally put up any signs that purposely do not tell the truth.

Comment: I know of a place where the radiation sign approach is currently in use. I do not know what the affect of the sign has been because the site did not get much use or attention before the sign. Our biggest concern so far has been that the bats of concern at this site have been flying into the signs.

Comment: **(Real Security Systems)** Concerning real security systems, the price has really been coming down. If you are in an area that has cell phone access, primarily the Eastern U.S., you can get a turn key, off the shelf, remote solar powered system for $2,000 to $3,000. If you are in area that has a security system available you can use cell side band system that is even cheaper. Within the next 5 years there should be a lot of technology that be d eveloped so that we will be able to put real alarm systems into more sites where you are close enough to respond.

3. Cable Nets for Bat Habitat Preservation John Kretzmann, New Mexico Abandoned Mine Land Bureau, Sante Fe, New Mexico

Question: **(Barn Own Response to Cable Nets)** Does anyone have information on the response of

Barn Owls to cable nets?

Answer: In New Mexico, our research suggests that Barn Owls need at least a 10 inch diameter opening which would be larger that the cable net closures we are usin g for bats. In most of our mines, we usually have a conventional bat gate opening in addition to the opening that is cable netted. Also the populations of bats in these mines are small (in the neighborhood of a few dozen).

Comment: We have found dead Ba rn Owls, dead tortoises, and dead bob cats under cable netting. Which is another good reason for monitoring prior to installing netting.

Question: **(Commercial Availability of Cable Nets)** Are the cable nets you use custom made or are they commercially available?

Answer: There are at least two companies in the U.S. that I have used in the Southwest.

Comment: In Colorado, we have contractors that custom make the cable nets on site. This reduces the cost by half to two thirds.

Comment: Some of our earlier nets were built on site by contractors but I found that where the cables crossed and where the connectors were placed that unless they were done with a hydraulic ram it was possible to spread the net and make an opening large enough fo r a person to crawl through. Because of this I have specified that be pressed together hydraulically.

Question: **(Corrosion of Cable Nets)** Do you get any galvanic corrosion at the junctures where the stainless steel and galvanlized steel come into contact ?

Answer: No.

Comment: **(Maternity Colony Avoidance of Cable Nets)** In my experience, I have never seen a maternity colony use a cable net. They are used for hibernation sites and have been widely used in National Parks. The cable nets have excluded mate rnity colony where they have been used. If cable nets are to be considered, then multiple surveys should be conducted during the warm season before any single entrance site is closed with a cable net.

Comment: The site I showed at the large adit opening, Dr. Scott Altenbach said he would be comfortable with placing cable net over the opening for a Townsends Big Eared Bat maternity colony. The entrance was such a large opening he felt that the bats would be able to handle a cable net because of the size o f the opening. I was not completely comfortable with that and installed a bat grate as well as the cable net. We have not done any monitoring of bat response at the site.

Comment: I am aware of a large Leptonictorus colony of 20,000+ that has had a cabl e net for some time. It is a post maternity season fall roost and are flying in and out nightly.

Question: **(Welding Cable Nets)** Have you considered welding your bat grates in the cable netting rather than bolting?

Answer: I have hesitant to weld to a ca ble because I think it would be too destructive to the cable itself.

4. Solid and Invertebrate Door Gate Option Mike Warton, Mike Warton & Associates, Cedar Park, Texas.

Question: **(Paint Effectiveness)** Concerning the paint you apply to your gates, how effec t has your paint been over time?

Answer: We try to design our gates to be low maintenance. We use a rustoleum paint that works well on steel for about 3 years before it begins to show sign of wear. We recommend that our gates be painted regularly, that hinges and locks be lubricated for optimum operation.

Question: **(Tourist Gate 800 Feet into Cave)** Concerning the gate that you installed 800 feet inside the cave, why was it installed that far into the cave?

Answer: The Gorman Cave is abo ut 3,500 feet long. When it became a Texas State Park, they were interested in taking people on tours in the cave. I was hired to determine how far back people could venture in the cave with encountering a hazard or becoming a hazard to the bats. We det ermined that people could safely travel 810 feet into the cave. At this point, the cave was about 16 feet in diameter. We were able to drill a hole down 110 feet from the surface at this point and used this hole to lower in all the steel and equipment we needed to install the bat gate.

5. Culvert Closure Design and Construction Jim Langdon, Idaho Panhandle National Forest, Couer d=Alene, Idaho

Question: **(Benefit of Bat Gate Inside a Culvert)** Are there any benefits to putting the bat gate inside the culvert rather than the entrance to the culvert?

Answer: I prefer to put the gate inside the culvert. It is less expensive. In fact the major benefit of installing a culvert as an access into a c ave or mine is because it is relatively inexpensive.

Comment: I realize that when you have portal creep and unstable portals that culverts may be the only option for installing a bat gate. I would really like to see some pre - and post-gate monitoring to see how the bats are responding to the culverts. I had one bad experience where the bat colony deserted the mine after the culvert was installed. I worry about the reflection of sound by the culvert and how that would effect the ability of the bat to man euver through the culvert. It would seem that applying a coating of sound absorbing material to the inside surface of the culvert could increase bat use.

Question: **(Merit of Using a Cupola at the end of a Culvert)** Wouldn=t it be more bat friendly to bring the culvert out to a cupola rather than install a bat gate within the culvert?

Answer: That could be but it would be much more expensive. Most of the situations where I install culverts is in mine s that not stable and expected to collapse in from 2 to 15 years.

6. Flyover Barriers as a Method for Cave Bat Protection Blake Sasse, Arkansas Game & Fish, Little Rock, Arkansas

Comment: **(Alternative to Chain Link Fence)** On possible alternative to chain li nk fence that is more vandal proof is 3/4 inch sharp edged expanded metal which does not reduce air flow and is very difficult to cut or climb.

Question: **(Rope Access at Cave Entrance)** At Bone Cave, would people be able to gain access by just lowering a rope down at the entrance?

Answer: That is a consideration, when you are using a fence at an entrance. Someone could gain access with a rope at the top of the cave. In this case, the entire cave is just the entrance so there is not really a big attractio n for someone who has the technical climbing skills.

SESSION 3 INTERACTIVE DISCUSSION

Question: **(Air Flow Data)** Is there any real data that shows the comparative effects of different types of construction material on air flow (i.e. squa re bars, angle iron, round bars, etc.).

Answer: There is no data that I am aware of. In most situations, we have very slow air flow. To make it easier on the bats we tend to place the gate in an area of the entrance where air flow is least restricted. This reduces the air flow velocity even further. In this type of situation, the type of material you are using really does not effect air flow. So all of this time we have been spending on talk about air flow really may be a red herring.

Comment: The one place we may be affecting air flow is with the vertical columns. They present a wide flat surface. This is a problem at the larger entrances. Minimum to no vertical columns seems to be the best alternative.

Comment: Anyone thinking about building a bat gate should be contacting BCI and making sure that they have the latest design improvements for construction of gates.

Question: **(Concrete versus Steel Culverts)** How would concrete culverts compare to steel culverts?

Answer: Concrete is at least twice the cost of steel and would not work at a remote site unless you have access to an excavator.

Comment: In California, we have been using 6 foot diameter concrete sewer pipe because it is easy to work inside in areas where portal was weak or the rock in the mine entrance was weak and we could

not anchor a bat gate effectively. This way we can seal the pipe/portal interface with polyurethane foam and then backfill around it. We place the bat gate either inside the sewer pipe or a t the end of the pipe. We have found this to be very cost effective. I am more comfortable with this long term than I would be with steel pipe.

Comment: In Colorado we have use a use a high density polyethelene pipe in combination with a precast concrete bulkhead in corrosive environments.

Question: **(Life Expectancy of Culverts)** What would the costs and life expectancies be for 4 to 5 foot diameter culverts?

Answer: A typical cost for a 54 inch culvert will be $3,000 that is installed with an excavat or. If a culvert is not sitting in water the life expectance would be 40 to 50 years. If it is in water you have to be very careful about any cuts that would violate the zinc coating. I have used a zinc paint to improve longevity. You could also use a polymer coated pipe that is more expensive but adds significant corrosion resistance.

Question: (**Manganal Steel Comparison)** What is the composition of Manganal Steel, how can it be welded and cut, and what are the relative costs?
Answer: It is about 12-14 percent Manganese plus iron. It can be cut with a conventional torch. You must use Manganal welding rod when it is welded.

Comment: Stainless steel is about 2.5 - 3 times greater than mild steel. Material cost is about 15 - 30 percent of the total cost of the job. If using stainless steel means you avoid having to rebuild the gate due to vandalism just once you have more than offset the cost of the stainless. I know of one job where the use of stainless steel made the cost of the bat gate double what it would have been with mild steel. Stainless also presents a problem in that it is not easily cut so many of the pieces have to be prefabricated.

Comment: The steel yard will charge you between $4.50 to $6 for mild steel for 4 by 4 by 3/8 angle per foot. Stainless will cost between $19 and $28 per foot.

Comment: There is now a product on the market called modified steel with more carbon content that increases the difficulty of cutting with a hack saw by about 3 times. We are gettin g modified steel for the same price as mild steel.

Question: **(Windows in Cable Nets)** How do you determine how many bat windows to use in a cable net without compromising the strength of the cable net and how well do the bats use them?

Answer: If you need to deal with a large number of bats using cable nets, there are some options that I have not used but that I believe are technically feasible. This would include suspending a bat cupola structure from strong cables or beams if the distance is not too lon g then placing cable netting around it.

Concerning how bats respond to cable nets, we have seen it used effectively for hibernation sites. With Leptonictorus and Mycrotis these bats are exceedingly agile and a larger colony should be able to handle it. You really have to understand which species you are dealing with and why the bats are using cave or mine. Is it a maternity colony where bats will be in and out several times per night and be vulnerable to predation? Is it a transient colony? That is why you need to do monitoring and have a good biological assessment.

SESSION 4: CLOSURE DESIGN: PART 2

1. Ladder Gate Design Kirk Navo, Colorado Division of Wildlife, Monte Vista, Colorado

No questions

2. Horizontal Bat Gate Option Overview Dave Dalton, Gating Consultant, Tucson, Arizona

No questions

3. Angle Iron Gate Roy Powers, American Cave Conservation Association, Duffield, Virginia

Question: **(Benefits of Angle Iron in Time Savings)**What are the benefits of angle iron in terms of time savings and cost of materials?

Answer: Material cost is only a fraction of the cost of constructing a bat gate. The cheapest strong material that you can buy is mild steel. It took 10,500 man hours to construct the first Hubbard Cave Gate. It took 475 man hours to complete a gate of similar size. We completed the School House Gate (also similar is size to Hubbard Cave Gate in 4.5 days).

Comment: Two years ago we built a angle iron gate that was 51 feet wide and 14 feet high with a small auxillary side gate that was completed in 2.5 days.

Question: **(Removable Bar)** Do these gates have removable bars?

Answer: Yes. My experience is that most of the vandalism with these gates has been at the door. By eliminating a door to the gate and using removeable bars you tend to eliminate the problem with vandalism. A removable bar is probably 10 times more vandal proof than a door in the gate.

4. Rectangular Tube Gate Marion Vittetoe, Gating Consultant, Tucson, Arizona

Question: **(Length of Welding Leads)** How far can you extend your welding leads if you can ‐t actually drive to the construction site?

Answer: Actually we carry all our equipment to the construction site and the lead length is not an issue. With our leads we could go 300 feet.

Question: **(Pin Spacing)** How far apart where your wall pins?

Answer: The pins were placed at every other bar.

Comment: **(Stretcher Access with Removable Bars)** I would like to point out the advantage of putting in more than one removable bar in a gate. If you have at least two removable bars in a gate you can carry an injured person through the opening in a stokes litter.

Question: **(Type of Steel)** What type of steel do you use?

Answer: We only use mild steel because you can=t get anything else in Tucson Arizona.

5. Round Bar Manganal Steel AJail Bar@ Bat Gate Mark Mesch, Utah Division of Oil, Gas, and Mining, Salt Lake City, Utah

Question: **(Bat Response to Manganal Gates)** How are the bats responding to these types of gates?
Answer: We are involved in several studies for the last 3 years with Southern Utah University. So far the results are that there are no negative effects on bat use.

Question: **(Cost of Manganal Gates)** What are costs of these gates?

Answer: Gates that we build today run around $75 per square foot installed including everything.

Question: **(Suitability of Manganal Gate for Large Openings)** What is the utility of round bar gates for small openings versus large openings.

Answer: A very large Managanal Gate was installed in White Rocks Cave and it has worked fine.

6. Bat Cupola Design Considerations John Kretzmann, New Mexico Mining and Minerals Division, Sante Fe, New Mexico

No Questions

7. Material Selection Jim Werker, National Speleological Socity, Hillsboro, New Mexico

Question: **(Finish & Paint to Extend the Life of Steel)** What is your experience with the use of finishes or paint to extend the life of the steel?

Answer: It has been my experience that putting a finish coating on a gate is more of a problem than a help. You can get a galvanic reaction with some finishes. Paint can peal off and fall into the mine or cave and add to the contamination of the environment.

Question: **(Stainless Steel Recommendations)** What type of stainless steel would have the least problem with carbide deposits and also be the least expensive?

Answer: Probably type 304L. It is low in carbon and does not get carbide precipitation. Type 321 is alloyed with titanium and is more expensive but it is better. If you are going to be doing field welding this is the type you should be using.

8. The Problem of Bat Population and its Relation to Gate Area Roy Powers, Jr., American Cave Conservation Association, Duffield, Virginia

Question: ***(Bat Behavior based on Memory)*** Has there been any work done on bat memory and could this have any impact to your observations?

Answer: John McGreggor in Kentucky has done some work in this area and he feels that in some cases bats fly based on memory. He has recorded bats making flying maneuvers without making any sounds. I think that this may have contributed to what I observed but is not the total answer.

Comment: My observations concerning bat memory and acoustic clutter are that many bats, once they learn an area don=t seem to ecolocate as much. We also find that once we add a gate or modify a gate that many of the bats will hit the gate until they gain enough experience flying through it. We even have one gate where after 10 years the California Leave Nos e bats just keep hitting the gate. In another situation, a fence was placed around a shaft opening. Prior to installation of the fence the bats would just flow out of the shaft at a very low elevation. After the installation they would fly up to the 7 -8 foot tall fence and just jump over the fence and then continue flying close to the ground. At this site we find that with the passage of time fewer and fewer bats are using this jumping behavior. It appears that the younger bats who have always had the fence immediately gain altitude upon leaving the shaft and don =t drop down near the ground until after they fly over the fence. The older bats that were there prior to the fence installation still exhibit the jumping behavior. So it seems that the bats have definitely learned a certain flying pattern that they remember and repeat.

Comment: I have also noticed that bats will fly into gates and signs at the cave or mine entrance. I have not, however, observed mortalit y because of it.

Question: **(Bat Mortality due to a Bat Gate)** Is the situation that you are describing a situation where we should go back and take down the bat gate and maybe construct a bat cupola out side the entrance that would give the bats more room and time to react?

Answer: We have for a temporary solution cut out enough bars in the gate that we are no longer seeing bat mortality. I agree that removal of this gate and construction of something like a cupola outside the

entrance should be a good solution.

Comment: This is one of the most perfect Indiana bat hibernacula in existence. The interior temperature is just like a meat locker. It is a perfect refrigerator that once was an old iron mine. Most of it has collapsed. The current entrance could also collapse and kill or entrap 80,000 to 130,000 bats in the winter. Are we going to see a significant proportion of the Midwest Indiana Bat population killed in this mine someday when it collapses?

SESSION 4 INTERACTIVE DISCUSSION

Question: **(Bar Spacing in Gate)** Is there any documentation of the effects on bat usage of a gate with bars that are 5 and 1/8 inches apart versus 5 and 3/4 inches apart, and should be still be experimenting with this distance or is this pretty much standard?

Answer: The bats would be most happy if there was no gate at all. The distance is based on finding the maximum distance that will keep most of the people out and still allow the bats to use the entrance. The change of spacing to 5 and 3/4 inches was due to the response of Indiana bats and Gray bats to the 5 and 1/8 spacing where there was an immediate negative response by the bats.

SESSION 5: CONSTRUCTION MANAGEMENT

1. Contract Management Paul Krabacher, Colorado Division of Minerals & Geology, Grand Junction, Colorado

Comment: **(Unnecessary Insurance Costs)** From the contractor=s perspective, you need to understand what the costs are associated with each aspect of the bid. If you specify that the contractor needs $10 million worth of liability insurance on a bid for one to three gates and I ask my insurance man for $10 million worth of underground mine insurance. Whenever my insurance man hears the words mine, cave, or underground the cost goes through the roof and it has a term of a minimum of 1 year. I then end up paying $8,000 for a one year policy that I only need for 4 months. The State of Idaho has eliminated its specifications for automobile insurance and reduced the cost of their gates by 20 percent. We are not working underground. I am working around the entrance to a mine adit. Take the words Aunderground@ and Amines@ out of the bid and talk about Asafety closures.@

2. Eastern Consultant Perspective Kristen Bobo, American Cave Conservation Association, Cookeville, Tennessee

No Questions

3. Western Consultant Perspective Ed Winchester, Frontier Environmental Services, Ridgecrest, California

Comment: **(ACAA Copyrighted Bat Gate Design)** The design plans for the ACAA bat gates in the Bats and Mines publication is copyrighted by ACCA and even thoug ht its use is free we ask that the date of construction and ACAA be written on the gate. These gate designs change and you need to check in with BCI or ACAA and make sure the have the most up to date gate design specifications.

Comment: **(Cost of Dummy Video Cameras)** I found that you can get dummy video cameras in Cabelas sale catalog for $12.99.

Comment: **(MSHA Applicability)** In terms of work at an abandoned mine site like building a bat gate, that would not be considered a mining activity and would not be regulated by MSHA.

Answer: That is great until there is a person hurt at the site. If a contractor errors on the side of caution and complies with MSHA from the beginning you will have a much better time when you have an accident and the investigators find that your are MSHA contractor NO. 2 IL. Here is my safety record and here is my IAPP, you will immediately get a lot be tter cooperation when they learn that you really knew what you were doing from the beginning. Some MSHA districts will be interested in your work and others won=t.

Comment: At the national level, it has been determin ed that construction of bat gates is regulated under OSHA.

4. Partner and Volunteer Logistics Mark Stacy, Indiana DNR, Division of Reclamation, Jasonville, Indiana

Question: **(Administrative Fee)** Do you pay Indiana Karst Conservancy an administ rative fee?

Answer: Yes. We pay them a 5 percent administrative fee per project that we believe to be very reasonable.

Question: **(Bat Gates at Mines with No Bats)** Do you ever install gates at a mine merely because it has the potential to be bat habitat even if there are no bats currently using the mine?

Answer: Yes. One in particular was at Turkey Run State Park. It was an old mine where the park had installed a chain link fence over the mine entrance that had been in place for 20 to 30 years. The entrance to the mine was immediately adjacent to a major hiking trail where 750,000 people visit the park on an annual basis. There was a sign at the entrance indicating that it was a coal mine. The chain link fence insured that there was no bat usage but we expected that there could be because of it being immediately adjacent to a stream. We removed the chain link fence and installed a bat gate. Within 6 months, we had bat activity in the mine.

Question: **(Determining Project Cost)** How do you determine what the cost of a closure project is

that is being done by Indiana Karst Conservancy (IKC)?
Answer: IKC will assess the project in the field and estimate the amount of man hours necessary to do the project. We will determine the labor cost by multiplying the estimated number of man hours by the hourly minimum wage rate. IKC will then estimate the materials cost. The total of the man hours cost and the materials cost will be the total project cost.

Question: **(Estimated Cost Exceeded)** What happens if IKC goes over the estimate?

Answer: We pay based on the estimate. There are no additions to the project cost.

Question: **(Types of Mines)** Are most of the mines where you are installing gates coal mines?

Answer: Yes, they are all coal mines.

5. Safety Issues John Burghardt, National Park Service, Mining and Minerals Branch, Denver, Colorado

Question: **(Prying Rocks at Mine Entrance)** I was concerned about the practice of prying down rocks at a mine entrance with a long bar. At Mammoth Cave the prevalent opinion is that you will destabilize everything around it. Is this the case?

Answer: Very definitely. For instance, In some place we start barring down and we end being there all day. I find that I can use the bar to sound the rock for stability. If hit the rock with the bar and it makes a low drum sounding noise it is usually hollow behind the rock. Sometimes we find that rocks are barely hanging in place ready to fall. In this case, I will not enter the mine without taking these rocks down. But in general, I bar down as few rocks as possible in order not to disturb the stability of the entrance. When you are going to working in the mine entrance in order to install a bat gate, you will need to clean the ribs and roof. The pry bar is also good for probing in front of you in a wet mine.

6. On-Site Coordination and Work Jim Nieland, U.S. Forest Service, Amboy, Washington

No Questions

7. Personnel and Qualifications Bob Hall, Bureau of Land Management, Kingman, Arizona

No Questions

SESSION 5 INTERACTIVE DISCUSSION

Comment: **(Chicken Wire Exclusions)** In Colorado, when we choose not do a bat compatible closure we are required to install a fence to exclude use by bats.

Comment: Concerning the chicken wire bat exclusion closure, you need to put the chicken wire up

after dark and you have watched the mine opening with night vision equipment and made sure that any owls or bats have had a chance to exit the mine prior to installation of the chicken wire. You should also consider making awnings or what will appear to bats returning to the entrance as a solid barrier but where there is still a gap where animals still inside can see a window to get out. We know that bats will avoid chicken wire initially because of the small size of the opening. We have found however, that if the mine is a highly desirable location for the bats, that single non maternity bats will eventually land near the wire and crawl threw the chicken wire on a daily basis and especially for hibernation. In order to prevent this, you need to do the permanent closure within a two days to a week of the chicken wire closure. This can not be done during hibernation or maternity season. Early spring or early fall is the best time for this procedure.

Question: **(Large Contractor Bidding)** In States that have a large number of mine closures, do you ever have large contractors successfully bid on this work?

Answer: In Colorado, we have found that the projects are so competitive that the large contractors never get the bid. We have found that there is just a handful of contractors that get most of the bids.

Comment: In central Oregon, we do not have a lot of volunteers that are experienced in metal fabrication. We hire local welders that bring their welding equipment to the site and provide the welding service on site. We have someone to coordinate the project with the volunteers moving the steel and the welder cutting and welding the steel.

Comment: The Indiana Karst Conservancy is a very unique organization, we have a lot of members with engineering backgrounds and a membership that is very dedicated to the goals of doing a good job to protect the caves and mines.

Question: **(Mines where a gate should not be installed)** Is there ever a case where you should not build a bat gate in order to enhance the welfare of bats?

Comment: This has come up in the West where we are dealing with Uranium mines. I don't think there has been any definitive study of genetic mutations. I think there is great deal we still do not know in this area.

Answer: There have been several situations where caves have been protected for bats that were mortality traps for the bats due to flooding and freezing. In some cases large numbers of bats have died as a result.

Answer: In some cases, the mine opening was so unstable it would have been better just to exclude the bats.

Answer: We have had colonies of bats that were entombed when areas in the back of mines collapsed. If you find mines that are unstable it would be a good idea to consider evicting the bats before the mine collapses.

Question: **(Transportation of Steel & Equipment)** From the contractor=s perspective, how do you transport all of this equipment to the site?

Answer: We have reduced our equipment to a minimum, taken the back seat out of a Jeep Cherokee and fit in all in the Jeep and do not pull a trailer. We do this for convenience because we are on the road for months at a time. We require the steel to be delivered to the site.

Answer: We did a remote job in a wilderness area that was supported by helicopter where the contractor had each load bundled with the weights of each bundle specified for ease of tr ansport by the helicopter.

Answer: In Indiana we have never had to do any jobs by helicopter but we have been amazed far and over what terrain four guys can carry a generator and keep their footing. Sometime you have to get very innovative in order to ge t your equipment to a site.

Answer: In Colorado, we have actually used pack horses and mules in some remote locations.

Answer: We have used ATVs with trailers at some remote locations.

Comment: Keep in mind the one Jeep works for a consultant but not fo r a contractor. In order to get the steel and material to a site it takes a lot more than one vehicle.

Comment: Concerning the use of helicopters for transport, I have found the cost of $100 per sling load to be very reasonable not counting mobilizati on cost. If I am close to an airport where there is low mobilization cost, my cost of using a helicopter is very reasonable. This compares very reasonably in the case where you are going to have to pay labor cost for people to carry steel or equipment in to a remote site.
Comment: In the San Juan area of Colorado, there are very few projects that we don=t use helicopters for transport.

SESSION 6: MONITORING AND MAINTENANCE

1. Bat Response to Gates J. Scott Altenbach and Richard E. Sherwin, Department of Biology, University of New Mexico, Albuquerque, New Mexico and Shauna Haymond, Holistic Wildlife Services, Rio Rancho, New Mexico

No Questions

2. Pre- & Post-Gate Biological Monitoring Mike Herder, Bureau of Land Management, St. George, Utah

Question: **(Bullet Camera Range)** How far can you see with the Bullet Cameras?

Answer: They come in a lot of different configurations and different resolutions. It is not necessarily the camera that limits the distance you can see but the supplemental infrared light source that you are using. Many of these cameras have a built in light source but it has been my experience that you still need a supplemental infrared light source. You need to do a lot experimenting to ensure that you will see the area that you want to have illuminated. These cameras are really effective where you are monitoring colony activity inside the cave or mine. A lot of work is necessary to ensure that you will be able to see the area of concern.

Question: **(Counting Software Development)** Can you give us more information on the counting software?

Answer: Such a counter would be very valuable in situations such as Bracken Cave where there are millions of bats. Dr. Tom Kuntz at Boston University has been experimenting with developing a counting software package that would track a video and count the number of bats in each frame and determine which bats are the same from one frame to the next so that you could get an accurate count from the video tape. I do not know at what stage they are in the development of this software.

3. <u>Pre- & Post-Gate Microclimate Monitoring</u>

Comment: **(Climate and Temperature Changes in Missouri Caves)** Bill Elliot and Rick Clawson published a paper in the 1999 National Cave and Karst Management Symposium titled ATemperature Data Logging in Missouri Bat Caves.@ This study overlaps with BCI who set up data loggers with us in three of the caves and we set up loggers in an additional five sites that are still set up today. This gives us three years of data. We have also be able to obtain good weather data from the University of Missouri. I have found that over the last 25 years the annual average temperature in Missouri has not shifted noticeably. However, I have noticed that the extreme low temperatures we are experiencing in January now and not nearly as low as they were 20 to 25 years ago. It has been our experience that it takes extremely cold temperatures in order to drive cold air into many of the caves in Missouri. Without these extremely low temperatures during winter driving cold air into the caves, we think that there will be a gradual increase in the temperature of the caves. This could be very important for bats like the Indiana bat that require these cold temperatures during hibernation.

4. <u>Closure Repair and Maintenance</u> Dave Bucknam, Colorado DNR, Minerals & Geology Division, Denver, Colorado

Comment: **(Funding for Post Gate Monitoring)** I have heard several times from the State Mining agencies that it is their job to close these mines and that they can=t spend this money for any post gate monitoring. This is not true. The Office of Surface Mining has been encouraging the States to come up with a post construction monitoring plan for bat gates because it is very important that we know that the project has actually been successful. This would include beginning and ending dates, frequency of monitoring, and what will be done as a corrective action. There is only a very few States that have such a plan. It sounds like Colorado is moving in this direction.

Question: **(High Carbon Dioxide Levels in Mines)** Are the black damp mines always coal mines?

Answer: Although high carbon dioxide levels are usually associated with coal mines you have high carbon dioxide levels in other mines.

Comment: In Texas, in certain geologic areas you have bad air caves.

Question: **(Identification of Closures in the Field)** In the Western U.S., how do you identify the hundreds of caves, mines, and gates in the field?

Answer: In Colorado, we put a brass cap on the gate that includes the project code and feature code. If it is a back fill we have an ID pipe.

Question: **(Public Notification on Closure Damage)** Is there any way a member of the public that saw a problem with a gate could notify you so that it could be repaired?

Answer: No we don-t but that is a good idea.

5. Human Access: Policies, Management, & Monitoring

Question: **(Applicability of the Federal Cave Resource Protection Act)** Concerning the Federal Cave Resource Protection Act, does it provide any protection for caves or mines that are n ot on public land?

Answer: Not at all. It is Act is specifically addressed to Federal Lands that administered by the Departments of Interior and Agriculture.

Comment: Some States do have their own cave protection laws. All of the cave an d bat protection laws have been posted on the National Speleological Society Website.

Comment: **(Limiting Visits to Hibernation Colonies)** Concerning monitoring and hibernation sites, we recommend that even the bat biologists do not enter bat hibernation si tes in caves or mines more than once every two to three years. Even then great precautions are necessary to not disturb the bats. It would be better to get an incomplete count than to disturb the bats.

Comment: **(Monitoring Recreational Use of Caves)** Sometimes you have to close part of a cave for recreational purposes. I know that at Carlsbad Caverns they have to really monitor this closely because it is an honors system.

Comment: In the Forest Service, many of our caves have a caving access permit sy stem where the permit clearly specifies what can and can not be done. We ask them to report any irregularities they observe in the cave. This way we can use the rules as an educational tool.

6. Demonstration of Gate Monitoring Database

Question: **(Data Analysis)** Can you do any analysis with the data in place in ARCVIEW?

Answer: There is a simple statistical, charting, and graphing function in the system.

Question: **(Import and Export of Data)** How could you import and export data with this system?

Answer: You could import from a delimited text file. So if you can convert your existing database into a delimited text file you can import it into the system. This should work with most standard databases.
Question: (**Limiting Access to the Public**) What criteria would be used to limit public access?

Answer: Locations of important Bat roosts. In some cases, general information can be given that would not show specific sensitive site information. Because of the nature of these GIS systems, any data t hat would be made available to the public can be strictly limited to that which is not sensitive due to legal or environmental concerns.

Comment: Under a recent interpretation of the Freedom of Information Act, you can no longer restrict information about Threatened and Endangered Species. So you can not longer keep specific site information away from people who would use it to illegally collect these species.

Comment: **(Public Availability of Data)** In Wyoming, we have done something similar with ARCVIEW and GIS and in the process of updating our inventory for this system. I would like to see this information available to the public. Many of our land owners are sensitive about making this information available to the public but I would at least like to make it available to out contractors. It would great if the contractors could access this information over the Internet with out having to come into our office.
Comment: If cave information was publically available it would immediately be an illegal disclosure of cave location formation.

Comment: Most abandoned mine programs have a similar type of inventory. The bat gate data base is an extension of the AML database because we specifically wanted to look at bats, bat surveys, and post gate monitoring and maintenance. I have been told by my computer people that sensitive information can be controlled so that it is not available to the public.

SESSION 6 INTERACTIVE DISCUSSION

Comment: **(Conflict over Release of Locations to Public)** I would like the panel to comment on what seems to be a conflict between the direction of information accessibility through tools like a GIS system to the desire to keep certain information privileged such that even responsible professionals can not work with it. An example would be that builders and developers need to know where these features are if they are to avoid disturbing them.

Comment: In my experience with the Texas Speleological Survey that maintains the State Cave Files and we often get requests fr om consultants, developers, and State agencies for specific cave data. They want to know exactly what caves are on a specific piece of land or within a specific corridor. This is because something is being planned for that area like a new highway, power line, subdivision, or development. If we as cavers say that we must protect this data and not let it out and are unwilling to share the data then we are insuring that they will be impacted because decisions will be made to develop these lands without any provisions to protect the cave resources because no one knew they were there.

Comment: The Federal Cave Resources Protection Act regulations clearly explain when you can release site specific information. You can release it when that release furthers the purpose of the Act. Certainly, administrative and research functions further that purpose. The Act allows us to keep the information confidential but it does not mandate that we have to keep it confidential.

Comment: We need to be cautious and ensure t hat the information is not made public in a way that we can not control the use of the information. We have learned from sad experience that when cave locations become well know it attracts public use.

Comment: In Virginia there are two levels of screening concerning who has access to data of cave locations. There is a board appointed by the Governor that reviews requests for information. The Virginia Cave Association is a private group that is not required to supply information. It is not at all uncommon that we get requests that are disguised as legitimate. About a year ago we had a request from an employee of a State agency that requested information on caves across the State within a specific elevation range. It turns out that it as an illegal personal request and the employee lost his job over it.

Question: **(Modification of Mines to Improve Bat Habitat**) Is there a need for research on how we could artificially improve a mine for use as bat habitat (i.e . air flow, temperature, etc.)?

Answer: Certainly in caves there is a reluctance to due any modifications because of the complex ecosystem that had developed over a long period of time. In the case of a mine, abandoned tunnel, or aqueduct there could be some ideal opportunities for experimentation with substrates, artificial crevices, recreating the entrance features, modifying internal temperatures to either increase or decrease its ability to trap coal air, altering humidity levels, etc.

Comment: **(Power of GIS to Link Related Geographic Data)** The power of the GIS based database is that you can link bat data with other geographic base data and hav e the software integrate the information and provide useful analysis that would not be available any other way. You can add geographic data about towns, highways, rainfall, superfund sites, and then use the system to see if the bat data is in any way rela ted to other geographically available data.

Comment: The Utah database is in response to a recognized need for better information related to the management of bats, their habitats, and the response of bats to gates. The database is a tool that could be utilized by scientist to answer questions that could lead to better management of the caves and mines

used by bats as habitat.

Comment: Many States have a Natural Heritage database. In Missouri we work with the Missouri Speleological Survey and are adding a lot of the top biological caves and the information is being protected. It is very useful when roads are being built and infrastructures are being constructed. We are very interested in using a database to track cave gates because this information is currently being lost.

Comment: In Nevada, we have installed two culvert bat gates with the result that for two of those gates we now know that the bats have quit using those mine entrances after the culvert gates were installed. We would like to be able to share this data in the hopes that we could eventually know enough to be able to determine when and where these types of gates are appropriate and when they are not. I would be in support of a database that would allow us to better protect bats through more knowledgeable decisions on how to design gates.

Comment: If we could develop a national database similar to what Utah has developed it has the potential to be a very powerful ecological tool. It could have the ability to allow us to look beyond a local window of knowledge so that we could look at much larger scales that we have not been able to see or think about.

Comment: In order for such a database to useful on a national scale we need to have common data fields.

Comment: Concerning the establishment of a national database, it is really not appropriate for a Federal agency or a State to manage the database. It seems most appropriate that a non profit private association could undertake this task so that it could better protect the data that is shared.

Question: **(Swarming Activity of Bats)** Could you give me some more information on the swarming activity of bats?

Answer: There is very little scientific data on the swarming behavior of bats. We suspect that some of these swarming sites are very important for some bat species. We still know very little as to the timing of these events and what is actually happening during swarming. There is a great need for more research in this area.

Comment: **(Vandalism by Fire)** I have not he ard anyone address the threat of fire as a form of vandalism. In New Mexico we had a situation where the mine timbers in an abandoned mine were set on fire with the result that very nearly destroyed a winter hibernaculum of Townsends Big Eared bats. We need to give more thought to the design of bat friendly closures where the mine involves significant mine timbers on how to minimize the possibility of vandalism by fire.

Comment: Colorado has discontinued the use of timbers in its bat closures. Current ly we have a closure at a mine with mine timbers where we are going to use a grated culvert in order to minimize the

possibility of setting fire to the timbers.

BAT GATE DESIGN: ***A Technical Interactive Forum***

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