CLEARING THE WATERS

A quarterly newsletter by the Surface Water Quality Bureau

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Clearing The Waters is available on our website at: https://www.env.nm.gov/surface-water-quality/newsletters/

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Caves and Karst expert Dr. George Veni; The Unique Hydrology and Management Challenges in Karst Wetlands

By Susan Styer, WPS Environmental Scientist - Southern Field Team

The International Year of Caves and Karst in 2021 is a worldwide celebration bringing awareness about cave and karst features occurring around our planet. On April 8th 2021, Dr. George Veni presented *The Unique Hydrology and Management Challenges in Karst Wetlands* at the New Mexico Environment Department Surface Water Quality Bureau's New Mexico Southern Wetlands Roundtable webinar, a biannual event organized by the Wetlands Program. The following article summarizes Dr. Veni's presentation, and he graciously agreed to review my attempt to capture the highlights. His presentation included an explanation of karst aquifers and karst wetlands and their unique hydrology and management challenges.

Dr. George Veni is the Executive Director of the National Cave and Karst Research Institute (NCKRI) in Carlsbad, NM and 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. He has conducted extensive karst research throughout the United States and in several other countries. Dr. Veni is also the President of the International Union of Speleology and lead organizer of the International Year of Caves and Karst. He has served as a doctoral committee advisor and taught karst science and management courses for several universities and NCKRI since 1989. He has published and presented nearly 270 papers, including six books, on hydrogeology, biology, and environmental management in karst terrains.

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NCKRI was created by the U.S. Congress in 1998 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.*

Caves and Karst Features

Many people are familiar with caves, but few are familiar with the role they play in the environment or with the term karst. Karst describes a type of terrain. It is formed primarily by dissolution of the bedrock which is typically deposits of carbonates such as limestone, dolomite and marble or evaporites of gypsum and halite. Caves, sinkholes, underground steams, and large springs are common features associated with karst topography. Perennial streams are not characteristically common features in karst areas because water drains internally underground through caves, sinkholes, and fractures quite differently than water draining overland into streams.

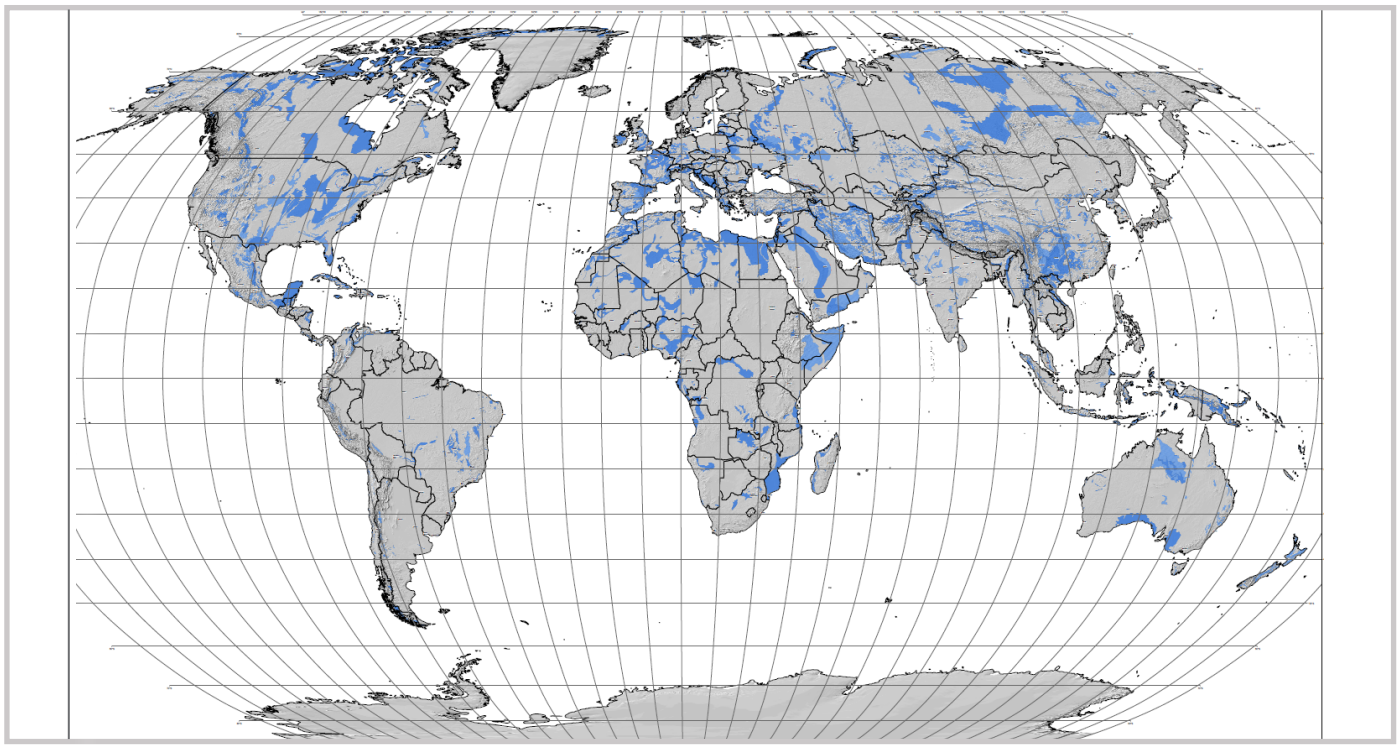

Figure 1: Worldwide karst locations.
As indicated by the blue areas on the map, approximately twenty-five percent of the landscape in the United States and an estimated twenty percent of the planet's land surface is karst. The main focus in creating this map was to represent land surface areas based on carbonate karst. It is estimated that the percentages of karst are significantly higher when evaporites, and especially buried carbonates and evaporites, are included. Because subsurface mapping is limited in many parts of the world, buried karst is not represented in this map. Figure provided by George Veni from Chen et al., 2017.

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Karst Aquifers and Their Unique Hydrology

Aquifers are sourced by water occurring at the surface that flows subsurface collecting as reservoirs in rocks. Karst aquifers differ from other types of aquifers because they are the most complex type of aquifer system in the world, can produce the largest volumes of water, and are most vulnerable to contamination due to their unpredictable scale of porosity and permeability. The openings in both carbonate and evaporite rocks vary considerably in scale from conduits to caves. Some openings are microscopic in size and some are so large a plane or train could pass through them. Karst aquifers form over time as slightly acidic meteoric water moves through the land surface dissolving rock as it travels through fractures. The fractures eventually may enlarge into conduits and become hydrologically more efficient than the fractures in which they were flowing. As these conduits enlarge, they capture water from surrounding fractures and expand at ever increasing rates. "*Caves*" are the result of a conduit that has increased sufficiently to allow a human to fit into the cavity. Whereas "*conduits*" are classified as anything larger than 10 millimeters in diameter, and include caves but generally refer to cavities not large enough for a human to enter. Caves and conduits both function, regardless of their size, hydrologically the same in terms of sediment transport, lack of filtration of contaminants, chemistry, and habitat for aquatic fauna. Conduits are the most important structures in the karst aquifer system because 99% of the water flows through them, creating the world's largest springs and most productive flows from wells. Unfortunately, these high flow rates allow pollutants to be rapidly carried long distances without natural filtration to drinking water sources.

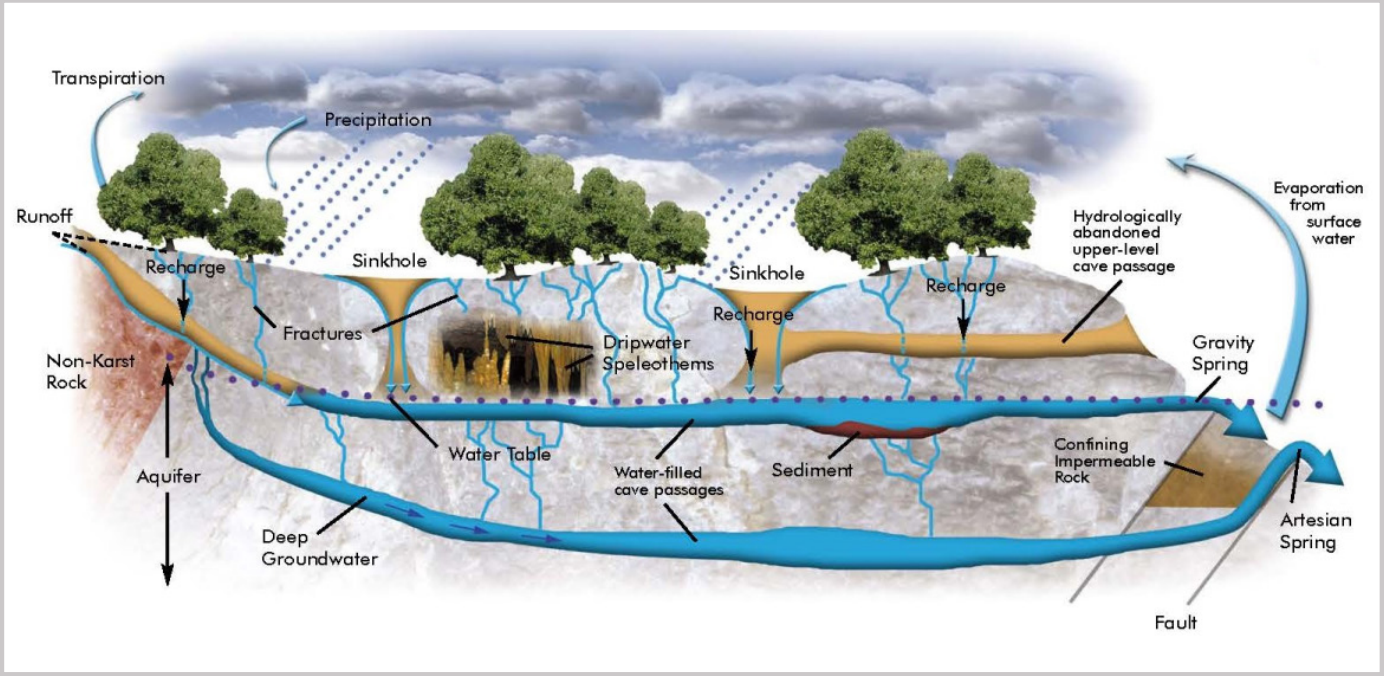

Figure 2: The hydrologic cycle and how karst aquifers work. Figure provided by George Veni from Living with Karst *(Veni and DuChene, 2001)*

Karst aquifers, as seen in Figure 2, are complex because of their "triple-permeability system." This triple-permeability system stores and transmits groundwater through three different interconnected flow systems. There are many places precipitation enters the subsurface. Some amount will enter the bedrock slowly making its way to the water table through microscopic fractures and tiny pores taking tens of thousands of years before it eventually flows to the surface as a spring. Secondly, groundwater in a fractured part of the aquifer may take years to hundreds of years, traveling through tiny fissures and porous rock before it emerges at the surface. Lastly,

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groundwater in the conduit flow part of the aquifer will move very quickly through caves and conduits. An analysis of groundwater tracer studies from around the world found the mean flow rate of karst aquifers is about 1,600 meters/day.

Two vertical zones divide the karst aquifer, the vadose and phreatic. The vadose zone extends from the surface to the water table with drainage associated in a vertical direction. Occasionally groundwater is present in this zone. The area below the water table is the phreatic zone. In this zone all of the fractures, pores, caves and other voids are filled with groundwater. The drainage in this zone moves mostly horizontally and may surface at an aquifer's spring.

Karst Wetlands

Karst wetlands can be observed on the land surface and categorized into three major types. The first type is a sinkhole, which is a natural depression in the land surface that may form a pond. A karst window is another form of sinkhole wetland and is described as perennial waters that form wetlands far away from any streams and are a result of water, at the water table level, flowing in one side of the sinkhole and out the other side. An example of a karst window is Cedar Sink in Mammoth Cave National Park (Photo below). One other form of sinkhole wetlands is a polje. The polje's flow regime, which is much like a karst window but at a much larger flood-like scale, is desirable for farming and often these areas are converted to prime agricultural areas. Poljes are rare in the US.

Figure 3: A karst window diagram at Cedar Sink in Mammoth Cave National Park. Photo provided by George Veni.

The second type of karst wetland are springs. Two basic categories that springs can be divided into are descending and rising. Descending springs are gravity fed and because of an extreme change in elevation, they have a complete disconnect in aquatic habitat between the spring and the stream it feeds. Rising springs occur when groundwater rises out of an orifice that flows directly into the river, allowing a connected or continuous aquatic habitat to exist. These two types of springs have management and hydrologic implications in terms of understanding how these aquifers work. See Figure 4 and 5.

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Figure 4 (left): Afqa Grotto is a descending spring found in Lebanon. Photo provided by George Veni.

Figure 5 (right): Carlsbad Main Spring is a rising spring found along the Pecos River in Carlsbad, NM. Photo provided by George Veni.

The last type of karst wetland are continuous and discontinuous streams. Most streams are continuous, flowing along their entire length from their source to the ocean. In karst, streams are more frequently discontinuous in two main ways. First, the entire flow of a stream can abruptly go underground, captured by a cave entrance or sinkhole, features then also known as "swallow holes" or "swallets" (Figure 6). Second, their flow can gradually diminish as the water sinks underground over the course of what is then known as a "losing stream," which are especially common in arid areas and are not limited to karst aquifers. In each case, water may reappear from a spring downstream or, with major flooding, water may overflow the swallow hole or losing stream and become a continuous stream for a short period.

Figure 6. Gouffre Balaa is an example of a discontinuous stream in Lebanon. This example is also called a swallow hole or swallet. Photo provided by George Veni.

Management Issues in Karst Areas

There are a few unique hydrologic aspects of karst that create management issues, such as abrupt changes in groundwater levels caused by large rain events. Changes in groundwater levels occur when large amounts of water move quickly through the system and cause a great fluctuation in water levels within the restricted conduits, essentially creating internal flood conditions. This abrupt change in water level also influences water chemistry and spring discharge making aquatic habitat conditions variable.

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Another management challenge is groundwater depletion. Karst aquifers which are often viewed as "extremely productive" are highly vulnerable to depletions due to well pumping. Although there is seemingly a large supply of water because it is easily produced from conduits and caves, large-scale pumping is frequently not sustainable in the long term. Many karst aquifers that have been depleted have not only lost spring flow and gone dry, but also the unique and sometimes endangered species associated with the spring location.

Managing and assessing the groundwater drainage basins is also challenging because karst aquifer systems tend to ignore surface water drainage divides and the direction of water flow underground is rarely predictable without extensive study.

Groundwater contamination is another management issue in karst aquifers. Trash, pollutants and bacteria can easily enter the aquifers because there is no natural filtration system. One of the main reasons to organize *The International Year of Caves and Karst in 2021* is to educate people worldwide because most do not understand the vulnerabilities of contamination and depletion.

Another challenge to manage karst wetlands is accessing and managing habitat. In most karst areas, many of the species that are endemic or have adapted there, specifically karst ciénega habitats, will often use the spring orifices themselves as a form of refugia. During drought conditions they may retreat to these areas and even underground until normal conditions resume. Accessing these habitats is somewhat difficult for assessing and evaluating them, and NCKRI is currently developing a program to gain knowledge about groundwater fauna in southeast New Mexico. By studying the groundwater fauna, a better understanding will also be gained about the hydrogeology of the karst aquifer system.

For additional educational sources or to locate events during *The International Year of Caves and Karst in 2021*, both local and around the world, consider visiting these websites;

More information about NCKRI can be found at www.nckri.org/index.htm

International Year of Caves and Karst: www.iyck2021.org

Karst Information Portal: www.karstportal.org

International Union of Speleology: www.uis-speleo.org

Due to the COVID pandemic, many of the meetings and events worldwide have been scheduled or will be continued in 2022!!

NMED SWQB would like to thank Dr. Veni for sharing his expert knowledge about caves and karst along with photos and figures and agreeing to make this article possible.

Dr. Lewis Land is a karst hydrogeologist also with the National Cave and Karst Research and is the Institute's lead geophysical investigator. He will author an article about caves and karst that will be highlighted in an upcoming issue of* Clearing the Waters *later this year.

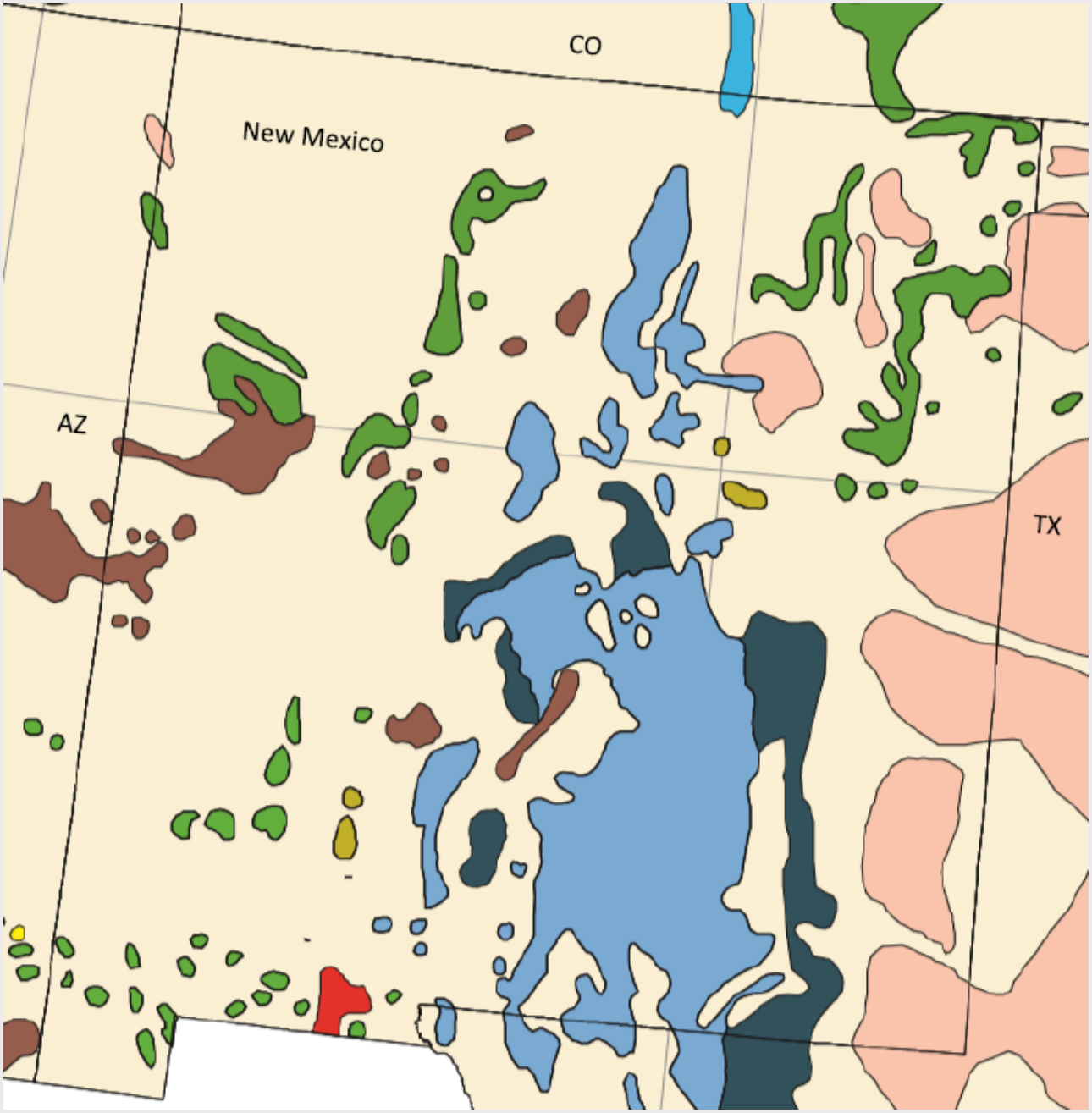
Caves and Karst are Priceless Resources in New Mexico

By Susan Styer, WPS Environmental Scientist - Southern Field Team

Caves and karst have a diverse ecologic, scientific, cultural and economic impact for the State of New Mexico. Some facts about Caves and Karst in New Mexico:

This information was primarily taken with some adaption from New Mexico House Memorial 12 Bill titled, International Year of Caves & Karst. *This proclamation requesting acknowledgment of the importance of caves and karst in New Mexico passed on March 8, 2021 and was introduced by Cathrynn N. Brown and Gail Armstrong to the 55th Legislature, State of New Mexico, First Session 2021.*

- Carlsbad Caverns national park alone has an economic benefit of about thirty-four million dollars ($34,000,000) each year for New Mexico.
- New Mexico cave and karst tourist destinations include Bottomless Lakes State Park, Santa Rosa Blue Hole, the Ice Cave and Bandera Volcano, and El Malpais National Monument. The Ice Cave and Bandera Volcano are on private land near the monument.
- The country's first underground wilderness was established in New Mexico to protect the spectacular Lechuguilla cave.
- The country's first underground national conservation area was established in New Mexico to protect the equally amazing Fort Stanton-Snowy River Cave national conservation area.
- The primary water supplies for roughly fifteen percent of New Mexico are karst aquifers, especially supporting the communities in the southeast quadrant of the state.
- Insect-eating bats from New Mexico's caves and around the country save American agriculture twenty-three billion dollars ($23,000,000,000) each year in pesticides. This also reduces the amount of chemical pesticide entering surface and groundwater.
- Caves in New Mexico, and worldwide, are the main repositories of thousands of years of rich - cultural history found nowhere else.
- Recognizing New Mexico's significance and interest in the area the United States Congress established the National Cave and Karst Research Institute, located in New Mexico in partnership with the state and under the administration of the New Mexico Institute of Mining and Technology.



Cave and Karst areas in New Mexico.

For a legend to this map and to learn more about locations of karst, fissures, tubes and caves in New Mexico and locations within the United States please visit; https://pubs.usgs.gov/of/2004/1352/.

Map sourced from; Digital Engineering Aspects of Karst Map: A GIS Version of Davies, W.E., Simpson, J.H., Ohlmacher, G.C., Kirk, W.S., and Newton, E.G., 1984, Engineering Aspects of Karst: U.S. Geological Survey, National Atlas of the United States of America.

New Mexico River Stewardship Program Request for Proposals Coming Soon!

The Surface Water Quality Bureau is excited to announce the upcoming release the River Stewardship Program Request for Proposals (RFP) on April 30, 2021. Through this procurement, NMED is looking for projects that align with the River Stewardship Program goal to enhance the health of rivers by addressing the root causes of poor water quality and stream habitat. As an example, the Lower Jaramillo Creek project was funded in 2020 under the 2019 River Stewardship Program RFP to restore wetlands and the stream channel to address nutrient and turbidity impairments on a 7-mile stretch of Jaramillo Creek in the Valles Caldera National Preserve. Restoration of the Lower Jaramillo Creek is scheduled to begin this summer.

The New Mexico Legislature appropriated $1.25 million in capital outlay funds for Fiscal Year 2021 and $1.5 million for Fiscal Year 2022 for the River Stewardship Program "to plan, design and construct projects that improve surface water quality and river habitat state-wide." Each year, NMED requests funding from the New Mexico Legislature for the River Stewardship Program to address critical surface water quality needs and to provide state matching funds so New Mexico continues to receive federal Clean Water Act grant funding. Including some older funds that were reauthorized for the River Stewardship Program, this RFP will have approximately $2.9 million available for award to multiple projects that meet River Stewardship Program goals.

The RFP is available to download at:https://www.generalservices.state.nm.us/statepurchasing/active-procurements.aspx.The RFP includes an opportunity for potential applicants to ask questions, and questions are due no later than May 20, 2021. Proposals are due via an electronic submittal process described in the RFP no later than 3:00 PM Mountain time on June 29, 2021.

For more information about the RFP or River Stewardship Program, contact Kate Lacey Mendoza at Kathryn.mendoza@state.nm.us.

Valles Caldera National Preserve, New Mexico. Photo Credit: Keystone Restoration Ecology

Watershed-Based Planning Solicitation for Applications

By Abe Franklin, WPS Program Manager

The Surface Water Quality Bureau is pleased to announce plans to release a Solicitation for Applications (SFA) for watershed-based planning (WBP) projects in June. This SFA will be similar to the previous SFA for WBP projects, which is still available at www.env.nm.gov/surface-water-quality/funding-sources.

The SFA will solicit applications to develop or update comprehensive WBPs to identify and build the methods, programs, and partnerships required for eligible streams to meet their water quality standards. Each new planning project must address at least one total maximum daily load (TMDL) for an impaired stream, or develop a hydrologic solution to a water quality problem in a limited category of streams without TMDLs (Category 4C streams). Also eligible is New Mexico's only stream in assessment Category 4B, Sandia Canyon (near Los Alamos). Streams in Category 4B are thought to have adequate planning such that a TMDL is not required, but their plans may need to be updated or expanded.

Projects funded under the SFA will require a minimum forty percent non-federal match, which may consist of cash expenditures or in-kind contributions of labor, equipment, and materials. The SFA will include opportunities for potential applicants to ask questions. The SFA will be open for approximately sixty days. Applications will be submitted via email. More information about watershed-based planning, including guidance on developing WBPs, is available at www.env.nm.gov/surface-water-quality/wbp. More information on the SFA including an application form and instructions will be posted at www.env.nm.gov/surface-water-quality/funding-sources. For more information about the SFA, please contact Abe Franklin at abraham.franklin@state.nm.us.

To be notified of SWQB goings-on including the SFA and the RFP described above, please add yourself to the SWQB email list, by clicking here.

EVENTS & ANNOUNCEMENTS

April

April 30th - May 4th. Belen - Join the Valencia Soil & Water Conservation District for their Earth Day Science Fiesta Events and City Nature Challenge 2021. During the dates of April 30th through May 3rd, they are having various local organizations hosting several fun activities to help celebrate Earth Day and the importance of connecting with the local environment. During those same dates, they also have several guided hikes you can register for to take part in the worldwide Nature Challenge 2021 while learning about the common wildlife at Whitfield Wildlife Conservation Area. Each hike will be approximately 1 to 1.5 hours. For more information: https://www.valenciaswcd.org/calendar-of-events-1/

May

May 14th - May 16th. Ft. Union Ranch near Watrous, NM - Join Albuquerque Wildlife Federation and the Hermit's Peak Watershed Alliance to restore Higgins Canyon on Fort Union Ranch. Our restoration activities are part of a larger, landscape-scale conservation effort that includes the nearby Rio Mora National Wildlife Refuge. During this project, volunteers will hand-build rock restoration structures designed by Bill Zeedyk to help hold water on the landscape and improve the habitat for riparian plants and the wildlife they support. For more or to sign up: Contact Scial at 505-480-2906, or by email at rioscial@gmail.com or the AWF's website; abq.nmwildlife.org/projects.html.

Save the Date

July 22, 23 & 24. Wagon Mound, NM. Ranch Water Conservation Workshop and Road Drainage Workshop at Wagon Mound. Three Information Packed Days in a Row to Help You Better Manage Your Water Resources. Thursday July 22, 2021: Ranch Water Conservation Workshop Sponsored by Bats International, NRCS, Rangeland Hands, Inc. and Sol Ranch. Friday and Saturday July 23 and 24, 2021 Ranch Road Water Harvesting Road Drainage Workshop Sponsored By Rangeland Hands, Bats International, Turner Brothers Ranch and Various Local Donors. More Information Forthcoming. Contact: Steve Carson 505-470-3542 rangehands@gmail.com.

Announcements

The Pueblo of Laguna's Surface Water Quality Program will be seeking proposals for the development of a Watershed Based Plan. The request for proposal is still being developed. If you would like to be notified when the RFP becomes available, please contact E. Nikki Woodward via email: ewoodward@pol-nsn.gov
CONTACT: E. Nikki Woodward Water Quality Specialist | Pueblo of Laguna | Office: 505.552.5040

Share with Wildlife call for project information was released in March, 2021 with proposals due May 28th, 2021. The call will be posted on the Share with Wildlife page (Applications-Reports tab) when it is released: http://www.wildlife.state.nm.us/conservation/share-with-wildlife/
Contact: Ginny Seamster virginia.seamster@state.nm.us

If you have a related event that you would like distributed, please send an email to susan.styer@state.nm.us