



2016 - 2017
ANNUAL REPORT

www.nckri.org

Table of Contents

Executive Director's Report	1
NCKRI Founders' Awards Dinner	2
NCKRI Partners and Friends.....	7
NCKRI Research	8
Geology & Geophysics along US Highway 285	8
Capitan Reef.....	10
The World's First Geophysical Survey of Bat Guano:	
Phase 3.....	11
Phase 1 Study of the San Solomon Springs	12
How Big is the Big Room?.....	13
Karst Information Portal	14
Education Program.....	15
Public Outreach.....	15
Local Workshops	16
National Workshops.....	17
International Workshops.....	17
Student Activities.....	18
Cave and Karst Studies Program at NMT	18
Lighting and Lampenflora in Carlsbad Cavern	18
Conferences and Meetings.....	20
Rentals.....	20
San Antonio Stakeholders Dinner.....	20
Southwestern Region Winter Technical Meeting	21
15th Multidisciplinary Conference on Sinkholes	21
Outreach.....	22
Professional Partnerships	22
Professional Meetings	22
Guest Lectures by NCKRI	22
Co-Sponsored Speakers.....	23
International Outreach	23
National Outreach	23
Community Outreach	23
Media	24
Board of Directors	25
Chairman's Report	25
Board Members	25
NCKRI Staff	26
Staff Education and Publications.....	28
Continuing Education	28
Conference Proceedings Papers	28
Journal Papers.....	28
Unrefereed Papers.....	28
2016-2017 State and Federal Budget	29
2016-2017 Corporate Budget	29

Cover photo

The beautiful 35,000-year old paintings in France's Grotte de Chauvet are not open to the public, but this photo is from Chauvet II, a startlingly accurate artificial cave that opened to visitation this past year. NCKRI was invited to visit this "cave" and learn techniques to better build our museum—once we raise the money to build it. NCKRI photo by George Veni.

Back Cover Photo

New Mexico Tech graduate student and NCKRI scholar Zoë Havlena uses a portable spectrophotometer to measure the density of photosynthetic cells in the Chinese Theater, one of the lampenflora study sites in Carlsbad Cavern. See the story on page 18. NCKRI photo by George Veni.



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 (a.k.a. New Mexico Tech or NMT). Funds not produced by agreements through NMT are accepted directly by NCKRI.

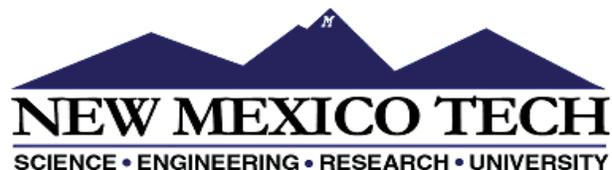
NCKRI's enabling legislation, the National Cave and Karst Research Institute Act of 1998, 16 U.S.C. §4310, identifies NCKRI's mission as to:

- 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, 2016 to June 30, 2017. Digital copies of this and previous reports are available for free at www.nckri.org

NCKRI is a proud institute of:



EXECUTIVE DIRECTOR'S REPORT



Photo courtesy of Binford Creative

I like looking forward and planning ahead. As the national and global economies have recovered slowly over the past few years, funding and opportunities for NCKRI have begun to slowly increase. Some are apparent in this year's Annual Report in our research and educational programs, as well as potential projects not covered in these pages. Despite our progress, we still have a lot of work to get NCKRI to the next level in our growth. And to get there, it is often useful to look backward to remind ourselves of where we've been.

Sometimes it is easy to forget our roots and origins. This report celebrates them. On June 10th, 2017, we held an awards dinner to honor the seven individuals who were critical in creating NCKRI. I hope you enjoy the photos and learning about those good people in the next few pages. In preparing for the event, reviewing historical records, and visiting with the honorees, I was reminded of their long view forward as they planned ahead for NCKRI. There is no exact date for when the concept of NCKRI was born, but it took roughly 15 years to see that vision grow into a federal act that Congress approved in 1998.

What is equally clear, yet more important when looking back, is that these magnificent seven were the tip of an equally magnificent, large team of supporters across the county. I still meet and hear from people who contributed to making NCKRI a reality. The most difficult part in planning our awards dinner was limiting the number of awardees. Ideas, funds, community and political backing, administrative frameworks, plus a huge amount of individual and collective time were offered by probably hundreds of people in large ways and small.

NCKRI owes them all a debt of gratitude that can never be repaid, except to succeed in meeting the goals laid out by Congress and entrusted to those of us honored to work here. I thus dedicate this year's Annual Report to the unsung heroes of NCKRI, both past and present. Through your past and ongoing support, we see the coming years as our best ever.

A handwritten signature in black ink that reads "G. Veni". The signature is written in a cursive, slightly stylized font.

George Veni, Ph.D.

NCKRI FOUNDERS' AWARDS DINNER

On the 10th of June 2017, NCKRI honored seven individuals whose work was critical in establishing this Institute. We held our Founders' Awards Dinner to honor their efforts in elevating the status of cave and karst research, education, and management not only on a national level but internationally as well. Without their hard work and dedication, NCKRI would probably have remained an idea that was never brought to fruition. Therefore, it was our privilege to bring our Founders together for one night with a beautiful party to pay tribute and present them each with NCKRI's highest award, the Medal of Speleological Service Award. The Honorees were as follows (unless otherwise indicated, all photos in this section are provided courtesy of Binford Creative):

Ronal Kerbo

It all began with an idea. As the Cave Specialist at Carlsbad Caverns National Park, Ronal Kerbo saw the struggles within the federal government in dealing with cave and karst resources. It needed a single source to go to for information and technical expertise. NCKRI began to form in his mind as the solution. As Mr. Kerbo recruited support for his idea, he saw that the needs were greater than the federal government's. Everyone in the public and private sector needed a reliable go-to source on caves and karst. Mr. Kerbo found partners locally, around the State of New Mexico, as well as federally, who also saw those needs. He became a key player in the 1994 National Park Service Report to Congress on the significance of cave and karst resources, which provided the technical basis for NCKRI's creation, and which evolved NCKRI's mandates into what we have today.



Ronal Kerbo

Mayor Bob Forrest

Mr. Bob Forrest served as mayor of Carlsbad from 1986 to 1994, as the NCKRI concept was growing. He initiated the city's involvement and support of hosting NCKRI in Carlsbad. When he came back as mayor from 2002-2010, he advocated and assured that funding was in place to construct NCKRI Headquarters. The original deal was that the city would pay a third of the cost, with the rest paid by the state and federal government. When construction costs exceeded what the state and federal governments could pay, Mayor Forrest found the resources to make sure that construction was completed. He also pushed for NCKRI to be located in the Cascades, an upcoming new and beautiful social and retail center for Carlsbad. When construction of other buildings at the Cascades is wrapped up, this will be the best spot in town for NCKRI to engage with the public.

Mayor Gary Perkowski

The years between Mayor Forrest's terms were critical to NCKRI, and Dr. Gary Perkowski



Mayor Bob Forrest



Mayor Gary Perkowski

stepped in as Carlsbad mayor as more than a match for the job. NCKRI was created during Mayor Perkowski's tenure. This was the time when agreements needed to be hammered out, signed, and money committed. This was the time when doers stand tall above talkers. Mayor Perkowski never faltered. He never failed. And once NCKRI was created and its partnership with the city sealed, Mayor Perkowski made sure we were welcomed in town, found offices, and became a

vital part of the community so we could steadily take our next steps ahead.

Dr. Daniel Lopez

As the State of New Mexico got involved in the creation of this new cave institute, it needed a home that would administratively manage things while NCKRI got on its feet. Various universities were considered, and they saw it as risky. Cave science? Who cares? Dr. Daniel Lopez did. Dr. Lopez was President of the New Mexico Institute of Mining and Technology, or New Mexico Tech as most call it. This high-powered university focuses on science and technology, and where

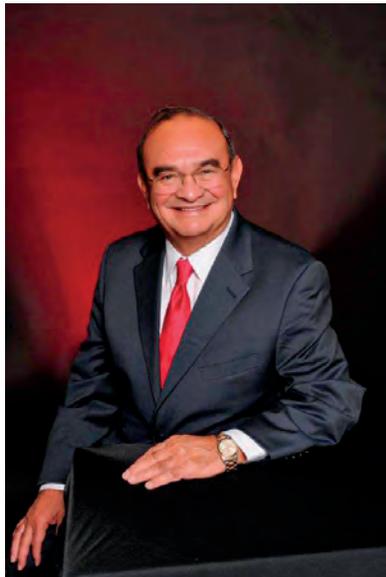


Photo Courtesy of New Mexico Tech
Dr. Daniel Lopez

some saw a risk, Dr. Lopez saw an opportunity in offering NCKRI a home. But he did more than that. It's said that your friends stand with you when times are tough, and during the past several years of the recession when New Mexico's higher education's budget was cut to balance the state's budget, Dr. Lopez and the staff under his direction made sure NCKRI was not specifically targeted for cuts and was supported in all ways possible.

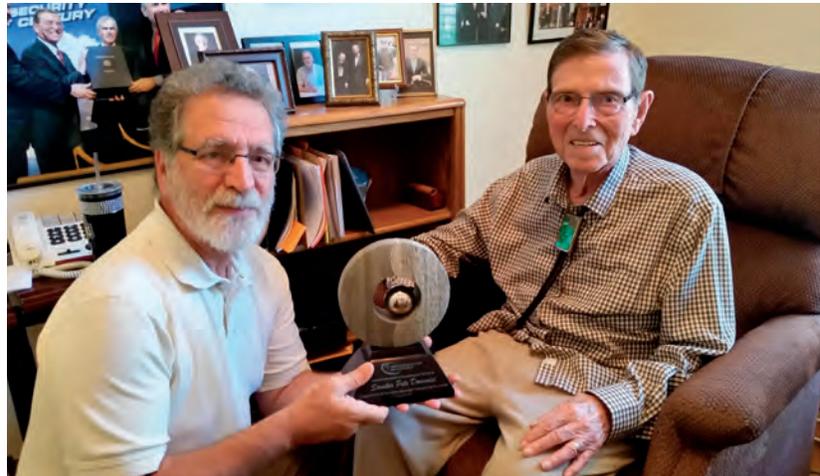


Photo courtesy of Nancy Domenici

Senator Pete Domenici was unable to attend the dinner, but was presented his award by **Dr. George Veni**

State Representative John Heaton

NCKRI Headquarters is in fact the John Heaton Building. Congressman Heaton served this district in the New Mexico House of Representatives from 1997-2010. He was instrumental in making the state a partner in the creation of NCKRI and bringing us to New Mexico (other states wanted us, but didn't have a John Heaton working for them). He got NCKRI the funding match required at that time for the federal dollars.



Representative John Heaton

Later, he nearly doubled our state funding that allowed us to furnish NCKRI Headquarters and survive the recession. Congressman Heaton found the funds for the fabulous sculpture of Jim White that graces the building, and so much more. Since retiring from the legislature, he still comes to visit and look for opportunities to support NCKRI.

Senator Pete Domenici

Politicians are not the obvious people to honor with a speleological award, but they were all significant in the founding of the Institute. Senator Pete Domenici is the longest serving US senator from New Mexico, with 38 years of service. His involvement with caves was not immediate, but inevitable. With a strong interest in science and technology, he served on Senate committees on energy, water, environment, national parks, and other public lands. He has been one of New Mexico's greatest advocates. His first major action involving caves was his sponsorship of the Lechuguilla Cave Protection Act of 1993, the first federal legislation passed to protect a cave. He followed this up in 2009 with his support to create the Fort Stanton-Snowy River Na-

tional Conservation Area. Senator Domenic's greatest speleological contribution was in 1998 when he, along with Senator Jeff Bingaman, championed the National Cave and Karst Research Institute Act of 1998 which created NCKRI.

Senator Jeff Bingaman

Senator Jeff Bingaman, New Mexico's second longest serving senator who retired in 2013 after 30 years, proved a natural advocate for caves and karst. His record on natural resource protection is exemplary, including nearly a decade as Chairman of the Senate Committee on Energy and Natural Resources. His entry into the underground world was dramatic when he sponsored the Federal Cave Resources Protection Act of 1988. This legislation was the first and remains the most comprehensive and significant act to recognize the tremendous value of caves on federal lands. He also spearheaded the Omnibus Public Land Management Act of 2009 which included designation of the Fort Stanton-Snowy River National Conservation Area. In his last years in the Senate, he worked to secure adequate funding to study and stop White Nose Syndrome, a deadly



Senator Jeff Bingaman



Mayor Gary Perkowski speaking at the NCKRI Founders' Awards Dinner.



NCKRI Founders' Awards, the first Medals of Speleological Service.



NCKRI Founders' Award Dinner arrangement, featuring a beautiful blue agate theme.

fungus that since 2006 has killed millions of bats in North America. And of course, partnering with Senator Domenici, he sponsored the 1998 legislation that created NCKRI.



Ron Kerbo greeting Carlsbad Caverns National Park Superintendent Doug Neighbor.



Representative John Heaton proudly carrying his award.



Barbara and Mayor Bob Forrest.



Todd Beasley and Mark Joop.



Senator Jeff Bingaman and Anne Bingaman checking in with NCKRI Event Planner, Courtney Gasow.



NCKRI Board members Dr. Calvin Alexander and Jack Swickard visit with NMT Board of Regents Chair Deborah Peacock.



NCKRI Education Director Dianne Joop and Board member Dr. Calvin Alexander.



Guadalupe Mountains National Park Superintendent Eric Brunnemann visiting with retired Superintendent Larry Henderson.



Representative John Heaton reminiscing with Senator Jeff Bingaman and Anne Bingaman.



County Commissioner Stella Davis, and Carlsbad City Councilor Wanda Durham trading stories with Chris Salinas.



We were happy to meet Grace and Dr. Andrew Nwanne, Vice President of Academic Affairs of New Mexico State University-Carlsbad.



NCKRI Board Member and NMT Associate Vice President Carlos Romero, NMT President Dr. Steve Wells, and NMT Regent Jerry Armijo.



Paul Shoemaker and Larry Henderson enjoying a good story.



NMT Vice President of Academic Affairs Dr. Doug Wells shares a drink with friends.



NMT Regent Chair Deborah Peacock and NMT Director of Government Affairs David Manzano.



A small gift was left for all of our guests on every plate.



Barbara Romero, Beth Wells, and NMT Vice President of Research and Economic Development Dr. Van Romero.



Guests enjoyed a delicious dessert after dinner!

NCKRI PARTNERS AND FRIENDS

Membership

NCKRI's Annual Membership program is offered to all interested persons wanting to support NCKRI activities. You can join on-line 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, 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 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, 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

Annual Giving

Our Annual Giving Program recognizes those individuals and organizations who provided services or financial gifts during FY 2016-2017 in support of NCKRI programs:

- Dr. Calvin Alexander
- Dr. Hazel Barton

- Dr. Van Brahana
- James Branch
- Dr. Robert Brinkmann
- Amy Calderon
- Carlsbad Rotary Club
- Richard Cervantes
- Paul & Sandra Cosand
- Brianna & Loren Darby
- Eddie David
- Edwards Aquifer Authority
- Jim Evatt
- Dawn & Sid Formanek
- Courtney Gasow
- Jim Goodbar
- Dr. Ron Green
- Robert E. Gulden
- Jenkins Furniture
- Gary Jones
- Dianne & Mark Joop
- Matthew Kalch
- Christi Kerbo
- Ronal Kerbo
- Ted Lee
- Dave Lester
- Lisa Montelione
- Natural Bridge Caverns
- Dale Pate
- Carlos Romero
- Dr. Van Romero
- Christopher Salinas
- San Antonio River Authority
- John Scheltens
- Jason Shirley
- Wade Smith
- Dave Steensen
- Jack Swickard
- Dr. George & Karen Veni
- Roger Waddle
- David J. Weary

NCKRI RESEARCH

Geology & Geophysics along US Highway 285

In October 2015, the New Mexico Department of Transportation (NM DOT) reported that a new sinkhole had opened on the east shoulder of US Highway 285 south of the village of Loving, New Mexico, about 15 kilometers north of the Texas/New Mexico state line (see map below). The sinkhole is approximately 1.5 m in diameter and 1 m deep, and although relatively small, it is located less than 6 m from the edge of the roadway. Because of nearby oil and gas activity, there is

a substantial amount of traffic along this portion of US 285, including many large trucks. Sinkholes along this route thus pose a significant geohazard to transportation and general public safety.

Surface geologic maps indicate that gypsum bedrock of the Permian age Rustler Formation is present at or near the surface beneath Highway 285 between Loving and the state line. Sinkholes and caves formed in the Rustler Formation are widespread in this part of the state, and it is not an insignificant consideration that gypsum bedrock of the Rustler

Formation crops out within ~6 meters of the new sinkhole (see photo below).

In November 2016, Dr. Land began conducting an investigation of sinkholes and other karst geohazards along the Highway 285 corridor south of Loving, assisted by other NCKRI staff and personnel with the New Mexico Bureau of Geology and Mineral Resources. This work, which is funded by a contract with NM DOT through Amec Foster Wheeler, Inc., included geologic reconnaissance mapping, followed by electrical resistivity (ER) surveys of potential karst geohazards identified during the surface mapping phase of the investigation. Additional resistivity surveys in the Spring of 2017 were conducted adjacent to all bridges and bridge abutments located on Highway 285.

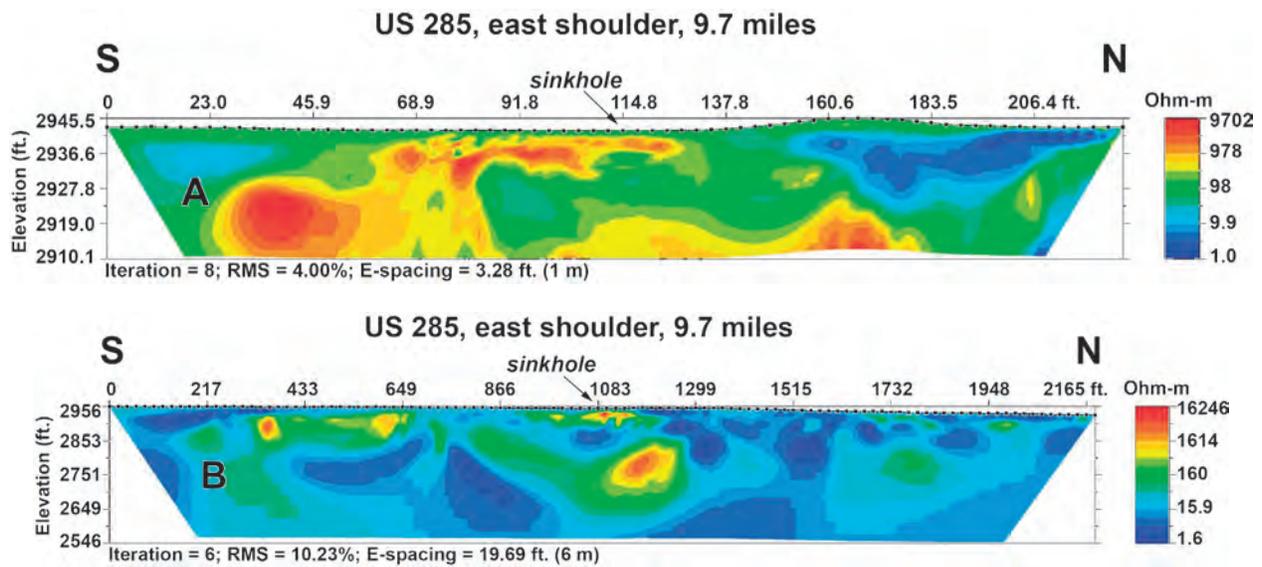
The NCKRI team conducted initial tests of the ER method adjacent to a small sinkhole formed in gypsum bedrock a few meters east of the original Highway 285 sinkhole. One ER survey used a 42-electrode array at one-meter electrode spacing, for a total array length of 42 m and an approximate depth of investigation of 11 m. This survey (Survey A, at the top of the next page) clearly shows the presence of the sinkhole and its connection to a more resistive area extending several meters north and south of the



Map of southeastern New Mexico and adjoining areas of west Texas, showing locations of selected naturally occurring gypsum sinkholes (e.g. Bottomless Lakes State Park and Bitter Lake National Wildlife Refuge) and those resulting from human activity (JWS and Loco Hills sinkholes; Wink sinks). BLSP = Bottomless Lakes State Park; BLNWR = Bitter Lake National Wildlife Refuge; CC = Carlsbad Cavern



Small sinkhole formed in gypsum bedrock of the Rustler Formation, ~6 m east of Highway 285 sinkhole. Beer bottle for scale.



Electrical resistivity surveys of east shoulder of US 285, approximately 9.7 miles (15.6 km) north of the Texas/New Mexico state line. A: depth of investigation ~35 feet (10.7 m). B: ER survey of same site, but with increased electrode spacing and greater total array length. Depth of investigation ~410 feet (125 m). Both surveys passed within ~1 m of the sinkhole shown on the previous page. Positions of electrodes are shown by small black squares along the length of each profile.

sinkhole, indicating the presence of an elongate cave or solution conduit formed in gypsum bedrock in the shallow subsurface. Such features could collapse, especially at these shallow depths, or funnel overlying soils underground to create cover-collapse sinkholes that might threaten the highway.

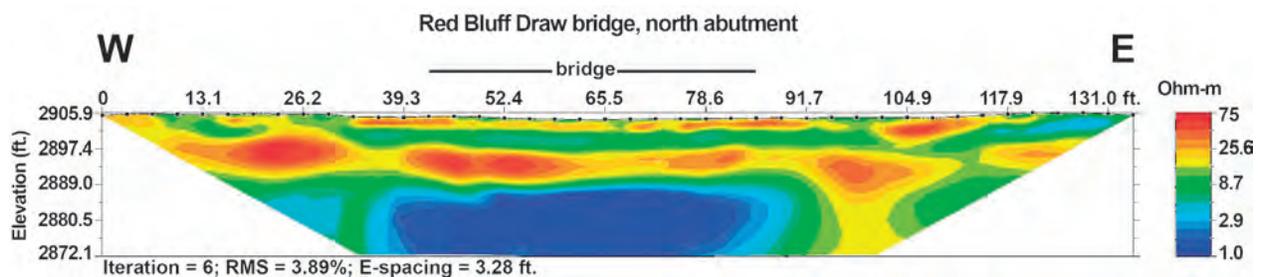
An additional ER survey was conducted at the same site using a 112-electrode array at a 6-m electrode spacing, for a total array length of 666 m, and an exploration depth of approximately 125 m. Evidence

for the sinkhole shown above is still present on the deep survey, indicated by a small high resistivity anomaly near the center of the profile (Survey B in the figure above). The deeper survey also shows evidence for a possible cavity formed in gypsum bedrock about 45 m below the surface cavity.

Buried anthropogenic material provided ground truth for some of the surveys of bridges along the Highway 285 corridor. An ER survey conducted at the base of the north abutment of the bridge over

Red Bluff Draw shows a broad area of very low resistivity extending beneath the entire bridge (see the ER survey in the figure below). Engineering drawings indicate that a buried concrete apron is present at the base of the north and south bridge abutments. The low resistivity zone on the ER profile is probably caused by electrically conductive iron reinforcing rods embedded in the concrete apron.

The project report should be available next year as a NCKRI Report of Investigation.

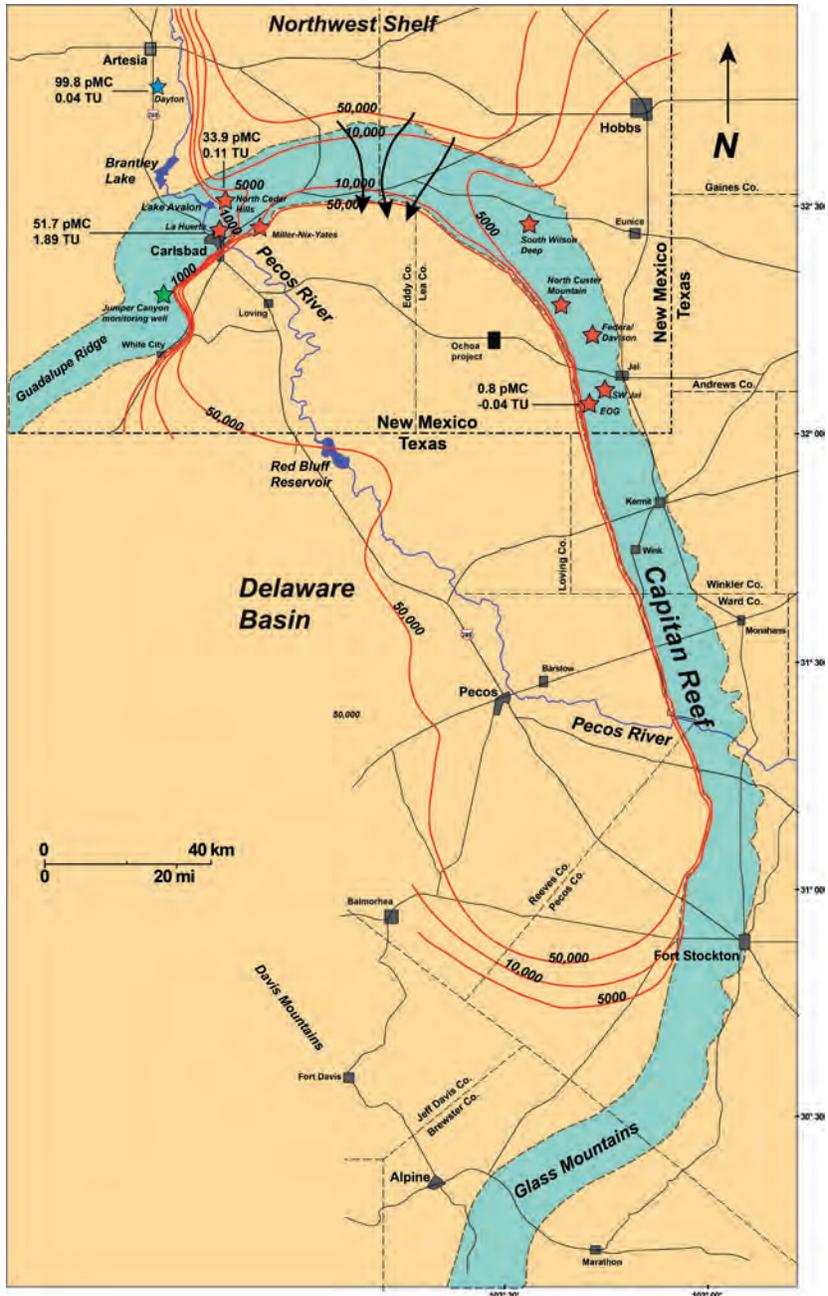


ER survey of north abutment of the bridge over Red Bluff Draw. Broad zone of electrically conductive material (blue shading) reflects the presence of a buried concrete apron containing iron reinforcing rods at the base of the abutment.

Capitan Reef

Dr. Lewis Land continued investigations of water level variations and groundwater residence time in the Capitan Reef aquifer in Eddy and Lea counties, southeastern New Mexico, in collaboration with personnel from the US Geological Survey and US Bureau of Land Management (BLM). Water samples and water level data were collected from nine monitoring wells and an oil industry water supply well completed in the reef aquifer (see map to the right). 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. Water levels in the eastern segment of the aquifer in Lea County are not influenced by meteorological phenomena, showing only long declines throughout the 1960s and 1970s because of groundwater withdrawals by oil companies for water flooding oil fields. When BLM personnel renewed water level measurements in 2012, they found water levels in the eastern segment of the reef had risen over 150 m since the last measurements were made. This rise raises interesting questions about sources of recharge and the age of groundwater in the eastern segment of the reef aquifer.

Water samples were collected from wells in both the eastern and western segments of the aquifer and analyzed for general chemistry, stable isotopes, carbon-14, and tritium. Total dissolved solids (TDS) of water samples collected near Carlsbad are less than 2,000 mg/L, consistent with use of this part of the aquifer for drinking water by Carlsbad residents. TDS values for water from the deeper eastern segment of the aquifer range from 24,000 to 141,000 mg/L, more typical of oil field brines. Tritium concentrations in Eddy County suggest that water is a mixture of recent and pre-modern



Surface and subsurface extent of Capitan reef in southeastern New Mexico and west Texas. Red and green stars show locations of Capitan Reef aquifer monitoring wells. Chloride ion concentrations (mg/L) indicated by red contour lines.

groundwater, whereas tritium concentrations from wells in Lea County are effectively zero, indicating that water is entirely pre-modern.

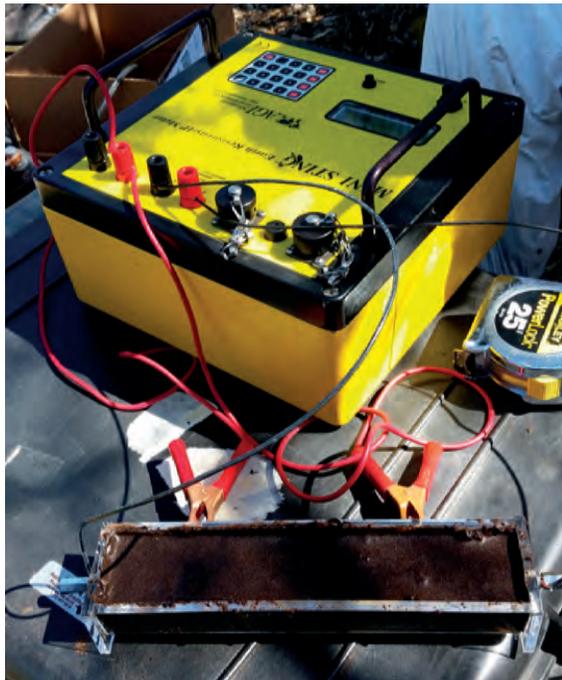
Age of groundwater in the eastern segment of the Capitan Reef may be influenced by the presence of one or more injection wells in southern Lea County, which Dr.

Land recently learned were injecting produced water from oil and gas wells into the middle Permian Artesia Group. Because these units are hydrologically connected to the Capitan Reef, these injection wells may also be contributing to the steady rise in water levels observed in the monitoring wells in Lea County.

The World's First Geophysical Survey of Bat Guano: Phase 3

In 2014 and 2016, NCKRI used electrical resistivity to conduct the world's first geophysical study of bat guano. The study site was in Bracken Cave, located near San Antonio, Texas, which is home to the world's largest bat colony. Based on our interpretation of the data, we found the guano was as deep as 35 m!

After finishing our survey last year, our partners in the project at the Southwest Research Institute, led by Dr. Ron Green, newly-elect President of NCKRI's Board of Directors, began coring the guano to determine the age of the guano layers and study the bones, DNA, pollen, and to other materials in the guano to better understand the paleoecology and paleoenvironment of the cave and surrounding area. However, they couldn't core deeply presumably because rocks, too small to be seen by the resistivity equipment, blocked the way about 2-3 m down.



NCKRI photo by George Veni
The first test of the resistivity of water-saturated bat guano.



Photo courtesy of Allan Cobb
Small red flags amid almost 700 m of yellow resistivity cable mark the locations of 112 electrodes in this 3D survey in Bracken Cave.

To try and find a path for coring through the buried rocks, for this third phase of the project we picked a site that our previous resistivity surveys suggested has no observable rocks, and deployed a highly detailed 112-electrode 3D survey with the electrodes only 0.5 m

apart—the closest they can be placed. This tightly-spaced array wouldn't allow us to see deeply, but we did see to about 5 m, which is below the depth where coring stopped, and found what seems to be a rock-free zone. Future coring will confirm or refute these results.

NCKRI conducted this survey in February 2017, just before the bats returned from Mexico, in partnership again with the cave's owner Bat Conservation International (BCI), members of the National Speleological

Society's Bexar Grotto (NSS), and employees of Advanced Geosciences, Inc. (AGI), which manufactured our resistivity equipment:

- Tom Brown (NSS)
- Allan Cobb (NSS)
- Jason Greenwood (AGI)
- Steve Gutting (NSS)
- Dr. Hector Hinojosa (AGI)
- Fran Hutchins (BCI)
- Markus Lagmanson (AGI)
- Mats Lagmanson (AGI)
- Kurt Menking (NSS)
- Dr. Evelyn Mitchell (NSS)
- Jill Orr (NSS)
- Linda Palit (NSS)

With a small, specialized, resistivity box provided by AGI, we also made the first direct measurements of the electrical resistivity of pure bat guano. We tested it under different moisture and compaction conditions to better interpret the results of our surveys in the cave.

We plan to return one more time to Bracken Cave and redeploy the equipment to see deeper through the guano and find the original cave floor. The cave is formed in a limestone that is generally poorly cavernous, and that survey will be important for understanding the hydrogeology of the cave's aquifer.

Oil and Water: Phase 1 Study of the San Solomon Springs

In September 2016, Apache Corporation announced the discovery of Alpine High, a large oil and gas complex in west Texas. While the announcement has been met with the expected excitement, some stakeholders expressed concern about the impact on water resources and water quality in that region.

Near the middle of the area are the largest flowing springs in west Texas, the San Solomon Spring Group. This series of karst springs provide water for much of the agricultural activity in the area and the town of Balmorhea. The main San Solomon Spring is the centerpiece of Balmorhea State Park, another important component of the local economy.

Concern for the San Solomon Spring system began over 30 years ago, when the Texas Water Commission proposed it as part of a “critical area” that “is experiencing or is expected to have ground-water problems resulting from ground-water overdrafts from an aquifer.”

Observing this decline, the US Fish and Wildlife Service (USF-

WS) federally listed the Comanche Springs pupfish (*Cyprinodon elegans*) and Pecos gambusia (*Gambusia nobilis*), which inhabit the spring system, as endangered species. In 1999, flow ceased from the most upgradient spring—Phantom Lake Spring Cave. In 2012, USFWS proposed federal endangered listing and critical habitat for the Phantom Cave snail (*Pyrgulopsis texana*), Phantom springsnail (*Tryonia cheatumi*), and a diminutive amphipod (*Gammarus hyalleloides*), which are only known from four of the six San Solomon Springs.

Relatively little is known of the hydrogeology of the aquifer that feeds the San Solomon Spring Group. Studies in the 1980s by The University of Texas determined the springs were fed by two sources of water: Cretaceous limestones immediately to the northwest and a more distant source, sustaining much of the baseflow, from Permian limestones in the Apache Mountains 40-80 km to the northwest. These results were confirmed by later additional analyses by the university and the Texas Water Development Board.

Investigations of the karstic na-

ture of the aquifer are limited to two studies. Cave divers have explored and surveyed Phantom Lake Spring Cave to a total surveyed length of 3,075 m. The cave continues unexplored upstream and downstream, and is the deepest underwater cave in the US at a depth of 140.8 m at the current limit of exploration.

NCKRI conducted the other study, a dye trace described in our 2012-2013 Annual Report. We demonstrated that groundwater flows downstream through the cave to the main San Solomon Spring, about 6 km away, at a speed of about 1 km/day.

Despite these studies, the Texas Water Development Board found that data about the San Solomon area were insufficient to adequately characterize its hydrogeology. The Apache Corporation asked NCKRI for assistance, we suggested, and were contracted to conduct a scoping study, to evaluate all available data in order to best recommend a series of studies to characterize the aquifer.

With the results of those recommended subsequent studies, Apache, Corporation in consultation with the appropriate state and federal management agencies, can then develop effective strategies for oil and gas production that prevent adverse impacts to karst groundwater. The scoping study is currently underway and will be completed in the fall of 2017.

In addition to gaining knowledge to protect an important public water supply and a federally protected ecosystem, NCKRI’s interest in this area is much broader. Karst aquifers in arid regions have seen relatively little study. As a result, some aspects of their hydrology are not fully understood. A detailed investigation of the San Solomon Spring system may yield valuable insights to help hydrogeologists better understand groundwater flow in arid karst areas around the world.



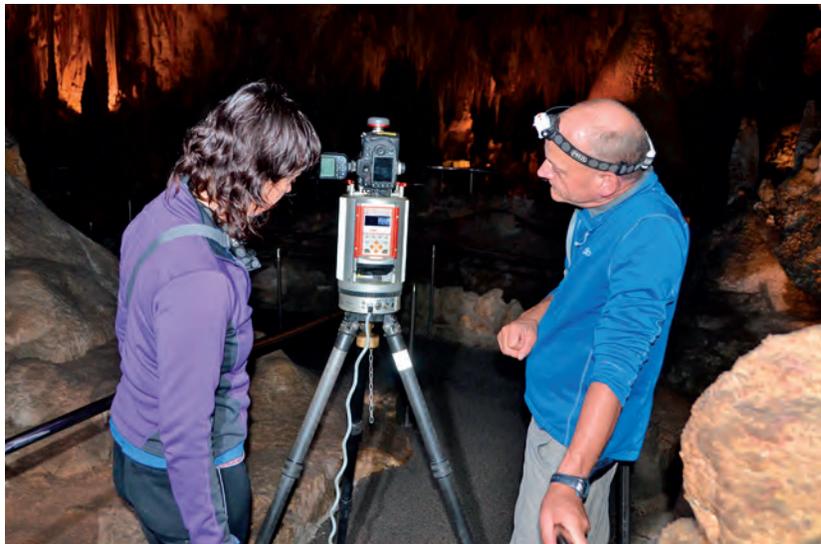
NCKRI photo by George Veni

Dr. Lewis Land examines East Sandia Spring, the fourth largest of the six-spring San Solomon Spring Group in Reeves County, Texas.

How Big is the Big Room?

Surveying caves has always been a challenge in the dark, and often wet and difficult conditions underground. Once surveyed, two figures have been fairly easy to compare: length and depth. Cave length is the summed length of all of its passages. Depth, better described as vertical extent, is the difference in elevation between a cave's highest and lowest points. But how "big" is a cave?

Volume has been the hardest figure to measure accurately. In many of the world's largest caves the ceiling isn't just too high to measure but even too high to see with most caving lights. Typically, ceiling heights were estimated, but so were many other dimensions of a cave as its shape was sketched by hand into a notebook. However, several years ago, technology has made it possible



NCKRI photo by George Veni
British cavers Jane and Tim Allen watch the LiDAR unit as it slowly turns, collecting data and taking photographs of each surveyed area in the Big Room.

for the even the largest caves to be surveyed precisely and in amazing detail.

LiDAR (Light Detection and Ranging) shoots pulsed laser beams at rates of up to 400,000 pulses per second. By measuring the angle of the beams and time of the reflection back to the LiDAR instrument, the locations of millions to billions of pinpoints on a surface can be displayed as a three-dimensional map of points called a "point cloud."

British cavers Andy Eavis, Tim Allen, and Richard Walters organized a project to use LiDAR to survey the world's largest chambers and determine

which is in fact the largest. The Big Room of Carlsbad Cavern, of New Mexico's Carlsbad Caverns National Park, was on their list to survey. NCKRI helped facilitate the project and assisted with the field work in September 2016.

It has been known for some time, that while large, the Big Room is not the world's largest room. However, it was by far the most complicated room to date for the team to survey. The irregular shape of the room and abundant and large speleothems (like the Giant Domes in the photo to the left) required that the LiDAR unit had to be set up for more than triple the number for scans needed for some much larger rooms. The survey was done mostly from the trail that follows the edge of the room.

Preliminary results from the scans indicate the Big Room has a volume of about 930,000 m³. Its unusual shape provoked some discussion of what exactly is a "room" and where the Big Room ended and giant-size passages began. The results of this and other scans will be released and evaluated during the 17th International Congress of Speleology in July 2017.



NCKRI photo by George Veni
Giant Domes, 20-m high stalagmites, are iconic features of the Big Room in Carlsbad Cavern. The pink and green colors resulted from different types of lighting, which are now replaced with uniform white LED lights under study by NCKRI (see page 18).

Karst Information Portal

The Karst Information Portal (www.karstportal.org) is a NCKRI project in partnership with the University of South Florida Libraries (USF), University of New Mexico, and the International Union of Speleology. It is designed to serve many functions, with its primary function at this time as a free, digital, open access, international library of all things cave and karst related. To better serve that and future functions, the Portal was launched on a new platform through the USF Libraries Digital Collections on 23 August 2016. The new platform offers the Portal a more effective library search capacity, as well as greater functionality on many levels.

In the 2016-2017 year, there were 259,183 downloads of the 3,877 records currently available through the Portal. This was the result of 93,579 unique visits to the Portal. Also during this period, 253 titles were added to the collection, encompassing over 1,500 pages of content. Many of these titles were from a backlog of items submitted in

the previous year, which provided an opportunity to cross-train USF staff on copyright clearance work (nothing is posted on the Portal without permission).

Posting reports and other materials to the Karst Information Portal is not a matter of a simple click-and-paste command. Hidden behind each posted item is a series of codes and commands designed to make the materials as easily discoverable as possible through the Portal's powerful search engine.

As part of this effort, this year the USF team members dual-registered the DOIs (Digital Object Identifiers, which make searching for publications easier and more effective) for the 2013 and 2015 Sinkhole Conferences. For the 2013 Sinkhole Conference, the proceedings volume as a whole was dual-registered so its individual papers can be registered to increase their discovery and use. The success of these efforts are reflected in the huge number of annual downloads.

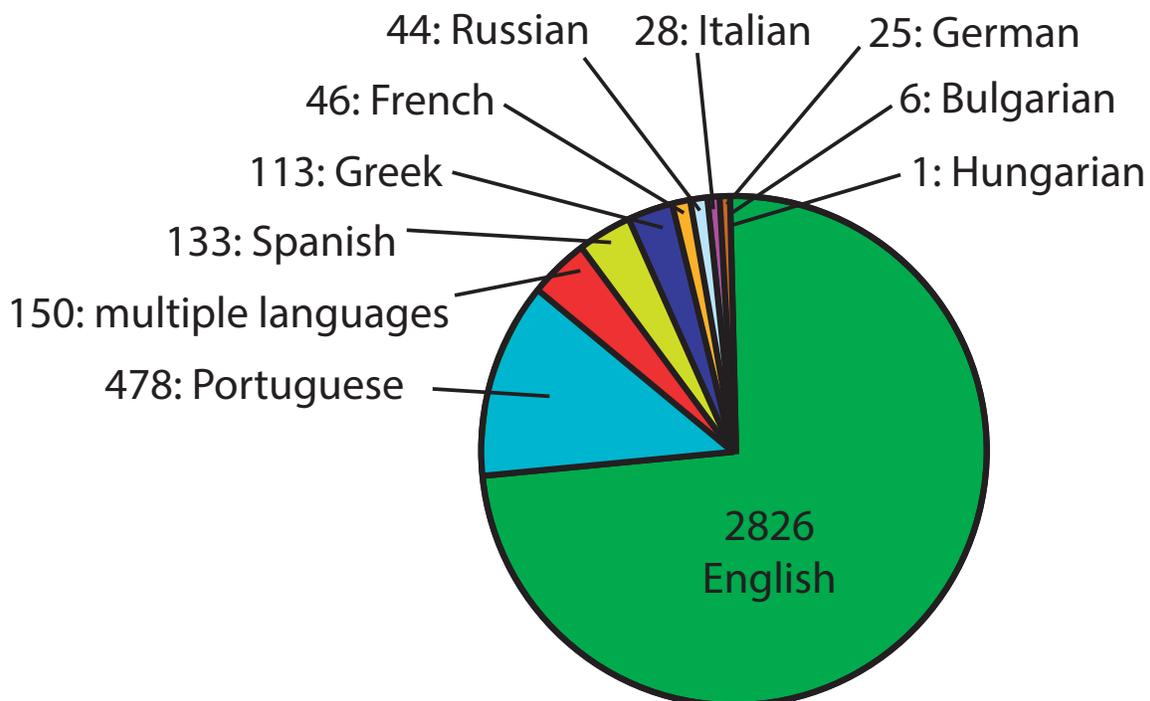
The materials on the Karst Information Portal cover a variety

of languages, as shown below in the pie chart below. The top 10 most accessed titles, which were downloaded between 249 and 346 times during the past year, are the:

- NCKRI annual reports;
- Proceedings of the 2015 Sinkhole Conference, which NCKRI manages;
- Proceedings of the DeepKarst 2016 Conference, which NCKRI organized in the Spring of 2016; and
- Seven Russian publications that until now have been difficult to find in Western libraries.

The plans for the upcoming year are to improve the Portal's statistics reporting, including pulling statistics from the previous platforms to evaluate long-term patterns of Portal use, and determining the geographic points of origin for usage. We will also now be able to more quickly process incoming materials submitted for inclusion on the Portal.

Any organization that wishes to make its publications freely and internationally accessible through the Portal is encouraged to contact us.



EDUCATION PROGRAM

NCKRI's Educational Programming this year has been diverse and supported through many partners and sponsors.

The City of Carlsbad, in partnership with NCKRI, was awarded a grant to support the design and construction of an experiential exhibit for our outdoor vertical classroom. This classroom will be used as a training site and practice area for people who use ropes and "vertical work" as a part of their job, as well as giving NCKRI visitors a practical learning experience on vertical caving techniques used by cave explorers and scientists. Visitors will also learn about the applied physics involved with these techniques. NCKRI held the initial design meeting to develop this exciting experience. Please check out NCKRI's Facebook page for updates on this exciting project.

Guano Loco Productions is working with NCKRI to produce a docudrama on the life story of Jim White, the cowboy who explored much of what is now known as Carlsbad Cavern, and his efforts that helped create Carlsbad Caverns National Park. Last year, NCKRI received a City of Carlsbad Lodgers Tax grant which funded Guano Loco's cross-country trip to interview people for the film. The team has been working on editing this material and conducting additional research to cross-reference the interviews for accuracy.

Guano Loco Productions and NCKRI together have leveraged \$984,220 in grants and in-kind donations for this project. Our team is currently seeking partners for support to film the recreation scenes of the docudrama. For updates on this project please visit our Facebook page, If you would like to support this project please visit <https://support.nckri.org/bylanternlight>

Public Outreach

NCKRI's Education Director, Dianne Joop, continued work this year to grow NCKRI's social media audience. Following NCKRI's social media launch for our film *By Lantern Light*, our audience reach grew to 12,000 people last summer. This growth gave us insight on how and when our audience tunes into NCKRI's Facebook page (<https://www.facebook.com/NCKRI/>), so we made a few adjustments, launched our first Facebook Live post (see the photo below), and saw tremendous growth in our audience, reaching 55,000 people this year! Thank you to all who "like" and "follow" us!

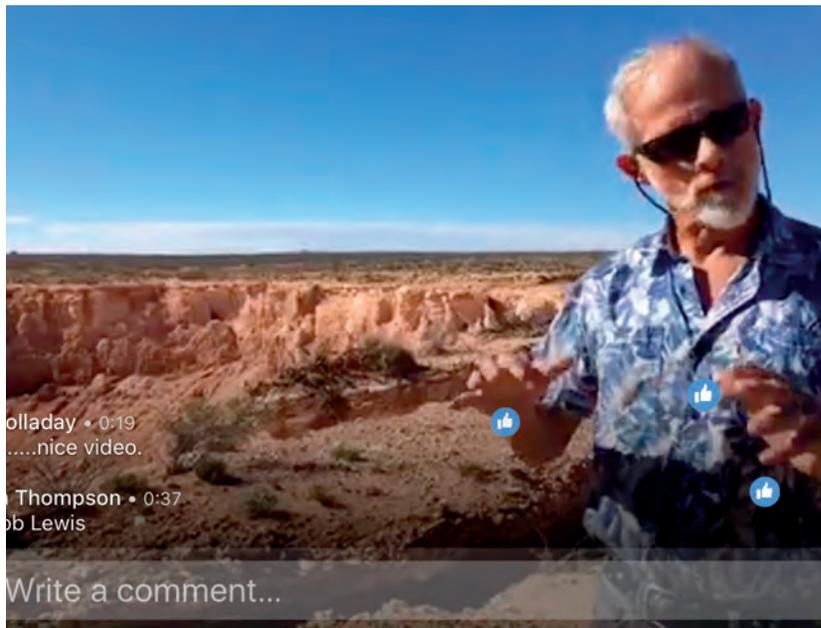
NCKRI partnered with Guadalupe Mountains National Park in sponsorship to the 25th Annual Christmas on the Pecos. Together, we worked to design and build a holiday exhibit along the Pecos River for viewing by the 15,000 attendees of this annual Carlsbad Chamber of Commerce event (see the photo

on the next page). We would like to thank NCKRI Volunteer Mark Joop and NPS Volunteer Neil LaBreek for devoting their time to help us make this happen!

Less visible but highly important work of NCKRI's Education Program involves working with other NCKRI programs and staff where educational opportunities may exist, either directly by hosting groups, like a Carlsbad Rotary Club meeting at NCKRI Headquarters and giving presentations, and indirectly by upgrading the appearance of our exhibit booth and other materials.

NCKRI's Education Director would like to express a huge thank you to all of the organizations and individuals that support NCKRI's Education Program activities. Your donations and time are directly valued, however your support and expertise is invaluable.

If you would like to support NCKRI's Education Program please visit www.support.nckri.org



NCKRI photo by Dianne Joop
NCKRI's first live feed was a social media hit when Dr. Lewis Land explained the origin of a giant sinkhole collapse.



Photo courtesy of Elizabeth Jackson

NCKRI partnered with Guadalupe Mountains National Park to sponsor and decorate a home for Carlsbad's 25th Annual Christmas on the Pecos.

to host a week-long workshop for land managers for National Environmental Protection Act training and Carlsbad Caverns National Park to conduct a series of mini-workshops for interpretation professionals for the Living Desert State Park's docents. Through this series, participants learned about the geologic history of the region, cave and karst geology, and bats.

Additional training was provided by Dr. Lewis Land, who led a group of environmental science students from New Mexico State University-Carlsbad on a field trip to Lake McMillan, an area significantly impacted by gypsum karst geohazards in the early 20th century.

Local Workshops

This year NCKRI's Education Program hosted and conducted different types of interpretive and educational workshops/programs. We are so excited to have held our first "themed" bat-birthday party (see photos below), in addition to hosting multiple school groups.

NCKRI's Education Director, Dianne Joop, in partnership with the National Park Service, worked with Guadalupe Mountains National Park



NCKRI photo by Courtney Gasow

NCKRI hosted its first bat-themed birthday party.



NCKRI photo by Courtney Gasow

The birthday-boy is happy with the bat he made.



NCKRI photo by Courtney Gasow

Dianne Joop teaches children at the birthday party about bats with many innovative and fun activities.

National Workshops

NCKRI continued its support for the Texas Hydro-Geo Workshop, organized by the Bexar Grotto of the National Speleological Society and the Edwards Aquifer Authority. Karst experts from around the country taught more than 30 modules, including NCKRI Board members and staff: Dr. Calvin Alexander (Tracer Testing in Karst), Dr. Ron Green (Developing Scientific and Field Notebooks), and Dr. George Veni (Cave Geology and Karst Feature Evaluation Using the TCEQ Forms). The third Texas Hydro-Geo workshop was held in September 2016, attended by over 300 students, and organized at Cave Without A Name by former NCKRI Board Vice President, Geary Schindel.

Dr. Lewis Land led field trips for students, interns, faculty, and alumni from out-of-state universities that included:

- Wheaton College, Illinois, on a trip up Dark Canyon through the backreef section and the Seven Rivers Embayment, and ending at the giant gypsum sinkholes at Bottomless Lakes State Park, New Mexico;
- Sul Ross University, Texas, to examine the geology and hydrogeology of New Mexico's southern Sacramento Mountains; and
- The University of Texas Permian Basin up Dark Canyon through the backreef section and the Seven Rivers Embayment, and ending at Sitting Bull Falls, where lower Guadalupian strata are exposed along with modern tufa deposits.

Dr. Veni also led a tour of Carlsbad Cavern for a team of archeologists from Texas.

International Workshops

Since 2008, China's International Research Center on Karst (IRCK) has conducted the annual International Karst Training Course in the city of Guilin. The IRCK generously

funds the participation of students and professionals from around the world, as well as lectures from an array of international experts. In November 2016, NCKRI was invited to teach a short course on The Impacts and Management of Climate Change on Karst Hydrology and Ecosystems. The IRCK also arranged for NCKRI to teach this short course at Southwest University, in the city Chongqing, which included a tour of some local karst and the World Heritage Wulong Karst (see photo below).

Adopt-A-Bat

Donations to NCKRI's Adopt-A-Bat program support maintenance and expansion of scientific monitoring of the bat roost at NCKRI Headquarters. To donate, please visit www.support.nckri.org.



NCKRI photo by George Veni
China's Tianlong ("Sky Dragon") Bridge in the Three Natural Bridges Gorge of the Wulong karst is an intact section of an enormous collapsed cave, and one of the tallest natural bridges in the world.

STUDENT ACTIVITIES

Cave and Karst Studies Program at NMT

Cave and Karst Studies at New Mexico Tech (NMT) is NCKRI's Academic Program. It has been taught through NMT's Earth and Environmental Sciences Department for many years, led by Dr. Penelope Boston in collaboration with other faculty. However, Dr. Boston accepted a research position with NASA, where we wish her the very best, and the Academic Program has slowed while we search for a new Academic Program Director. But slowed does not mean stopped.

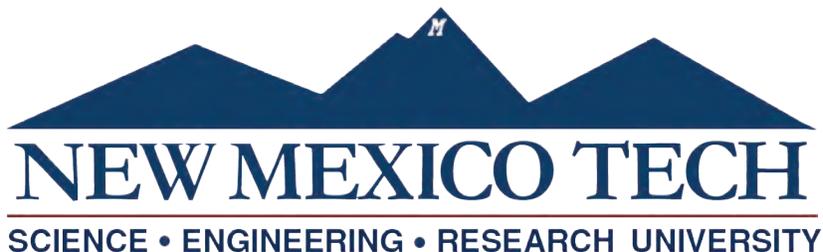
In June 2017, Katrina Koski completed her PhD research to receive her doctoral degree. Her dissertation focused on karst aquifer hyporheic zones, where water is stored in the fractures and pores. Her research examined the influence and interaction of groundwater in the hyporheic zone with major groundwater conduits. Dr. Lewis Land assisted Ms Koski in selecting a site and gaining permission for her field experiment.

Additionally, NCKRI has been delighted to support another outstanding student for the following important and novel project.

Lighting and Lampenflora in Carlsbad Cavern

Lighting in show caves has a troublesome side-effect: algae. This is the common term for the light-loving plant and microbial communities properly called "lampenflora." These green biofilms not only detract from the visitor experience of a cave, but biodegrade the crystalline speleothem surfaces. Over the past few decades, several investigations have studied lampenflora for clues to reduce it. NCKRI is now taking such research to a new level.

Carlsbad Caverns National Park



recently modernized its lighting in system from a combination of sodium halide, incandescent, and fluorescent lights to an entirely LED system, with the capacity for

Carlsbad Caverns.

The influence of LED color temperature (2700°K vs. 3500°K), substrate type (sediment, porous limestone, and dense limestone/cal-



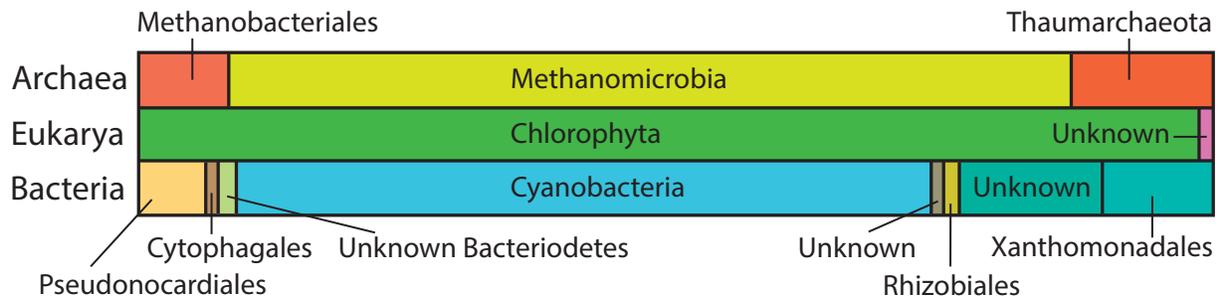
NCKRI photo by George Veni

New Mexico Tech graduate student and NCKRI scholar Zoë Havlena measures air flow and temperature at the base of the Giant Domes (see photo on page 13), one of the lampenflora study sites in Carlsbad Cavern.

adjusting the color temperature and intensity. To understand how such adjustments may reduce lampenflora, the park contracted NCKRI. Through our Academic Program and partnership with New Mexico Tech, we funded a Master's thesis study by graduate student Zoë Havlena with the New Mexico Tech Biology Department, along with her advisor Dr. Thomas Kieft. The study is conducted in close collaboration with Dr. George Veni at NCKRI and Rodney Horrocks, Cave Specialist at

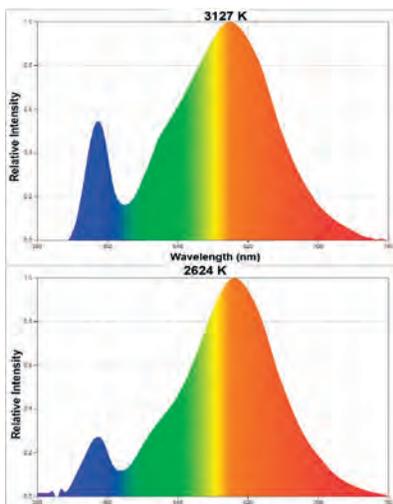
Carlsbad Caverns National Park (see photo on page 13), and light intensity (<100, 100-500, and >500 lux) on the growth of lampenflora are the primary factors examined. Lower color temperatures should be less conducive to growth since there is less intensity of light at wavelengths primarily used for photosynthesis.

The degree of detail examined by this investigation is unprecedented in lampenflora research. We are collecting a diverse set of high-precision data for a year that include: color temperature, light



Relative abundance of major microbial communities in one lampenflora sample from Carlsbad Cavern.

intensity, light spectra (see figure of two spectra below), air flow, air temperature (see photo on previous page), aerial grid measurements of growth, and microbial cultures (see photo below). Six general locations for all color temperature and substrate type combinations are under study throughout the cave’s Big Room, with four sites per location for the three levels of light intensity plus a site where no lampenflora is observed—a total of 24 monitored sites. Additionally, reflected light spectrophotometry, formerly limited to laboratories, is employed in the cave at each site to quantify the changes in photosynthetic cell density (see back cover photo).



Light distribution spectra at two experimental sites showing difference in intensity, particularly at the blue range, between the different color temperatures.

Currently, about the half of the year-long study is complete. Genetic analyses of the cultures is providing information on the composition of the microbial communities. DNA extraction and high-throughput amplicon sequencing of 16S and 18S rRNA genes for bacteria, archaea, and eukarya show a diversity of microbes, including phototrophs (cyanobacteria, Chlorophyta, and Chrysophyceae), as well as heterotrophic bacteria, fungi, and protozoa. The figure at the top of page illustrates the diversity found in only one sample.

This initial phase of the project focuses on monitoring and characterizing the growth of lampenflora. It will be complete by the end of 2017. The upcoming second phase of the study will

explore potential inhibitors or other methods that can be used to combat lampenflora growth. The results of the project will be published in Ms. Havlena’s Masters thesis and other scientific publications.



NCKRI photo by George Veni
A stalagmite is swabbed in Carlsbad Cavern for microbial analysis as part of the lampenflora study. The small papers are temporary photographic reference markers.

CONFERENCES AND MEETINGS

Rentals

It's been a great year at NCKRI for private event rentals. We've made great strides to introduce the community to our facility through private rental space. Week-long corporate meetings, graduation and "bat" birthday parties, baby showers, luncheons, training workshops, and holiday parties are some of the events which have driven traffic up at NCKRI Headquarters by as much as 350%. Monies collected through rentals are boosting our general fund to provide resources which will ultimately give our visitors a complete experience in learning about the importance of caves and karst.

We have also hosted our own private events throughout the year. We proudly entertained the Carlsbad Hoteliers Group meeting as well as a luncheon for the Carlsbad Rotary Club. The National Park Service National Environmental Protection Act training was facilitated at NCKRI. The Pecos Valley Grotto holds its monthly meeting at NCKRI, inviting the public to share in their caving experiences.

If you need meeting space in Carlsbad, contact NCKRI's Event Planner Courtney Gasow at 575-628-2702 to learn about availability and all of our space and set-up options, a couple of which are shown in the photos on this page.



NCKRI photo by Courtney Gasow
Table decorations for a party rental.



NCKRI photo by Courtney Gasow
Decorative table arrangement for a holiday party.

San Antonio Stakeholders Dinner

Our spring Board meeting took us to San Antonio, Texas, this year. Natural Bridge Caverns generously gave us meeting space, but also provided an iconic scenic backdrop to meet and greet cave and karst stakeholders from central Texas. Along with their wonderful facilities and congenial staff, Natural Bridge was a perfect location for the event.

After the NCKRI board meeting, board members toured the caverns and then welcomed our guests at a cocktail party held in the lovely sinkhole entrance to the cave. Many guests joined a NCKRI-led tour of part of the cave where they learned about the benefits and challenges of living in karst.

From corporate executives, political ambassadors, and government officials to representatives of some

of the most prominent show caves in the state, diversity was the theme of the night, but a mutual interest in caves and karst was the focus. The attendees' provided a wonderful example of those within our small community who have a shared interest in the preservation and education of these unique landscapes.

The party moved from drinks in the sinkhole to dinner in the nearby pavilion. Our outgoing chairman, Dr. Bob Brinkmann, was presented with an award honoring him for all of his accomplishments as head of the board. Dr. Ronald Green, voted in as our new president earlier in the day, graciously thanked all board members, as well as outlining some of his personal goals for NCKRI in the upcoming year. It was a wonderful and informative evening allowing NCKRI to make new acquaintances and rekindle old

relationships, which are so important to our Institute.

Many thanks, to Natural Bridge Caverns and the San Antonio River Authority for their generous sponsorships.



Stakeholders' Dinner under the pavilion (left) and cocktail party in the Natural Bridge Caverns entrance sinkhole (right).

NCKRI photos by Courtney Gasow

Southwestern Region Winter Technical Meeting

About every three years, the Southwestern Region of the National Speleological Society rotates its Winter Technical Meeting to Carlsbad and NCKRI was pleased to host it for the second time in December 2016.

About 70 cave explorers, managers and scientists from Arizona, New Mexico, and Texas converged for the Region's business meeting and then, switching to conference mode, to exchange information and ideas on their latest exciting discoveries. Breaking tradition, the next "Winter Tech" meeting in December 2017 will be in Carlsbad, and we'll be happy to welcome everyone back.



15th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of 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.

The next Sinkhole Conference will be held on April 2-6, 2018 in Shepherdstown, West Virginia. NCKRI is partnering with the Karst Waters Institute to host the meeting, which will include the 3rd Appalachian Karst Symposium in addition to field trips, short courses, and more to make for an exciting event.

Watch the conference website for news and updates: <http://www.sinkholeconference.com/>



NCKRI photo by George Veni

Stormwater injection wells in sinkholes are common in West Virginia where the 15th Sinkhole Conference will be held. The conference is the best opportunity to discuss how to reduce sinkhole flooding while minimizing sinkhole collapse and groundwater contamination, among other important topics.

OUTREACH

Professional Partnerships

NCKRI is pleased to announce that Guadalupe Mountains and Carlsbad Caverns National Parks chose NCKRI Headquarters as their City of Carlsbad visitor center. This agreement creates opportunities for new educational and other collaboration, leveraging the broader partnership NCKRI already has with the National Parks Service. The upcoming year should prove very exciting and we look forward to welcoming these two magnificent national parks to our facility.

In 2013, NCKRI signed a Memorandum of Understanding with the International Research Center on Karst (IRCK), the international branch of China's Institute of Karst Geology, to promote and facilitate collaboration between our programs. In November 2016 we continued this collaboration when NCKRI was invited to attend the launching of a major research initiative, the IRCK's Academic Committee meeting (of which NCKRI is a member), and to investigate some field sites to exchange ideas and for potential collaboration (see the photo below).

Over the past year, NCKRI has also initiated or followed up on meeting with several agencies and organizations to increase cave and karst awareness and explore potential joint projects. Those groups include the American Geosciences Institute, American Water Works Association, Association of State Drinking Water Administrators, Bat Conservation International, National Association of County and City Health Officials, Petroleum Recovery Research Center, Solution Mining Research Institute, Texas Parks and Wildlife Department, the University of Texas at San Antonio, US Environmental Protection Agency, US Fish and Wildlife Service, and the US Geological Survey.

Professional Meetings

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

- 2016 National Speleological Society Convention; Ely, Nevada, USA
- 2017 National Speleological Society Convention; Rio Rancho, New Mexico, USA
- European Speleological Congress; Dalesbridge, Yorkshire, UK
- Explorers Club Annual Dinner; New York City, New York, USA
- Geological Society of America Convention; Denver, Colorado, USA
- Karst Record Conference VIII; Austin, Texas, USA
- Mayors' Energy Summit; Carlsbad, New Mexico, USA
- National Association for Interpretation National Workshop, Corpus Christi, Texas, USA
- New Mexico Brackish Water Working Group Meeting, Socorro, New Mexico, USA
- Paving and Transportation Conference, Albuquerque, New Mexico, USA

- US Geological Survey Karst Interest Group Workshop; San Antonio, Texas, USA
- NCKRI staff also organized or co-organized the following events:

All staff:

- Are working on the 15th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst, to be held in Shepherdstown, West Virginia, USA, in April 2018.

Dr. George Veni:

- Panel discussion moderator: Best Practices in Speleothem Science. Climate Change: The Karst Record 8th International Conference, Austin, Texas, USA, 2017.
- Advisor, 17th International Congress of Speleology, Sydney, Australia, 2017.
- Field trip co-leader, USGS Karst Interest Group Workshop, San Antonio, Texas, 2017.

Guest Lectures by NCKRI

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

- By Lantern Light: A Preview.



NCKRI photo by George Veni
Professor Lei Mingtang uses a rangefinder to measure 185 m across China's biggest cover collapse sinkhole. The far end of the sinkhole extends far out of the photo, but notice the large water tank slowly sliding down toward the bottom.

Carlsbad Rotary Club, Carlsbad, New Mexico.

- Caving Where We Shouldn't: Mount Emory Cave, Big Bend National Park, Texas. Bexar Grotto, San Antonio, Texas.
- Hydrogeologic Review of Upper Cibolo Creek, Bexar, Comal, and Kendall Counties, Texas. Seminar for the San Antonio River Authority, San Antonio, Texas.
- I&W Brine Cavity: Evaluation of the Probable Extent and Impacts of its Collapse. Bexar Grotto, San Antonio, Texas.
- Origin, Status, and Prospects for the I&W Brine Well Cavity. Community Focus, Carlsbad, New Mexico.
- Sinkholes in the Permian Basin Region of West Texas and Southeastern New Mexico: Analysis of the Economic Impact of the I&W Brine Well. Carlsbad Republican Women's Club, Carlsbad, New Mexico.
- The Alpine High Play and the San Solomon Spring Group: Can Oil and Water Mix? Society of Petroleum Engineers, Midland Chapter, Midland, Texas, and Save Our Springs Too and Big Bend Conservation Alliance, Balmorhea, Texas.
- The National Cave and Karst Research Institute and The New Mexico Bureau of Geology and Mineral Resources: A Unique Collaboration Between State and Federal Agencies. Sertoma Club, Roswell, New Mexico.

Co-Sponsored Speakers

NCKRI co-sponsors the Edwards Aquifer Authority's Distinguished Lecture Series in San Antonio, Texas. In September 2016, Dr. Maureen Muldoon of the University of Wisconsin-Oshkosh gave the distinguished lecture on *Fractures—They Mess up Your Flow System (and They Are Everywhere)*. She was followed in May 2017 by *Who done it? Investigative Insights*

and *Answers to Three Groundwater Mysteries*, presented by Dr. E. Scott Bair of Ohio State University.

International Outreach

NCKRI is an Affiliated Organization of the International Union of Speleology (UIS) where Dr. Veni is the Vice President of Administration. During the past year, the UIS has worked diligently to have 2021 designated as the International Year of Caves and Karst by the United Nations Educational, Scientific, and Cultural Organization (UNESCO). International Years are global events that advance public education and support for research. At the time of this writing, four countries formally support the proposal, as do many international and national organizations. NCKRI is supporting this effort and working to gain other organizational and national support.

The major need to make the International Year of Caves and Karst a reality is a country to propose it. While UIS has written the proposal, only a UNESCO member country can present the proposal for voting. If approved, the International Year will be a huge opportunity to promote cave and karst research, management, and public education worldwide.

National Outreach

- NCKRI has a position on the Steering Committee for the National Cave and Karst Management Symposium, which is held every two years. The next meeting will be in Eureka Springs, Arkansas, in October 2017.
- NCKRI is an organizational member of the US Fish and Wildlife Service's White-nose Syndrome Stakeholder Committee.
- NCKRI's expertise was called upon by the City of Fair Oaks, Texas, to advise on the management of a newly opened cave.
- Dr. George Veni continued his second three-year term, appoint-

ed 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 collect and analyze 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.
- Dr. Veni also serves as an advisor to the Karst Division of the Geological Society of America Karst Division.

Community Outreach

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 photo by George Veni
NCKRI assisted the City of Fair Oaks, Texas, in the management of a sinkhole that opened in a creek bed and led to a hydrologically important cave.

NCKRI staff:

- Participated in the Carlsbad Chamber of Commerce's annual Bat Brigade. This delegation of community leaders visits the leaders of New Mexico government at the state capitol 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, Education, and Tourism Committees, and participated in related activities supporting new businesses and community leaders.
- Regularly attended Carlsbad Department of Development board meetings.
- Participated in the Pecos River Water Users Organization meetings.
- Attended the meetings of the New Mexico Association of Museums Southeast Region and Creative Carlsbad.
- Evaluated a potential sinkhole for the City of Roswell and advised them on further research and remediation needs.

NCKRI's most notable support for the local community has involved a brine well cavity on the south side of the City of Carlsbad. In 2008-2009, three brine well cavities collapsed in southeast New Mexico and west Texas creating sinkholes over 100 m in diameter and 40 m deep (see NCKRI's 2008-2009 and 2009-2010 Annual Reports). The cavities were formed by injecting fresh water into deep salt beds to dissolve the salt, and pump out the resulting brine for oil field drilling. Another brine well was soon identified on the south side of Carlsbad near the intersection of two highways, an irrigation canal, the railroad, and several businesses and homes. It was determined as unstable and its operations closed by

the state. See NCKRI's 2010-2011 Annual Report and *Report of Investigation 2* on the electrical resistivity survey we conducted of the cavity (NCKRI publications can be downloaded at http://nckri.org/about_nckri/nckri_publications.htm).

During the past year, NCKRI has worked with emergency personnel, educated the public about the situation through lectures, meetings, and interviews, and supported legislation through testimony to the New Mexico legislature to create a Brine Well Authority. That governmental body will engineer a solution to fill the cavity so that it never collapses. The Authority will be established on July 1, 2017, during NCKRI's next reporting year.

Media

- Apache Hires US Cave Institute to Study Water in West Texas' Alpine High Oil Field. David Hunn, Fuel Fix, May 2016. <http://fuelfix.com/blog/2017/05/26/apache-corp-hires-u-s-cave-institute-to-study-water-in-west-texas-alpine-high-oil-field/>
- Brine Well Bills are On the Move. Adrien Hedden, Carlsbad

Current-Argus, February 2017. <http://www.currentargus.com/story/news/2017/02/08/house-vote-brine-well-bills/97647436/>

- Effort Underway to Stop Cavern Collapse in Carlsbad. Morgan Lee, The Associated Press, Santa Fe New Mexican, March 2017. http://m.santafenewmexican.com/news/local_news/effort-underway-to-stop-cavern-collapse-in-carlsbad/article_0b2bc4ad-df08-5f8e-ad3d-519f749f1a2d.html?mode=jqm
- 500 Million Years Later, Sink Holes Still a Problem in King of Prussia. Philadelphia Inquirer, July 2016. http://www.philly.com/philly/news/20160726_500_million_years_later_sinking_in_King_of_Prussia.html
- Guadalupe Mountains: A Unique Geoheritage Site in New Mexico. KUNM Public Radio Earth Science Week interview with Dr. Lewis Land.
- Huge Sinkholes are Now Appearing in the Wrong Places. Roger Schneider, The Associated Press, The Washington Post, May 2017. <https://www.washingtonpost.com/national/>



NCKRI photo by George Veni
Emergency planners (upper left) look into the 2008 JWS Sinkhole for a preview of what a brine well collapse in Carlsbad will look like if not prevented.

health-science/huge-sinkholes-are-now-appearing-in-the-wrong-places/2017/05/08/b807bcce-3415-11e7-ab03-aa29f656f13e_story.html?utm_term=.9b1e31aed52e

- Interview on Alpine High oil field and its impact on the San Solomon Springs; West Texas Talk, Marfa Public Radio, Marfa, Texas, September 2016, <http://marfapublicradio.org/do/>
- Interview on I&W brine well cavity. KOBR Eyewitness News, Roswell, New Mexico, February 2017. <http://www.kob.com/new-mexico-news/brine-well-could-cause-massive-sinkhole-carlsbad-george-ven-national-cave-karst-research-institute/4396125/?cat=500>
- Lawmakers Consider Bills to Address Massive Carlsbad Sinkhole. Rebecca Moss, The New Mexican, Santa Fe, January 2017. http://www.santafenew-mexican.com/news/legislature/lawmakers-consider-bills-to-address-massive-carlsbad-sinkhole/article_2aac4e4-0e7a-5dce-9666-27f893acb169.html
- Mosaic Disputes Discharge Concerns. Maddy Hayden, Carlsbad Current-Argus, February 2017. <http://www.currentargus.com/story/news/local/2017/02/17/mosaic-permit-renewal-raises-concerns/96250490/>
- Texas Parks Department Admits it Never Studied Impact of Oil Drilling on Balmorhea Springs. David Hunn, Houston Chronicle, FuelFix, October 2016. <http://fuelfix.com/blog/2016/10/10/texas-parks-department-admits-it-never-studied-impact-of-oil-drilling-on-balmorhea-springs/>
- Will Water and Oil Mix in Balmorhea? David Hunn, Houston Chronicle, September 2016. <http://www.houstonchronicle.com/business/article/Apache-s-oil-discovery-divides-small-town-9241540.php?t=1064b178d5438d9cbb&cmid=twitter-premium>

BOARD OF DIRECTORS

Chairman's Report Dr. Robert Brinkmann



Dr. Robert Brinkmann,
Chairman of the Board

As I complete my last term as Board Chair, I want to thank all of the stakeholders of the National Cave and Karst Research Institute for their support. The last several years moved fast and were eventful. We have completed our beautiful building and developed new programs and events in it. We have conducted research and hosted conferences on a variety of important cave and karst topics. We have produced educational materials and have served as a national resource on cave and karst information.

We have also expanded our national mission. Bucking tradition, the board met in several different cities during my term to promote greater national outreach. We met in the Explorer's Club in New York City and were hosted by Natural Bridge Caverns in San Antonio, Texas. We also met in Denver and Vancouver.

Since I first got involved with NCKRI, the board has also changed considerably. We now have a board that is more diverse in background and interests. It includes not only cave and karst experts, but also

policy makers, representatives from the business community, and local stakeholders. This change has allowed us to expand our influence in interesting ways.

Over the last several years, the board has done much more outreach in Washington D.C., in states, and local communities to advance our mission. We have friends throughout the country in positions of authority who are familiar with NCKRI and who want to help us achieve our goals.

The new Board Chair, Ron Green, has been active with NCKRI for many years. He is a nationally known karst hydrologist and he has been part of the board team that focused on national outreach over the last several years. He will be a fantastic chair and I am very pleased to leave my post in such able hands.

Board Members

- Dr. Robert Brinkmann, Chairman
 - Dr. Ronald T. Green, Vice Chairman
 - Carlos Romero, Secretary/Treasurer
 - Dave Steensen, National Park Service Representative
 - Jason Shirley, City of Carlsbad Representative
 - Jack Swickard, Member at Large
 - Dr. E. Calvin Alexander, Jr.
 - Dr. Hazel Barton
 - Richard Cervantes
 - Eddie David
 - Tom Edwards
 - Dave Lester
 - Lisa Montelione
 - Dale Pate
 - John Scheltens
 - Dave Weary
- New board members elected at the end of this reporting year are:
- Dr. Lisa Goggin
 - Gary Hartwick
 - Dr. Johanna Kovarik

NCKRI STAFF



Photo courtesy of Binford Creative

From left to right: Dr. Lewis Land, Courtney Gasow, Dr. George Veni, Dianne Joop, and Loren Darby.

Dr. George Veni, Executive Director

Dr. Veni is an internationally recognized hydrogeologist specializing in caves and karst terrains. Prior to NCKRI, he owned and served as principal investigator of George Veni and Associates for more than 20 years. Much of his work has been in Texas, but he has also conducted extensive karst research throughout the United States and in several other countries. He served as the Executive Secretary of the National Speleological Society's Section of Cave Geology and Geography for 11 years and President of the Texas Speleological Survey for 13 years. He was the Chairman of the 15th International Congress of Speleology, a member of the governing board of the International Union of Speleology from 2002-2009, and the Union's Vice President of Administration

from 2009 to the present. He has served as a doctoral committee advisor for geological, geographical, and biological dissertations for multiple universities and taught karst geoscience courses as an adjunct professor for Western Kentucky University for 12 years. Three cave-dwelling species have been named in his honor. He has published and presented over 220 papers, including four books, on hydrogeology, biology, and environmental management in karst terrains.

Ms. Dianne Joop, Education Director

Ms. Dianne Joop is an experienced educator in formal and informal techniques, with her focus on caves, karst, science, and math. Before transitioning into education, she spent nearly a decade in theatrical and television production experience with Kentucky Edu-

cational Television, the state of Florida, Discovery Channel, among others. In 2001, Ms. Joop stepped on a submerged can in an underground stream and took a nasty fall, and declared at that moment to make a difference in the world's understanding of caves as important and vulnerable resources. She began teaching in a private school while working on her M.A. in science and history education at Union College. She joined the National Speleological Society (NSS) and began assisting with and developing cave education programs. In 2006, Ms. Joop held an internship with the National Association of Geoscience Teachers pilot Geoscience Teacher in the Park program at Mammoth Cave National Park. In her spare time, while teaching science, math and theater full time for public and private schools, she assisted with

cave and karst education programs and workshops with Union College Outdoors, the American Cave Conservation Association, and Western Kentucky University. Ms Joop is also a Certified Interpretive Trainer and Certified Interpretive Guide.

**Dr. Lewis Land,
Karst Hydrogeologist**

Dr. Land focuses his research on regional investigations of karstic aquifers and associated phenomena in southern New Mexico. He is NCKRI's lead geophysical investigator. Prior to his career as a hydrogeologist, he 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. His doctoral research included submersible investigations of submarine sinkholes in the Straits of Florida. Before coming to work for the New Mexico Bureau of Geology and Mineral Resources in 2002, from which he transitioned over to NCKRI, Dr. Land spent two years with the North Carolina Division of Water Resources conducting geophysical surveys of aquifers beneath the coastal plain of North Carolina. He has served on several graduate student committees at New Mexico Tech, and is an adjunct faculty member in the NMT Department of Earth and Environmental Sciences. He is a Past-President of the New Mexico Geological Society (NMGS), and served for five years on the NMGS Executive Committee.

**Ms. Courtney Gasow,
Event Planner**

Ms. Gasow joined NCKRI in April of 2016 as its first 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 Hous-

ton, 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, UK, studying British history for two years and also attended University of Houston-Downtown with a focus on psychology. She is currently finishing a degree in Sociology/Psychology.

**Loren Darby,
Office Manager**

Loren Darby joined NCKRI as the Office Manager in September of 2016. She supervises and performs financial, administrative, and managerial work to support NCKRI's programs. Loren grew up in Carlsbad where she attended high school and college. She started her 20-year career in banking at Carlsbad National Bank while in high school participating in the Business Professionals of America program. In 1997, she moved to Grants, New Mexico, and started working at The First Bank of Grants which within one year became Wells Fargo Bank. During her 17 years at Wells Fargo she furthered her career in banking, moving up the ranks and became a Service Manag-

er, a position she held for 15 years. While at Wells Fargo she was selected to participate in The Potential Leaders Program, which not only gave her the opportunity to attend a lot of valuable training but to also learn a lot about herself. In the spring of 2014, Loren was offered a position with the State of New Mexico Department of Transportation as a Financial Specialist. She has received numerous awards for her excellent performance throughout her career. Loren has been very active in the community in Grants, New Mexico, where she chaired the American Cancer Society's Relay for Life for 15 years. In 2014 she was invited to Phoenix, Arizona to attend the American Cancer Society's Leadership Summit. Loren has also been a 4-H parent leader for the past eight years. She chaperons and participates with the kids as often as possible and served on the Cooperative Extension Advisory Committee.



NCKRI photo by George Veni
Loren Darby holds her 40 Under 40 Award, recognizing her as one of the outstanding young leaders in Carlsbad.

STAFF EDUCATION AND PUBLICATIONS

Continuing Education

NCKRI staff polish and expand their skills whenever possible.

Formal training attended by staff members in the past year includes:

- Who Done It? Investigative Insights and Answers to Three Groundwater Mysteries. Dr. Scott Bair, Distinguished Lecture Series, Edwards Aquifer Authority.
- Blackbaud Raisers Edge Training.
- InDesign training modules.
- Photoshop training modules.
- Lightroom training modules.

Conference Proceedings Papers

- Veni, G. 2017. Field trip stop 1: Genesis Cave. In: Field Trip Guide Book of USGS Karst Interest Group Workshop, 2017: The Multiple Facets of Karst Research Within the Edwards and Trinity Aquifers, South-Central Texas, In: US Geological Survey Karst Interest Group Proceedings, San Antonio, Texas, May 16-18, 2017, Scientific Investigation Report 2017-5023, pp. 207-211.
- Veni, G. 2017. Karst science: a national and international review and status report. Keynote address, In: US Geological Survey Karst Interest Group Proceedings, San Antonio, Texas, May 16-18, 2017, Scientific Investigation Report 2017-5023, pp. 8-10.
- Veni, G. and Green, R. 2017. Field trip stop 2: Bracken Bat Cave. In: Field Trip Guide Book

of USGS Karst Interest Group Workshop, 2017: The Multiple Facets of Karst Research Within the Edwards and Trinity Aquifers, South-Central Texas, In: US Geological Survey Karst Interest Group Proceedings, San Antonio, Texas, May 16-18, 2017, Scientific Investigation Report 2017-5023, pp. 230-239.

Journal Papers

- Chen, Z., Auler, A.S., Bakalowicz, M., Drew, D., Griger, F., Hartmann, J., Jiang, G., Moosdorf, N., Richt, A., Stevanovic, Z., Veni, G., and Goldscheider, N. 2017. The World Karst Aquifer Mapping project: concept, mapping procedure and map of Europe. *Hydrogeology Journal*, DOI 10.1007/s10040-016-1519-3, 15 p.

Unrefereed Papers

- Havlena, Z., Kieft, T., Veni, G., and Horrocks R. 2017. Lighting and substrate effects on lampenflora microbial communities in Carlsbad Cavern. In: 2017 National Speleological Society Convention Program, Rio Rancho, New Mexico, p. 44.
- Land L. 2016. Using brackish water from karstic aquifers to augment freshwater resources in the semi-arid southwest. GSA annual meeting, Denver, CO, Abstracts with programs; (reprinted) Southwest Region Winter Technical Meeting, Carlsbad, New Mex-

ico, *Southwestern Caver*, 2016, 54(6): 50.

- Land L. 2017. Geophysical surveys of a potentially extensive cave system underlying BLM and National Park Service units, Guadalupe Mountains, New Mexico. Symposium on the application of geophysics to engineering and environmental problems (SAGEEP), Denver, CO, Abstracts with programs.
- Veni, G. 2016. Caving where we shouldn't: Mount Emory Cave, Big Bend National Park, Texas. In: National Speleological Society Convention Program Guide, Ely, Nevada, pp. 101; (reprinted) National Speleological Society Southwest Region Winter Technical Meeting, Carlsbad, New Mexico, *Southwestern Caver*, 2016, 54(6): 49.
- Veni, G. 2016. The future of cave exploration and its contributions to cave science. In: National Speleological Society Convention Program Guide, Ely, Nevada, p. 84.
- Veni, G. 2016. World's first geophysical survey of bat guano. In: EuroSpeleo, 5th European Congress of Speleology, Congress Guide, Yorkshire, United Kingdom, p. 38.
- Veni G. 2017. An introduction to the National Cave and Karst Research Institute. In: Red or Green 2017, 74th Annual NSS Convention Guidebook, Rio Rancho, New Mexico, p. 43-44.



2016-2017 STATE AND FEDERAL BUDGET

Unaudited reports ending June 30, 2017

FUNDS REPORT			
	National Park Service	Administered by New Mexico Tech	Combined
Beginning Fund Balance	\$0	\$240,692	\$240,692
Revenues			
State Appropriation	\$0	\$359,005	\$359,005
Federal Appropriation	\$298,418	\$0	\$298,418
Total Revenue and Fund Balances	\$298,418	\$599,697	\$898,115
Expenses			
Personnel			
Staff Salries & Student Wages	\$193,859	\$122,170	\$316,029
Fringe Benefits	\$70,316	\$46,474	\$116,790
Total personnel	\$264,175	\$168,644	\$432,819
Operating			
Rent, Utilities, Telephone	\$12,138	\$50,578	\$62,716
Supplies & Other	\$0	\$32,655	\$32,655
Exhibit Design	\$0	\$0	\$0
Travel	\$0	\$21,891	\$21,891
Contractor Services	\$0	\$14,959	\$14,959
Property & Equipment	\$0	\$0	\$0
NMT Administative Support	\$0	\$20,000	\$20,000
NMT F&A Costs from NPS Budget (8%)	\$22,105	\$0	\$22,105
NPS Overhead Costs to GRD on NPS Appropriation (6%)	\$0	\$0	\$0
Tranfers	\$0	\$0	\$0
Total Operating	\$34,243	\$140,083	\$174,326
Total Funds Expended	\$298,418	\$308,727	\$607,145
Gain/(Loss)	\$0	\$50,278	\$50,278
Ending Balance	\$0	\$0	\$290,970

2016-2017 CORPORATE BUDGET

NCKRI Inc. **Unaudited** Annual Statement of Activities and Changes in Net Assets
For the Year Ending June 30, 2017
Administered by NCKRI

Public support and services:		Functional expenses	
Unrestricted Contributions	\$3,891.17	Contract	\$5,867.01
Conferences	\$0.00	Conferences	\$935.00
Program	\$120.00	Program	\$4,799.50
Rent and Lease	\$10,230.00	Operations	\$7,072.93
Education	\$40.00	Travel	\$11,332.75
Supplies	\$0.00	Supplies	\$26,131.04
Other	\$4.65	Other	\$447.82
TOTAL PUBLIC SUPPORT AND REVENUE	\$14,285.82	TOTAL PROGRAM EXPENSES	\$50,719.04
End of year balance			\$63,678.69



National Cave and Karst Research Institute

400-1 Cascades Avenue
Carlsbad NM 88220 USA