National Cave and Karst Research Institute

2017 - 2018

ANNUAL REPORT

www.nckri.org

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Cover photo

Nettle Cave, part of Australia's Jenolan Caves System, was one of the featured field trip sites visited during the 17th International Congress of Speleology in 2017. NCKRI participates in these important congresses that occur only once every four years. NCKRI photo by George Veni.

Back Cover Photo

The Mammoth Site in Hot Springs, South Dakota, is an ancient sediment-filled sinkhole with an amazingly rich concentration of mammoth bones. The site is excavated actively and open to the public. NCKRI and Mammoth Site staff met this year to discuss potential collaborations of this fascinating karst feature. NCKRI photo by George Veni.

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 (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, 2017 to June 30, 2018. Digital copies of this and previous reports are available for free at www.nckri.org

NCKRI is a proud institute of:

NEW MEXICO TECH
SCIENCE • ENGINEERING • RESEARCH UNIVERSITY

EXECUTIVE DIRECTOR'S REPORT

I spent part of March 2018 in Washington, DC, where I took the photo below of the Jefferson Memorial. It was a lovely day, with the cherry blossoms just starting to bloom—matching my hopeful mood about NCKRI's future.

About 10 years ago our country entered a deep economic recession. I had been working at NCKRI for only a year and was looking for an increase in funds to grow our Institute, but the timing was terrible. Everyone was cutting budgets, not increasing them.

Over the years, I've visited DC periodically to keep our congressional leaders and federal agencies aware of the importance of caves and karst, and NCKRI's value to them. But this year my hopes were higher. New Mexico Senator Tom Udall, supported by New Mexico Senator Martin Heinrich, was pushing to increase NCKRI's federal funding. A few weeks later my cheery outlook was fulfilled as a $500,000 increase in our annual federal appropriation was approved!

On behalf of NCKRI's Board of Directors and its staff, our deepest appreciation goes to Senator Udall for leading this effort. We also thank Senator Heinrich, whose staff provided us invaluable legislative guidance, and the many members of the Senate's Interior Appropriations Subcommittee for their approval of this increase.

Such boons don't happen in isolation. The support of the New Mexico Institute of Mining and Technology was critical. The directors of 20 state geological surveys signed onto a letter to the Senate Subcommittee, stating the national importance of caves and karst and NCKRI's importance to their study and management. Far too many people to mention in this limited space also worked behind-the-scenes for this success. We thank them all.

It is also crucial to stress that this advancement would not have been possible without the assistance, cooperation, and partnerships of many individuals and organizations who have worked with NCKRI and boosted us during the past lean years. We would not have reached this point without you.

So what's next? During our next fiscal year we will hire more staff to grow NCKRI programs, dedicate extra money toward those programs, and develop a student research grant program as a long-term investment in expanding cave and karst science nationally. Look for how NCKRI has grown in next year's Annual Report!

George Veni, Ph.D.

NCKRI RESEARCH

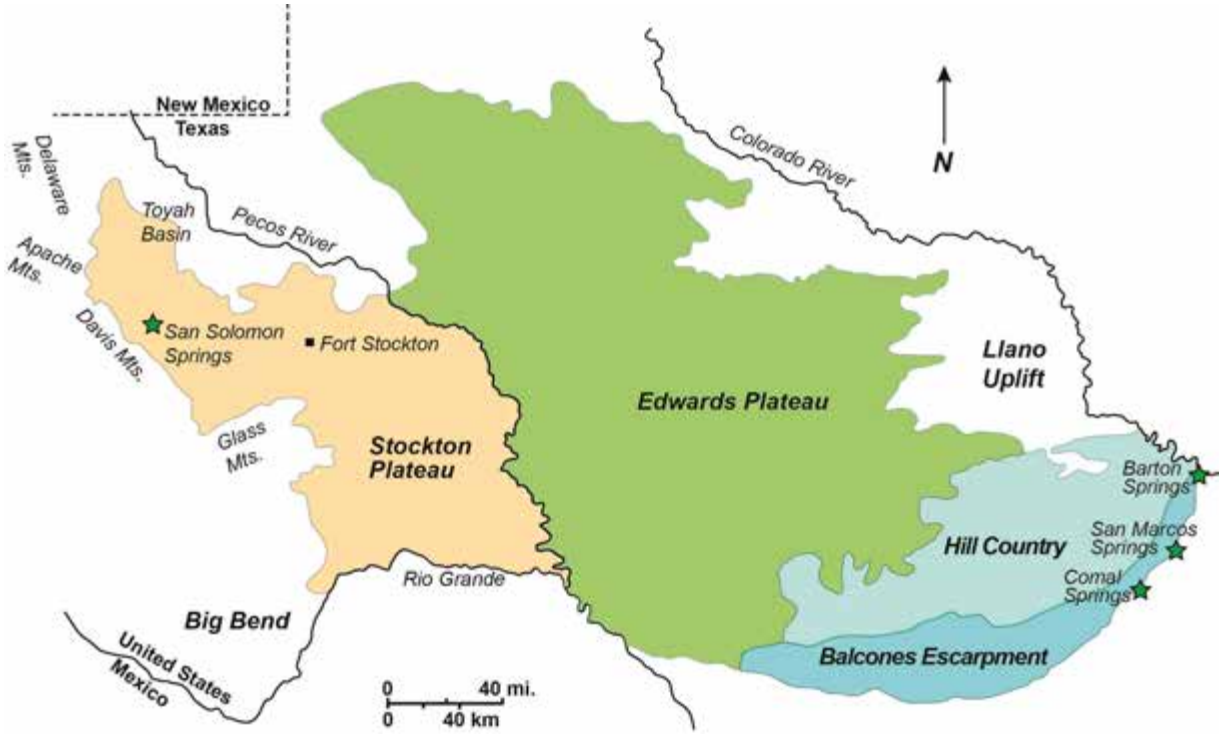
Oil and Water: Phase 1 Study of the San Solomon Springs

The San Solomon Spring Group is a series of karst springs that discharge groundwater from Cretaceous limestones along the northeast flank of the Davis Mountains in West Texas. The springs and related groundwater provide water resources for much of the agricultural activity in the area, as well as the municipal water supply for the town of Balmorhea, Texas. The main San Solomon Spring is the centerpiece of Balmorhea State Park, another important component of the local economy. The springs also provide habitat for several federally listed endangered species, including the Comanche Springs pupfish (*Cyprinodon elegans*) and Pecos gambusia (*Gambusia nobilis*).

In September 2016, the Apache Corporation announced the discovery of major oil and natural gas deposits in the area known as the "Alpine High." In its efforts to avoid compromising water resources and water quality of the San Solomon Spring Group, Apache contracted NCKRI to conduct a scoping study to evaluate available data and previous work on the hydrogeology of the springs and determine what additional research is needed to properly characterize the springs and the aquifer that feeds them.

The San Solomon Spring Group is located at the far western edge of the Edwards Plateau and the greater Edwards-Trinity Aquifer System, one of the largest karst regions in the United States (see map below). The San Solomon Spring area also lies within the boundaries of several regional investigations of the Edwards-Trinity Aquifer conducted over the past few decades by multiple researchers. These studies indicate that the aquifer which discharges at the San Solomon Spring Group occupies a different hydrologic regime that has little to do with the Edwards-Trinity Aquifer.

Geochemical and other data show that most of the flow from the springs is ultimately derived from groundwater recharge in alluvial basins in central Culberson County. This water then flows through Permian carbonates of the Capitan Reef complex in the Apache Mountains, and finally into Cretaceous limestones juxtaposed by faults against the Capitan Reef carbonates. The groundwater flows from the springs out of the Cretaceous Buda Lime-



Physiographic map of south-central Texas. The various components of the greater Edwards-Trinity Aquifer System are indicated by color shading. The portion of the Edwards Plateau west of the Pecos River is sometimes referred to as the Stockton Plateau.

stone.

While the hydrology of the area has thus been fairly well-characterized on a regional scale, a detailed understanding of the local and sub-regional groundwater flow system is much more limited. NCKRI proposed a study of the area shown in the map below. These proposed boundaries were recommend as flexible and should be expanded as needed to collect potentially relevant data, or if later analysis of the data suggests they are insufficient to encompass the entire area (excluding the alluvial basins) that is estimated to drain to the spring group.

NCKRI recommended eight categories of research:

1. Synoptic groundwater elevation study
2. Synoptic groundwater chemistry study
3. Groundwater tracer studies
4. Geologic mapping
5. Groundwater monitoring study
6. Groundwater ecology study
7. Precipitation studies
8. Geophysical studies

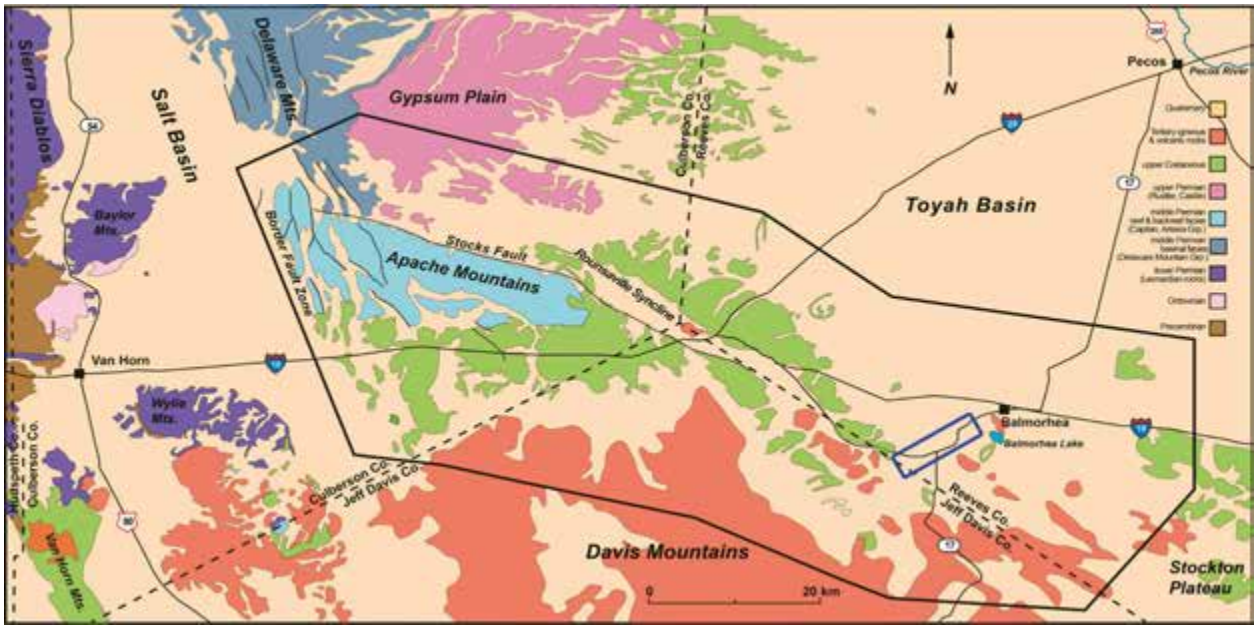
These recommendations follow or improve on the national standards for monitoring and studying karst aquifers. While each individual study will provide useful information and insight, combined they will maximize insight into understanding groundwater flow in the area.

In addition to supporting effective groundwater management for the region, NCKRI's interest in this area is broader. Karst aquifers in arid regions have seen relatively little study. Detailed study of this system may yield valuable insights to help hydrogeologists better understand groundwater flow in arid karst areas around the world.

The full results of this study are available for free download from NCKRI's website as Report of Investigation 8 (http://www.nckri.org/about_nckri/nckri_publications.htm).

NCKRI photo by George Veni

Continuous and precise measurement of flow from the San Solomon springs is one of NCKRI's recommendations. It will improve on the current monitoring methods, and produce data that will lead to a better understanding of the aquifer.



Generalized geologic map of the Pecos-Van Horn region of West Texas. Heavy black line shows the proposed study area. Blue rectangle shows the location of the San Solomon Spring Group.

Groundwater in the Capitan Reef

During the past year, Dr. Lewis Land completed his investigations of water level variations and groundwater residence time in the Capitan Reef Aquifer in Eddy and Lea counties, southeastern New Mexico. In addition to being the host rock for Carlsbad Cavern, the Capitan Reef is also a karstic aquifer that is the principal source of fresh water for the city of Carlsbad.

East of the Pecos River, the Capitan Reef is a brackish water reservoir, with chloride concentrations greater than 10,000 mg/L near the Eddy-Lea County line (the US Environmental Protection Agency recommends maximum chloride concentrations of 250 mg/L for human consumption). This brackish water is a valuable resource for industrial applications in southeastern New Mexico. Both the petroleum and potash mining industries have expressed interest in exploiting brackish water in the reef aquifer in southeastern Lea County for water-flooding mature oil fields and the processing of potash ore.

The impact of brackish water withdrawals from Lea County on fresh water resources near Carlsbad, and baseflow into the Pecos River, is thought to be minimal because of the presence of a partial hydraulic barrier near the Eddy-Lea County line that inhibits flow between the eastern and western segments of the reef. This hydraulic barrier is attributed to low-permeability sediment deposited in submarine channels that cut across the reef during middle Permian time (see photo below). Evidence for this barrier is based primarily on hydrograph response to meteorological events, as measured in a series of monitoring wells installed in the reef aquifer by the US Geological Survey (USGS) in the 1970s.

Water in the western segment of the Capitan Reef is presumably very young because of its proximity to recharge areas in the northern Guadalupe Mountains. If brine in the eastern segment of the aquifer is hydrologically isolated by the submarine canyon, it may be very old, possibly representing recharge that occurred during the Pleistocene. Knowledge of the age distribution of groundwater within the reef aquifer would provide valuable insight into groundwater flow paths and flow rates, and the impact of brackish water withdrawals on fresh water resources within the reef.

Dr. Land obtained water samples from several USGS monitoring wells, and from a water supply well in southeastern Lea County, and had the samples analyzed for tritium and carbon-14 content. The results indicate that water in the western segment of the reef aquifer in Eddy County is relatively young, consistent with its position near the recharge area in the Guadalupe Mountains to the west. The one sample available for ^{14}C and tritium analysis in the eastern segment of the reef has a corrected radiocarbon age greater than 33,000 years, and no measurable tritium. These results support our initial hypothesis that water in the eastern segment of the Capitan Reef aquifer is very old, and partially isolated from water in the younger, western segment of the reef.

NCKRI photo by Lewis Land

Partial exposure of Permian-age submarine canyon fill, Last Chance Canyon, Eddy County, New Mexico.

Preventing a Catastrophe: The Carlsbad Brine Well Cavity

Typically this Research section of the NCKRI Annual Report presents information on research NCKRI has conducted during the past fiscal year. However, NCKRI's mandates include supporting, facilitating, and promoting research, and this year we spent a lot of time doing just that to prevent a catastrophe from occurring in our hometown of Carlsbad.

In 2008–2009, three brine well cavities collapsed in southeast New Mexico and West Texas creating sinkholes measuring up to about 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, thus dissolving the salt and pumping out the resulting brine for oil field drilling.

Another brine well cavity was identified at that time in Carlsbad near the intersection of two highways, an irrigation canal, the railroad, and several businesses. It was determined as unstable and its operations closed by the state. See NCKRI's 2010–2011 Annual Report and Report of Investigation 2 (http://www.nckri.org/about_nckri/nckri_publications.htm) for details on the geophysical survey we conducted of the cavity.

These cavities are not karstic in the usual sense of a natural process. They are anthropogenic, human-created, karst cavities. Karst primarily involves the dissolution of rock, and these cavities formed by people injecting water to dissolve rock salt. The perspective that NCKRI brings to this situation from natural karst features is valuable to solving this problem, and there is no doubt that the knowledge NCKRI will gain from these anthropogenic features will prove valuable to better understanding natural karst cavities and collapses.

Since the initial collapses nearly 10 years ago, NCKRI has served as a technical advisor to the city and state on the cavity in Carlsbad. Among our many activities, we:

- Participated in emergency planning exercises with city, county, and state emergency personnel in preparation for a collapse;
- Educated the public about the situation through many guest lectures and meetings;
- Assisted personnel with the New Mexico Bureau of Geology and Mineral Resources in December 2017 with a drone flyover and down to the bottom of the JWS Sinkhole, the first of the three collapses that occurred in 2008–2009;
- Led and co-led several field trips for governmental and other groups to present the collapses that already occurred to examine the likely impacts of a collapse in Carlsbad; and
- Determined that a collapse of the cavity in Carlsbad would cost over $1 billion in damages and economic impacts!

NCKRI photo by George Veni

Signs warn drivers of a potential risk of sinkhole collapse along Carlsbad highways.

Last year we supported legislation through testimony to the New Mexico Legislature to create a Brine Well Authority, a governmental body that will engineer a solution to fill the cavity so that it never collapses. But there was a problem with the Brine Well Authority. It had money to hire a firm to create a plan to fix the cavity, but no money was provided by the State for the actual repair.

This year NCKRI co-chaired the State's Technical Committee to write a request for proposals to contract an engineering firm to fill the cavity. While this sounds intuitively easy, it will actually be a highly complex and delicate operation. It was imperative the request for proposals include all of the specifications needed to assure a permanent solution that minimizes the risk of inducing a collapse during the repair.

With that complete, NCKRI served as the technical expert at the State Legislature, supporting the efforts of Representative Cathrynn Brown and Senator Carroll Leavell in getting the State to fund the repair. With literally only minutes to spare, the funding was approved.

To be clear, while NCKRI played an important role in these efforts, we were part of a large partnership of governmental and private organizations, private citizens, and political leaders who made the funding a reality. NCKRI believes strongly in partnerships and was honored to be part of this team.

At the time of this writing, the repair plan is being finalized. Re-entry of the cavity to begin its stabilization is expected to start in early 2019. Remediation work by the engineering firm is expected to continue around-the-clock for about two years. In the meantime, NCKRI continues to co-chair the Technical Committee and serves as a resource for the project as needed.

Cave Samples Archive

NCKRI has taken its first steps to develop a cave sample archive for any and all cave and karst materials. Materials collected from and related to caves and karst are scattered around the world. Most are in personal repositories, often at universities. Many are at risk of destruction when the individual researchers die or retire. Universities often do not wish to maintain those materials. Similar problems exist at some state and national parks, as well as other organizations. When the employee who was interested in those studies retires, dies, or is transferred, the successors to those jobs often value their limited storage space more than these cave materials which they frequently don't understand.

Some cave and karst materials include biological specimens, and cultural and paleontological remains. These are generally stored in permanent archival facilities dedicated to such materials, and often recorded in digital databases. In contrast, geological samples such as minerals and speleothems more commonly have no permanent archives and are not well databased. Consequently, unnecessary destructive sampling occurs in caves when samples already exist that could be studied, and to greater advantage by building on previous research.

The initial scope of the NCKRI archive is to collect materials at risk of being lost, which mostly involves geo-samples but can include other materials at risk of destruction. The archive will be open to materials from domestic and international sources. All items in the proposed archive will be databased and linked to all relevant analyses, publications, and other information sources.

As the NCKRI archive grows and once urgent needs are met, linkages will be developed with other archives to establish a global network of easily accessed information that will benefit all cave and karst scientists and managers. This network will promote better research decisions, and fewer destructive activities on future sampling of these very limited, important, and unique resources.

No direct funding has been identified for this project thus far given its initial stage. Funds are needed to construct, equip, and staff an appropriate facility. This year, NCKRI received its first major donation of cave minerals and speleothems from Dr. William White, retired professor from The Pennsylvania State University and a renowned world leader in karst research. Dr. White's donation includes source data on all of the samples and research conducted on them to date. Another speleothem donation was made by Jim Currens, cave geologist retired from the Kentucky Geological Survey.

NCKRI has been discussing the archive with a team of geo-sample database and digital repository experts to plan for digitally storing information on the samples, linking the database internationally, and making the database and linkages expandable to grow easily as more needs are discovered.

Searches for funds to support this project are just beginning. Please contact us at info@nckri.org or 575-887-5518 if you would like to support the NCKRI Cave Samples Archive financially or with cave samples.

NCKRI photo by George Veni

Dr. William White donated these 10 boxes of cave minerals to NCKRI, containing 1,056 specimens from 23 US states, two US territories, and six countries.

NCKRI photo by George Veni

Caves hold diverse materials with valuable information. The color, shape and texture of speleothems, as well as their microscopic contents, are rich records of past climates. The sediments on cave floors can preserve bones and materials from past cultures.

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 (UIS). 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 related to caves and karst.

In July 2017, NCKRI and USF teamed up to give a presentation about the Portal at the International Congress of Speleology in Sydney, Australia. This lecture on how the Portal is organized and its data encoded for greater accessibility was important to gain additional international participation in the project.

A few months later, USF upgraded the look of the Portal to increase the ease of its use, and that use continues to grow. NCKRI publications alone have seen extensive downloads over the past year, for example:

- NCKRI Symposium 3, 2013, Proceedings of the 20th National Cave and Karst Management Symposium Proceedings, 615 downloads from 60 countries;
- NCKRI Symposium 4, 2014, Proceedings of the 6th International Workshop on Ice Caves, 458 downloads from 51 countries;
- NCKRI Symposium 6, 2015, Proceedings of the 14th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impact of Karst, 3,454 downloads from 101 countries (see map below).

Meanwhile, more publications continue to arrive daily for posting on the Portal. NCKRI has submitted over 1,400 publications this year from reports around the world for inclusion on the Portal.

The UIS has initiated a project to scan the 12 proceedings volumes of its International Congresses of Speleology that were not available digitally, or even in paper form to most people. Those proceedings are now being posted on the UIS website and the Karst Information Portal. To date, seven of the twelve proceedings sets have been posted, totaling thousands of pages of valuable information. Volunteers have been enlisted to scan the remaining five volumes over the coming year.

Any organization that wishes to make its publications freely and internationally accessible through the Portal is encouraged to contact NCKRI. Keep in mind that there is a wonderful backlog of material to post, so your information may not appear immediately.

Additionally, 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 are codes and commands designed to make the materials as easily discoverable as possible through the Portal's powerful search engine. The small delay to include these codes is well worth it!

This map is from the Karst Information Portal's digital dashboard. It shows the number of downloads around the world, in this case for NCKRI Symposium 6, during the 2017-2018 fiscal year. The dashboard has other tools and is available to all authors included in the NCKRI Symposium series to help them track basic information on where, how, and when their publications are used.

NCKRI-Assisted Research

Each year, NCKRI participates in cave and karst research and management programs organized by others. We provide assistance where possible while working to expand our own range of knowledge. Following is a summary of some of those projects and activities over the past year:

- Dr. George Veni returned to a couple of places he had studied for many years before joining NCKRI. In September 2017 he assisted with karst information and management needs at Government Canyon State Natural Area, Texas. He then conducted a field evaluation at Camp Bullis Military Training Site, Texas, to advise on a possible research project.
- In October 2017, Dr. Lewis Land participated in a field trip to the groundwater recharge area of the Roswell Artesian Basin to help evaluate some of the hydrologic conditions in the aquifer with the New Mexico Interstate Stream Commission.
- Continuing a little to the west, Dr. Land also assisted in a hydrologic assessment of the north end of the Snowy River Passage of Fort Stanton Cave. The trip was sponsored by the Bureau of Land Management (BLM). Fort Stanton is the third longest cave in New Mexico and Snowy River is one of the longest passages known in the world.
- In November 2017, the New Mexico Environment Department recruited Dr. Land to assist in a hydrologic assessment of wetlands in southeastern New Mexico.
- Although his funded research on the deep portion of the Capitan Reef Aquifer is complete (see report on page 4), Dr. Land continued participating in quarterly water level measurements of the aquifer's monitoring well network, in collaboration with personnel from the BLM.
- And as the fiscal year drew to a close, Dr. Veni assisted his former student, Miljana Golubović Deliganni, with the production of her first book, *Environmental Karst Geomorphology*. This is the first such book published in Greek.

In addition, NCKRI answered the usual hundreds of calls and messages from around the world seeking information and advice. We also provided peer reviews for several major manuscripts on karst processes in Egypt and the US, and on karst geophysical research.

Most notably, the Florida Geological Survey asked NCKRI to review their new model for predicting sinkhole occurrences in Florida. This model will be critically important to Floridians' efforts to avoid sinkhole-prone areas and for their planning to minimize triggering collapses

NCKRI photo by George Veni.

The photo angle makes Turquoise Sink look shallow and small. In fact it drops about 5 m and slopes to a depth of 18 m. Its sudden opening concerns the management of Texas' Government Canyon State Natural Area about the potential for other such sinkholes to open suddenly, and possibly harming visitors and infrastructure.

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 were crucial in its creation and to serve as major supporters. Each founding partner maintains one permanent position on NCKRI's Board.

- City of Carlsbad
- New Mexico Tech
- US National Park Service

Institutional Partners

Organizations with formally defined, mutually supportive relationships with NCKRI through 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)
- Guano Loco Productions
- Institute of Karst Geology (China)
- Instituto do Carste (Brazil)
- International Union of Speleology
- Karst Research Institute (Slovenia)
- 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, but without a formal agreement. NCKRI and its Affiliates exchange information, and cooperate with each other in projects and activities.

- Bat Conservation International
- Carlsbad Municipal Schools
- Edwards Aquifer Authority
- Fort Stanton Cave Study Project
- Karst Waters Institute
- National Speleological Society
- Passmore Lab
- 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 2017-2018 in support of NCKRI programs:

- Dr. Calvin Alexander
- Bert Ashbrook
- Zelda Bailey and Pat Tucci
- Carol and Dave Belski
- Dr. Van Brahana
- Representative Cathrynn Brown
- Kimberly Brown
- Dave Brumbaugh
- Connie Campbell-Brashear
- Carlsbad Rotary Club
- Richard Cervantes
- Chevon Catalyst Grant Program through the Carlsbad Foundation
- Jim Coke
- Paul and Sandra Cosand
- Jon Cradit
- Bob Crisman
- Jim Currens
- Eddie David
- Jim Evatt
- Joseph Filasky
- Bill and Peri Frantz
- Clay Gates
- Dr. Ron Green
- Bob Gulden
- Larry Henderson
- Rod Horrocks
- Jay Jorden
- Christi Kerbo
- Ron Kerbo
- Lance Kyle/Cascade Caverns
- David Klinger
- Markus Lagmanson
- Dr. Penny Lukin
- John Lyles
- Erin Lynch
- Douglas Neighbor
- Deborah Peacock
- Pecos Valley Grotto
- Carlos Romero
- Dr. Van Romero
- Dr. Ira Sasowsky
- Charley Savvas
- Seneca Caverns
- Dave Steensen
- Leanne Stepchinski
- Lee Stevens
- Fred Stone
- Jack Swickard
- Jake Turin
- Sam Upchurch
- Brian Vauter
- Dr. George Veni
- Karen Veni/Night Cat Books
- Misti and Roger Waddle
- Dave Weary
- Dr. Steve Wells
- Drs. Elizabeth & William White

EDUCATION PROGRAM

NCKRI's Education Program has continued to work in diverse directions to meet its diverse goals.

NCKRI is continuing the production of a docudrama telling the story of the life and discoveries of Jim White, the lead explorer of Carlsbad Cavern. This project, between NCKRI and Guano Loco Productions, was on hold much of the year and was reactivated to resume at full speed in our next fiscal year.

In a related development, Passmore Lab has teamed with NCKRI to produce a general film on caves that would be developed for use by science museums and other educational institutions.

The City of Carlsbad, in partnership with NCKRI, was awarded a grant to complete the design and construction of the "Drop Zone," our outdoor vertical classroom and exhibit. NCKRI's courtyard will be converted into a space to provide the general public with many of the authentic vertical experiences found in caves. It will also be used as a training site and practice area for people who use ropes and related "vertical work" as a part of their jobs. While teaching basic rope skills is peripheral to NCKRI's goals, the Drop Zone will attract larger numbers of people to NCKRI to learn about caves and karst, which is a key NCKRI mandate. We anticipate opening the Drop Zone in 2019.

Meanwhile on the inside of NCKRI Headquarters, we have increased our efforts to bring temporary exhibits to our indoor museum space. In the Spring of 2018, in association with the International Cave Photographers Meeting, 21 photographers from 12 countries submitted fabulous photos for a "Caves of the World" photo exhibition (see photo on next page). The exhibition opened in conjunction with a cave photography show for the public by the International Cave Photographers Meeting (see page 18).

NCKRI photo by Dianne Joop.

Rice University students learn about the stratigraphy and structure of the Capitan Limestone, host rock of Carlsbad Caverns and many other important caves.

NCKRI photo by George Veni

NCKRI and its exhibit designers met at the designers' offices in Seattle in October 2017. They reviewed the Drop Zone design in detail, including this scale model of the NCKRI courtyard with the Drop Zone exhibit.

Also in 2018, NCKRI's Education Director, Dianne Joop, co-led the 2018 Rice University Geology Field Camp with Dr. Andre Droxler and Dr. Mitch Harris. Ms. Joop worked with National Park Service staff to lead the group of Texas students into Carlsbad Caverns National Park. NCKRI looks forward to assisting again with this and other field educational programs in 2019.

Everyone at NCKRI, especially Dianne Joop, sends a huge "thank you" to all of the organizations and individuals that support NCKRI's Education Program activities. Your donations, time, assistance, and expertise is invaluable. If you would like to learn more about how you can support NCKRI's Education Program and other programs, please visit www.nckri.org. For updates on all of these and other exciting projects, check out NCKRI's Facebook page.

NCKRI photo by George Veni.

A karst field trip examines large, solution-enhanced fractures associated with slumping along the Lake McMillan Reservoir, Eddy County, New Mexico.

NCKRI photo by George Veni.

The many holes of Salt Shaker Sink are one of the more puzzling features examined by Dr. Veni's Karst Feature Evaluation module during the Texas Hydro-Geo Workshop.

Local Workshops

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

Dr. Lewis Land gave a guest lecture to Rick Wiedenmann's environmental science class at New Mexico State University-Carlsbad on the status of the brine well cavity in Carlsbad. The following month he led the class on a field trip to examine gypsum karst at Lake McMillan north of Carlsbad.

National Workshops

Once again, NCKRI joined as a sponsor and participant in the US Forest Service's CavesLIVE education web program. We distributed information, promoted the event, and conducted associated educational programs.

NCKRI continued its support for the 4th Texas Hydro-Geo Workshop, organized by the Bexar Grotto of the National Speleological Society and the Edwards Aquifer Authority in September 2017. Karst experts from around the country taught more than 40 modules, including NCKRI Board members and staff: Dr. Calvin Alexander (Workshop Steering Committee member), Dr. Ron Green (*Developing Scientific and Field Notebooks*), and Dr. George Veni (*Cave Geology* and *Karst Feature Evaluation Using the TCEQ Forms*). This event was attended by over 200 students, and organized at Cave Without A Name by former NCKRI Board Vice President, Geary Schindel.

In March 2018, Dr. Lewis Land led a karst field trip for Dr. Bogdan Onac and his students from the University of South Florida to Bottomless Lakes State Park. The topic of the field trip was the impact of evaporite karst processes on the hydrology and geomorphology of the Pecos River region.

Photo Courtesy of Chris Howes.

Visitors enjoy the international array of superb photographs taken by cave photographers from around 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. However, for the past couple of years the Academic Director position has been vacant. We are now delighted to announce now that starting in January 2019, our new Academic Director will be Dr. Daniel Jones.

In the meantime, while the Academic Program's activities slowed during our search for a new director, they did not stop. NCKRI has continued to support an outstanding NMT student, collaborate with her on a new project, and also assist a non-NMT student, as described below.

Lampenflora Response to Altered Lighting Conditions in Carlsbad Cavern

NCKRI, New Mexico Tech, and the National Park Service at Carlsbad Caverns National Park continued their study on the problem of photosynthetic biofilms ("lampenflora," often generically called "algae") that grow around artificial lighting systems in show caves. These biofilms pose problems for show caves around the world. They are unsightly and contribute to the discoloration and degradation of speleothems and other cave surfaces upon which they grow, making their removal a top priority for cave managers.

New Mexico Tech photo by David Lepre.
NMT student Zoë Havlena prepares lab materials for analysis in her study of lampenflora from Carlsbad Cavern.

Since photosynthetic capability is dependent on the type of light available, this study was contracted by the National Park Service to investigate the impact of the color output by the cave's lighting system as a potential means of reducing the problematic microbial growth. Following the Park Service's updating of Carlsbad Cavern's lighting system with light-emitting diodes (LEDs), this research project sought to understand the influence of color temperature, light intensity, and substrate type on the proliferation of biofilms. The new LED system allows for adjustment of the color temperature, essentially changing the relative amounts of blue, yellow, and red light. One goal of the project is to identify which light qualities will discourage the growth of lampenflora while providing an aesthetically pleasing light for visitors.

Zoë Havlena took on this project as her Master's thesis topic at NMT. She monitored the response of the biofilms to the lighting conditions using a combination of qualitative and quantitative methods over a 12-month period. Portable handheld spectrophotometry identified changes in color of the lampenflora, which was used as a non-destructive approach to measuring the abundance of the main pigment used in photosynthesis, chlorophyll. Additionally, the DNA sequences at each of the study sites were obtained and analyzed for taxonomic identification and biodiversity.

Ms. Havlena identified several different types of photosynthetic microbes, including green algae (Chlorophyta), golden algae (Ochrophyta), and a few different genera of cyanobacteria ("blue-green algae," see photo below). Many non-photosynthetic microbes were also observed in the study samples, including potential human material unknowingly shed by tourists. The distribution of the microbial species across the different studied locations in the cave showed little variation, even in sites with different types of substrates or lighting levels. This might indicate that the lampenflora biofilms are aggressive colonizers of any cave surface in close enough proximity to light fixtures that support their growth.

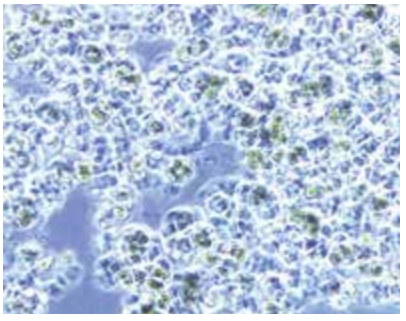


Photo courtesy of Zoë Havlena.
Photomicrograph of cyanobacteria cultivated from lampenflora at the Chinese Theater in Carlsbad Cavern.

This knowledge of microbial community composition agrees with the visual and colorimetric data on biofilm rates of growth. The lampenflora, as observed through photographs and spectrophotometry,

NCKRI photo by George Veni.

A hot-wire anemometer measures slight air currents at a lampenflora sampling site at the Chinese Theater in Carlsbad Cavern; green spots of lampenflora are visible on cave coral to the left of the orange tags.

was seen to grow throughout the entire 12-month study period. Color temperature and rock type appear to have only minor effects on microbial biodiversity and chlorophyll abundance.

Legacy lampenflora (biofilms present at the beginning of the study) did not decrease from the altered lighting, and regrowth at two sites cleaned at the beginning of the study was also observed under both high and low lighting conditions. These observations indicate that while the lighting changes did help reduce the levels of growth, more aggressive control methods are also needed to fully remove the lampenflora.

As a second phase of this study, laboratory cultures of algae and cyanobacteria derived from Carlsbad Cavern's lampenflora biofilms are now under examination at New Mexico Tech. Over the next year we will explore chemical treatment options for removing non-native biological growths that may be environmentally friendly to cave ecosystems, or at least friendlier than bleach, which is currently used in most show caves.

Microbiological and Viral Sampling Transect of Fort Stanton Cave

In October 2017, NCKRI teamed with NCKRI scholar and NMT student Zoë Havlena to collect a series of microbial samples from Fort Stanton Cave, New Mexico. The goal of the project is to study spatial changes in microbial diversity along a transect with different micro-environmental conditions. The transect began at the cave's entrance and ended in the Snowy River Passage. This transect includes areas with over a century of human visitation to areas of little and recent human travel, and sampling from multiple substrates including rock, mud, gypsum silt, calcite, manganese dioxide, and water.

Few studies have conducted such a focused investigation on microbiological geography in a cave. Additionally, this study is the first foray into viral analyses in Fort Stanton Cave, and in fact would be one of the few viral data sets for any cave system. Microbiological research in caves is a specialty, and research of cave viruses is even more so. Portions of Fort Stanton Cave represent not only a relatively untouched cave environment, but also one with a distinct geologic origin.

Prior studies have found that some microbial life in Fort Stanton Cave is unique. Discoveries in viral communities could give insight into the diversity and evolution of microbial life within Fort Stanton and elsewhere. Understanding viral composition in an environment such as Fort Stanton Cave is also of great interest to astrobiologists, where these types of communities might be analogous to potential life beyond our planet. Understanding how they are distributed through caves could be equally significant.

We thank the US Bureau of Land Management for its permission and support to conduct this research, and the members of the Fort Stanton Cave Study Project for their field support and excellent assistance. Analyses of the samples are currently pending.

NCKRI photo by George Veni.

Zoë Havlena (left) and Wayne Walker of the Fort Stanton Cave Study Project (right) approach the entrance of Fort Stanton Cave. The first sample of their transect was collected just outside the cave on the sunny side of the entrance drip line.

NCKRI Support for Non-NMT Students: Natasha Sekhon

Students are the future of cave and karst science, education, and management. Thus, NCKRI has been happy to support all students when possible, not just those at NMT. Over the years we have assisted non-NMT students by serving on their thesis or doctoral committees, providing them internships for research at NCKRI, scholarships to the Sinkhole Conferences, and with data, information, and guidance.

This year NCKRI was happy to host Natasha Sekhon at our headquarters. Ms. Sekhon is a PhD student at The University of Texas at Austin. We provided her with office, storage, and lab space, plus some field assistance as she collected data for her dissertation.

The intensity and duration of droughts, forest fires, and hurricanes are expected to worsen under our current climatic warming conditions. In order to better model future climate scenarios, it is vital that we have a deeper understanding of past climate change scenarios. Due to their continuous growth, widespread geographic occurrence, and precise date-ability, speleothems are at the forefront of establishing land-based climate archives.

The semi-arid to arid Southwestern United States heavily relies on its wet season to keep it out of droughts. Can stalagmites from caves capture historical flood events? How have flood events evolved through time? What is the current climate regime of the Southwestern United States? Ms Sekhon's dissertation focuses on answering these questions by conducting multiple geochemical analyses on stalagmite cores and on modern water monitoring data.

Sitting Bull Falls, located in New Mexico's Lincoln National Forest, is well-positioned to answer these questions. Behind the falls, a small cave drips water constantly, probably due to a perennial spring about 3 km upstream. This year-round drip water allows for high-resolution calcite growth, despite being in a semi-arid environment. Geochemical analyses by Ms Sekhon include trace metals, stable isotopes, and fluorescent imaging to reconstruct the region's climate history.

Additionally, Ms Sekhon monitored active drip and surface water sites to characterize modern responses and calcite chemistry to changing seasons. Results from her dissertation will have broad impacts on understanding the climatic history of the region. Further, the results will enhance understanding of the capabilities of using stalagmites from caves for the purpose of high-resolution paleoclimate studies in semi-arid regions of the world. NCKRI looks forward to the results of Ms Sekhon's research and what should be a bright and productive career.

Photo courtesy of Natasha Sekhon.

PhD student Natasha Sekhon collects water from the Sitting Bull Falls stream for trace metals, stable isotopes, alkalinity, and total organic carbon after a storm event. She will use modern variability in water chemistry to help her interpret variations in past climates preserved in speleothems.

PUBLICATIONS

NCKRI has produced three publications this year. As with all NCKRI publications, they are posted on our website and can be downloaded for free from http://nckri.org/about_nckri/nckri_publications.htm.

NCKRI hosted the Sinkhole Conference this year in partnership with the Karst Waters Institute (see pages 16-17 for the conference report) and published the proceedings as NCKRI Symposium 7: *Proceedings of the 15th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst and the 3rd Appalachian Karst Symposium*, edited by Dr. Ira D. Sasowsky, Michael J. Byle, and Dr. Lewis Land.

The 53 papers presented at the conference are compiled in the 425-page proceedings volume and are organized under the following headings:

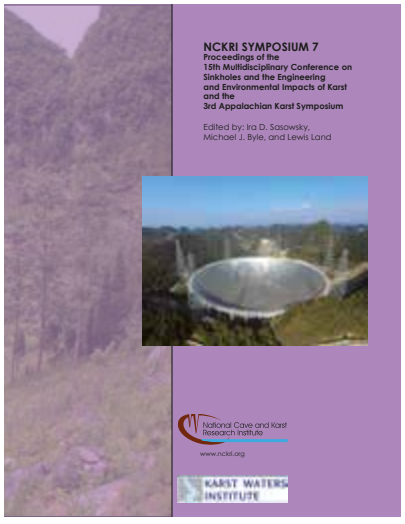
- Karst Hydrogeology;
- Sinkhole Litigation and Liability;
- GIS Mapping-Management of Karst;
- Karst Hydrology/Geochemistry;
- Appalachian Karst;
- Formation of Karst and Sinkholes;
- Karst Geophysics; and
- Geotechnical and Modeling Investigations in Karst.

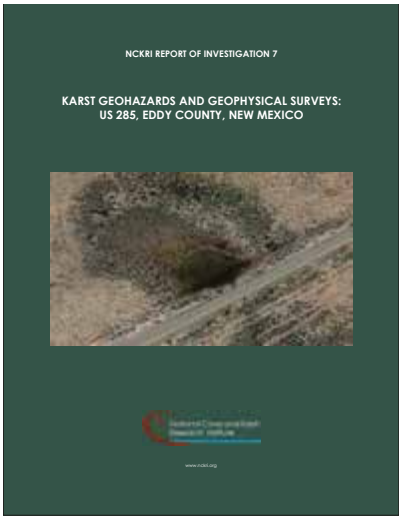
The Report of Investigation series highlights research projects conducted by NCKRI. Two new reports were produced this year. While at first glance neither are in themselves nationally significant projects, like many NCKRI projects, they were selected carefully toward developing broad data sets to better evaluate karst and research methods in diverse hydrogeologic settings.

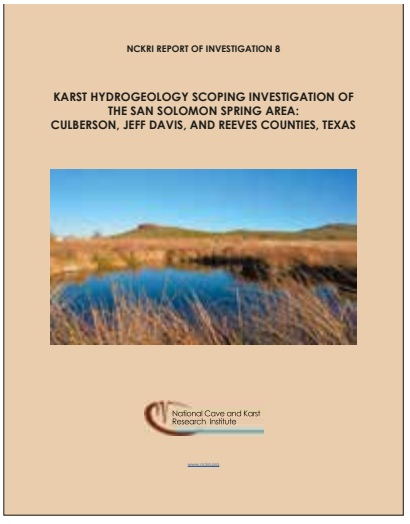
Report of Investigation 7, Karst Geohazards and Geophysical Surveys: US 285, Eddy County, New Mexico was written by Drs. Lewis Land and George Veni from NCKRI, with invaluable contributions by their co-authors Colin Cikoski and David McCraw from the New Mexico Bureau of Geology and Mineral Resources.

The purpose of this project was to guide the New Mexico Department of Transportation in it efforts to upgrade US Highway 285 to avoid problems with sinkhole development (see photo above) and other geohazards. The study was also a valuable investigation of a shallow evaporite karst, interbedded with non-karst units. The work leading to this 89-page report was summarized in NCKRI's 2016–2017 Annual Report.

Report of Investigation 8, Karst Hydrogeology Scoping Investigation of the San Solomon Spring Area: Culberson, Jeff Davis, and Reeves Counties, Texas. This 20-page study was authored by Drs. Lewis Land and George Veni. This project and its results are described in this annual report on pages 2-3. The San Solomon area is within the Chihuahuan Desert, as is NCKRI. This location offers NCKRI ideal opportunities to investigate often poorly-studied arid and semi-arid karst aquifers. *Report of Investigation 8* is one such study.







CONFERENCES AND MEETINGS

Rentals

It's been another great year at NCKRI for private event rentals. Week-long corporate meetings, graduation and birthday parties, baby showers, luncheons, training workshops, and holiday parties are some of the events which continue to drive up traffic at NCKRI Headquarters. Monies collected through rentals are boosting our general fund to provide resources which will ultimately give our visitors a full experience in learning about the importance of caves and karst.

One new rental feature is the availability of cubicles for anyone needing small, semi-private office space. If you need office or 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.

NCKRI photo by Dianne Joop.
Clean, efficient, cubicle workspaces are available for rent at NCKRI. This is one of several different layouts to choose from.

15th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst and the 3rd Appalachian Karst Symposium

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 we jointly organized this 15th conference with the Karst Waters Institute on 2–6 April 2018 at the National Conservation Training Center just outside of Shepherdstown, West Virginia. This conference was combined with the 3rd Appalachian Karst Symposium and a number of long-time attendees said it was the best Sinkhole Conference to date! Over 140 people registered from 10 countries and 18 US states.

This year the conference short courses included:

- Geologic Site Characterization in a Karst Setting;
- Grouting in Karst;
- Stormwater Management in Karst– A Regional Perspective;
- Identifying Closed Depressions from Lidar-Derived Digital Elevation Models.

In addition to the traditional day-long field trip, an extra half-day trip was again added at the end of the conference. Given its popularity, this half-day trip may become a traditional trip too. See the Publications section of this report on page 15 for information on the conference's proceedings.

The 15th Sinkhole Conference included a record number of six students to receive the Barry F. Beck Sinkhole Conference Student Scholarship. The scholarship includes registration to the conference, its trips and courses, and up to $1,000 in reimbursement for travel expenses. This conference's Beck Scholars were:

- Joshua Benton, GIS student, Northern Virginia Community College;
- Emily Bausher, Master's student, Geology, West Virginia University;
- Yong Je Kim, PhD student, Civil Engineering, University of Central Florida;
- Ryan Shamet, PhD student, Civil Engineering, University of Central Florida;

NCKRI photo by George Veni.
The full-day Sinkhole Conference field trip, Karst of the Appalachian Great Valley, included a stop at this interesting West Virginia karst window—a site where an underground stream is unroofed and exposed at the surface for a short distance.

NCKRI photo by George Veni.

Not all sinkholes are alike. The half-day Sinkhole Conference field trip, Karst of the Urban Environment, included this example of how a sinkhole can be converted to water storage, purification, and decorative use.

- Mohammad Shokri, PhD student, Civil Engineering, Water Resources, University of Central Florida; and
- Moataz Hesham Ali Soliman, PhD student, Civil Engineering, University of Central Florida.

While this group of outstanding students were all from US universities, past scholars include students from four non-US countries. All eligible students are encouraged to apply for the next conference.

The Beck Scholarships are partly supported by conference funds, but mostly by generous tax-deductible donations. Please visit www.sinkholeconference.com to donate and for more information about the scholarship and conference.

This year's conference would not have been possible without the help of the many excellent volunteers of the conference's Organizing Committee and short course instructors:

- Dr. Calvin Alexander
- John Barry
- Richard Benson
- Michael Byle
- Robert Denton
- Dr. Dan Doctor
- Dr. Joe Fischer
- Dr. Yongli Gao
- Dr. Jack Hess
- Brian Hunt
- Clint Kromhout
- Dr. Jim LaMoreaux
- Bashir Memon
- Michael Miluski
- Dr. Boo Hyun Nam
- Dr. Ingrid Padilla
- Sam Panno
- Gheorghe Ponta
- Dr. Ira Sasowsky
- Dr. Brian Smith
- Deana Sneyd
- J. Brad Stephenson
- Drew Thomas
- Dr. Dorothy Vesper
- John Wall
- David Weary
- Ming Ye
- Lynn Yuhr
- Wanfang Zhou

Preparations have already begun for the 16th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst, which will be held on 20–24 April 2020 in San Juan, Puerto Rico. In June 2018, NCKRI's Dr. George Veni and NCKRI Event Planner Courtney Gasow traveled to Puerto Rico where they met with Dr. Ingrid Padilla and Dr. Brian Smith. Together they selected the conference venue and examined potential field trip locales.

Drs. Padilla, Smith, and Veni, together with Dr. Jim LaMoreaux, will jointly chair this 2020 meeting. Dr. Lewis Land will be the Senior Editor for the proceedings volume, with Mike Byle and Clint Kromhout serving as Assistant Editors (other committee positions are still being set at the time of this writing). The 2020 Sinkhole Conference will be the first held outside the continental United States, on an island that is world famous for its extensive cockpit karst type sinkhole landscape.

NCKRI photo by George Veni.

Puerto Rico's Rio Camuy Cave is a possible field trip stop for the 2020 Sinkhole Conference. This enormous cave was flooded and damaged heavily by Hurricane Maria in September 2017.

Southwestern Region Winter Technical Meeting

The Southwestern Region of the National Speleological Society rotates its Winter Technical Meeting to Carlsbad every three years, but in December 2017 NCKRI was pleased to host the conference for the second consecutive year. About 70 cave explorers, managers and scientists from Arizona, New Mexico, and Texas converged again to exchange information and ideas on their latest discoveries. NCKRI will be happy to welcome back "Winter Tech" again in three years!

International Cave Photographers Meeting

Since 2011, many of the world's best cave photographers have converged about every 2 years to meet in areas with fabulously photogenic caves. The first three meetings took place in Europe. The top locale selected to extend the conference to other continents was the Guadalupe Mountains of southeast New Mexico in the USA.

NCKRI was happy to support and assist with the organization of this meeting. It was mostly an opportunity for friends to visit, and work together photographing extraordinarily beautiful caves from 21–29 April 2018.

NCKRI's primary role was on the final day of the meeting. Traditionally the photographers give a public show of the photos they took during their week together, and NCKRI served as the venue for the event. Many of the photographers also contributed photos from caves in other parts of world to create a photographic exhibit (see page 11) that was enjoyed by NCKRI visitors for several months.

NCKRI photo by George Veni.

The Witch's Fingers in Carlsbad Cavern are one of many features that attract tourists and cave photographers from around the world.

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.

Photo courtesy of Chris Howes.

NCKRI's meeting room was standing-room only as people from around the region got ready for the show by 40 cave photographers from 12 countries.

OUTREACH

Professional Partnerships

For several years, NCKRI has collaborated with the International Union of Speleology (UIS), most visibly on the Karst Information Portal (see page 7). The UIS serves as the "United Nations" of cave exploration, research, management, and education. Its 54 member countries work to advance speleology (the study of caves) in all ways—mirroring NCKRI's mandates, making our partnership natural.

The NCKRI-UIS partnership was enhanced by NCKRI's Executive Director, Dr. George Veni's, position on the UIS Bureau (governing board) since 2002. That relationship grew closer when Dr. Veni was elected UIS President in July 2017. He hopes to leverage his NCKRI and UIS positions to advance speleology in ways that would not be possible from either position alone. Several UIS activities will connect strongly to NCKRI next year.

NCKRI also initiated and followed up on meetings with several organizations to increase cave and karst awareness and explore potential joint projects. Those groups include the American Geosciences Institute, American National Standards Institute, ASTM International, National Association for Interpretation, New Mexico Bureau of Geology and Mineral Resources, The Mammoth Site, US Bureau of Land Management, US Fish and Wildlife Service, US Geological Survey, and the Wyoming Geological Survey.

Professional Meetings

NCKRI attended, sponsored and/or had a booth at the following conferences during the past year (*NCKRI staff organized or assisted in the organization of the italicized meetings below*):

- *4th International Cave Photographers Meeting, Carlsbad, New Mexico, USA*
- *15th Multidisciplinary Conferences on Sinkholes and the Engineering and Environmental Impacts of Karst; Shepherdstown, West Virginia, USA*
- *17th International Congress of Speleology; Sydney, Australia*
- *Geological Society of America Convention; Denver, Colorado, USA*
- Mayors' Energy Summit, Carls-

Photo courtesy of Mladen Garašić and José Ayrton Labegalini.

The UIS Bureau for 2017-2021 immediately after it was elected (L-R): Gyula Hegedűs (Adjunct Secretary/Hungary), Dr. Mladen Garašić (Adjunct Secretary/Croatia), Zdeněk Motyčka (Vice President of Administration/Czech Republic), Satoshi Goto (Adjunct Secretary/Japan), Dr. George Veni (President/USA), Dr. Nadja Zupan Hajna (Treasurer/Slovenia), Bärbel Vogel (Adjunct Secretary/Germany), Dr. Fadi Nader (Secretary General/Lebanon), Bernard Chirol (Adjunct Secretary/France), and Nivaldo Colzato (Adjunct Secretary/Brazil); Efrain Mercado (Vice President of Operations/Puerto Rico) and Dr. Tim Moulds (Adjunct Secretary/Australia) are not shown.

bad, New Mexico, USA
- National Association for Interpretation's InterpTech Conference; Pacific Grove, California, USA
- New Mexico State University TransCon Conference; Las Cruces, New Mexico, USA
- University of New Mexico Paving and Transportation Conference; Albuquerque, New Mexico, USA

Guest Lectures by NCKRI

NCKRI staff were invited to give the following presentations:

Dr. George Veni:
- *Sinkholes and New Findings to Minimize Their Occurrence*. Society of Independent Professional Earth Scientists, Midland Chapter, Midland, Texas.
- *The UIS and the Bexar Grotto*. Bexar Grotto, San Antonio, Texas.
- *World's First Geophysical Survey of Bat Guano: Phase 1 and 2 Results*. West Virginia University, Morgantown, West Virginia.

Dr. Lewis Land:
- *Anthropogenic Sinkholes in Southeastern New Mexico*, and *Evaluation of Groundwater Residence Time in a High Mountain Aquifer System (Sacramento Mountains, USA): Insights gained from use of multiple environmental tracers*. University of South Florida Best of Karst Meeting.
- *I&W Brine Well Cavity: Evaluation of the Probable Extent and Impacts of its Collapse*. Carlsbad Downtown Lions Club and Carlsbad Heights Lions Club, Carlsbad, New Mexico.
- *Sinkholes, Karst and Water in Southeastern New Mexico, or how Bottomless Lakes State Park helps keep us legal with Texas*. Enchanted Evenings Educational Program, Bottomless Lakes State Park, New Mexico.
- *Statewide Assessment of Brackish Water Resources in New Mexico*. Society of Independent Professional Earth Scientists, Midland Chapter, Midland, Texas.

Co-Sponsored Speakers

NCKRI co-sponsors the Edwards Aquifer Authority's Distinguished Lecture Series in San Antonio, Texas. In December 2017, Dr. Charles Kreitler of The University of Texas at Austin gave the distinguished lecture on *Groundwater Management*.

Photo courtesy of Oana-Alexandra Dumitru.

Dr. Lewis Land was this year's featured guest lecturer for the University of South Florida's Best of Karst Meeting in March 2018.

International Outreach

NCKRI is an Affiliated Organization of the International Union of Speleology (UIS) where Dr. Veni is President. During the past year, the UIS has continued to work to have 2021 designated as the International Year of Caves and Karst by the United Nations Educational, Scientific, and Cultural Organization (UNESCO).

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. NCKRI is supporting this effort and working to gain additional organizational and national support.

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 one is planned for Bristol, Virginia, on 7-11 October 2019.
- NCKRI is an organizational member of the US Fish and Wildlife Service's White-nose Syndrome Stakeholder Committee and participates in the committee's monthly teleconferences.
- Dr. George Veni continued his second three-year term, appointed 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 and NCKRI Board Member Dr. Calvin Alexander serve as advisors to the Karst Division of the Geological Society of America.

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 staff:

- Participated in the Carlsbad Chamber of Commerce's annual *Bat Brigade*. This delegation of community leaders visits leaders at the New Mexico state capitol to support needs in the City of Carlsbad and Eddy County.
- Attended board meetings of the Carlsbad Chamber of Commerce, and its Education, Government Affairs, and Tourism Committees, Carlsbad Department of Development, and participated in activities supporting the community.
- Serve on the board of Creative Carlsbad to promote and enhance the arts and arts education in Carlsbad.
- Participated in the Pecos River Water Users Organization.
- Attend the meetings of the New Mexico Association of Museums Southeast Region.

Photo courtesy of Andreas Matthes.

At the end of each year, NCKRI sends photos on magnets to many of its friends to spread joy for the holidays. This photo of some unusual underwater speleothems in Cenote Zapote in Quintana Roo, Mexico, was sent at the end 2017 with the words "Jingle Bell Rock!" The origin of these strange speleothems is not yet understood.

Media

NCKRI staff were interviewed and featured in local to international media this year, including:

- *Experts Warn of Sinkhole Risk in Popular New Mexico Area*. Susan Montoya Bryan, Associated Press, published January–February 2018 in 31 national and international print and network television news reports.
- *House to Consider Bill to Prevent Carlsbad Well Collapse*. Dan McKay, Albuquerque Journal, 12 February 2018. https://www.abqjournal.com/1132399/house-to-consider-bill-to-prevent-carlsbad-well-collapse.html.
- *NM Senate, House Approves Funding to Stabilize Giant Sinkhole-in-Waiting*. Jen French, KOB 4 News, Albuquerque, New Mexico, 12 February 2018. http://www.kob.com/new-mexico-news/nm-senate-house-approve-funding-to-stabilize-giant-sinkhole-in-waiting/4785612/?cat=500.
- *Many Owed Thanks for Brine Well Bill Success*. John Heaton, Carlsbad Current-Argus, 1 March 2018. http://www.currentargus.com/story/opinion/columnists/2018/03/01/many-owed-thanks-brine-well-bill-success/381517002/.
- *Here's Why New Mexico's Oil Boom is Raising a Lot of Questions About Water*. Keith Schneider, Los Angeles Time, 25 March 2018. http://www.latimes.com/nation/la-na-new-mexico-permian-basin-20180325-story.html.
- *Public Lands at Risk From Extraction Could Be Rolled Back*. Adrian C. Hedden, Energy of Southwest New Mexico and West Texas, Carlsbad Current-Argus, April-June 2018, p. 22–23.
- *Cave Photographers From Around the World Meet In Carlsbad*. Adrian Hedden, Carlsbad Current-Argus, 26 April 2018, p. 2A. https://www.currentargus.com/story/entertainment/2018/04/26/cave-photographers-around-world-meet-carlsbad/551963002/.
- *The Science Behind Florida's Sinkhole Epidemic.* Chris Bodenner, Smithsonian Magazine, May 2018. https://www.smithsonianmag.com/science-nature/science-behind-floridas-sinkhole-epidemic-180969158/.
- *Here's an Update on Progress Made on the Brine Well*. Dale Janway, Carlsbad Current-Argus, 13 May 2018, p. 5A. https://www.currentargus.com/story/opinion/columnists/2018/05/13/update-progress-made-brine-well/603198002/.
- *Concerns Grow as Public Land Protections Against Extraction Could Be Rolled Back*. Adrian C. Hedden, Carlsbad Current-Argus, 30 May, p. 1A, 2A. https://www.currentargus.com/story/news/local/2018/05/30/president-donald-trump-order-public-land-protections-against-extraction-roll-back/653474002/.

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, as the Union's Vice President of Administration from 2009-2017, and as President from 2017 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 230 papers, including five books, on hydrogeology, biology, and environmental management in caves and karst terrains.

Ms. Dianne Joop, Education Director

Ms. 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 Educational Television, the state of Florida, the 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 its 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, 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

Ms. 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. Ms. Darby 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 Manager, 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, Ms. Darby 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. Ms. Darby 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. Ms. Darby has also been a 4-H parent leader for over nine years. She chaperones and participates with the kids as often as possible and served on the Cooperative Extension Advisory Committee.

Continuing Education

NCKRI staff polish and expand their skills whenever possible. All formal training attended by one or more staff members in the past year was conducted in the short courses managed by NCKRI at the 15th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst (see pages 16-17):

- Stormwater Management in Karst—A Regional Perspective. Instructor: Robert K. Denton, Jr.
- Grouting in Karst. Instructors: Joseph A. Fischer and Michael J. Miluski.
- Geologic Site Characterization in a Karst Setting. Instructors: Lynn Yuhr and Richard C. Benson.
- Identifying Closed Depressions from Lidar-Derived Digital Elevation Models. Instructors: Dr. Dan H. Doctor and John Wall.

NCKRI photo by George Veni.

The Lidar short course by Dr. Dan Doctor and John Wall sold out at the Sinkhole Conference!

STAFF PUBLICATIONS

Conference Proceedings Papers

- Boczar, J., Veni G. 2017. Linked Data, the Semantic Web, and the Karst Information Portal. Proceedings of the 17th International Congress of Speleology, Kevin Moore and Susan White (eds.), Australian Speleological Federation, v. 2, pp. 389–391.
- Land, L. 2017. Sinkholes as transportation geohazards in mixed evaporite-siliciclastic bedrock, southeastern New Mexico. Geological Society of America Convention, Seattle, Washington, https://gsa.confex.com/gsa/2017AM/meetingapp.cgi/Paper/302060.
- Land, L., Cikoski, C., Veni, G. 2018. Sinkholes as transportation and infrastructure geohazards in mixed evaporite-siliciclastic bedrock, southeastern New Mexico. NCKRI Symposium 7: Proceedings of the 15th Multidisciplinary Conference of Sinkholes and the Engineering and Environmental Impacts on Karst, Ira D. Sasowsky, Michael J. Byle, and Lewis Land, eds. National Cave and Karst Research Institute, Carlsbad, New Mexico, pp. 357–367.
- Pu, J., Li, J., Zhang, T., Veni, G., Yuan, D. 2018. Vertical distribution of dissolved inorganic carbon in a karst groundwater-fed surface water reservoir in Guangxi, South China. Proceedings of the International Symposium KARST 2018 "Expect the Unexpected," Saša Milanović and Zoran Stevanović, eds. Centre for Karst Hydrogeology and Hydro-Energy Power Plant "Dabar," Belgrade, Serbia, pp. 189–198.
- Veni, G. 2017. International Union of Speleology: overview of its past, present, and future. National Speleological Society Southwest Region Winter Technical Meeting, Carlsbad, New Mexico, Southwestern Cavers, 56(6): 57.
- Veni, G. 2017. Karst, science, and life: lessons from Dr. Nick Crawford. Geological Society of America Convention, Seattle, Washington, https://gsa.confex.com/gsa/2017AM/meetingapp.cgi/Paper/297224.
- Veni, G. 2017. World's First Geophysical Survey of Bat Guano: Phase 1 and 2 Results. Proceedings of the 17th International Congress of Speleology, Kevin Moore and Susan White (eds.), Australian Speleological Federation, v. 2, p. 145–147.

Books and Book Chapters

- Sasowsky, I.D., Byle, M.J., Land L., eds. 2018. Proceedings of the Fifteenth Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impact of Karst, Shepherdstown, West Virginia. National Cave and Karst Research Institute Symposium 7. Carlsbad (NM): National Cave and Karst Research Institute.
- Stafford, K. Veni, G., eds. 2018. Hypogene Karst of Texas. Texas Speleological Survey Monograph 3, 122 p. https://www.texasspeleologicalsurvey.org/publications/Monograph-Hypogene.php.
- Veni, G. 2018. Hypogene caves and karst of the Edwards Plateau, Texas. In: Hypogene Karst of Texas, Kevin Stafford and George Veni, eds., Texas Speleological Survey Monograph 3, pp. 64-77.

Unrefereed Papers

- Lommler, J., Land, L. 2018. Sinkhole identification. New Mexico State University TransCon Conference, Las Cruces, New Mexico, Abstracts with Program.
- Land, L. 2017. Brackish water resources and groundwater residence time in the Capitan Reef aquifer. National Speleological Society-Southwestern Region Winter Technical Meeting, Carlsbad, New Mexico.
- Land, L. 2017. Sinkholes as transportation geohazards in mixed evaporite-siliclastic bedrock, southeastern New Mexico. National Speleological Society-Southwestern Region Winter Technical Meeting, Carlsbad, New Mexico.

2017-2018 CORPORATE BUDGET

NCKRI Inc. **Unaudited** Annual Financial Summary of Activities and Changes in Net Assets
For the Year Ending June 30, 2018

Public support and services:		***Functional expenses***	
Unrestricted Contributions	$7,990.65	Contract	$2,026.63
Conferences	$62,955.00	Conferences	$30,893.15
Rent and Lease	$13,341.25	Operations	$16,744.52
Education	$5,059.00	Travel	$26,934.65
Supplies	$0.00	Supplies	$8,692.40
Other	$1,018.99	Other	$4,964.05
TOTAL PUBLIC SUPPORT AND REVENUE	$90,364.89	TOTAL PROGRAM EXPENSES	$90,255.40
End of year balance			**$63,678.69**

2017-2018 STATE AND FEDERAL BUDGET

NEW MEXICO TECH
National Cave & Karst Research Institute

Fiscal Year 2018 Year-to-Date Summarized Financials
as of June 30, 2018

Revenue		FY18 Budget	YTD Actual	Balance Budget to Actual
State of NM		$ 358,586	$ 358,586	$ -
Federal		$ 301,000	$ 263,189	$ 37,811
Sponsored		$ 760,535	$ 534,005	$ 226,530
	TOTAL	$ 1,420,121	$ 1,155,780	$ 264,341
				81.39%

Expenses/Balances		*FY18 Budget*	*YTD Actual*	Balance Budget to Actual
State of NM				
	Salary	$ 205,815	$ 130,693	$ 75,122
	Fringe	$ 74,643	$ 41,949	$ 32,694
	Rent/Utilities	$ 54,336	$ 59,425	$ (5,089)
	Travel	$ -	$ 31,143	$ (31,143)
	Supplies & Other	$ 3,792	$ 40,659	$ (36,867)
	Overhead	$ 20,000	$ 20,000	$ -
	SUBTOTAL	$ 358,586	$ 323,869	$ 34,717
				90.32%
Federal				
	Salary	$ 187,519	$ 172,245	$ 15,274
	Fringe	$ 67,507	$ 57,340	$ 10,167
	Rent/Utilities	$ 15,500	$ 14,131	$ 1,369
	Travel	$ 3,000		$ 3,000
	Supplies & Other	$ 5,178	$ (22)	$ 5,200
	Overhead	$ 22,296	$ 19,496	$ 2,800
	SUBTOTAL	$ 301,000	$ 263,190	$ 37,810
				87.44%
Sponsored				
	Salary	$ 305,363	$ 292,964	$ 12,399
	Fringe	$ 119,174	$ 95,665	$ 23,509
	Rent/Utilities	$ 29,900	$ 11,782	$ 18,118
	Travel	$ 13,253	$ 12,333	$ 920
	Supplies & Other	$ 152,463	$ 40,949	$ 111,514
	Overhead	$ 140,382	$ 80,310	$ 60,072
	SUBTOTAL	$ 760,535	$ 534,003	$ 226,532
	FY18 Carryforward		$ 290,971	
	TOTAL		$ 325,688	
Summary		**51% BR without CF**	**$ 0.41**	**BR with CF**

Though the State of NM cut the FY2018 budget by 1%, a large carryforward plus reduced expenditues for salaries have allowed for greater than expected balances in those Funds. Currently the budget is not large enough to carry the new faculty hire in FY 2019. Given trends, there is an expectation of a $325,000 carryfoward into FY2019. That carryforward will enable the faculty hire for at least 6 years. There are efforts underway by the Executive Director to enhance the business model. Overall the fiscal health is stable, but with a negative watch due to State and Federal appropriations risk.

National Cave and Karst Research Institute

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