National Cave and Karst Research Institute

2015-2016

ANNUAL REPORT

www.nckri.org

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Cover Photo
The interaction of rock and water is at the heart of karst. While Carlsbad Cavern, at Carlsbad Caverns National Park, New Mexico, is often considered a dry cave, water is present and important, as beautifully shown in this photo that also graces NCKRI's newest traveling display. NCKRI photo by Dianne Joop.

Back Cover Photo
NCKRI Headquarters is an elegant multipurpose facility that has hosted many conferences, meetings, and parties. If you're planning an event in Carlsbad, we hope you will have it at NCKRI, where the rental fees support cave and karst research, education, and management. NCKRI photos and layout by Dianne Joop and Courtney Gasow.

National Cave and Karst Research Institute

Vision and Values

The National Cave and Karst Research Institute (NCKRI) will be the world's premier cave and karst research organization. NCKRI promotes and performs projects of national and international application, of the highest quality and integrity, through dedicated staff and partners.

Organization and Mission

NCKRI is a non-profit 501(c)(3) corporation. It was created by the U.S. Congress in 1998 in partnership with the National Park Service, State of New Mexico, and the City of Carlsbad. Federal and state funding for NCKRI is administered by the New Mexico Institute of Mining and Technology (aka New Mexico Tech or NMT). Funds not produced by agreements through NMT are accepted directly by NCKRI.

NCKRI's enabling legislation, the National Cave and Karst Research Institute Act of 1998, 16 U.S.C. §4310, identifies NCKRI's mission as to:

1) further the science of speleology;
2) centralize and standardize speleological information;
3) foster interdisciplinary cooperation in cave and karst research programs;
4) promote public education;
5) promote national and international cooperation in protecting the environment for the benefit of cave and karst landforms; and
6) promote and develop environmentally sound and sustainable resource management practices.

NCKRI Annual Report Series

NCKRI produced this publication as part of its annual reporting of activities. The reporting period covers NCKRI's fiscal year, from July 1, 2015 to June 30, 2016. Digital copies of this and previous reports are available for free at www.nckri.org.

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EXECUTIVE DIRECTOR'S REPORT

The leader of the world's most powerful country takes his family on vacation. Where should they go? The US holds many of Earth's most incredible landscapes among 411 National Park Service properties. To celebrate the Park Service's centennial, President Obama decided to visit two national parks. Yosemite was an obvious selection. Why was his other choice a cave, Carlsbad Caverns?

Dianne Joop and I were honored when asked to serve on the President's Carlsbad motorcade. Since he was on vacation, we didn't expect much time to visit with him, but we expect his substantial resources piqued his interest to learn about our country's greatest hidden resources.

Carlsbad Cavern is a World Heritage Site, one of 23 in the US, recognized for its "outstanding universal value." Carlsbad Cavern is located in karst. The US is 25% karst or related terrain. Karst is a landscape formed by bedrock dissolving slowly, creating sinkholes, underground rivers, and caves. Over 40 million Americans depend on karst for their main sources of water. Abundant and clean freshwater is of national importance. Rainfall on karst moves into limestone down cracks, sinkholes, and caves. That natural plumbing system carries the water to rise from springs. Many cities, including the City of Carlsbad, are located to tap that water for drinking, agriculture, industry, and tourism.

The First Family learned Carlsbad Cavern is home to 800,000 bats. The millions of bats across our country save American agriculture $23 billion annually in pesticides not sprayed on crops. The First Lady, who strongly promotes eating healthily, must certainly love the bats for helping keep our environment and bodies chemical-free. But bats aren't the only critters underground. Caves contain unique microscopic organisms. Some hold promise to cure diseases. Others teach us how to find life on other planets.

The President has called for action to stop climate change. The beautiful crystalline wonders in caves hold the world's best records of past climates from which we better understand our modern climate. From the Caverns' Visitor Center on the Guadalupe Escarpment, the Obamas saw the Permian Basin, our country's most productive oil and gas region. Much of that yield is from paleokarst—karst buried eons ago and whose cavernous pores hold vast quantities of fuel that power our nation. While these fuels release carbon into our atmosphere, paleokarst has a great capacity for storing enormous volumes of greenhouse gases deeply and harmlessly underground.

Carlsbad Cavern is a grand, stable space. That is not true of all karst. A 2015 study by NCKRI Board Director David Weary calculated over $300 million/year in sinkhole damages in the US. Undoubtedly a conservative figure, sinkhole costs are unrecorded in several states. Another 2015 study, co-authored by NCKRI, found sinkholes cost one Florida community $2 million/year per square mile!

The true values and costs of caves and karst are hidden by their underground and dispersed nature. Seen as local features, their total national impact is missed. More work is needed to study caves and karst, and to educate the public about them. Congress came to understand the value of karst areas, the need to protect them for the public welfare and to study them to protect the public, and created NCKRI to meet those needs.

All of us at NCKRI expect the First Family enjoyed visiting Carlsbad Caverns National Park, where they learned many of the values and challenges of our national underground heritage.

Photo courtesy: White House Photographic Corps

Carlsbad Caverns Presidential motorcade drivers, 17 June 2016: (l-R) Patty Fugate, Dan Rempel, Cherie Folk, President Barack Obama, Deanna Younger, Todd Beasley, NCKRI Education Director Dianne Joop, and NCKRI Executive Director Dr. George Veni.

The Microbial Breakdown of Fabric in Caves: Responding to Management Questions from Carlsbad Caverns National Park

Overview

Cosmetic camouflage of infrastructure is necessary in publicly accessible caves and an ongoing challenge for cave managers. In such caves, matters of visitor safety, convenience, and interpretation activities place requirements on staff to install mechanisms, wiring, and other artificial constructs. Despite the necessity of these items, care is taken to attempt to disguise or at least minimize their visual impact or other interference with the visitor experience.

In this spirit, Carlsbad Caverns National Park was wrestling with the decision about how to conceal recent improvements in electrical wiring and lighting in Carlsbad Cavern itself. One suggestion was to drape camouflage printed fabric over a variety of items. We were asked to assess the suitability of using fabric comprised of polyester, or other synthetic materials, for this purpose. A very rapid response was requested, so a three-part effort was quickly formulated.

Part 1 involved scanning electron microscopic (SEM) evaluation of several fabric samples that had been in the cave for a few months to detect any microbial growth or other deleterious effects on the fabric.

Part 2 consisted of an investigation into the published literature on the effects of microorganisms on a variety of different fiber types ranging from polyester (the material under initial consideration) to other fibers.

Part 3 is a longer term incubation study of fabric samples inoculated with various microorganisms versus a sterile uninoculated control. These experiments are ongoing, but preliminary observations are included below.

This study was conducted by Dr. Penny Boston at New Mexico Tech.

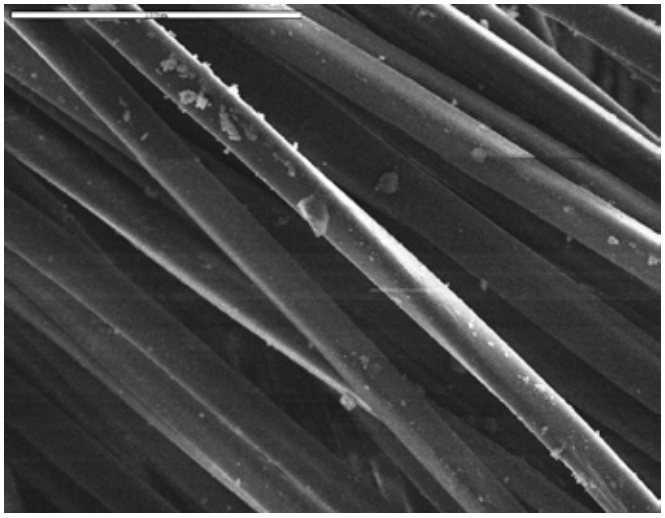
Part 1 – Scanning Electron Micrograph (SEM) Results

SEMs of several fabric fragments aseptically collected from two previously cave-exposed fabric test specimens revealed significant microbial attachment and growth on the fiber samples. See Figure 1 below, which shows a non cave-exposed example of the material under consideration for use in Carlsbad Cavern. Figures 2-4 show examples of microbial growth detected on samples placed in the cave. Clearly, within only a few months of exposure, organisms were already attaching to the fibers. Furthermore, fabric is composed of cross-woven fiber bundles thus providing a truly stupendous surface area for attachment and microbial growth.

Part 2 – Literature Search Results

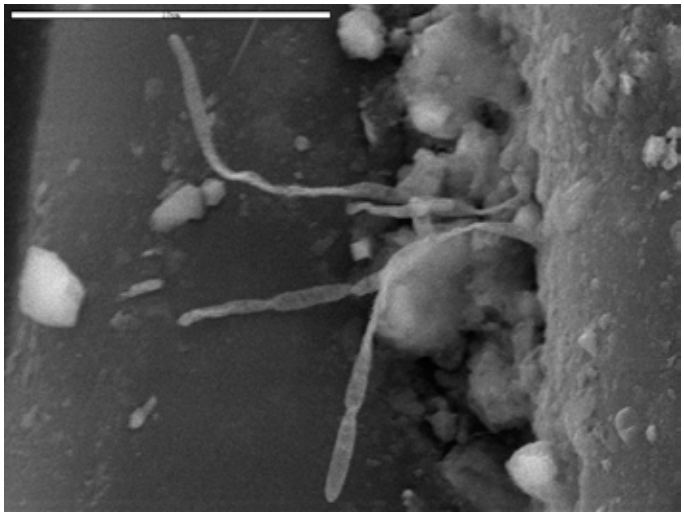
We conducted a survey of 65 papers in the scientific literature. Topics ranged from microbial breakdown of polyester, nylon (several different varieties), polycarbonate, polyamide, Kevlar, and Teflon™ (polytetrafluoroethylene) to studies of the mechanisms of microbial attack on such materials.

Our analysis of these findings led us to conclude that only the Teflon fibers were likely to significantly resist microbial breakdown. Teflon fiber fabrics are hard to find and extremely expensive. Polyester appears extremely degradable by a wide varie-



SEM image by M.N. Spilde and P.J. Boston

Figure 1: Control. Polyester fragment of fabric under consideration for purchase by Carlsbad Caverns National Park. Note a very small amount of debris and no observable organisms.



SEM image by M.N. Spilde and P.J. Boston

Figure 2: Example of segmented filamentous microbial forms attached to fiber surface. Morphology resembles some members of the Streptomycetes group.

ty of microorganisms. If nylon must be used, then using Nylon 6 or Nylon 6-6 is more refractory (resistant) to microbial degradation than other types of nylon; that is, less likely to break down and provide a nutrient source for microorganisms. Nylon 4 appears to be a highly usable nutrient for many organisms and we recommended against its use in caves for any purpose.

Part 3 – Fabric Breakdown Laboratory Study: Preliminary Results

After three months of incubation, initial observation of fabric samples growing in liquid medium in the presence of the cave organisms already on the samples show significant slimy biofilm growing on most of the surfaces. Unsurprisingly, there is no such coating on the sterile controls. We are allowing ample time for organisms to attach, and potentially to degrade the materials themselves. They will be analyzed with SEM techniques at the six month and one year time points. Relevant changes will be observable pitting or etching of fiber surfaces.

These results have been shared with Carlsbad Caverns National Park, which decided against using any fabrics in the cave. When the study is complete, the full results will be published to benefit all show caves.

Karst Information Portal

The Karst Information Portal (KIP) is an online tool (www.karstportal.org) for caves and karst that NCKRI created in partnership with the University of South Florida, International Union of Speleology, and the University of New Mexico. Its primary tool is a virtual open access library that has seen dramatic growth in use each year, with thousands of publications available for free download from tens of countries around the world.

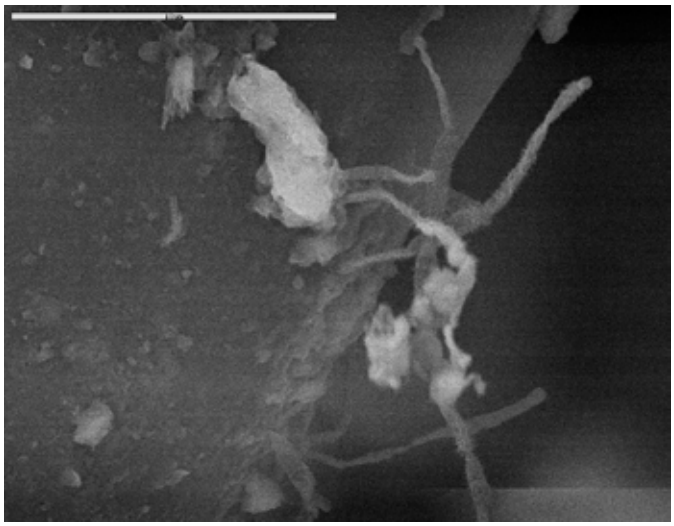
Since KIP's origin in 2006, we have migrated through three different database architectures and platforms. We undertook these migrations to address comments and suggestions from its users. Much of this year was engaged in the fourth migration, this time to the SobekCM digital repository platform. This decision follows careful consideration of: 1) input from users on KIP's functionality; 2) alignment with funding and technological capacity to continue support for KIP; and 3) assuring accessibility and long-term preservation of the content.

The migration of KIP data and structure required a few months. It was followed by a period of extensive testing to ensure that the system functions up to our expectations. By the time you read this, testing should be complete. We will then focus on a careful clean-up of the metadata—a challenge that has proved difficult to address without the tools that are part of the SobekCM system. Afterward, we will post the hundreds of new publications we have received during this upgrade to add to KIP's library collection. Moving KIP to SobekCM will ensure its value to the cave and karst community well into the foreseeable future.

KIP has also served as the basis for distributing NCKRI conference proceedings, programs, and individual papers. In past years, most cave and karst conferences would print about 500 copies of their proceedings. Some would be given to the conference attendees and the rest would usually take years to sell out. As a result, the information was distributed slowly and to relatively few people. KIP has dramatically changed this situation.

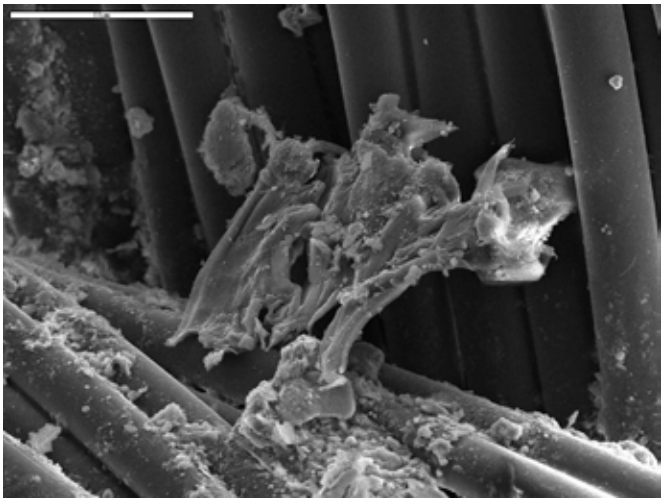
NCKRI has freely distributed information on its recent conferences through KIP with these results:

- National Cave and Karst Management Symposium (2013), 1,002 downloads to 73 countries;



SEM image by M.N. Spilde and P.J. Boston

Figure 3: Example of fuzzy segmented filamentous microorganisms and globular fuzzy forms, which resemble forms associated with the Actinobacteria group.

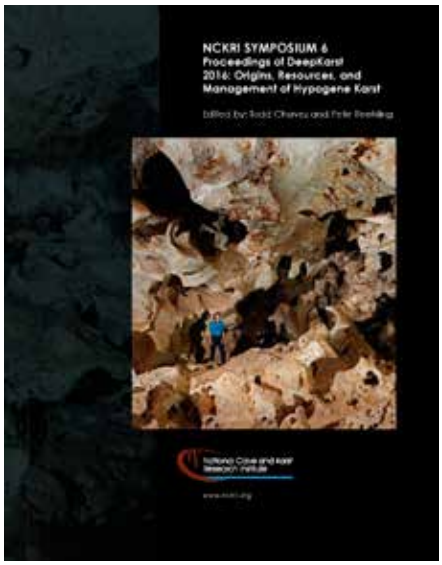


SEM image by M.N. Spilde and P.J. Boston

Figure 4: Significant organic and inorganic debris has accumulated on the enormous surface areas of this cave-exposed sample. The prominent form in the center is likely a human skin fragment, a high nutrient pollutant which encourages the growth of unwanted organisms. Show caves experience large amounts of shed hair, skin, and other debris from visitors, making the potential for high degrees of such contamination very likely.

- 6th International Workshop on Ice Caves (2014), 1,061 downloads to 61 countries;
- The Sinkhole Conference (2015), 4,386 download to 105 countries.

The KIP team at the University of South Florida's Scholar Commons program also produced the proceedings of NCKRI's DeepKarst conference, which was not posted this year because of KIP's upgrade, but will be posted soon. We expect many and international downloads of these proceedings as well.



NCKRI produced two new publications this year, Symposium 5 and 6, the proceedings of the Sinkhole Conference and the DeepKarst Conference. Both can be downloaded for free from the Karst Information Portal.

NCKRI photo by George Veni

NCKRI's resistivity equipment collects data while carefully balanced on the steep entrance slope of Bracken Cave, under the supervision of Bexar Grotto member and St. Mary's University professor Dr. Evelynn Mitchell.

The World's First Geophysical Survey of Bat Guano: Phase 2

Two years ago, NCKRI used electrical resistivity to conduct the world's first geophysical study of bat guano. Bracken Cave is located near San Antonio, Texas, and our study found the guano was at least 18 m deep. The bottom of the guano was not found.

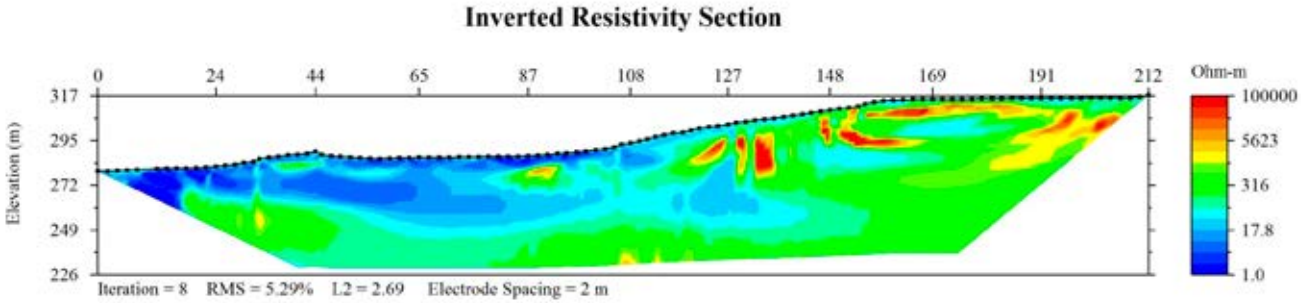
Returning in January 2016, when most bats were away in Mexico for the winter, NCKRI partnered again with the cave's owner, Bat Conservation International, and members of the National Speleological Society's Bexar Grotto, to search for the bottom of the guano and the bottom of the cave.

The walls of the visible portion of the cave are jagged, evidence of collapse into the original cave passage which formed solutionally, by water dissolving the limestone. That original cave floor is now probably covered by a thick layer of clay, then rocks that collapsed to form the jagged walls, which were later topped with guano. Our goal was to see the bottom of this sequence of sediments.

After two long days and two long resistivity surveys, we penetrated 35 m downward to what appears to be the bottom of the guano. However, looking deeper to 55 m, it isn't clear if we found the original cave floor (see the resulting image of one of the surveys at the top of the next page). We plan to return in early 2017 to redeploy the equipment to see deeper still and find the original floor.

Geophysical surveys are rarely conducted in caves. We hope the results of this study will provide useful local results, but also useful insights to guide future in-cave studies elsewhere.

In the meantime, our partners at the Southwest Research Institute, led by Dr. Ron Green, Vice President of NCKRI's Board of Directors, began coring the guano for analysis. One major goal of the project is to radiocarbon date the guano layers and study the bones, DNA, pollen, and other materials in the guano to better understand the paleoenvironment and paleoecology of the cave and surrounding area. Other partners in this study who are analyzing the materials are Dr. Bogdan Onac, of the University of South Florida, and Dr. Rickard Toomey, of the Mammoth Cave International Center for Science and Learning.



Electrical resistivity profile of Bracken Cave. The flat area to the right is on the surface. The inclined area to the right of the middle is the floor of the cave's sinkhole entrance, which slopes left into the cave where the floor is roughly level. Most of the blue areas are probably bat guano. The black squares at the top of the profile mark the electrode locations, which were 2 m apart.

New Mexico's Brackish Water Resources

During the second quarter of 2016, Dr. Lewis Land conducted a statewide assessment of brackish water resources and water quality in New Mexico, funded by a contract with the New Mexico Environment Department (NMED). Access to adequate supplies of fresh water is becoming an increasingly critical issue in arid and semi-arid regions of the southwestern United States. Diminishing fresh water supplies and extended periods of drought in New Mexico and other southwestern states have generated an interest in non-traditional water resources, and the development of new technologies such as desalination of brackish water to exploit those resources.

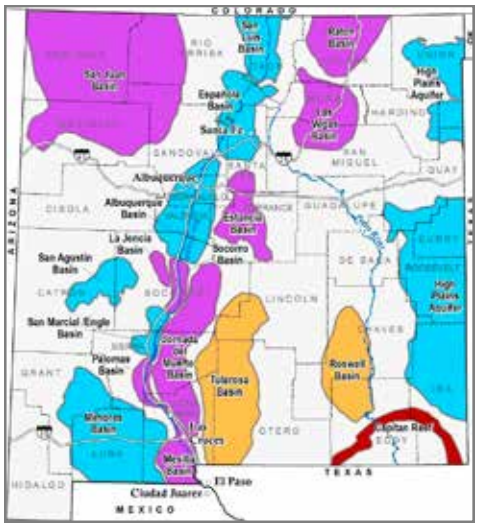
New Mexico has limited supplies of fresh water, but has very large reserves of brackish groundwater. However, our knowledge of the quality and volume of these brackish water resources varies significantly across the state.

One part of this report involved a focused investigation on brackish water in the eastern Tularosa Basin, including sampling of selected wells in the basin near the village of Tularosa. However, the statewide assessment addresses brackish water resources in every significant groundwater basin, or aquifer, in New Mexico, including the two principal karstic aquifers in the Pecos Valley: the Capitan Reef aquifer and the aquifer in the Roswell Artesian Basin (see the figure and table to the right).

The Capitan Reef is a fossil limestone reef of Middle Permian age that is dramatically exposed along the southeast flank of the Guadalupe Mountains, where it serves as the host rock for the Big Room in Carlsbad Cavern. A few kilometers northeast of Carlsbad Caverns National Park, the reef dips into the subsurface and passes beneath the city of Carlsbad, where it forms a karstic aquifer that is the principal source of fresh water for that community. The reef continues in the subsurface east and south for over 100 kilometers to its southeastern-most outcrop in the Glass Mountains of west Texas.

Throughout most of its extent, water in the reef is a brine, with a total dissolved solids (TDS) content >10,000 mg/L. This highly saline water, apparently useless for human consumption, has significant industrial applications. Both the petroleum and potash mining industry have expressed interest in exploiting brackish water resources in the reef aquifer for hydraulic fracturing of oil wells and processing potash ore. The use of treated Capitan Reef brine for these industrial purposes (as opposed to using fresh water) will significantly reduce the impact of withdrawals on the limited freshwater resources in southeastern New Mexico and west Texas.

The Roswell Artesian Basin occupies over 10,000 square kilometers in the Pecos Valley in Chaves and northern Eddy counties. The artesian basin is one of the most intensively farmed regions in the state outside the Rio Grande Valley. The basin derives virtually all of its irrigation and drinking water from groundwater stored in

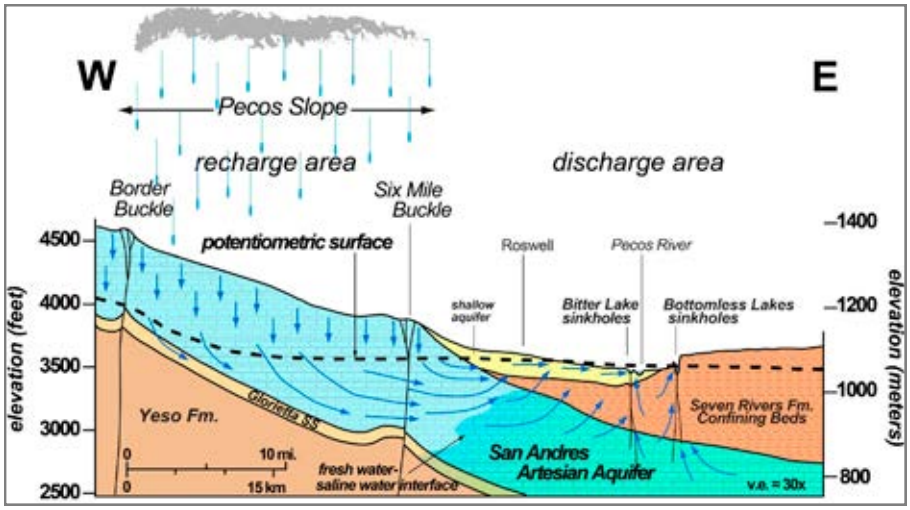


Basin/Region	Number of available records	Mean TDS (mg/L)
San Luis Basin	300	330
San Agustin Basin	185	341
Española Basin	612	390
Mimbres Basin	265	617
San Marcial and Engle Basins	32	704
Albuquerque Basin	987	881
High Plains Aquifer	560	996
Socorro and La Jencia Basins	379	1,002
Mesilla Basin	408	1,217
Estancia Basin	561	1,288
Palomas Basin	203	1,297
Jornada del Muerto Basin	173	1,354
Raton and Las Vegas Basins	80	2,336
San Juan Basin	1,011	2,373
Tularosa Basin	959	3,184
Roswell Artesian Basin	632	3,548
Capitan Reef Aquifer	13	54,046

Major groundwater basins and aquifers in New Mexico, color-coded according to mean total dissolved solids (TDS). Groundwater with a TDS of 1,000 mg/L or greater is brackish. The karstic Roswell Basin and Capitan Reef aquifers contain the highest salinity groundwater in the state.

a karstic artesian limestone aquifer contained within the Permian San Andres and Grayburg formations.

Mineral content of groundwater in the artesian aquifer increases downgradient to the east toward the Pecos River, and a well-defined freshwater-saline water interface has been mapped beneath the city of Roswell (see figure to the right). Chloride concentrations range from 15 mg/L, in the unconfined western part of the aquifer, to as high as 7,000 mg/L in a flowing artesian well east of the city. Discharge from that well was used as feedstock for a pilot desalination facility in the mid-20th century.



West-east hydrostratigraphic cross section of the Roswell Artesian Basin, including the freshwater-saline water transition zone.

Capitan Reef Aquifer

Dr. Land continued investigations of water level changes in the Capitan Reef aquifer in Eddy and Lea counties, southeastern New Mexico, with personnel from the Bureau of Land Management, the US Geological Survey, and Sandia National Labs. This investigation includes quarterly measurements of water levels in monitoring wells installed in the Capitan Reef, and collecting water samples from selected wells.

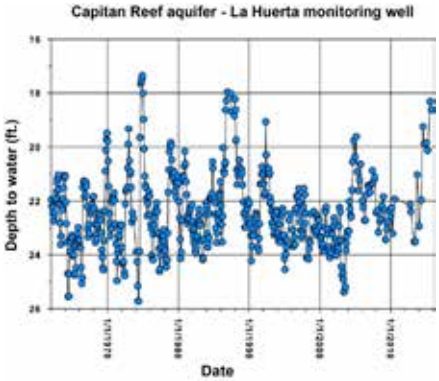
In 2016, Dr. Land gave a presentation on variations in hydraulic head in the reef aquifer at a meeting of the National Groundwater Association in Albuquerque, New Mexico. Water levels in the western segment of the Capitan Reef in Eddy County, near Carlsbad, respond quickly to meteorological events because of proximity to recharge areas in the Guadalupe Mountains (see graph at bottom left). Water levels in the eastern segment of the aquifer in Lea County are not influenced by meteorological phenomena, showing only long declines through the 1960s and 1970s because of withdrawals by oil companies for waterflooding oil fields in the Permian Basin region (graph at bottom center).

NCKRI photo by Lewis Land

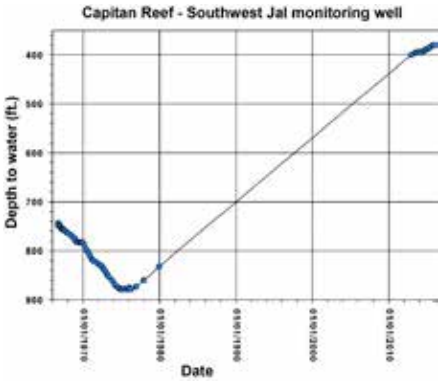
Sandia National Labs personnel deploying snap sampler to collect a water sample from Capitan Reef well.

This difference in hydrograph response is attributed to Permian-age submarine channels near the modern Eddy-Lea County line, resulting in a partial hydraulic barrier that restricts flow of groundwater to the eastern segment of the reef.

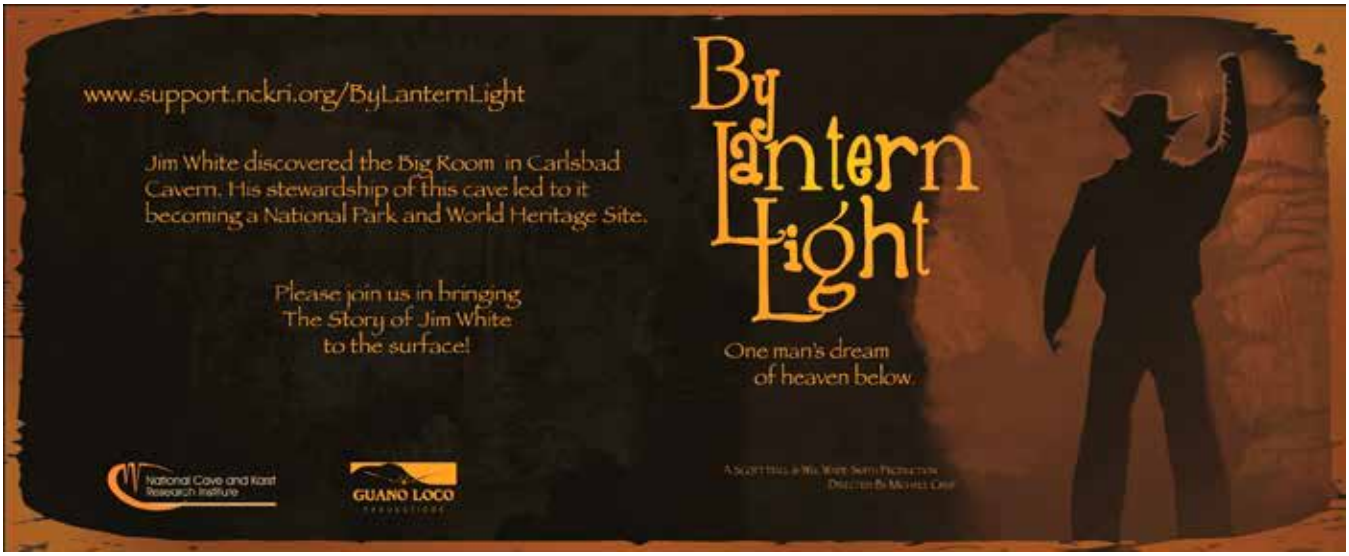
When BLM personnel began renewed water level measurements in the reef aquifer in 2012, they discovered that water levels in the eastern segment of the reef had risen about 150 m since the last measurements were made in the late 1970s. This remarkable rise raises interesting questions about sources of recharge and the age of groundwater in the eastern segment of the reef aquifer. Dr. Land and collaborators at Sandia National Labs recently collected water samples from wells in both the eastern and western segments of the reef (above photo), which will be analyzed for general chemistry, stable isotopes, carbon-14 and tritium. These data will lead to a better understanding of regional groundwater flow dynamics in one of the most important karstic aquifers in New Mexico.



Capitan Reef hydrograph from City of Carlsbad #13 monitoring well in Eddy County, western segment of the reef.



Capitan Reef hydrograph from Southwest Jal monitoring well in Lea County, eastern segment of the reef.



By Lantern Light

NCKRI's Education Program focused this year on producing a docudrama film to tell the story of the life, explorations, and discoveries of James Larkin White, aka Jim White. NCKRI's Education Program Director, Dianne Joop, and Guano Loco Productions conducted extensive research into the life of Jim White and the history of Carlsbad, New Mexico. The team used this research to develop a list of people to interview, establish the production's design concept, and initiate scripts for the recreation of important events in Jim White's life.

The story of Jim White is a compelling tale that will educate people about his discoveries in New Mexico, and about caves in general and their importance.

With support of a City of Carlsbad Lodger's Tax grant of $150,000, Guano Loco Productions has produced four marketing pieces to help promote NCKRI's story and location in Carlsbad, and develop teaser reels for the docudrama. Production on the film commenced in June 2016 when Guano Loco Productions began a cross-country trip to interview people for the film. The film is targeted for national release in 2017.

Outdoor Classroom

The City of Carlsbad, in partnership with NCKRI, was awarded a grant to support the design and construction of our Outdoor Vertical Classroom and Exhibits. This classroom will be used as a training, practice, and demonstration site for people who use ropes and do vertical work as a part of their job.

This space will also be used to launch our Vertical Voyages program, which will provide the general public with authentic experiences using ropes and techniques commonly used to explore caves. NCKRI held an initial design meeting to develop this exciting experience and follow-up work is proceeding. Please check out NCKRI's Facebook page for updates on this exciting project.

Partnerships

NCKRI's Education Program is enthusiastic about the growing support that is expanding its cave and karst interpretation and educational media. Working with Guano Loco Productions on our docudrama, *By Lantern Light*, we have leveraged a record $835,815 in grants and in-kind donations, which are mostly for that project but some of which support our Education Program in general.

NCKRI's Education Director Dianne Joop sends a huge "Thank you" to all of the organizations and individuals that supported NCKRI's Education Program this year. Your support and expertise is invaluable.

If you would like to learn more about how you can support NCKRI's Education Program, please visit www.nckri.org/education.

NCKRI photo by George Veni

Beams in NCKRI's courtyard, designed and tested for rope training and demonstrations, will soon be transformed into NCKRI's Vertical Voyages.

Outreach

This year NCKRI's Education Director's work has focused on growing NCKRI's social media audience. NCKRI launched a social media push for *By Lantern Light,* which has grown an audience of more than 12,000 people.

Interpretation Workshops

This year Dianne Joop, NCKRI's Education Director conducted a series of mini-workshops at New Mexico's Living Desert State Park for its docents and other interpretation professionals. Through this series, participants learned about geologic history, cave and karst geology, and bats.

NCKRI's Education Program also sponsored a National Park Service weeklong workshop focusing on the National Environmental Policy Act and Wilderness Management.

National Workshops

NCKRI continued its support at the second Texas Hydro-Geo Workshop, organized by the Bexar Grotto of the National Speleological Society and the Edwards Aquifer Authority. It was attended by over 300 people, mostly university students. Karst experts taught 26 modules, including NCKRI Board members and staff: Dr. Calvin Alexander (*Tracer Testing in Karst*), Dr. Ron Green (*Surface Geophysics—DC Electrical Resistivity*), and Dr. George Veni (*Cave Geology* and *Karst Feature Evaluation Using the TCEQ Forms*). The event was orchestrated at Cave Without A Name by former NCKRI Board Vice President, Geary Schindel.

International Workshops

NCKRI offers workshops directly in its headquarters or by traveling to others. We also provide workshops remotely. In early 2016 we were contacted by Carlos Garcia, a Peace Corps volunteer working in the rural region of Huari, Peru. As the Director of Environmental Initiatives, one of Mr. Garcia's projects is a series of free environmental video lectures that he translates into Spanish for the Huari communities. NCKRI's Drs. Penny Boston and George Veni were invited to join the list of internationally acclaimed scientists and environmental resource managers who have contributed to this program. They provided video presentations about cave microbiology and hydrogeology.

NCKRI photo by George Veni

A well that comes through the roof of Cave Without A Name, Texas, to pump water from the underground river in the background, is one of many instructive features found in the cave and why it is home to the Texas HydroGeo Workshop.

Annual Giving

Our Annual Giving Program recognizes those individuals and organizations who provided services or financial gifts during FY 2015-2016 in in support of NCKRI programs:

- Dr. Calvin and Sheri Alexander
- Luciana Alt and Vitor Moura
- David Brumbaugh
- Dr. Robert Brinkmann
- Richard Cervantes
- City of Carlsbad, New Mexico
- James Cogburn
- Eddie David
- Tom Edwards
- Dave Foster
- GoodSearch.com
- Dr. Ronald Green
- Guadalupe Mountains National Park
- Guano Loco Productions
- Benjamin Hutchins
- Mark Joop
- Peter Jones
- Ted Lee
- David Lester
- Professor Lu Yaoru
- Dr. Penny Lukin
- Logan McNatt
- Richard W. Miller
- National Center for Suburban Studies, Hofstra University
- Dale Pate
- John Scheltens
- Jason Shirley
- Dave Steensen
- Jack Swickard
- George and Karen Veni
- Anderson Ward
- David Weary

Membership

NCKRI's Annual Membership program is offered to all interested persons wanting to support NCKRI activities. You can join online at www.nckri.org or call us at 575-887-5518. When you become a member, you will receive reduced rates on publications, special presentations, classes, lectures, and facility rentals, and in the future, discounts in the Museum Store.

NCKRI Partners

NCKRI recognizes four levels of partnership and uses their descriptions below in defining its relationships with NCKRI partners:

Founding Partners

NCKRI's Founding Partners played a crucial role in the creation of the Institute and continue to serve as major supporting partners. Each founding partner maintains one permanent position on NCKRI's Board.

- City of Carlsbad
- New Mexico Institute of Mining and Technology
- US National Park Service

Institutional Partners

Organizations with formally defined, mutually supportive relationships with NCKRI through Memoranda of Agreement, Memoranda of Understanding, contracts, or other written and signed agreements that are in effect for periods of at least one year and which define each party's specific roles and responsibilities.

- American Geosciences Institute
- Emil Racovita Institute of Speleology (Romania)
- Institute of Karst Geology (China)
- Instituto do Carste (Brazil)
- International Academy of Karst Sciences
- International Union of Speleology
- Karst Research Institute
- New Mexico Bureau of Geology and Mineral Resources
- US Forest Service
- US Geological Survey
- University of New Mexico
- University of South Florida

NCKRI Affiliates

Organizations that have demonstrated meaningful support for NCKRI and its goals, or their intent to do so, but without a formal defining agreement. NCKRI Affiliates are approved by the NCKRI Board of Directors. NCKRI and its Affiliates exchange news and information as available, and coordinate and/or cooperate with each other in projects and activities. Each organization may also extend other benefits according to their internal rules and abilities.

- Bat Conservation International
- Carlsbad Municipal Schools
- Edwards Aquifer Authority
- Fort Stanton Cave Study Project
- Karst Waters Institute
- National Speleological Society
- NASA
- US Bureau of Land Management
- US Fish and Wildlife Service

Cache and Karst!

Geocaching is an exciting and educational way of exploring our planet. Using a global positioning system (GPS) unit and coordinates of geocache sites, geocachers visit interesting and unique locations around the world to find hidden souvenirs of their discovery.

In this year's annual report, NCKRI highlights volunteers Desiree and Dwayne Kicker who created a geocache hidden outside of NCKRI Headquarters. The photo below shows them with the container that they specially designed. Information about the cache is at https://www.geocaching.com/geocache/GC6G1T6_cache-and-karst, where you'll also find great reviews like, "This is one of the nicest and most well done caches we've come across. Really fun find." We thank the Kickers and all of our volunteers for their thoughtfulness.

STUDENT ACTIVITIES

Cave and Karst Studies Program at NMT

Cave and Karst Studies at New Mexico Tech (NMT) is NCKRI's Academic Program and taught through NMT's Earth and Environmental Sciences Department. A variety of regular courses and special topics were taught by Dr. Penelope Boston on a rotating 2-year frequency, several in collaboration with other faculty over the years.

Dr. Boston has long provided leadership at our academic partner, New Mexico Tech, but also professionally in her field as demonstrated by her change in status at the end of this fiscal year. She is now the Director of Astrobiology for NASA. We thank Penny for her amazing work and are confident that she will develop excellent research programs for NASA. The search for a new director of NCKRI's Academic Program at NMT will begin in the next fiscal year.

Throughout the past year, researchers and students of the Cave and Karst Studies program continued to be engaged in excellent and exciting research with new and ongoing projects, setting very high academic and research standards at NMT and for cave and karst science in general.

Student Projects

Aaron Curtis successfully defended his dissertation in late 2015 and graduated in May of 2016. His dissertation title was *Dynamics and Global Relevance of Fumarolic Ice Caves on Erebus Volcano, Antarctica.* Aaron has been awarded a NASA Postdoctoral Fellowship to work at the Jet Propulsion Laboratory under the guidance of Dr. Aaron Parness and Dr. Karl Mitchell on the development of a robotic capability for climbing ice cave walls. This builds upon the work that Aaron did on the properties of ice caves and fumaroles in Antarctica, melded with the work that Dr. Penny Boston has done with the climbing robot FreeClimber in lava tube environments to modify the robot's mobility to be suitable for ice surfaces.

Hilary Kelly continues to work on her dissertation project, *Microbial Biosignatures Detectable from a Novel Robotic Platform,* and was granted a fourth year of her Harriet G. Jenkins Fellowship by NASA (to extend from August 2016 - July 2017). She gave a presentation at the 47th Lunar and Planetary Science Conference in March in Houston, Texas, entitled *Diagnostic characteristics of macroscopic biopatterns detected with novel robotic platform.* Ms. Kelly is aiming at a late 2016 or early 2017 PhD defense date.

Zhidi Wu, an undergraduate senior, is completing work on her Senior Thesis entitled *Microbiological Impacts of Hydrological Dyes*. She will be presenting the work at the fall 2016 meeting of the Geological Society of America. After graduating in August 2016, Ms. Wu will begin graduate studies with Dr. Andrew Luhmann, the recently hired karst hydrology professor at New Mexico Tech.

NCKRI photo by George Veni

Dye injection into caves and sinkholes has long been a crucial tool in studying, defining, and protecting karst aquifers. However, the effect of these dyes on microbial ecosystems native to caves has never been studied until the current work by NCKRI Scholar Zhidi Wu.

NCKRI Headquarters Becomes the John Heaton Building

NCKRI Headquarters is owned and was specially constructed for NCKRI by the City of Carlsbad. When the City decided to name it after former New Mexico State Representative John Heaton, we were delighted.

Representative Heaton was instrumental in establishing the State of New Mexico's support in the state-federal-city partnership that created NCKRI in 1998. In 2002, he produced funds for our hydrogeologist position held by Dr. Lewis Land, in 2006 he significantly increased the state's general funding for NCKRI and procured a grant for our monumental sculpture of Jim White, and throughout his terms in office set up many other funds and programs to benefit the entire community. The dedication on March 24th 2016 was one of the best-attended events at NCKRI.

NCKRI photo by Dianne Joop

John Heaton holds a beautiful photograph of Lechuguilla Cave, by renowned cave photographer Peter Jones, presented as a gift from NCKRI by Dr. George Veni during the city's dedication.

NCKRI photo by George Veni

14th Sinkhole Conference attendees on the new half-day field trip.

14th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts on Karst

Since 1984, "The Sinkhole Conference" series has been among the most significant in creating a better understanding of karst processes that result in environmental problems. It was placed under NCKRI's management in 2011.

NCKRI believes in partnerships and for the first time the conference was jointly organized when the Minnesota Ground Water Association joined us to hold the 14th Sinkhole Conference on October 5-9, 2015 at the Mayo Civic Center in Rochester, Minnesota. It was the biggest Sinkhole Conference to date with 234 people registered from 11 countries and 21 US states.

This time the conference included short courses on:

- Minnesota Environmental Management Rules, Regulations and Permits for Southeast Minnesota Karst Landscapes and Karst Aquifers,
- Geologic Site Characterization with Emphasis on Karst
- Groundwater Tracing as a Hydrogeologic Tool in Karst and Other Landscapes, and
- Grouting in Karst.

In addition to the traditional day-long fieldtrip, an extra half-day trip was added at the end of the conference, *Karst in our Built Environment: the Rochester Area*.

The 69 papers presented at the conference are compiled in the 611-page proceedings volume, which along with the program and field trip guidebooks, are available for free download at http://nckri.org/about_nckri/nckri_publications.htm with all other NCKRI publications.

None of this would have been possible without the help of the many excellent volunteers of the conference's Organizing Committee:

- Dr. Calvin Alexander
- Scott Alexander
- Michael Alfieri
- Kelton Barr
- John Barry
- Dr. Phil Carpenter
- Dr. Dan Doctor
- Dr. Mindy Erickson
- Dr. Ralph Ewers
- Dr. Joe Fischer
- Dr. Yongli Gao
- Jeff Green
- Brian Hunt
- Sean Hunt

- Dr. Jim LaMoreaux
- Jeanette Leete
- Bashir Memon
- Sam Panno
- Gheorghe Ponta
- Dr. Ira Sasowsky
- Dr. Brian Smith
- Deana Sneyd
- J. Brad Stephenson
- Audrey Van Cleve
- Lynn Yuhr
- Wanfang Zhou

The Organizing Committee has already begun work on the next Sinkhole Conference, which will be held on April 2-6, 2018 in Shepherdstown, West Virginia. Watch the website for news and updates: http://www.sinkholeconference.com/.

NM Tech Alumni Reception

NCKRI is a proud institute of the New Mexico Institute of Mining and Technology (NMT), so when NMT looked to hold a reception for alumni in Carlsbad, NCKRI was the obvious site for the event. The December 2015 reception was fun and informative. We anticipate that this reception will be the first of many NMT events at NCKRI.

Artisans for Parks

NCKRI organizes events and conferences each year, but the ones it sponsors by hosting them at NCKRI Headquarters can be just as important. That was the case with Artisans for Parks.

Sadly, there is a large deficit in the amount of money needed to support our national parks, even though every federal dollar spent for our parks generates $10 in return to our country's economy. Knowing this, cave photographer Peter Jones and cave artist Lois Manno organized a fundraiser to support Carlsbad Caverns National Park. Their successful event mostly occurred at the park, but it was kicked off at NCKRI on June 30th to the acclaim and support of many Carlsbad residents. The over $4,000 raised from this event will be used as needed by the park to support programs and activities not normally covered by its federal budget.

NCKRI photo by George Veni

Lewis Land shows DeepKarst participants a gypsum karst sinkhole in the Pecos River valley that is potentially formed by hypogenic action.

DeepKarst 2016

Hypogenic karst is formed by deep, rising waters, creating distinct types of caves and related features. Much remains to be learned about this new and exciting field, which has direct application to geologists, engineers, hydrologists, land managers and planners, and oil and gas professionals.

In April 2016, NCKRI organized DeepKarst, a conference that focused on hypogenic karst processes. DeepKarst met at NCKRI Headquarters in Carlsbad, New Mexico, an area where hypogenic karst phenomena are abundantly developed in limestone caves in the Guadalupe Mountains, and as artesian groundwater resources in the Pecos River valley.

The conference proceedings total 203 pages and include 31 papers presented by the attendees from 10 countries and 12 US states.

Numerous field trips were offered during this conference. Lewis Land and Rod Horrocks, Carlsbad Caverns Cave Specialist, led trips through Lower Cave in Carlsbad Cavern while George Veni coordinated a trip above them along the tourist trails. Dr. Land also led a surface geology field trip focusing on hypogenic water resources and karst morphologies in the Pecos River valley of southeastern New Mexico. Dr. Art Palmer and Peggy Palmer organized 13 optional trips to seven caves. We thank the following who volunteered their time and expertise to organize this conference, even with some knowing that they would not be able to attend the event:

- Gosia Allison-Kosior
- Stan Allison
- Cory Blackeagle
- Paul Burger
- Todd Chavez
- Dr. Dave Decker
- Harvey DuChene
- Dr. Anita Erőss
- Dr. Amos Frumkin
- Jim Goodbar
- Larry Henderson
- Rod Horrocks
- Dr. Alexander Klimchouk
- Jill Orr
- Dr. Art Palmer
- Peggy Palmer
- Dr. Victor Polyak
- Paula Provencio
- Dr. Michael Queen
- Pete Reehling
- Dr. Kevin Stafford

Professional Partnerships

NCKRI established a Memorandum of Agreement (MOA) with the US Geological Survey. The purpose of the MOA is broad. It defines the general relationship and intent to work together when possible for mutual benefit and the advancement of cave and karst science, education, and management. It also serves as a foundation for developing agreements for specific joint projects. We look forward to working closely with the US Geological Survey for many years to come.

NCKRI also met with the US Environmental Protection Agency, American Association of State Geologists, and the American Water Well Association to build better understandings of karst groundwater resource issues and relationships with these organizations.

Professional Meetings

NCKRI attended, sponsored and/or had a booth at many conferences during the past year:

- National Speleological Society Convention; Waynesville, Missouri, USA.
- Southeastern New Mexico Energy Summit; Carlsbad, New Mexico, USA
- National Cave and Karst Management Symposium; Cave City, Kentucky, USA.
- National Groundwater Association meeting; Albuquerque, New Mexico, USA.
- Geological Society of America Convention; Baltimore, Maryland, USA.
- New Mexico Association of Museums Convention, Carlsbad, New Mexico, USA.
- New Mexico Geological Society, Socorro, New Mexico, USA.
- DeepKarst 2016; Carlsbad, New Mexico, USA.
- Paving and Transportation Conference; Albuquerque, New Mexico, USA.

NCKRI staff also organized or co-organized the following events:

Dr. George Veni:

- Served as a member of the Organizing Committee for the New Mexico Association of Museum's conference, held in Carlsbad, New Mexico, USA.
- Was a Scientific Committee Member for the *International Workshop on Ice Caves VII*, Postojna, Slovenia.
- Co-Chaired the *14th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts on Karst*, Rochester, Minnesota, USA.
- Chaired *DeepKarst 2016*, Carlsbad, New Mexico, USA.
- Is serving as a Co-Chairman for the *15th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts on Karst*, to be held in Shepherdstown, West Virginia, USA, in 2018.

NCKRI photo by George Veni

Dr. Lewis Land attended the Paving and Transportation Conference to address the threat of sinkhole collapse along many of the country's roads.

Dianne Joop:

Served as a member of the Organizing Committee for the New Mexico Association of Museum's conference, held in Carlsbad, New Mexico.

Lewis Land:

- Served as co-editor for the proceedings of the *14th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts on Karst*, Rochester, Minnesota, USA.
- Organized and co-organized the main field trips for *DeepKarst 2016*, Carlsbad, New Mexico, USA.

Meeting and Conference Rental Space

NCKRI's conference space and classrooms are ready for hosting your workshops, trainings, meetings, and conferences. Our facilities can easily accommodate up to 150 people. They are rented by a wide variety of organizations and businesses looking for a versatile and professional meeting setting, as well by individuals for private parties in one of Carlsbad's most scenic locations, the Cascades at Carlsbad along the beautiful Pecos River. Caterers are welcome! All funds from the rentals go to support and build NCKRI and its programs. For more information, contact Courtney Gasow at cgasow@nckri.org or by calling 575-628-2702.

Guest Lectures by NCKRI

Drs. Land and Veni were invited to give the following presentations and lectures:

- *Cooperative Projects Between Cavers, State Surveys, Agencies, and NGOs*. National Speleological Society, Waynesville, Missouri.
- *11 Orders of Magnitude: the Range and Implications of Recharge Rates on Karst Hydrology and Management*. Banquet lecture for the National Cave and Karst Management Symposium, Cave City, Kentucky; "Lunch and Lecture," US Forest Service, Denver, Colorado; Brownbag Lunch Lecture, National Park Service, Denver, Colorado.
- *The Latest in NCKRI Research: Mapping the World's Karst, Predicting and Preventing Sinkholes, the First Geophysical Survey of Bat Guano!* Baltimore Grotto, Baltimore, Maryland.
- *WallsMap as a GIS-Based Cave and Karst Database*. Webinar for the Illinois Geological Survey.
- *An Introduction to Caves, Karst, and NCKRI*. Community Focus, Carlsbad, New Mexico.
- *Sinkholes: the Quiet National Crisis*. Roswell Rotary Club, Roswell, New Mexico.
- *Madla Natural Area: Deep in the Heart of Caves, Karst, and Aquifers*. Keynote fundraising lecture, Friends of Madla Natural Area, Grey Forest, Texas.
- *Karst Hydrology of the Roswell Artesian Basin*. Bottomless Lakes State Park Enchanted Evenings, Roswell, New Mexico.
- *Impact of the Recent Drought on Groundwater Resources in New Mexico*. Roswell Rotary Club, Roswell, New Mexico.

Education

- Dr. Land led a group of environmental science students from New Mexico State University-Carlsbad on a field trip to the site of the old Lake McMillan reservoir. This area was significantly impacted by gypsum karst geohazards in the early 20th century, forcing its abandonment.

Co-Sponsored Speakers

NCKRI co-sponsors the Edwards Aquifer Authority's Distinguished Lecture Series in San Antonio, Texas. In October 2015, Dr. Zoran Stevanović came from the University of Belgrade in Serbia to give the distinguished lecture on *Hydrology, Management, and Engineering Controls in Karst*. He was followed in April 2016 by *A Water Wonk's World*, presented by Oregon State University's Dr. Michael Campana.

NCKRI photo by George Veni

Dr. Dave Decker examines potential hypogenic karst features in Coffee Cave next to the old Lake McMillan reservoir during the DeepKarst Conference. Caves like this created the many sinkholes which plagued the lake and made it impossible to hold water.

National Involvement

- Dr. George Veni was appointed to a second 3-year term by the Secretary of the US Department of the Interior to serve on the Resource Advisory Council for the Bureau of Land Management's Pecos District. The council meets 2-4 times a year to review information, make field observations, hear public comments and develop recommendations for the Bureau.
- Dr. Veni continues his service on the Aquifer Science Advisory Panel of the Edwards Aquifer Authority (EAA). The panel meets about twice a year in San Antonio, Texas, to review active and proposed EAA research and management programs. The Edwards is one of the country's major complex karst aquifers.
- Dr. Veni continues to represent NCKRI in the US Fish and Wildlife Service's White-nose Syndrome Stakeholder Committee. During the past year, this bat-killing fungus has tragically reached the West Coast to now cross North America.

Photo courtesy: Bracken Engineering

NCKRI and Bracken Engineering, of Tampa, Florida, teamed to study the causes of sinkhole collapse. We discovered that sinkholes form much more often with urban infrastructure, explained why, and proposed a model ordinance to minimize their occurrence. See the Sinkhole Conference proceedings (page 11) for details.

Community Involvement

NCKRI hosts the monthly meetings of the Pecos Valley Grotto of the National Speleological Society on the third Thursday of each month at 7 p.m. Anyone interested in cave exploration and cave research is welcome to attend.

NCKRI staff:

- Participated in the Carlsbad Chamber of Commerce's annual *Bat Brigade*. This delegation of community leaders visits leaders of New Mexico government to raise their awareness and support for issues in the City of Carlsbad and Eddy County.
- Regularly attended board meetings of the Carlsbad Chamber of Commerce, and its Government Affairs, Tourism Council, and Education Council committees, Carlsbad Department of Development, and participated in related activities supporting new businesses and community leaders.
- Participated in the Pecos River Water Users Organization meetings.
- Regularly attend the meetings of the New Mexico Association of Museums Southeast Region.
- Provided information on the karst hydrogeology of the Capitan Aquifer to the City of Carlsbad's Water and Sewer Commission.
- Participated in the Lincoln National Forest's revision of their Land Resource Management Plan.

Media

NCKRI was featured in the following reports:

- *What You Don't Know About Sinkholes Can Hurt You*. John Weiss, Post-Bulletin, Rochester, Minnesota, 8 October 2015, http://m.postbulletin.com/news/local/what-you-don-t-know-about-sinkholes-can-hurt-you/article_dcbcfbe2-ab5a-55ab-9d42-2a9c410a420a.html?mode=jqm
- *Laser Beams Brighten Prospects for Cave Science*. JoAnna Wendel, *Eos, 96, 7 December 2015*. DOI:10.1029/2015EO040995. https://eos.org/articles/laser-beams-brighten-prospects-for-cave-science
- *Where is the World's Deepest Cave?* Patrick J. Kiger, Discovery News, 21 December 2015, http://news.discovery.com/earth/where-is-the-worlds-deepest-cave-151221.htm
- *Don't freak, but sinkholes have opened up all over Seattle*. Samantha Larson, Crosscut.com, 2016, http://crosscut.com/2016/01/dont-freak-but-sinkholes-have-opened-up-all-over-seattle/
- *Descending into Darkness, We Shed Light on Ourselves*. David Kelly, LA Times, 29 February 2016, http://www.latimes.com/travel/la-tr-d-nps-caverns-20160215-htmlstory.html
- *Cave Institute Hosts Meeting: Scientists Visit From Around the World*. Maddy Hayden, Carlsbad Current-Argus, 13 April 2016. http://www.currentargus.com/story/news/local/2016/04/12/cave-and-research-institute-hosts-conference/82944124/
- *3.1 quake Reported Near Border*. Maddy Hayden, Carlsbad Current-Argus, 18 May 2016. http://www.currentargus.com/story/news/local/new-mexico/2016/05/17/31-quake-reported-near-texas-new-mexico-border/84499686/
- *IRNR Researchers Survey Bat Populations in Texas, Anticipating White-nose Syndrome*. Eva Vigh, Conservation Matters, Texas Water Resources Institute, June 2016, http://twri.tamu.edu/publications/conservation-matters/2016/june/irnr-researchers-survey-bat-populations-in-texas-anticipating-white-nose-syndrome/

BOARD OF DIRECTORS

Message From the Chairman of the Board

Dr. Robert Brinkmann, Chairman

Member since May 2010; Bachelor's and Master's degrees in Geology, PhD in Geography. Vice Provost for Scholarship and Engagement, Hofstra University. Bob works on many karst issues, particular karst policy, urban karst, environmental sustainability, and geomorphology.

Although many of you are reading this after the 2016 presidential election, I am writing this update as I help Hofstra University organize academic programming around the first presidential debate to be held on our campus on September 26th, 2016. By any measure, this election cycle has been one for the record and we anticipate a lively and raucous debate.

This year found me reflecting several times about karst, the Presidency, and leadership in general.

There are two notable references to George Washington and caves. The first involves his ancestry. His great great grandfather was from South Cave, which is in the East Riding of Yorkshire England. While the term "cave" refers to a stream in the area, the name provides the first inkling of a presidential connection to our field of study. The second reference to a cave connected to our first Commander-in-Chief comes to us from our own continent in Virginia where a small cave in the Blue Ridge Mountains called George Washington's Cave purportedly has a graffiti signature of George Washington in a back room.

Our renaissance man president, Thomas Jefferson, actually was the first (and probably only) president to conduct research in caves. As far as I know, he was the only president to actually map caves (most notably, Madison's Cave Virginia). He also made significant contributions to the field of paleontology via his interest in caves. He was presented the bones of the newly discovered species *Megalonyx jeffersonii* (Jefferson's ground sloth) found in a West Virginia cave by a friend and he subsequently gave them to the American Philosophical Society after he wrote a scientific paper on them. Of course, this sensation brought forth great interest in cave exploration and vertebrate paleontology in North America.

Abraham Lincoln, perhaps our greatest president, was probably the president most familiar with karst systems due to his upbringing in karst regions of Kentucky and Illinois. He was born in a cabin just above a site where a stream disappears into the vast underground cavernous systems of Kentucky. Known as a sinking stream, the site is thought to be the main source of water for the Lincoln family during the early days of the president's life. What is fascinating about the connection of Lincoln to karst is that today we celebrate the president by finding his grizzled visage in cave formations in tourist caves throughout the country. Many of us have been on tours where the guide tells us to look a certain way or squint just right to see the shape of Lincoln's face. Even in Borneo, at a cave known as Deer Cave, guides point out the outline of Lincoln's face in the entrance.

Of course, our most outdoor president, Teddy Roosevelt, was certainly familiar with caves. He declared Jewel Cave in South Dakota the 14th National Monument in 1908, the first cave to earn that distinction. Today, a 2013 NCKRI study found nearly 200 US National Park Service properties contain or potentially contain caves and karst. As our only president born and raised in New York City, Roosevelt certainly had an impact on the way we manage cave and karst lands.

Many geologists may not want to admit it, but Herbert Hoover was the first US president trained as a geologist. While he was largely a mining geologist most known for his work on metallic sulfide deposits, he certainly knew of some of the low temperature hydrothermal lead and zinc ore bodies found in some karstic dolomites in the upper Mississippi River valley.

President Eisenhower is perhaps

Courtesy of the Hofstra University Libraries, Special Collections Department.

A Lincoln mourning pin. The face of President Lincoln is found in rock in many show caves throughout the country.

Courtesy of the Hofstra University Libraries, Special Collections Department

President Nixon during a 1957 visit to Long Island, New York, at the Garden City Hotel. Long Island, specifically Oyster Bay, was the home of President Theodore Roosevelt for many years and his image graces many important sites across the island. President Roosevelt transformed the way we think about public lands and President Nixon used his visit to a cave in China to promote international cooperation.

best known in caving circles as the only president to delist a cave from national monument status. President Taft listed Wyoming's Shoshone Cavern as a US National Monument in 1910. By mid-century, local officials thought they could run the cave better than the federal government. Following intense pressure, President Eisenhower delisted the cave in 1954 and turned it over to the community. In a generation, the cave was abandoned and the federal government took ownership again through the Bureau of Land Management.

One of the most noteworthy cave visits by a president occurred in 1976 when President Nixon visited Reed Flute Cave in Guilin, China. The visit was seen as a highly controversial initiative, as relations with China were dicey, and as upstaging official United States foreign policy.

To us, the most important cave visit occurred when President Obama and the First Family visited Carlsbad Caverns National Park in June of 2016 (page 1). He met many of the park' staff as well our own George Veni and Dianne Joop. It was a remarkable moment for all of us who seek to advance cave and karst research and education in the US.

As you can tell, US presidents have always had an interest in caves. However, this year it is worth noting another president who has given much to the cause of cave and karst research.

At the end of June 2016, President Daniel H. Lopez is retiring after 29 years as President of New Mexico Tech. As many of you know, President Lopez was one of the movers and shakers who helped to found the National Cave and Karst Research Institute. While we are grateful to all of the US Presidents who helped to shape our national policies toward cave and karst landscapes and build our appreciation of these special places, it is President Lopez who I want to recognize at this time for helping to build a national research center focused on cave and karst science.

Our organization continues to change and grow. We also have other departures to recognize. Suzanna Hernandez, who worked as our Advancement Director, has moved on to exciting new challenges. Professor Penny Boston has left New Mexico Tech to a dynamic new positon at NASA. Our Office Manager Debbie Herr, who has been with NCKRI for as long as I can remember, will retire at the close of the summer. We are so grateful for everything they have done for us.

As this fiscal year closes, we welcome two new board members: Hazel Barton is a Professor at the University of Akron and Lisa Montelione is a City Councilwoman from the City of Tampa. They each bring unique expertise that will help us tremendously into the future.

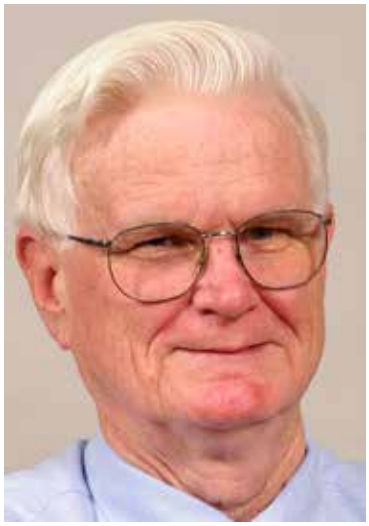
Dr. Ronald T. Green
Vice-Chairman
Member since 2007; Bachelor's Degrees in Industrial Engineering and Geology, Master's Degree in Geophysics; and PhD in Hydrology. Ron is a hydrogeologist with the Southwest Research Institute, San Antonio, Texas, where much of his work focuses on karst aquifers.

Richard Cervantes,
Secretary/Treasurer
Member since 2005; permanent position representing New Mexico Tech (NMT); Master's Degree in Accounting and Information Systems, and is also a CPA. Richard is NMT's Associate Vice President of Research and Economic Development. He is responsible for administrative affairs including budget preparation, fiscal and project management, proposal development and contract negotiation, and provides oversight for those activities at NCKRI.

Jason Shirley
Member since November 2015; permanent position representing the City of Carlsbad, New Mexico, appointed by the Mayor of Carlsbad. Jason has been a resident of Carlsbad, New Mexico for 21 years. He is an Associate Pastor at Word Of Life Church in Carlsbad. He and his wife Tiffany own several small businesses which employ over 20 people. They are the founders of *Project Safe Escape*, a non-profit focused on teen pregnancy and drug use prevention. Jason has been a member of the City Council in Carlsbad since 2012 and serves his community on many boards and committees including the Mayor's Nuclear Task Force, The Eddy Lea Energy Alliance Executive Board, and Carlsbad Main Street.

Dave Steensen
Member since January 2009; permanent position representing the National Park Service (NPS); Bachelor's Degree in Geology, Master's Degree in Environmental Systems/Applied Geology. Dave is the Chief of the Geologic Resources Division of the National Park Services (NPS), located in Denver, Colorado. One of his responsibilities as Chief is oversight and support of the NPS cave and karst resource management program.

Dave Lester
Member at Large
Member since May 2012; Master's Degree in Business Administration. Dave has spent over three decades founding, building, and operating successful entrepreneurial companies and guiding non-profit organizations. As a principal and chief officer, he has managed two public offerings and served as president, executive VP, board member, secretary, treasurer and chief financial officer of NASDAQ traded public companies. He was an advisor during the founding and early years of NCKRI. Dave is a Fellow of the National Speleological Society (NSS) and has served on its Board of Governors. He co-chaired the 1996 convention and chaired the NSS's 2011 convention. He has been actively involved in cave and karst research and exploration in the US and internationally, including National Geographic and NSS sponsored projects. He holds issued and pending United States and international patents and holds a commercial pilot license.



Dr. E. Calvin Alexander, Jr.
Member since October 2011; Bachelor's Degree and PhD in Chemistry. Calvin is an Emeritus Professor in the Earth Sciences Department at the University of Minnesota, Minneapolis. He serves on the Board of the Deep Portage Learning Center. He is a Fellow of the National Speleological Society. Calvin works on many aspects of karst hydrogeology and the impacts of human activities, particularly agriculture, on karst systems and vice versa, the limits that karst systems place on sustainable agriculture and other human activities.

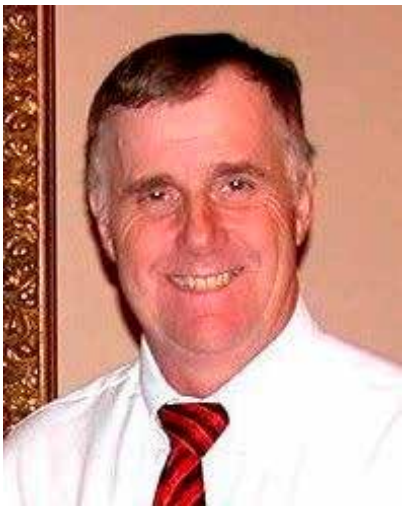
Eddie David
Member since May 2014. Bachelor's Degree in Petroleum Geology. Eddie is the President of David Petroleum Corpo-

ration, a small independent oil and gas exploration company that is active in the Permian Basin of West Texas and Southeast New Mexico. Previously he worked as an exploration geologist for Texaco in Midland, Texas. Eddie has been active in several professional and community charitable organizations. He is a past President of the American Association of Petroleum Geologists, and has served on the boards of the Roswell Independent School District, United Way and the Conquistador Council of the Boy Scouts of America. He has also served and held several position in other community organizations in his home in Roswell, New Mexico.

Tom Edwards
Member since May 2014. Bachelor's and Master's Degrees in Mechanical Engineering, and an MBA. Tom pursues organizational innovation from the three perspectives of research, practical application, and teaching. His many years of practical experience include driving innovation from the top management team of a NYSE-listed company and as an independent consultant. This practical experience is augmented by doctoral research focused on improving the effectiveness of corporate venture capital investment as a method of innovation. Tom has served as profit and loss leader, his current challenge is building a graduate program in leadership for the college of engineering at Temple University in Philadelphia. He serves on the board of directors at Hedwig House and contributes to the mission of the Philadelphia Independence Network for autistic adults. He teaches graduate courses in management, strategy, and product development at Drexel and DeSales universities, and is an Associate Professor and Director of the Engineering Management Program at Temple University.

Dale Pate
Member from 2000-2002; 2006 to present. Bachelor's Degree in Geography. Dale is the National Cave and Karst Program Coordinator for the National Park Service. He served in an Acting capacity for this job from May 2007, and filled the full-time position in July 2012. Involved in cave and karst management since 1970, Dale served as the Cave Specialist (Supervisory Physical Scientist) for Carlsbad Caverns National Park from July 1991 to June 2012.

Jesse Richardson,
Member since May 2010; Bachelor's and Master's Degrees in Agricultural and Applied Economics from Virginia Tech; Juris Doctor from the University of Virginia School of Law. His research and experience focuses on land use law and water law. Jesse is the Lead Land Use Attorney for the Land Use and Sustainable Development Law Clinic at West Virginia University. He has worked extensively with communities in West Virginia and Virginia on land use planning issues, including issues related to karst and water resources.



John Scheltens
Member since May 2014. Bachelor's Degree in Civil Engineering. John has 35 years of experience in professional civil engineering, principally in public works and national drinking water policy. John served as a member of the Environmental Protection Agency's (EPA) National Drinking Water Advisory Council (NDWAC) from 1996-2002 and on many state and national water policy organizations, boards, and commissions to include Vice President of the Water Utility Council for the American Water Works Association in Washington, DC. John is an Honorary Life member of the National Speleological Society (NSS), where he served as national president from 1988-1992. As President, John led efforts to develop and pass the Federal Cave Resources Act of 1988 as well as developing MOUs between the NSS, the National Park Service, US Forest Service, and

Bureau of Land Management. John is currently a Sr. Principal Engineer for Applied Engineering Management Corporation, where he is engaged in international projects for drinking water training at US embassies.

Jack Swickard
Member since May 2013, writer. Former editor and general manager of the Roswell Daily Record and Farmington Daily Times in New Mexico; President of The Triton Group, a Roswell, New Mexico-based public relations consulting company specializing in government affairs and international law enforcement.

Bernard Szukalski
Member since May 2014. Bachelor's Degrees in Biology and Chemistry from Delaware Valley University. With a background in both environmental consulting and biomedical research, Bern joined leading GIS software developer Esri in 1986. During his 29-year career at Esri, he has held a variety of positions and responsibilities that have covered a broad spectrum of geospatial projects and software development activities. Currently he is a chief technology advocate and product strategist, focusing on ways to broaden access to geographic information via cloud-based GIS.

Dave Weary
Member since 2009, Bachelor's Degree in Geology from George Mason University, Master's in Geology from Virginia Tech. He has worked for the US Geological Survey (USGS) in Reston, Virginia, since 1988, and represents the USGS on the NCKRI Board. A research geologist, he is Chief of the USGS KARST Project. His major research activities include hydrogeologic studies and geologic mapping in the Missouri Ozarks and Shenandoah Valley of the Virginias, and the 2014 publication and continued work on the first GIS-based US national karst map. The map was developed in cooperation with NCKRI. the National Speleological Society, and other partners.

NCKRI STAFF

Dr. George Veni, Executive Director

Dr. Veni is an internationally recognized cave and karst hydrogeologist. Prior to NCKRI, he owned and served as principal investigator of George Veni and Associates for over 20 years. He has conducted karst research throughout the United States and in several other countries. His administrative work includes serving as the Executive Secretary of the National Speleological Society's Section of Cave Geology and Geography for 11 years, President of the Texas Speleological Survey for 13 years, Adjunct Secretary of the International Union of Speleology (UIS) from 2002 -2009, and UIS Vice President of Administration since 2009. He has been a committee member for geological, geographical, and biological dissertations at The University of Texas and Harokopio University (Greece), and taught karst geosciences courses for Western Kentucky University for 12 years. He has published and presented over 200 papers and five books on hydrogeology, biology, and environmental management in karst.

Dianne Joop, Education Director

Ms. Joop began working for NCKRI in June 2009 and brought a wealth of teaching experience, both formal and informal. While most of this experience was gained in Kentucky and Tennessee classrooms teaching at many levels, she also worked with cave and karst education programs with the National Park Service, American Cave Conservation Association, and Western Kentucky University. Ms. Joop holds a Master's Degree in Education, with a focus on science and history. She served for four years as the Education Division Chief of the National Speleological Society. She is an active and experienced cave explorer and surveyor on multiple and diverse projects.

Ms. Joop brings a broad and creative set of talents to NCKRI, with a Bachelor's Degree in Theatre, and through a decade of theatrical and television production experiences with Kentucky Educational Television, the state of Florida, Discovery Channel, and more. Since joining NCKRI, she now serves on education and cave and karst management committees for Carlsbad Chamber of Commerce, Carlsbad Municipal Schools, and the US Forest Service, and conducts cave and karst education programs nationally. In addition to her education projects at NCKRI, she also serves as NCKRI's webmaster.

Dr. Lewis Land, Karst Hydrologist

Dr. Land is a karst hydrogeologist with the New Mexico Bureau of Geology & Mineral Resources (NMBGMR). He serves as the Bureau's liaison with NCKRI and as NCKRI's lead geophysical investigator. Prior to his career as a hydrogeologist, Dr. Land spent eight years in the petroleum industry exploring for new oil reserves in the Mid-Continent and Rocky Mountain regions of the U.S., and offshore West Africa. He received his Ph.D. from the University of North Carolina-Chapel Hill, where his doctoral research included submersible investigations of submarine sinkholes in the Straits of Florida. Before coming to work for NCKRI and NMBGMR in 2002, Dr. Land spent two years working with the North Carolina Division of Water Resources conducting geophysical surveys of aquifers beneath the coastal plain of North Carolina.

Dr. Land's current research mostly focuses on regional investigations of karstic aquifers and associated phenomena in southern New Mexico, but have extended as far as Guatemala on NCKRI projects. He has served on several graduate student committees at New Mexico Tech (NMT), and is an adjunct faculty member in the NMT Department of Earth and Environmental Science. He is a Past-President of the New Mexico Geological Society (NMGS), and served for five years on the NMGS Executive Committee.

NCKRI Staff at the Jim White Sculpture at NCKRI Headquarters: Seated in front is Debbie Herr. In back from left to right: Lewis Land, George Veni, Courtney Gasow, and Dianne Joop

Debbie Herr, Office Manager

Debbie joined NCKRI in January 2008 to organize and lead its administrative activities after working as a secretary in the Truth or Consequences Municipal School District for over 11 years. She received an Associate's Degree in Secretarial Administration from New Mexico State University at Carlsbad, and has over 25 years' experience as a secretary, administrative assistant, and office manager in different business and educational settings.

Since joining NCKRI, Debbie has set up and organized NCKRI's filing system, and set up NCKRI's corporate accounting system. Debbie completes the corresponding monthly reports for NCKRI's corporate ac-

counts as well as tracking NCKRI's state and federal accounts. She has been the treasurer for several conferences and workshops held at NCKRI and has submitted appropriate reports to their committees. Debbie has worked on NCKRI's annual reports yearly and other reports as necessary. Debbie is also the recording secretary for the Board of Directors' meetings as well as the Executive Committee meetings. Debbie maintains the day-to-day operations in the office to ensure smooth administrative operations.

Courtney Gasow, Event Planner

Ms. Gasow joined NCKRI in April of 2016 as the new Event Planner. Courtney moved to Carlsbad in 2012 and worked on contract with the Carlsbad Department of Development organizing their national Nuclear Conference and coordinated various post conference meetings. Previous to this she lived in Houston, Texas, and worked as the event coordinator for an art gallery for three years specializing in modern masters. The majority of her 15 years of experience in events stems from working in administration and special projects for the SOSA group, a major fine dining organization in Texas. From conception to build out, she was instrumental in opening the first fine dining restaurant ever in a major US ballpark (Minute Maid Park) and also opened and managed three other restaurants under the tutelage of SOSA with a combined gross of $10 million annually. Courtney attended Richmond College in London, United Kingdom, studying British history for two years and also attended the University of Houston-Downtown with a focus on psychology. She is currently finishing a degree in Sociology/Psychology.

The Event Planner position at NCKRI is a new and interesting concept. Courtney is presently working on marketing NCKRI's space for public and corporate rentals. She has participated in classes to learn the current event planning software and is assisting in the coordination of several projects such as The Sinkhole Conference, Board meetings, and various fundraising functions. Her current goal is to spread the message of cave and karst by renting the NCKRI space and attracting an entirely new audience to the building in conjunction with educating them on the importance of the Institute.

NCKRI photo by George Veni

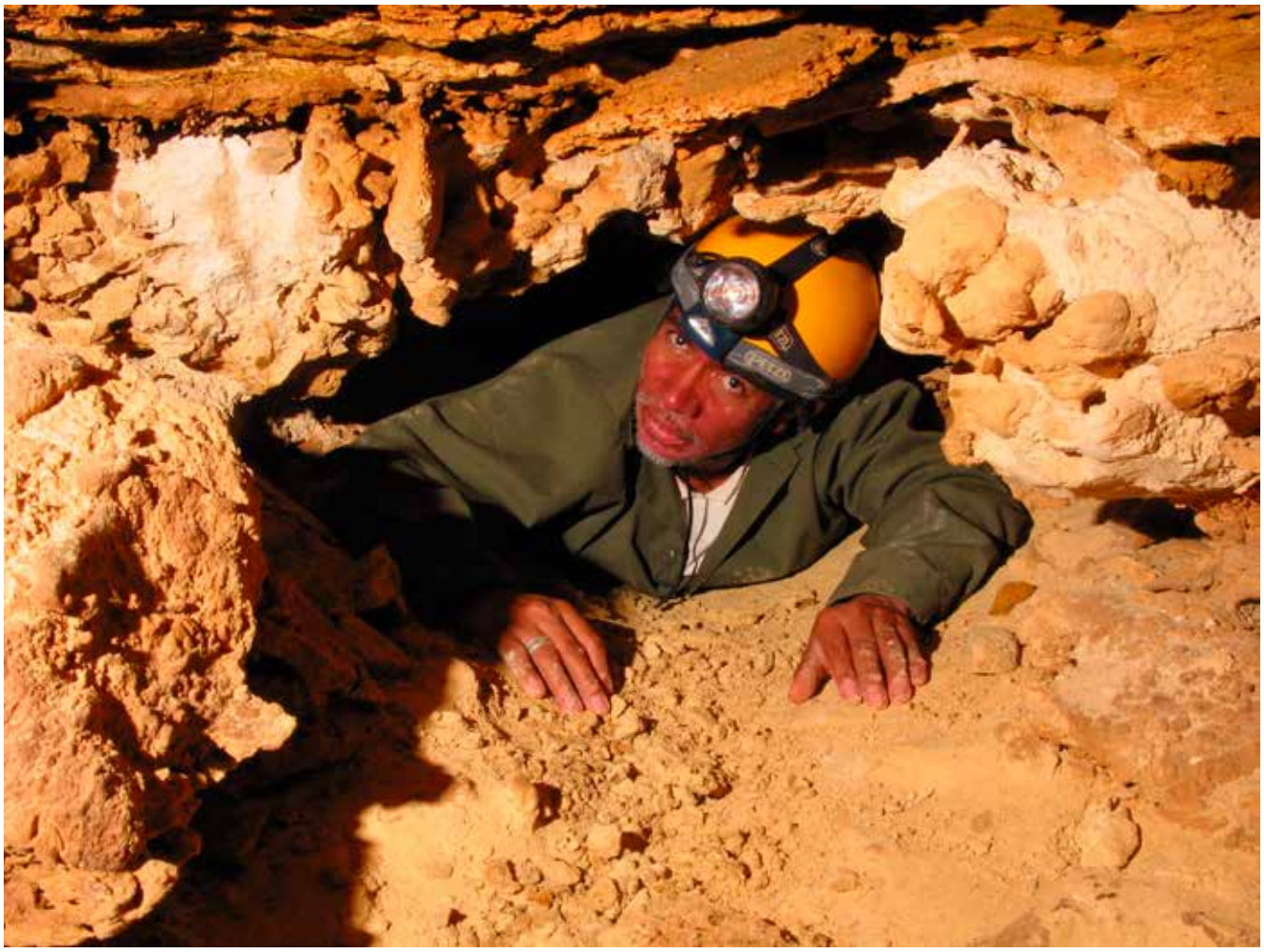
NCKRI staff attended the 2015 National Cave and Karst Management Symposium, which included a trip into Mammoth Cave, Mammoth Cave National Park, to study their trail construction and restoration methods.

Dr. Penelope Boston, Academic Director

Dr. Boston teaches classes in cave and karst science, geomicrobiology, astrobiology, and global systems, and supervises graduate students studying those topics at New Mexico Tech. She received a National Research Council Postdoctoral Fellowship at NASA-Langley Research Center, has held positions at the National Center for Atmospheric Research, University of Colorado, University of New Mexico, founded her own non-profit research institute (Complex Systems Research Inc.) and operated it for 14 years before joining NCKRI in 2002.

Dr. Boston is a Fellow of the NASA Institute for Advanced Concepts, Past President of the Association of Mars Explorers, and Senior Editor of the journal *Astrobiology*. She is a member of NASA's Advisory Council Committee on Planetary Protection, a member of the National Academy of Sciences COMPLEX committee, and past advisory board member for the *Journal of Cave & Karst Studies*.

This was Dr. Boston's final year as a member of NCKRI's staff. As the year ended, she accepted the job of Director of Astrobiology with NASA, where we expect she will excel studying caves and life on other worlds.



NCKRI photo by George Veni

NCKRI staff co-authored a study on the distribution of cave crickets, focusing on geologic and hydrologic factors across karst landscapes. Inside caves, cricket distribution can be affected by local geologic features, like this rock which crumbles into powder to create an excellent environment for cricket eggs.

Continuing Education

NCKRI staff polish and expand their skills whenever possible. Formal training attended by one or more staff members in the past year includes:

- *Managing White Nose Syndrome in Show and Wild Caves*, and *Integrating Karst Research and Citizen Science*, National Cave and Karst Management Symposium workshops.
- *Minnesota Environmental Management Rules, Regulations and Permits for Southeast Minnesota Karst Landscapes and Karst Aquifers*, 14th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst short course.
- *Geologic Site Characterization with Emphasis on Karst*, 14th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst short course.
- *Geoscience and Ethics*, Texas Board of Professional Geologists, training webinar.
- *Raiser's Edge Fundamentals,* Blackbaud class.

Journal Papers

- Weckstein, J.D., Johnson, K.P., Murdoch, J.D., Krejca, J.K, Takiya, D.M., Reddell, J.R., and Taylor, S.J. 2016. Comparative phylogeography of two codistributed subgenera of cave crickets (Orthoptera: Rhaphidophoridae: *Ceuthophilus* spp.). Journal of Biogeography, DOI:10.1111/jbi.12734, 14 pp.

- Land L, Timmons S. 2016. Evaluation of groundwater residence time in a high mountain aquifer system: Insights gained from use of multiple environmental tracers. Hydrogeology Journal. DOI 10.1007/s10040-016-1400-4.

Books and Book Chapters (not published by NCKRI)

- Veni, G. Hauwert, N. 2015. Historical review and forward view of cave and karst research in Texas. In: Caves and Karst Across Time, J. Feinberg, Y. Gao, and E.C. Alexander, eds. Geological Society of America Special Paper 516, DOI:10.1130/2015.2516(05), p. 49-66.

Conference Papers

- Land L. 2016. Sinkholes as transportation and infrastructure geohazards in southeastern New Mexico. 53rd Paving and Transportation Conference, Albuquerque, NM.
- Land L. 2016. Sinkholes as transportation and infrastructure geohazards in southeastern New Mexico. New Mexico Geological Society spring meeting, Socorro, NM, Abstracts with Programs.
- Land L. 2016. Brackish water resources and recharge rates in the Capitan Reef aquifer, southeastern New Mexico and west Texas. National Groundwater Association Conference on Hydrology and Water Quality in the Southwest, Albuquerque, NM.
- Land L. 2015. Crossing boundaries on public lands: An update on geophysical surveys of a potentially extensive cave underlying BLM and National Park Service Units. GSA annual meeting, Baltimore, MD, Abstracts with Programs.
- Veni, G. 2016. A re-evaluation of hypogene speleogenesis: definition and characteristics. In: NCKRI Symposium 6: Proceedings of DeepKarst 2016: Origins, Resources, and Management of Hypogene Karst, Todd Chavez and Pete Reehling, eds. National Cave and Karst Research Institute, Carlsbad, New Mexico, pp. 17-19.
- Veni, G., Campbell Brashear, C., and Glasbrenner, D. 2015. Building codes to minimize cover collapses in sinkhole-prone areas. In: NCKRI Symposium 5: 14th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts on Karst, Daniel H. Doctor, Lewis Land, and J. Brad Stephenson, eds. National Cave and Karst Research Institute, Carlsbad, New Mexico, pp. 471-476.

Edited Volumes

- Doctor DH, Land L, Stephenson JB, editors. 2015. Proceedings of the Fourteenth Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impact of Karst, Rochester, Minnesota. National Cave and Karst Research Institute Symposium 5. Carlsbad (NM): National Cave and Karst Research Institute.

Unrefereed Papers

- McCraw D, Land L. 2016. Sinkholes: A hidden, real New Mexico geohazard. Earth Matters. Winter, 2016.
- Veni, G. 2015. The role of the National Cave and Karst Research Institute in cave databases and management. National Speleological Society Convention Program, Waynesville, Missouri, pp. 114.
- Veni, G. 2015. Luck and the Gold King Mine spill. Basin Resources, Farmington, New Mexico, Fall, pp. 40; published as: Colorado mine spill at least spared aquifer *in* Albuquerque Journal, Albuquerque, New Mexico, 23 August, A11; Veni: luck and the Gold King Mine spill impact, Carlsbad Current-Argus, Carlsbad, New Mexico, 28 August, A4.
- Veni, G. 2016. Carlsbad area has many lessons for the Obama family. Op-Ed, Albuquerque Journal, Albuquerque, New Mexico, 26 June, http://www.abqjournal.com/798287/carlsbad-area-has-many-lessons-for-obama-family.html.

NCKRI photo courtesy of Lewis Land

Dr. Lewis Land enthusiastically samples brackish groundwater in New Mexico's Tularosa Basin. The final report of his study will be listed in NCKRI's next annual report.

2015-2016 STATE AND FEDERAL BUDGET

Unaudited reports ending June 30, 2016

FUNDS REPORT

	National Park Service	Administered by New Mexico Tech	Combined
Beginning Fund Balance	**0**	$ 161,884	$ 161,884
Revenues			
State Appropriation	0	$ 385,000	$ 385,000
Federal Appropriation	$ 312,000	0	$ 312,000
Total Revenue and Fund Balances	**$ 312,000**	**$ 546,884**	**$ 858,884**
Expenses			
Personnel			
Staff Salaries & Student Wages	$ 179,858	$ 140,074	$ 319,932
Fringe Benefits	$ 66,148	$ 56,482	$ 122,630
Total personnel	**$ 246,006**	**$ 196,556**	**$ 442,562**
Operating			
Rent, Utilities, Telephone	$ 15,115	$ 59,165	$ 74,280
Supplies & Other	$ 5,622	$ 23,895	$ 29,517
Exhibit Design	0	0	0
Travel	$ 5,761	$ 9,214	$ 14,975
Contractor Services	0	$ 10,412	$ 10,412
Property & Equipment	0	0	0
NMT Administrative Support	0	$ 10,000	$ 10,000
NMT F&A Costs from NPS Budget (8%)	$ 22,027	0	$ 22,027
NPS Overhead Costs to GRD on NPS Appropriation (6%)	$ 18,000	0	$ 18,000
Transfers	$ (3,363)	0	(3,363)
Total Operating	**$ 63,162**	**$ 112,686**	**$ 175,848**
Total Funds Expended	**$ 309,168**	**$ 309,242**	**$ 618,410**
Gain/(Loss)	**2,832**	**$ 75,758**	**$ 78,590**
Ending Balance	0	0	**$ 240,474**

2015-2016 Corporate Budget

NCKRI Inc. **Unadudited** Annual Statement of Activities and Changes in Net Assets
For the Year Ended June 30, 2016
Administered by NCKRI (contact us for audited statements of previous fiscal years)

Public support and services:		***Functional expenses***	
Unrestricted Contributions	$8,826.94	Conferences	$16,218.71
Conferences	$17,870.77	Contract	$931.73
Programs	$7,738.44	Programs (including Education)	$158,073.47
Rent and Lease	$20,271.67	Operations	$411.00
Education	$150,151.58	Travel	$11,847.76
Other	$100.00	Other	$1,872.10
TOTAL PUBLIC SUPPORT AND REVENUE	$204,959.40	TOTAL PROGRAM EXPENSES	$189,354.77
CHANGE IN ASSETS			**$15,604.63**

Our newly constructed, sustainably designed facility - located in the heart of the beautiful Cascades - is an unforgettable venue for everything from intimate gatherings to large events. With spectacular views of the Pecos River, our waterfront home offers an exciting, imaginative setting for just about anything you can dream!

National Cave and Karst Research Institute

400-1 Cascades Avenue
Carlsbad, New Mexico 88220, USA