

WELCOME & INTRODUCTION
to the
WORKSHOP ON THE SIGNIFICANCE OF CAVES IN
WATERSHED MANAGEMENT AND PROTECTION IN FLORIDA
April 16 & 17, 2003
Dr. Walt Schmidt

On behalf of the Department of Environmental Protection (DEP) / Florida Geological Survey, and the Hydrogeology Consortium, I welcome you to the *Workshop on the Significance of Caves in Watershed Management and Protection in Florida*. Just as one of our prior workshops was appropriately held here last May (titled: *Workshop to develop blue prints for the management and protection of Florida springs*) this location again is a natural and logical place to discuss caves, and their significance to our understanding the dynamics of groundwater movement. The Ocala, Marion County area is high on the Florida Platform and upper Eocene limestones that comprise the top of the Florida aquifer system in the area are located close to the land surface. As a result we have many landforms associated with karst geology readily observable in the vicinity. Sinkholes, caves, and springs are abundant and common, and contribute to make the area beautiful and famous. We all know of the world famous Silver Springs just east of here, and the equally well known rolling karst hills covered in rich grasses famous for their horse farms.

Anyone that has looked at a satellite photo or high altitude photograph of the State of Florida immediately notes the many circular lakes we have. And the fact that many of these lakes are not interconnected to each other. Many of these surface water features are the manifestation of surface erosion mechanics in conjunction with mechanical and chemical subsurface weathering of limestone's and dolostones. This "internal" drainage into the underlying rock layers has been occurring for millions of years and continues today. Where does the water go, if not drained off via surface streams? Well, our vast underground aquifers are as plentiful as they are because of this long standing dissolution of the carbonates. The prolific nature of the Floridian aquifer system is the result of millions of years of slightly acidic surface water entering the ground and dissolving away rock leaving behind voids and increased porosity. And these voids are interconnected thereby allowing groundwater replacement and movement in the subsurface. It's hard for the layman to comprehend how riddled with pore spaces some of our limestones and rock layers can be. Think for a moment of some photos you have seen, or locations you have visited on various fieldtrips. Visualize the volume of material that has entered subsurface horizons and rock layers from above. The volume of rock, sediment, soil, and water that was consumed at the Winter Park Sinkhole in 1981 (it took one house and a shed, a swimming pool, most of a four lane highway, part of a auto-repair facility, 2 Porsche sport cars – three others and a camper that were retrieved, many trees, and millions of cubic feet of soil / sediment). Think of the Devils Millhopper, Big Dismal, Lake Jackson, or Paines Prairie. There are thousands of examples. When we as geologists have an opportunity to view, this weathered and solution riddled rock when overburden or soil is scrapped off, we are amazed at what we see. Recall the, now famous photo taken by Bill Wisner in 1972, of the Buda limerock mine between Newberry and High Springs, that

showed the honeycomb of round solution pipes. In other instances, we plot depth to “top of rock” from cores and wells in one place, then find that within 100 feet away the same top of rock may be a couple of hundred feet deeper in elevation. Sea level changes, surface erosion, and subsurface solution has greatly modified our landscape and left behind what we see today.

Our departed colleague Bill Wilson reported in 1995 that based on his data and calculations he has estimated between 145-650 buried sinkholes per square mile in upland sites and between 1,200 and 8,700 per square mile in lowland sites. He further reported dissolution openings in the top of the Floridan aquifer ranging from 32,000-1,900,000 per square mile. While these numbers seem daunting themselves, consider he also estimated the cave density in parts of the unconfined Floridan aquifer system. He suggested the open cave density per unit area is typically 670-5,100 miles/mile². This is an enormous amount of cave passages, no wonder we have such large transmissivities. He suggested that such data would call for an average distance between cave passages of between 370 and 500 feet. Meaning no point in the aquifer would be more than maybe 200 feet from the nearest open cave! So,..... IS UNDERSTANDING CAVES AND ASSOCIATED CONDUITS IMPORTANT TO REALLY BEING ABLE TO CONSERVE AND PROTECT OUR AQUIFERS? IS CAVE AND GROUNDWATER DYNAMICS A CRITICAL COMPONENT TO GROUNDWATER PROTECTION, MOVEMENT, CLEAN-UP, AND GENERAL WATER MODELING EFFORTS? We are past the point that the answers to these questions are up for debate! It's clear to the professional hydrogeologic community, understanding cave systems is fundamental to understanding groundwater dynamics.

Caves and their relationships to our aquifers have been known and reported on for some time in Florida. As early as 1674, a Friar with the Spaniards exploring North Florida reported their group spent the night in a cave where more than 200 men could be lodged comfortably, and he went on to say “there was a brook which gushes from the living rock.” He was talking about the caves north of Marianna, we call Florida Caverns. We also have evidence in the form of artifacts of post-Columbian (prior to about 1500 AD) use of various caves by the earliest of human occupation of the area. Other records and various stories document Indian use of caves and use made during the Civil War. I know student chapters of the National Speleological Society (NPS) at FSU and other Universities have for decades gone out on caving trips and provided many surveyed and mapped reports of their fieldwork.

During the past two to three decades many professional cave diving groups such as the Cave Diving Section of the NPS, the National Association for Cave Diving, the U. S. Deep Caving Team, the International Association of Nitrox and Technical Divers, and the continuous local efforts of the Wakulla Karst Plain Projects team, have gathered an enormous amount of submerged cave data and mapped passage information. Some of the most highly respected members of the international professional cave diving community, reside and work in Florida and have shared their expertise and results of their work with other professionals so that we may understand our aquifer dynamics a little better, with the benefit of an “eye-witness.” The continuing contributions and cooperative efforts

between the professional cave diving community and our hydrogeology professionals is a natural and critical marriage to better understand and conserve our groundwater resources and these unique subterranean environments.

The Springs Task Force made numerous recommendations to further our knowledge and ability to protect and conserve our spring's resources. Knowing that springs are but one component of our karst landforms, and all the surface / subsurface features are interrelated, the Task Force recommended a comprehensive database be compiled to include these features and their surveyed maps. The Florida Geological Survey has coordinated with many professionals to instigate such an endeavor. One glitch in the effort, however, is the obvious concern for locational information to be made public for the many pristine springs and cave entrances. The FGS has proposed legislation to allow such data to be filed and maintained in a confidential manner in accordance with the instructions of the source of the information and or owner of the property. This however, is not being pursued this year due to other priorities within the DEP.

General and detailed understanding of karst features and subsurface hydrogeology is fundamental to the protection and hoped for cleanup of contaminated aquifers within our state. We at the FGS are involved in surface geologic mapping, subsurface detailed lithologic descriptions, and the spring's initiative with numerous in-house and contracted studies, and upgrading the DRASTIC maps with the Florida Aquifer Vulnerability Assessment (FAVA) project adding karst features. The subsurface caves and conduits clearly are a critical and important part of our overall understanding of our aquifer dynamics, groundwater transport, and surface water / groundwater interactions. So, you are the "choir" and we all know that. But coming together in a workshop such as this, helps us focus our efforts, and helps us speak with one voice when elected and appointed government officials ask us for input or for our professional opinion on recommendations to conserve and protect our groundwater resources. As individual scientists, geotechnical engineers, professional cave divers, etc, we appropriately disagree on things, maybe that's an understatement. But, workshops such as this help us form common ground for the big picture, and having a consistent message from the geoscience and hydrogeologic community to decision makers is important for our credibility.

This workshop is divided up into three general focus topics to initiate discussions. First is: *Bridging the Gap between Cavers & Scientists*, second is: *Utilization of Cave Data in Hydrogeological Investigations*, and last; *Cave Resource Management; Politics, Public Relations, and Funding*. Choose the group which interests you the most, or amble back and forth between groups. Thank for your interest and participation. We look forward to an interesting and useful couple of days.

c/Geo Invest/Hydrogeology

Significance of Caves in Watershed Management and Protection in Florida: April 16th and 17th, 2003, Ocala, FL

Plenary Session	Panel Discussions	Special Presentations	Panelists and Speakers
Sponsors of the workshop included: Florida Department of Environmental Protection, Florida Geological Survey, the Hydrogeology Consortium, and Hazlett-Kincaid, Inc.			
Agenda	List of Attendees - pdf - Excel worksheet	Florida Springs Protection Award	
			
			
			
The Woodville Karst Plain from space. Photo Courtesy NASA			

Special Presentations

(Note: some of these files are large and may take a few moments to view. Downloading to your computer may quicken the process)

[A Cave Database](#)

Mr. Al Krause
Cave and Karst Resource

Mr. Krause presents his work on the development of a database on Florida caves, which currently contains location and descriptive information as well as maps and photos for more than 4000 caves in Florida. [Cave Discharge Measurement](#)

Mr. Pete Butt
Karst Environmental Services, Inc.

Mr. Butt discusses the design and implementation of Karst Environmental's discharge measurement apparatus that can be installed inside caves to accurately measure cross-conduit velocity profiles and thereby discharge from spring vents and individual tunnels within an underwater cave.

Cave and Karst Education

Dr. Todd R. Kincaid
Hazlett-Kincaid, Inc.

Dr. Kincaid discusses the components of the Florida Geological Society's educational exhibit and video on Florida's karst ground water resources. The exhibit is comprised of a set of informative posters and a 25 minute video that will be made available for public use by the Florida Geological Survey. Contact Dr. Jon Arthur at the Survey for more information on how you can obtain a copy. **Water's Journey**

A Florida Springs Expedition

Mr. Wes Skiles
Karst Productions

Mr. Skiles presented his new high definition film "Water's Journey" on Florida Springs. The film takes the viewers on a journey from the spring recharge basins, through underwater caves, up from the springs and to rivers downstream. To learn more go to www.floridasprings.org/expedition/

Florida Springs Protection Award



Jim Stevenson Presented the Florida Springs Protection Award to:

Al Burt

Al Burt worked as a journalist for 45 years, the last 22 of which he spent as a roving Florida columnist for the *Miami Herald*. The recipient of numerous journalism awards, he has been a freelance contributor to many magazines, including *The Nation* and *Historic Preservation*, and is the author of several books, among them *Florida: A Place in the Sun* (1974), *Becalmed in the Mullet Latitudes* (1984) and *Al Burt's Florida* (1997). In his honor, the 1,000 Friends of Florida established the annual Al Burt Award for Florida journalism. (University Press of Florida)



Final Workshop Agenda

April 16-17, 2003

Ocala Florida (Ocala Hilton)

Day 1: April 16

0730 - 0830	Registration & Continental Breakfast
0830 - 0850	Welcome & Introduction - <i>Dr. Walt Schmidt (FGS)</i>
0850 - 0905	Workshop Overview - <i>Dr. Rodney DeHan (FGS)</i>
0905 - 0915	Breakout to Focus Groups
0915 - 1230	Focus Group Presentations & Deliberations

	Bridging the Gap <i>Dr. Rick Copeland Moderator</i>	Utilization of Cave Data <i>Dr. Jon Arthur Moderator</i>	Cave Resource Management <i>Dr. Rodney DeHan Moderator</i>
0915 - 0935	Mr. Wes Skiles <i>Cave Explorer & Videographer</i> <i>Karst Productions</i>	Dr. Todd Kincaid <i>Karst Hydrogeologist & Cave Explorer</i> <i>Hazlett-Kincaid, Inc.</i>	Mr. Ron Kerbo <i>Resource Manager</i> <i>National Park Service</i>
0935 - 0955	Mr. Jarrod Jablonski <i>Cave Explorer & Instructor</i> <i>Global Underwater Explorers</i>	Dr. Steve Worthington <i>Karst Hydrogeologist</i> <i>Worthington Groundwater</i>	Ms. Sandy Cook <i>Park Director & Resource Manager</i> <i>Wakulla Springs State Park</i>

0955 - 1015	Dr. Sam Upchurch <i>Karst Hydrogeologist SDII Global</i>	Mr. Geary Schindel <i>Karst Hydrogeologist & Resource Manager Edwards Aquifer Authority</i>	Mr. Casey McKinlay <i>Cave Explorer Woodville Karst Plain Project</i>
1015 - 1030	Break		
1030 - 1050	Ms. Angela Chellette <i>Resource Manager NFWFMD</i>	Mr. Hal Davis <i>Groundwater Modeler USGS - Tallahassee</i>	Mr. Tom Morris <i>Cave Explorer & Biologist Karst Productions</i>
1050 - 1110	Mr. Gary Maddox <i>Resource Manager FDEP</i>	Mr. Joe Meiman <i>Karst Hydrogeologist & Resource Manager Mammoth Cave National Park</i>	Mr. Harley Means <i>Resource Manager FDEP</i>
1110 - 1200	Focus Group Deliberations		
1200 - 1330	Lunch with Luncheon Presentation by Dr. Tom Scott of the FGS		
1330 - 1345	Return to Focus Groups		
1345 - 1515	Focus Group Deliberations		
1515 - 1530	Break		
1530 - 1700	Focus Group Deliberations		
1700 - 1730	<i>Special Presentations</i>		
	A Cave Database Mr. Albert Krause <i>Cave & Karst Resource</i>	Cave Discharge Measurement Mr. Peter Butt <i>Karst Environmental Services</i>	Cave & Karst Education Dr. Todd Kincaid <i>Hazlett-Kincaid, Inc.</i>
1700 - ?	<i>Mixer sponsored by Earth Tech Inc. of Orlando Florida</i>		

Day 2: April 17

0800 - 0830	Continental Breakfast & Mixer
0830 - 0840	Reconvene Plenary Session
0840 - 0855	Overview of Focus Group 1 Progress
0855 - 0910	Overview of Focus Group 2 Progress
0910 - 0925	Overview of Focus Group 3 Progress
0925 - 0940	Return to Focus Groups
0940 - 1110	Focus Group Deliberations
1110 - 1125	Break
1125 - 1200	Focus Group Deliberations
1200 - 1230	Preparation of Focus Group Findings

1230 - 1400	Lunch with Presentation of " Water's Journey " by Wes Skiles
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1400 - 1415	Presentation of The Florida Springs Protection Award to Mr. Al Burt by Mr. Jim Stevenson
1415 - 1425	Reconvene Plenary Session
1425 - 1445	Presentation of Findings from Focus Group 1
1445 - 1505	Presentation of Findings from Focus Group 2
1505 - 1525	Presentation of Findings from Focus Group 3

1525 - 1540	Concluding Remarks - Dr. Walt Schmidt (FGS)
1540	Adjourn Workshop

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Utilization of Cave Data in Hydrogeological Investigations

● Panelists

- Dr. Todd Kincaid, Hazlett-Kincaid, Inc.; Data collection considerations at Wakulla Springs
- Dr. Steve Worthington, Worthington Groundwater; Modeling issues related to the Mammoth Cave System
- Mr. Geary Schindel, Edwards Aquifer Authority (EAA); resource management issues and importance of cavers, cave data and communication
- Mr. Hal Davis, US Geological Survey; Use of cave data in Wakulla Springshed
- Mr. Joe Meiman, Mammoth Cave National Park; Resource Management issues and application of data in the Mammoth Cave System.

A vertical strip on the left side of the slide shows a topographic map of a karst area. It features contour lines, a network of cave passages, and a river. The map is color-coded with greens, yellows, and browns, and includes a scale bar and a north arrow.

Discussion topics

- Cave study template
- Need for MODFLOW modifications
- Incorporating cave data in hydrogeological studies
- Karst Data Management
- “VISKA” Very Intensely Studied Karst Area



Karst data management: need for centralization and standardization

- Data types:
 - Springs WQ
 - Sinkholes
 - Lineaments
 - Dye traces
- Reports and presentations repository
- Proposal for FGS to maintain data repository

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- Tracer methods/types
 - Contamination/spills
 - Temperature
 - Color
 - Fluorescent, biological (phage), radioactive, microspheres
 - Input and sample points: Conduits, wells, tubing, homeowner tap
 - Permitting?
 - DEP/DOH roles; WQ sampling protocols; coordination to avoid interference
 - Need for centralized data
 - Karst Environmental Services protocols – a model
 - Reporting requirements
 - Confidentiality issues (3-5 years?)
 - Security issues
 - Proposal: DEP/FGS to maintain statewide map of tracing results
 - Utilize MOA with organizations?

A vertical strip on the left side of the slide shows a topographic map of a karst area. It features contour lines, a network of streams, and several small black dots representing wells or monitoring points. The map is oriented vertically, with the top of the strip at the top of the slide.

“VISKA” Very Intensely Studied Karst Area (GW Demonstration Basin/Project)

• Desired characteristics

- Scale/size: 2nd mag springshed or part of 1st mag?, Fan/Man? Subset of Wakulla?, SRWMD areas Suwannee Farms, Ocala Natl. Forest (i.e. Silver Glenn); SWFWMD: Weeki Wachee?
 - Cost factors
 - Political issues and “connections”
 - Conservation easements
 - CREP program (Mammoth Cave) as cost-share model; NRCS examples
- Available historical data
- Depth <400’
- Land-use – ability to modify or implement BMPs and monitor results



“VISKA”

- Models to consider
 - Univ. Arkansas
 - USF
- Conduit characteristics: sat/unsat
- Good lithostratigraphic and hydrostratigraphic control
- Need more than one site? Yes!
 - Applications
- Protection of VISKA – public education, signage, conservation easements



“VISKA”

● Potential studies within a “VISKA” :

- SW/GW interaction
- GW flow model calibration
- GW dating
- FAVA validation
- Contaminant transport
- Tracer studies
- BMP issues related to stormwater ponds
- Speleogenesis
- Springshed delineation
- Surface geophysical investigations—WQ, cave detection, lithology
- BMP demonstration – did the BMPs work? How well?
- Total Maximum Daily Loads
- Minimum Flows and Levels



“VISKA”

■ Outreach/education

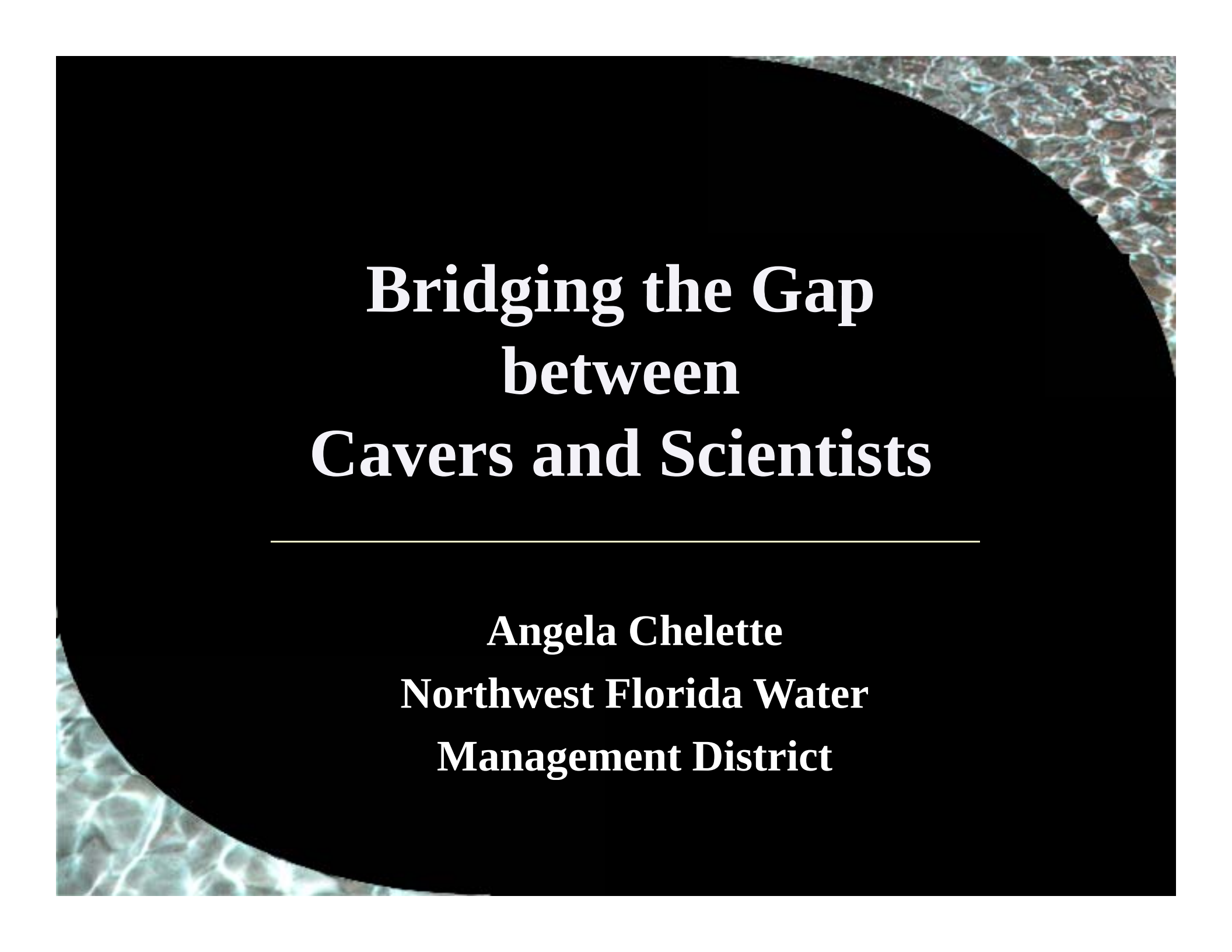
■ Funding approach

- Sell idea in the framework of solving a WMD/DEP problem (i.e. TMDL)
- ID a focus/pilot study
- Proposal
 - Initial “Strawman” document – non-site specific, “float” it out for review/reply
 - A steering committee comprised of 5WMD, USGS, FGS, FPS DEP, State Univ., DCA, Dept. Ag., NSS-CDS, HC, NACD, GUE, Dept. of State:
 - Hire consultant to initiate and “shepherd” the issue forward
 - Who’s on first... obtain funding first or select site and/or perform research first, then propose idea?
- Viska Access
 - Proposals?
 - Committee approval?



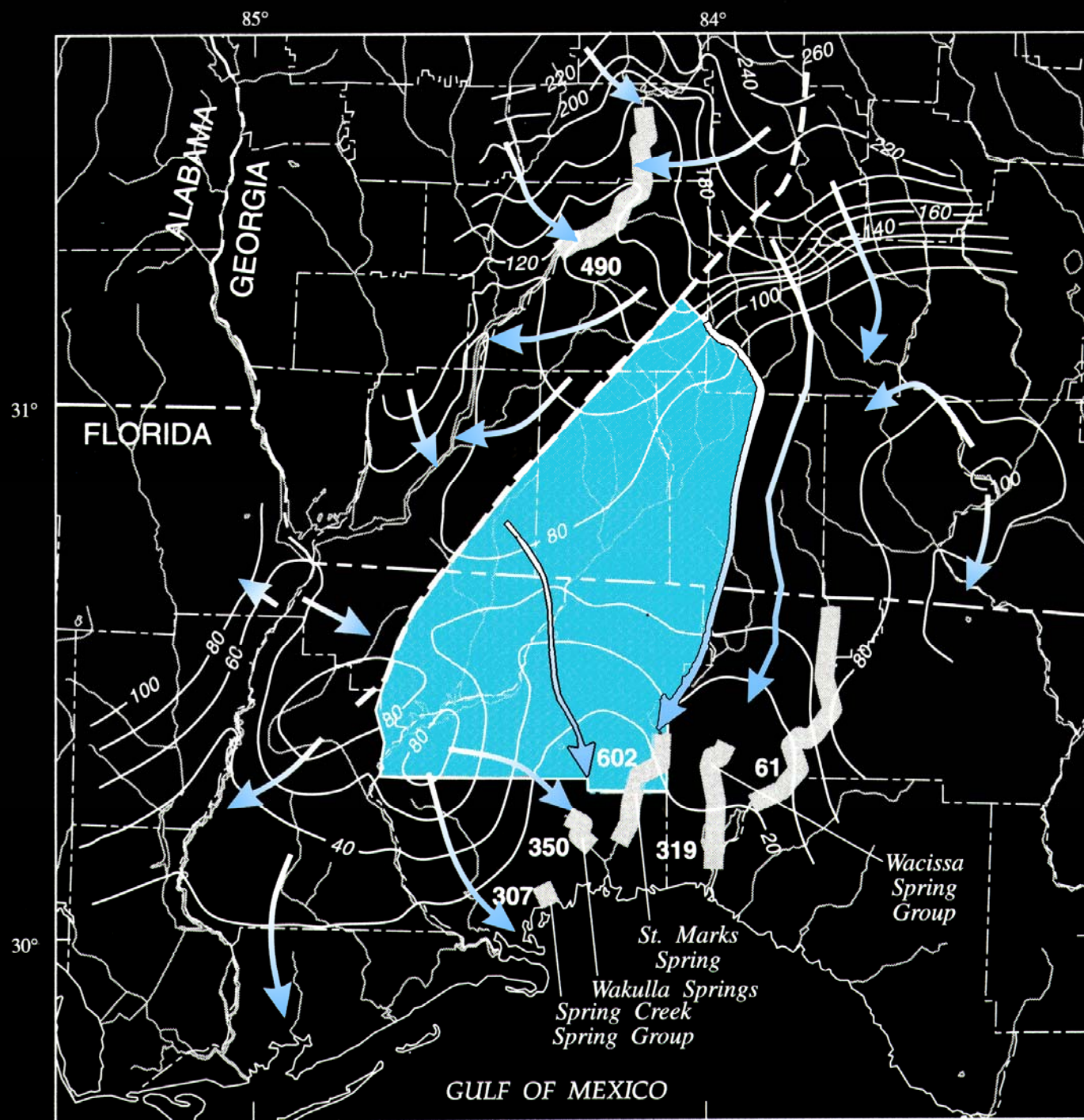
“VISKA”

- How to fund?
 - Partnerships – Nature Conservancy, Universities, USGS, NSF, NSS, 1000 Friends, DEP/EPA SWAP, USACOE
 - Demonstrate successes of applied hydrogeological studies that solve a high-priority environmental problem
 - “dark water” origins in Wakulla
 - SKAs in SWFWMD – retention ponds
 - Sell, sell, sell... “Marketing” of idea

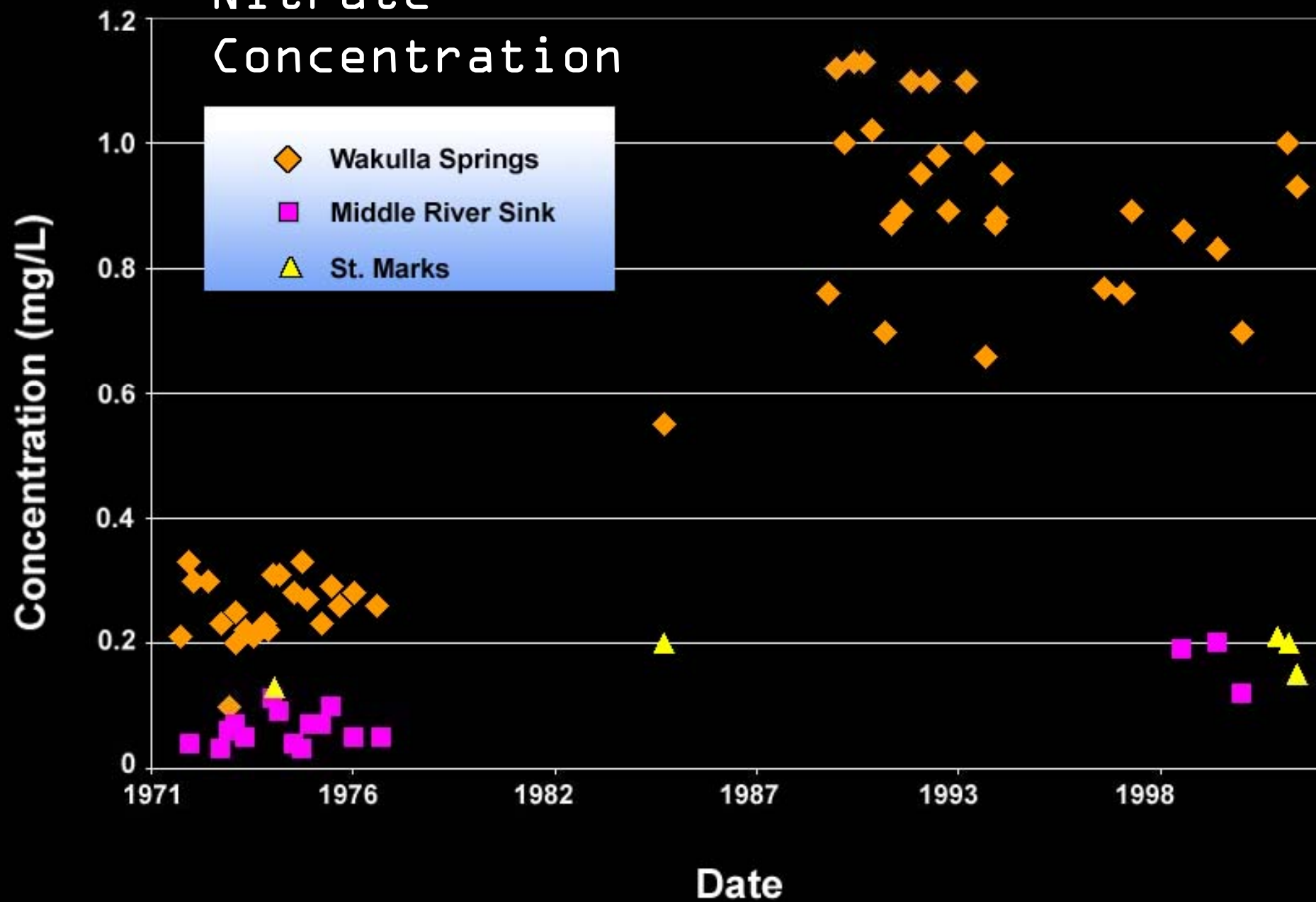
The background of the slide features a close-up, high-contrast photograph of water ripples, creating a textured, shimmering effect. A large, solid black semi-circle is positioned on the left side, partially overlapping the water image and serving as a backdrop for the title text.

Bridging the Gap between Cavers and Scientists

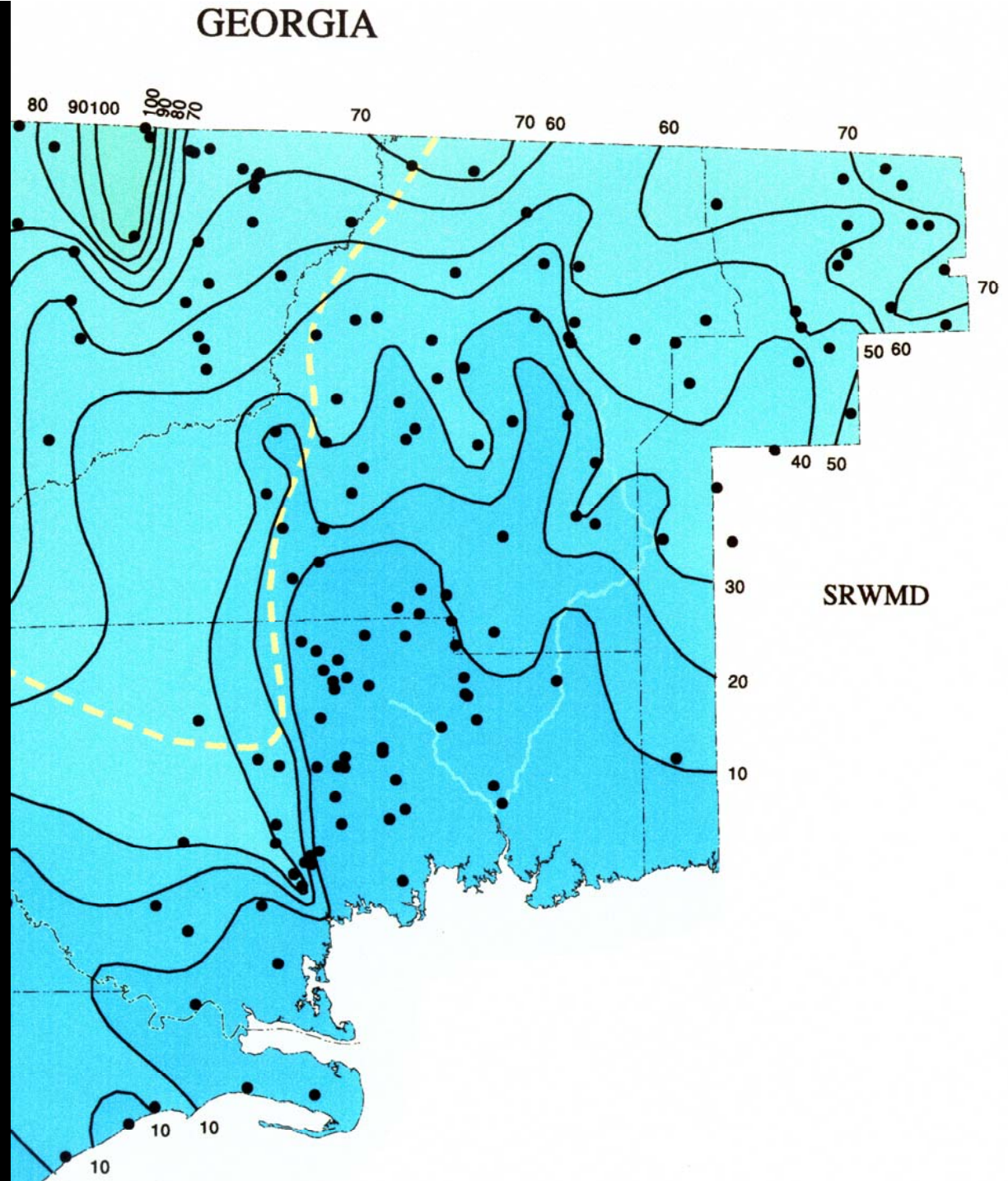
**Angela Chelette
Northwest Florida Water
Management District**



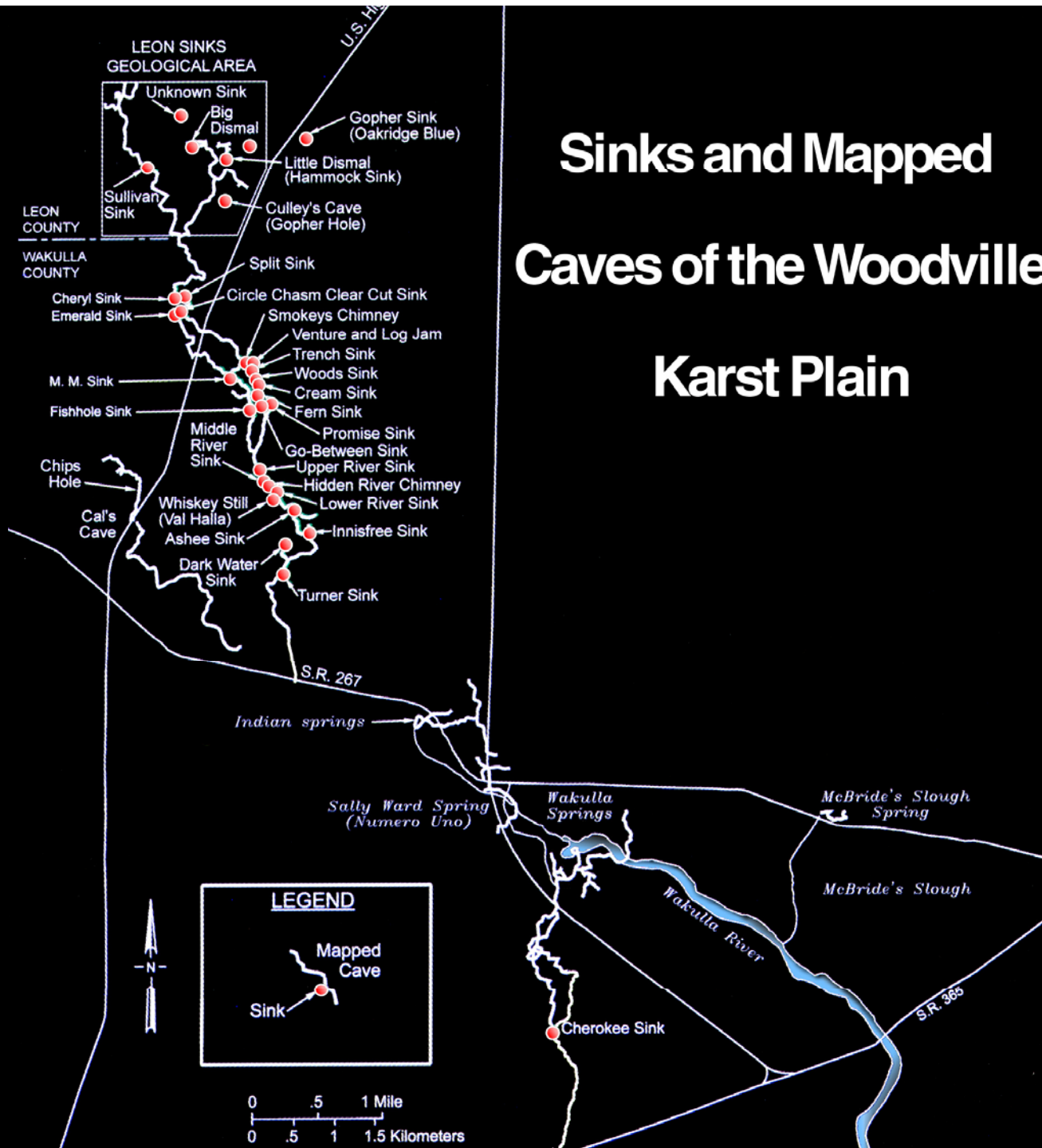
Nitrate Concentration



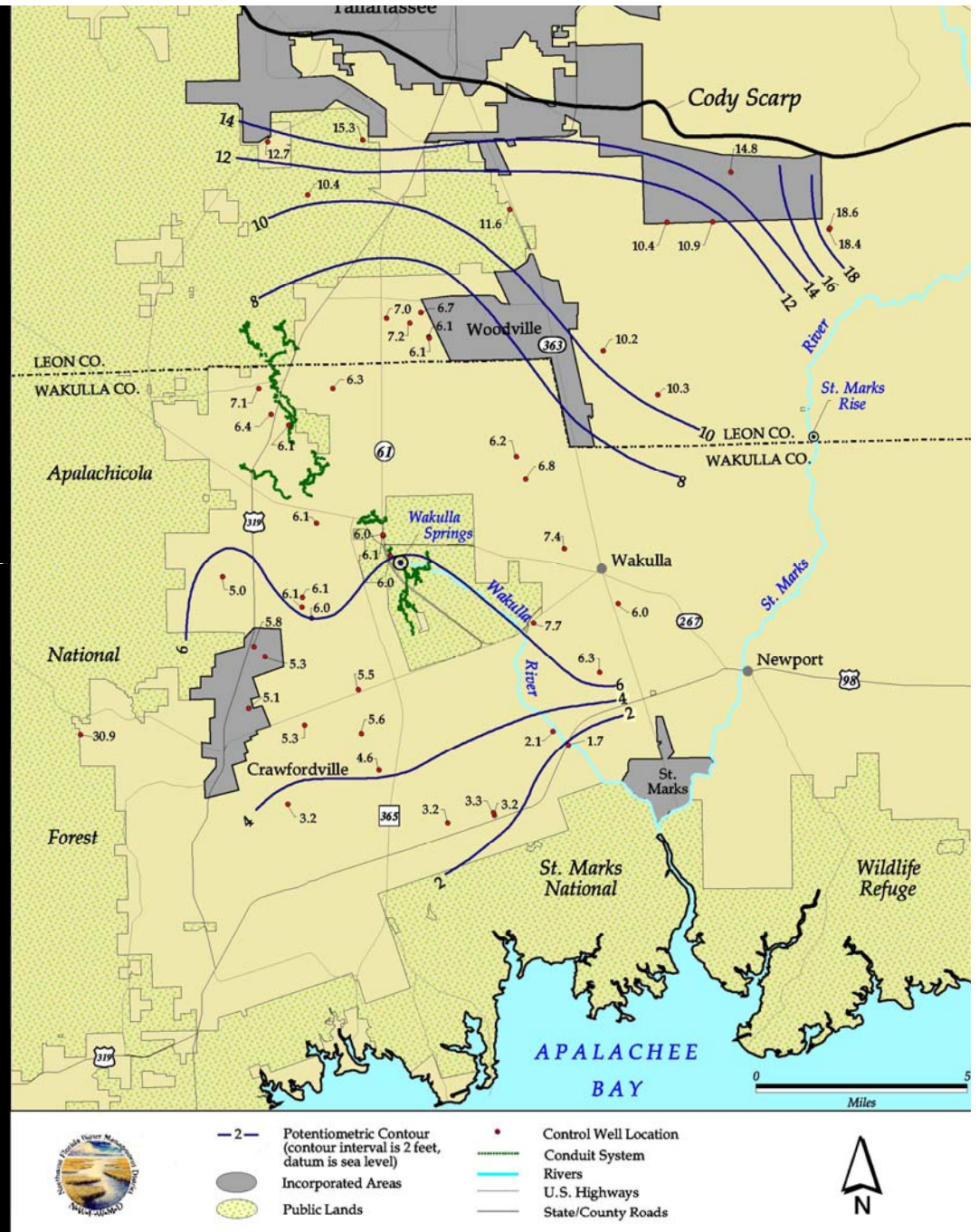
1986 Floridan Aquifer Potentio- metric Surface



Sinks and Mapped Caves of the Woodville Karst Plain

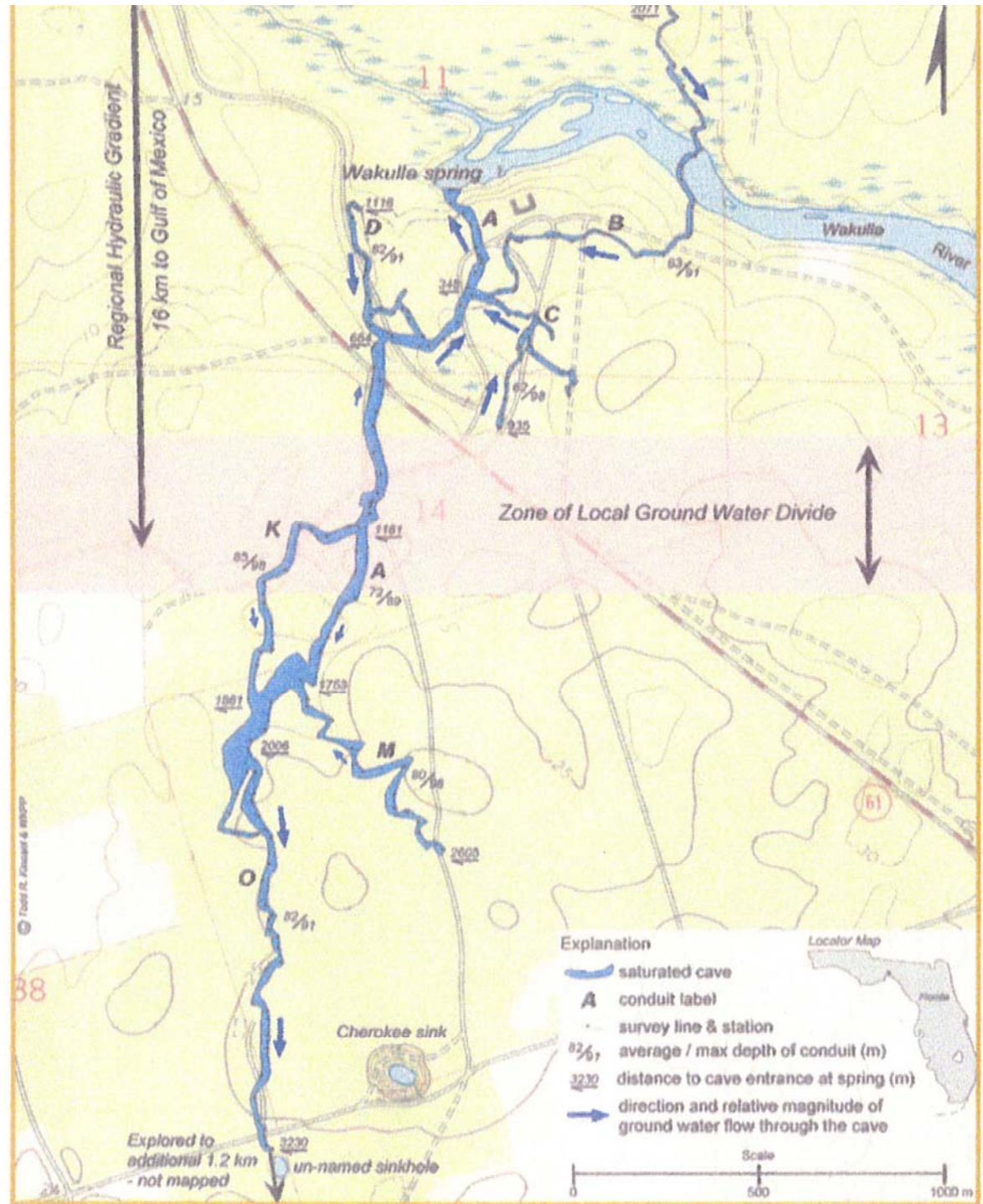


Floridan Aquifer Potentio- metric Surface Southern Leon and Wakulla Counties March 2000

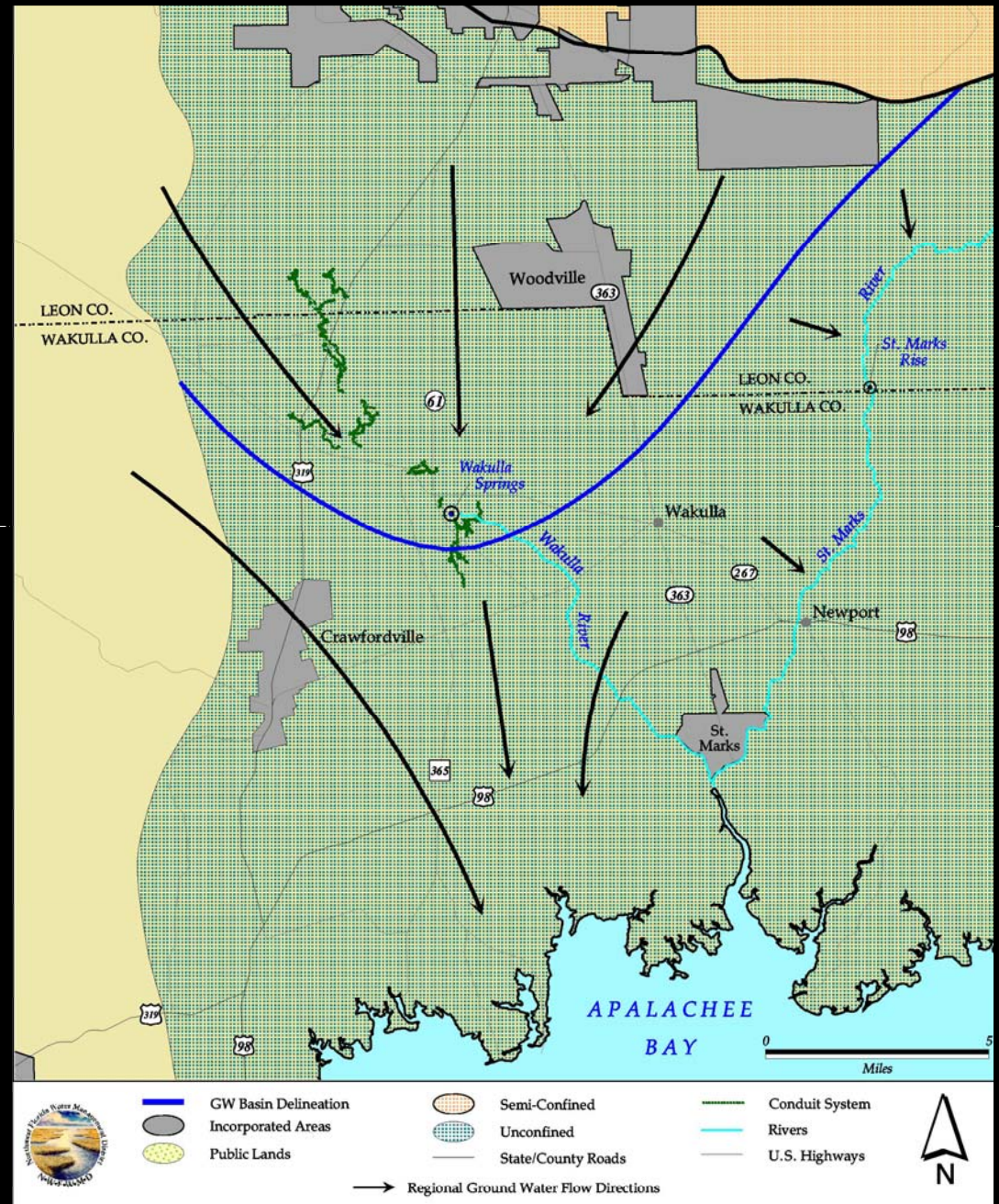


Zone of Local Ground Water Divide

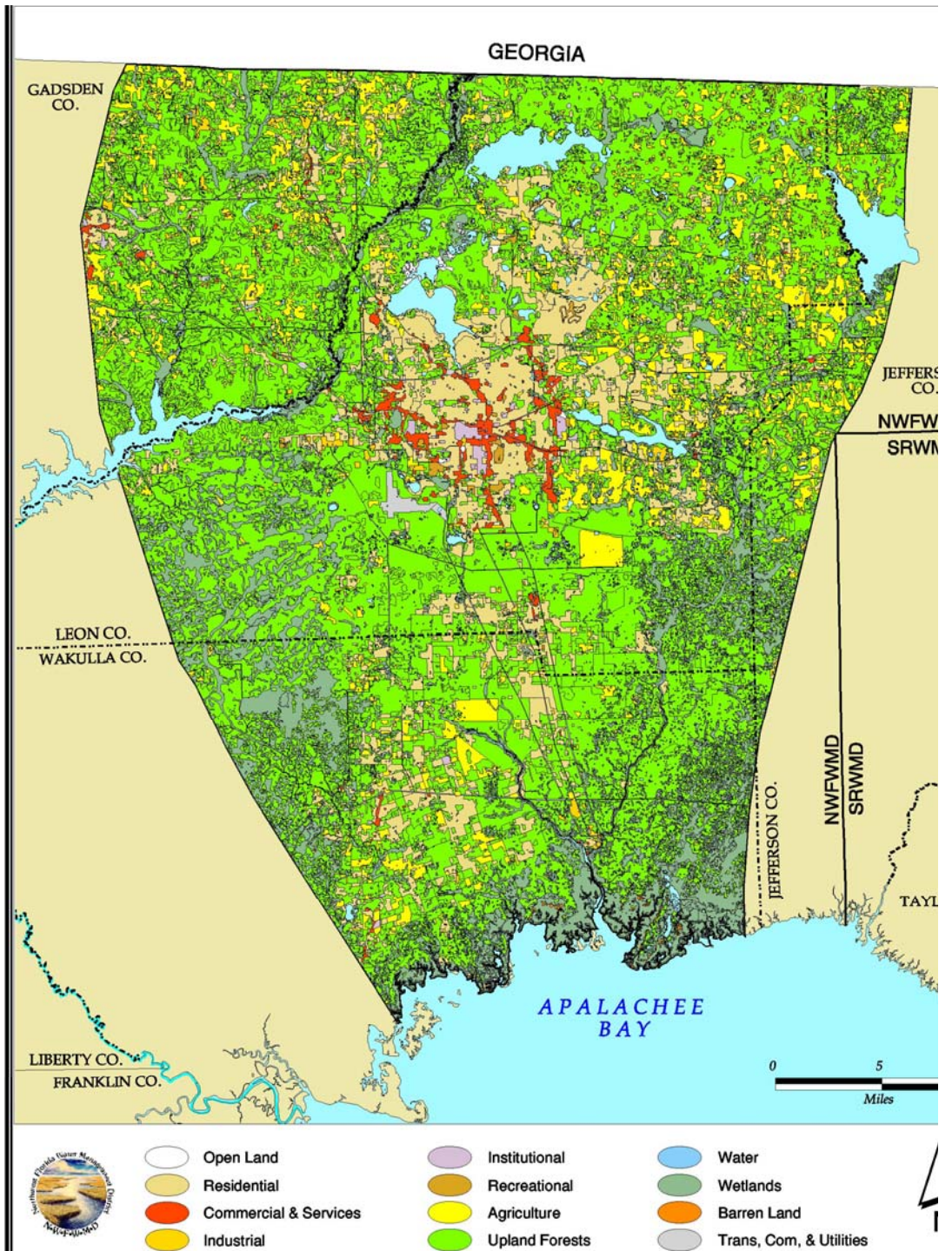
Chris Werner,



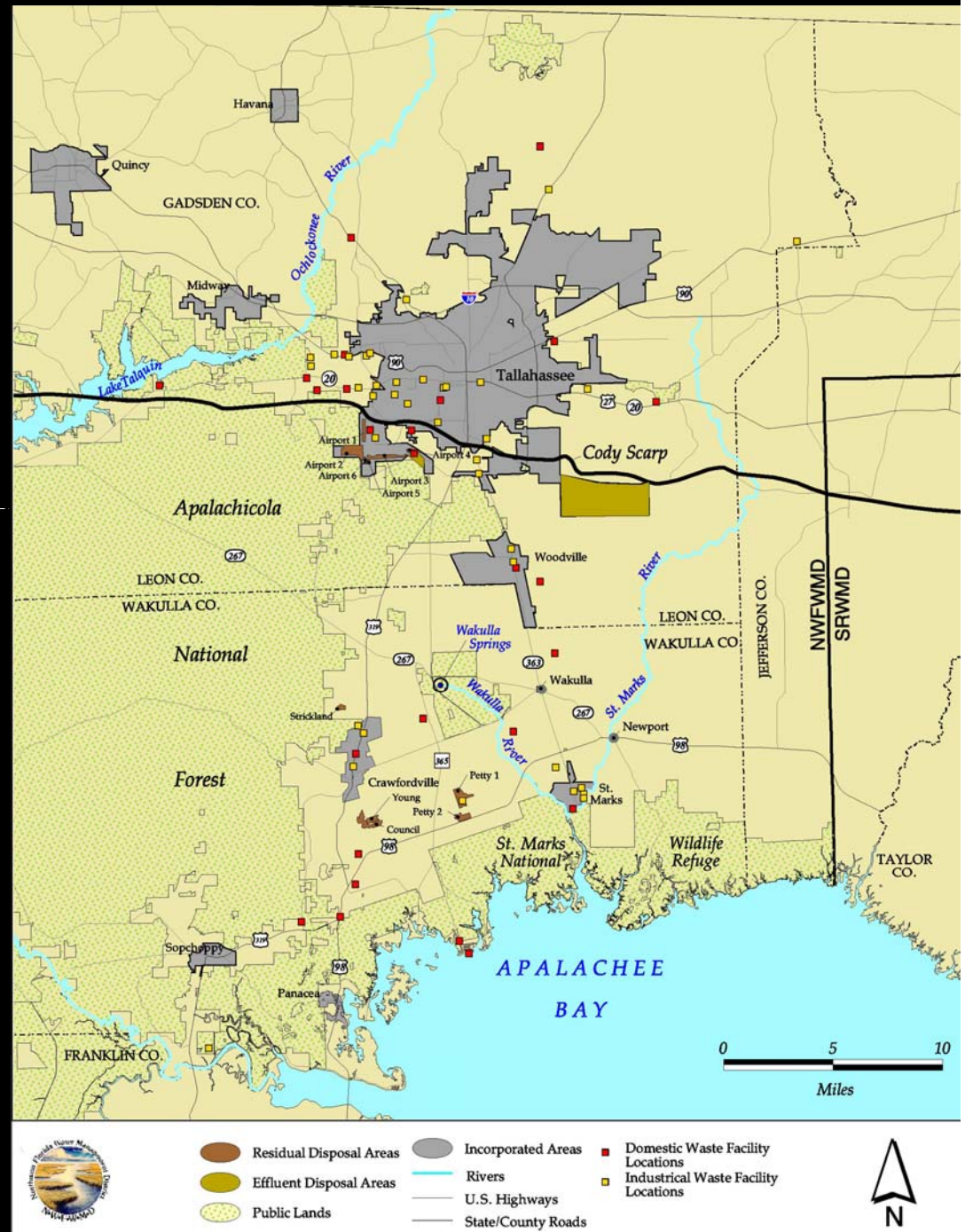
Ground Water Flow Directions



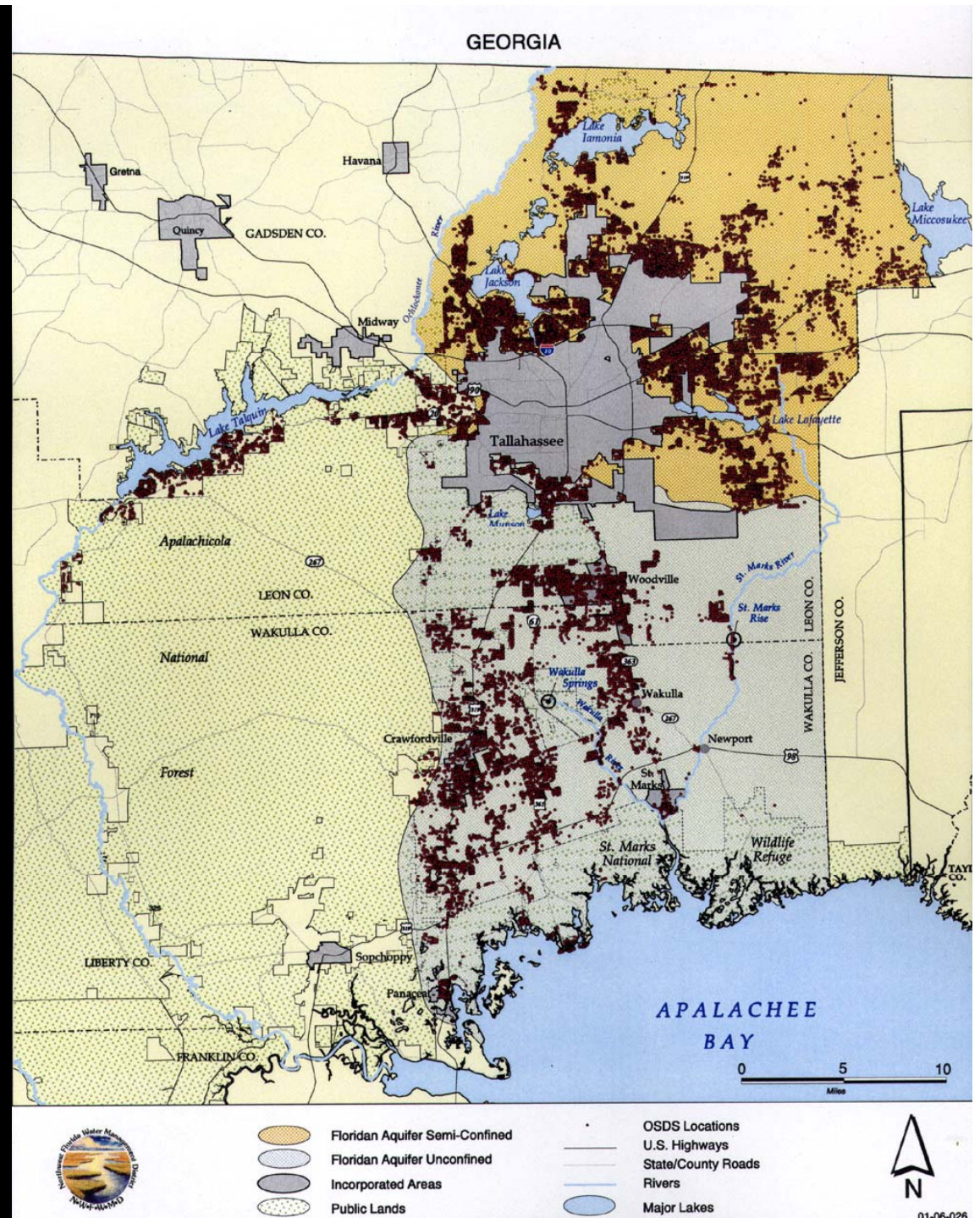
Land Uses



Waste Water Treatment Facility Effluent and Residual Disposal Areas

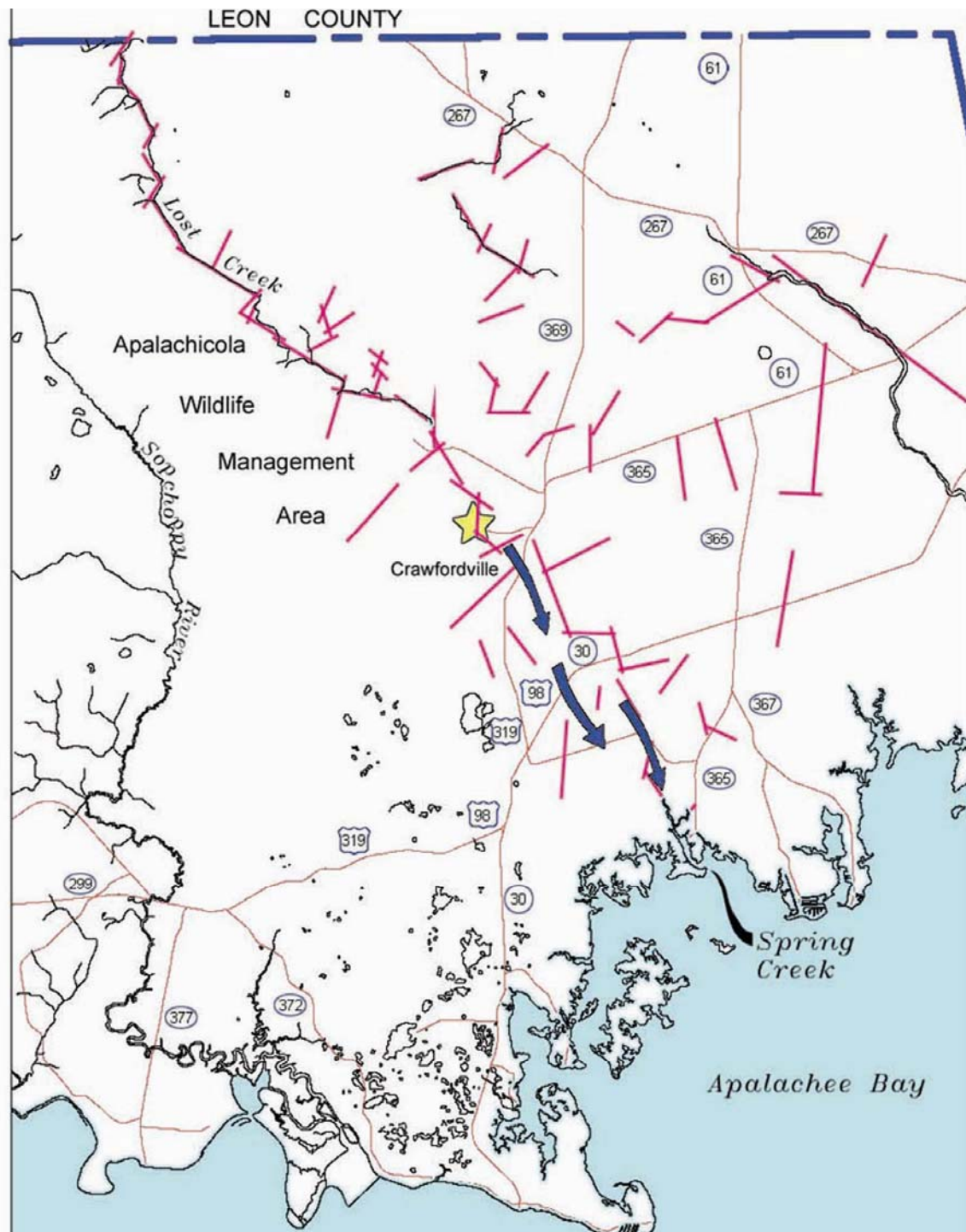


OSDS Locations



Lineaments based on Stream Segments & Other Surface Water Drainage Features

From Ed Lane, FGS

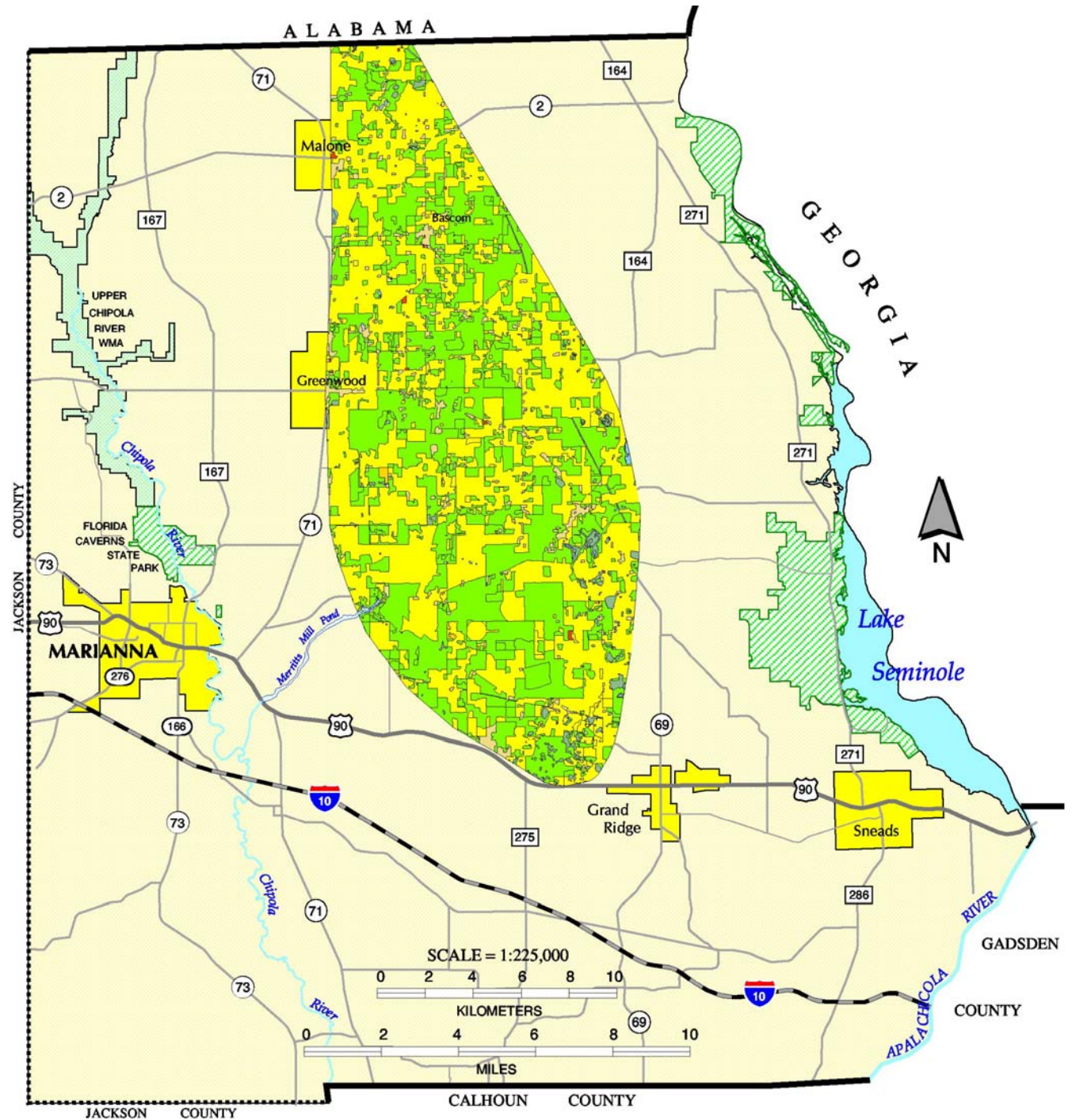


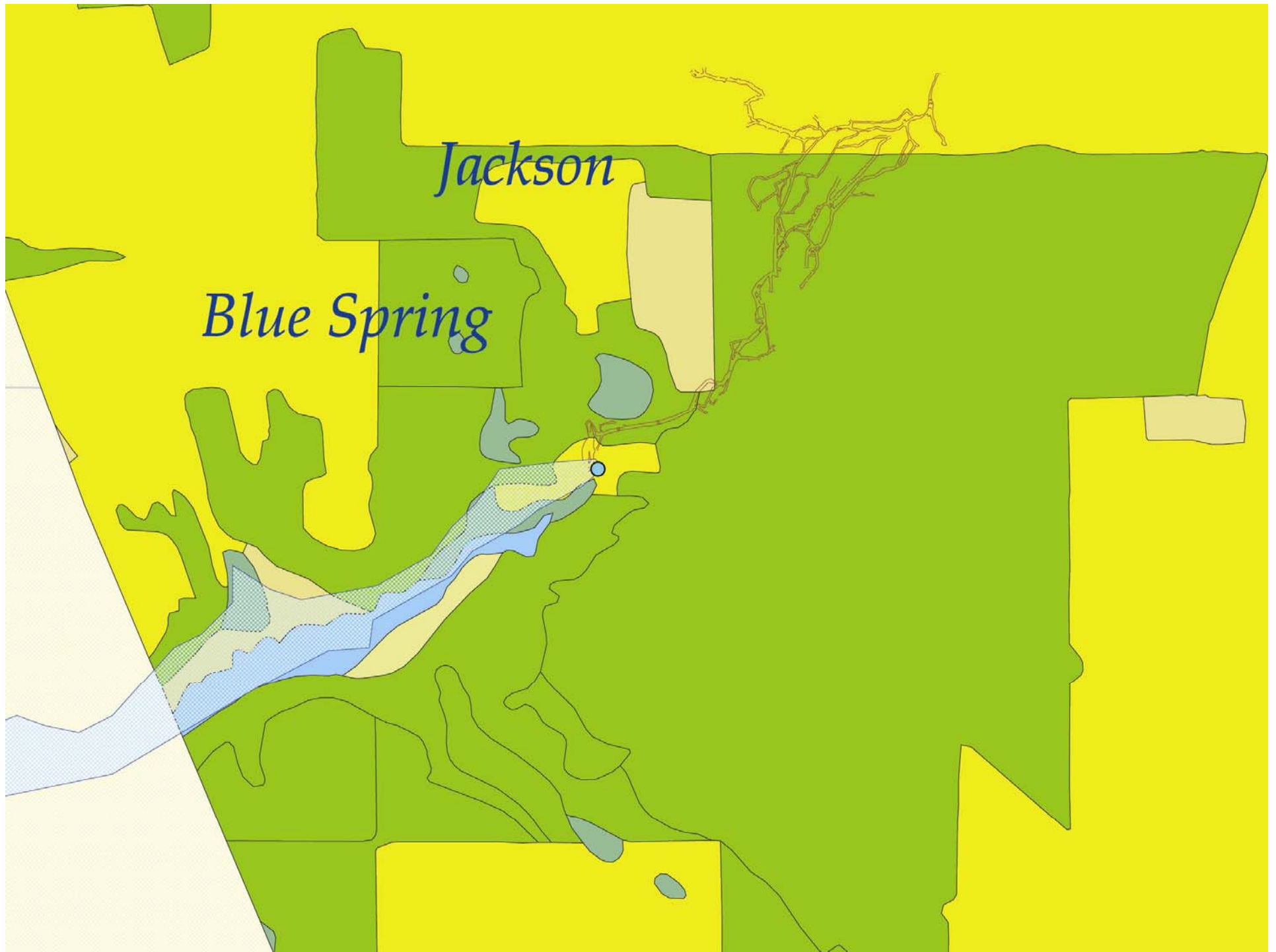
Jackson Blue Spring Conduit System

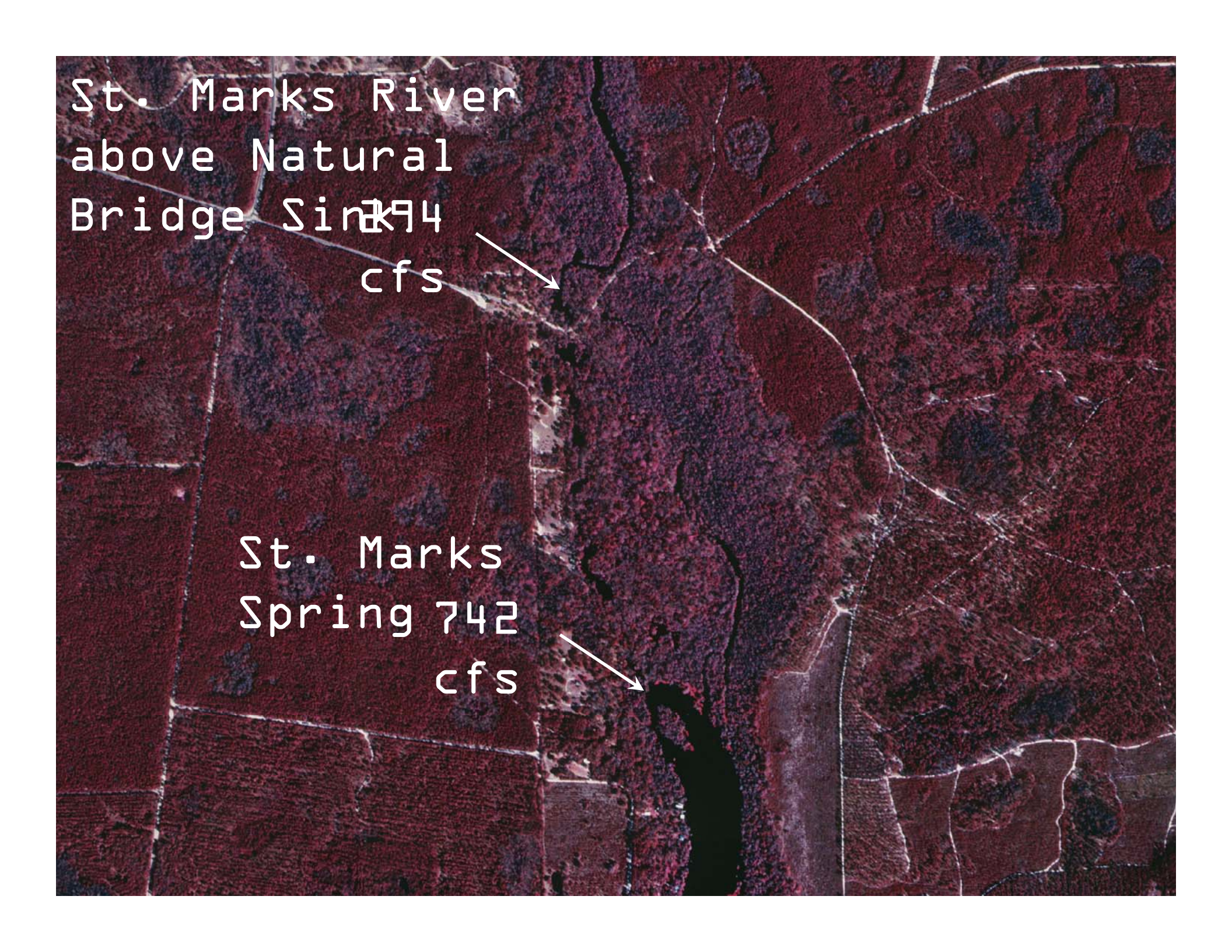
From FDEP GIS
Section



Jackson Blue Spring Land Use in Capture Zone







St. Marks River
above Natural
Bridge Sink
744
cfs

An aerial photograph showing a river and surrounding land. The river is a light brown color, winding through a landscape of dark brown and black vegetation. Two white arrows point to specific locations on the river. The first arrow points to a location labeled 'St. Marks River above Natural Bridge Sink 744 cfs'. The second arrow points to a location labeled 'St. Marks Spring 742 cfs'. The land is divided into rectangular sections by thin white lines, likely representing property boundaries or agricultural fields. The overall tone of the image is dark, with the river providing a contrasting light brown path.

St. Marks
Spring 742
cfs



<http://fnl.tfn.net>

"A diver told (Joe Follman)
that one can travel--swimming
with side-mounted tanks and



In my experience, both groups usually work together very well, BUT there is always room for improvement.

“Bridging the Gap” means cavers and scientists understanding each other’s needs and motivations.

What motivates each group?

- Scientists want to study caves or some aspect of them in order to answer questions (some scientists are also cavers);
- Cavers want to explore the “underground wilderness” through physical interaction and discovery (some cavers are also scientists);
- Both groups are curious about some aspect of caves.

Examples of the types of “services” provided by cavers to the scientific community:

- Eyewitness in-cave observations;
- Water quality sampling (collection of physical samples as well as “meter” analytes);
- Sediment and rock sampling;
- Biological observation and sampling;
- Flow measurement;
- Dye tracing assistance;
- Cave surveying & mapping;
- Radio-location assistance;
- Lithostratigraphic, biostratigraphic or hydrostratigraphic mapping or observation;
- UW photographic documentation (stills and video).

Examples of potential “services” provided by researchers to cavers:

- Enhanced understanding of in-cave observations and other aspects of the cave;
- Potential access to otherwise closed caves (some caves are only accessible for scientific data gathering purposes, which almost always includes an exploration and mapping component);
- Recognition of the value of caver participation in the scientific literature;
- Logistical and financial support.

WHAT SCIENTISTS NEED:

- 1) An understanding of when caver / diver services are needed, versus when other options should be pursued;
- 2) Awareness that Mother Nature is in charge: “Stuff” Happens – bad weather, low visibility, other factors which may affect the diver’s ability to perform within acceptable safety parameters;
- 3) A better general understanding of the training, planning and equipment requirements necessary to complete the types of dives needed, and associated risk management procedures;
- 4) Knowledge of basic human diving physiology, including physical stressors, and especially task loading;
- 5) Lead time notification – the proposed dive schedule. This allows time for the research staff to prepare equipment and arrange for on-demand services, such as laboratory analytical services. Additional sample prep may also be required in the field.

WHAT CAVERS NEED:

- 1) Presentation of the project goals and proposed methodology (*Research Project Plan*). This gives the cave team a better understanding of the scientific project underway, and a general idea of what will be required to accomplish the data gathering tasks; [kept in the dark...BS](#)
- 2) An understanding of the value of caver contributions to the overall effort;
- 3) Clear instructions from scientists in the use of any sampling equipment or data gathering devices, or necessary training to carry out the needed work;
- 4) Importance of QA/QC procedures in assuring data integrity;
- 5) Land side logistical support;
- 6) Financial support (depending on the nature of the project);

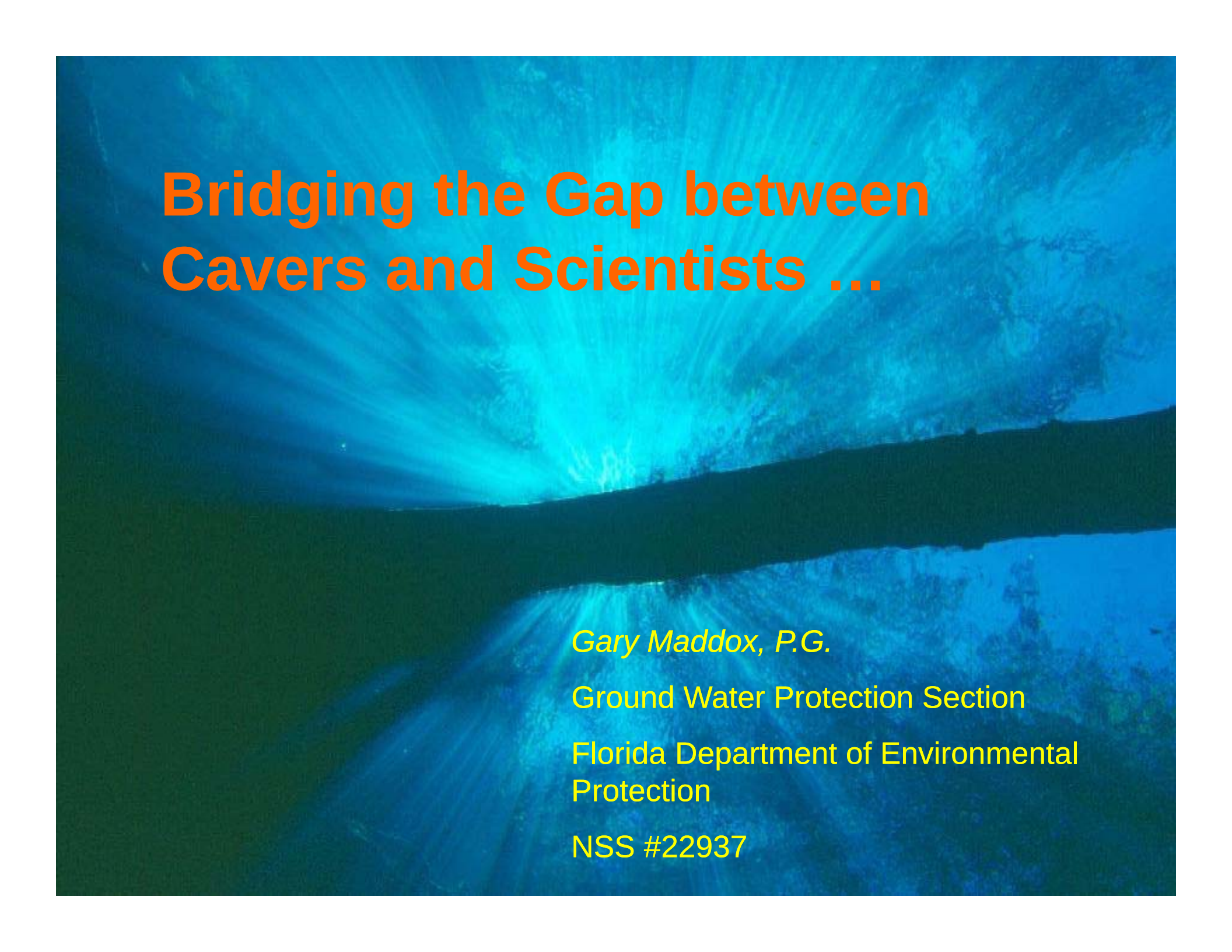
WHAT BOTH CAVERS AND SCIENTISTS NEED:

- *Pre-Dive Briefing* – time must be reserved at some point prior to the dive(s), so that expedition and support staff understand completely how to collect data / samples, and scientists understand factors which might affect the diver’s ability to perform these functions. Both groups must discuss the feasibility of the data gathering effort, and how it fits in with other dive objectives;
- *Dive Plan Review* – scientists and cavers need to discuss the Dive Plan. Depth, distance and cave configuration will help determine the logistics, equipment configurations, and degree of effort involved (i.e., staged dives, use of scooters, gas mixtures?);
- *Cave Map Access* (if available) – helps the scientist understand the dive(s), and provides a visual reference during planning discussions;

- *Post-Dive Debriefing* – scientists will need to interview members of the team to ascertain details about any issues or irregularities encountered during data collection;
- Follow-up and continued communication from cavers regarding changes in cave conditions, and from scientists, research results and publications.

What's missing from this picture?

- *Role of the cave owner / manager* - without cave access, neither group gets what it wants, so it makes a lot of sense for cavers and scientists to **WORK TOGETHER** in proposing projects which benefit both interests!
- *Educational outreach* - publicity about many cave projects can carry a positive educational message to the public, which benefits all who want to conserve and protect caves. Scientists and cavers, because of their specialized knowledge, should consider devoting time and effort to educating the public about their work ...

An underwater photograph showing sunlight rays (Tyndall effect) filtering through the water. A dark, horizontal silhouette, possibly a cave ceiling or a rock formation, runs across the middle of the frame. The water is a deep blue, and the light rays create a dramatic, ethereal atmosphere.

Bridging the Gap between Cavers and Scientists ...

Gary Maddox, P.G.

Ground Water Protection Section

Florida Department of Environmental
Protection

NSS #22937



***“Bridging the Gap”
means cavers and
scientists
understanding and
respecting each
other’s needs and
motivations...***

What motivates each group?



Devil's Den
Williston, FL

What motivates each group?

- Scientists want to study caves or some aspect of them in order to answer questions (some scientists are also cavers);



*Devil's Den
Williston, FL*

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*Devil's Den
Williston, FL*

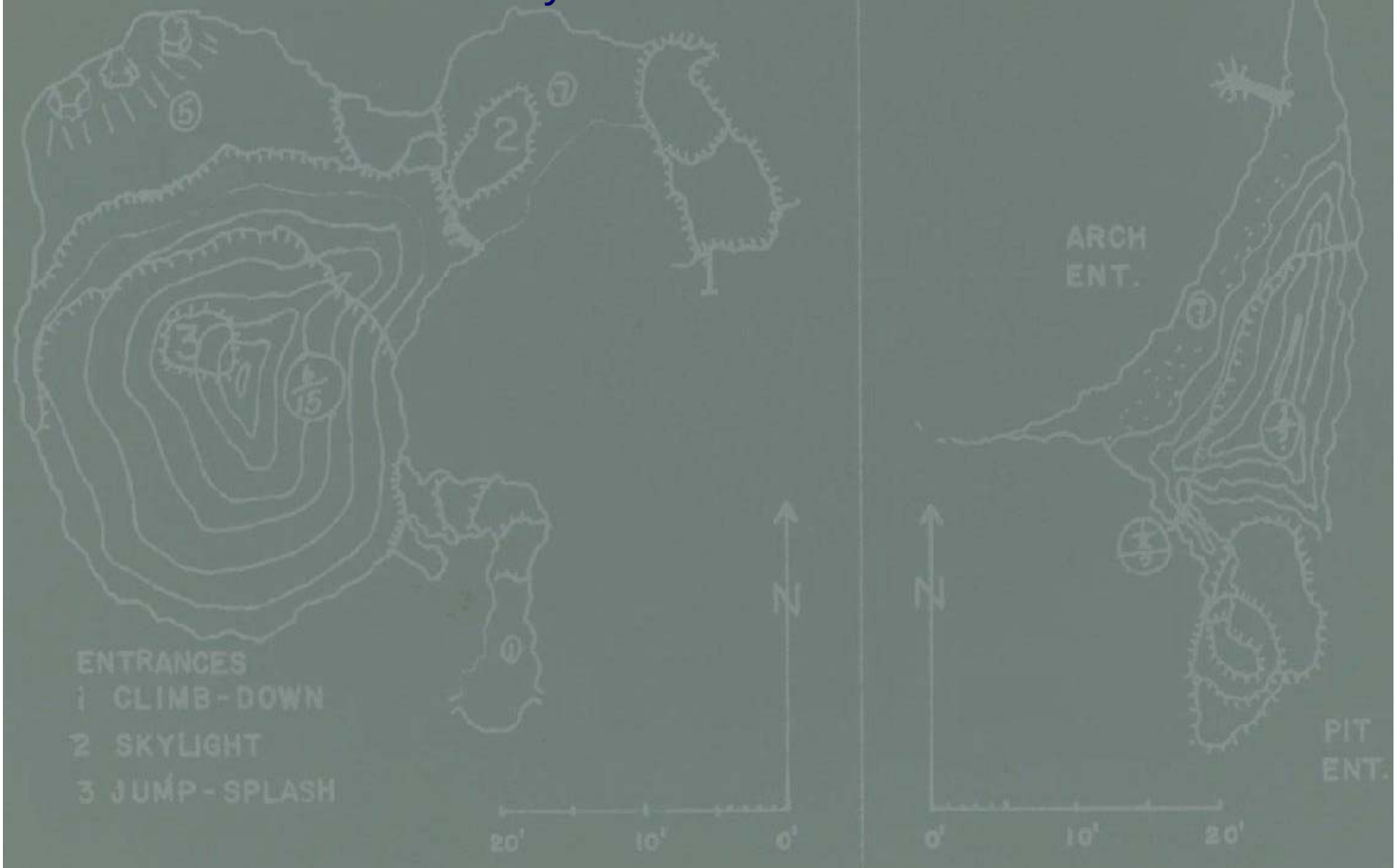
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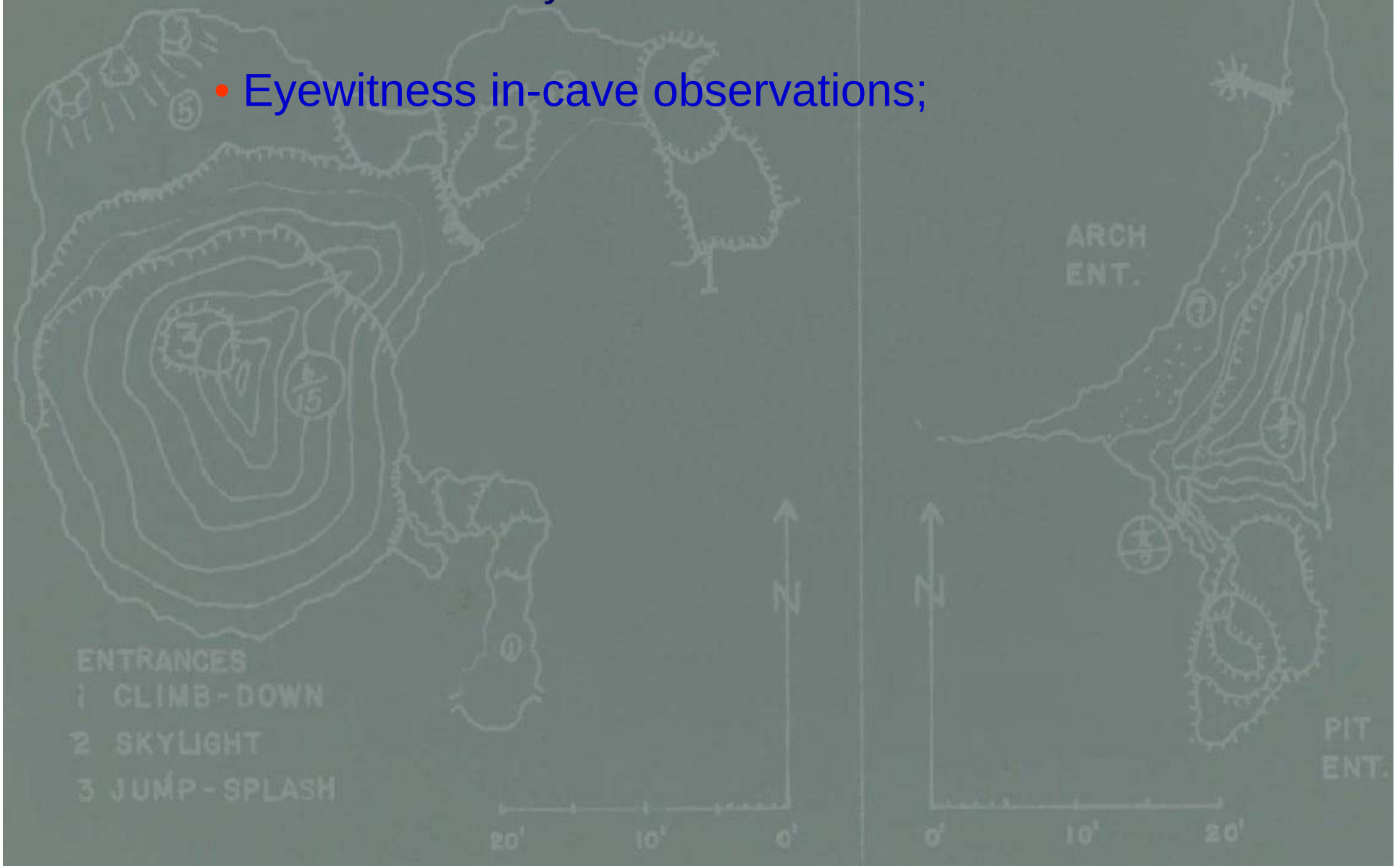
Devil's Den
Williston, FL

Examples of the types of “services” provided by cavers to the scientific community:



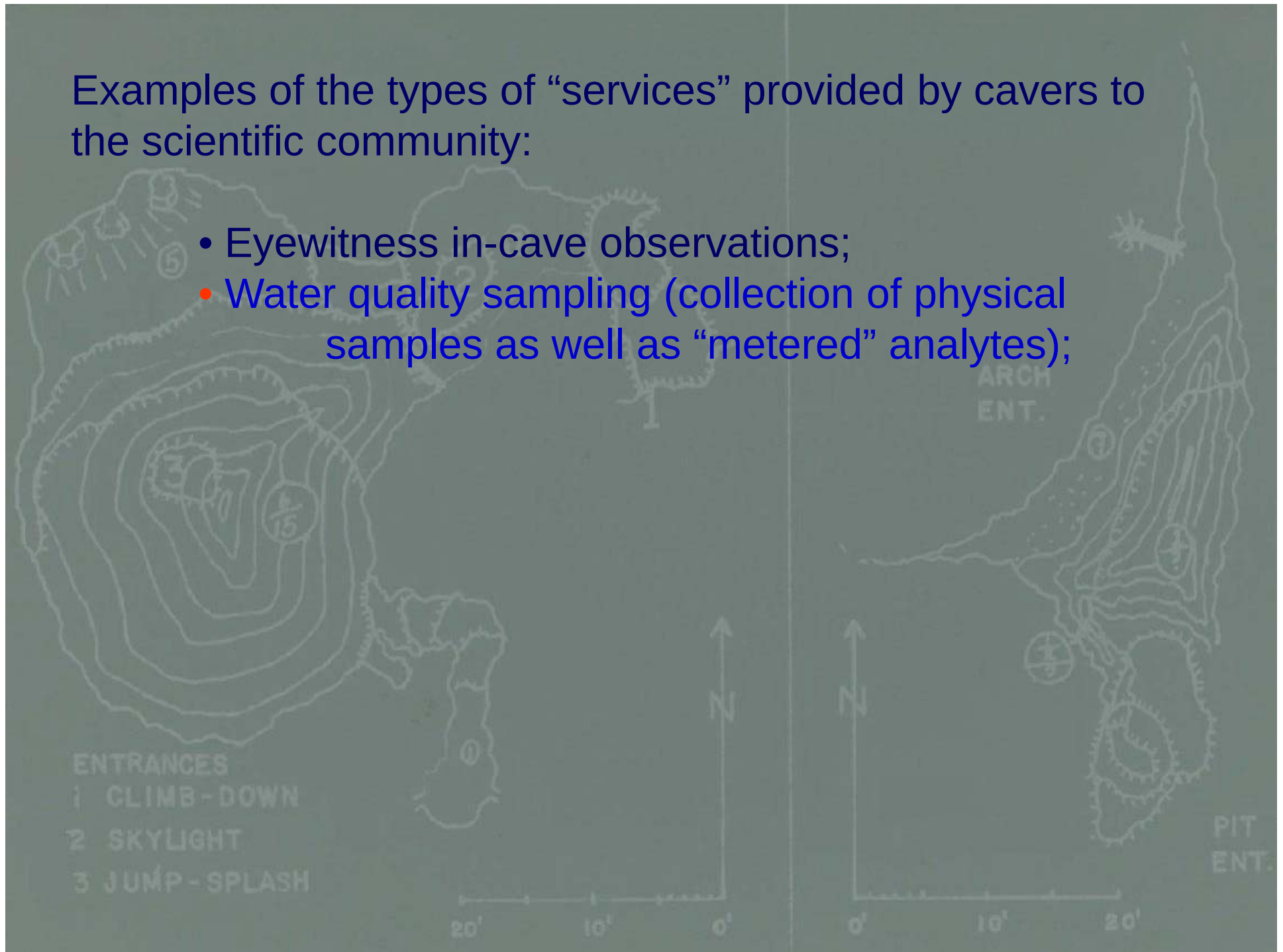
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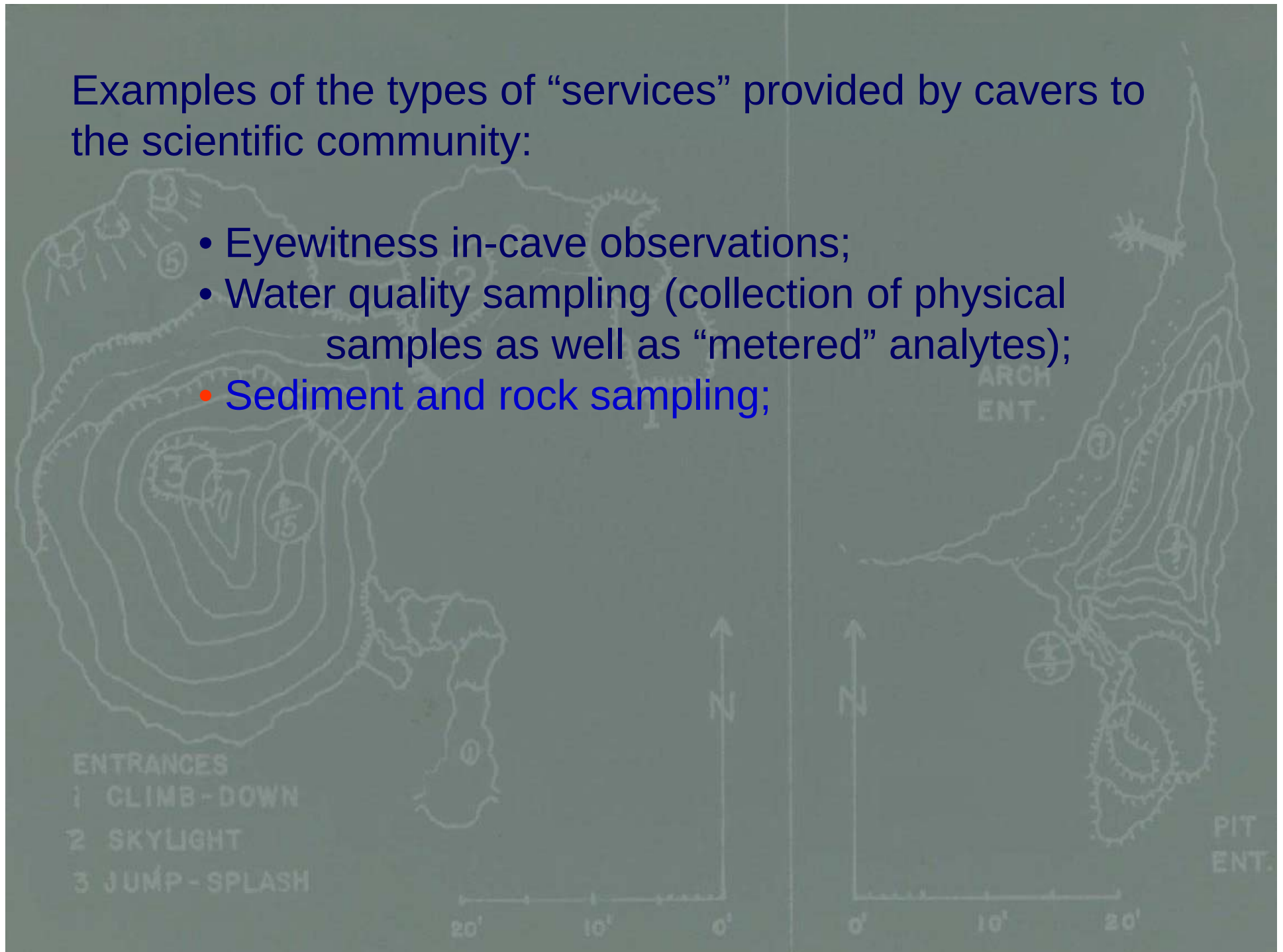
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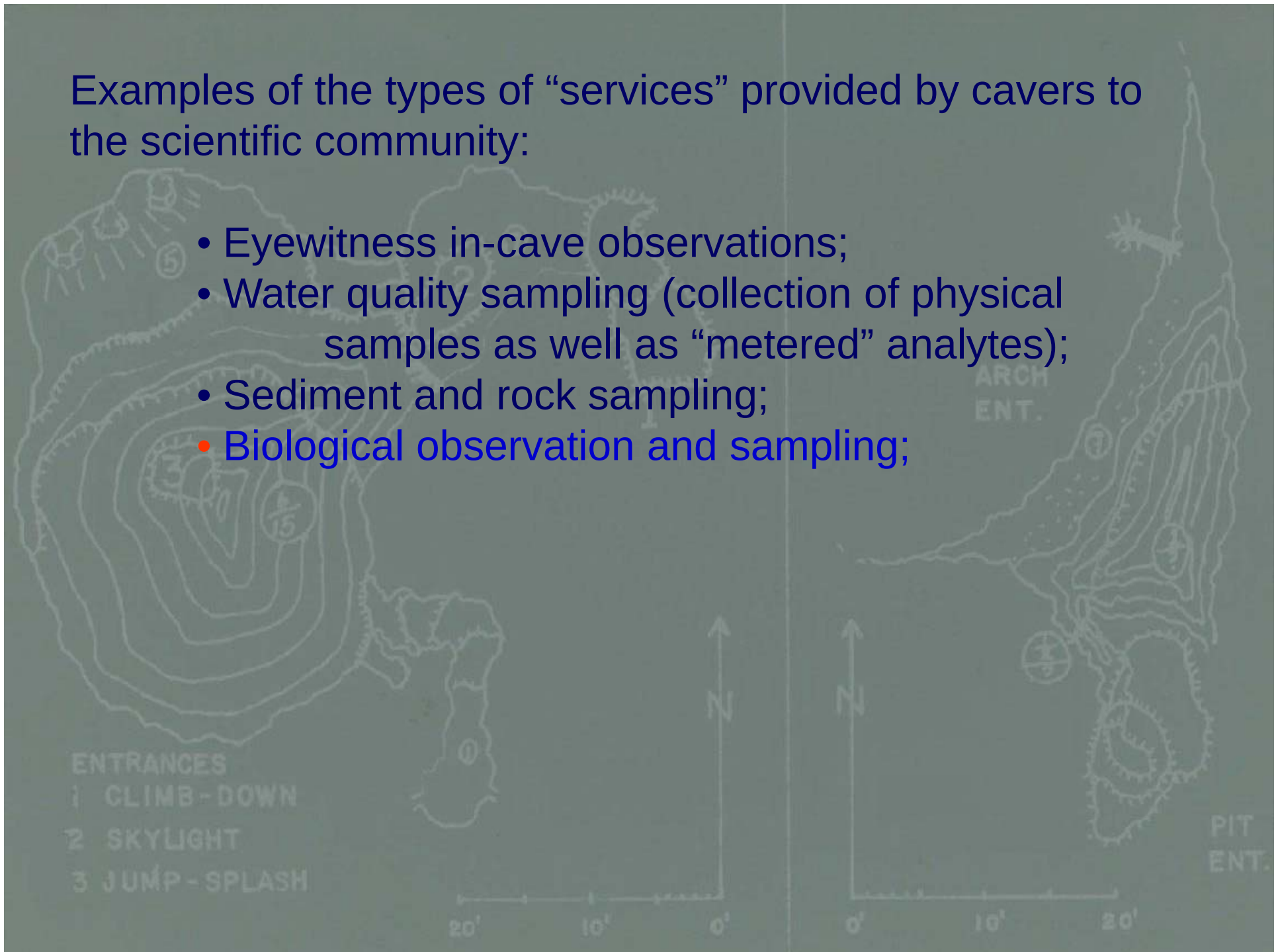
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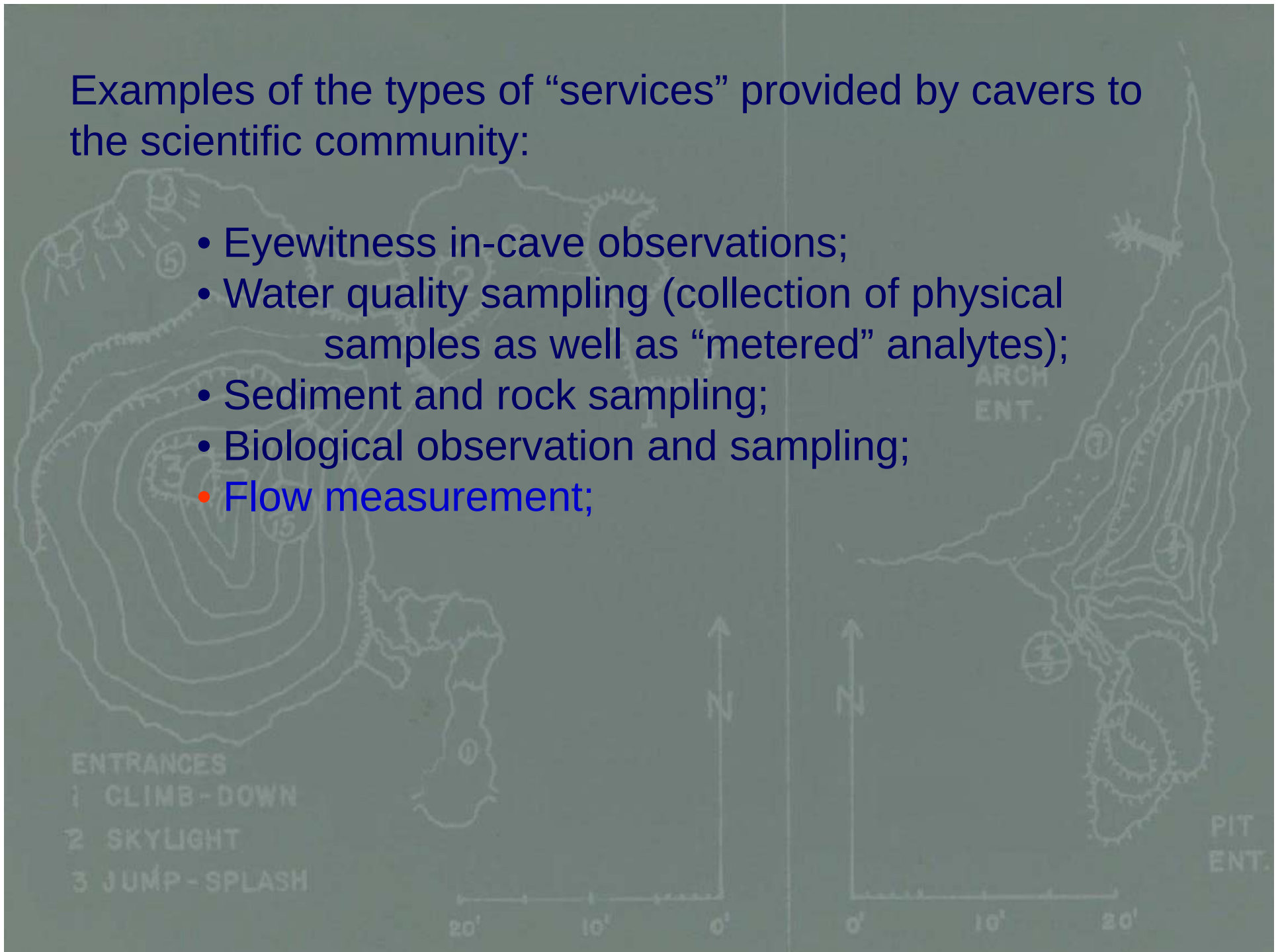
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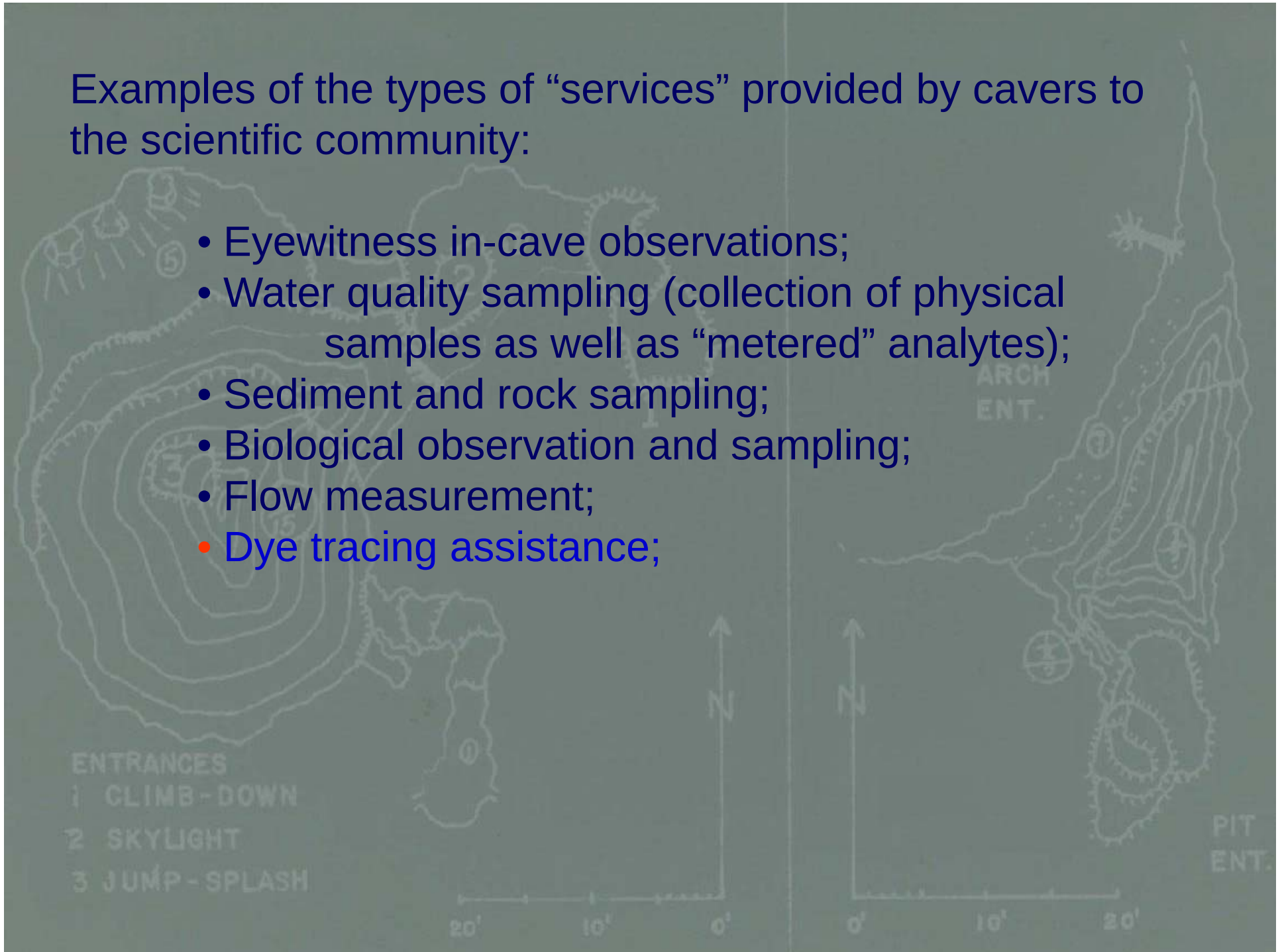
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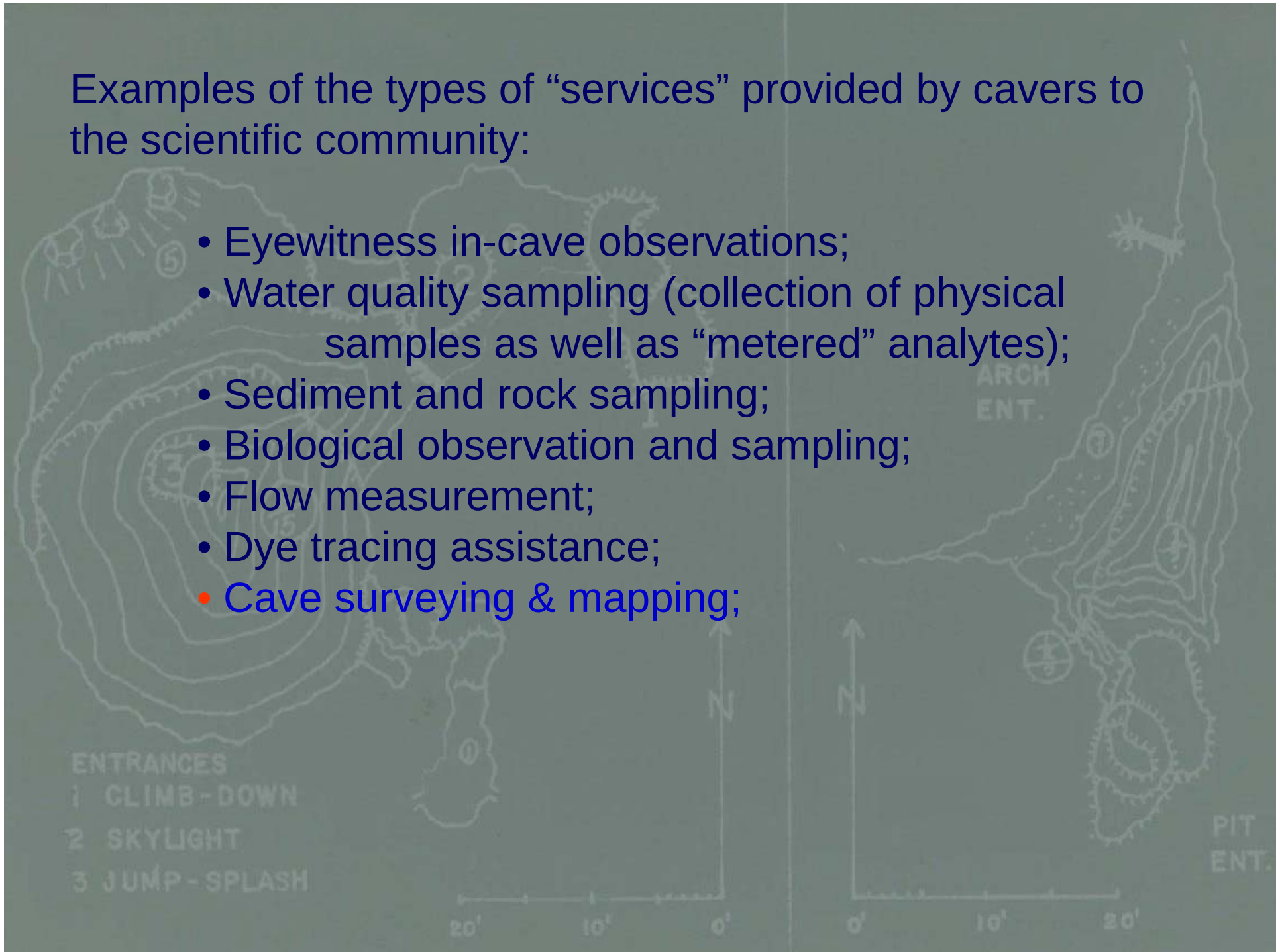
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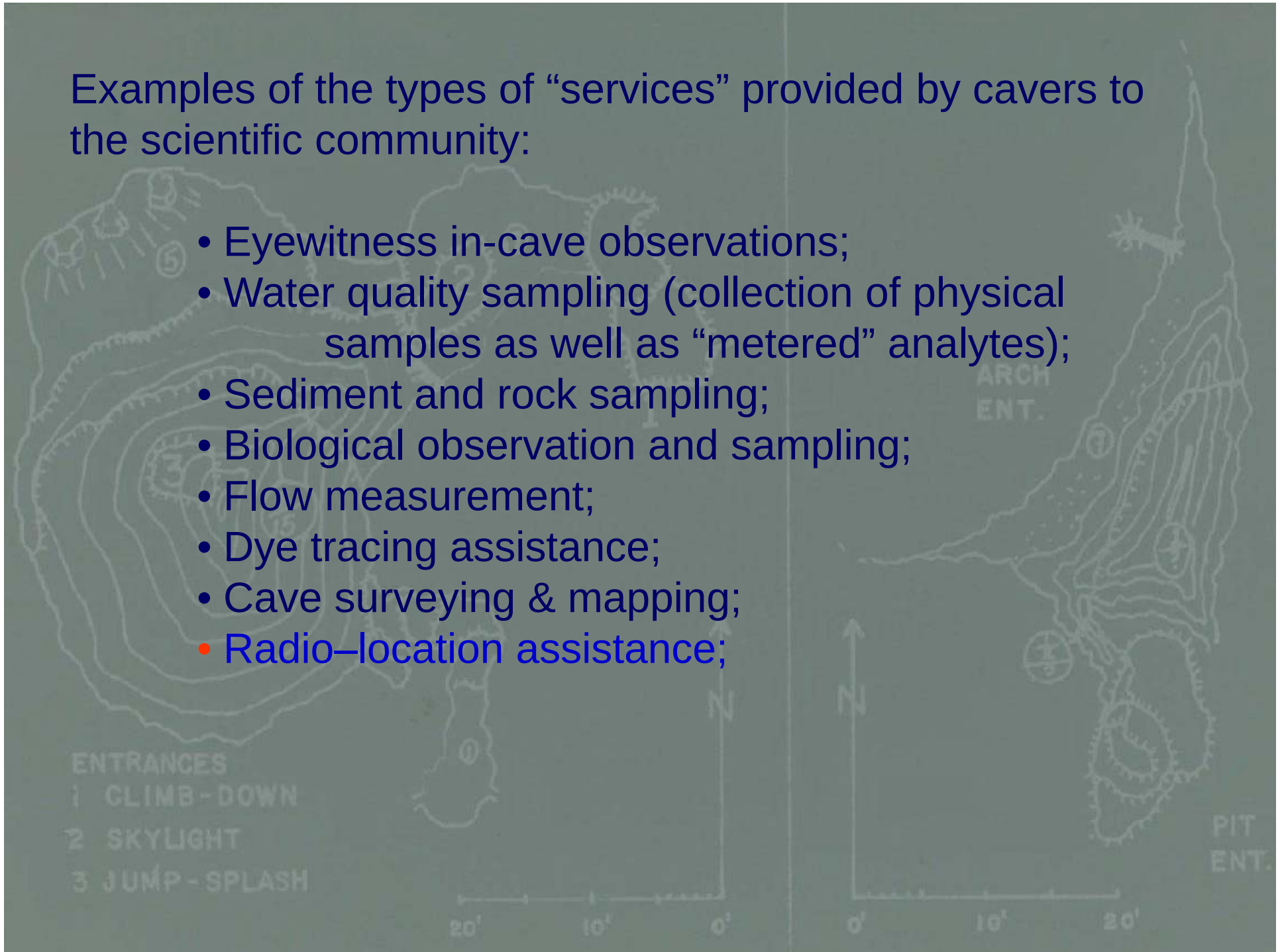
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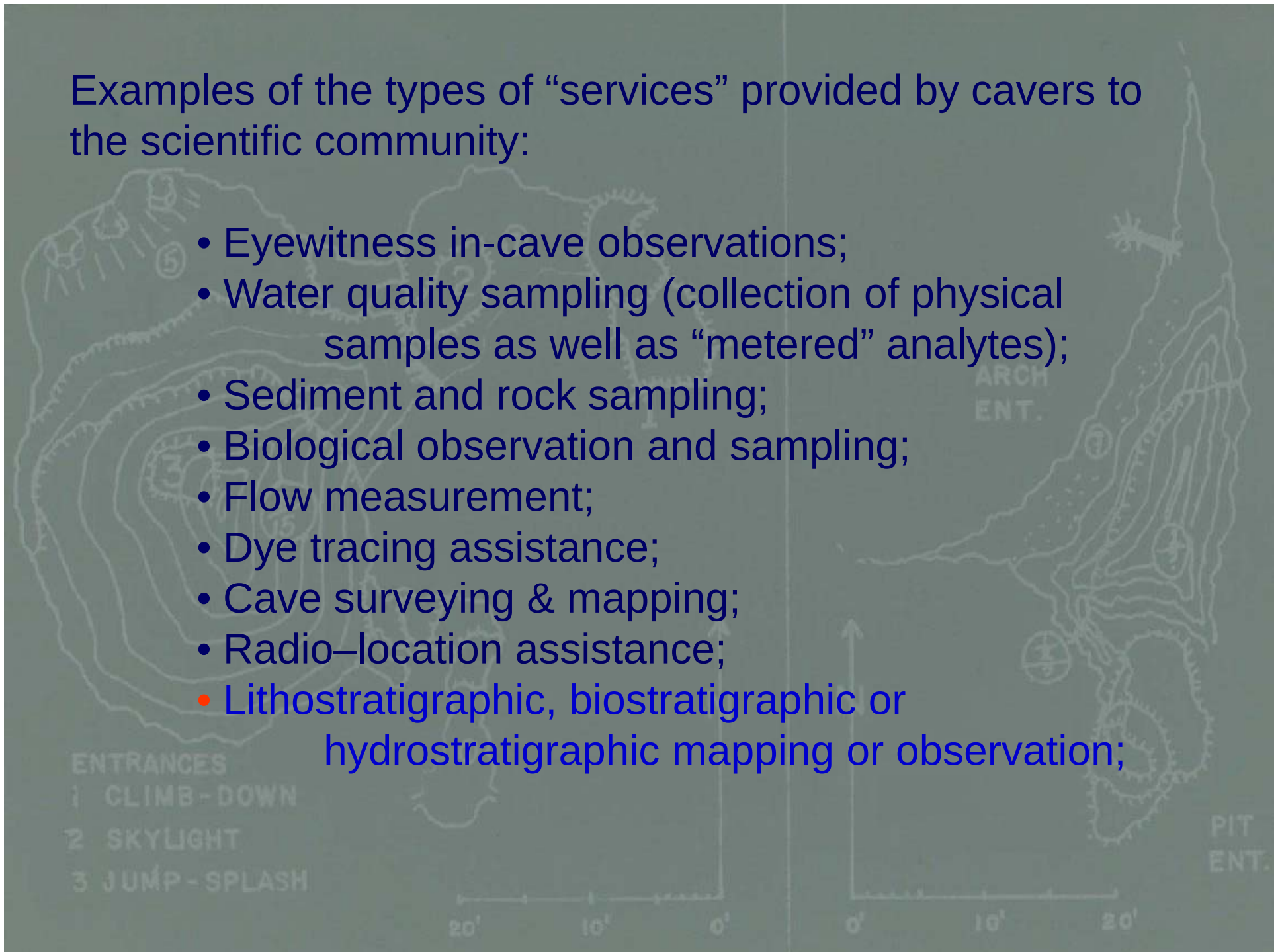
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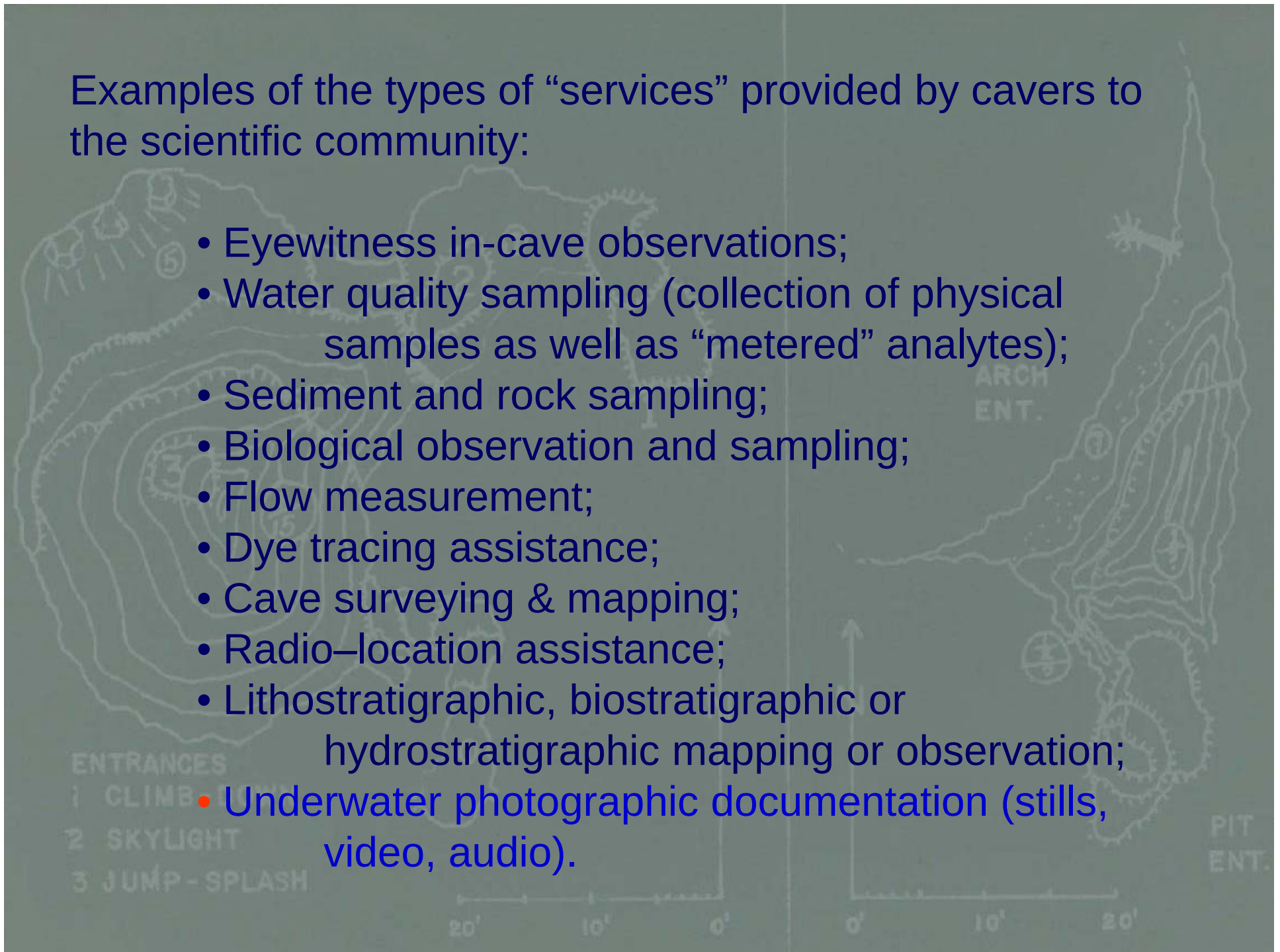
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- Underwater photographic documentation (stills, video, audio).





Emerald Sink
Wakulla County, FL

WHAT SCIENTISTS NEED:



*Emerald Sink
Wakulla County, FL*

WHAT SCIENTISTS NEED:

1) An understanding of when caver / diver services are needed, versus when other options should be pursued;



Emerald Sink

Wakulla County, FL

WHAT SCIENTISTS NEED:

- 1) An understanding of when caver / diver services are needed, versus when other options should be pursued;
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*Emerald Sink
Wakulla County, FL*

WHAT SCIENTISTS NEED:

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*Emerald Sink
Wakulla County, FL*

WHAT SCIENTISTS NEED:

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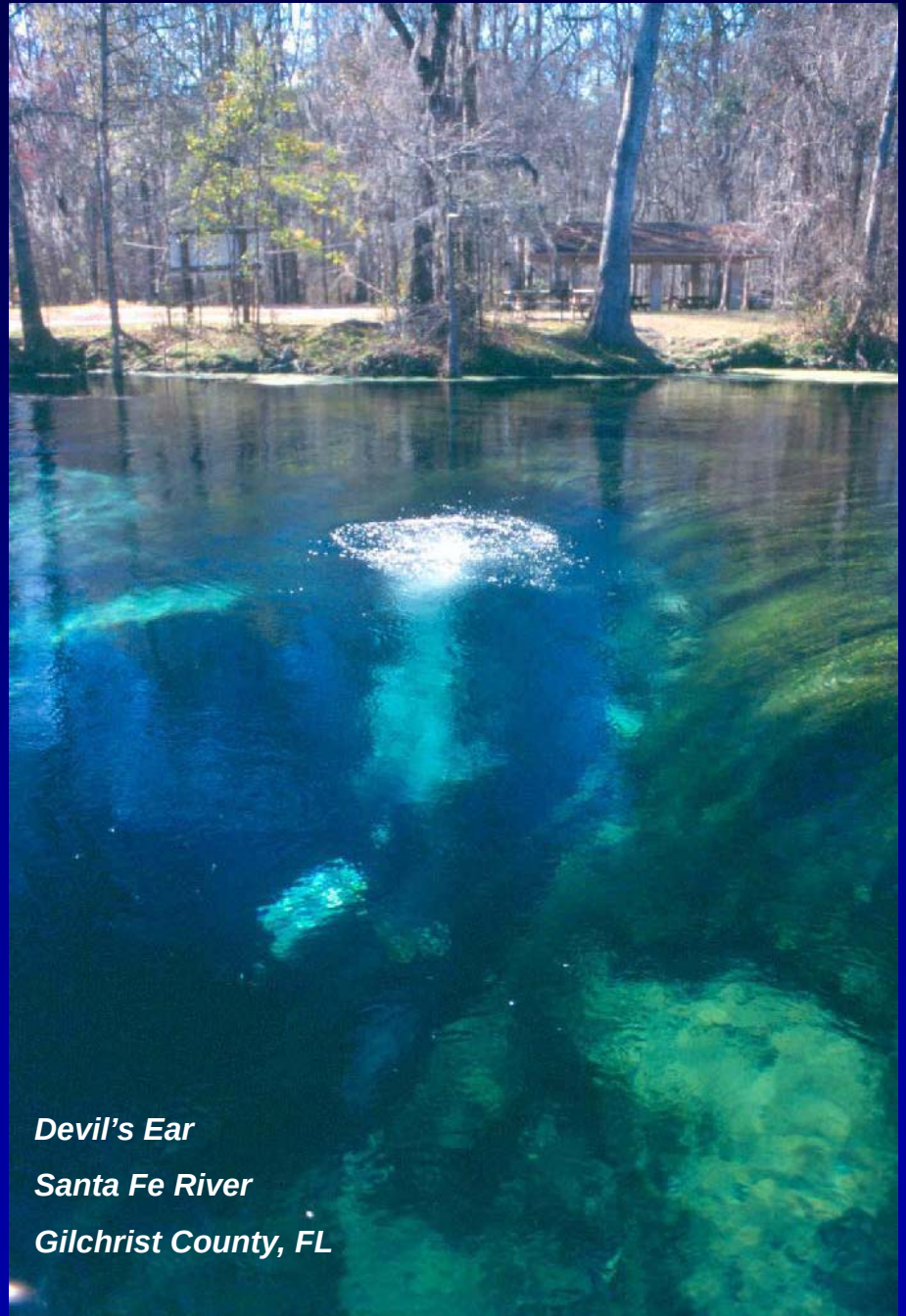
Emerald Sink

Wakulla County, FL

WHAT SCIENTISTS NEED:

5) Lead time notification – the proposed dive schedule. This allows time for the research staff to prepare equipment, and arrange for on-demand services, such as laboratory analyses. Additional sample prep may also be required in the field.

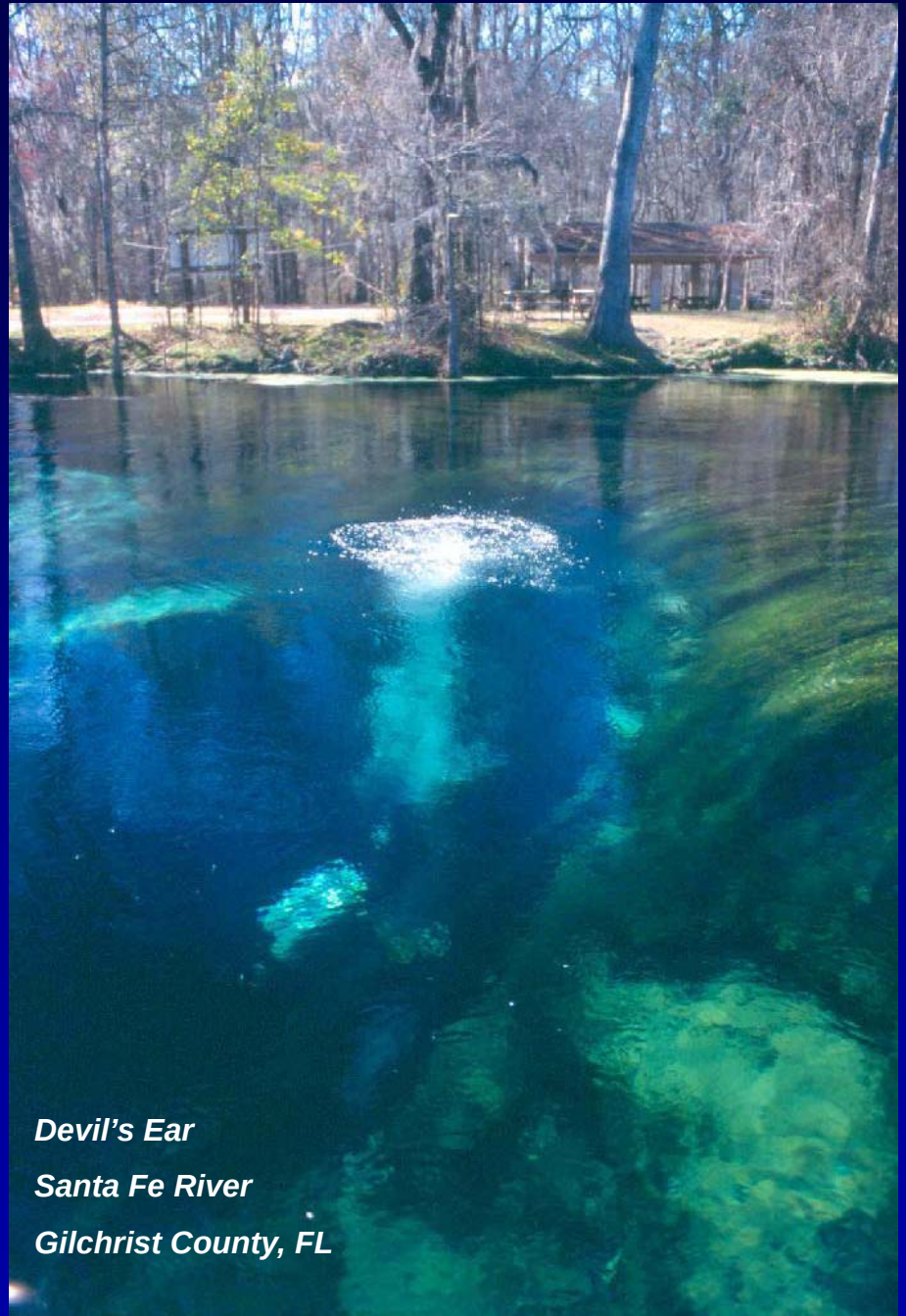
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*Devil's Ear
Santa Fe River
Gilchrist County, FL*

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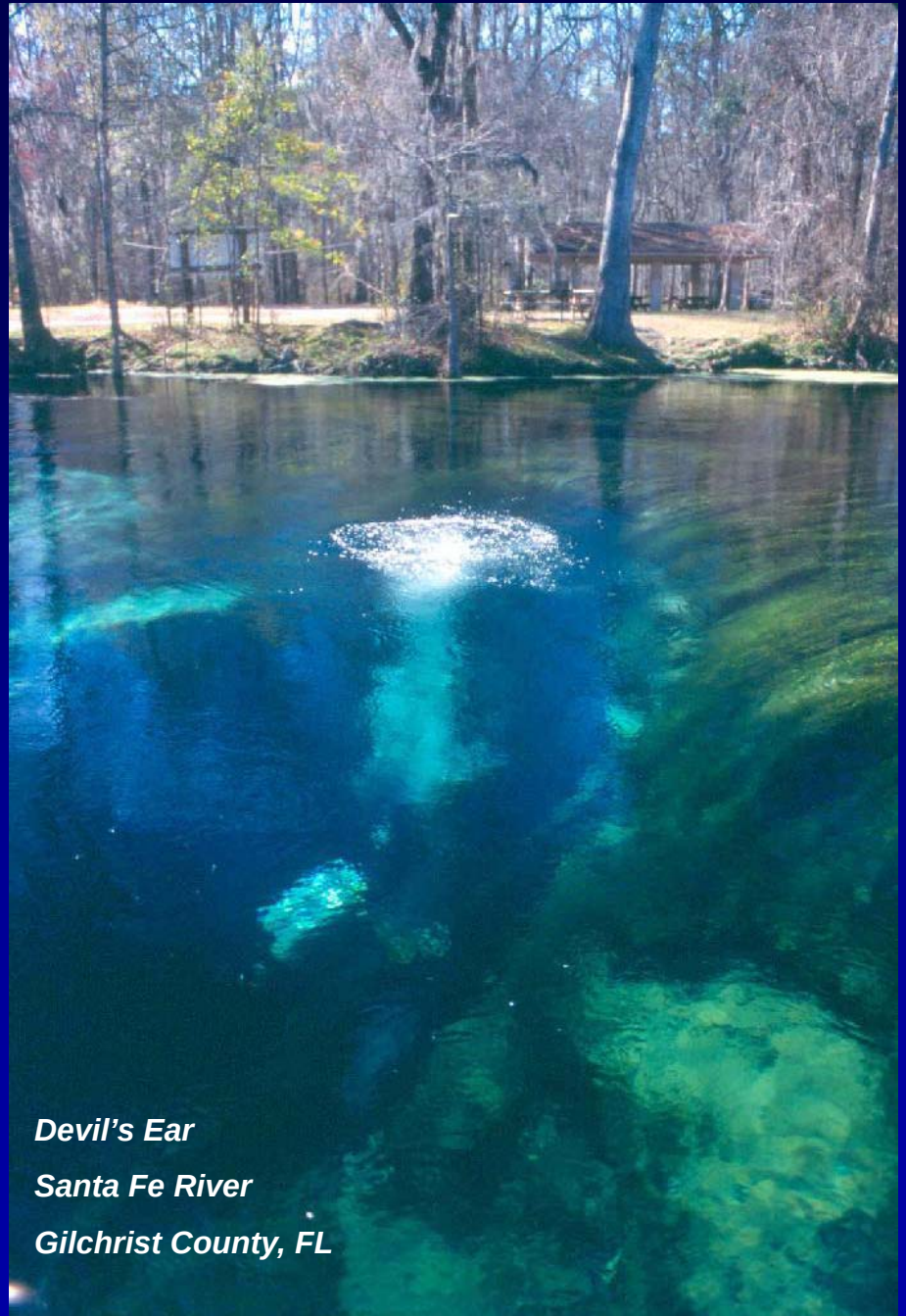


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Santa Fe River
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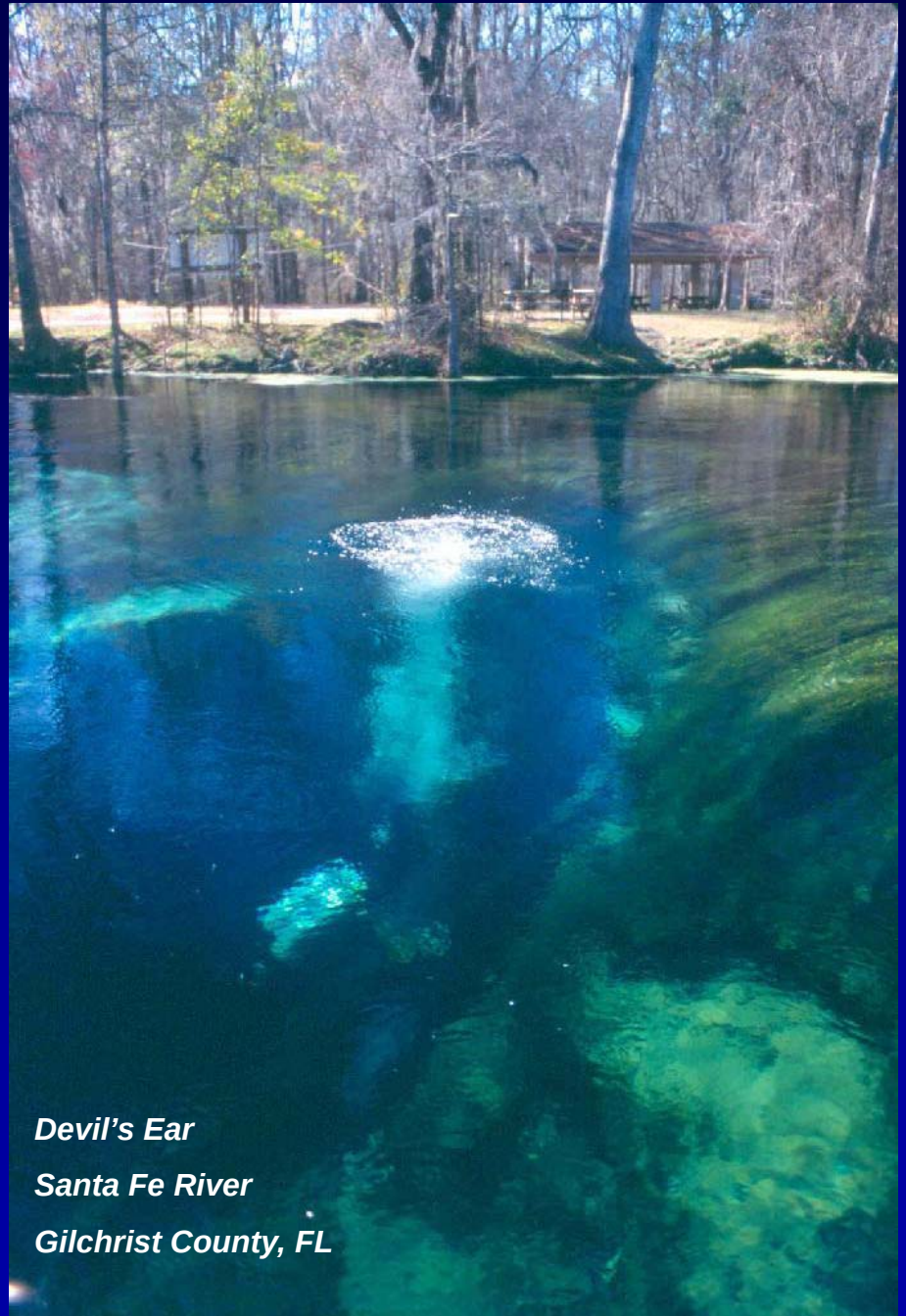
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*Devil's Ear
Santa Fe River
Gilchrist County, FL*

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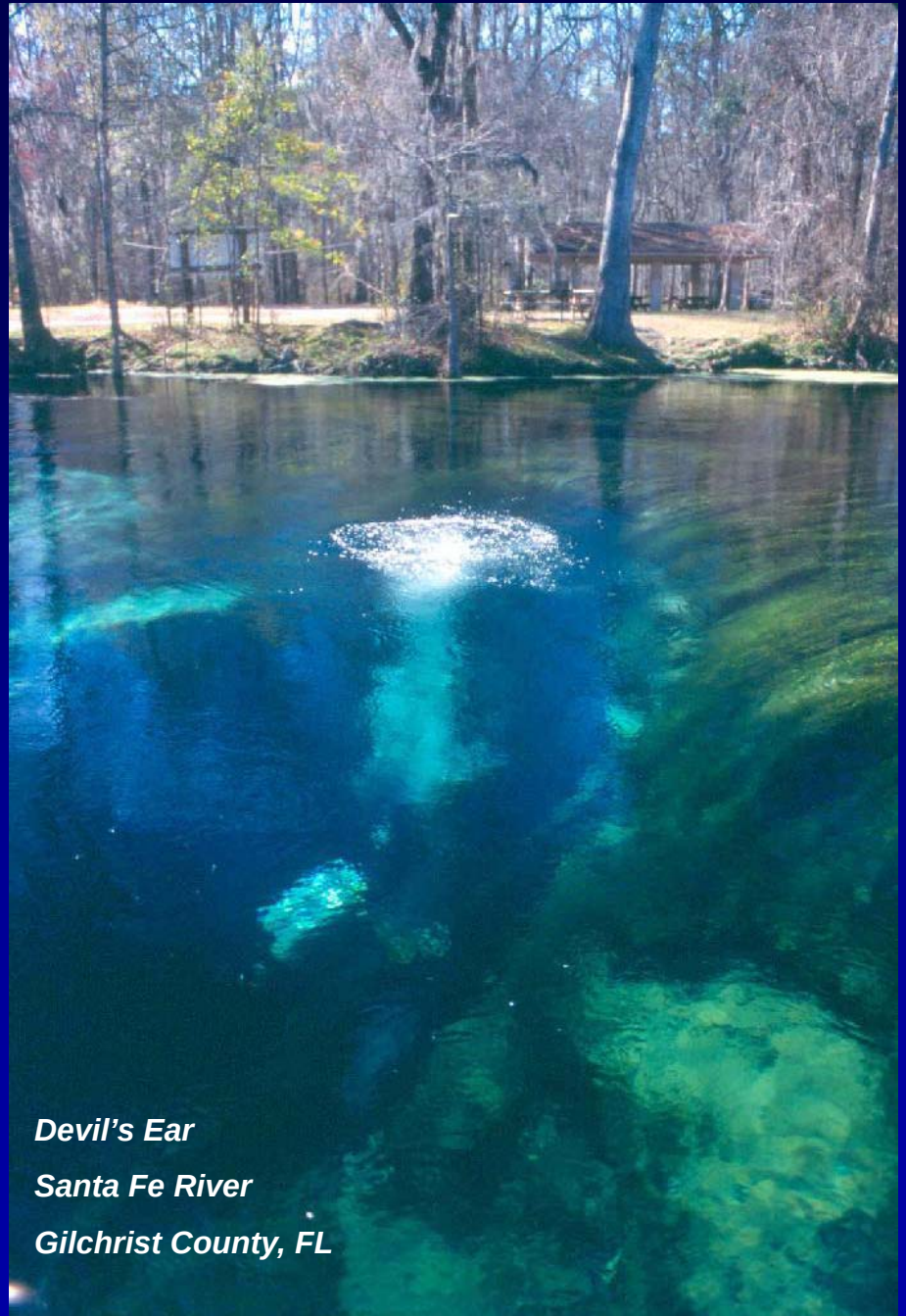


*Devil's Ear
Santa Fe River
Gilchrist County, FL*

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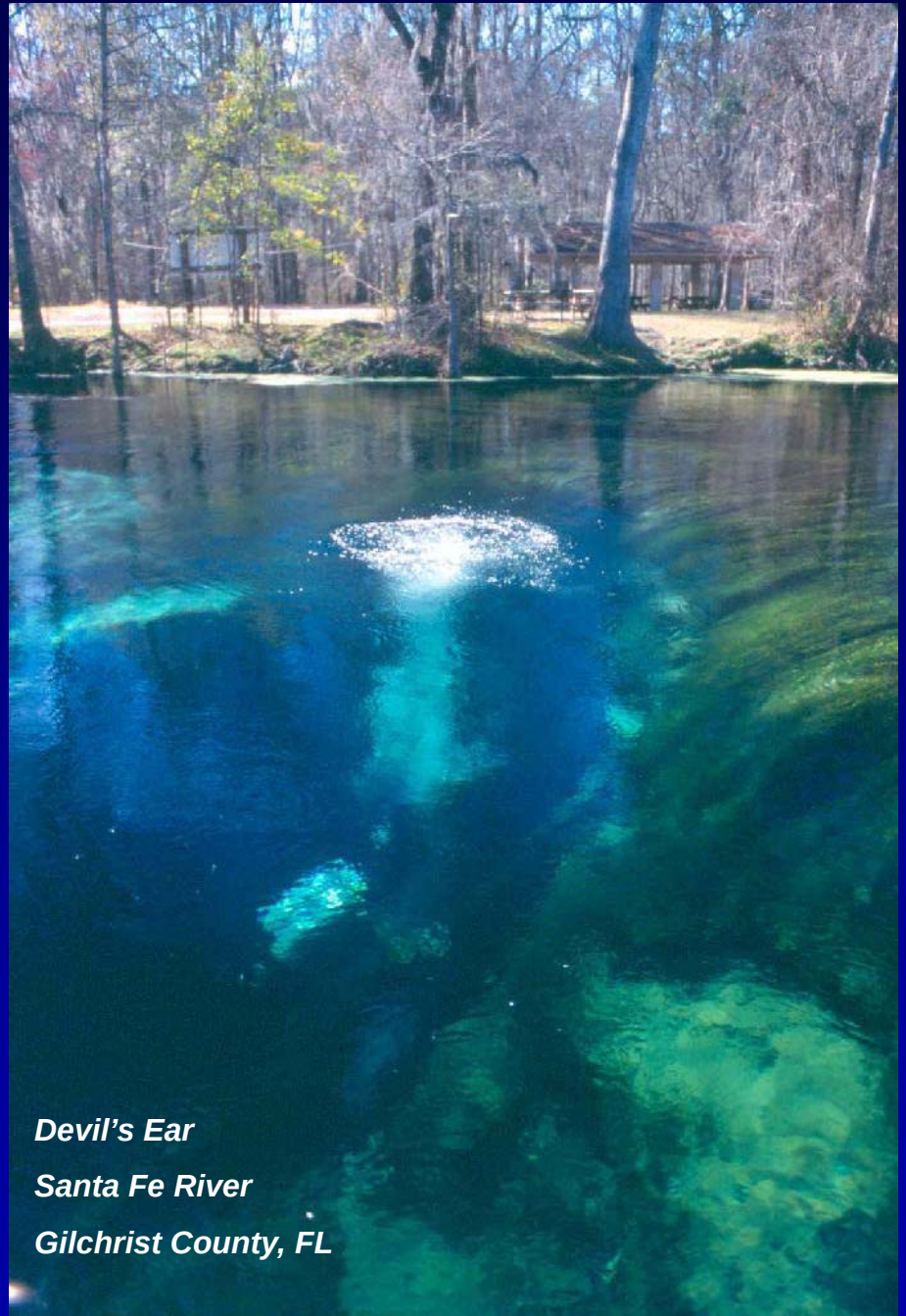
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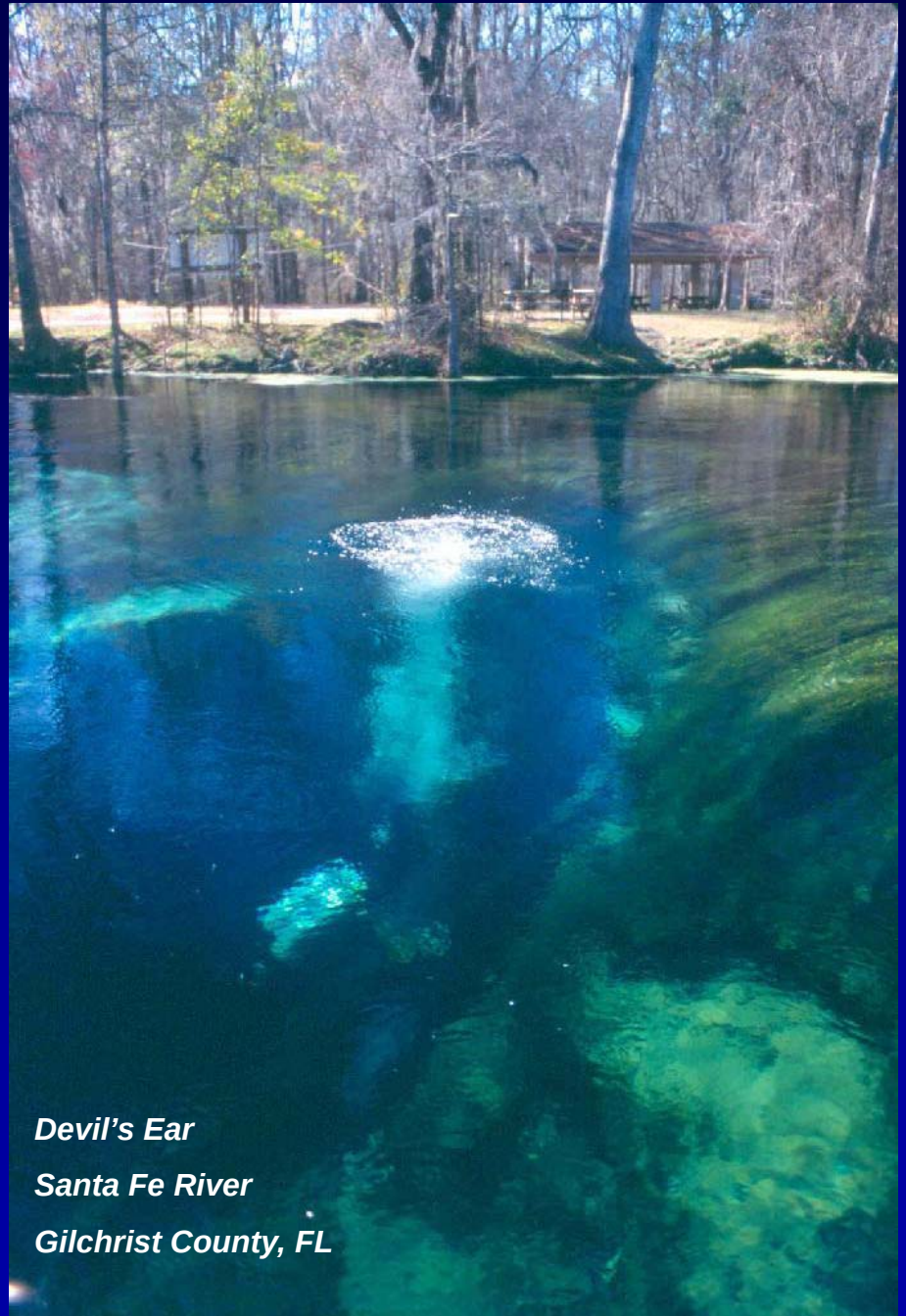
5) Surface logistical support;



*Devil's Ear
Santa Fe River
Gilchrist County, FL*

WHAT CAVERS NEED:

6) Financial support
(depending on the nature of
the project).



*Devil's Ear
Santa Fe River
Gilchrist County, FL*

WHAT BOTH CAVERS AND SCIENTISTS NEED:



*Devil's Den
Williston, FL*

WHAT BOTH CAVERS AND SCIENTISTS NEED:

1) *Pre-Dive Briefing* – time must be reserved at some point prior to the dive(s), so that expedition and support staff understand completely how to collect data / samples, and scientists understand factors which might affect the diver's ability to perform these functions. Both groups must discuss the feasibility of the data gathering effort, and how it fits in with other dive objectives;



Devil's Den
Williston, FL

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*Devil's Den
Williston, FL*

WHAT BOTH CAVERS AND SCIENTISTS NEED:

3) *Access to Cave Maps and other relevant support documentation* – helps cavers and scientists understand the dive(s), and provides a visual reference during planning discussions;



*Devil's Den
Williston, FL*



Devil's Den
Williston, FL

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4) *Post-Dive Debriefing* – scientists will need to interview members of the team to ascertain details about any relevant issues or irregularities encountered during data collection;

WHAT BOTH CAVERS AND SCIENTISTS NEED:

5) Follow-up and continued communication from cavers regarding changes in cave conditions. From scientists, sharing of research results in real-time, and publications resulting from the project.



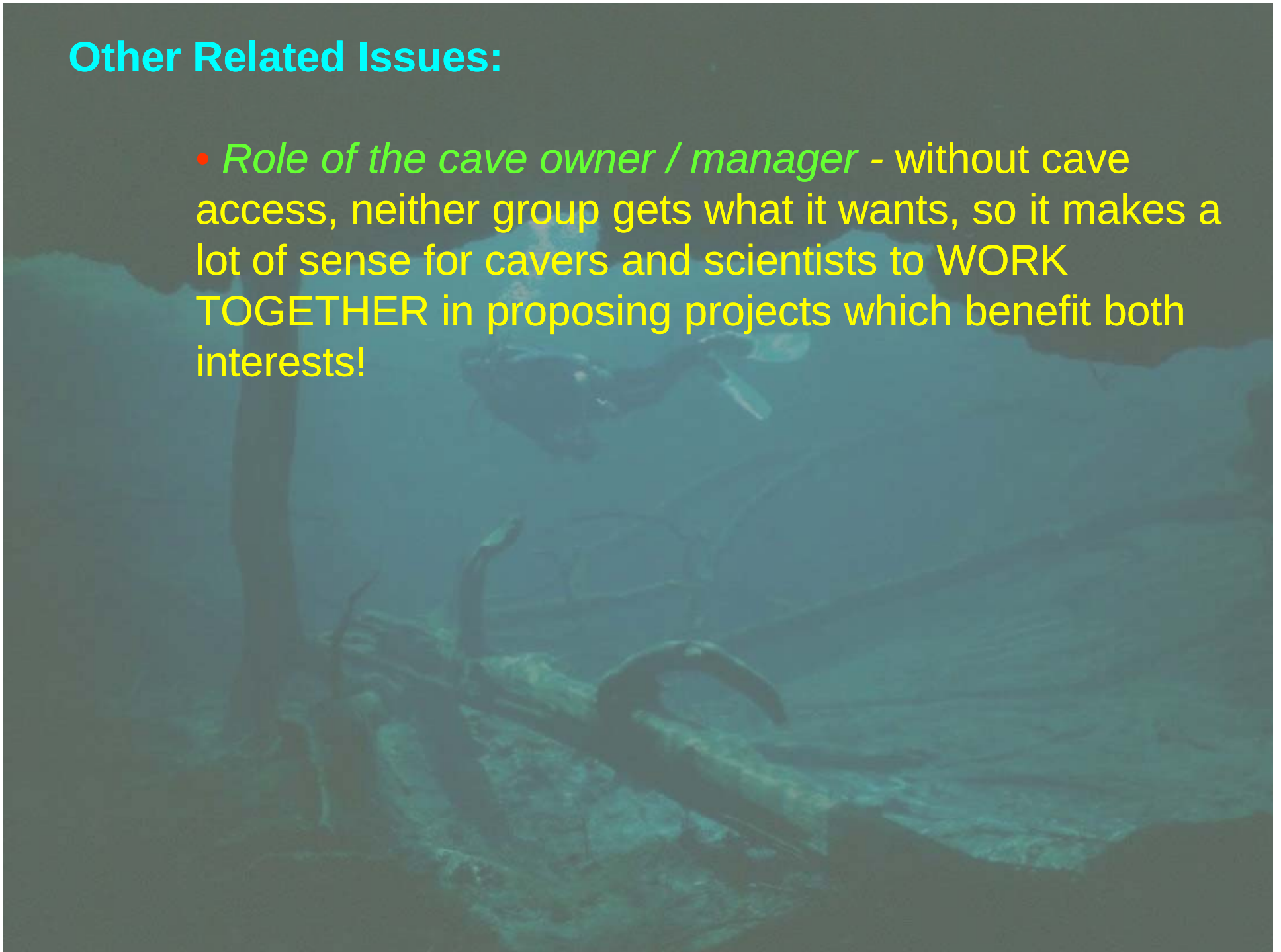
*Devil's Den
Williston, FL*

Other Related Issues:



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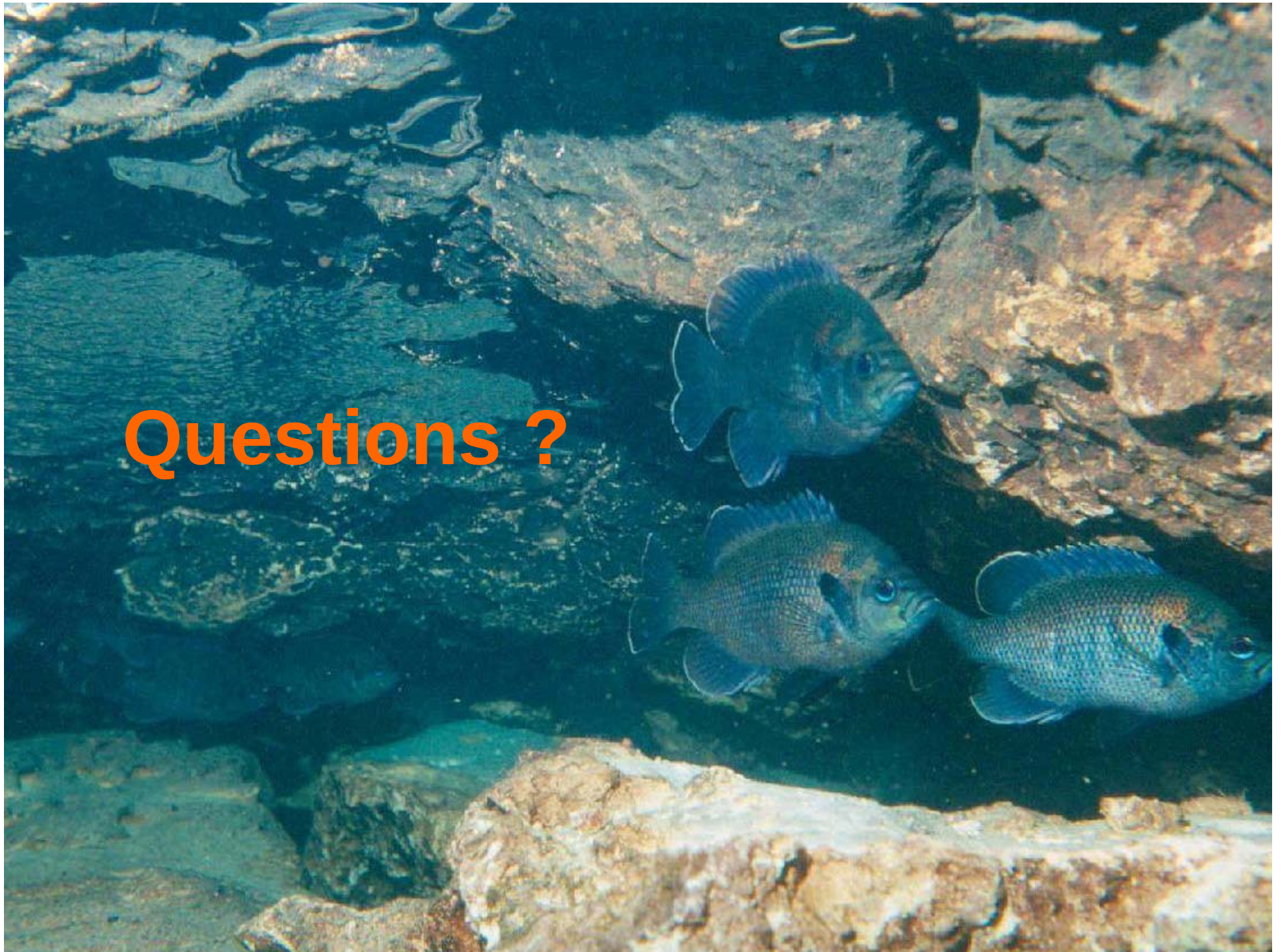
- *Role of the cave owner / manager* - without cave access, neither group gets what it wants, so it makes a lot of sense for cavers and scientists to WORK TOGETHER in proposing projects which benefit both interests!



Other Related Issues:

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- *Educational outreach* - publicity about many cave projects can carry a positive educational message to the public, which benefits all who want to conserve and protect caves. Scientists and cavers, because of their specialized knowledge, should consider devoting extra time and effort to educating cave owners / managers and the public about their work ...

Questions ?



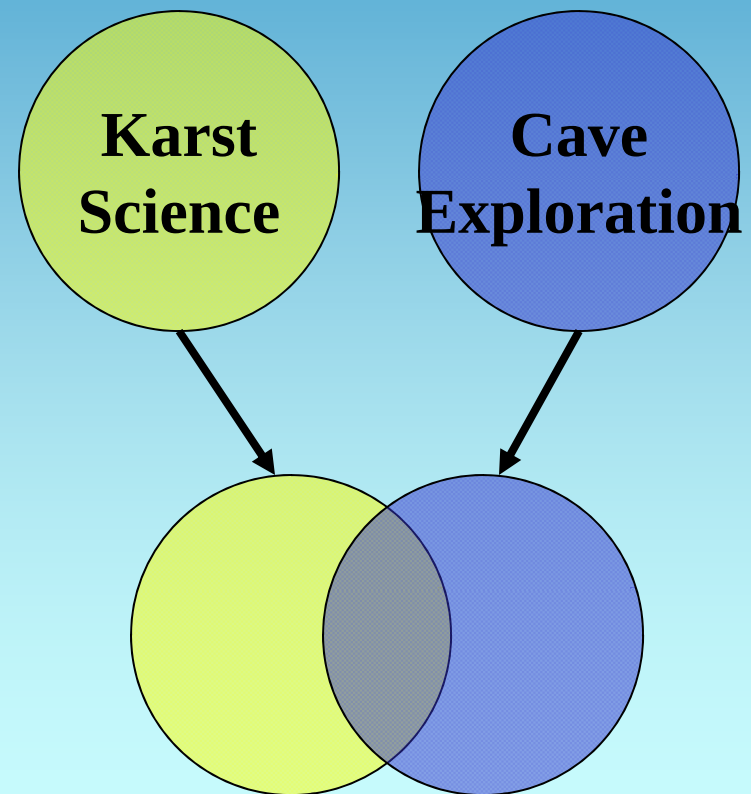
Bridging the Gap

Sam B. Upchurch
SDII Global Corporation
Tampa, Florida



The Opportunity to Share Interests is Important

- Cave divers provide access that most karst persons cannot enjoy
- Cave divers provide public awareness and popularize problems
- Karst scientists provide understanding and credibility



What Divers Bring to the Table

- Local knowledge
- Access to locations that are otherwise inaccessible
- Expertise
- Public involvement and awareness



What Karst Science Brings to the Table

- Credibility and access
- Contributions to community welfare
- Understanding as to why or when caverns systems develop
- Support by specialized scientists (biologists, paleontologists, geochemists, karst hydrologists)



Institutional Problems with Use of Cave Divers

- Liability issues
- Requirement to use occupation cave diving protocols
- Need for standard data collection protocols
- Need for quality assurance plans
- Absence of trained divers



Divers' Problems With Working With Institutions

- Loss of control of proprietary data
- Excessive rules and regulations
- Inability to communicate effectively
- No funds for support
- Needs are driven by schedules and budgets



How Karst Science Can Become Involved

- Funding sources
- Development of sampling protocols
- Development of quality assurance plans
- Find ways to involve the cave diving community
- Train cave divers to recognize important data (biota, karst features, cave sediments, conduiting, flow systems, etc.)



How Divers Can Become Involved

- Talk to the scientists and engineers and share information
- Express interest in what scientists do and ask to be involved
- Make interesting observations available
- Share cave maps



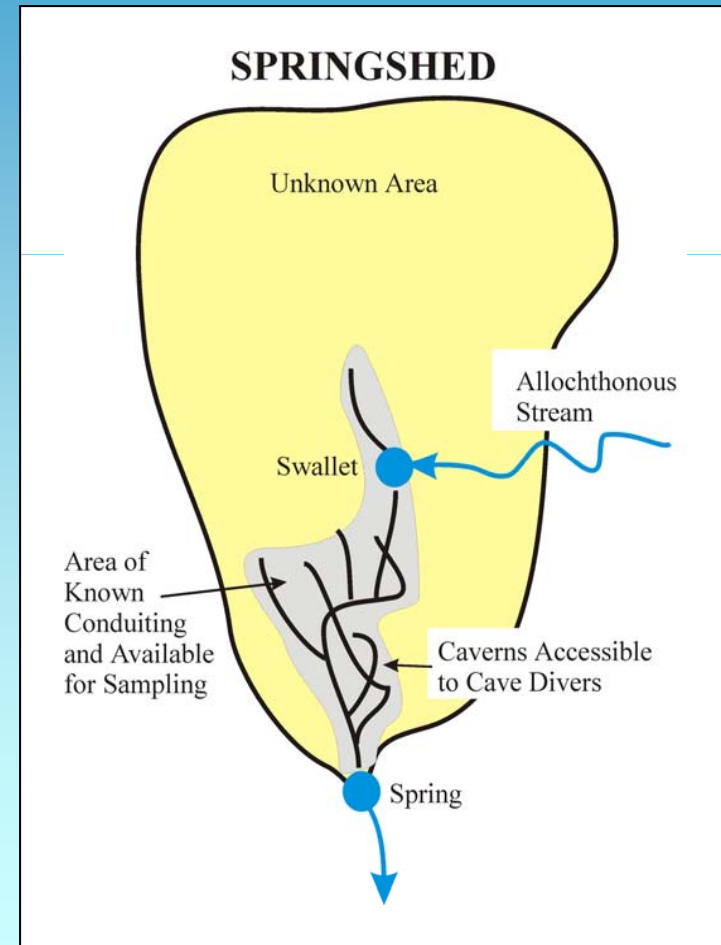
What We Need to Do Jointly

- Find ways to minimize institutional liability concerns
- Maintain communication
- Develop a clear set of goals to enhance communication and data transfer



What We Need to Do Jointly (cont.)

- Portions of cavern system are known
- Most of system is inaccessible to divers
- We need to find ways to integrate information
- We need to develop methods to look at the interface between the accessible cave system and the bulk of the springshed

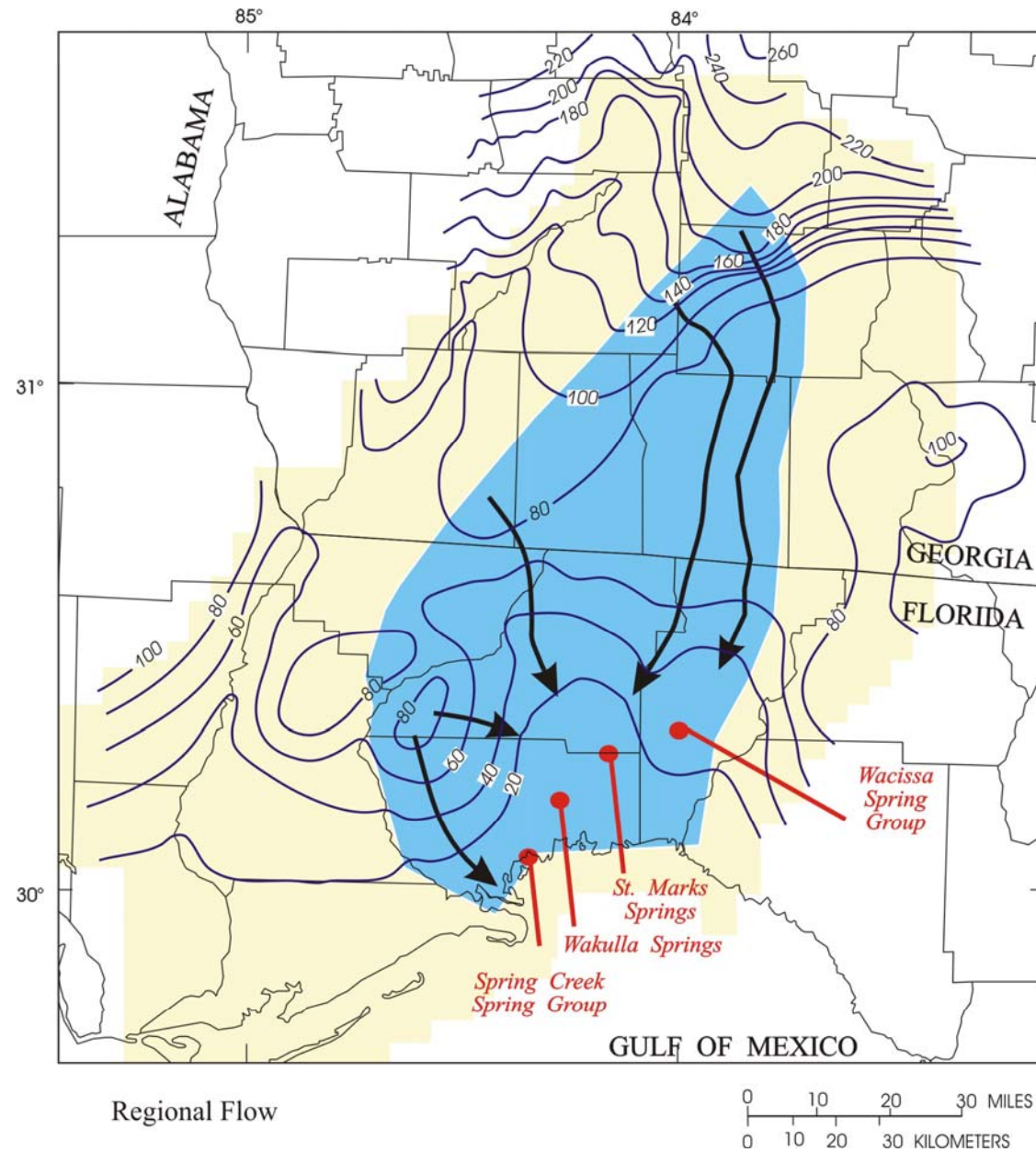


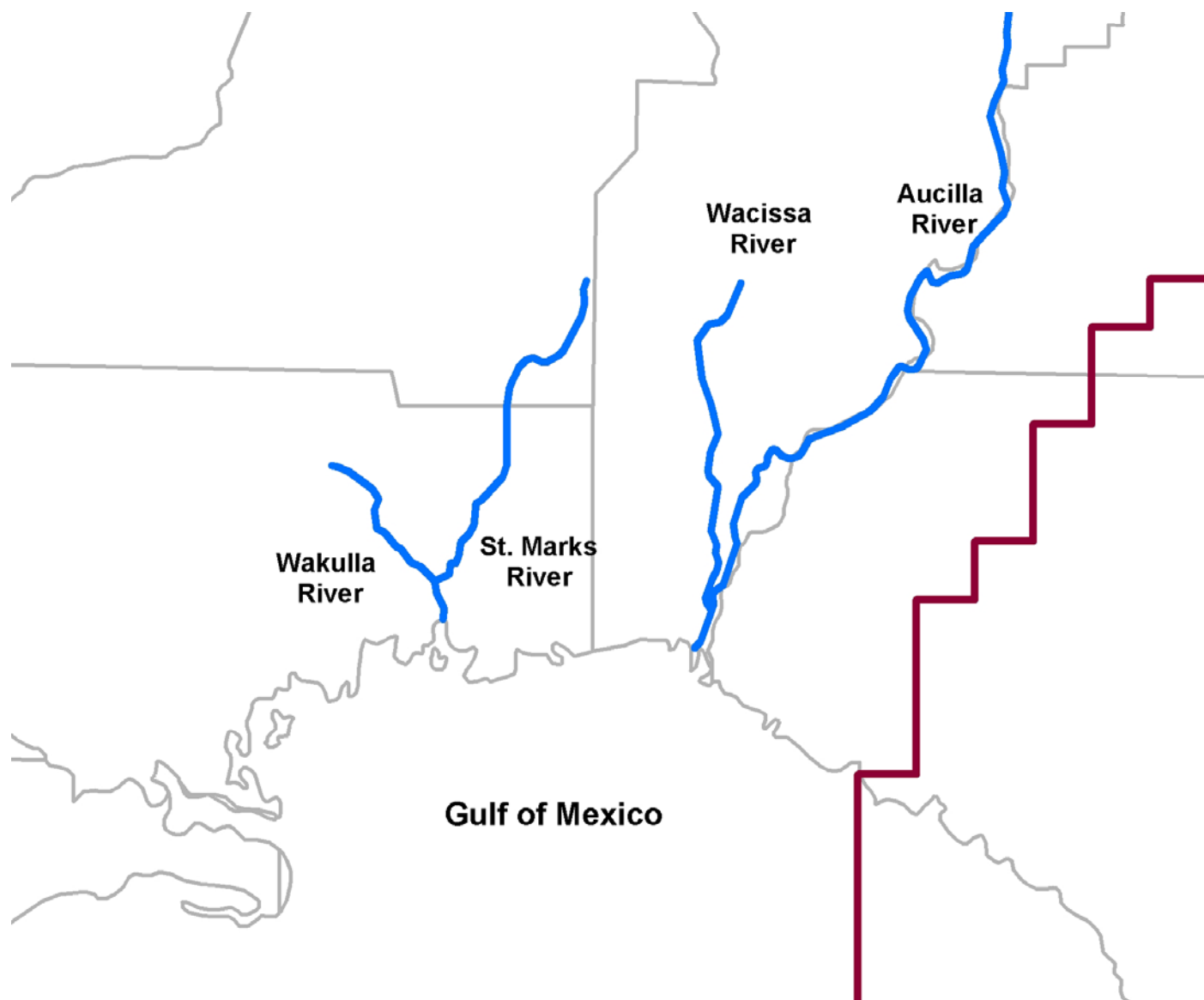
Proposed Consortium Action Items

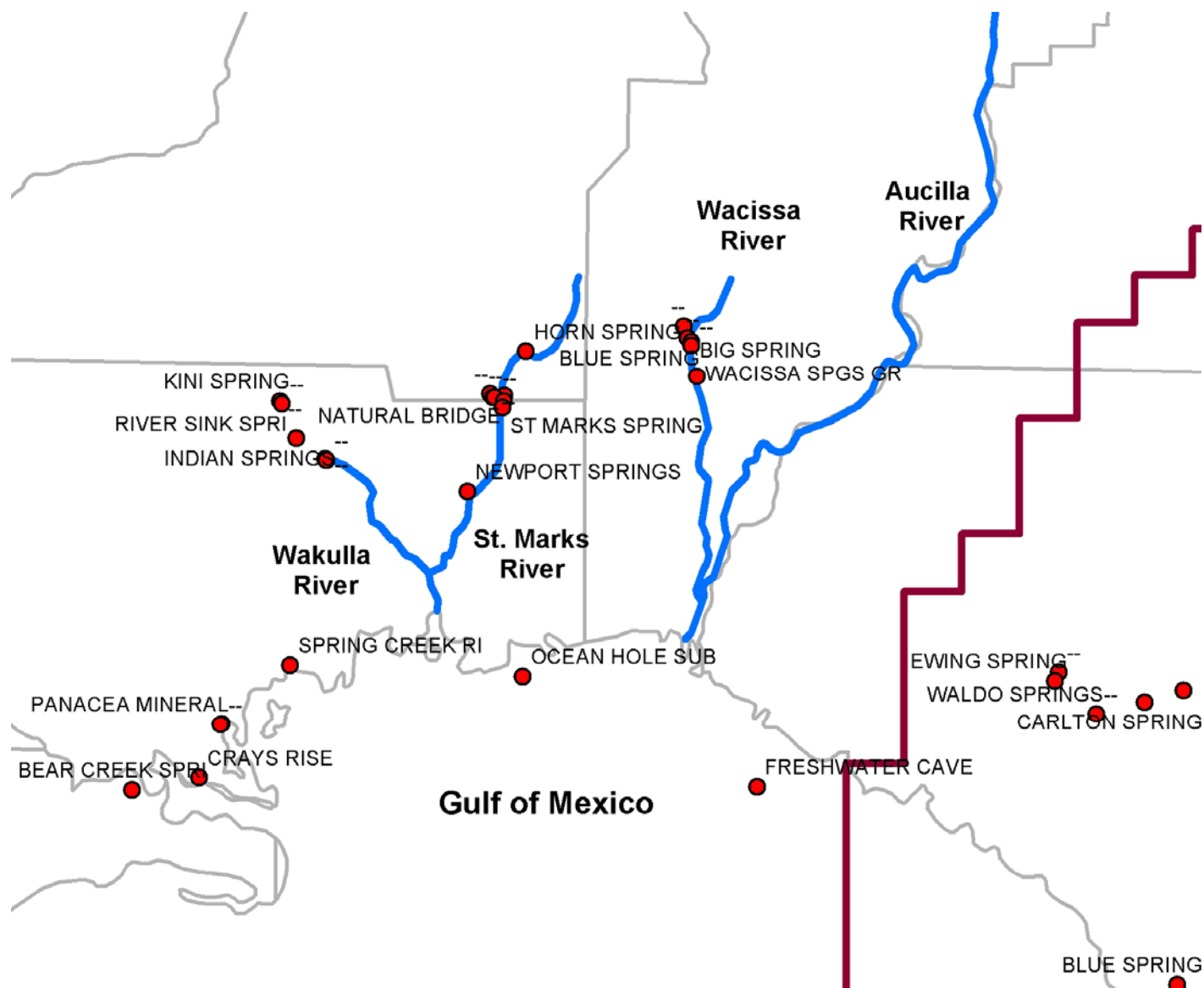
- Development of glossary of terms
- Development of sampling protocols and a quality assurance plan
- Develop training program to introduce cave divers to technical issues and karst science and karst scientists to cave diving
- Standardization of data and development of data repositories

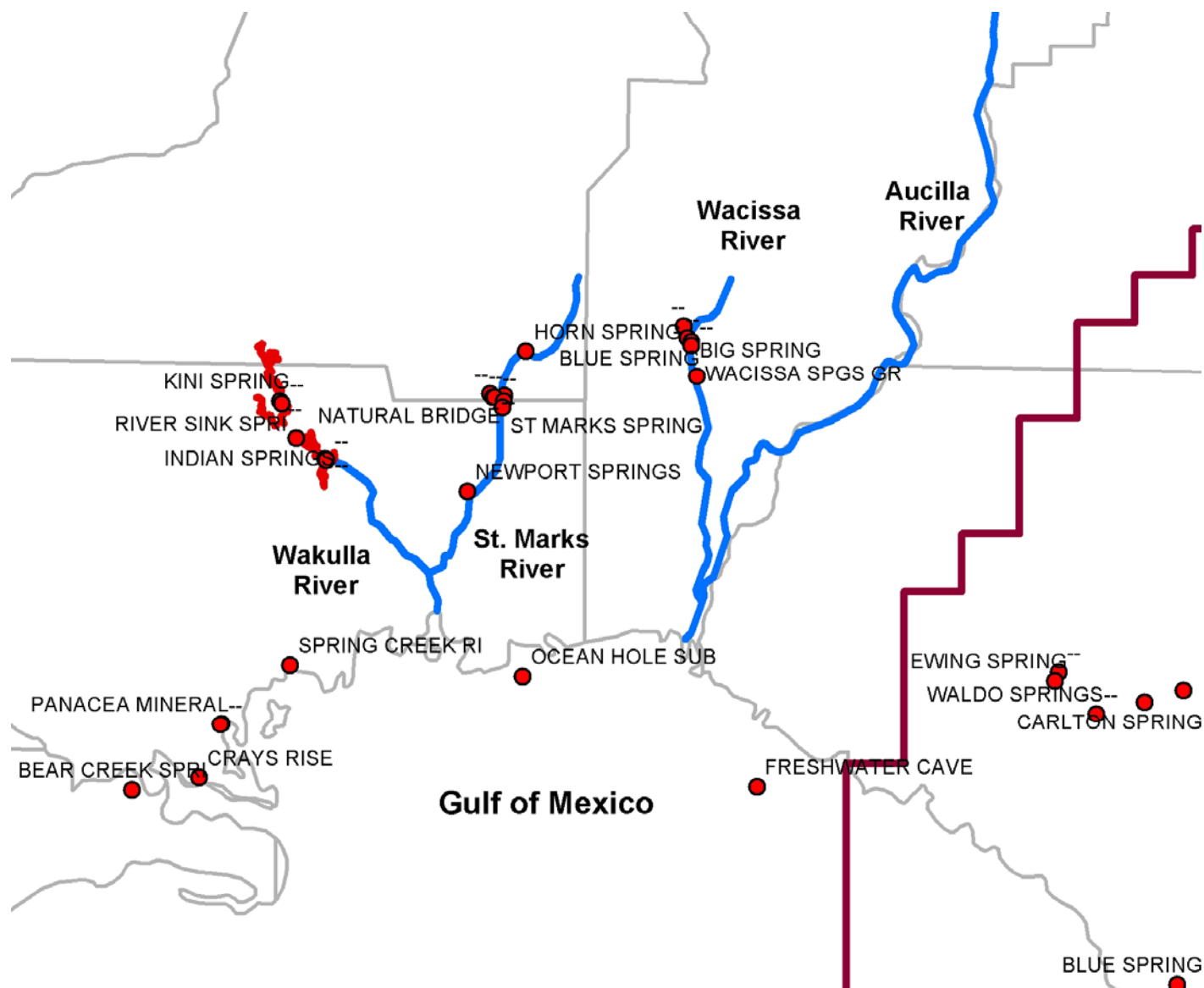


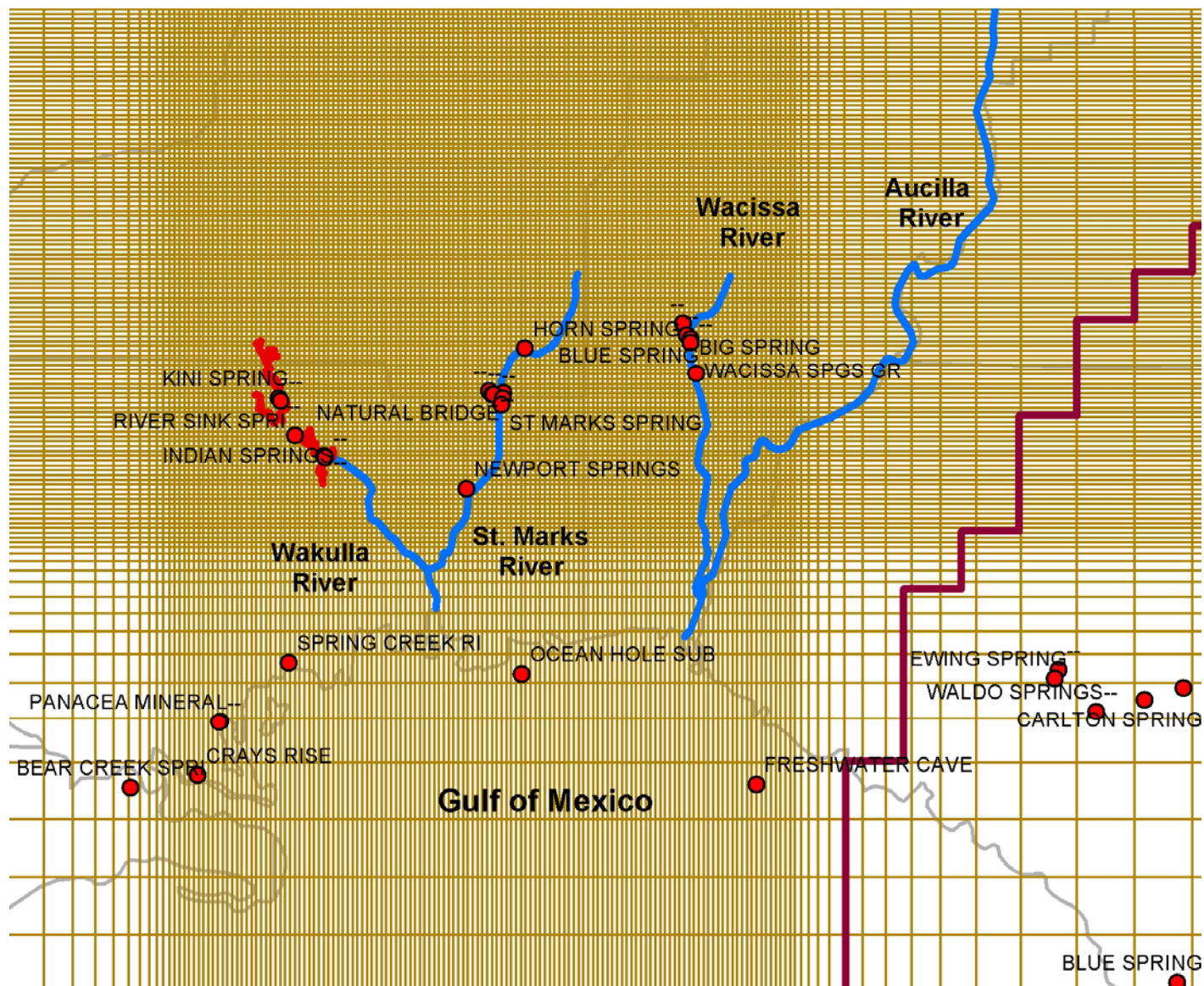
Regional Ground-Water Flow

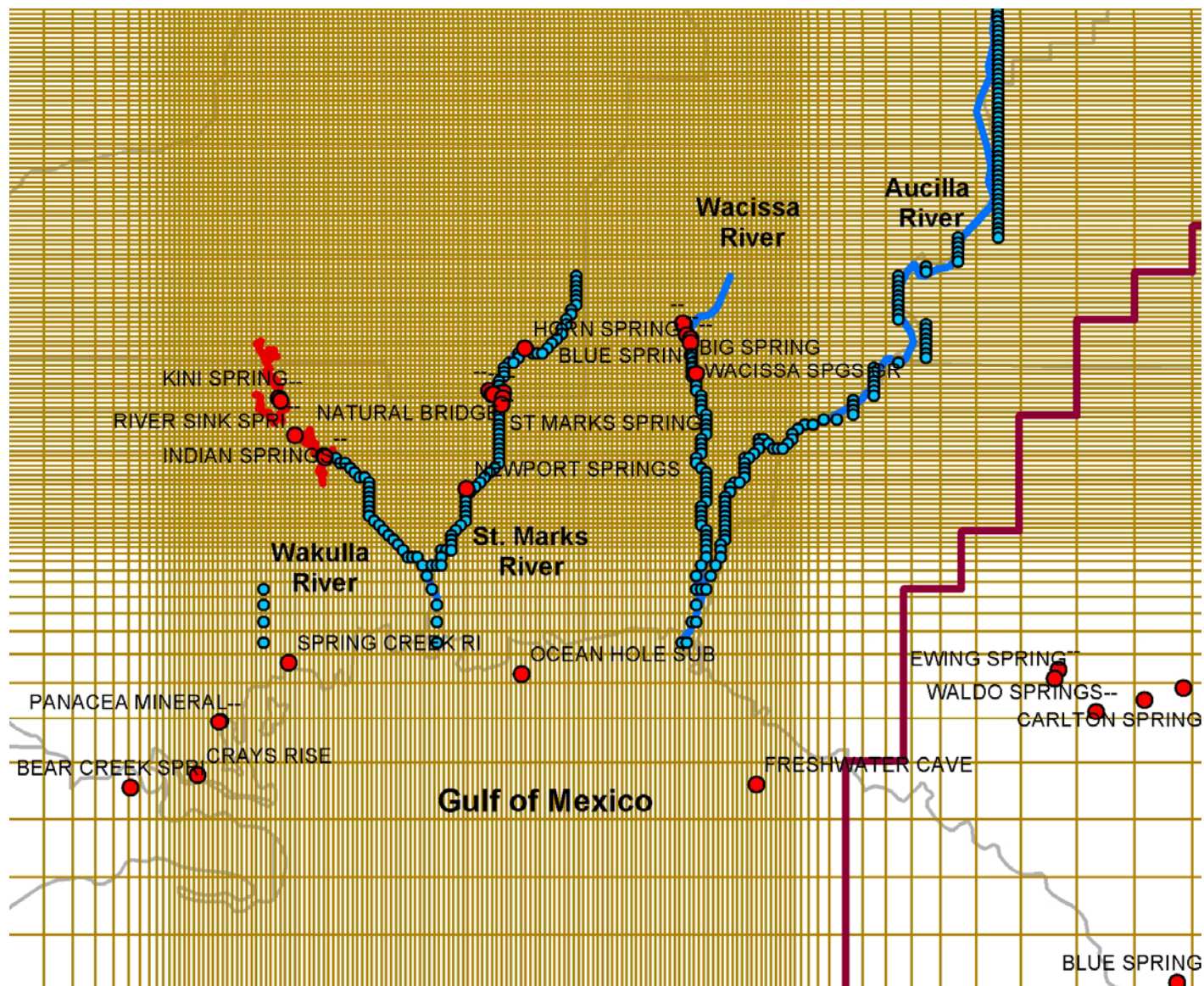


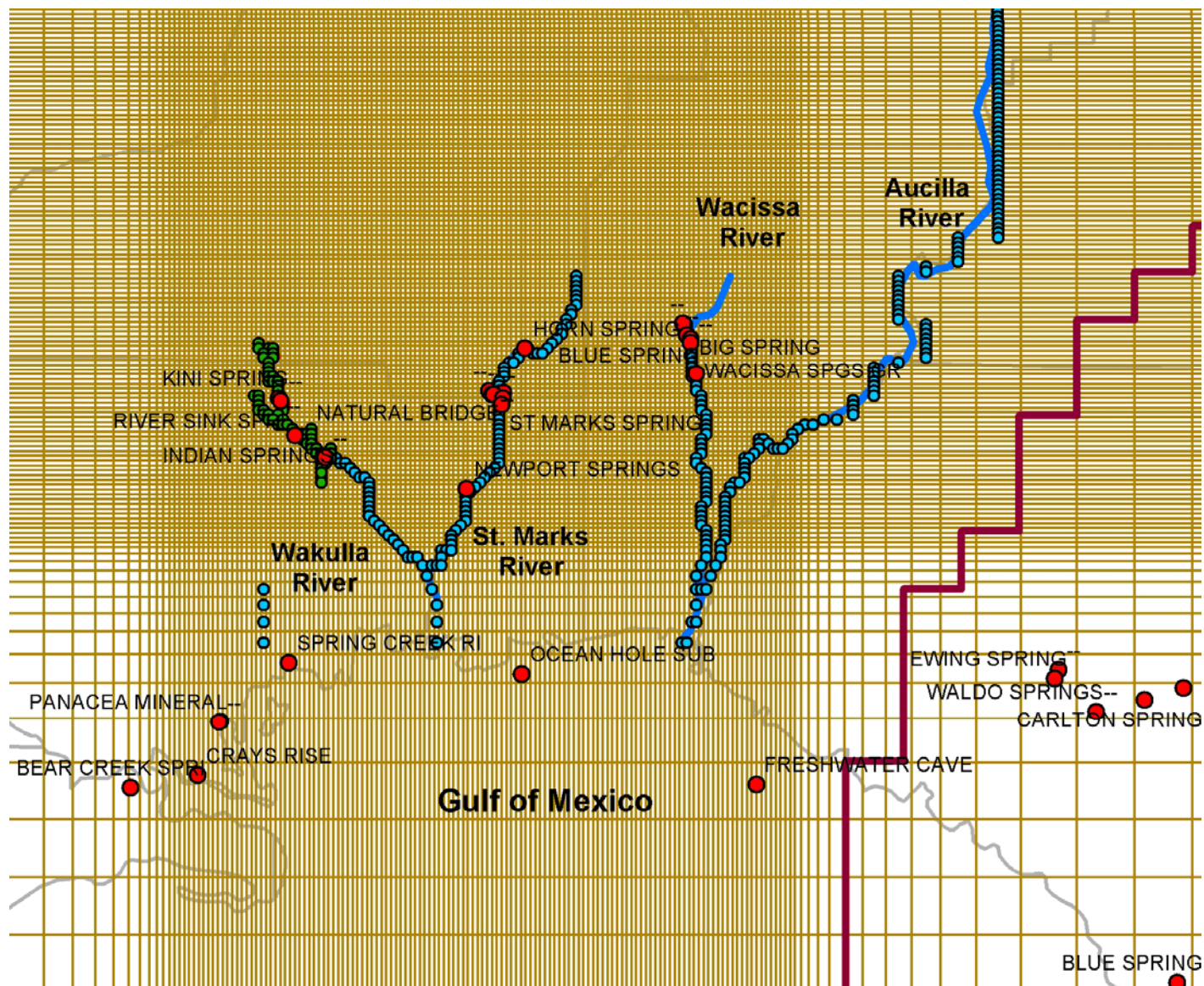


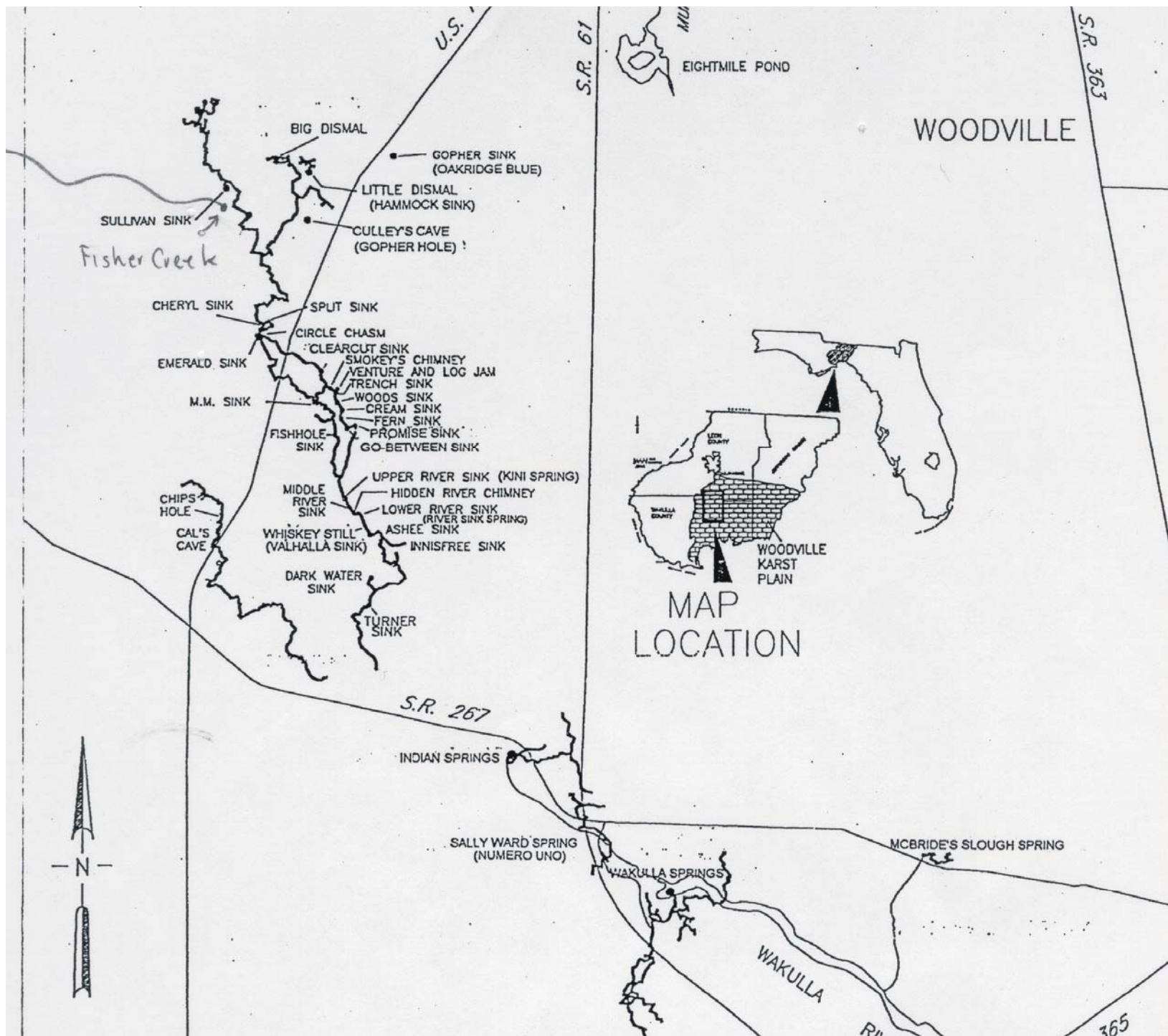




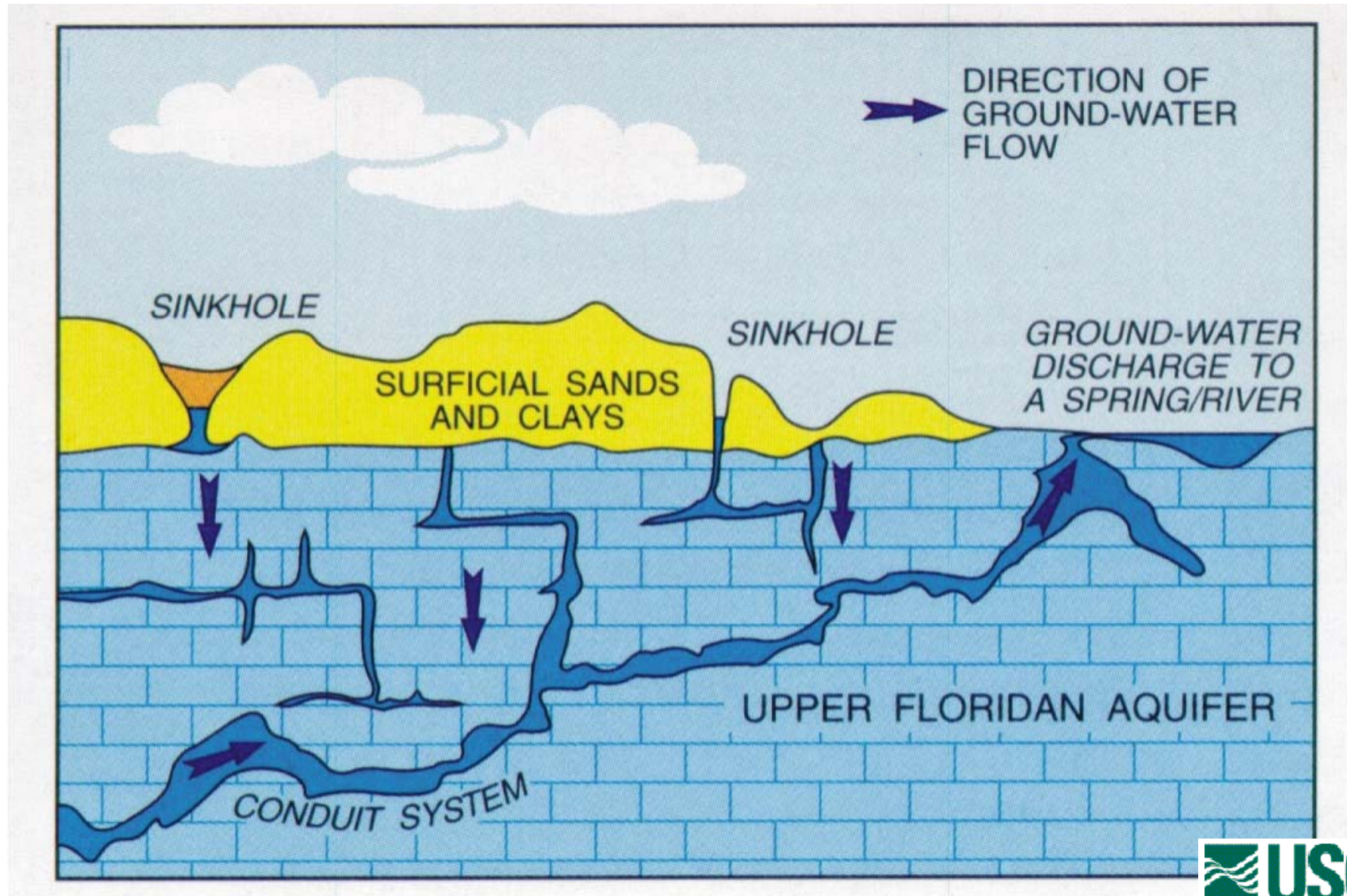


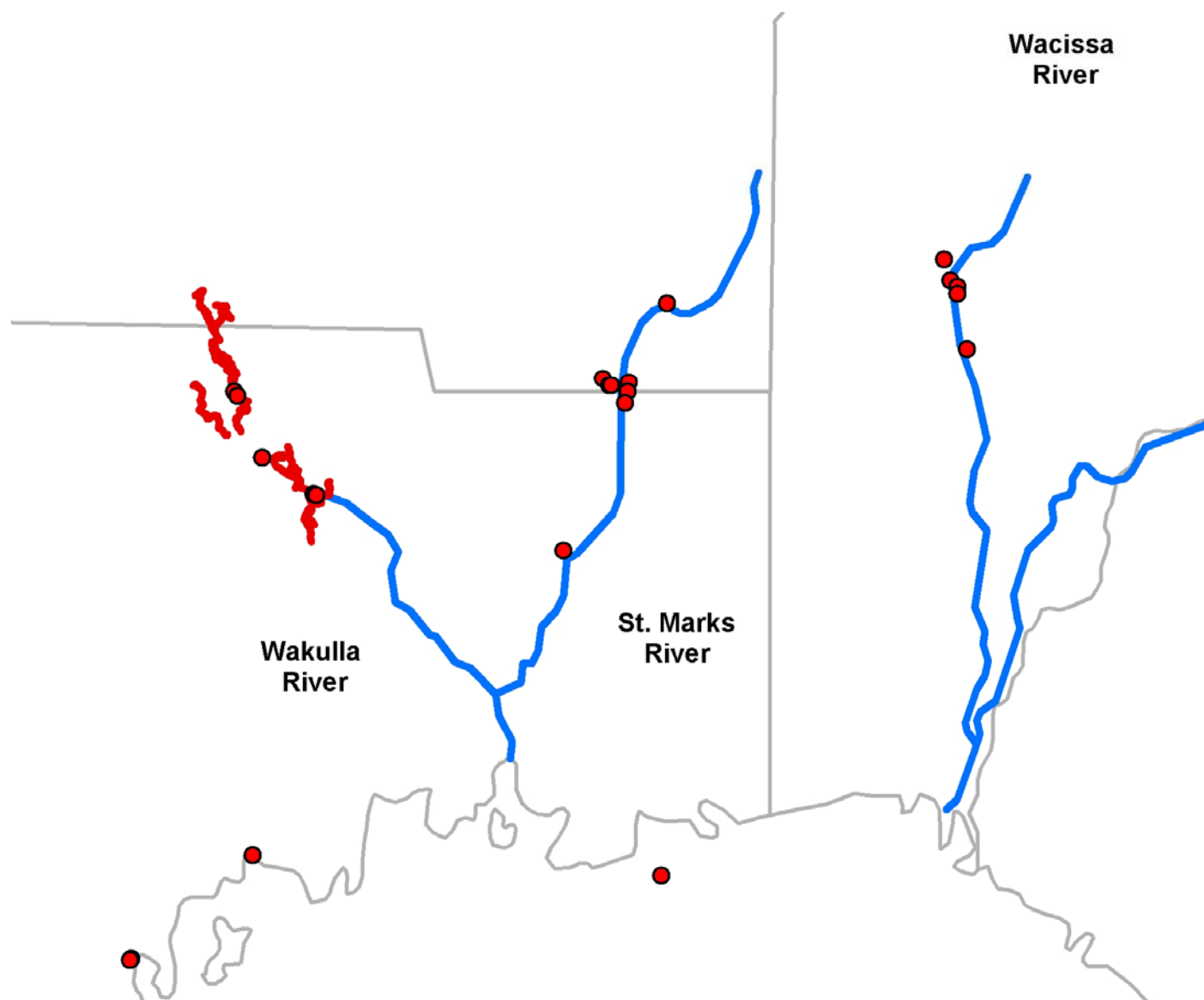


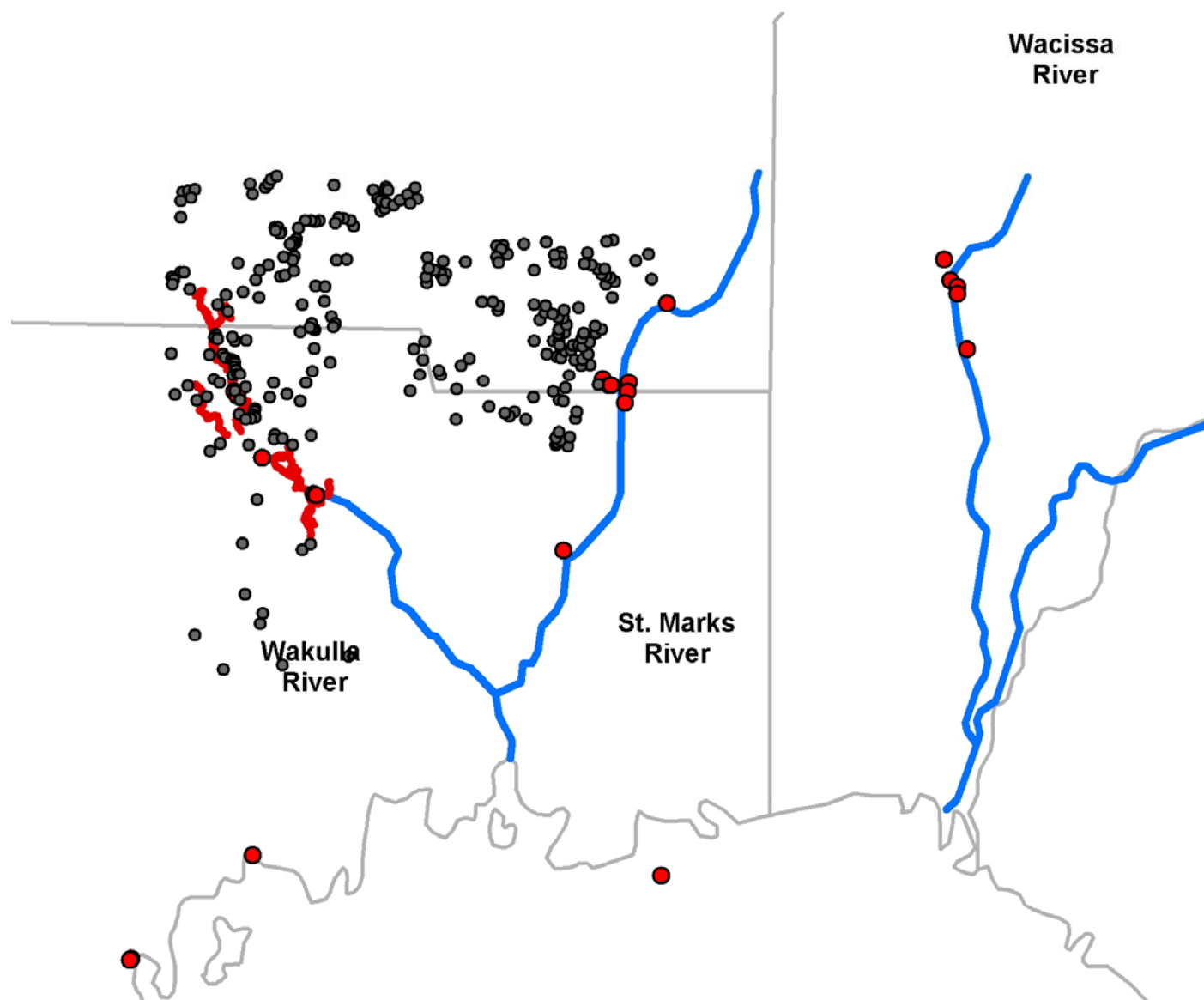


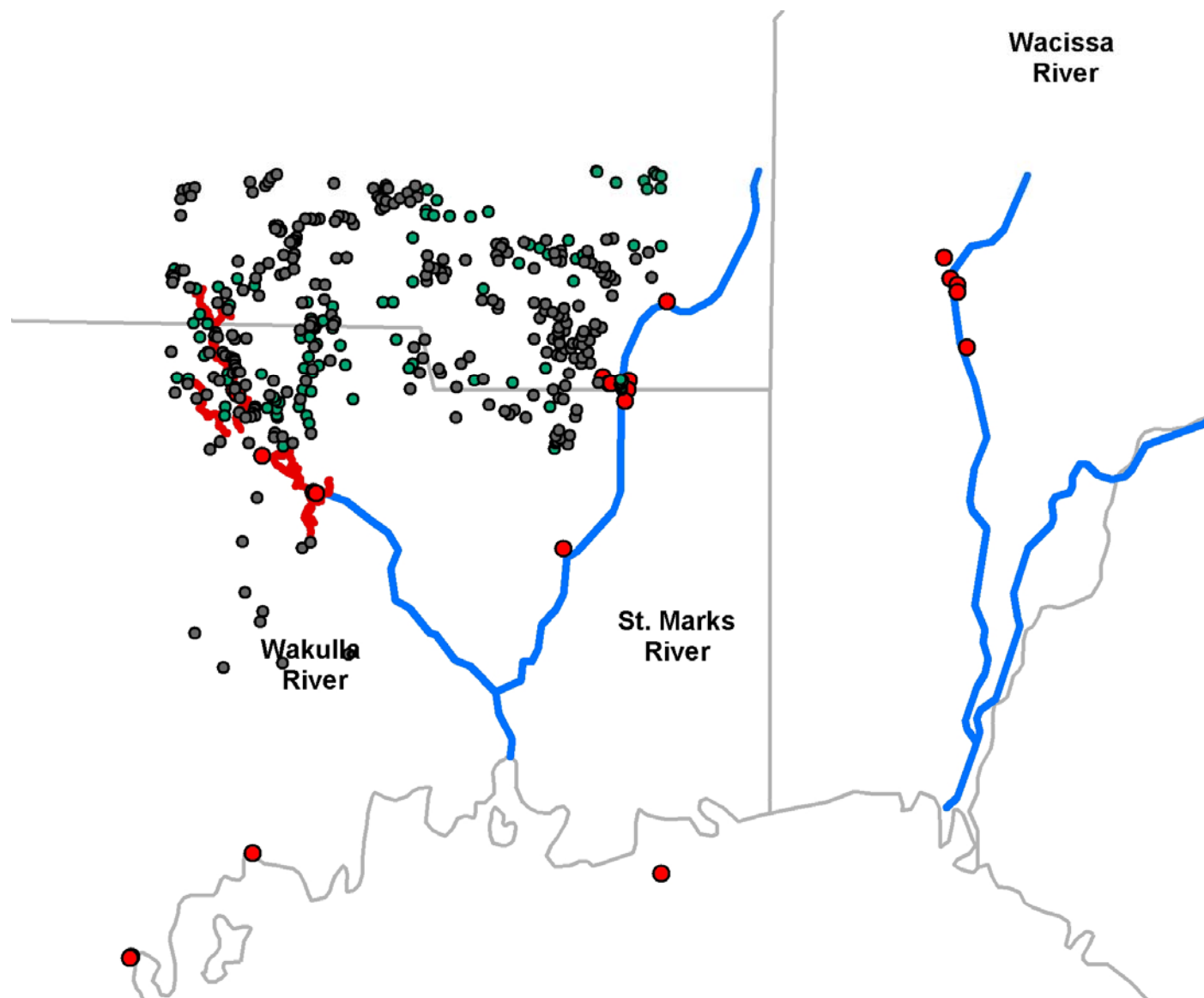


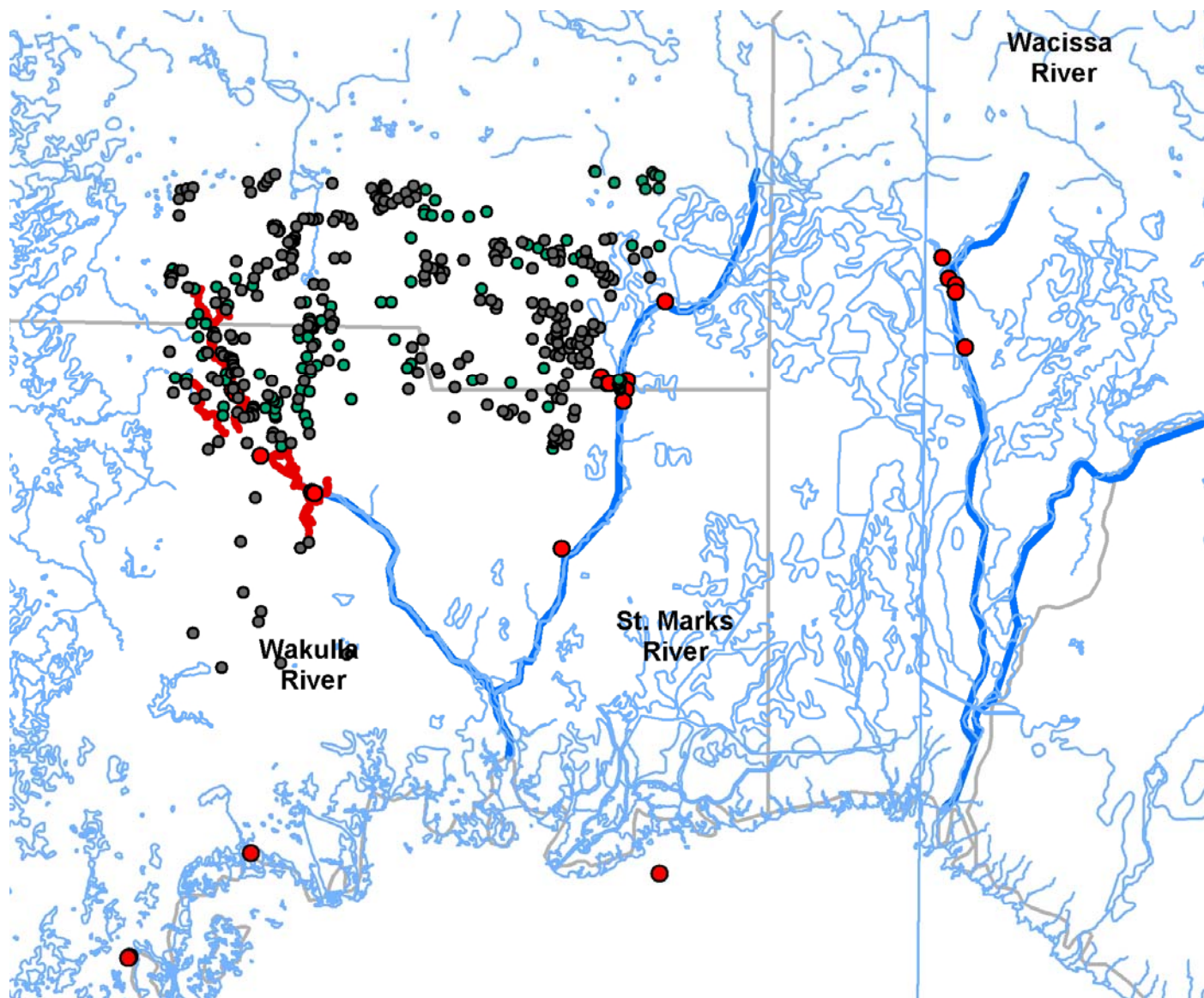
Karst Cross Section

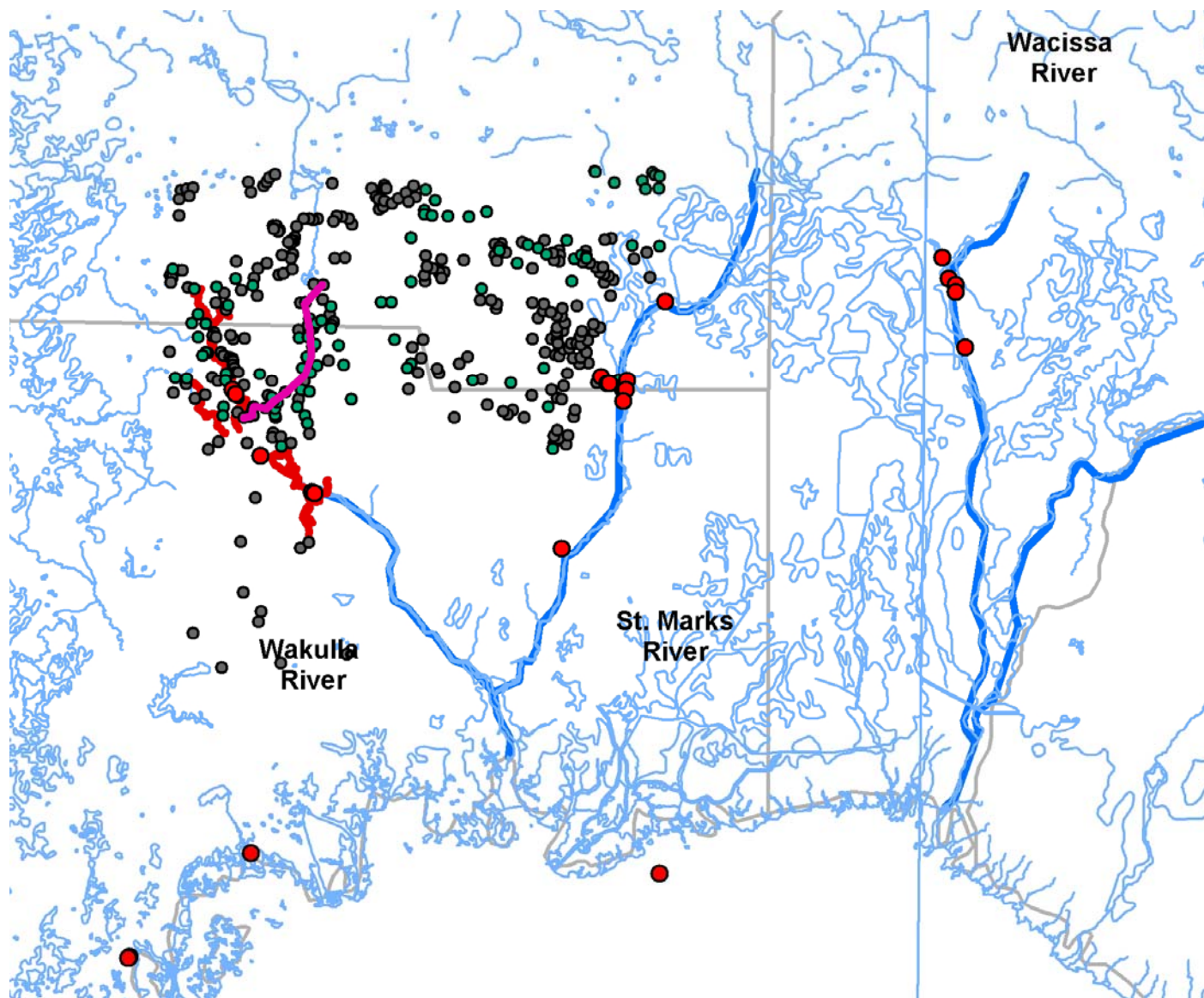


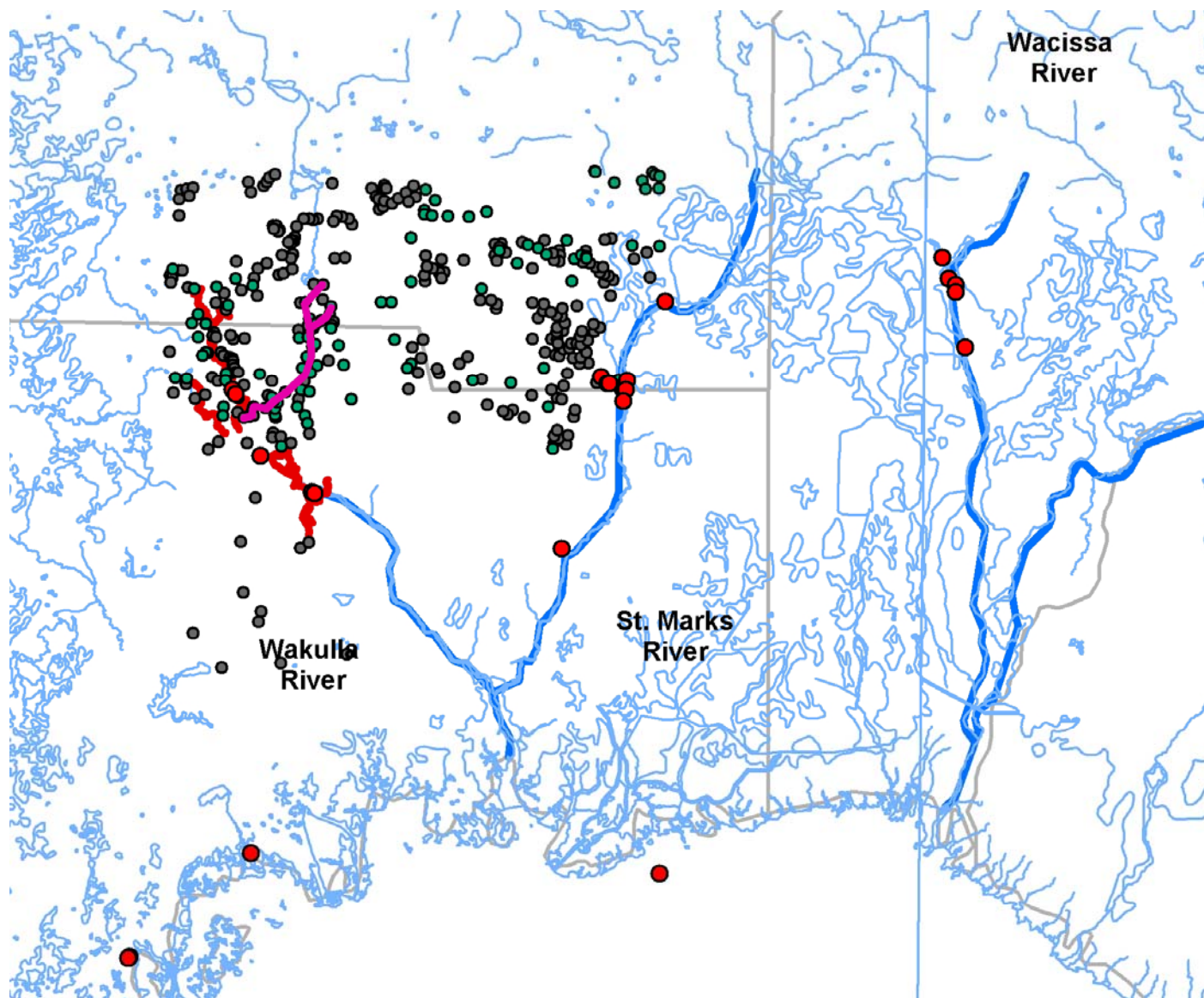


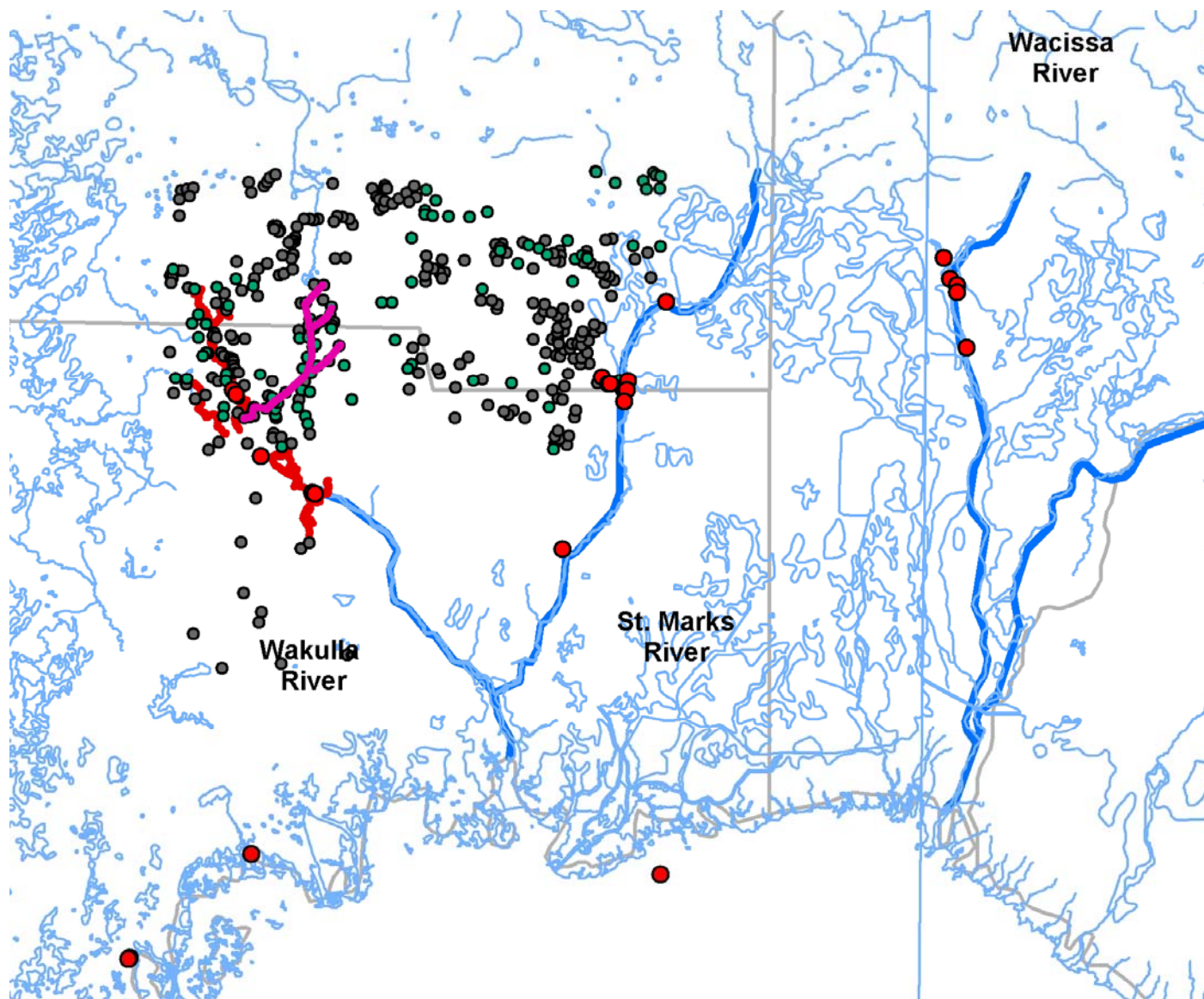


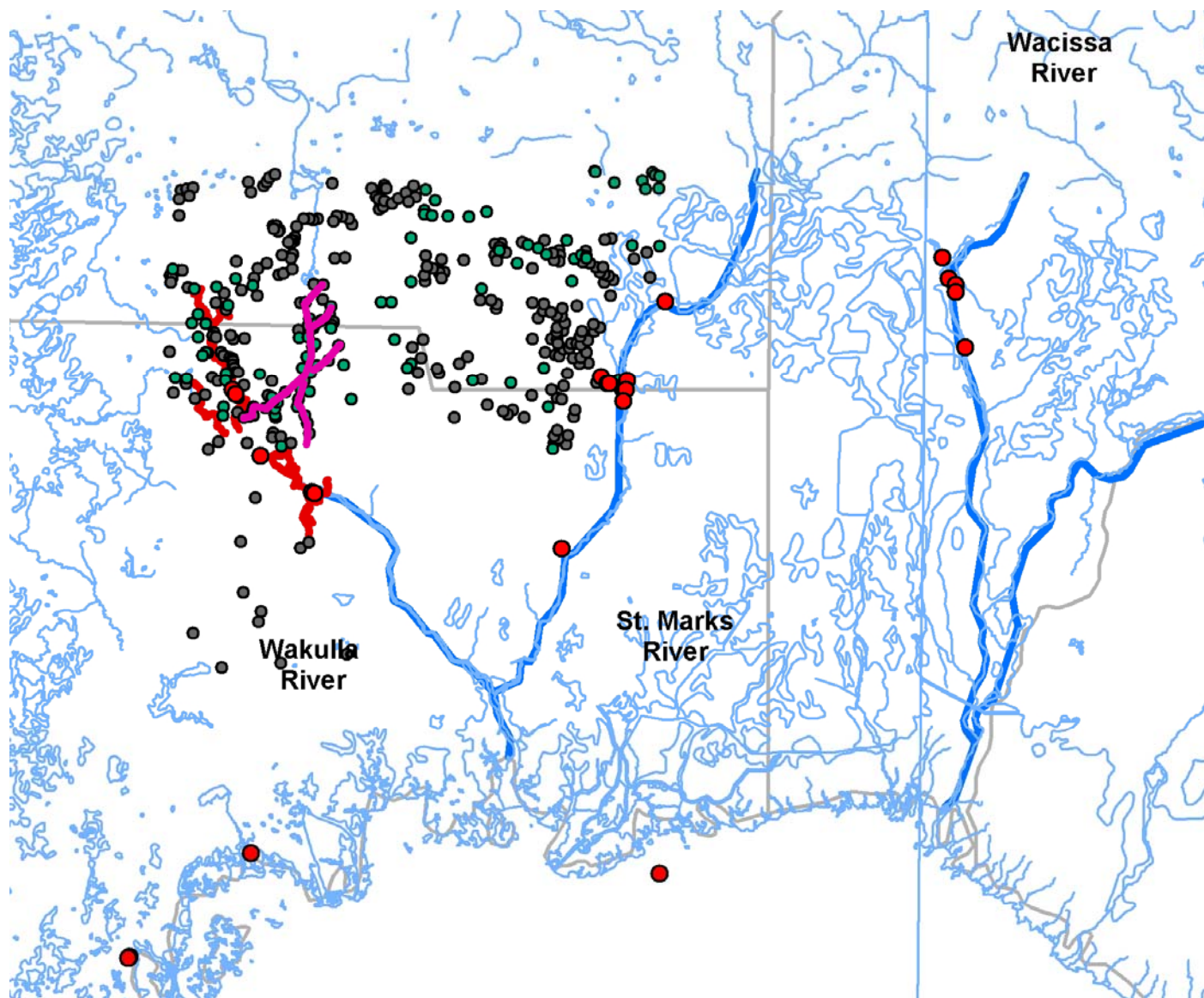


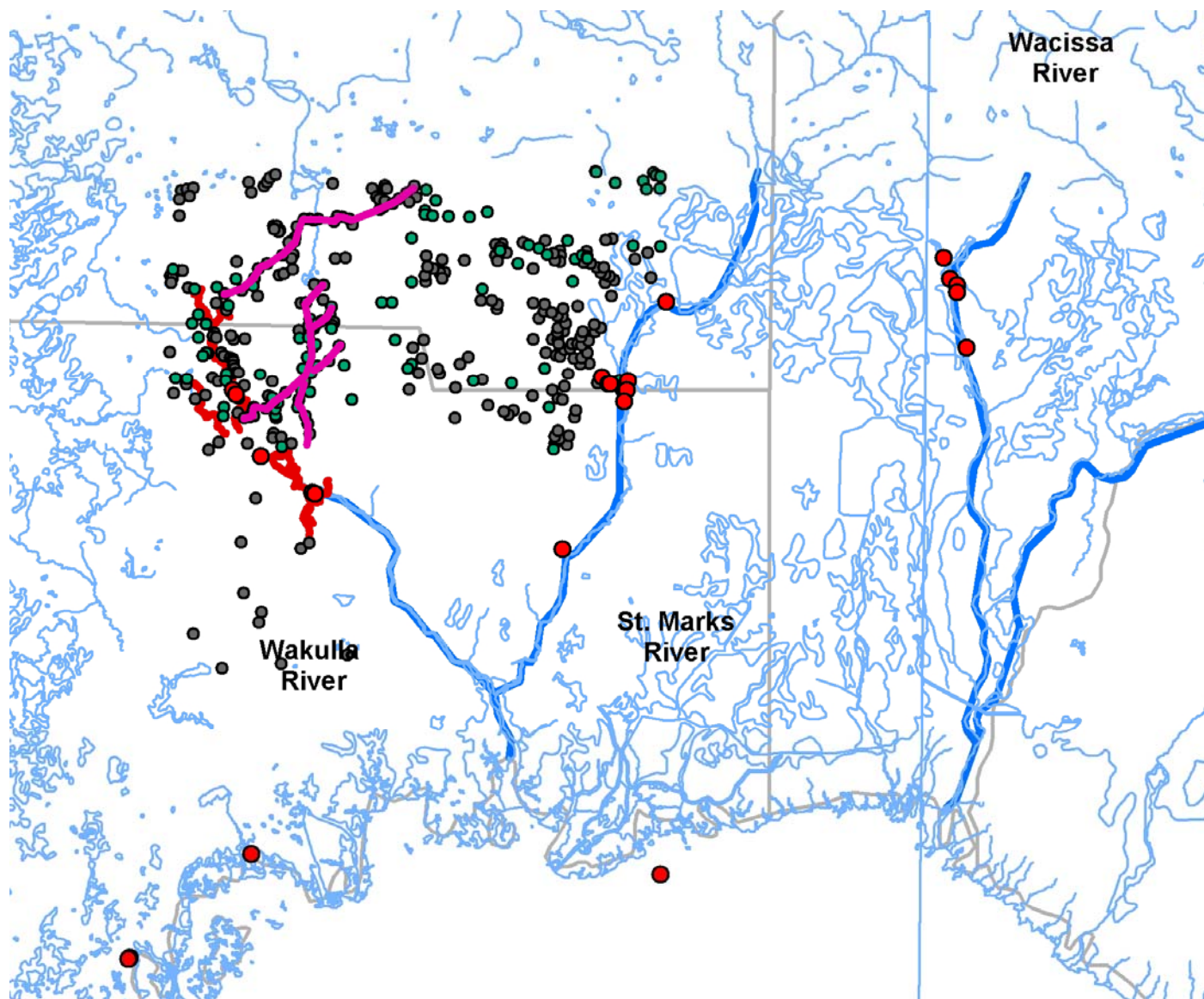


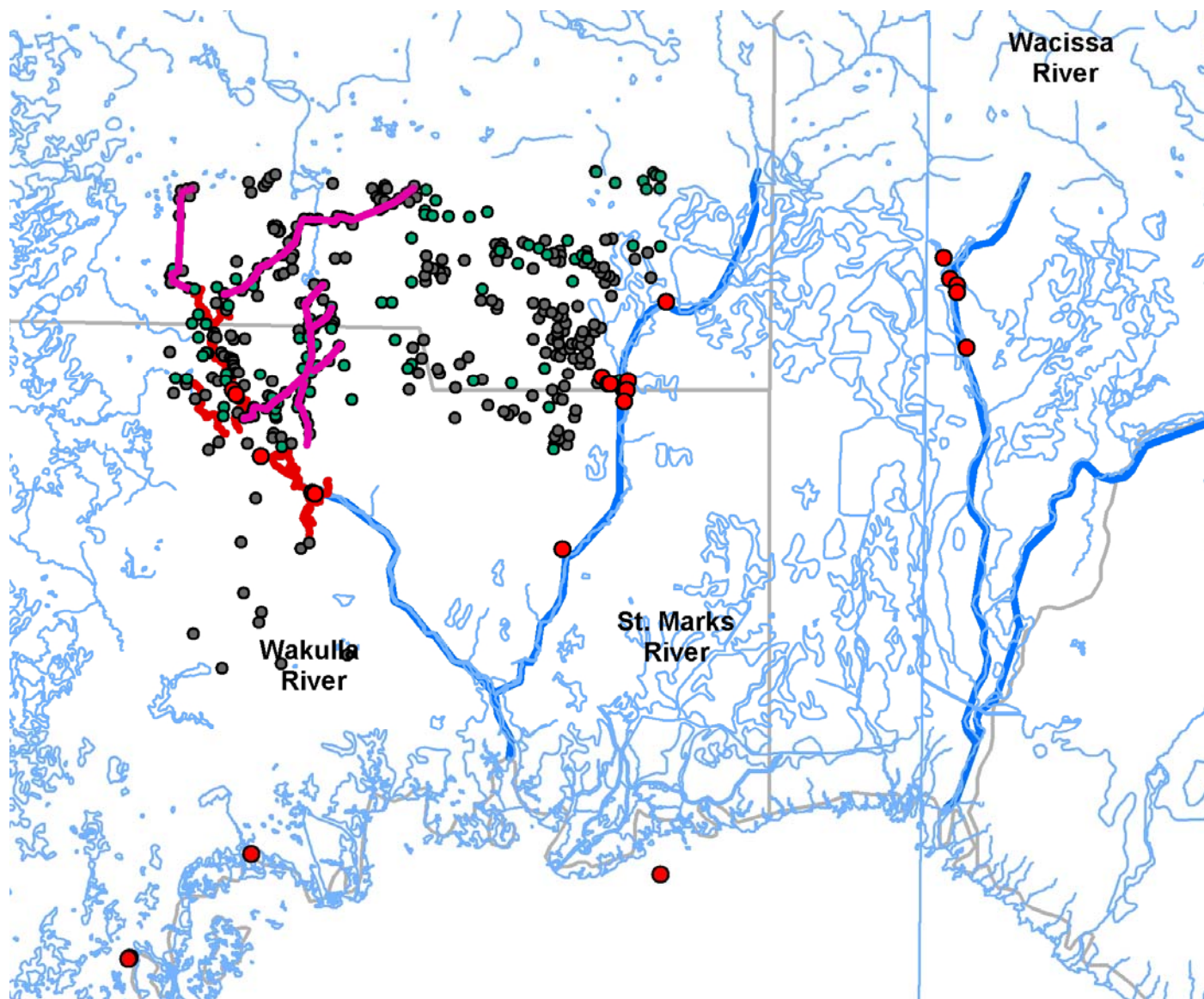


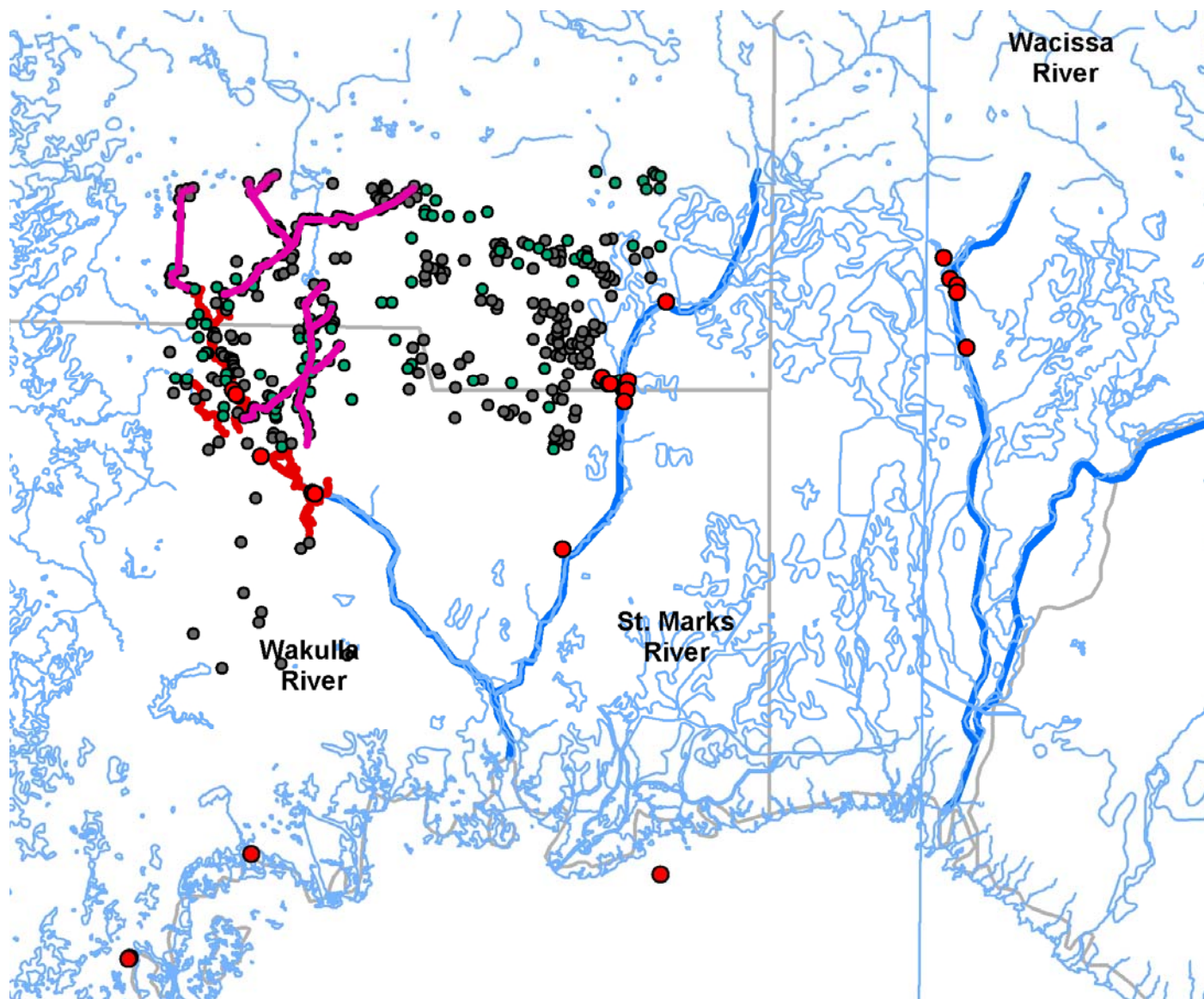


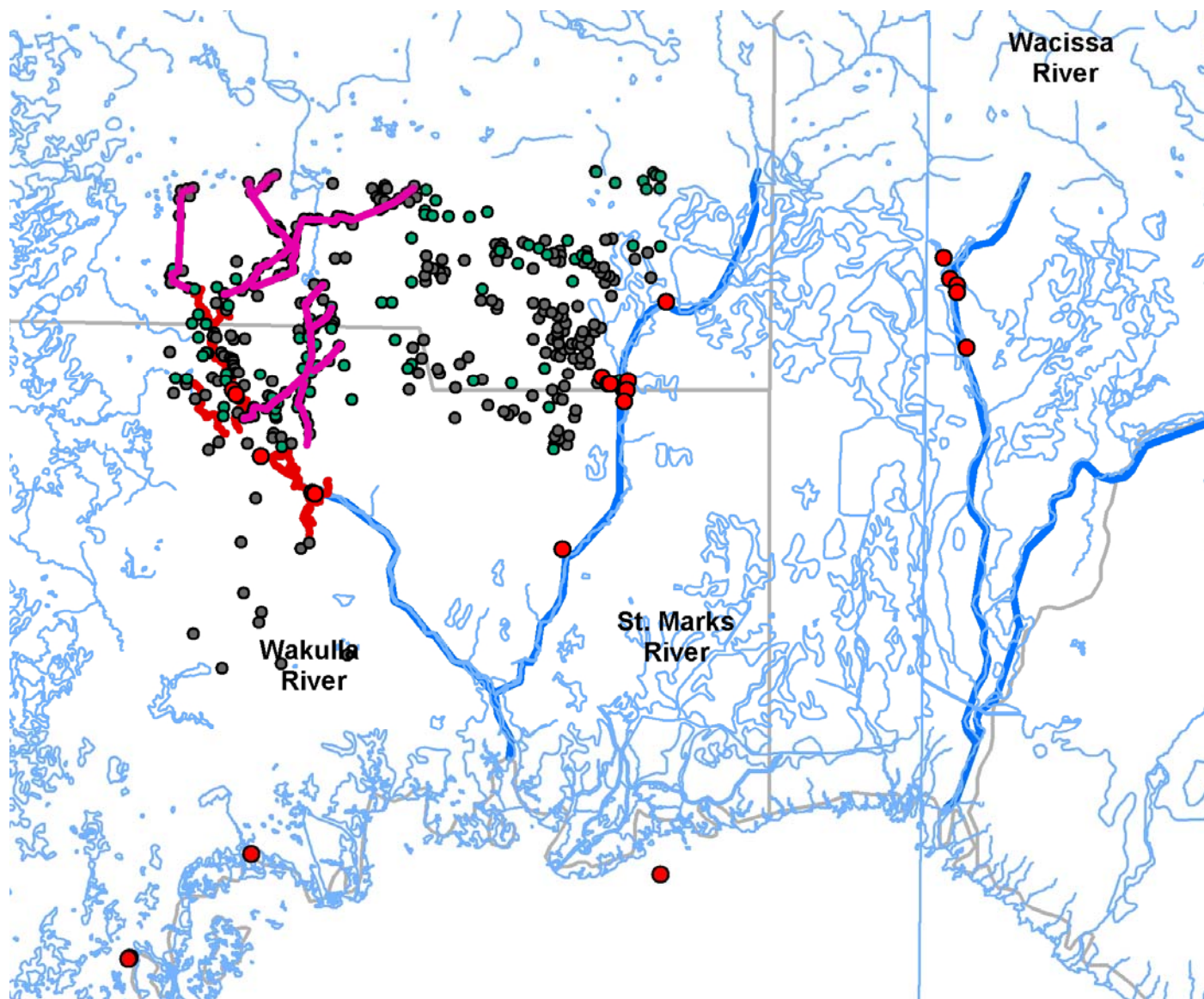


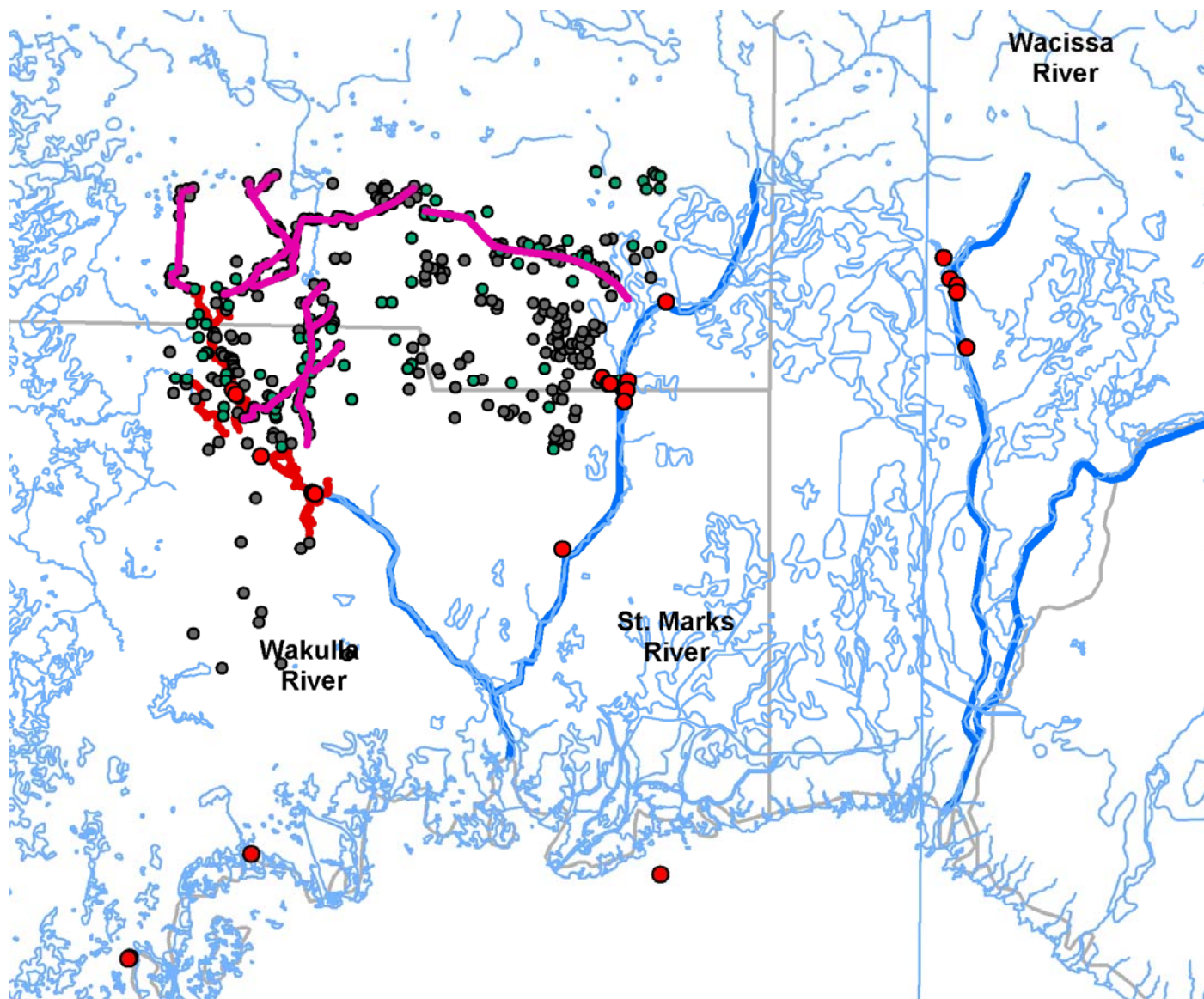


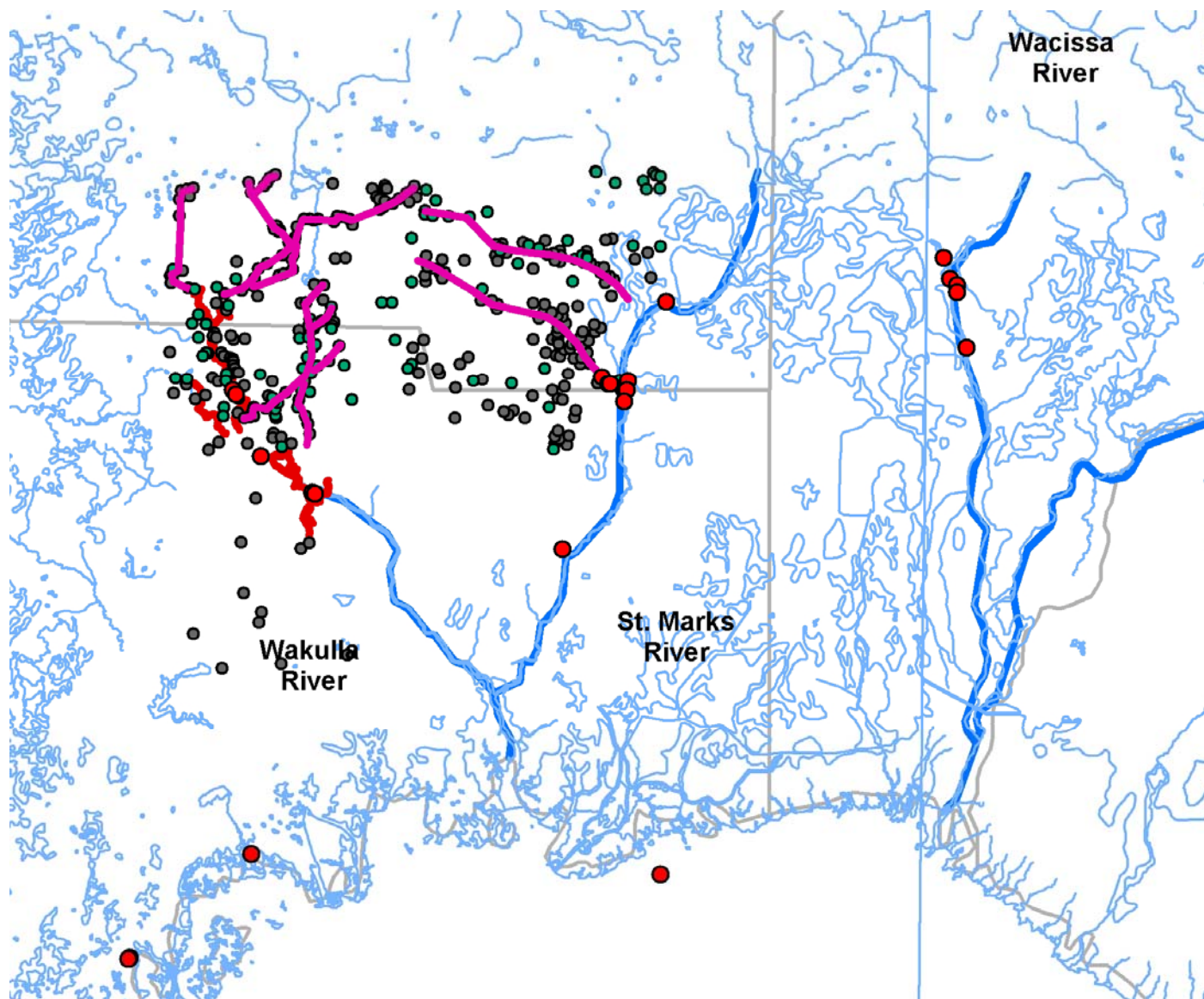


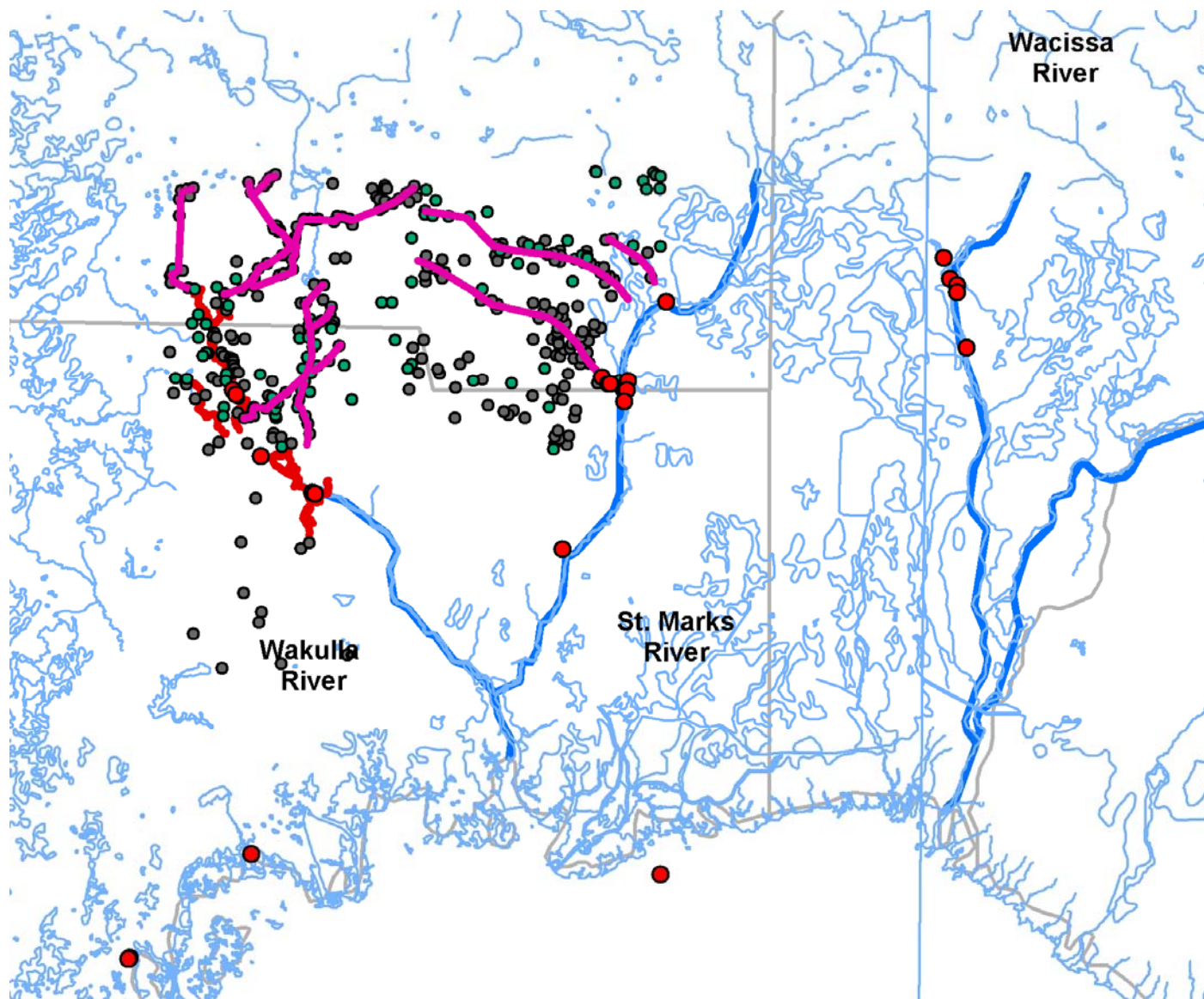


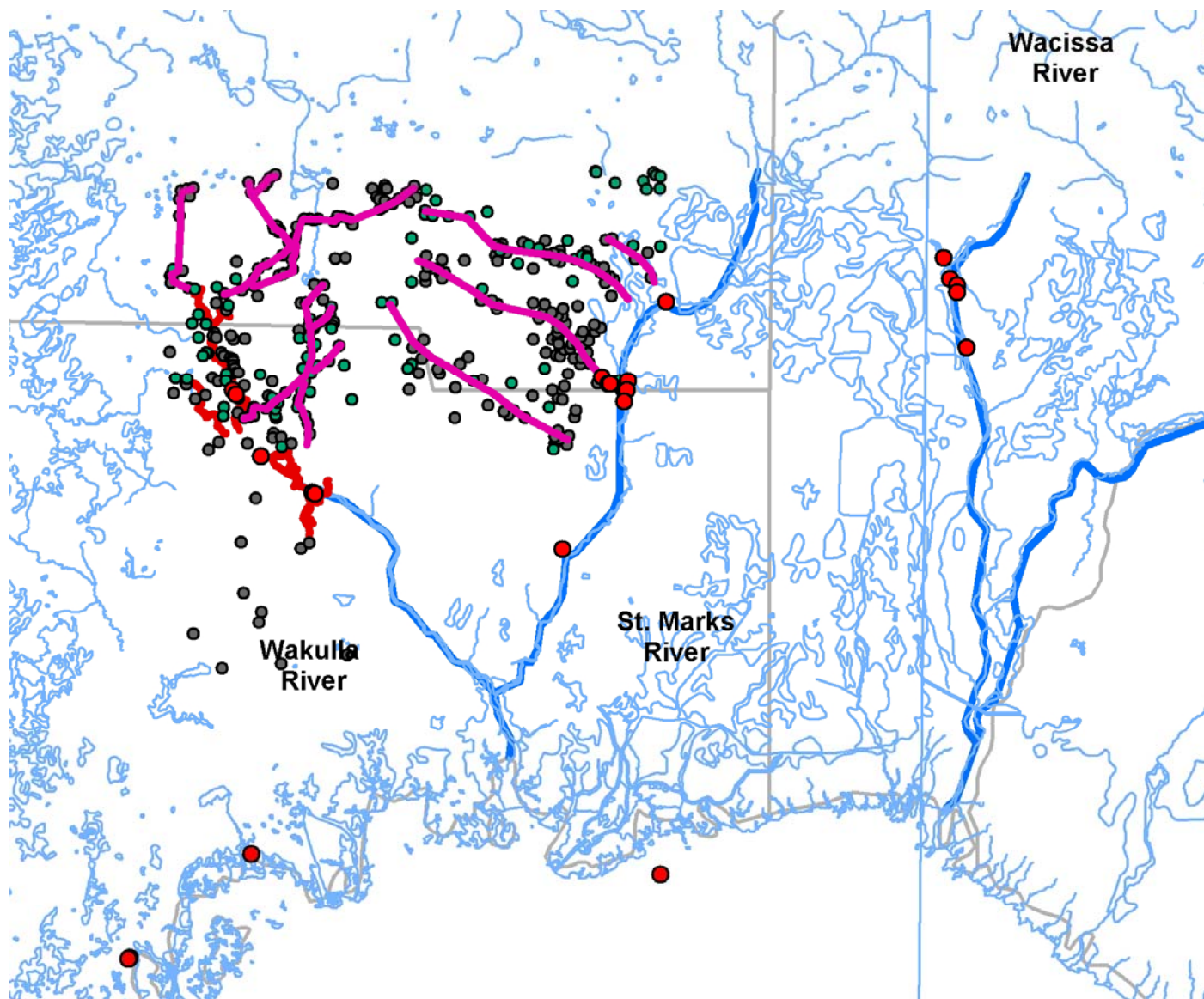






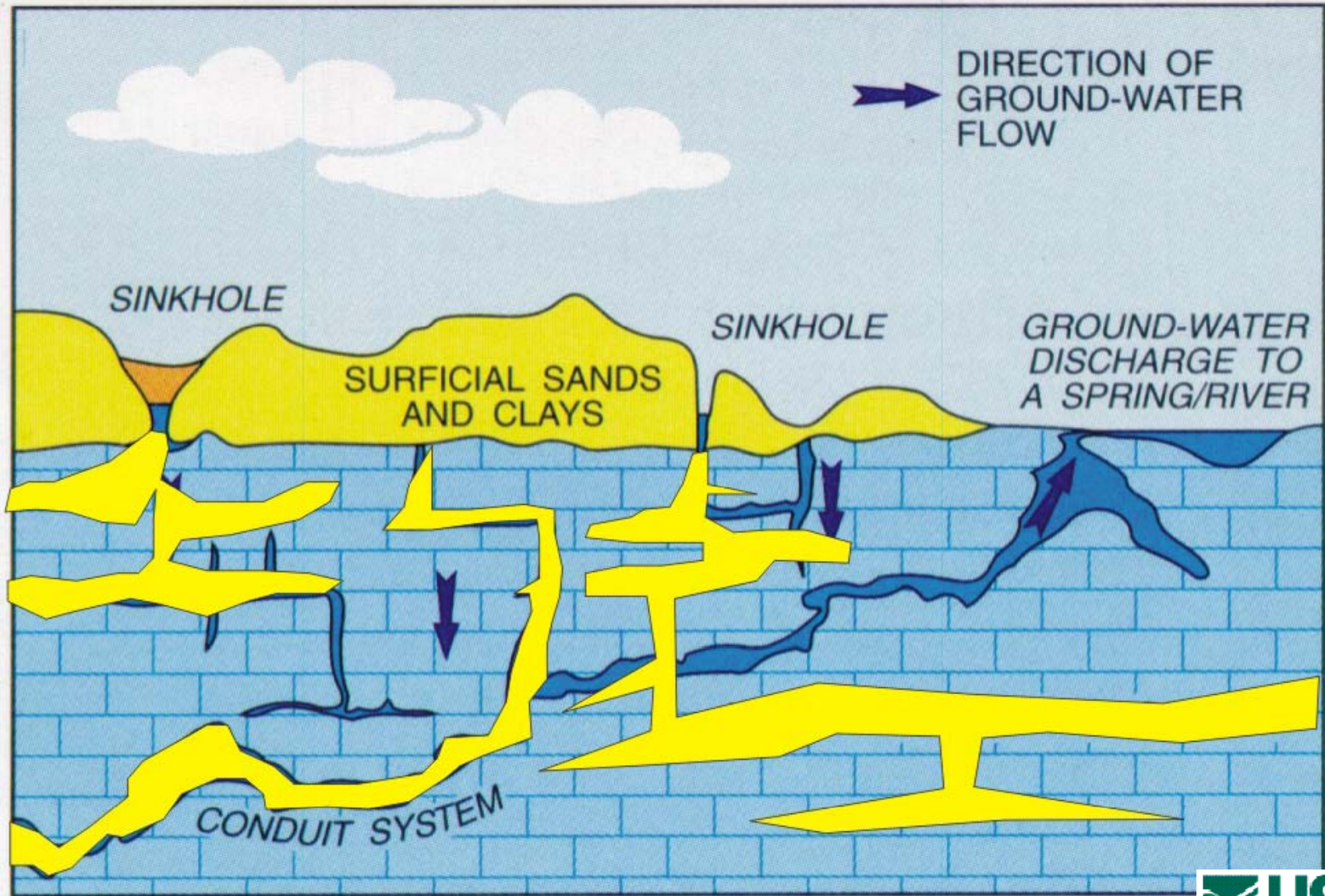




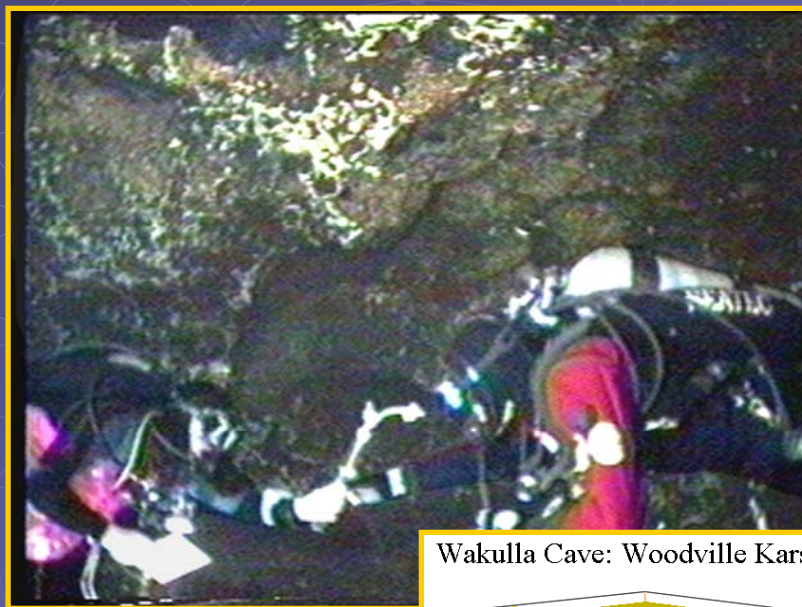


Karst Cross Section

26



Acquisition & Utilization of Cave Data



Todd R. Kincaid, Ph.D.

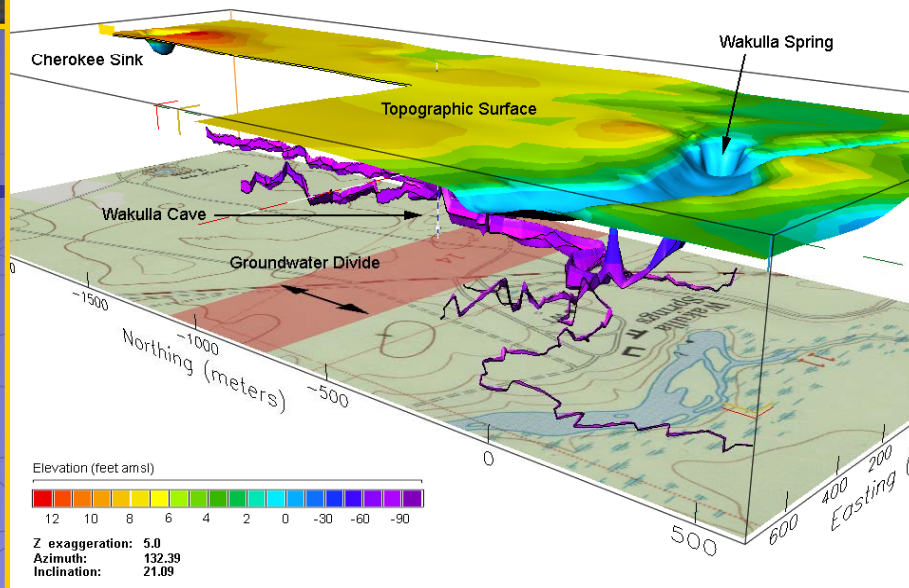
Hazlett-Kincaid, Inc.

www.hazlett-kincaid.com

Global Underwater Explorers

www.gue.com

Wakulla Cave: Woodville Karst Plain, North Florida



Issues: Diver vs. Scientist

- Acquisition

- What's Feasible?
- Logistical Limitations
- Technical Guidance

- Utilization

- Access
- Reliability



Data Acquisition: What's Feasible?

- Cave survey data
- Geochemical samples
- Tracer Injections
- Semi-permanent instrumentation
- Video
- ???



Data Acquisition: Cave Survey Data

Data: Moving Polar Coordinates

- Azimuth
- Distance
- Depth
- Width
- Height

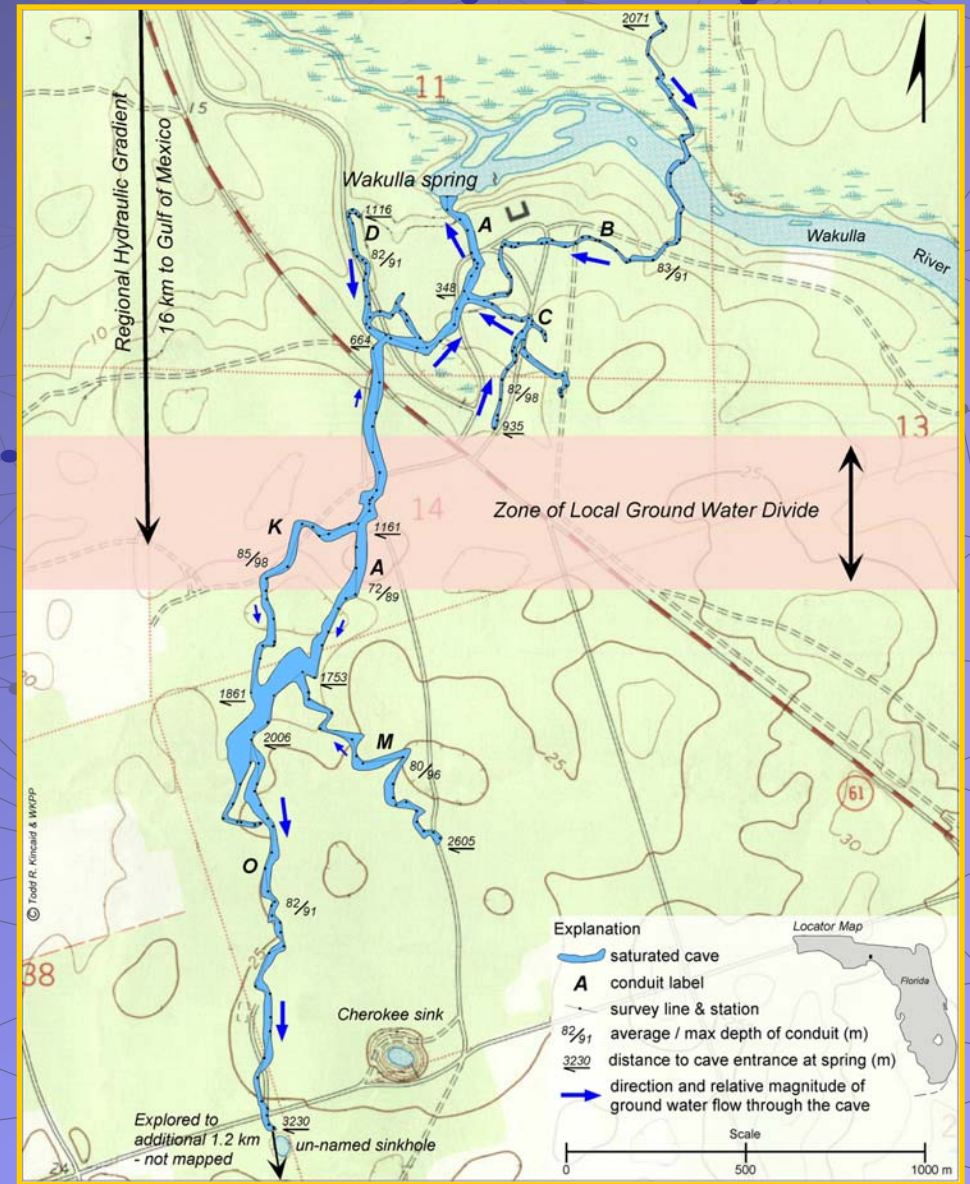
Limitations

- Time
- Precision

Emerging Technologies

- Sonar mapping
- Integrated digital devices
- Data loggers

Maximize Diver Utility
Minimize Diver Interface

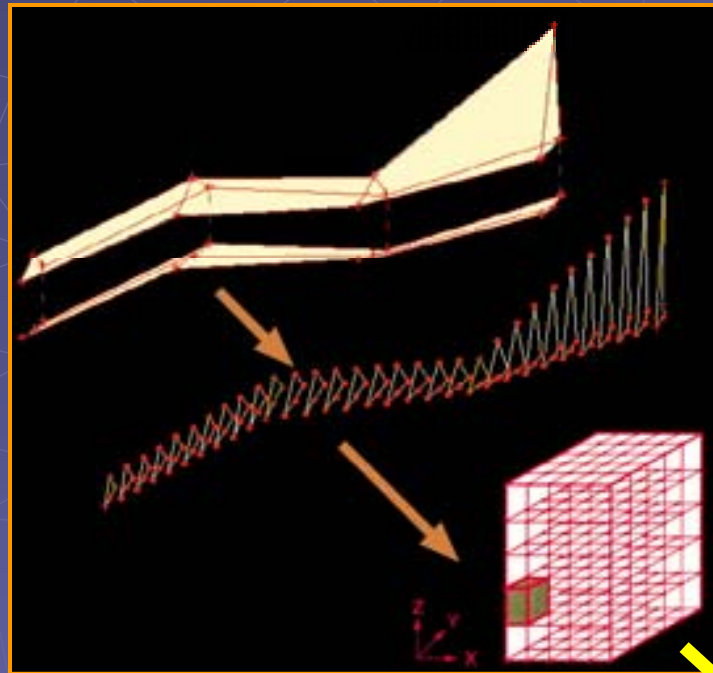


Cave Survey: Uncertainty

Azimuth Error

Profile Error

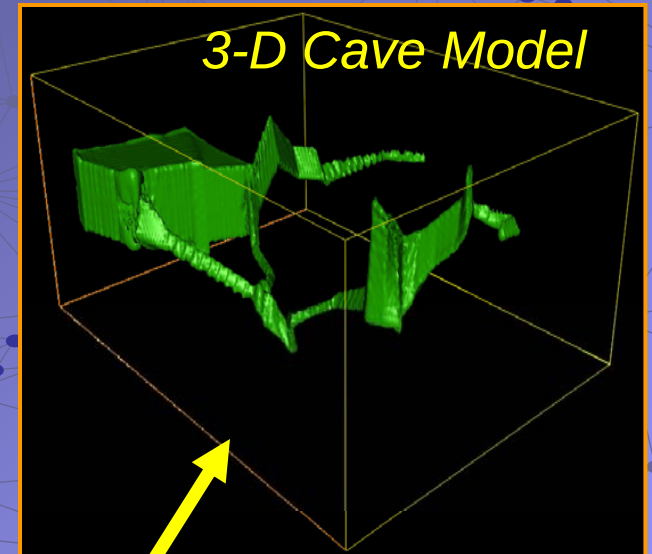
Cave Survey: 3-D Modeling



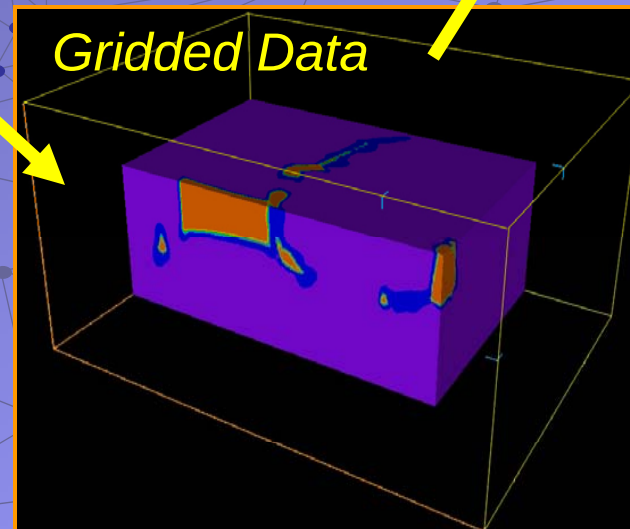
Data

Interpolation

Gridding



3-D Cave Model

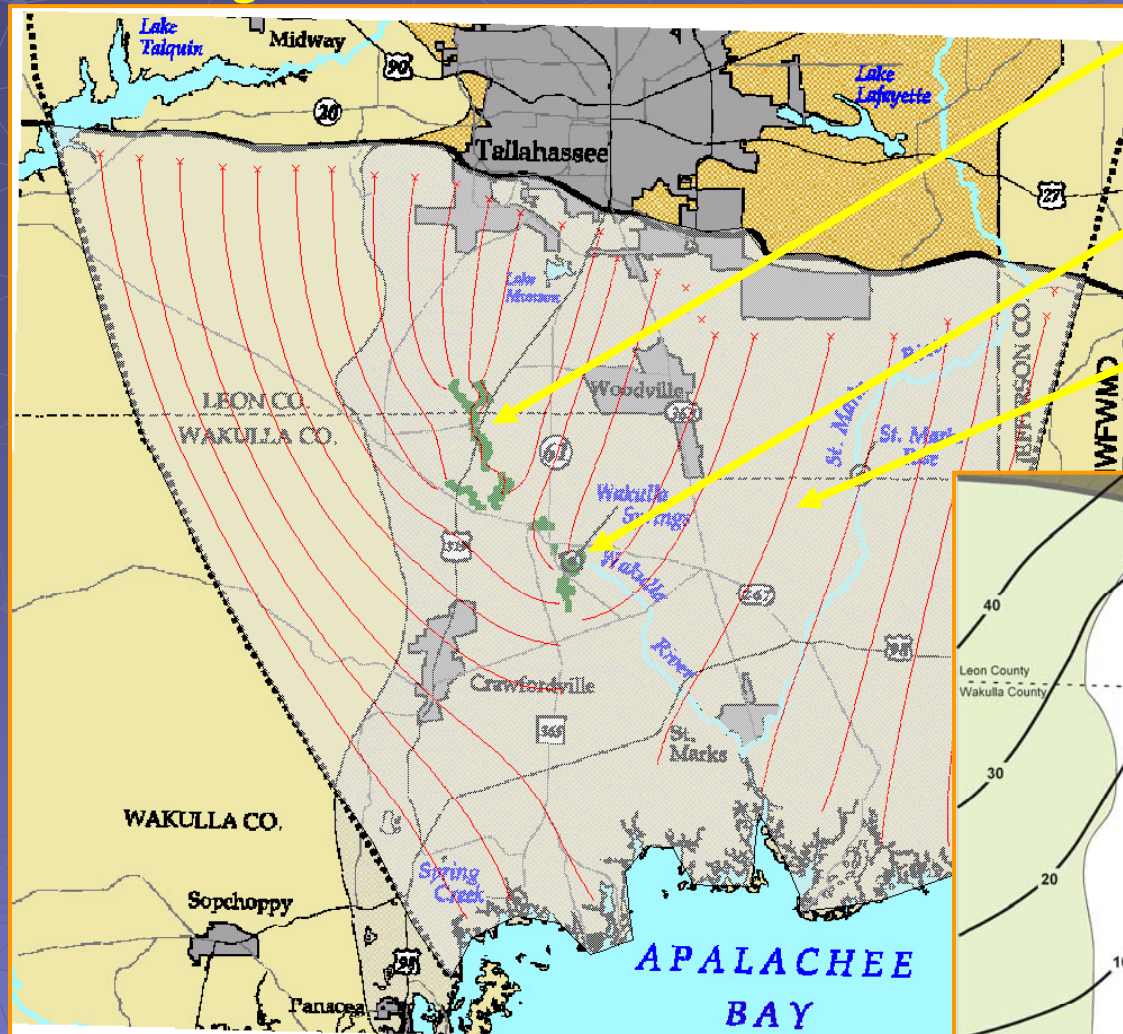


Gridded Data

Wakulla

Survey Data: Groundwater Modeling

Modeling with Conduits

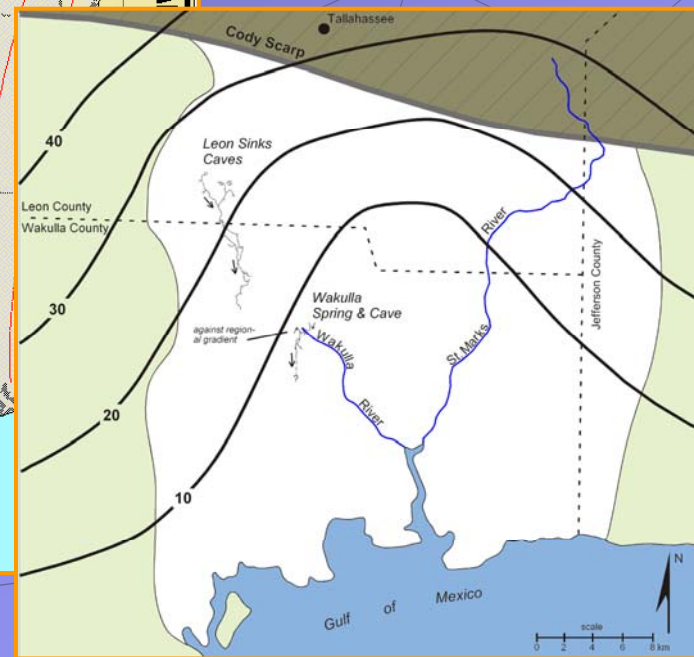


Conduits

Wakulla Spring

Flow Paths

Without Conduits



Data Acquisition: Geochemical Data

- Grab samples
- Data sonde profiles
- Instrumentation

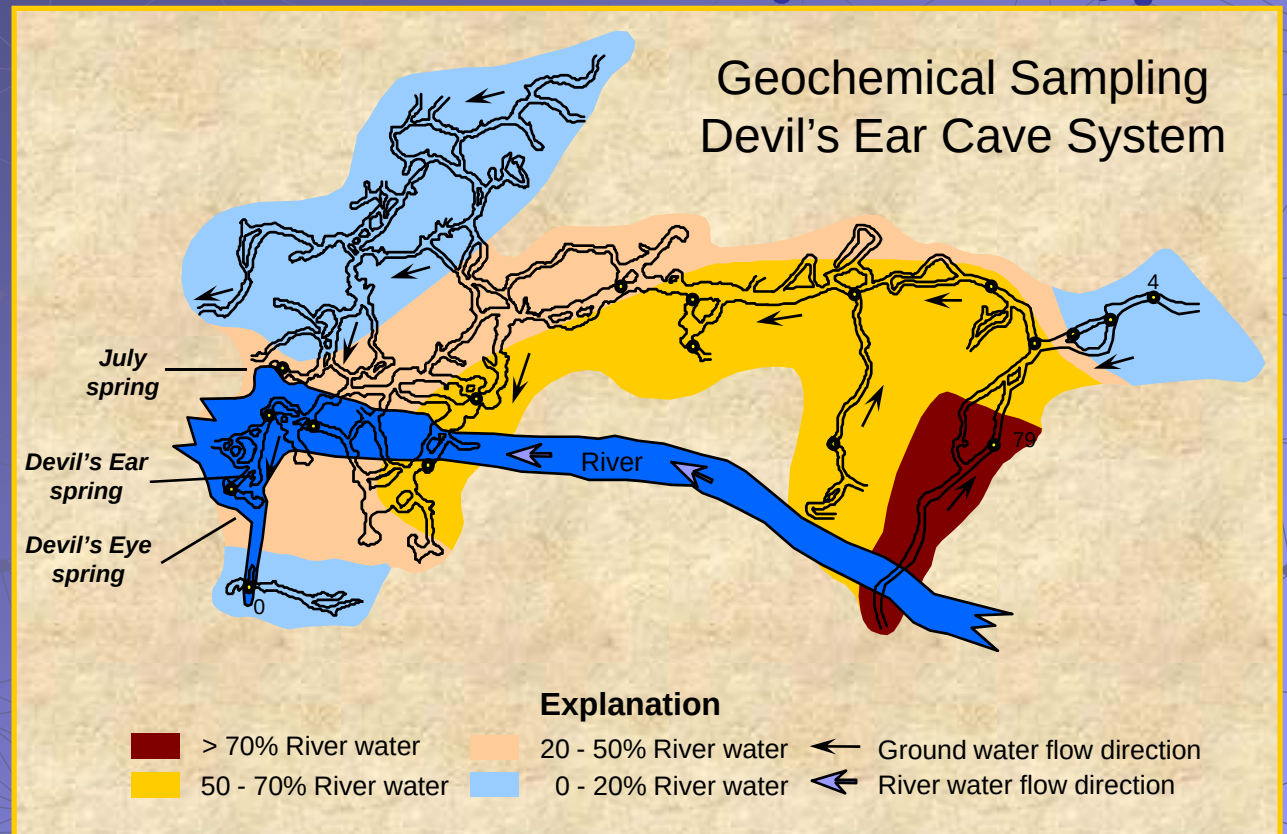
Example

- 100+ samples
- ^{222}Rn , $\delta^{18}\text{O}$, SF_6
- pen. > 4000 ft
- multiple events

Limitations:

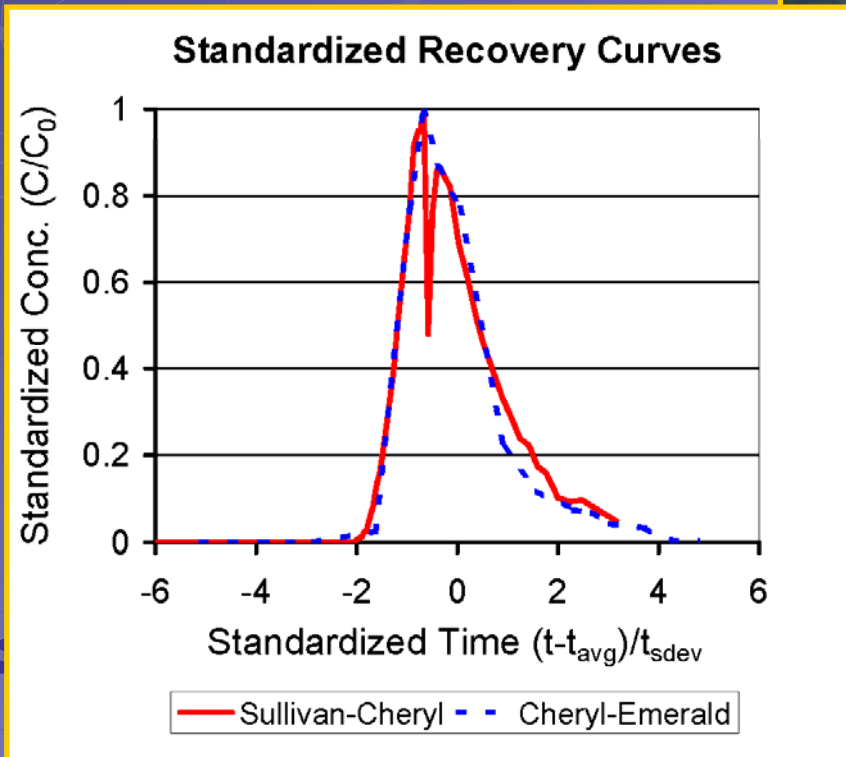
- Time
- Carrying capacity
- Training

- *Simplify sample collection and storage methods*
- *Minimize sample/apparatus size*
- *Provide thorough training on collection procedures*



Data Acquisition: Groundwater Tracing

In-cave injection and sampling increases probability of success!



	Velocity	Tracer Recovered
Sullivan-Cheryl	5,953 ft/day	> 20%
Cheryl-Emerald	9,638 ft/day	> 99%

Data Utilization: Issues

- Access
- Reliability

- Lines
 - 2-D projection of cave passages
 - Average passage characteristics
 - Land use (if known)
 - Ownership (if known)
- Points
 - 3-D information at survey stations or bends
- MetaData
 - History of data evolution
 - Projection / elevation datum

Cave Database

CAVE NAME	COUNTY	TOPO QUAD	SOURCE	LINES	POINTS	LINE ATTR.	POINT ATTR.	META DATA	ENTR/ LOCAL
Alachua Sink	Alachua	?	GUE & NSS-CDS	N	N	N	N	N	Y
Apopka Blue Spring	Orange	?	GUE	N	N	N	N	N	N
Arch Sink	Pasco	?	GUE	N	N	N	N	N	N
Big Dismal	Leon	Lake Munson	NSS-CDS	N	N	N	N	N	N
Blue	Jackson	?	FGS (Paula Polson)	N	N	N	N	N	N
Blue Hole	Columbia	Hildreth	GUE & SRWMD	Y	N	N	N	N	Y
Blue Springs	Madison	Ellaville	GUE & SRWMD & NSS-CDS	Y	N	N	N	N	Y
Blue Springs	Lafayette	Dowling Park	SRWMD	N	N	N	N	N	Y
Blue Springs	Jackson	?	NSS-CDS	N	N	N	N	N	Y
Bonnet Spring	Suwannee	Mayo	GUE & SRWMD	N	N	N	N	N	Y
Cathedral-Fallmouth System	Suwannee	Fallmouth	NSS-CDS	Y	Y	Y	Y	N	Y
Cheryl Sink	?	?	NSS-CDS	N	N	N	N	N	N
Church Sink	Leon	?	GUE	N	N	N	N	N	N
Convict Spring	Lafayette	Mayo SE	NSS-CDS	Y	N	N	N	N	Y
Cow Spring	Suwannee	?	GUE & SRWMD	N	N	N	N	N	N
Devil's Ear and Eye System	Columbia and Gilchrist	High Springs S'W	GUE & SRWMD	Y	Y	N	N	N	Y
Devil's Eye	Columbia	High Springs S'W	NSS-CDS	Y	Y	N	N	N	Y
Dogwood Springs	?	?	GUE	N	N	N	N	N	N
Eagle's Nest	Hernando	?	GUE	N	N	N	N	N	N
Emerald Sink	?	?	NSS-CDS	N	N	N	N	N	Y
Fallmouth	?	?	SRWMD	N	N	N	N	N	Y
Ginnie Springs	Gilchrist	High Springs S'W	GUE	Y	N	N	N	N	Y
Green Sink	Lafayette	?	GUE & NSS-CDS	N	N	N	N	N	N
Green - Snake Sink	?	?	NSS-CDS	N	N	N	N	N	N
Hart	?	?	SRWMD	N	N	N	N	N	N
Hole in the Wall	Jackson Co.	?	GUE & NSS-CDS	N	N	N	N	N	N
Hornzby Springs	Alachua	High Springs	GUE & NSS-CDS	Y	Y	Y	Y	Y	Y
Howard Park	?	?	GUE	N	N	N	N	N	N
Indian Springs	Wakulla	Lake Munson	GUE & NSS-CDS	Y	Y	Y	Y	N	Y
Isabella Spring (Black Hole)	Pasco	?	GUE	N	N	N	N	N	N
Leon Sinks Cave System	Leon & Wakulla	Lake Munson	GUE	Y	N	N	N	N	Y
Little River Spring	Suwannee	Branford	GUE & SRWMD	N	N	N	N	N	Y
Luraville Springs	Suwannee	Mayo	NSS-CDS	Y	N	N	N	N	Y
Manatee Springs	Levy	Manatee Springs	GUE & SRWMD & NSS-CDS	N	N	N	N	N	Y
McBrides Slough	Wakulla	Crowfordville East	GUE	Y	Y	N	N	N	Y
Morgan	?	?	SRWMD	N	N	N	N	N	N
Paradise Spring	?	?	GUE	N	N	N	N	N	N
			GUE & SRWMD &						

Cave Database



1% is better than nothing;
cave maps and the
protection of the karst
watershed

joe meiman
hydrogeologist,
mammoth cave national park

Religious Truths



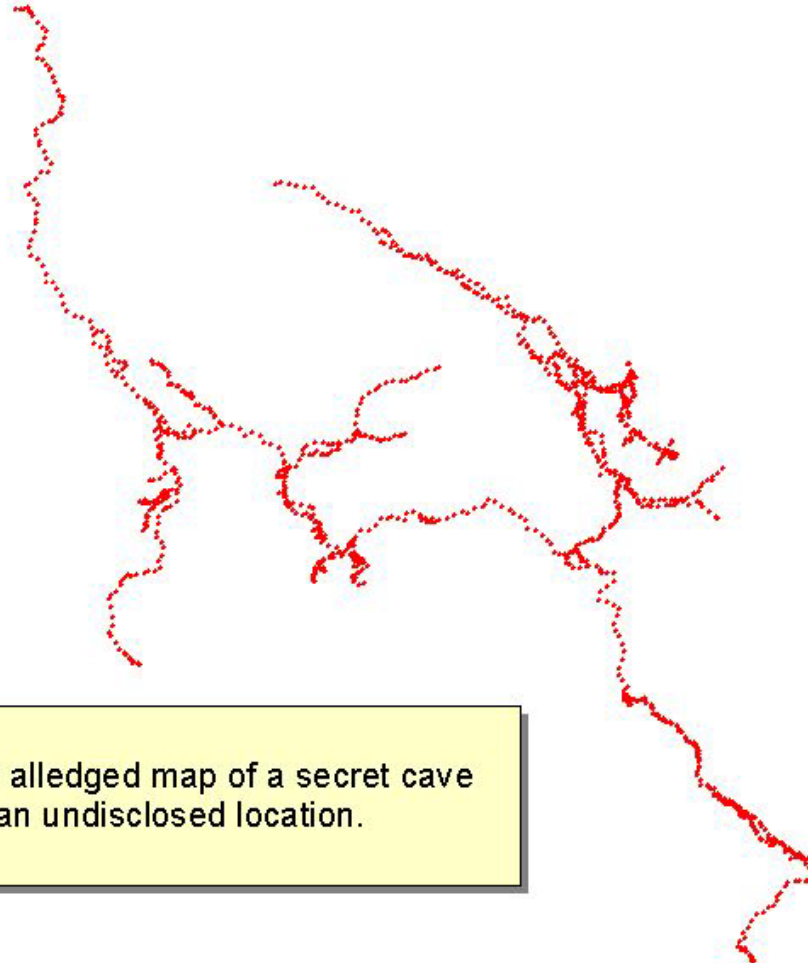
- Cavers are crazed stoners who eat their dead.
- Government Regulators are dull-eyed losers who could not find a real job.
- Farmers are gun-wielding, slack-jawed yokels.
- Scientists are fools; either too stupid to too lazy to be regulators or farmers.



so how do guys like this...

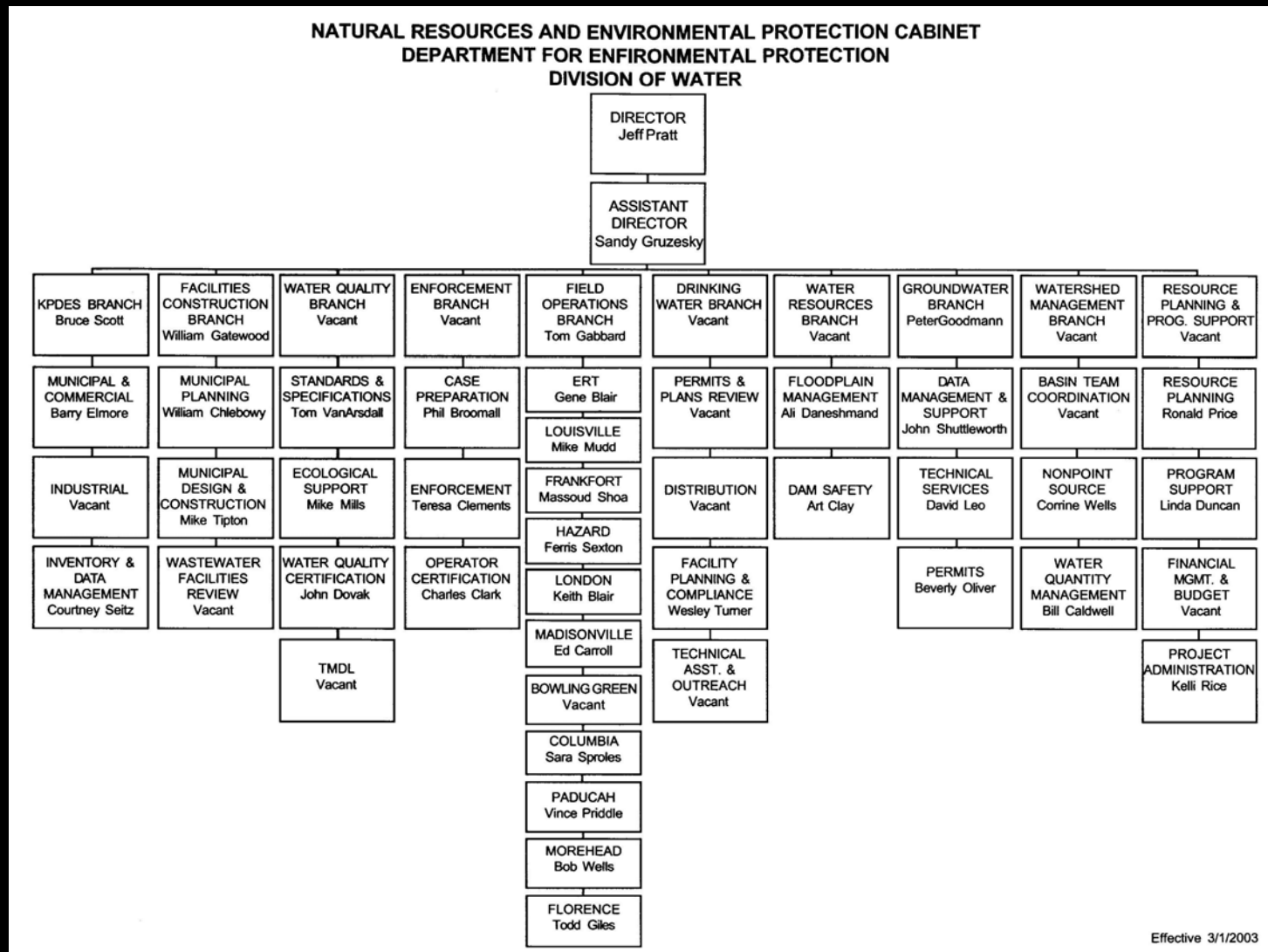


making stuff like this...



An alledged map of a secret cave
in an undisclosed location.

unknown to folks like this...



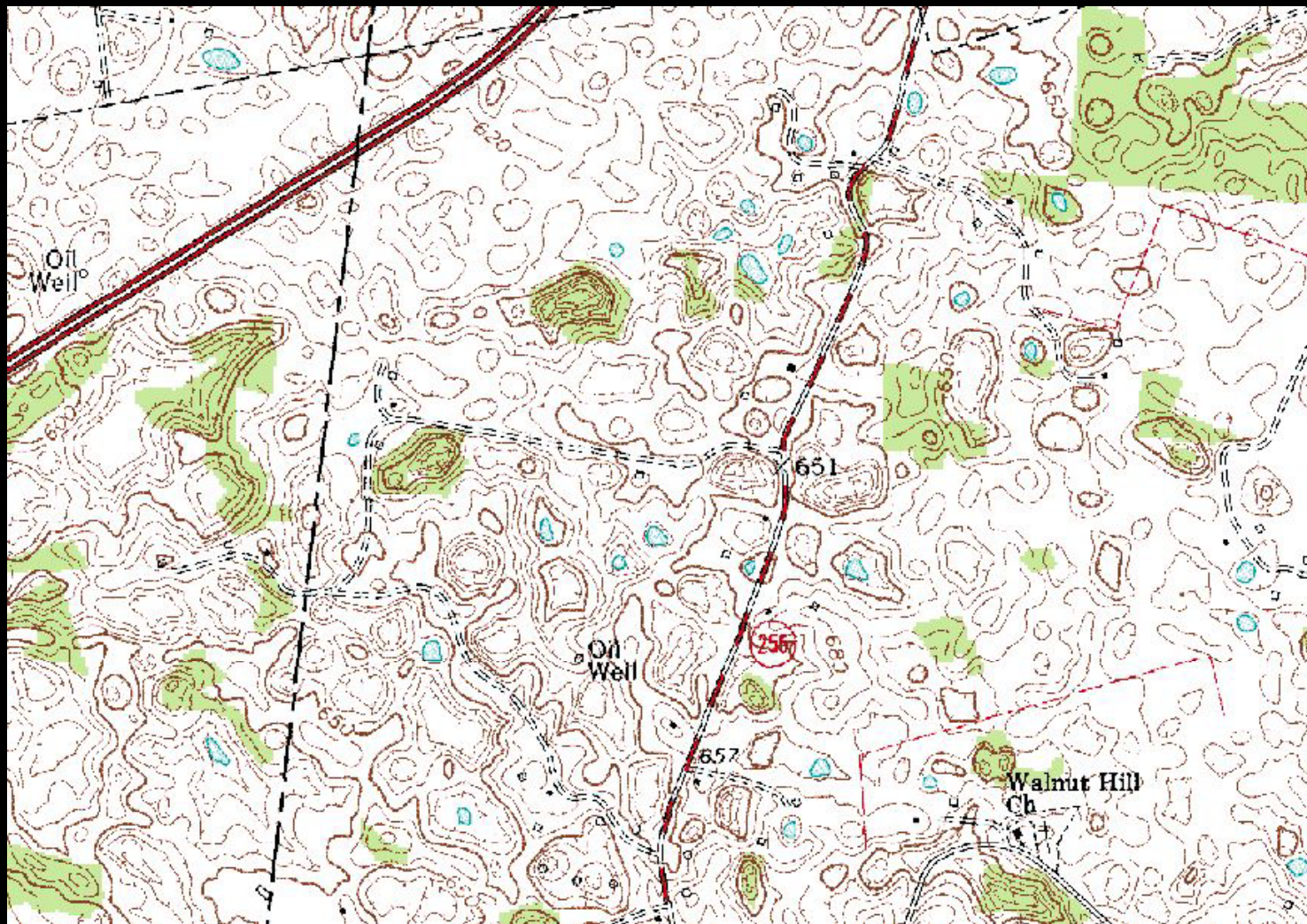
dealing with folks like this..



doing stuff like this...



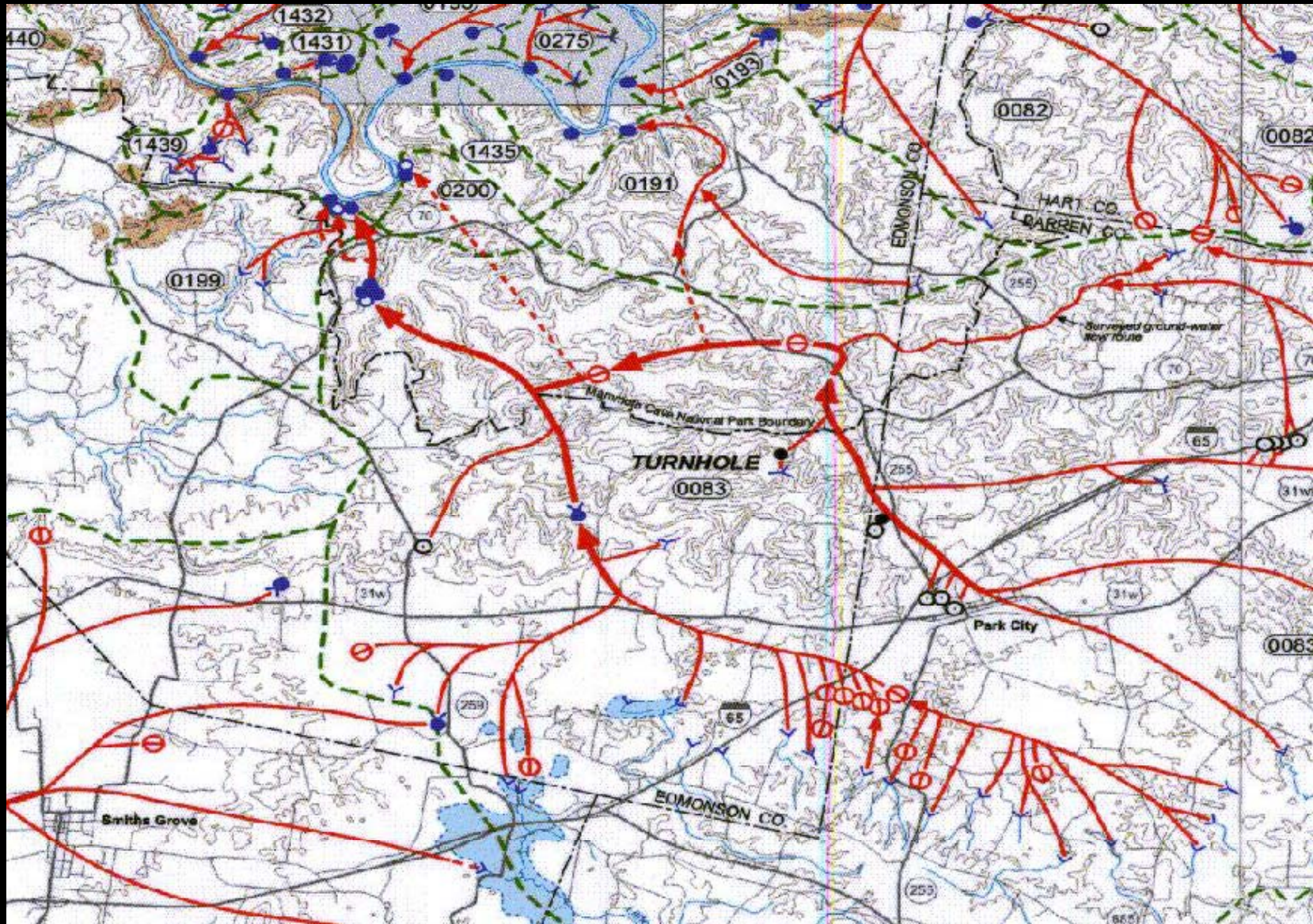
on this sort of stuff...



deal with guys like this?

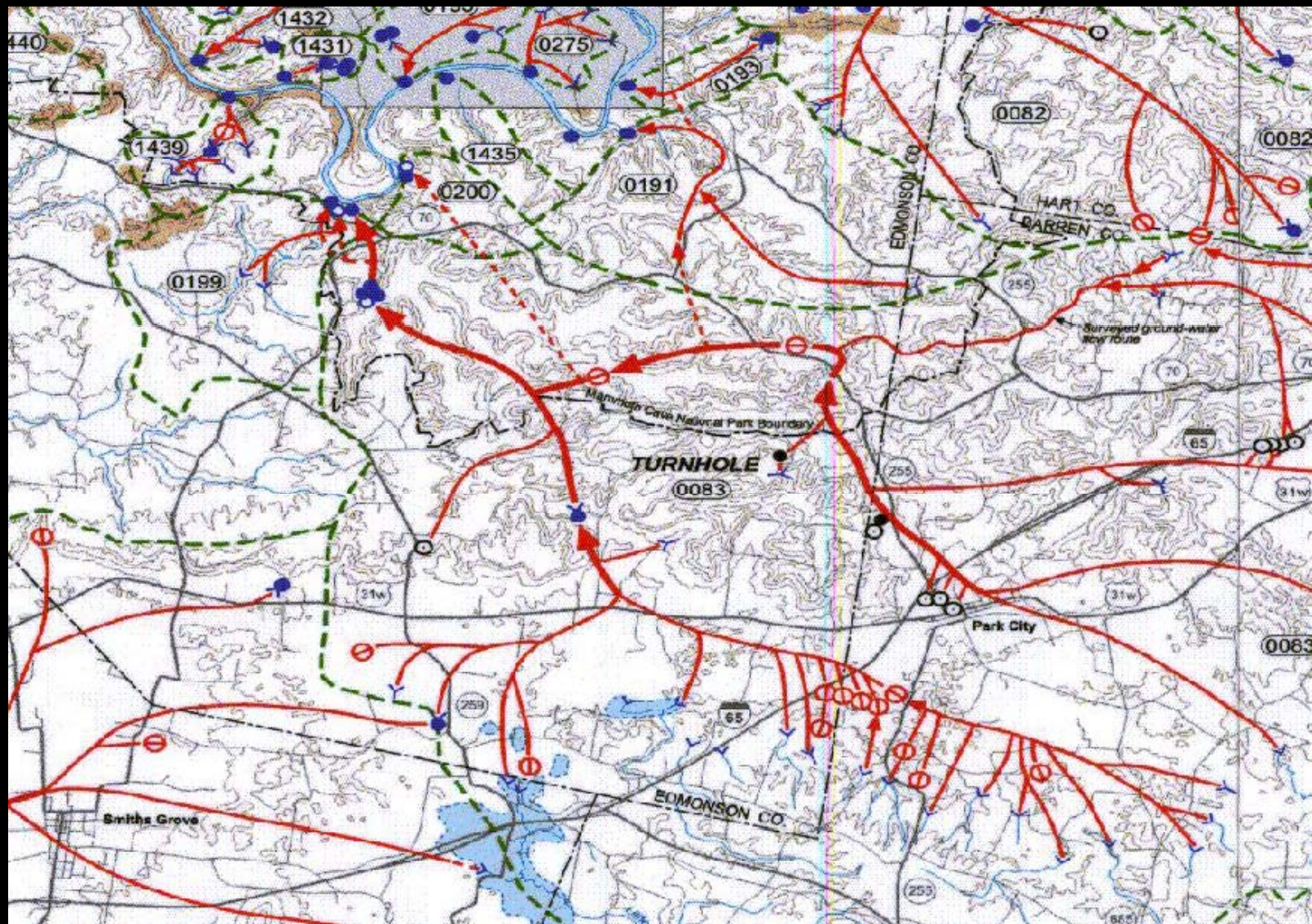


and turn out something like this?



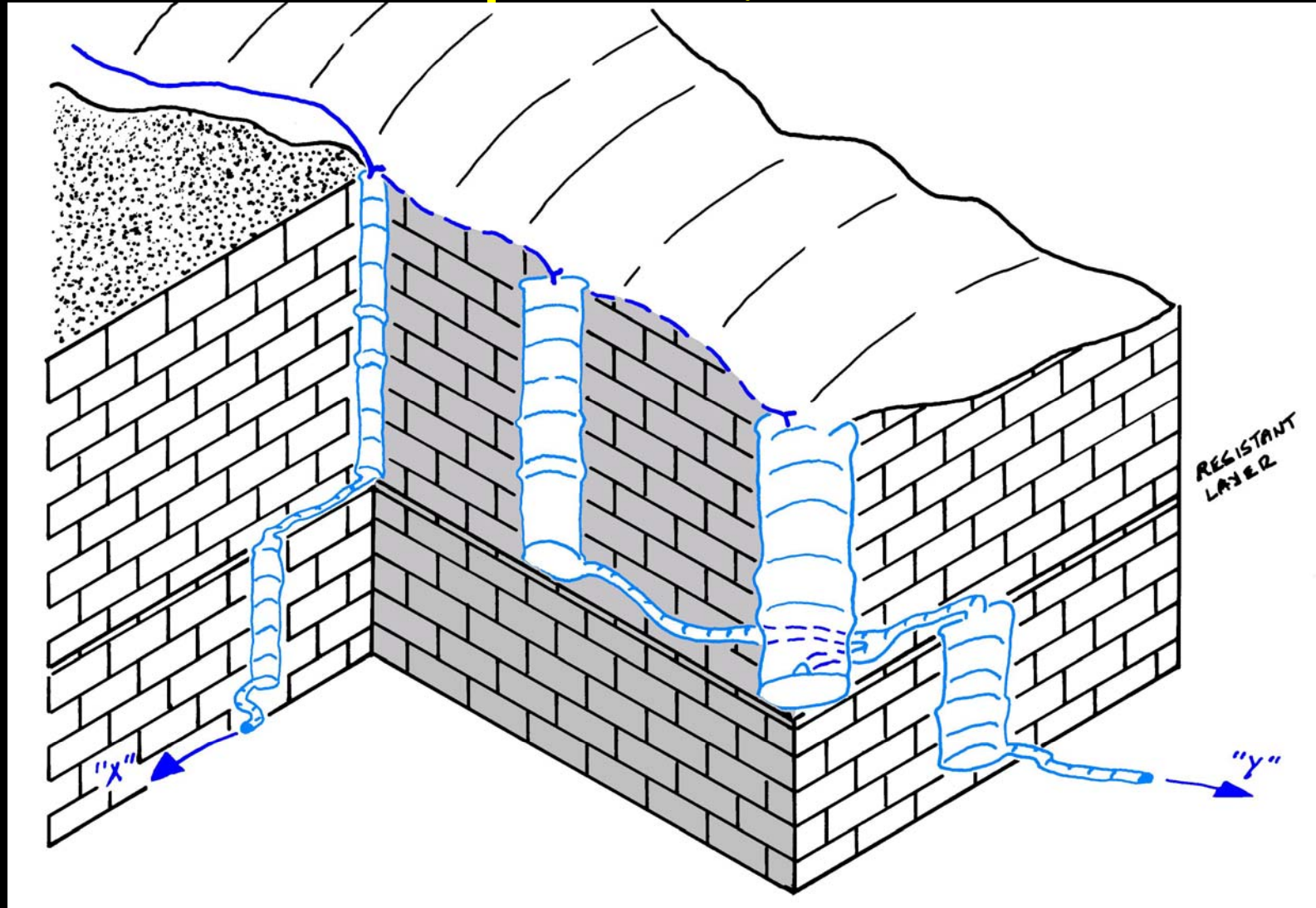
the real question might be
the ultimate value of a cave
map.

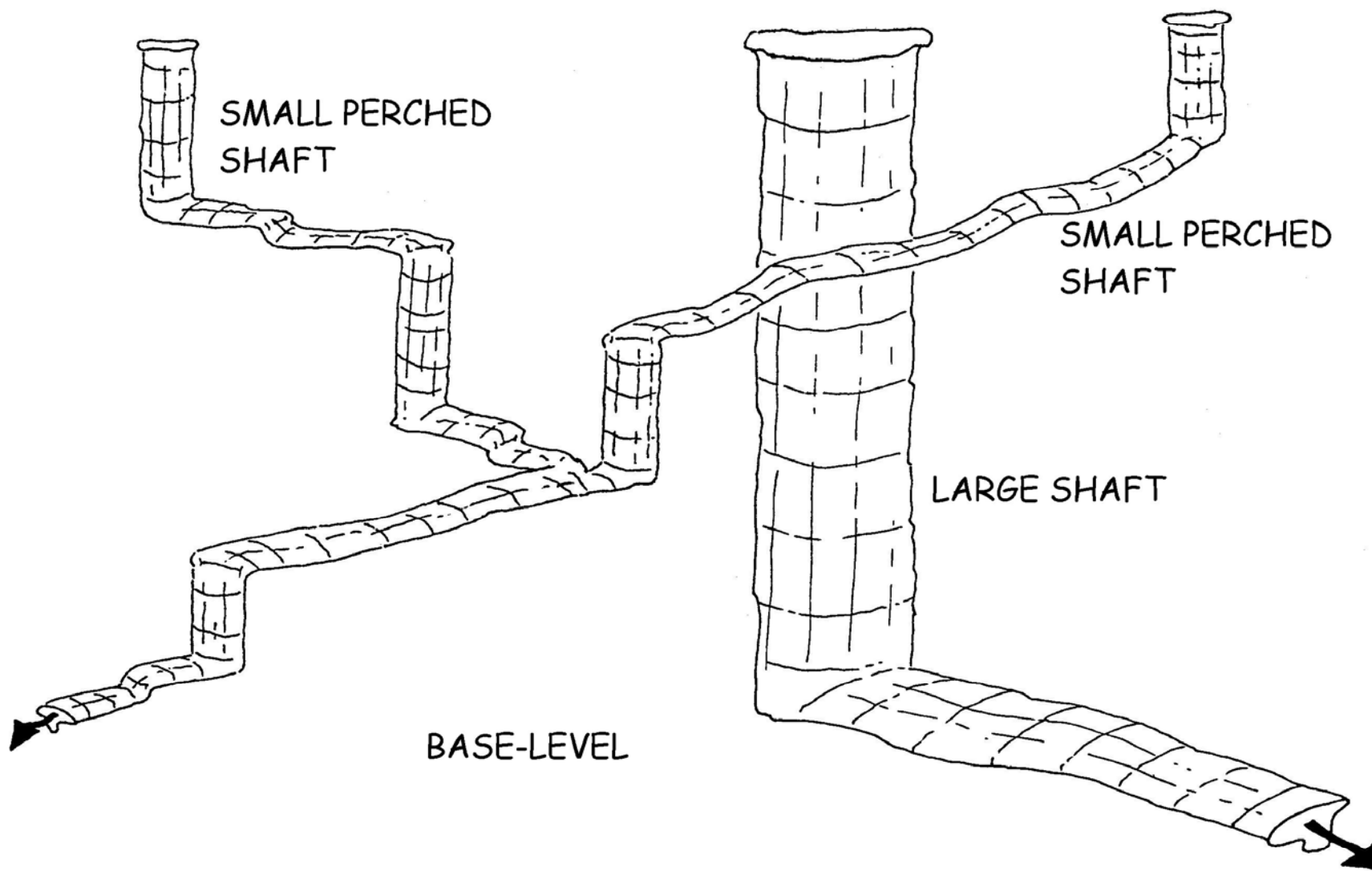
consider the previous image...



in south central kentucky,
perhaps the most studied karst
setting in the world, with about
1,000 km of mapped cave, the
precise description and location
of the cave is second to its
role, function, and relationship
within the aquifer.

cave maps combined with results of hydrogeologic studies can provide conceptual models





try this without a map



although watershed delineation is the most important element in protection and conservation of water quality in the mammoth cave region, cave maps are key to several aspects of understanding the karst aquifer.

- why things are where they are (geomorphology).
- overall geologic history of the karst aquifer.
- valuable contribution to visualization of the karst aquifer.
- damn cool wall hangings to amuse your friends.
- provides a "connectivness", a tangible result to non-caver types.

how it went down at mammoth cave

- internationally "celebrated" since the early 1800's.
- strong partnership with cavers.
- Cave Research Foundation
 - since 1957 the CRF has held monthly mapping expeditions, and have mapped over 560 km of the mammoth cave system and scores of smaller caves.



as crazy as it might sound,
the cave mapping efforts
have provided a sense of
grandness to mammoth cave,
resulting in public awareness
and consequently, funding
opportunities.

- strong local advocacy for the "world's longest known cave".
 - citizen groups for clean water



- over \$1M spent on agricultural BMP's.
- \$110M green river CREP.



field day with regulators

- the rules can be changed.



DOWN THE TUBES



Figure 2.17 Keller Well, an active vertical shaft in the Flint Ridge section of the Mammoth Cave system. Meter stick is 8 m below the observer. Depth to water is 17 m. (Photo by Roger W. Brucker)

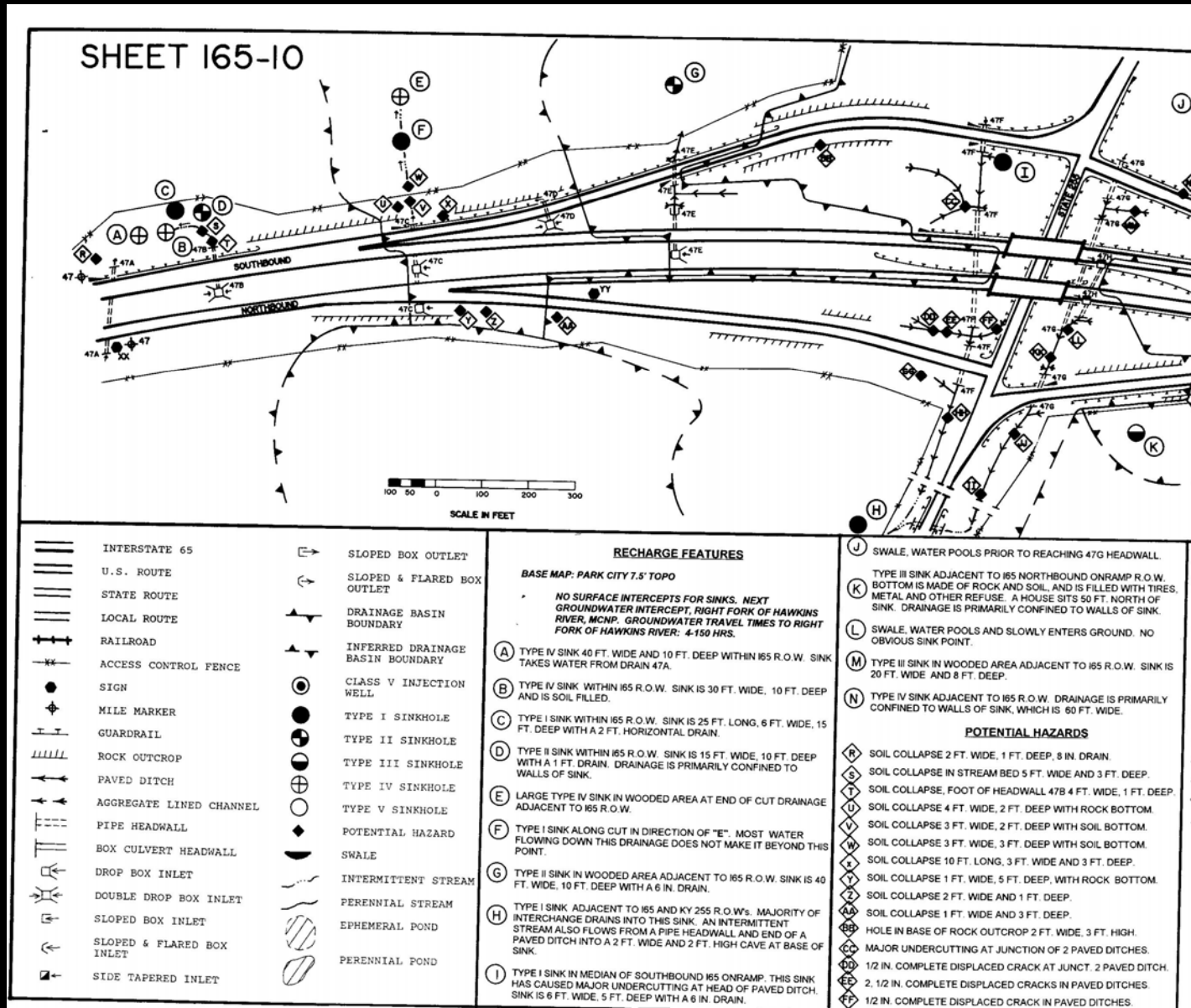


Figure 55. A vertical shaft being formed in Crystal Cave. As in most shafts in the Flint Mammoth Cave System, water enters the top of the shaft through a small canyon.

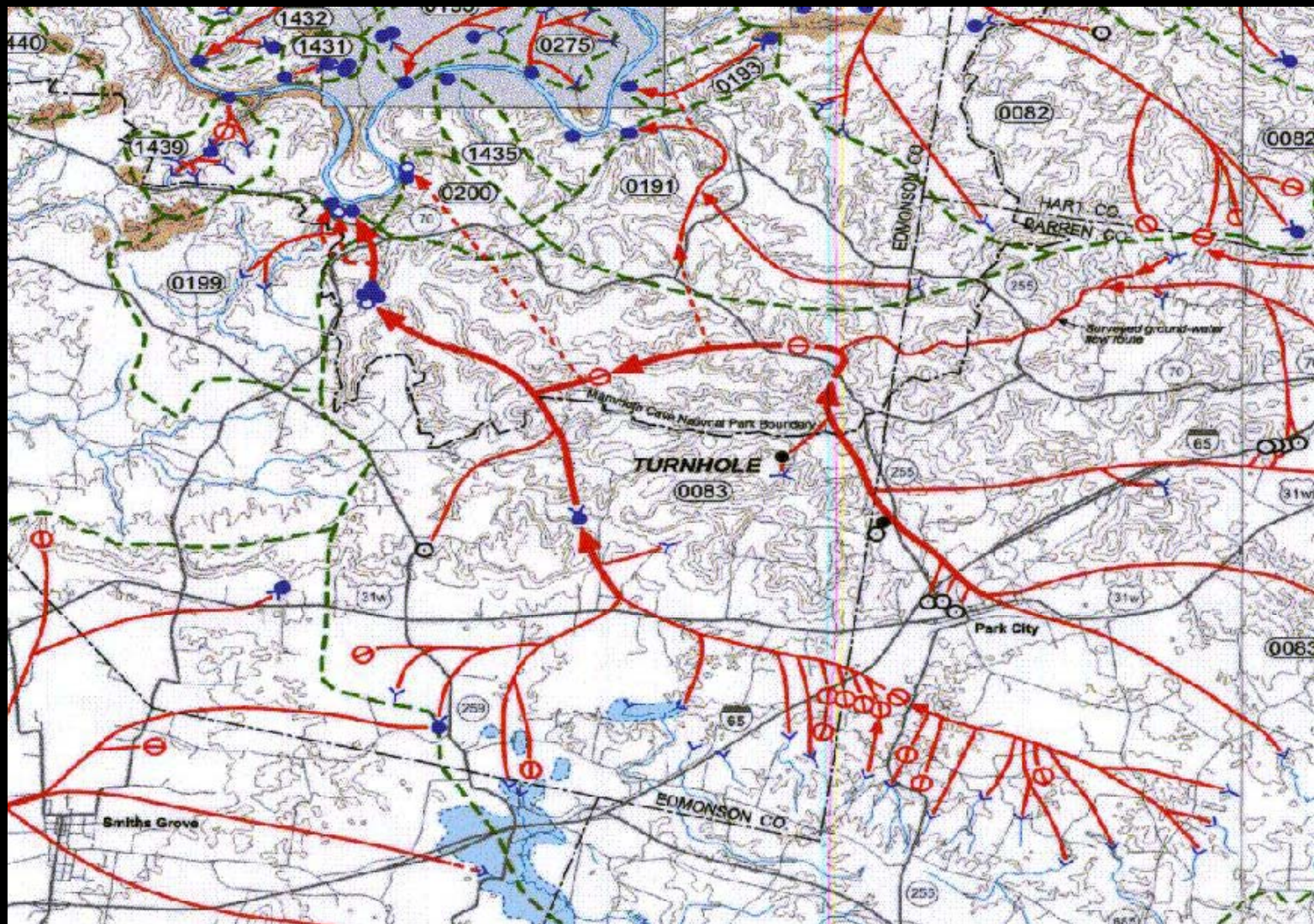
this sort of thing happens all
the time

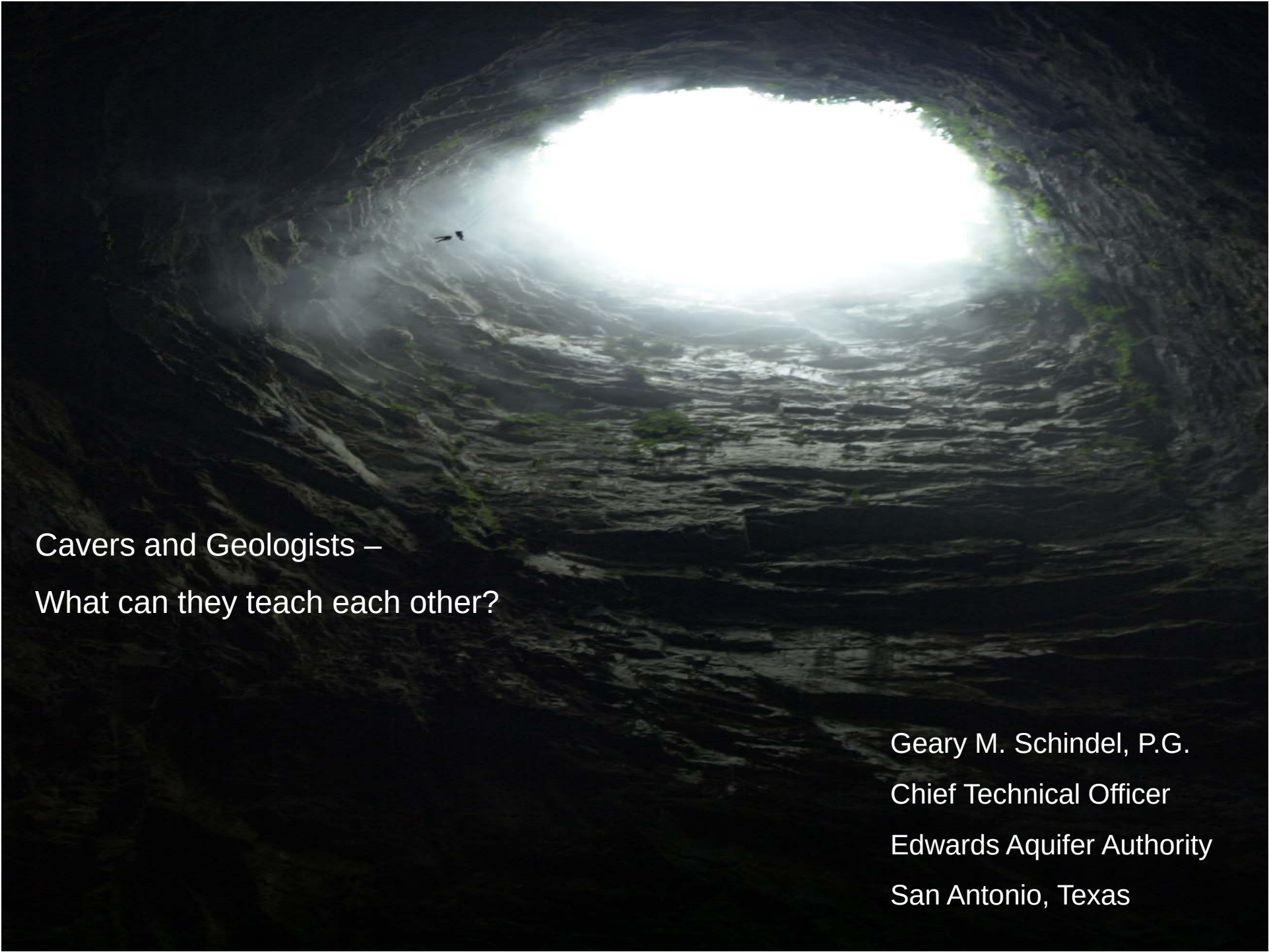


so we did this...



but it all comes down to this...





Cavers and Geologists –
What can they teach each other?

Geary M. Schindel, P.G.
Chief Technical Officer
Edwards Aquifer Authority
San Antonio, Texas

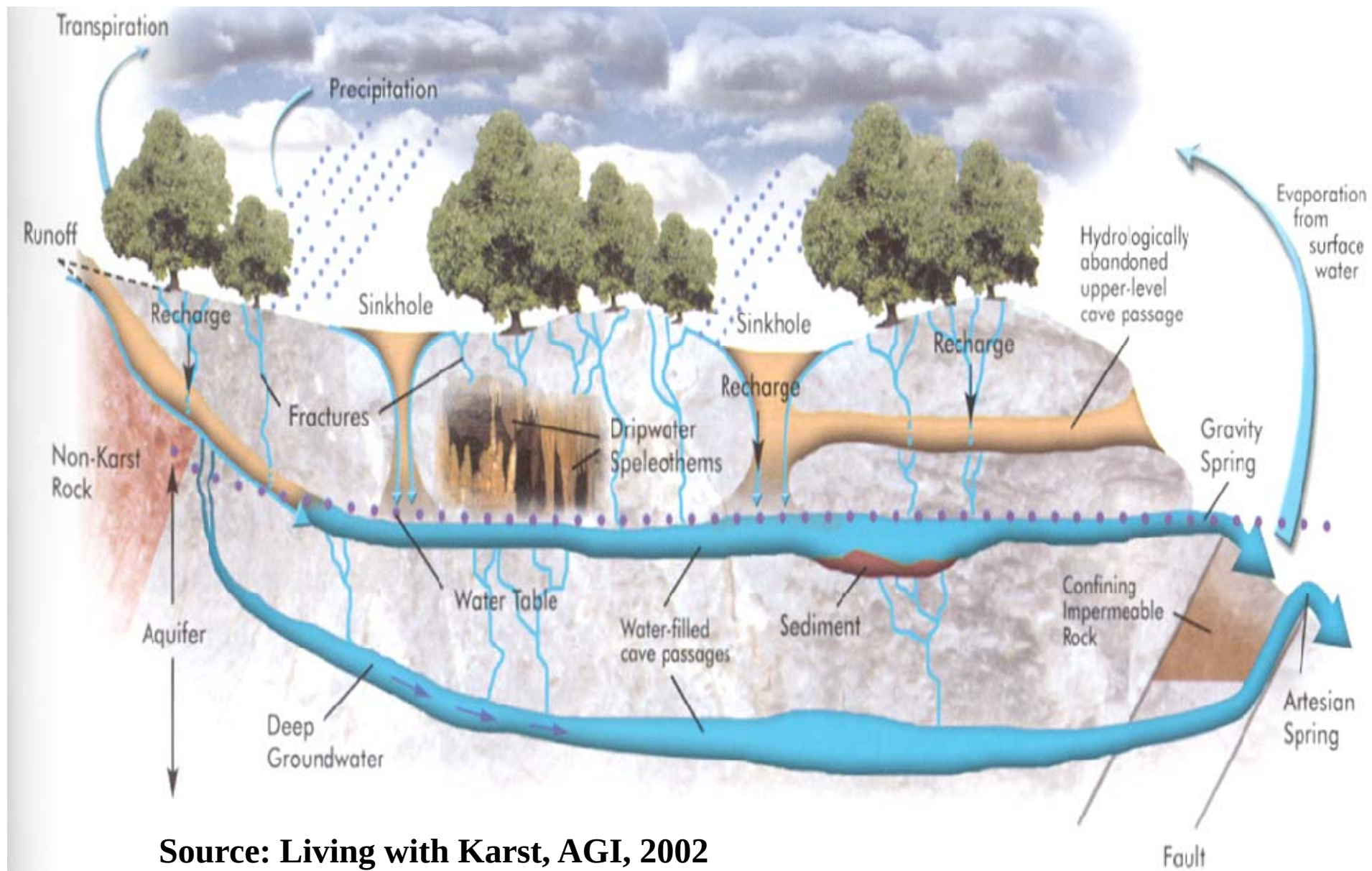
Karst is a landscape where dissolution is the dominant geomorphic agent. It is characterized by sinkholes, sinking streams, caves, springs, and a well integrated subsurface drainage network

A large, dark cave opening with a person standing on the rim, looking down into the abyss. The cave walls are dark and textured, and the light from the opening above creates a strong contrast.

Neversink, North Alabama



Dishman Lane sinkhole collapse, Bowling Green, Kentucky – Photo Center for Cave and Karst Studies, Western Kentucky Univ.

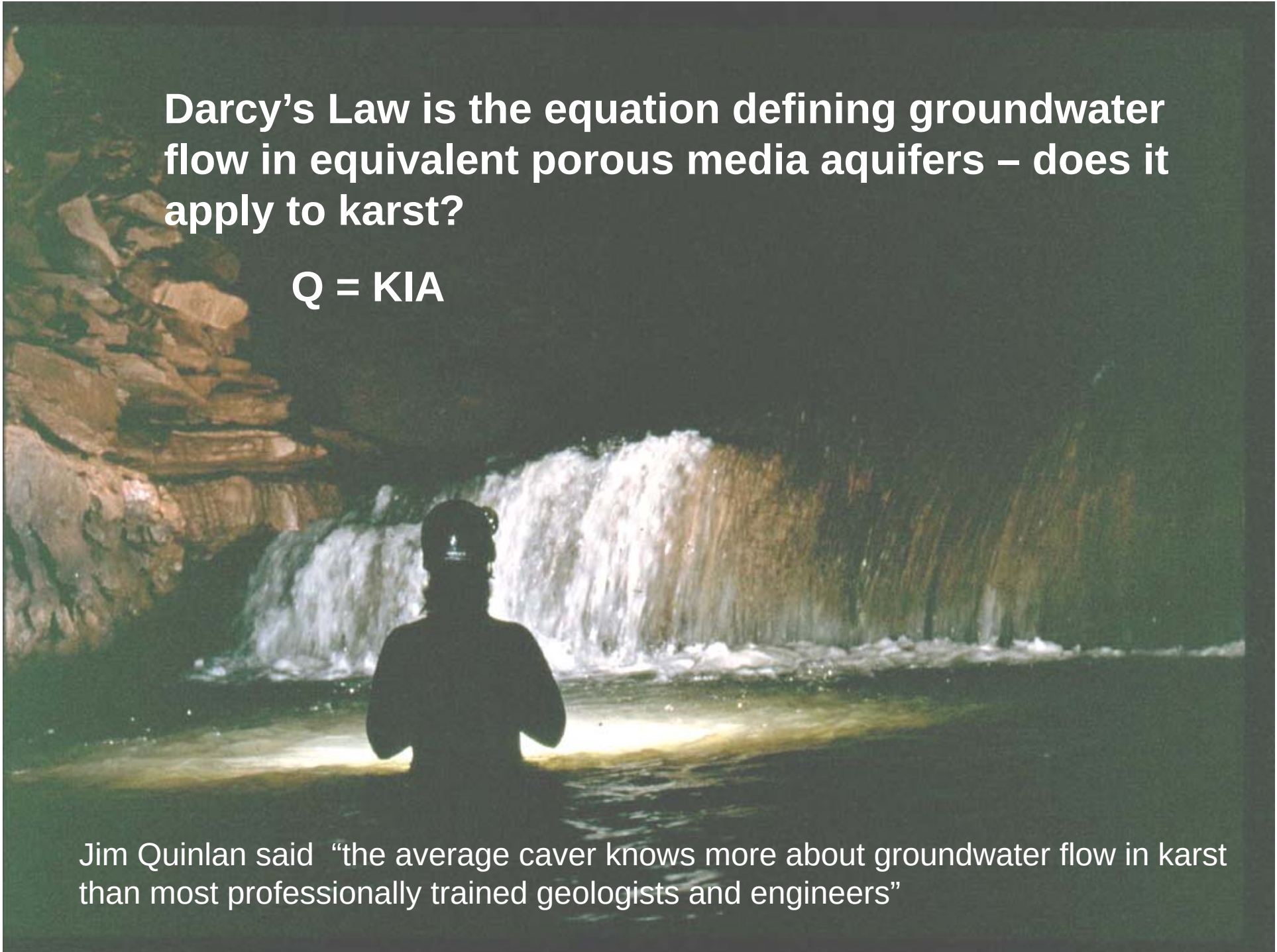


Source: Living with Karst, AGI, 2002

Darcy's Law is the equation defining groundwater flow in equivalent porous media aquifers – does it apply to karst?

$$Q = KIA$$

Jim Quinlan said “the average caver knows more about groundwater flow in karst than most professionally trained geologists and engineers”

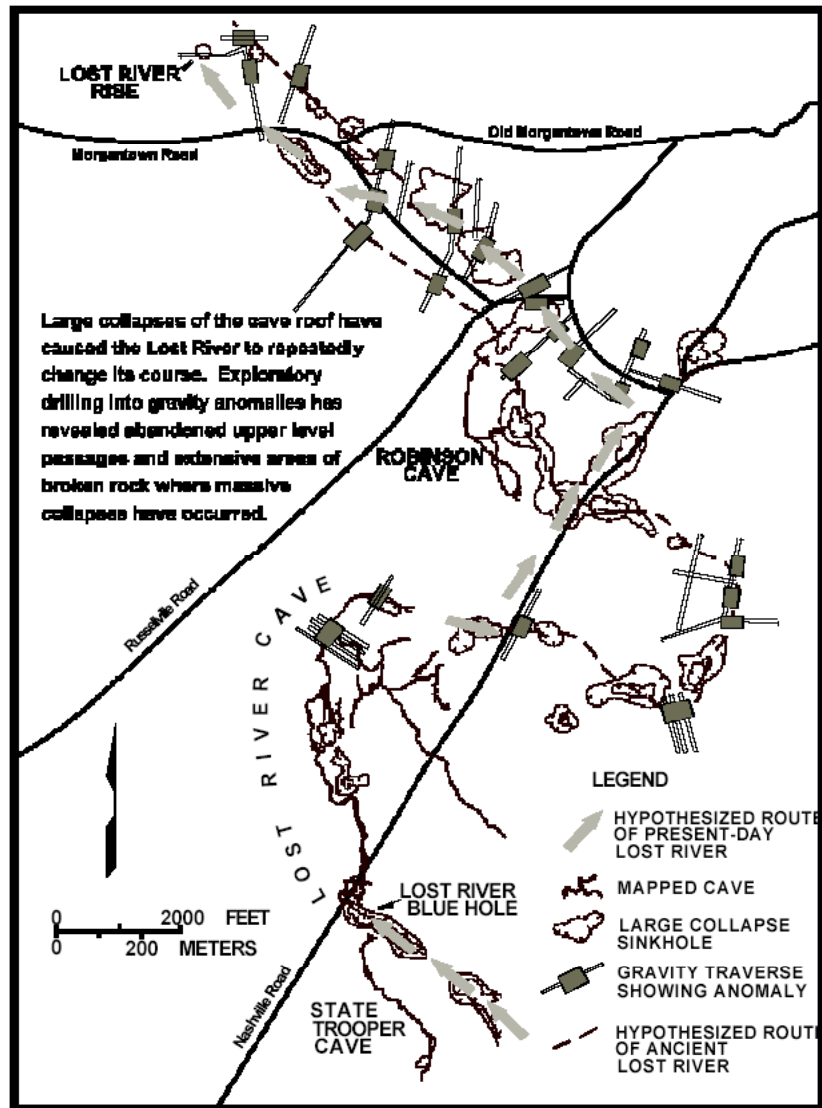


Few colleges or universities offer specific course work in karst hydrology – yet 20% to 30% of the US is karst and some states exceed more than 50%



Many karst aquifers contain unique biota – Many were first brought to the attention of scientists by cavers



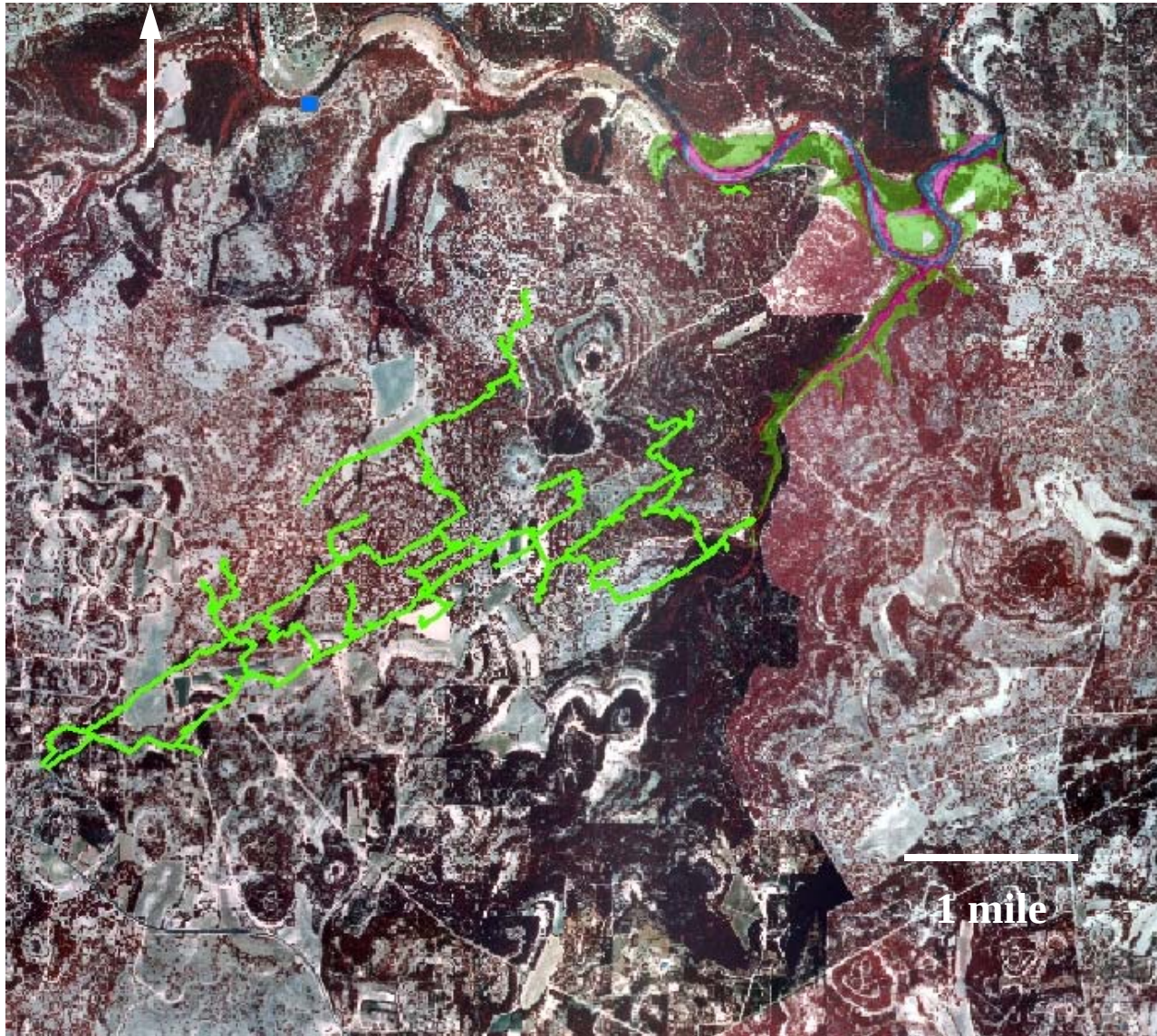


From Center for Cave and Karst Studies,
Western Kentucky University
Bowling Green, Kentucky

The cave maps produced by cavers often provide the basis for work by karst hydrologists, engineers, urban planners, biologists, environmental scientists, and regulators



Cave maps often provide insight into the preferential flowpaths of a karst aquifer



**Honey Creek Cave,
Comal County, Texas.**

**Mapped length of cave is
19+ miles**

Map provided by
Kurt Menking, Bexar
Grotto of NSS

EDWARDS AQUIFER REGION

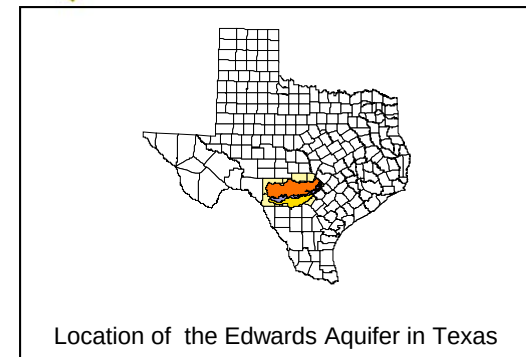
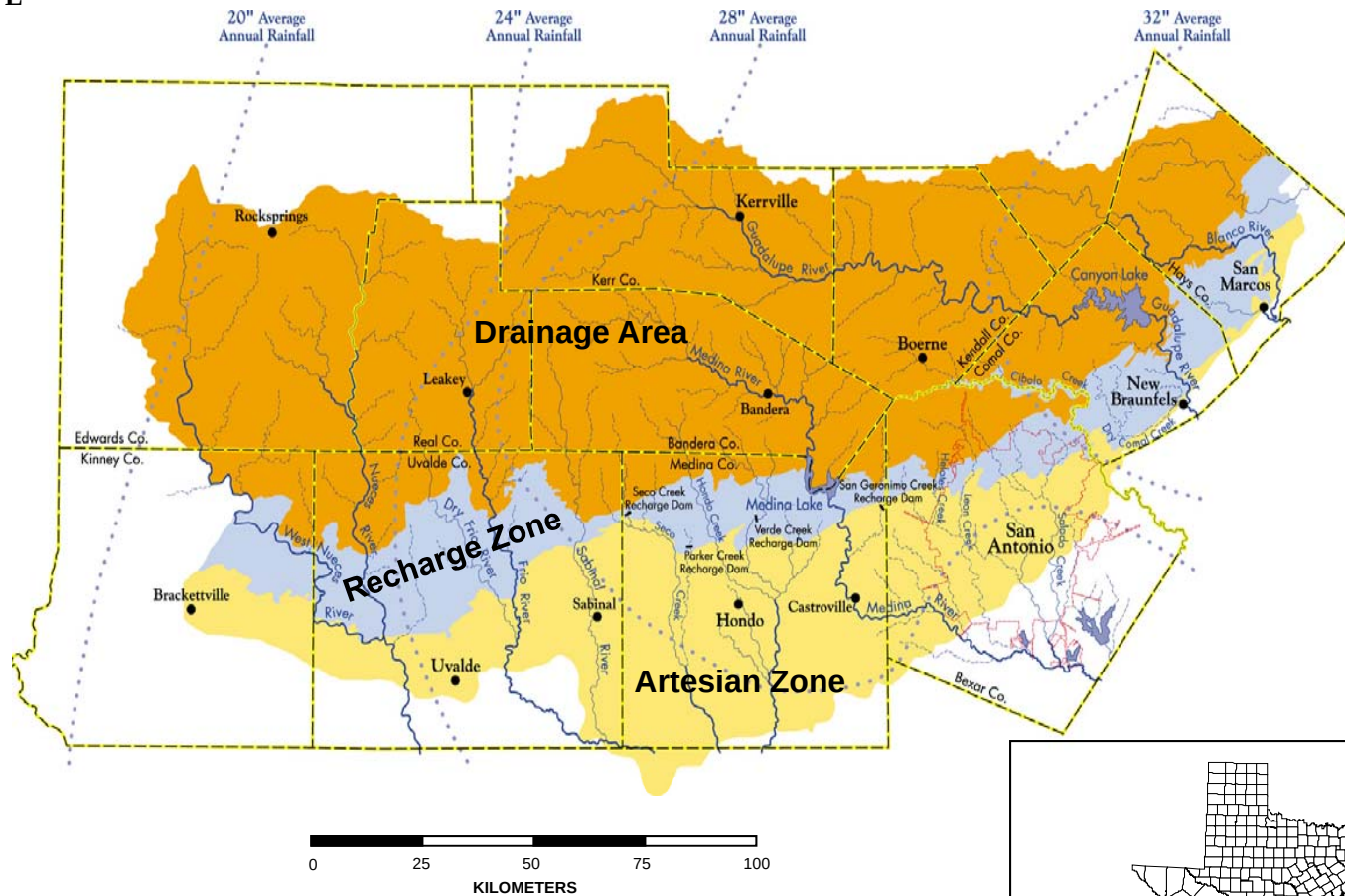
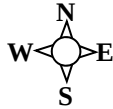
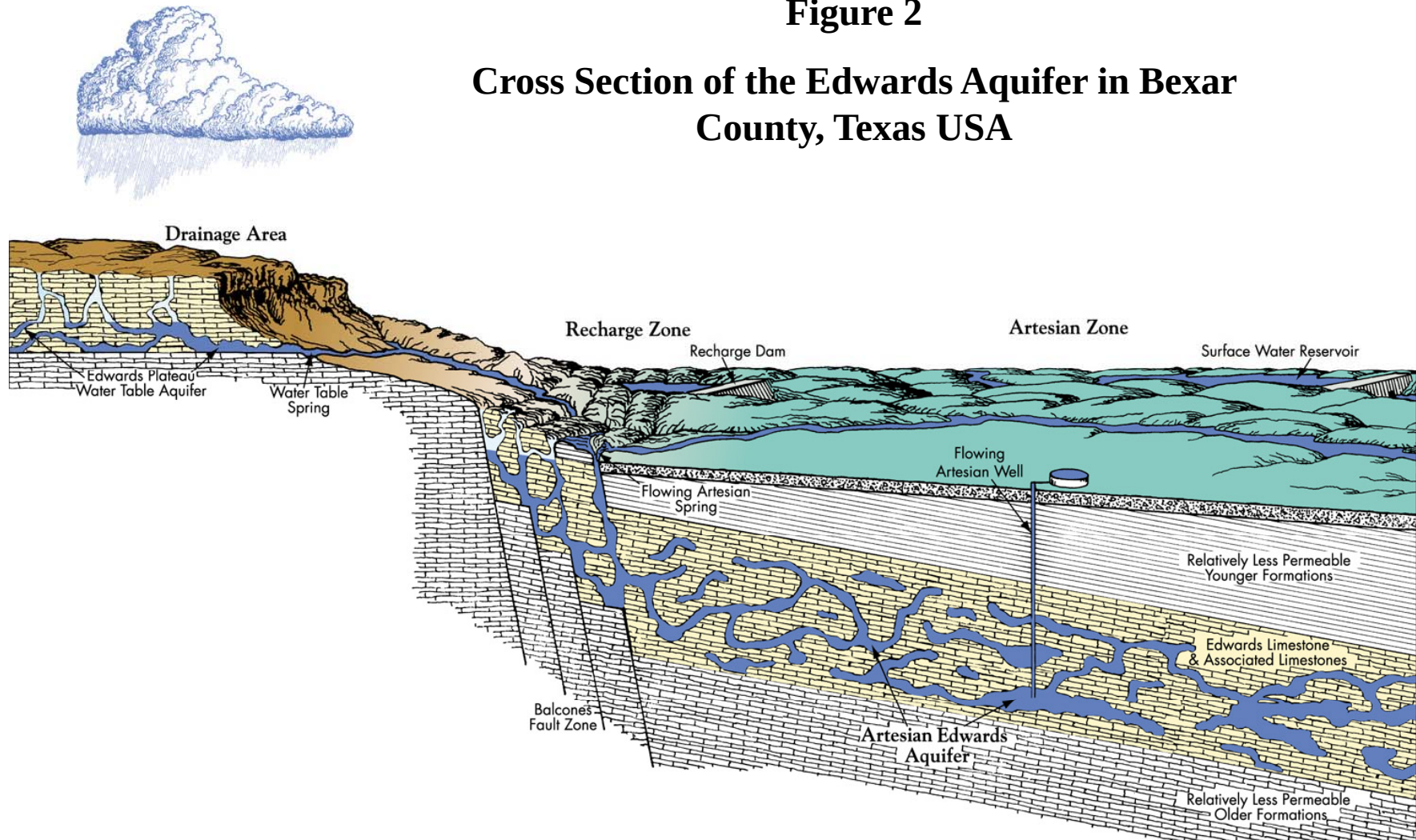
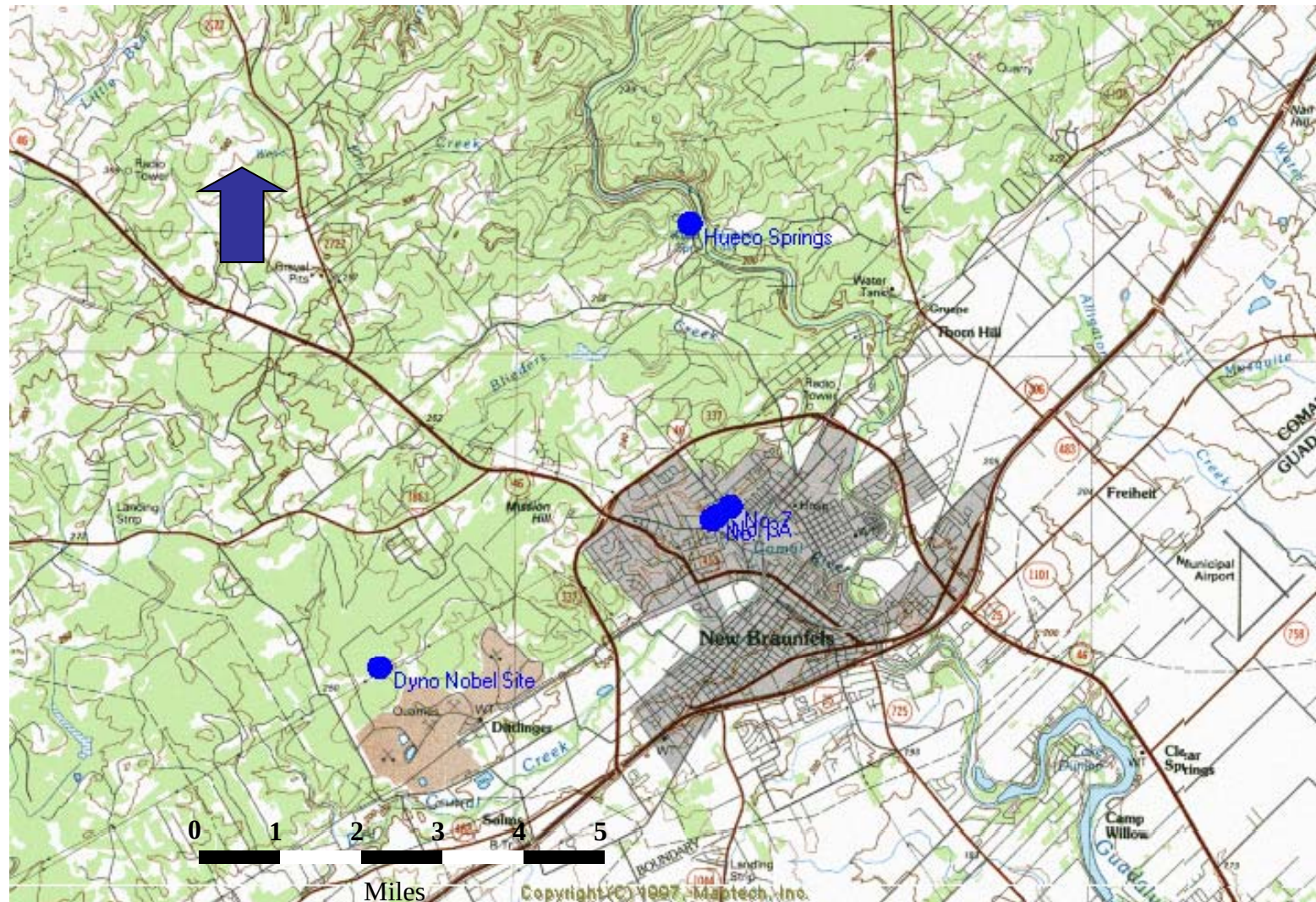


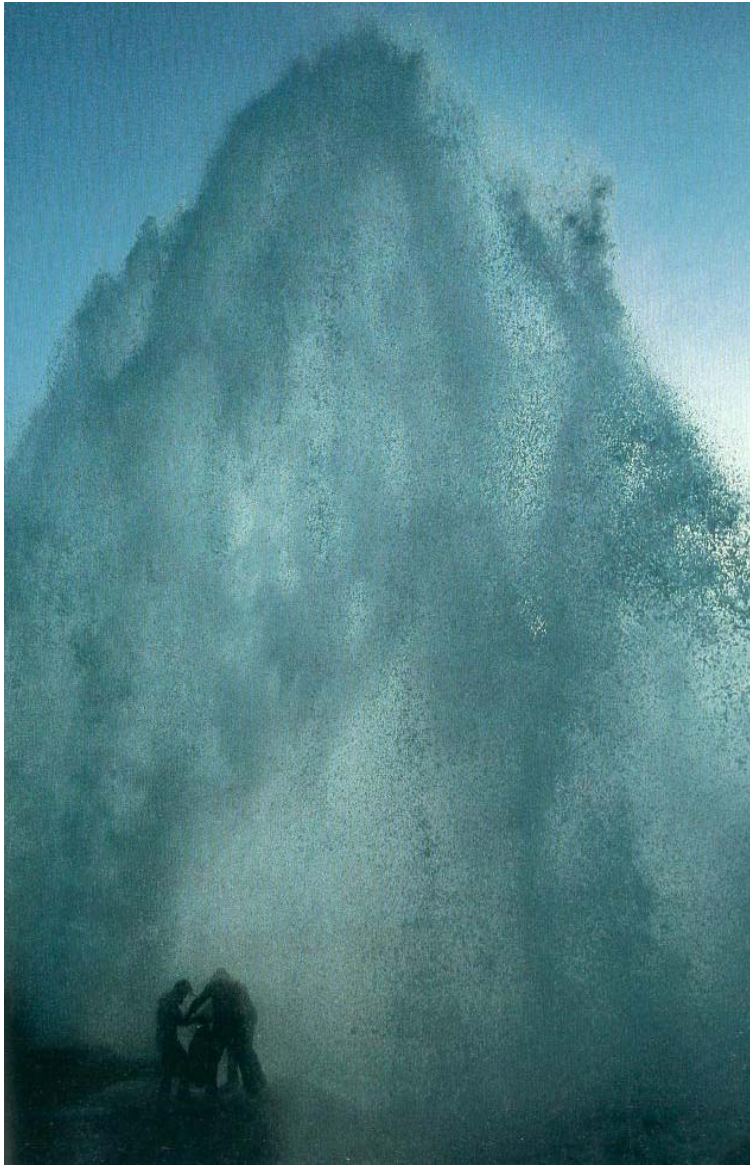
Figure 2

Cross Section of the Edwards Aquifer in Bexar County, Texas USA



Location of 2,000 gallon diesel fuel spill and Comal Springs - largest spring in western US with average discharge of 280 cfs



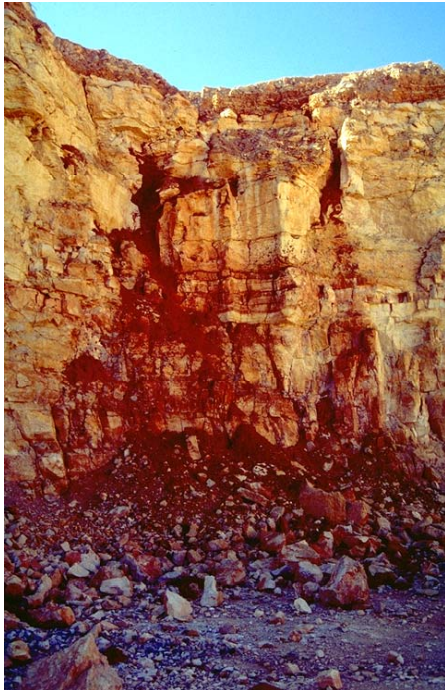


Catfish Farmer Well – artesian well flowing at >30,000 gpm. Bexar County, Texas



Valdina Farm Sinkhole, Medina Co., Texas. A 150 foot pit and recharge feature. Picture above is during flood, picture to right is during normal conditions





**Quarry wall in
Edwards
Limestone**



**Recharge feature
– 60 foot pit**

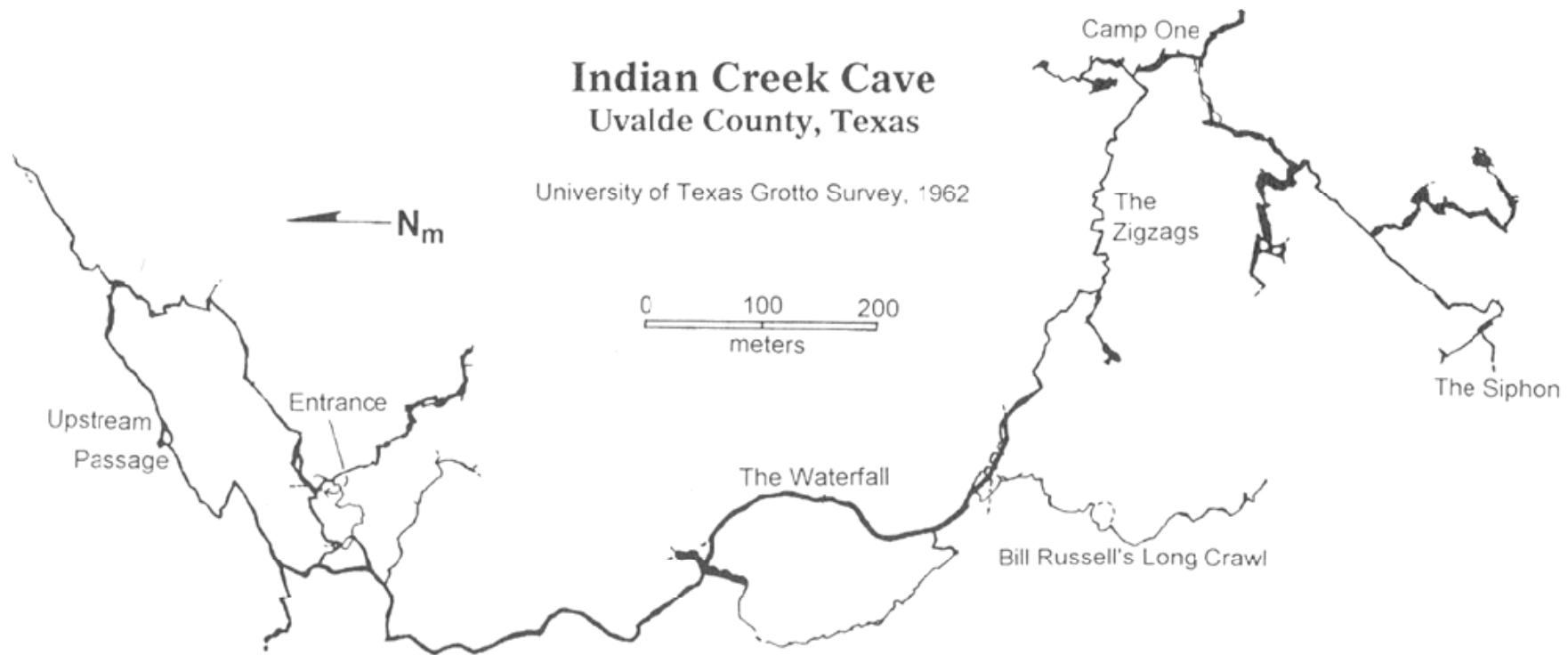


**Swimming in the
aquifer**

**Abandoned well
used as toilet
by homeless**



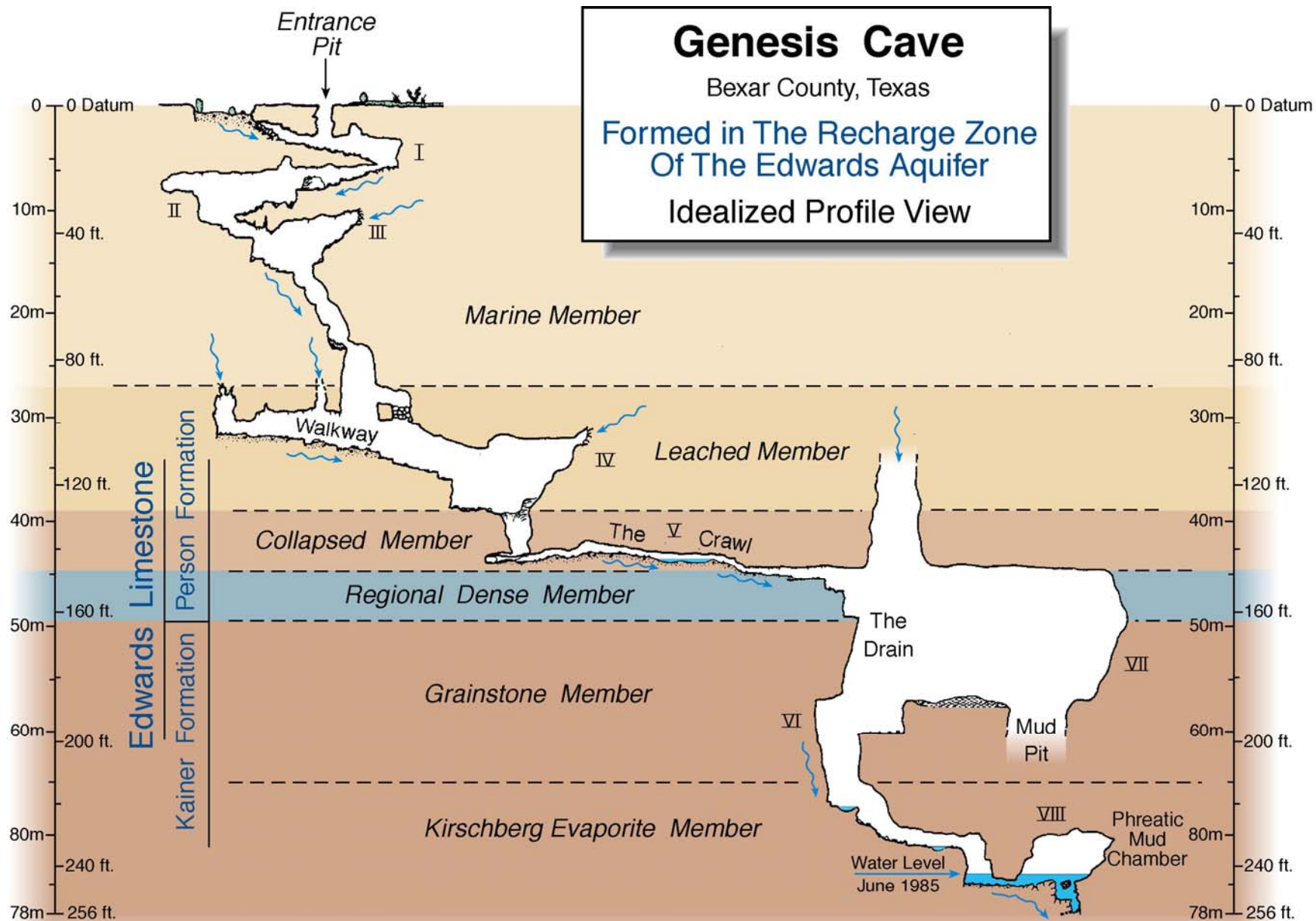
Cave maps often provide an insight into the preferential flowpaths in a karst aquifer



Mapped length is 6.7 kilometers

4th longest cave in Texas

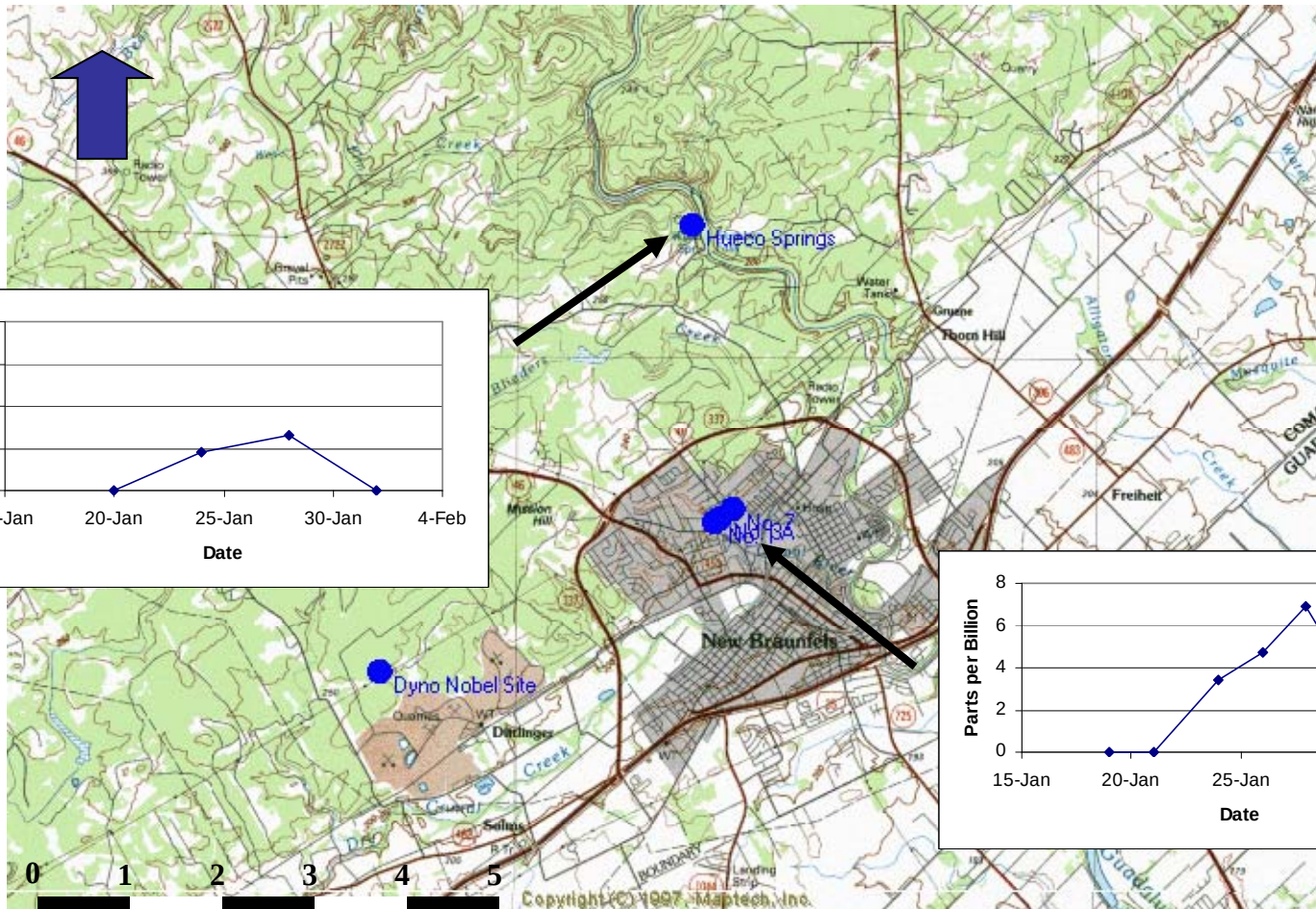
Source: Elliott and Veni, 1994



Texas Speleological Survey
after R.M. Waters, 1986.

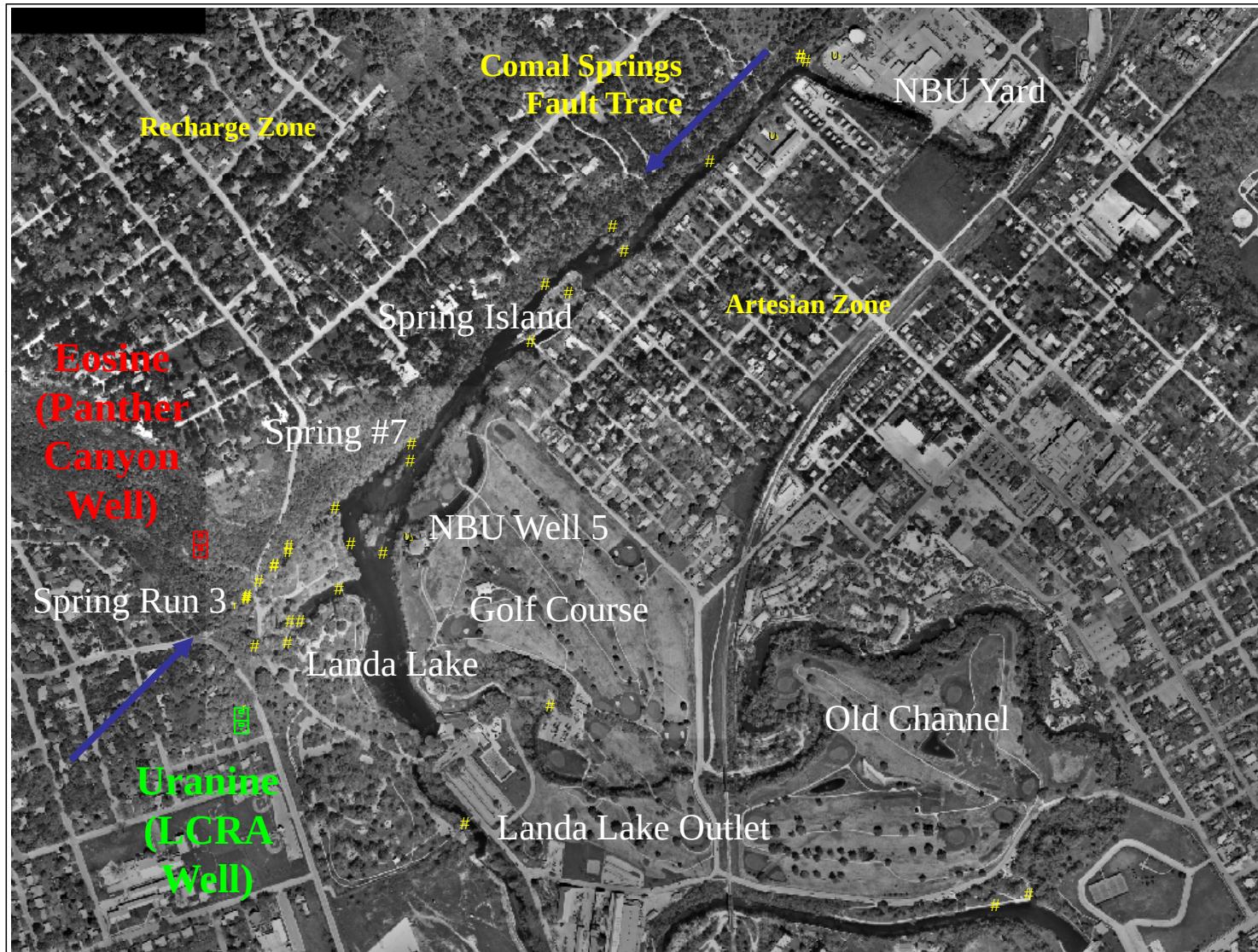


Spill site located adjacent to quarry. Diesel fuel used in formulation of explosives in quarry. Depth to groundwater is 280 feet

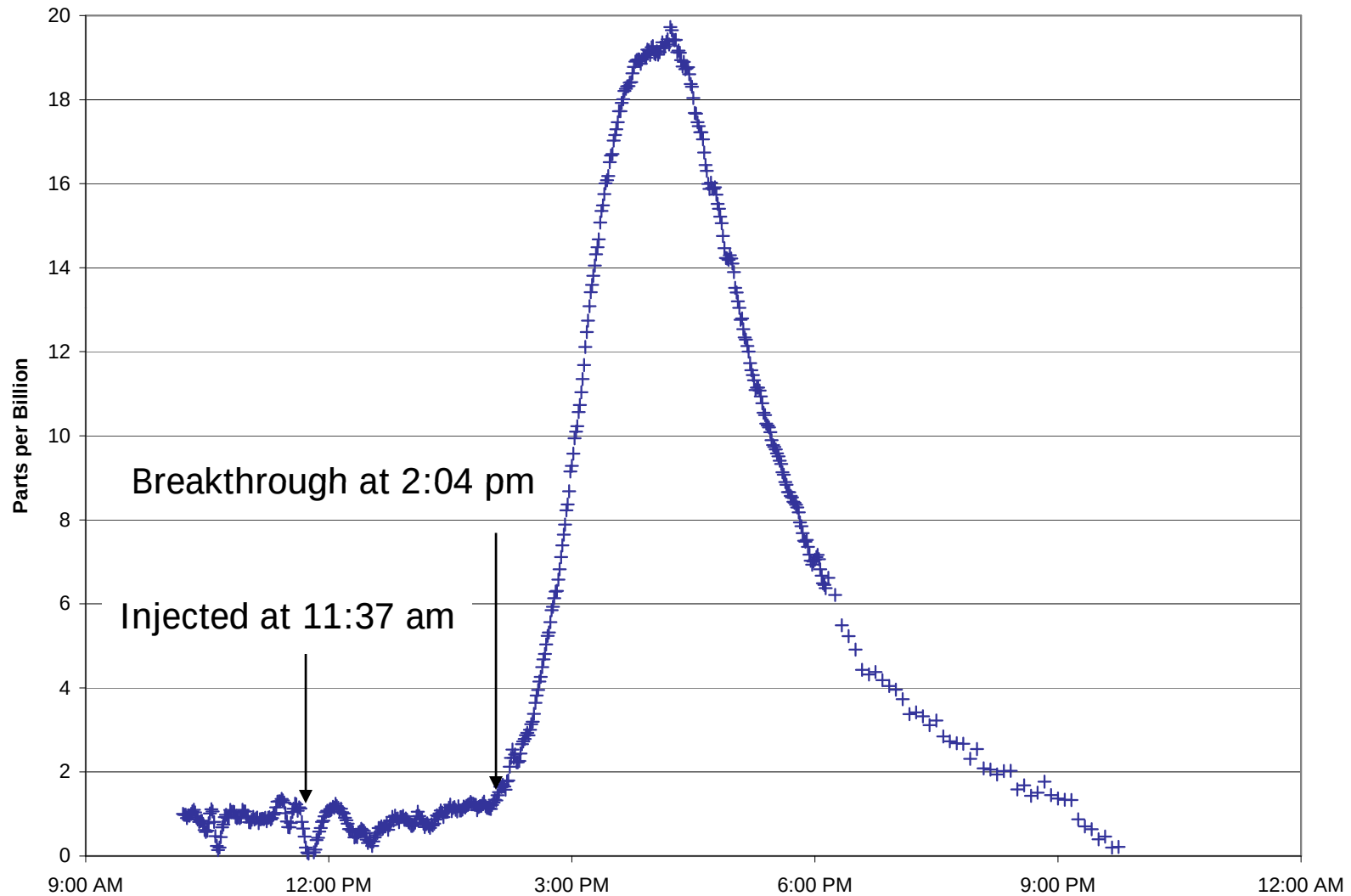


Miles

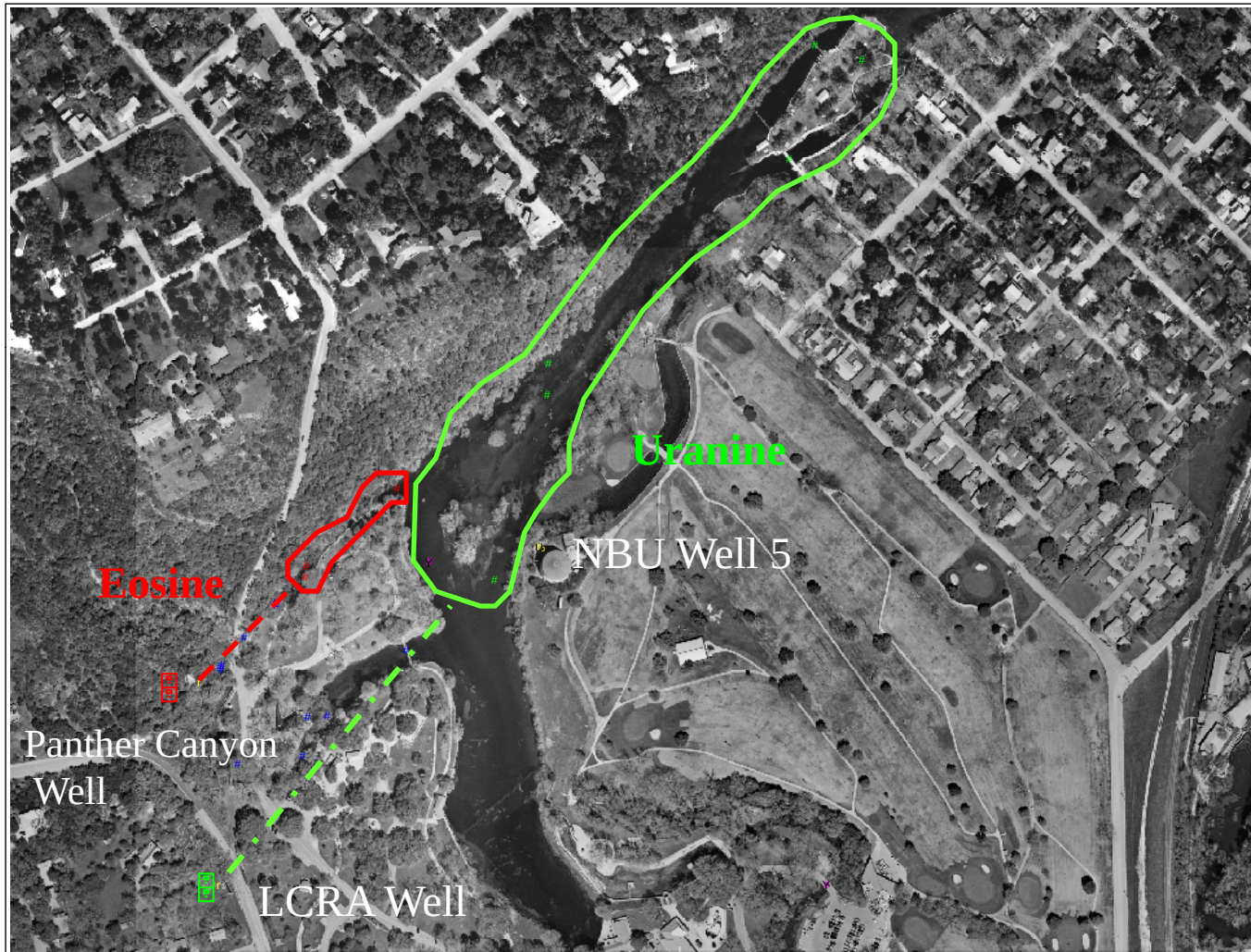
Tracer Test Sampling Points



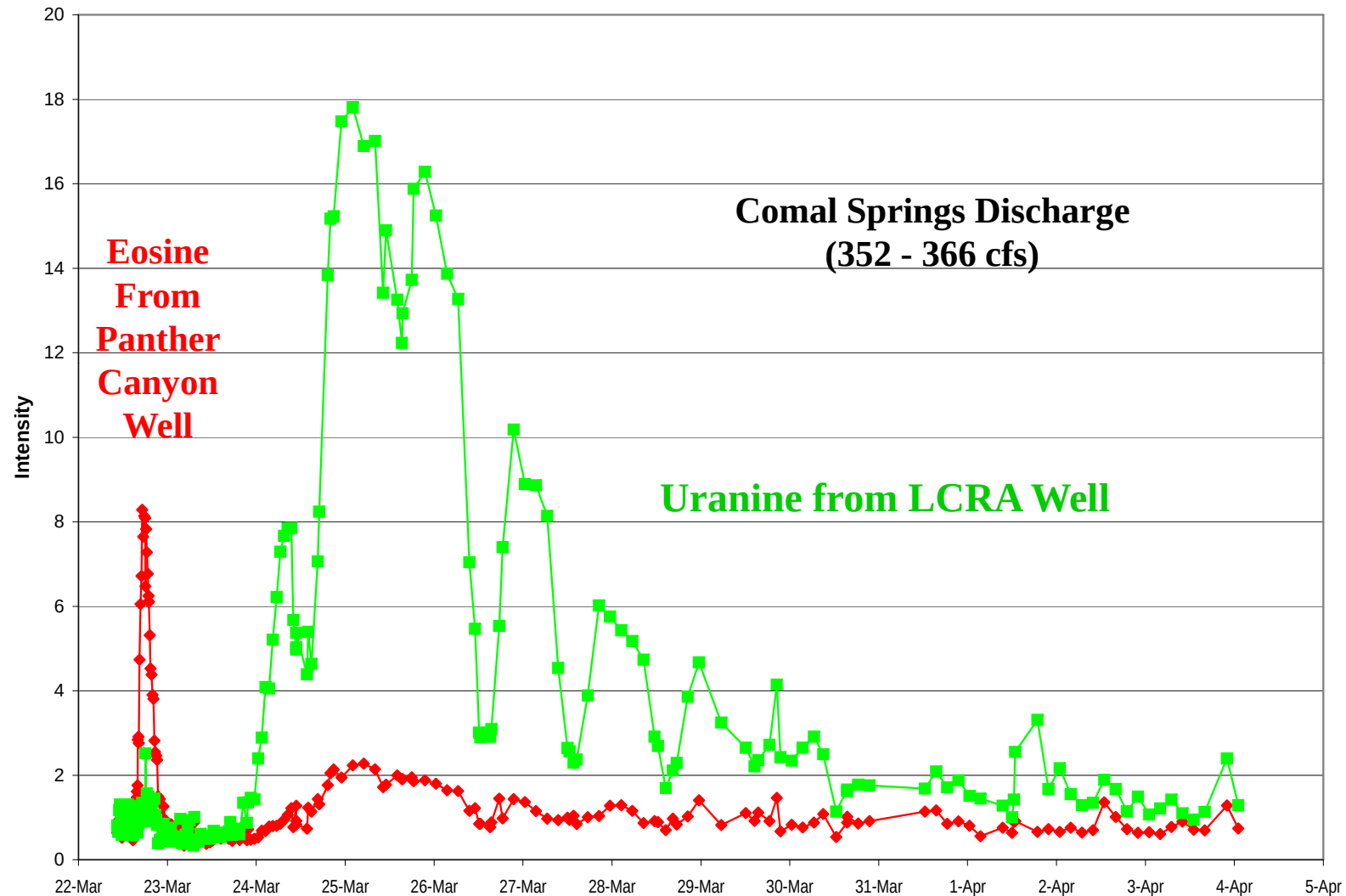
Eosine Breakthrough Curve on Filter Fluorometer at Spring Run #3



Uranine Tracer Test Results in the Landa Park Area



Breakthrough Curves at Landa Lake Outlet



Uranine results indicate photodegradation of dye as it crosses Landa Lake

Comal Springs Tracer Test

Estimated Travel Time Using Velocity Equation from Darcy's Law

$$v = Ki/n$$

T = 7,000 ft²/day from kriging in BEG ROI # 250

b = 500 feet (thickness)

n = 0.3 porosity from BEG ROI # 238

i = gradient = 0.01 ft/ft (21.7 feet of head over 2,000 feet)

v = Ki/n = 0.47 feet per day

or 11 year travel time from LCRA Well to Landa Lake

actual time from tracer test data was 36 hours

Comal Springs Tracer Test

Estimation of Conduit Size Using Continuity Equation

$$A = Q/V$$

A = Cross-sectional area in square feet

Q = Discharge in cubic feet second (360 cfs)

(50% of discharge from artesian zone)

(50% of discharge from recharge zone)

V = Velocity, feet per second

(0.023 ft/sec for artesian zone)

(0.069 ft/sec for recharge zone)

Comal Springs Tracer Test

Number of Conduits	Diameter of Conduits	Reynolds Number	Diameter of Conduits	Reynolds Number
	Artesian Zone	Artesian Zone	Recharge Zone	Recharge Zone
1	100 ft	212,861	57 ft	120,737
10	30 ft	63,509	18 ft	38,245
100	10 ft	20,937	6 ft	13,958

All Reynolds number are $> 2,000$; therefore, flow is turbulent and Darcy's Law does not apply to this portion of aquifer

Cavers and Geologists

- What is a caver?
Someone who is a member of the NSS, NSS CDS, or NACD
- How do you find a caver?
Local chapters of the NSS can be found from the NSS web page at www.caves.org
- State cave surveys can usually be contacted through cavers?
- Most cavers are willing to help and commonly volunteer maps and assistance once they understand what you want
- What is a karst specialist?
Someone through training and experience who has gained a certain level of competence in addressing karst problems.
- Currently, there is no certifications for specialists in the field of karst
- Some states maintain a list of recognized experts in karst
- Professionals should seek out the opportunity to enter caves with cavers or taking specialized training in karst

Cavers and Geologists

- Cavers need to start considering themselves professionals and stop thinking of themselves as someone who just crawled out from under a rock
- Cavers don't realize the importance of their maps and observations
- Karst specialists need to treat cavers with respect and stop looking at them as if they just crawled out from under a rock
- Karst specialists don't realize the importance of the years of field work locating springs and mapping in many states
- Relationships with cavers need to be developed before you need them – before the next big spill

Cavers and Geologists

- Cavers need to reach out to the non-specialist
- Cavers need to learn environmental regulations and reporting methods
- State regulatory agencies and consultants need to have access to karst specialists and use them for karst problems
- State surveys need to collect karst related data – spring and cave locations, maps, contact names, etc.

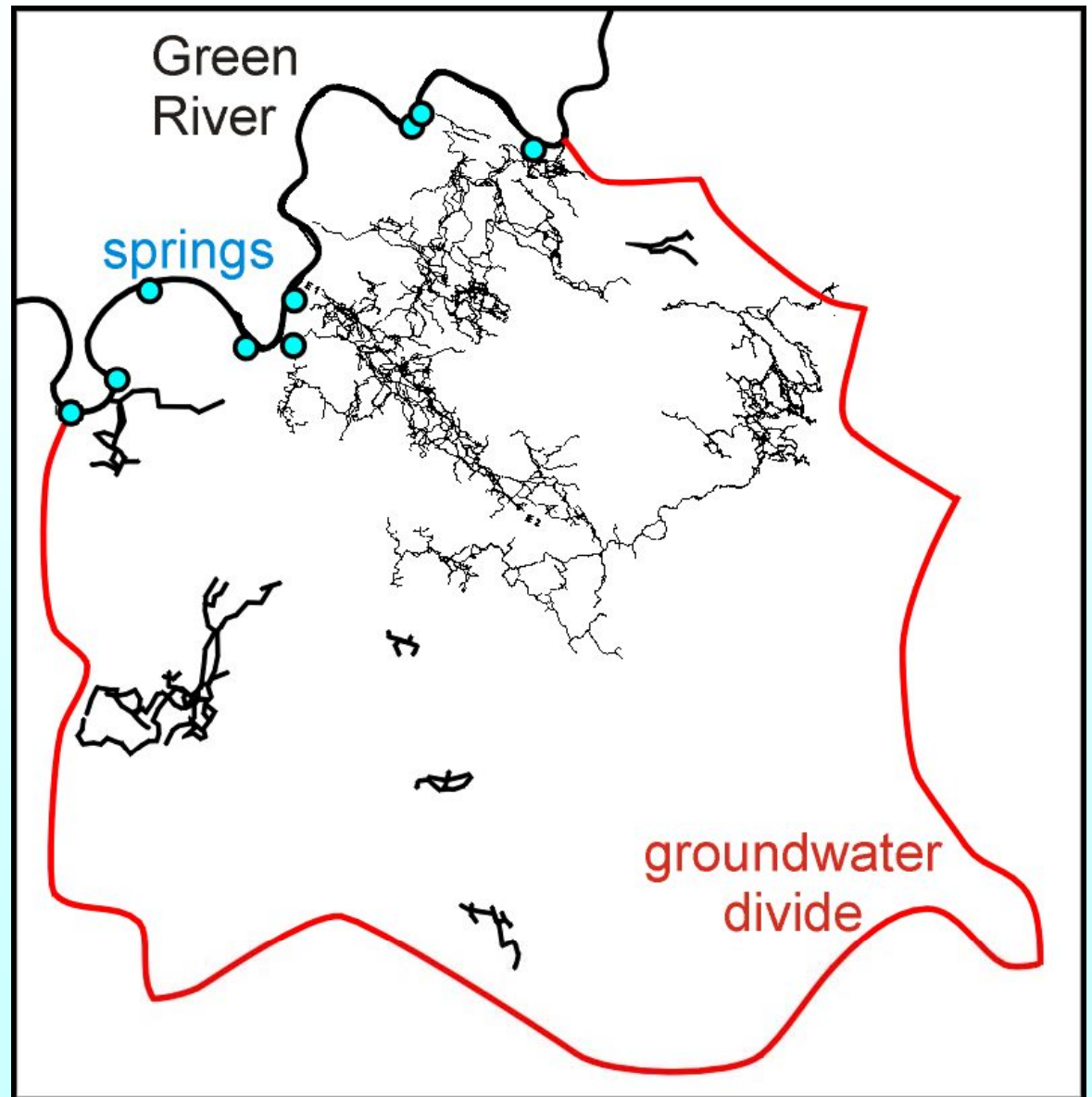
Characterization of the Mammoth Cave aquifer

Dr Steve Worthington
Worthington Groundwater

Mammoth Cave area

Mammoth Cave
300 miles

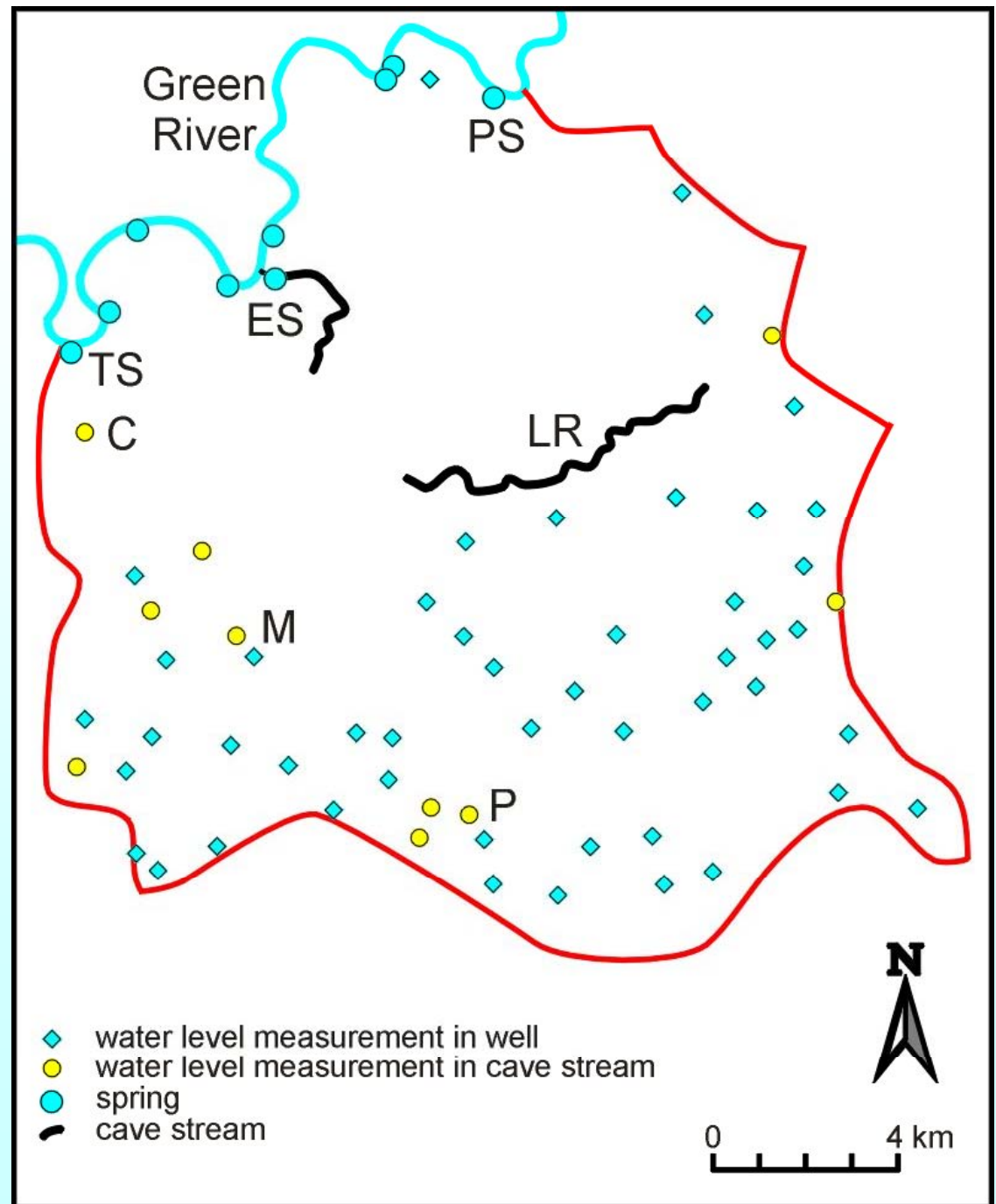
Martin Ridge
Cave



Model 1 assumptions

- Karst features are local scale
- Aquifer behaves as porous medium at large scale
- Useful data for calibration
 - 1) Heads in wells
 - 2) Hydraulic conductivity from well tests

Water level data



Hydraulic conductivity data

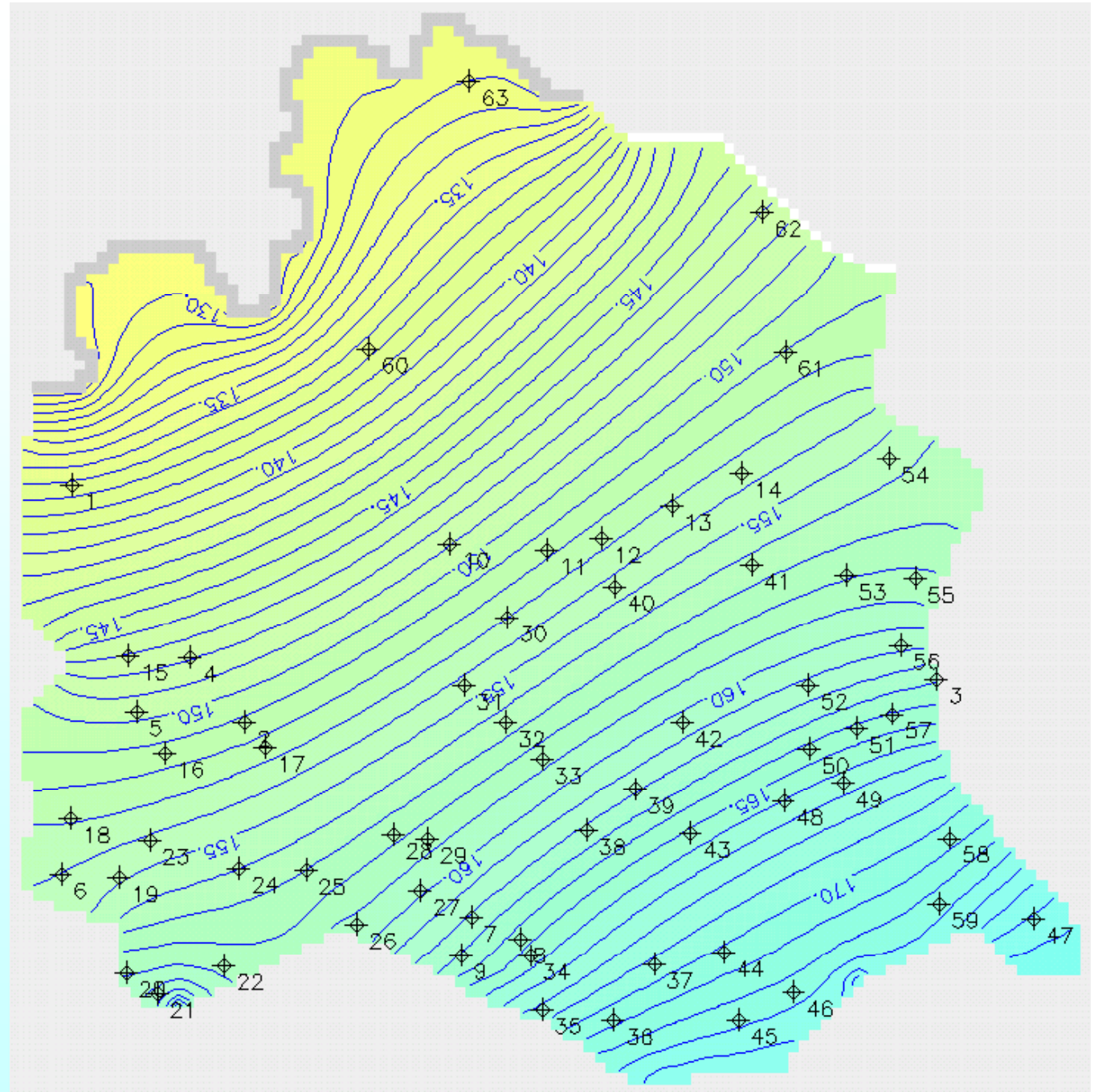
- Matrix 2×10^{-11} m/s
- Slug tests (geo. mean) 6×10^{-6} m/s
- Slug test (arith. mean) 3×10^{-5} m/s
- Pumping tests 3×10^{-4} m/s

- MODFLOW (EPM) 1×10^{-3} m/s

MODFLOW - homogeneous EPM simulation

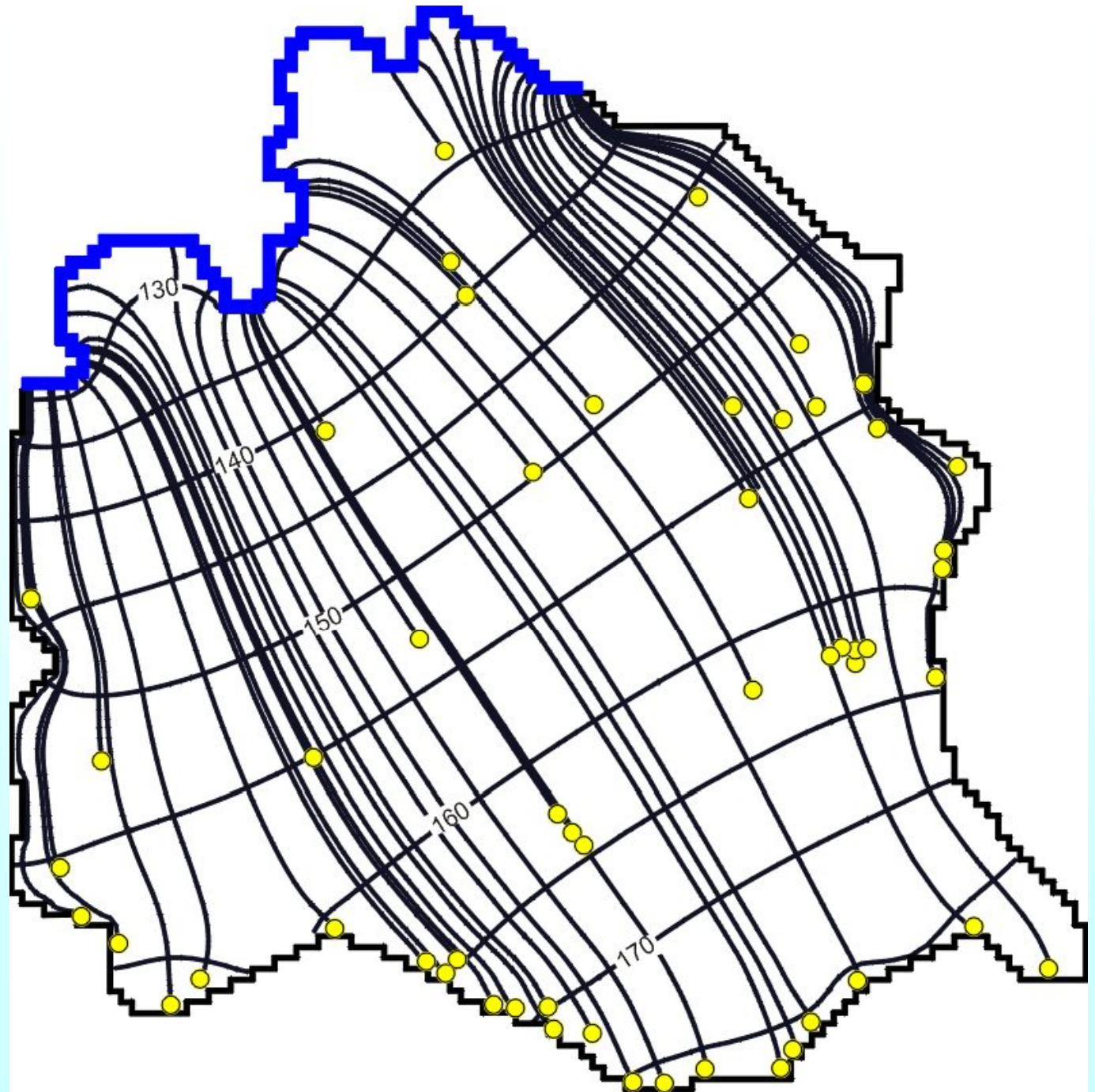
$K=1.1 \times 10^{-3}$ m/s

48 wells
mean absolute
error = 12 m



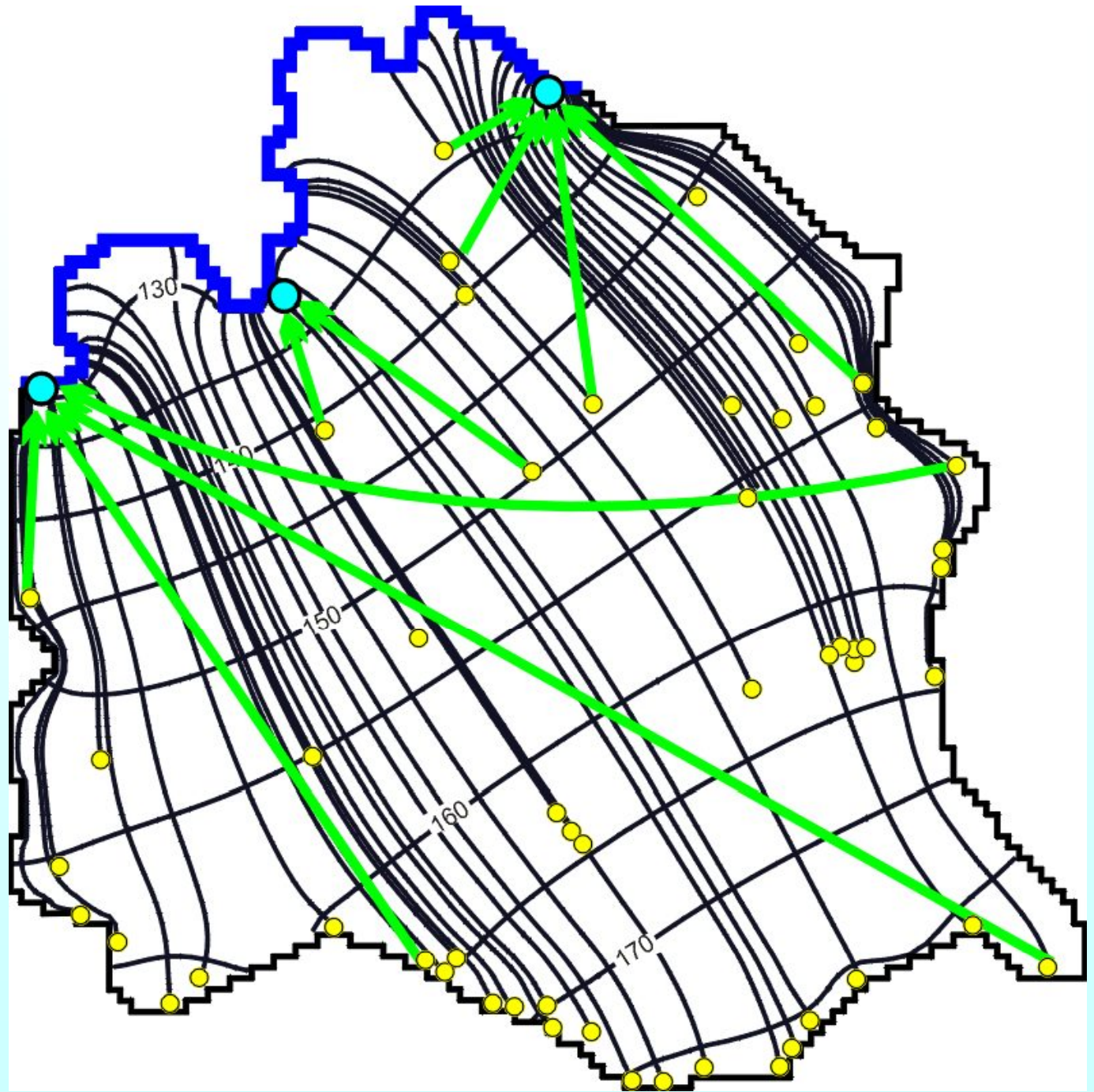
Simulated tracer paths

54 tracer
injection
locations



Actual
tracer
paths

from 54 inputs
to 3 springs



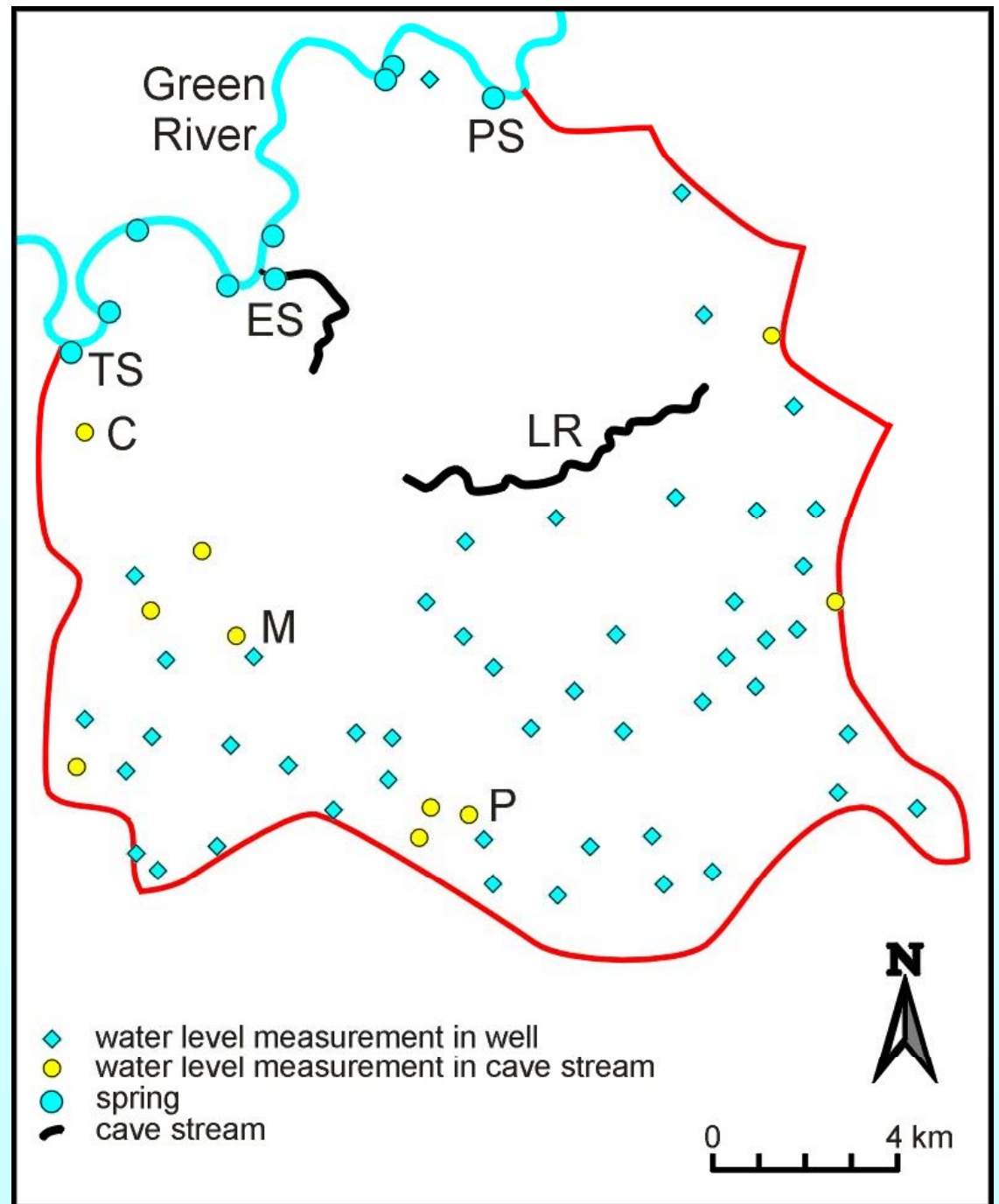
Problems with model 1

- Major assumption incorrect
- Lab studies and numerical models (e.g. Plummer and Wigley, 1976; Dreybrodt, 1996) suggest channel networks and caves should always form)
- Karst aquifers are not just “features”

Model 2 assumptions

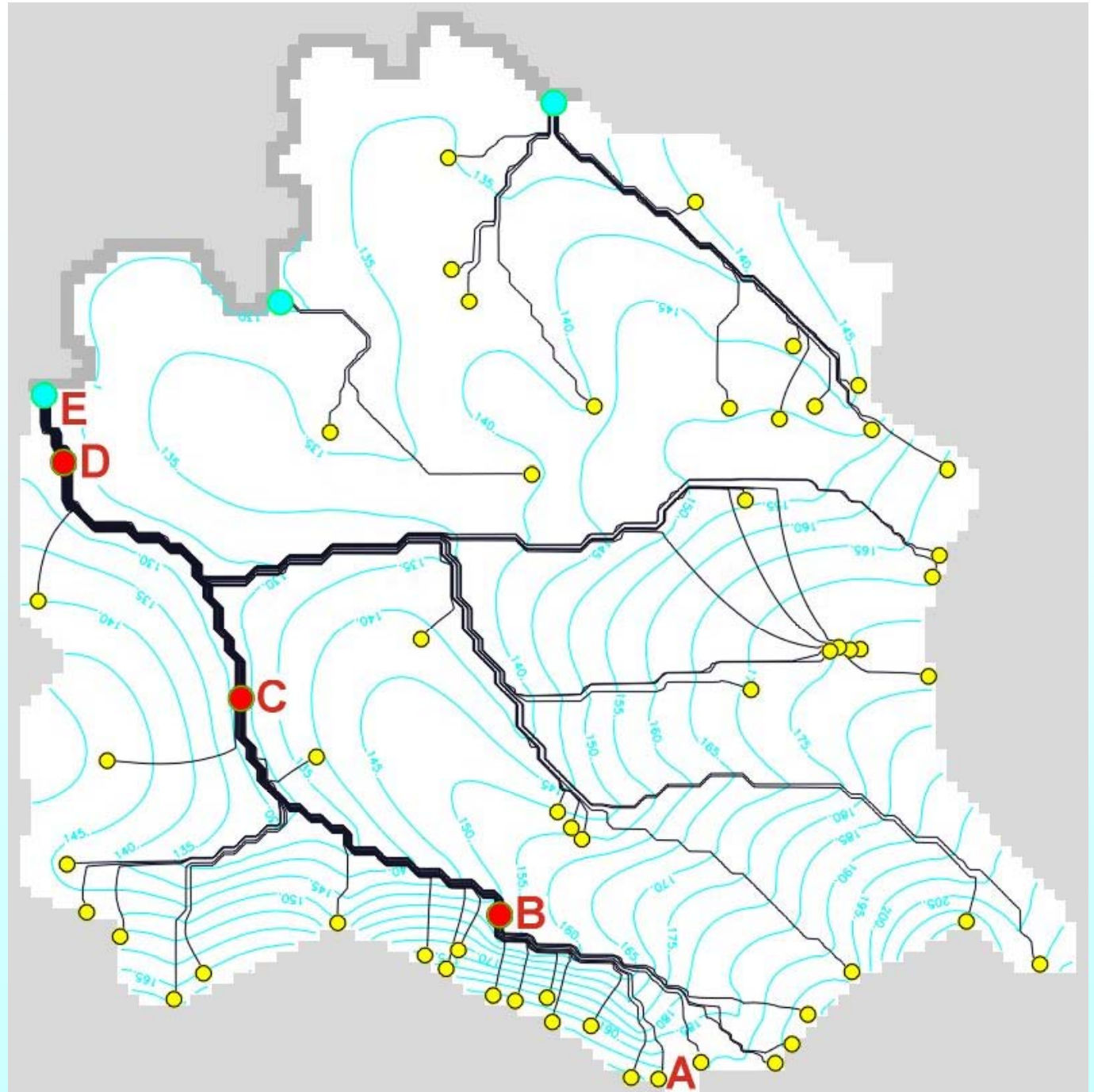
- Aquifer has integrated conduit network
- Useful data for calibration
 - 1) Heads in wells
 - 2) Hydraulic conductivity from well tests
 - 3) Heads and discharge in conduits
 - 4) Tracer tests

Water level data



Simulated tracer paths

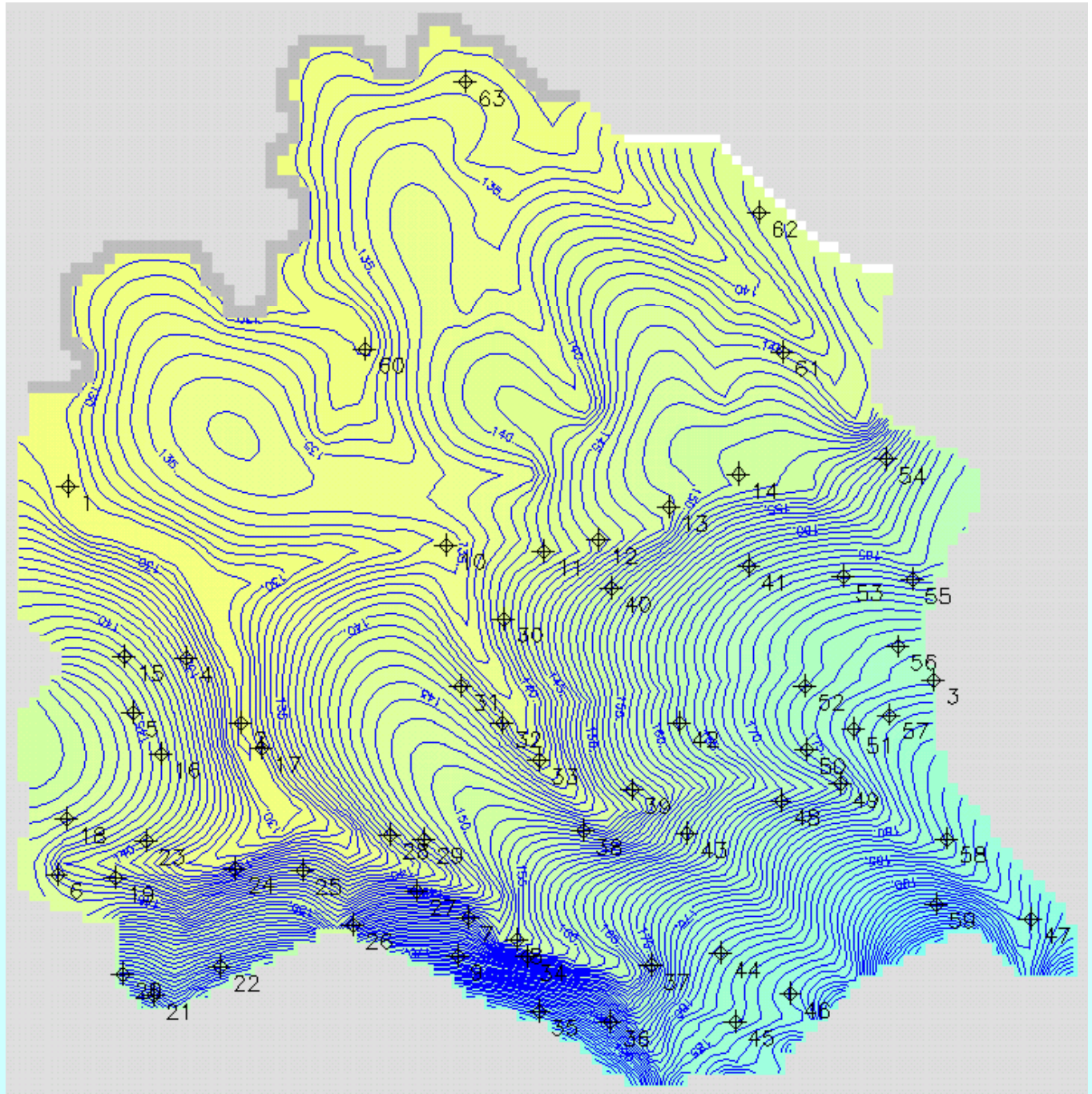
all 54 tracer
paths go to
correct spring



MODFLOW
with high K
cells

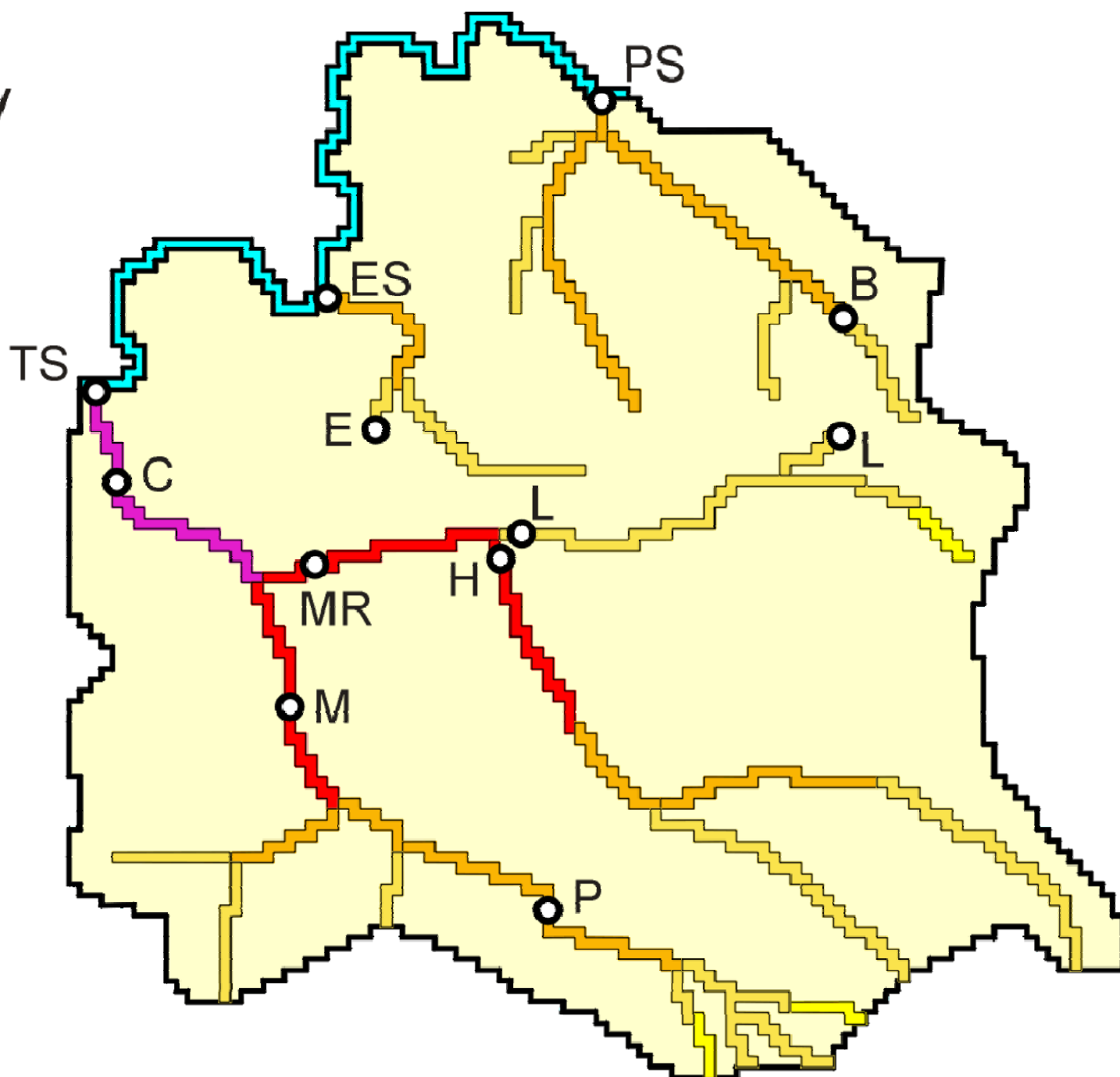
K 2×10^{-5} to 7
m/s

Mean absolute
error 4 m



Hydraulic conductivity distribution

K m/s



Results of MODFLOW with “conduits cells”

- Head error reduced from 11 m to 4 m
- Tracer paths accurately shown
- Model reasonable for steady-state
- Poor performance for transient (hours)
- Poor performance for transport
- No good codes available for karst aquifers

What generalizations can be made?

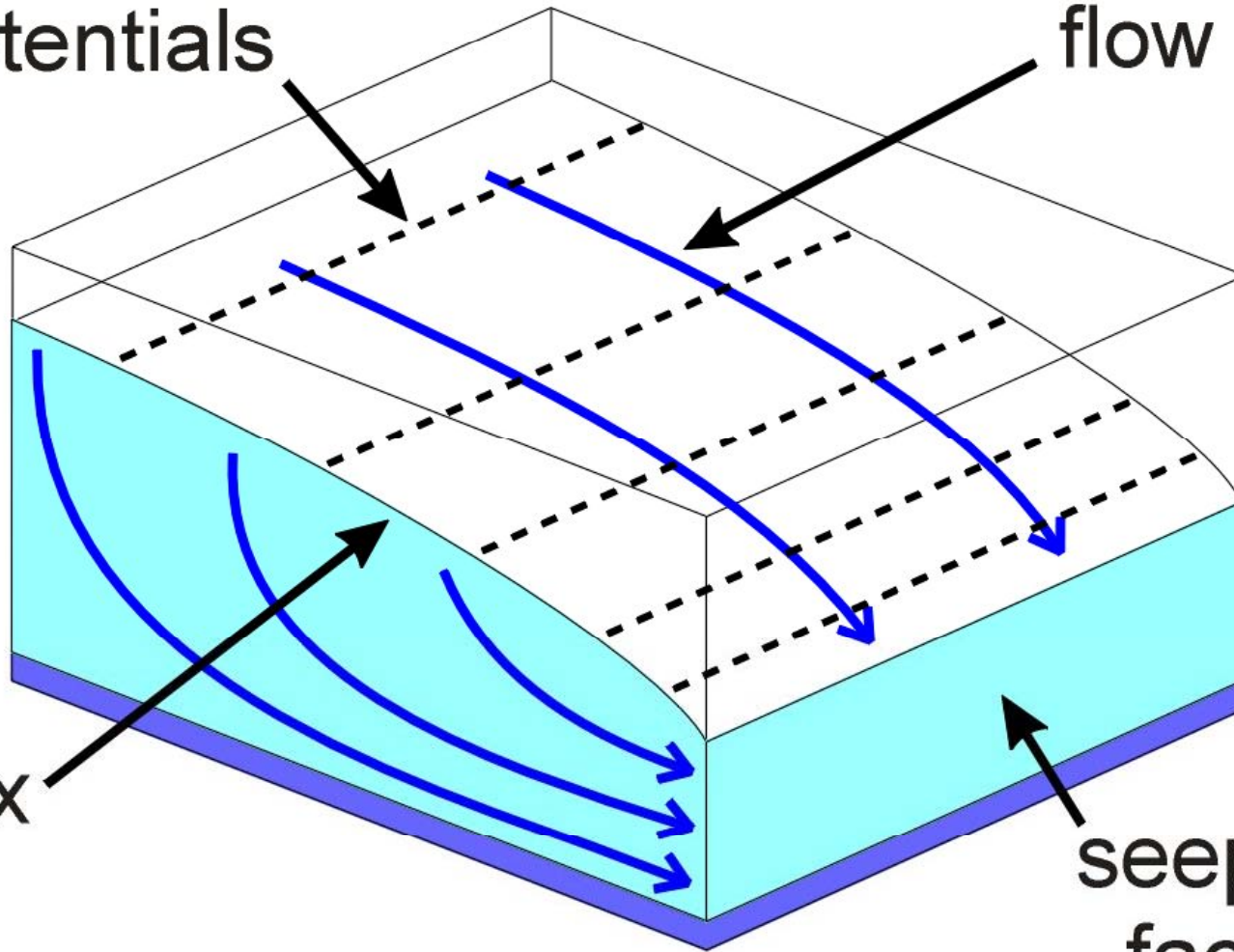
Ideal sand aquifer

parallel
equipotentials

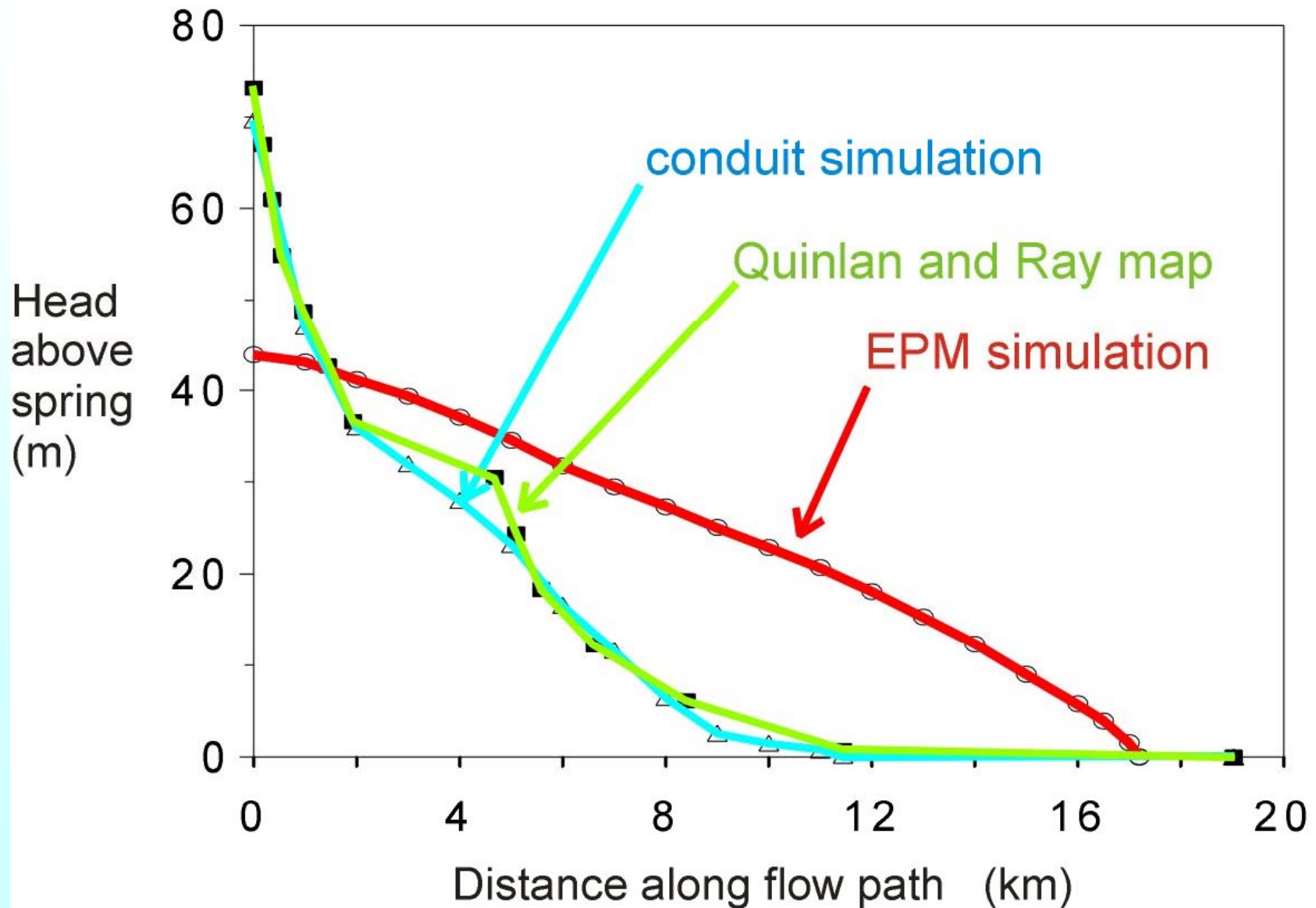
parallel
flow lines

convex
water
table

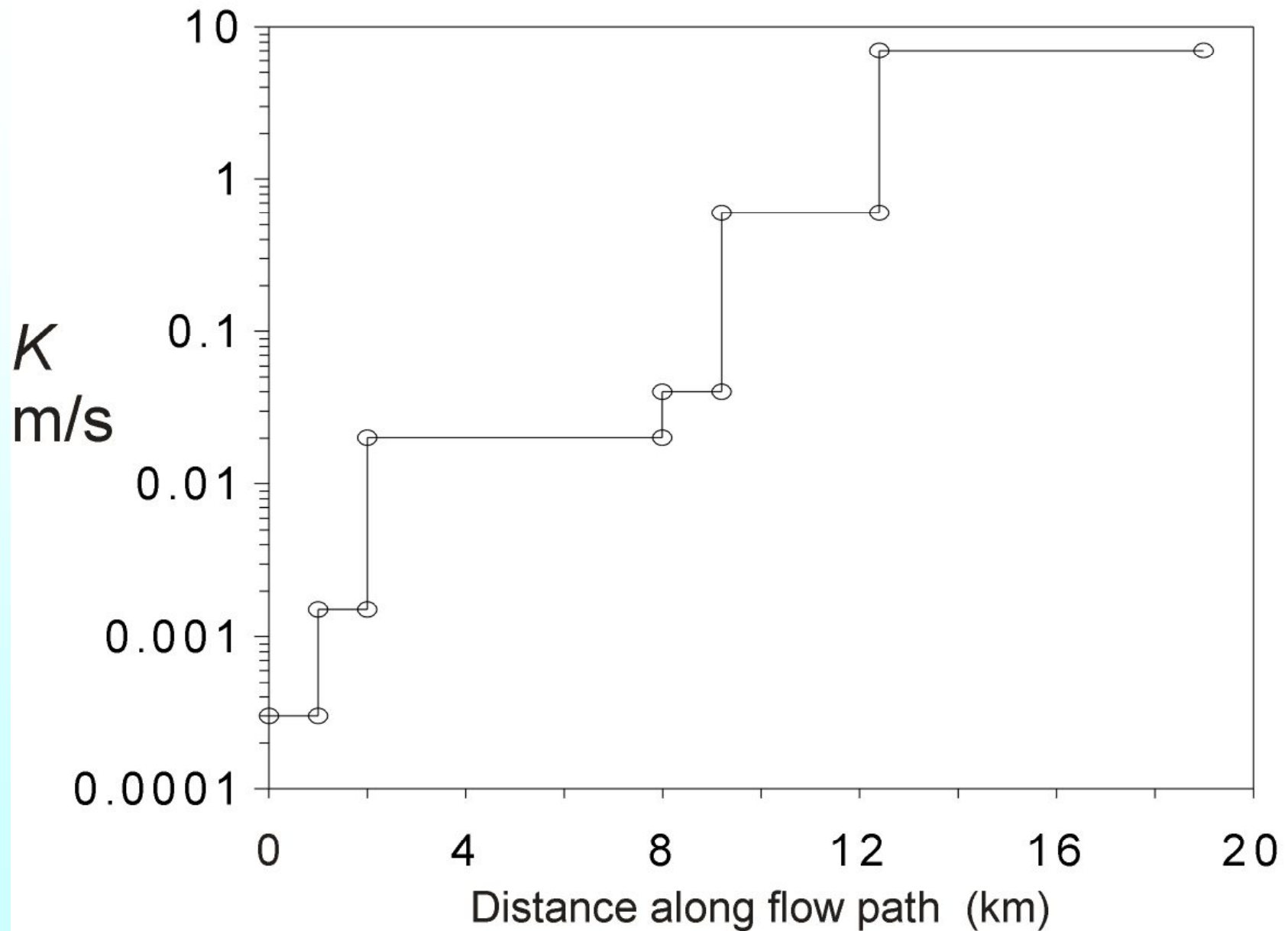
seepage
face



Hydraulic gradients from A to Turnhole Spring



Increasing K from sink A to Turnhole Spring



Ideal carbonate aquifer

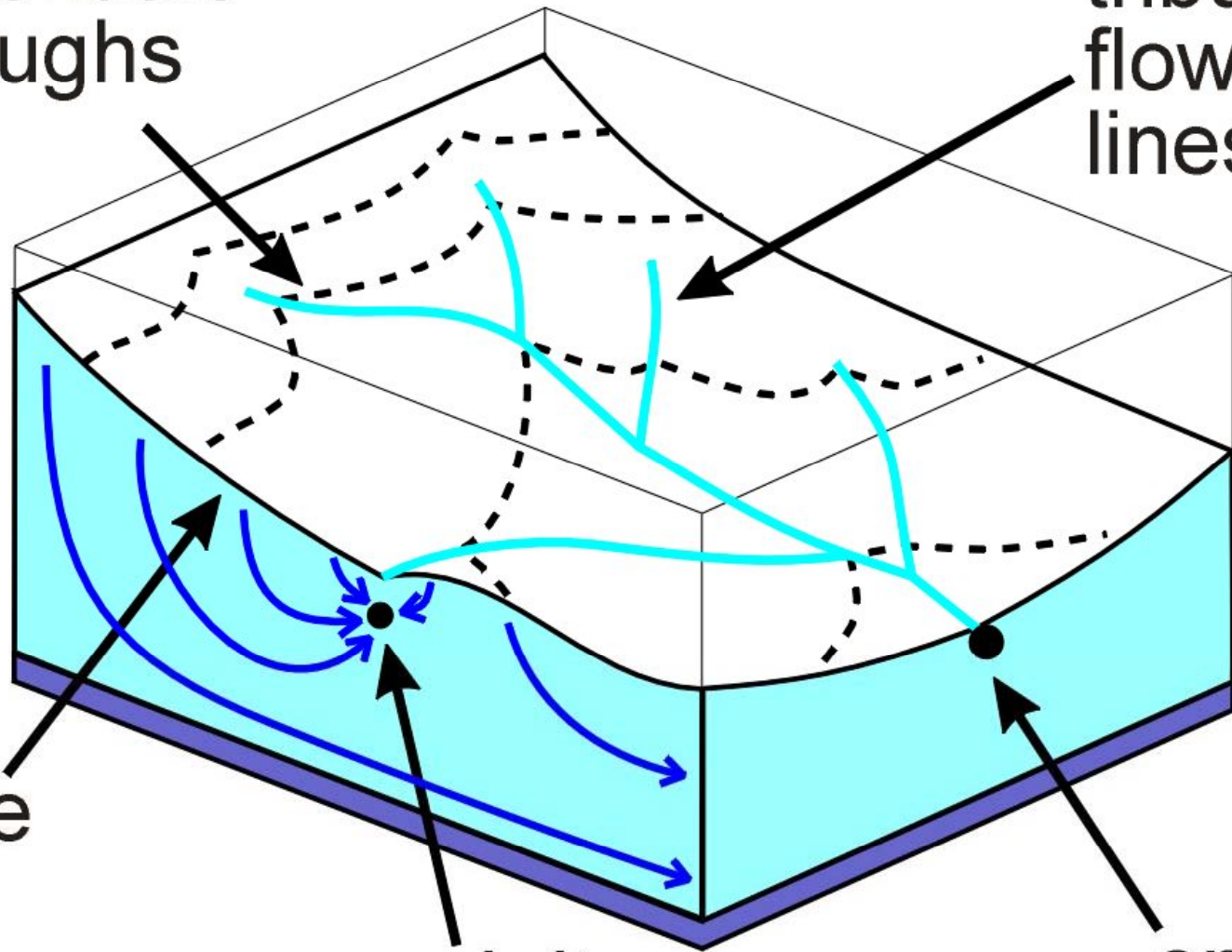
Equipotentials
form troughs

tributary
flow lines

concave
water
table

conduit

spring



Differences between karst aquifers and porous media

- Tributary flow to springs
- Flow in channels with high Re
- Troughs in the potentiometric surface
- Downgradient decrease in i
- Downgradient increase in K
- Substantial scaling effects

Triple porosity at Mammoth Cave

- Matrix K 10^{-11} m/s
 - Fracture K 10^{-5} m/s
 - Channel K 10^{-3} m/s - **most of flow**
-
- Matrix porosity 2.4% - **most of storage**
 - Fracture porosity 0.03%
 - Channel porosity 0.06%

Characterizing carbonates

- Wells are great for matrix and fracture studies
- but only ~2 % of wells at Mammoth Cave will hit major conduits
- Cave and spring studies, and sink to spring tracer tests are great for channel studies
- but little is learned about matrix and fracture properties

Comparison of Mammoth Cave and N. Florida aquifers

- Mammoth Cave area EPM 1.1×10^{-3} m/s
- Mammoth Cave area with conduits
 4×10^{-5} to 7×10^0 m/s
- Wakulla County 8×10^{-6} to 2×10^{-2} m/s
(Davis, USGS WRIR 95-4296)

Available global cave data

- About 100,000 km of caves passages at or above the water table have been mapped.
- About 1000 km of cave passages below the water table have been mapped.

Increase in mapped caves

- Total of mapped caves above the water table is increasing by about 8% each year.
- Total of mapped caves below the water table is increasing by about 15% each year.
- Only a very small fraction of all caves are known.

Significance of caves

- Known caves represent examples from a large and mostly unknown data set
- Most active conduits below water table
- Fossil passages analog for active conduits
- Fossil conduits 10 m high and wide and kilometers in length at Mammoth Cave
- Hydraulic parameters and tributary network in fossil and active systems

Problems with applying cave data

- Most cave data local scale, not aquifer scale
- Caves above the water table may not be representative of active conduits below the water table
- Water supply is usually from wells - what is relevance of cave studies?

Significance of Caves in Watershed and Protection in Florida



Managing the Hidden Resources of Wakulla Springs

Sandy Cook, Manager
Wakulla Springs State Park & Lodge

The 200,000 annual visitors see only a fraction of the parks unique resources



⌘ Of the nearly 6,000 acres, only about 50 acres are frequently visited.

⌘ Many miles of underground caverns have seen by only a handful of cave divers



Divers have obtained valuable
data on the parks resources for
many, many years
Although not all dive activity was
research related...

Summer 1930

- ⌘ Mastodon bones discovered
- ⌘ Dr. Herman Gunter & members of FI Geological Survey use divers with pumps & hoses and grapple hooks to remove bones

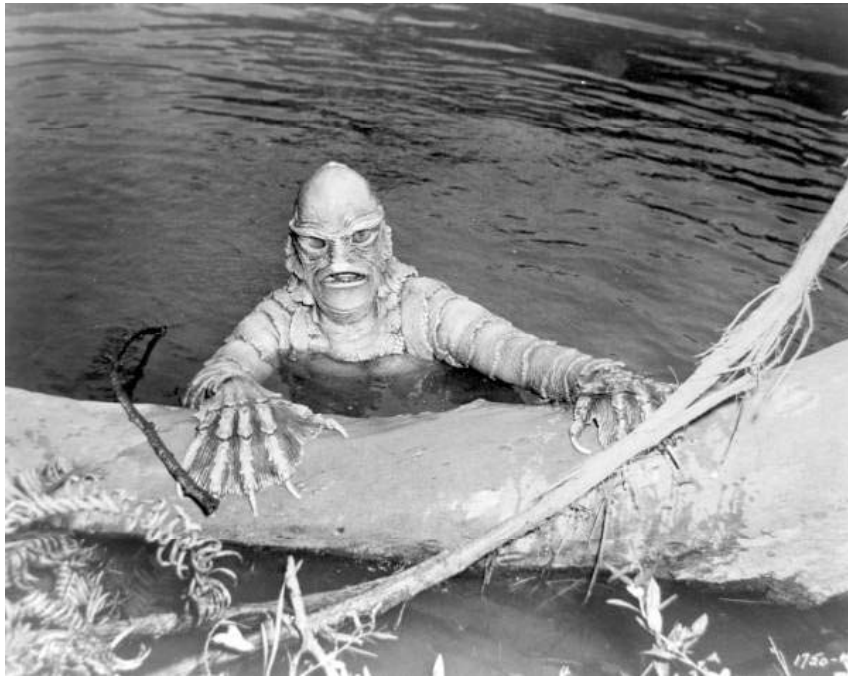




1954 Creature From The Black Lagoon

- ⌘ Filming of movie included lots of diving activities
- ⌘ Wakulla Springs lifeguard Rico Browning was hired to do the underwater scenes





1955 Jenkins & Salsman

- ⌘ Filming of
“Exploring Florida’s
Caves”
- ⌘ Jenkins & Salsman
were allowed to
participate since
they had the
needed air
compressor



Airport 77

⌘ Two months of filming underwater scenes which resulted in 4 - 8 minutes of screen time



1992 to current Woodville Karst Plain Project

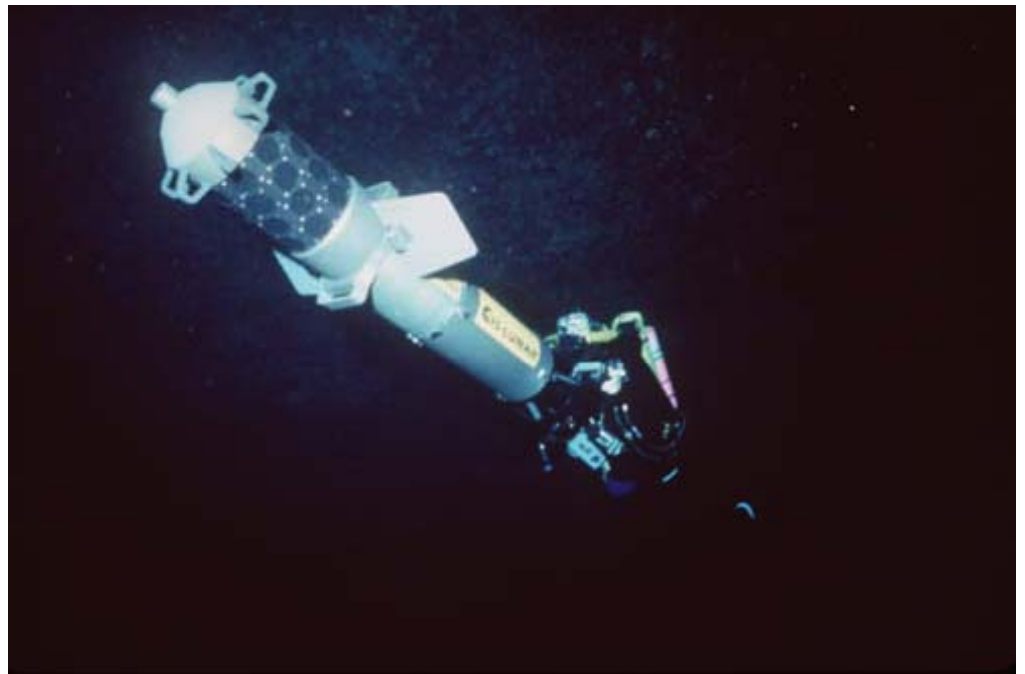
- ⌘ Have provided valuable information for land use decisions
- ⌘ Activities have not occurred without impact or controversy



Wakulla 1 & 2 Expedition

U.S. Deep Caving Team

- ⌘ Have also provided valuable information and gained world wide attention
- ⌘ Also not without impact and controversy



Controversy leads to support

⌘ 1993 Proposed land use change that would allow development of gas station on lands adjacent to park



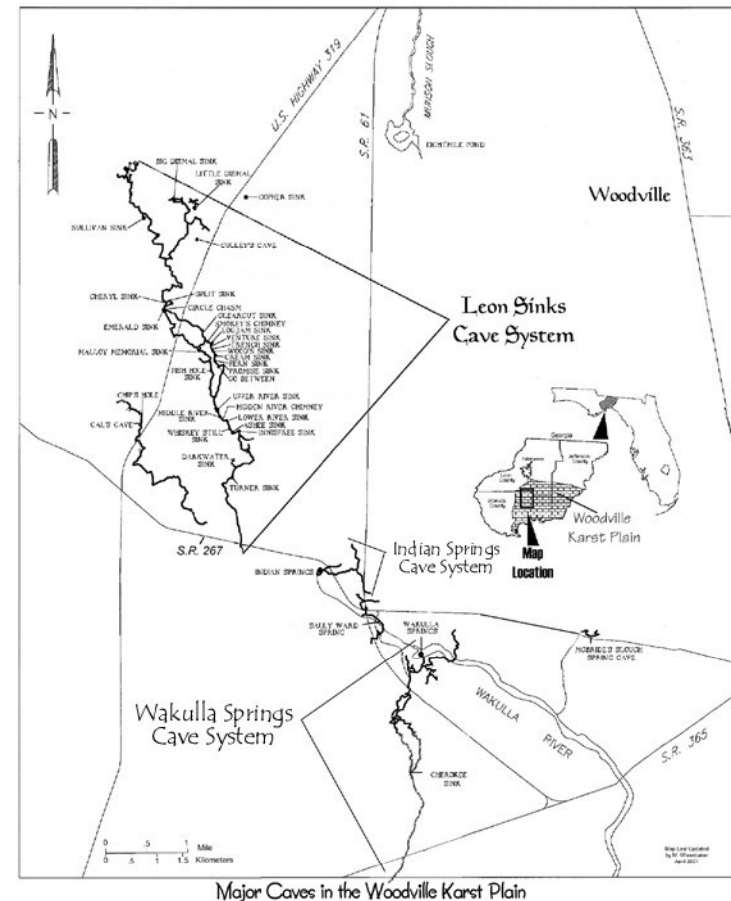
Friends of Wakulla Springs, Inc

- ⌘ Formalized as a result of the threat. Was instrumental in the movement to prevent development.
- ⌘ Continued interest in new threats



Dive data was also valuable

- ⌘ Members of the WKPP provided valuable data that was used.
- ⌘ Members also gave presentations at County Commission Meetings



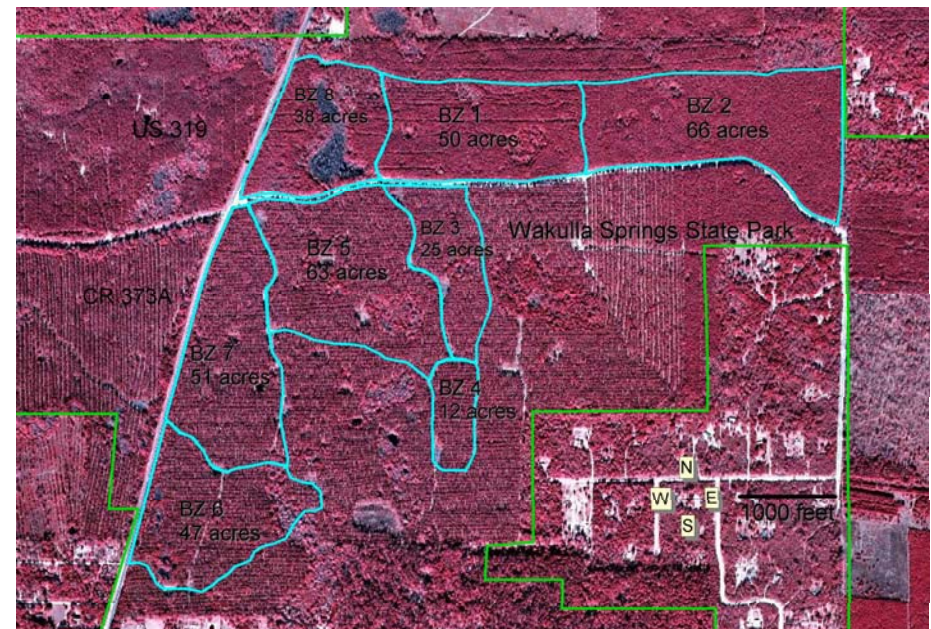
Wakulla Springs Protection Zone Ordinance

- ⌘ Activities & pressure by individual groups (and Jim Stevenson) led to passage of Wakulla County Ordinance # 94-28
- ⌘ Restricts activities that impact groundwater



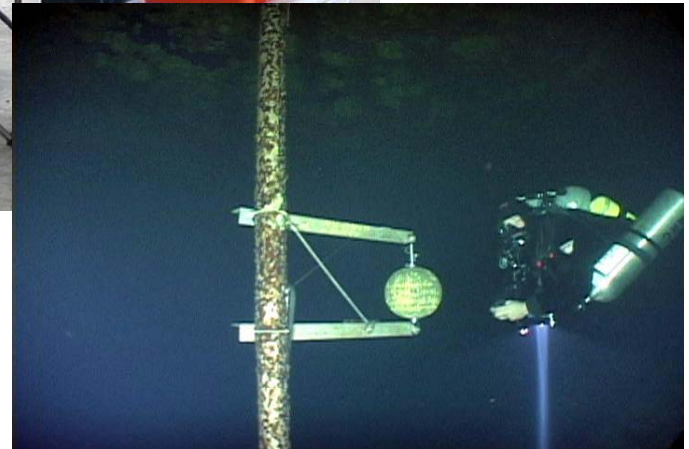
Land Acquisition

- ⌘ Wakulla Springs acquires additional acreage
- ⌘ Based on protection of groundwater rather than terrestrial features
- ⌘ 1999 - 1850 acres
- ⌘ 2002 - 1200 acres



Ongoing Research Projects & Support

- ⌘ Cave mapping
- ⌘ Aquatic plant surveys
- ⌘ Hydrilla control & monitoring
- ⌘ Water quality monitoring
- ⌘ Aquatic biology assessments
- ⌘ Nitrate studies
- ⌘ Flow data
- ⌘ Limpkin survey
- ⌘ Apple Snail Survey
- ⌘ Crustacian survey
- ⌘ Fish Survey
- ⌘ Lakewatch
- ⌘ Private landowner assistance



Butler Sink

⌘ Funds from Springs Initiative are being used to provide a well, troughs, fencing and earthworks around the sink to prevent further degradation



Wakulla Springs faces threats

- ⌘ Nitrate levels increase
- ⌘ Hydrilla invades the spring
- ⌘ Algae covers the spring basin
- ⌘ Runoff in sinkholes upstream
- ⌘ Sprayfield expansion in Tallahassee



Continued research & support is essential

- ⌘ Wakulla Springs
economic impact 7.5
million
- ⌘ One of the largest
employers in the
county
- ⌘ Voted the “Best
Place to Take an
Out of Town Guest”

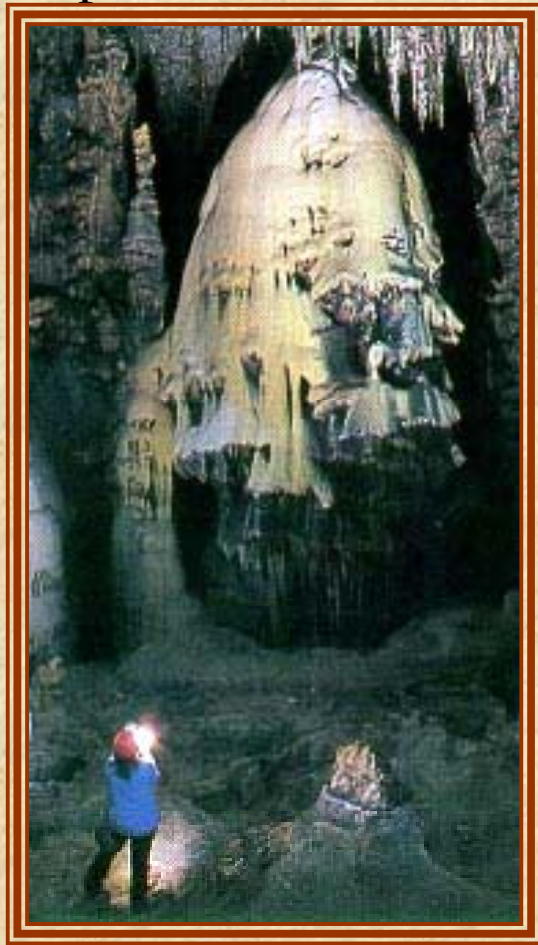




National Park Service

Cave and Karst Programs

<http://www2.nature.nps.gov/grd/geology/caves/index.htm>



- **STEWARDSHIP**
- **RESPONSIBILITY**
- **SCIENCE**
- **COOPERATION**
- **COORDINATION**
- **EDUCATION**

INSIDE EARTH

<http://www2.nature.nps.gov/grd/geology/caves/index.htm>

National Park Service

Cave and Karst Resources

- Cave and Karst Program
- Inside Earth Newsletters
- Tour of Cave and Karst Parks
- The National Cave and Karst Research Institute Act
- Federal Cave Resources Protection Act
- Dept. of Interior Cave Management Regulations
- Selected Cave Links



INSIDE EARTH
A Newsletter of the National Park Service Cave & Karst Programs



Vol. 5, No. 1 Late Spring 2002

Edited by Dale L. Pate

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Website Address:
<http://www2.nature.nps.gov/grd/geology/caves/newsletter.htm>
Webmaster: Jim F. Wood: jim_f_wood@nps.gov

**NATIONAL CAVE AND KARST
RESEARCH INSTITUTE
PROGRESS IN 2002**
by Zelda Chapman Bailey

Key activities during the two-year interim period (2000-2002) of establishing the National Cave and Karst Research Institute (the Institute) were defining the scope of operation, designing an organizational structure, forming partnerships, finding funding sources and a physical facility, and defining research needs. Considerable progress has been made in all these areas toward making the Institute operational.

The Institute will require about 12 employees to fully accomplish the goals, including the lead positions of Director, Science Coordinator, Education Coordinator, and Information Coordinator, and support staff under their direction. Voluntary advisory boards made up of representatives from a range of disciplines and organizations will play an important role in guiding the science and educational undertakings of the Institute. A nationwide announcement will be issued in summer 2002 to recruit the permanent Director for the Institute. The Director should report to Carlsbad early in fiscal year 2003. If additional operating funds are appropriated for 2003, additional positions will be recruited, probably including the Science Coordinator and administrative staff.

The Institute will not conduct research internally but will guide, focus, and encourage research through grants and partnerships. A primary function of the Institute will be to accumulate and organize data and information to make it accessible to investigators and for the Institute staff to use for synthesis of information on regional and national scales. The Institute will encourage focused research and studies in caves and karst systems so that a more

Inside Earth- Vol.5, No.1 - Late Spring 2002 1

National Park Service Cave and Karst Resources



*“Lower Cave”, Carlsbad Cavern,
Carlsbad Caverns National Park,
New Mexico*

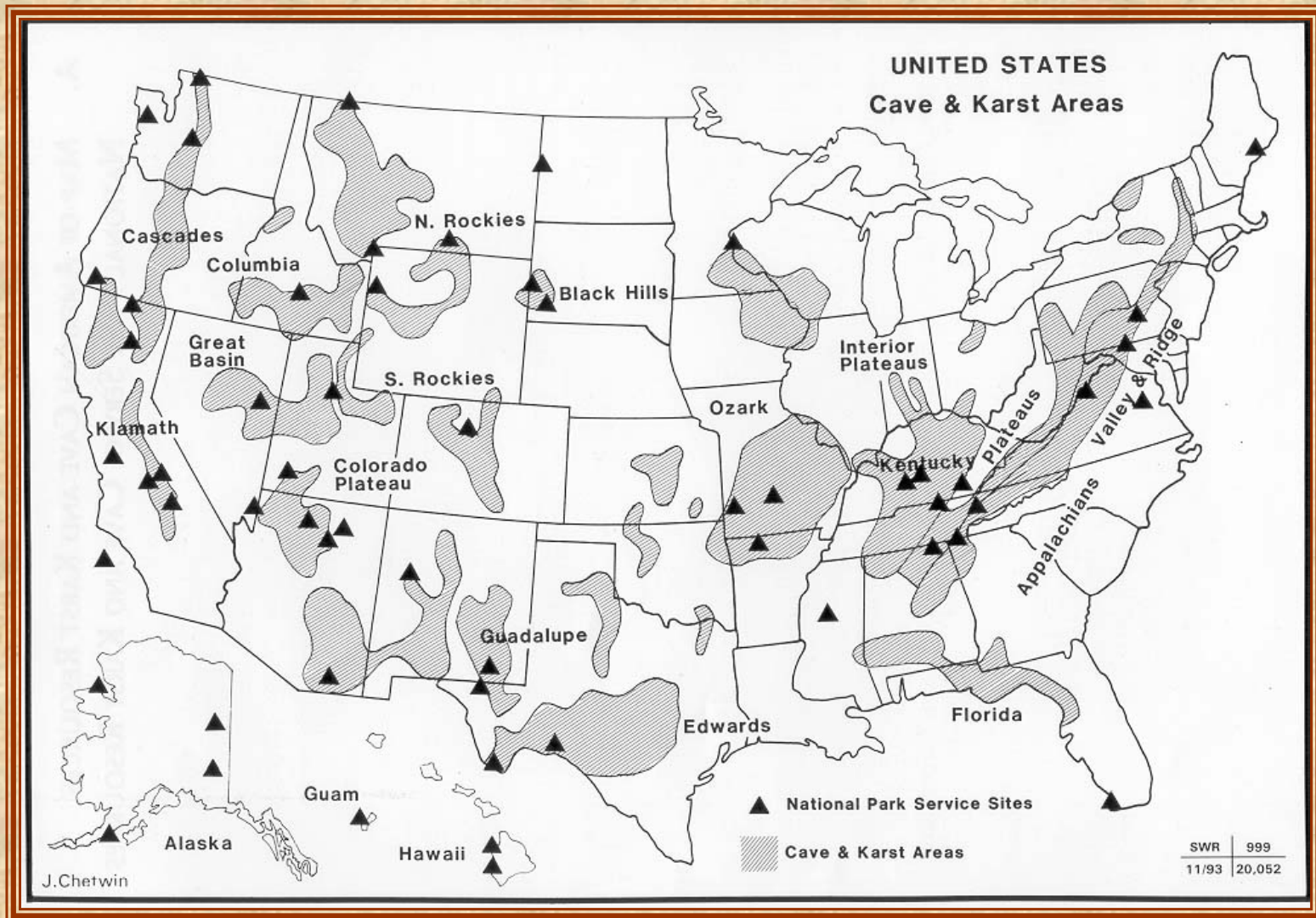
- Caves and karst features occur in 120 (81 contain caves and an additional 39 contain karst) parks in all regions of the National Park System. Over 3,900 caves are currently known throughout the system. Eleven parks provide regular guided tours of 17 caves. The number of caves per park unit ranges from 10 caves—as in the Chesapeake & Ohio Canal National Historic Park, to more than 400 caves—as in the Grand Canyon National Park.
- Ek, David, report to the 2001 Geologic Resources Division Annual Report

NPS national cave/karst program

- **The NPS national cave/karst program is managed by one person in a central office. Servicewide, as of 2002, 21 people stationed in 14 park units are devoted to cave and karst management, even though 81 parks have significant cave or karst resources.**



Cave and Karst Areas of the NPS



Karst - What does it mean?



- region of irregular topography with sinks, underground streams, caves and springs
- formed by water percolating through water soluble rock

Why are caves important?



- **Source of water supply**
 - ground water
- **Contain important information including:**
 - microbes
 - archeological material
 - paleoclimatic evidence
 - human history and evolution

How are caves threatened?

- mining: oil & gas
- landfills
- toxic waste repositories
- infra-structure
- spills
- overgrazing
- fires



The Federal Cave Resources Protection Act of 1988

- In 1988, the U. S. Congress created a major impetus for the involvement of the United States in cave and karst protection and management by passing the landmark **Federal Cave Resources Protection Act of 1988** (Public Law 100-691; November 18, 1988). The act directs the secretaries of the Department of the Interior and the Department of Agriculture to inventory and list significant caves on federal lands and to provide management and dissemination of information about caves. A current, nationwide assessment of significant federally owned caves is cataloging the known caves on federal land and further increasing the impetus for cave management and research.

Significant Cave Criteria-Biota



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

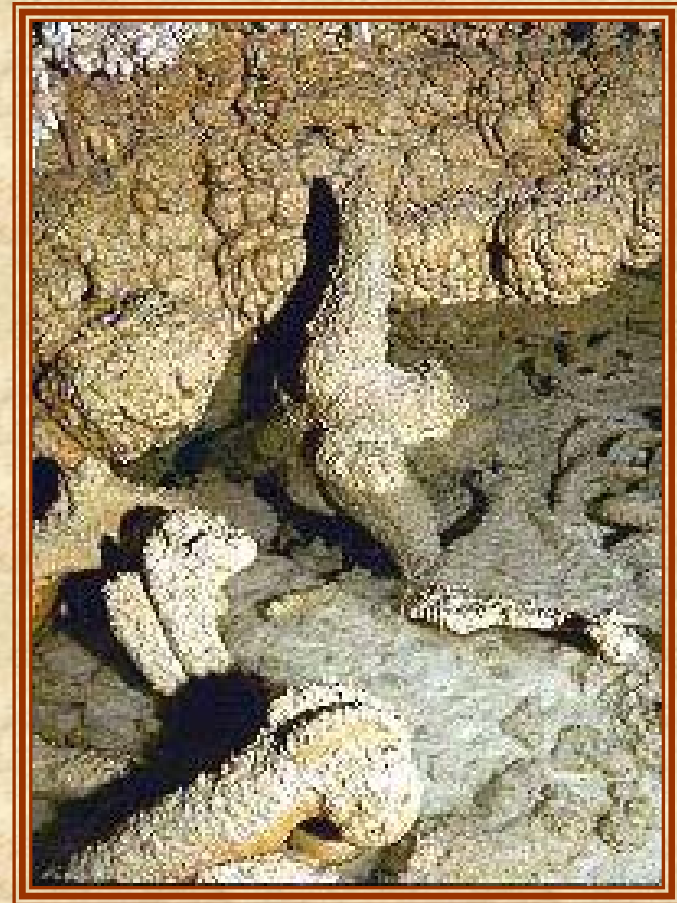
Significant Cave Criteria- Cultural



- **Cultural.** The cave contains historic properties or archaeological resources (as described in 36 CFR 60.4 and 43 CFR 7.3) or other features that are included in or eligible for inclusion in the National Register of Historic Places because of their research importance for history or prehistory, historical associations, or other historical or traditional significance.

Significant Cave Criteria- Geologic/Mineralogic/Paleontologic.

- **Geologic/Mineralogic/Paleontologic.** The cave possesses one or more of the following features:
- (i) **Geologic or mineralogic** features that are fragile, or that exhibit interesting formation processes, or that are otherwise useful for study.
- (ii) **Deposits of sediments or** features useful for evaluating past events.
- (iii) **Paleontologic resources** with potential to contribute useful educational and scientific information.



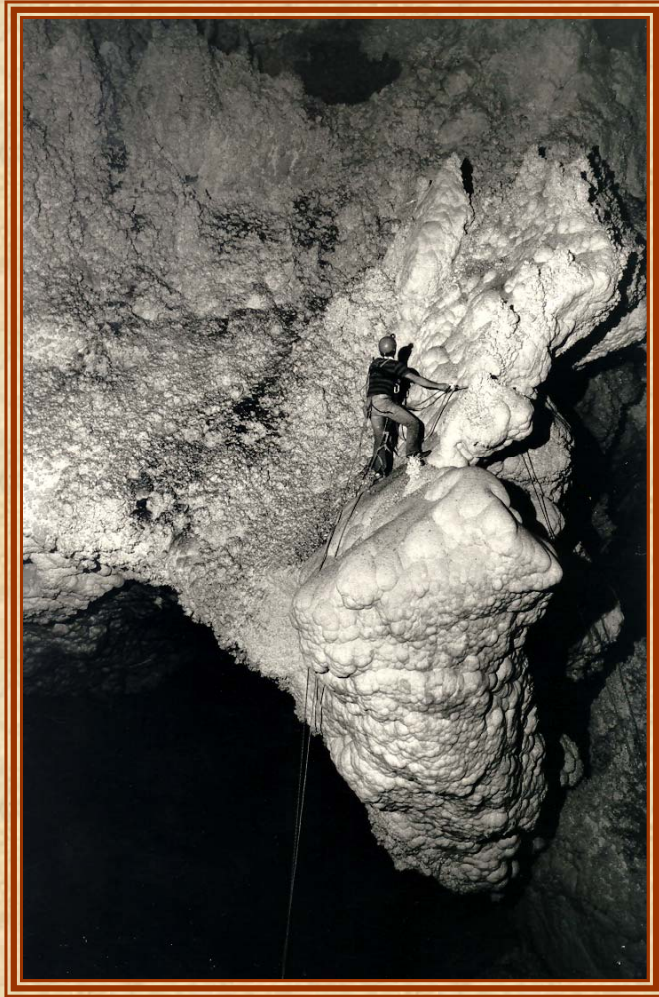
Significant Cave Criteria-

Hydrologic

- **Hydrologic.** The cave is a part of a hydrologic system or contains water that is important to humans, biota, or development of cave resources.



Significant Cave Criteria- Recreational



- **Recreational.** The cave provides or could provide recreational opportunities or scenic values.

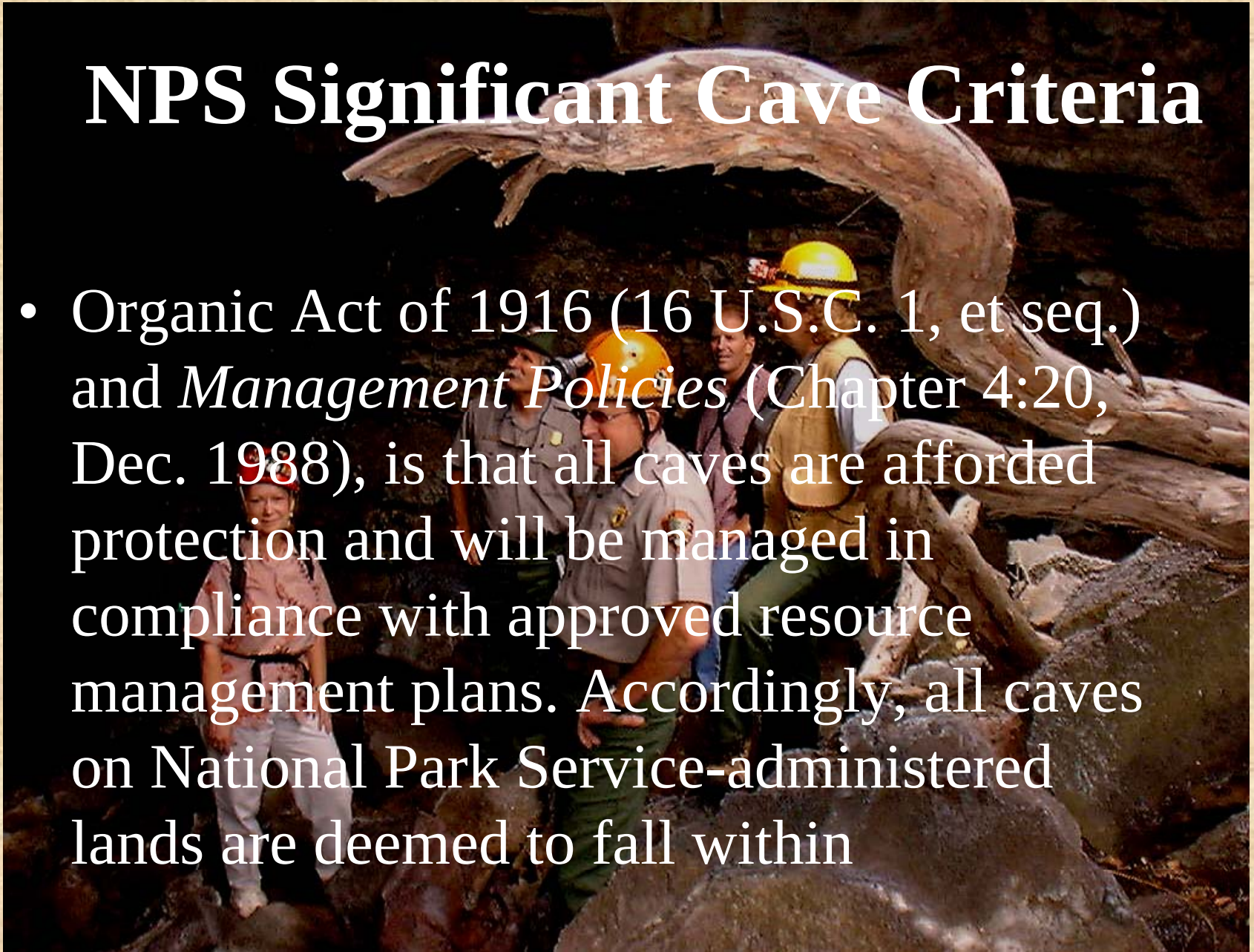
Significant Cave Criteria- Educational or Scientific

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



NPS Significant Cave Criteria

- Organic Act of 1916 (16 U.S.C. 1, et seq.) and *Management Policies* (Chapter 4:20, Dec. 1988), is that all caves are afforded protection and will be managed in compliance with approved resource management plans. Accordingly, all caves on National Park Service-administered lands are deemed to fall within



Cave Management Programs

A park's cave management program should include:

1. protection of natural processes in cave ecosystems and karst landscapes;
2. scientific studies and research in or about cave and karst resources and systems, to increase the park's scientific knowledge and broaden the understanding of its cave resources and karst processes;
3. detailed cartographic survey of caves and cave systems and a detailed inventory of resources within cave systems;
4. provision for educational and recreational opportunities for a broad spectrum of park visitors to safely visit, study, and enjoy caves at a variety of levels of interest and abilities;
5. establishment of regulations, guidelines, and/or permit stipulations that will ensure maximum conservation of cave resources and karst processes;

Cave Management Programs

A person wearing a blue full-body protective suit and a red helmet is walking away from the camera into a dark, narrow cave passage. The cave walls are dark and textured, and the floor is uneven. The person is carrying a flashlight, which is visible in their right hand.

5. establishment of regulations, guidelines, and/or permit stipulations that will ensure maximum conservation of cave resources and karst processes;
6. direction for cave restoration activities that remove unnatural materials or restore otherwise impacted areas;
7. establishment of standard operating procedures in the maintenance and upkeep of developed cave passages;
8. monitoring of natural environmental conditions and visitor use and impact;
9. protection of related cultural and biological resources; and methods for sustainable use of cave resources.

Resources - I

- **Biological resources include (but are not limited to)**
- **several species of endangered bats,**
- **ferns and lichens (in cave entrance ecotones),**
- **cave adapted fish, salamanders, and**
- **invertebrates (about which we know so little. We are currently unable to evaluate population stability, impacts from current and past human activities, nor the probabilities for species survival.)**



Resources - II

- Other resources range from ancient torch smudges on cave ceilings to civil war age saltpeter vats used to make gun powder.
- pack rat middens in Grand Canyon caves that yielded pollen as old as 4000 years.



Resources - III

- Cave-dwelling organisms have specialized adaptations such as extreme longevity and enhanced sensory perceptions.
- The adaptations reveal much about the evolutionary responses to past environmental changes and may provide valuable clues to current climate change



National Cave and Karst Research Institute

- **The National Cave and Karst Research Institute Act of 1998 (Public Law 105-325) mandated the National Park Service to establish the Institute. The Act stipulated that the Institute will be located in the vicinity of Carlsbad Caverns National Park in New Mexico (but not inside Park boundaries), and that the Institute cannot spend Federal funds without a match of non-Federal funds. The Institute is authorized to carry out its objectives internationally as well as nationally.**

National Cave and Karst Research Institute



- **Mission Statement**
- *"The National Cave and Karst Research Institute furthers the science of speleology by facilitating research, enhances public education, and promotes environmentally sound cave and karst management."*

National Cave and Karst Research Institute

Goals of the National Cave and Karst Research Institute:

- **Further the science of speleology through coordination and facilitation of research.**
- **Provide a point-of-contact for dealing with cave and karst issues by providing analysis and synthesis of speleological information and serving as a repository of information.**
- **Foster partnerships and cooperation in cave and karst research, education, and management programs.**

National Cave and Karst Research Institute

Goals of the National Cave and Karst Research Institute:

- **Promote and conduct cave and karst educational programs.**
- **Promote national and international cooperation in protecting the environment for the benefit of caves and karst landforms and systems.**
- **Develop and promote environmentally sound and sustainable cave and karst management practices, and provide information for applying these practices.**

National Cave and Karst Research Institute



- **Current Projects**

- Producing an improved national karst map and an associated web-based network of karst information in collaboration with USGS and University, State, and private groups.
- Sponsored publication of three cave related books with Denver Museum of Nature and Science “Vertebrate Paleontology of Pleistocene Cave Deposits in North America,” the National Speleological Society, “Cave Conservation and Restoration.” and a “Handbook for Cave and Karst Management for America’s Protected Lands” with the Karst Waters Institute.
- National inventory of microbial DNA in caves with Western Kentucky University Biotechnology Center.

Who is responsible for coordination of NPS cave resource management issues?

- **GRD**

- Staff: National Cave Management Coordinator**

- some project funding available**

- extensive network of contacts**

- **Service Contacts: 21 Cave Specialists Service Wide**

- **Network: Societies and academia**

Cave Statutes

General:

- **NPS Organic Act language**
- **Park enabling acts**

Specific:

- **Park enabling acts**
- **Federal Cave Resources Protection Act of 1988**
- **16 USC 4310 (1990)**
- **Lechuguilla Cave Protection Act of 1993**
- **National Cave & Karst Research Institute Act of 1998**

2001 NPS Management Policies

Chapter 4:

4.8.1.2 Karst (see page 42)

- maintain integrity**
- mitigate impacts**

4.8.2.2 Caves (see page 43)

- protect**
- remove inappropriate
development if impairing**

Chapter 6:

6.3.11.2 Caves (see page 69)

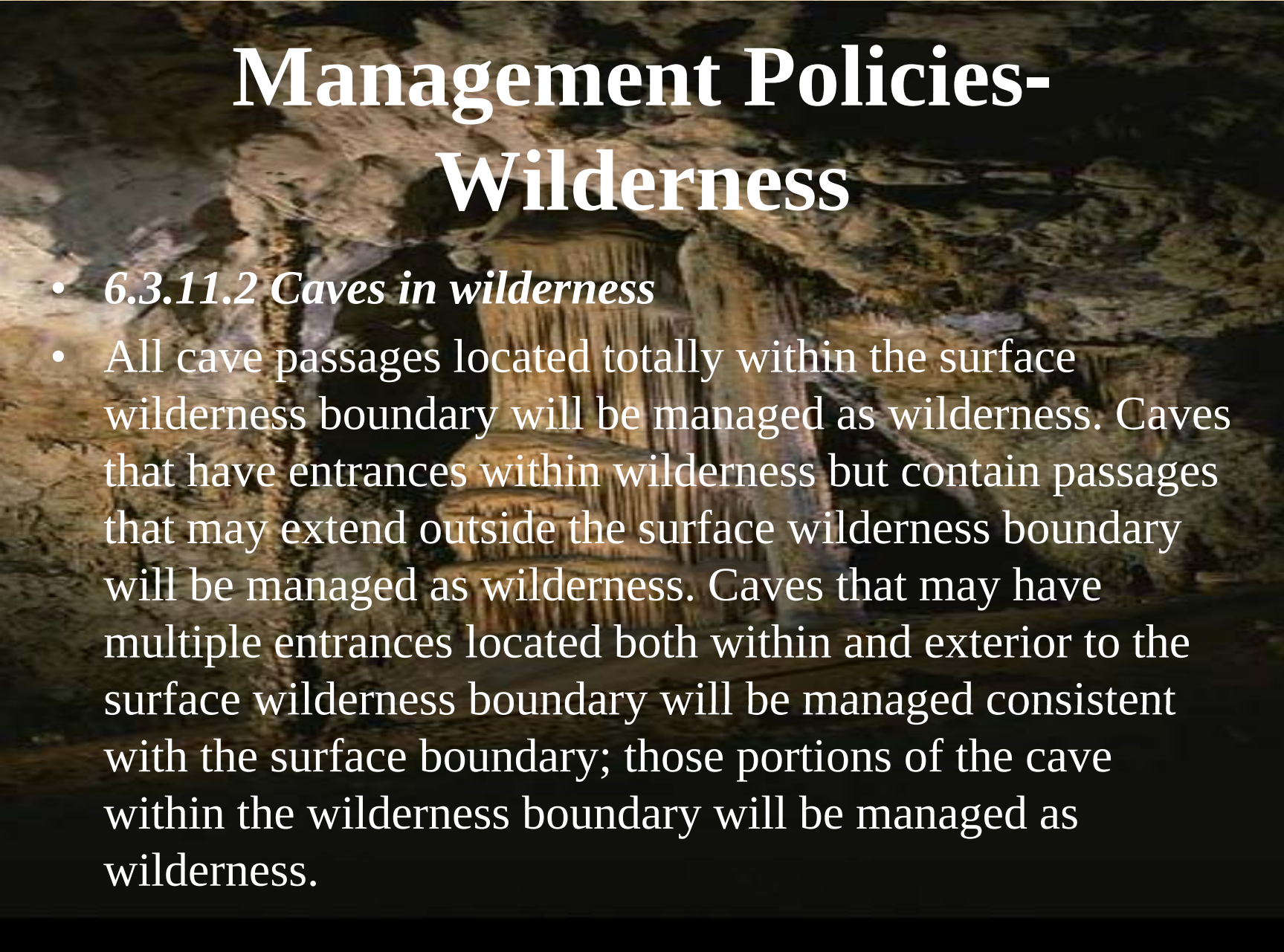
- manage as wilderness**

Management Policies-Karst

- *4.8.1.2 Karst*
- The Service will manage karst terrain to maintain the inherent integrity of its water quality, spring flow, drainage patterns, and caves. Karst processes (the processes by which water dissolves soluble rock such as limestone) create areas typified by sinkholes, underground streams, caves, and springs.
- Local and regional hydrological systems resulting from karst processes can be directly influenced by surface land use practices. If existing or proposed developments do or will significantly alter or adversely impact karst processes, these impacts will be mitigated. Where practicable, these developments will be placed where they will not have an effect on the karst system.

Management Policies-Caves

- **4.8.2.2 Caves**
- As used here, the term "caves" includes karst (such as limestone and gypsum caves) and non-karst caves (such as lava tubes, littoral caves, and talus caves). The Service will manage caves in accordance with approved cave management plans to perpetuate the natural systems associated with the caves, such as karst and other drainage patterns, air flows, mineral deposition, and plant and animal communities. Wilderness, and cultural resources and values will also be protected.

The background image shows a dark, cavernous space. In the center, a waterfall cascades down a rocky ledge. The walls and ceiling of the cave are rugged and textured, with some light reflecting off the wet surfaces. The overall atmosphere is mysterious and wild.

Management Policies- Wilderness

- *6.3.11.2 Caves in wilderness*
- All cave passages located totally within the surface wilderness boundary will be managed as wilderness. Caves that have entrances within wilderness but contain passages that may extend outside the surface wilderness boundary will be managed as wilderness. Caves that may have multiple entrances located both within and exterior to the surface wilderness boundary will be managed consistent with the surface boundary; those portions of the cave within the wilderness boundary will be managed as wilderness.



MANAGING THE CAVE ENVIRONMENT IN LIGHT OF NEW ECOLOGICAL UNDERSTANDINGS

By Dale Pate
Cave Resources Specialist
Carlsbad Caverns National Park

LECHUGUILLA CAVE

- Brief History
 - Discovery
 - Early Management
- Environment Types
- Human Impacts
- Microbial Studies
- Management Actions



Lechuguilla Cave

- Before May 1986
- Breakthrough
- 1986 to 1992
- After 1993

Length – 105 miles

Temp. - @ 68 degrees F.

Humidity – 100%

Total Darkness



VARIED & UNIQUE TYPES OF ENVIROMENTS

SUB-AQUEOUS
HELICITITES





LAKES & POOLS



CALCITE ENCRUSTED ORGANIC
MATERIALS



MASSIVE SULFUR & GYPSUM DEPOSITS

GYPSUM CHANDELIERS



HUMAN IMPACTS



FOOTPRINTS



DIVING IN
LAKE OF THE
BLUE GIANTS
& OTHER
DEEP POOLS



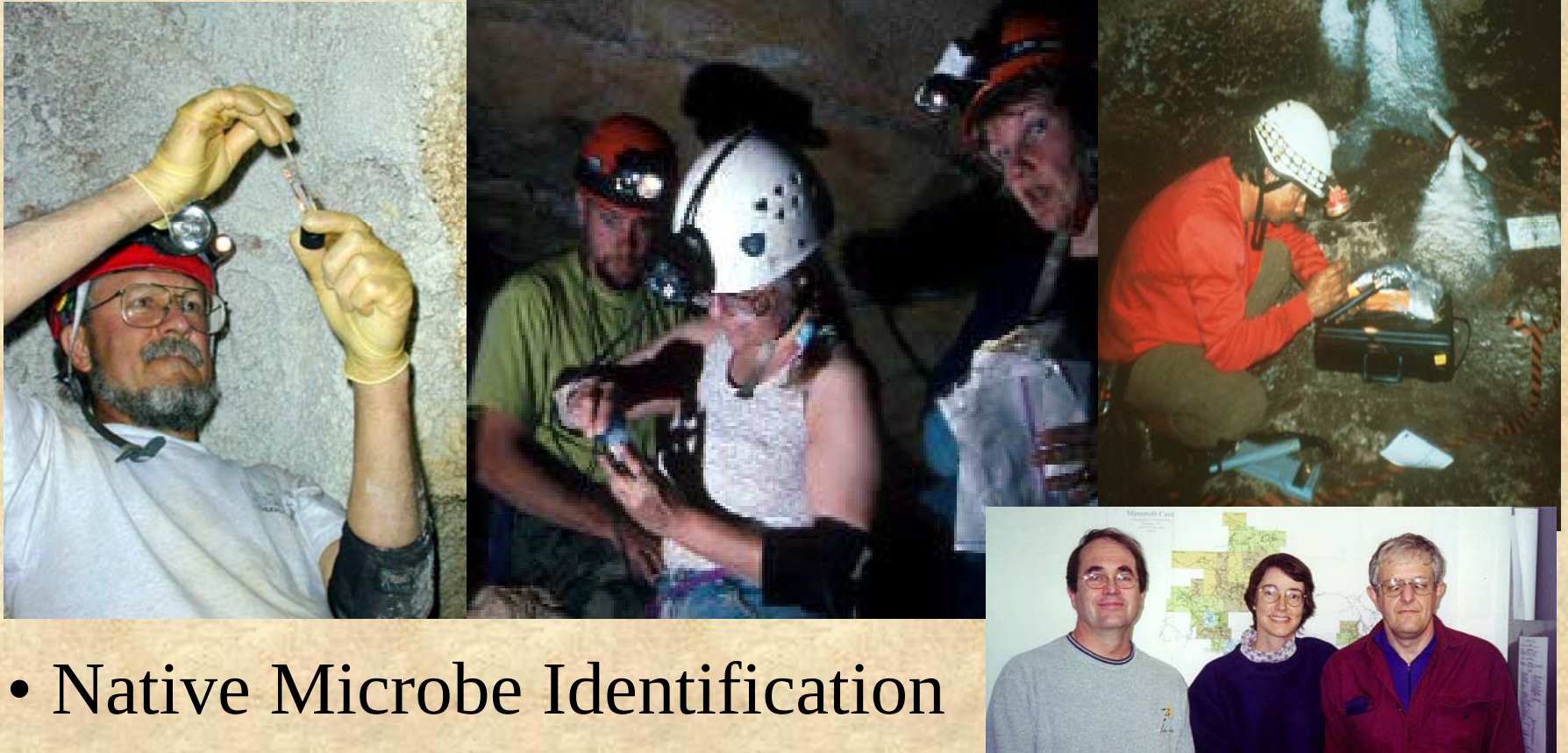


CAMPING IN THE CAVE

GEAR & EQUIPMENT STASHES



MICROBIAL STUDIES



- Native Microbe Identification
- Medicinal Values
- Human Impacts
- NASA - Life on Mars

MANAGEMENT ACTIONS

- Strict Access Policies
- Written Guidelines
- Practice Minimal Impact Techniques
 - Delineate Permanent Trails
 - Keep Away From Pools
- Monitor Compliance to Guidelines
- Human Impact Study
- Promote Additional Research

Develop Guidelines

APPENDIX F: GUIDELINES FOR ENTERING LECHUGUILLA CAVE

* The reason behind developing guidelines for entering Lechuguilla Cave is to allow limited access for scientific research, survey when in association with exploration, and NPS management related trips while impacting the cave as little as possible. Of primary importance are the (1) impacts to the cave and (2) the safety of all who enter.

BEFORE ENTERING CAVE

- * Everyone **must** sign a permit.
- * Expedition leaders are ultimately responsible for the personnel on their expedition. Expedition leaders should do their best to recruit cavers that are willing to follow the guidelines that have been established. Before assigning anyone to the Far East, a Expedition leader should be reasonably sure that individual is fully prepared for such a trip.
- * Every team entering the cave will have one designated team leader. Team leaders have tremendous responsibilities. They are responsible for the safety of their team and for the actions of their team members. If a team member is acting in an unsafe manner or not being careful and actually causing more damage to the cave, then it is the team leader's responsibility to correct that persons actions. If problems persist, then the team leader must abort the trip and have the team leave the cave. A team leader should gear team activities to the least experienced member of the team. This pertains to speed of travel as well as climbing leads. A team should also stay together unless an emergency requires different actions.
- * Everyone entering the cave is responsible for their actions while in the cave. They are also responsible for reporting to the team leader acts by other team members that are unsafe or damaging to the cave. The overall goal is to allow limited access to the cave while minimizing all impacts. It is everyone's responsibility to assure that Lechuguilla Cave remains as pristine as possible and that each team member is very safety aware while in the cave.
- * Clothing, boots, and caving gear should be clean before entering the cave to minimize the introduction of foreign bacteria, molds, and fungus into this unique ecosystem.
- * **BOOTS MUST HAVE NON-MARKING SOLES.** If you are in doubt, scrape boot over white floor or limestone rocks. Marking boots will definitely leave marks.
- * Using a frame pack in the cave can be a problem and a major nuisance. It is recommended that these **NOT** be used.
- * Electric lights are a must. No carbide lights or open-flame lights will be allowed in Lechuguilla. One of the reasons for this is safety, because of the flammability of the massive sulfur deposits found in the cave.





Establish & Maintain
Permanent Flagged Trail

Stay Away From Pools



Conduct Human Impact Study



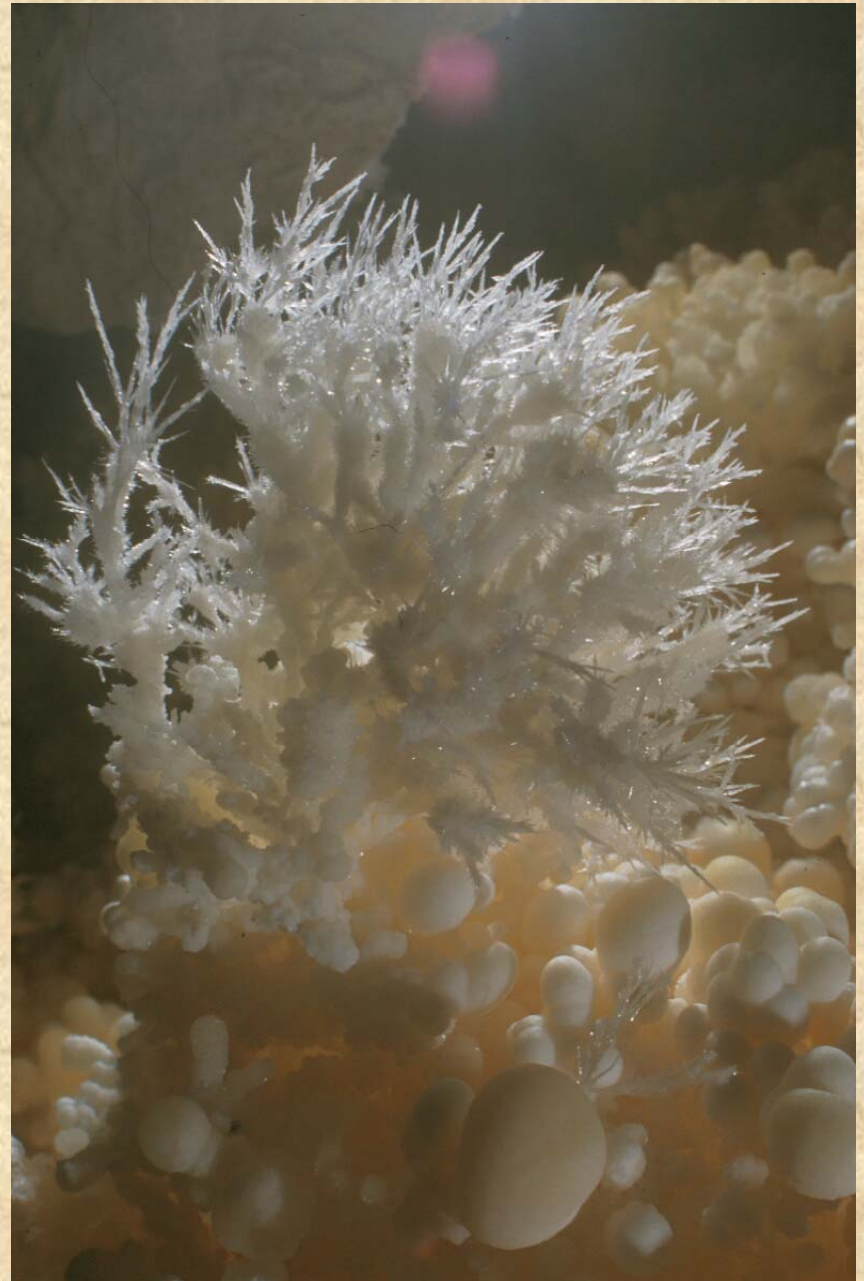






Thanks to everyone involved with the scientific study of Lechuguilla Cave.

Thanks to the following for the use of their photos:
Gosia Allison-Kosior, Stan Allison, Peter & Ann Bosted, John Brooks, Dave Bunnell, Dave Harris, Louise Hose, Jason Richards, Norm Thompson, Val Werker.

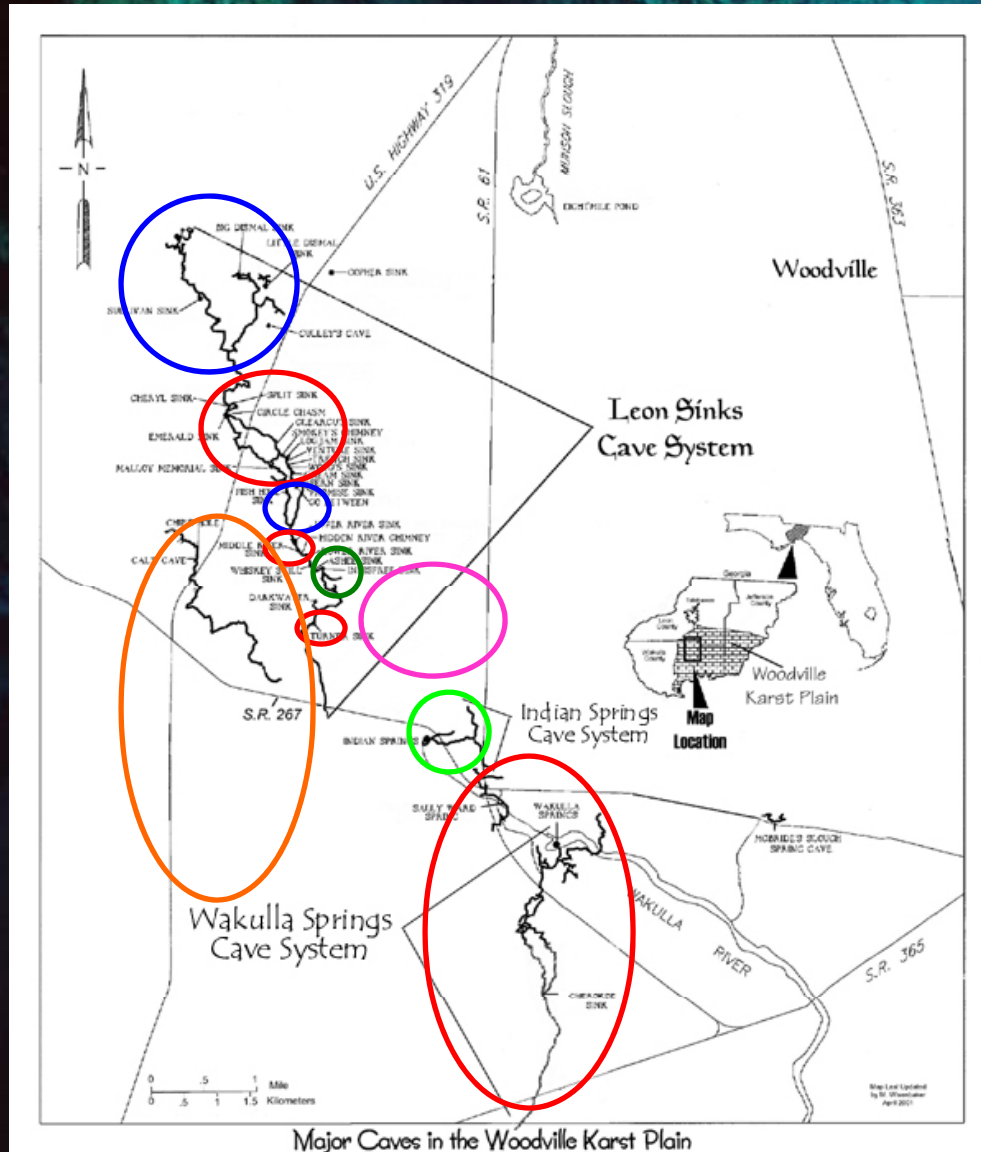


Woodville Karst Plain Project

An underwater photograph showing three divers in a cave system. The divers are equipped with scuba gear, including tanks and lights. They are positioned in a line, moving through a narrow passage. The cave walls are rocky and covered in some greenish growth. The water is dark, and the scene is illuminated by the divers' lights, creating a blue-green hue.

Hydrogeology Consortium Workshop
April 16-17, 2003

Woodville Karst Plain Project - WKPP



- Founded 1991
- 100+ members
- Goal - connect the cave systems of the Woodville Karst Plain
- Facilitate Research
- Protect & Preserve the Resource



Hydrogeology Consortium Workshop

- **Partners**

- State of Florida
- Department of Interior
- Department of Agriculture (USFS)
- YMCA
- St. Joe Paper
- Private Landowners



Hydrogeology Consortium Workshop

- **Politics**

- Roles & Responsibilities
- Risk Management
- Minimal Impact
- Responsive & Professional
- Interface



Hydrogeology Consortium Workshop

- **Roles & Responsibilities**
 - WKPP - Exploration
 - Researchers - Research
 - Resource Managers - Resource



Hydrogeology Consortium Workshop

- **Risk Management**
 - Qualified
 - Highest Training Standards
 - Proven Track Record
 - Safety Procedures



Hydrogeology Consortium Workshop

- **Minimal Impact**
 - Organized & Focused
 - Efficient & Effective
 - Results Oriented
 - Safety



Hydrogeology Consortium Workshop

- **Responsive & Professional**
 - Flexible
 - Multi-Task
 - Involved
 - Earth Day
 - Working Groups
 - Workshops
 - Unit Management Planning



Hydrogeology Consortium Workshop

- **Interface**
 - Researchers
 - Media
 - Film
 - Print
 - Public



Hydrogeology Consortium Workshop

- **Public Relations**
 - Promote the Resource
 - Positive Publicity
 - Promote Public Awareness
 - Print
 - Documentaries
 - Educational Media



Hydrogeology Consortium Workshop

- **Funding**
 - Cave Specific Projects
 - Land Acquisition
 - Budget Commitment



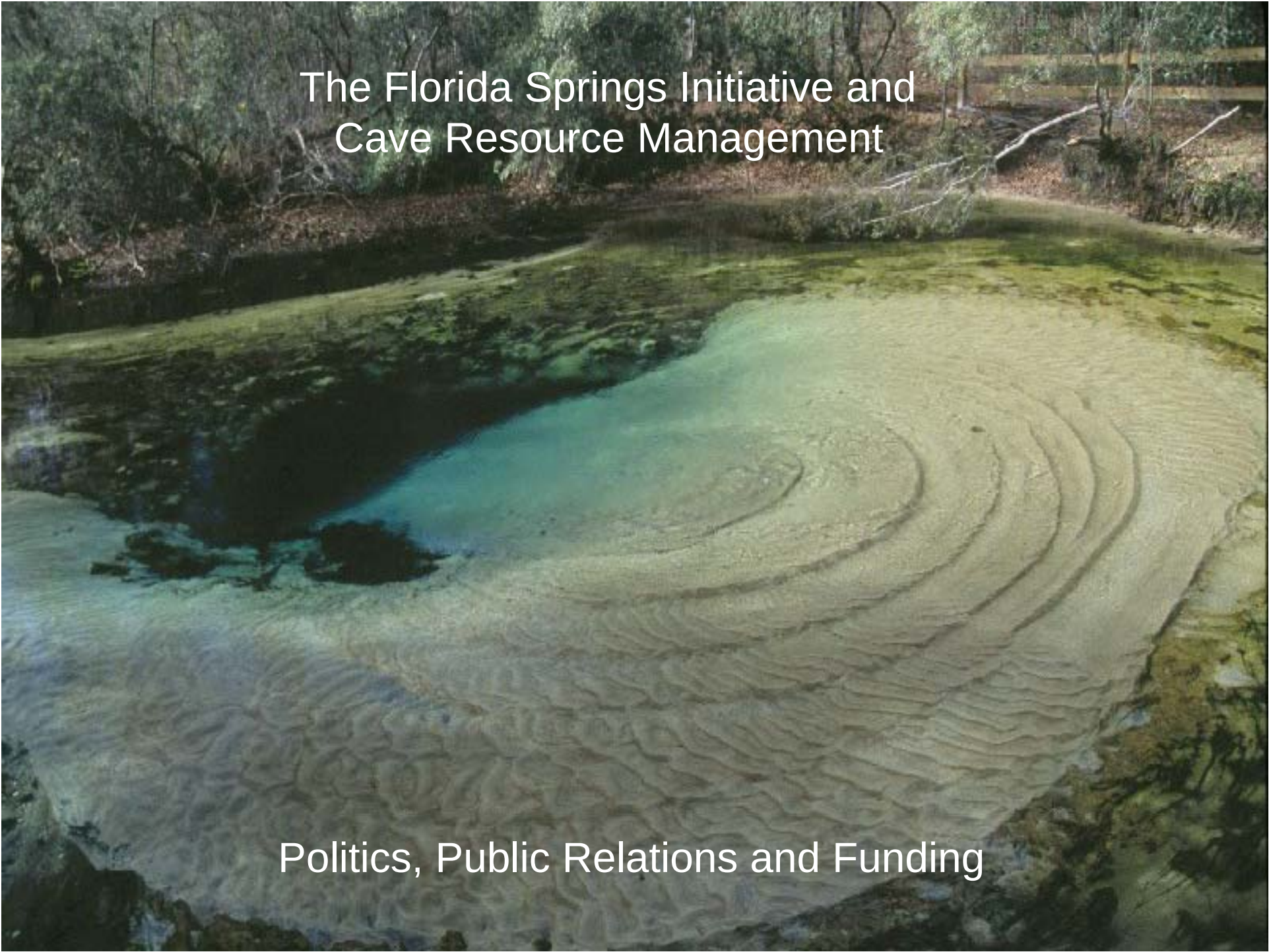
Hydrogeology Consortium Workshop

- **Long-Term Commitment**
 - Big Picture
 - Shared & Vested Interests
 - Protect the Resource



Questions



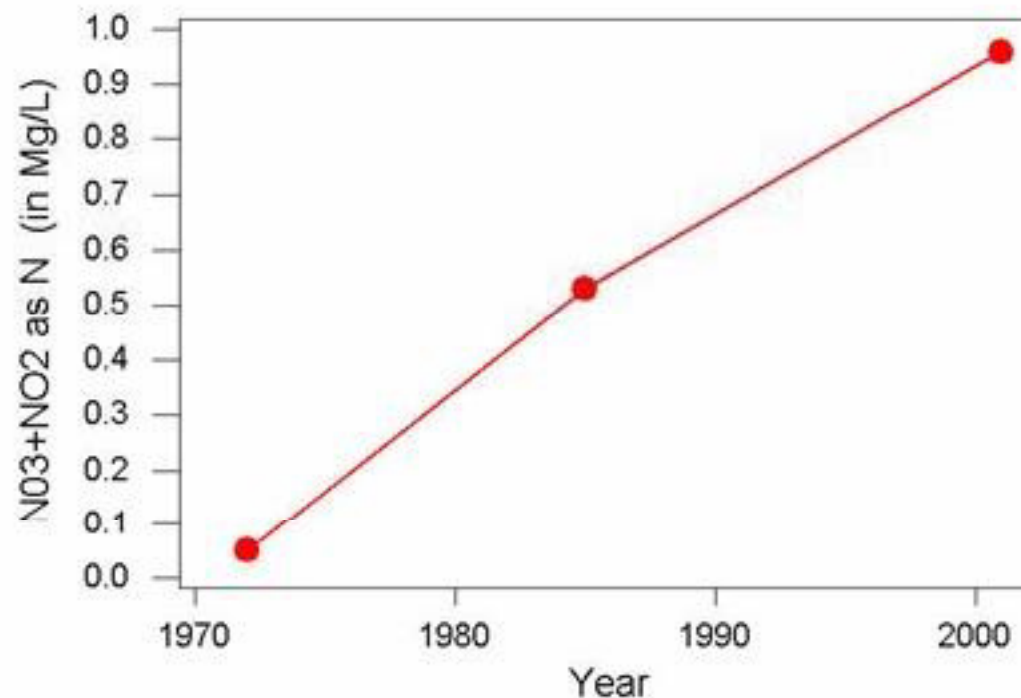
A photograph of a natural spring, likely in Florida. The water is clear and light blue, surrounded by a series of concentric, raised sand terraces that create a circular pattern. The background shows a dense forest with green trees and a wooden fence. The text "The Florida Springs Initiative and Cave Resource Management" is overlaid in white at the top.

The Florida Springs Initiative and Cave Resource Management

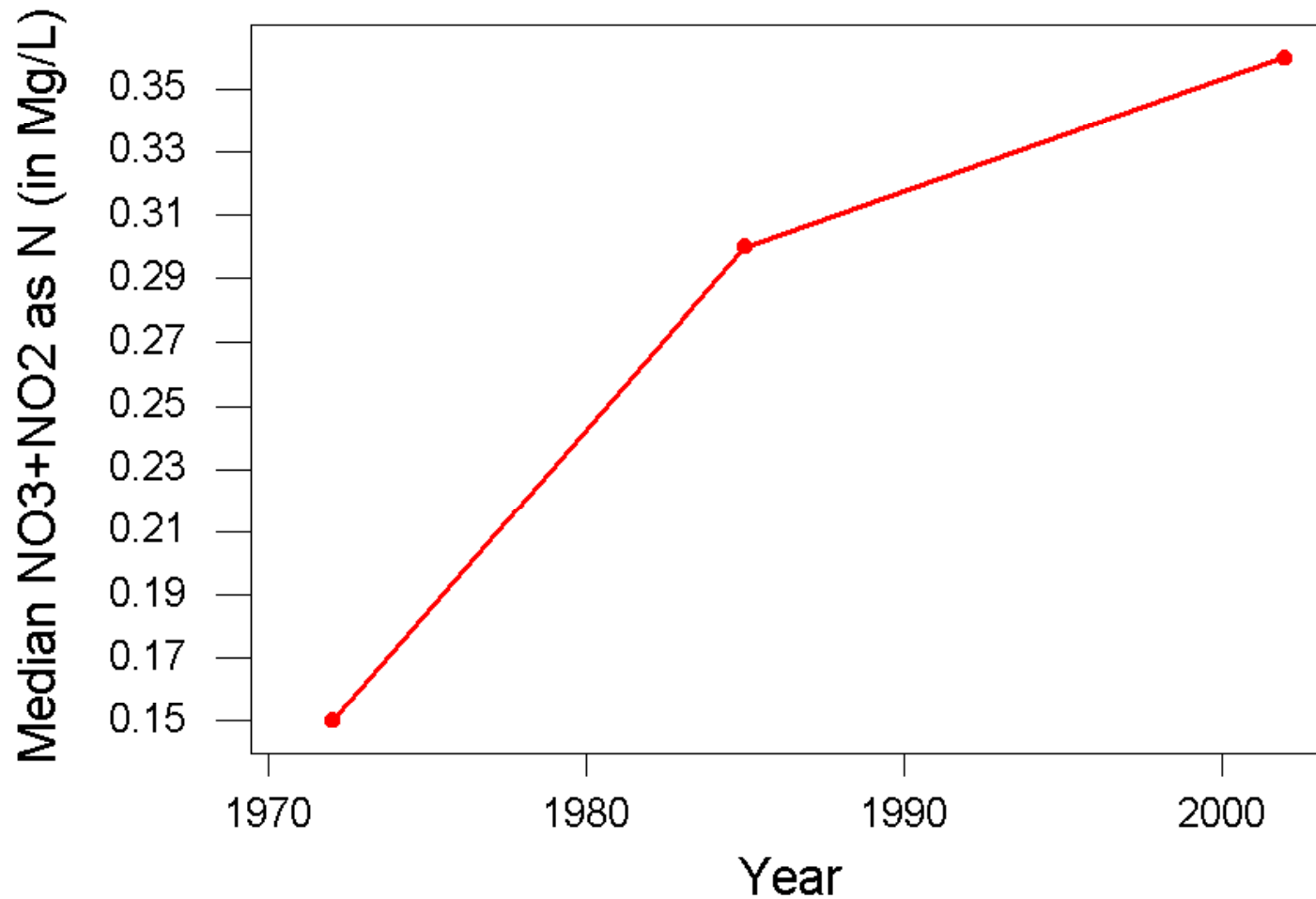
Politics, Public Relations and Funding

Trend? (only three events)

Median Nitrate Concentrations in 13
Selected First-Magnitude Springs in Florida



Median Nitrate Concentrations in Seven Selected Second-Magnitude Springs in Florida





- Increasing nutrients in spring water causing changes in spring and spring run ecology.
- Increasing algae growth.
- Increases in invasive plants like *Hydrilla*.
- Declining native populations of organisms – limpkins, apple snails and other aquatic species.

The Florida Springs Initiative

- Political climate is right for spring protection.
- Secretary David Struhs directed the formation of the Florida Springs Task Force based on noticeable declines in spring water quality and quantity.
- 1999 – 2000 the Task Force met and produced the Florida's Springs Strategies for Protection and Restoration.
- Supported by the Governor.
- Funding provided by the Florida Legislature at 2.5 million per year through the Florida Department of Environmental Protection.



Cave Management is Part of the Florida Springs Initiative



- Springs emerge from cave systems
- Management of the System is needed for Health of the Spring
- Primary Concern is the Water Quality/Quantity
- Conduit System (Where they are Located)
- Springshed

What is the Initiative Doing???

- The Initiative is Administered by DEP through Several Divisions
- Research and Monitoring Portion
- Landowner Assistance
- Public Education and Outreach
- Restoration
- Modeled after the Florida Springs Task Force Report



Research and Monitoring

- Limpkin Survey
- Spring Fauna Inventory
- Biological Monitoring
- Apple Snail Survey
- Water Quality Monitoring (quarterly at 1st magnitude springs)
- Discharge
- Water Age Dating
- Economic Survey
- Carrying Capacity of Silver Glen Springs.
- Fanning Spring Nitrate Study.
- Springshed Delineation.
- Spring Ownership Map.
- Spring Vulnerability Mapping.
- Spring Inventory.
- Effects of Nitrate on Fauna.

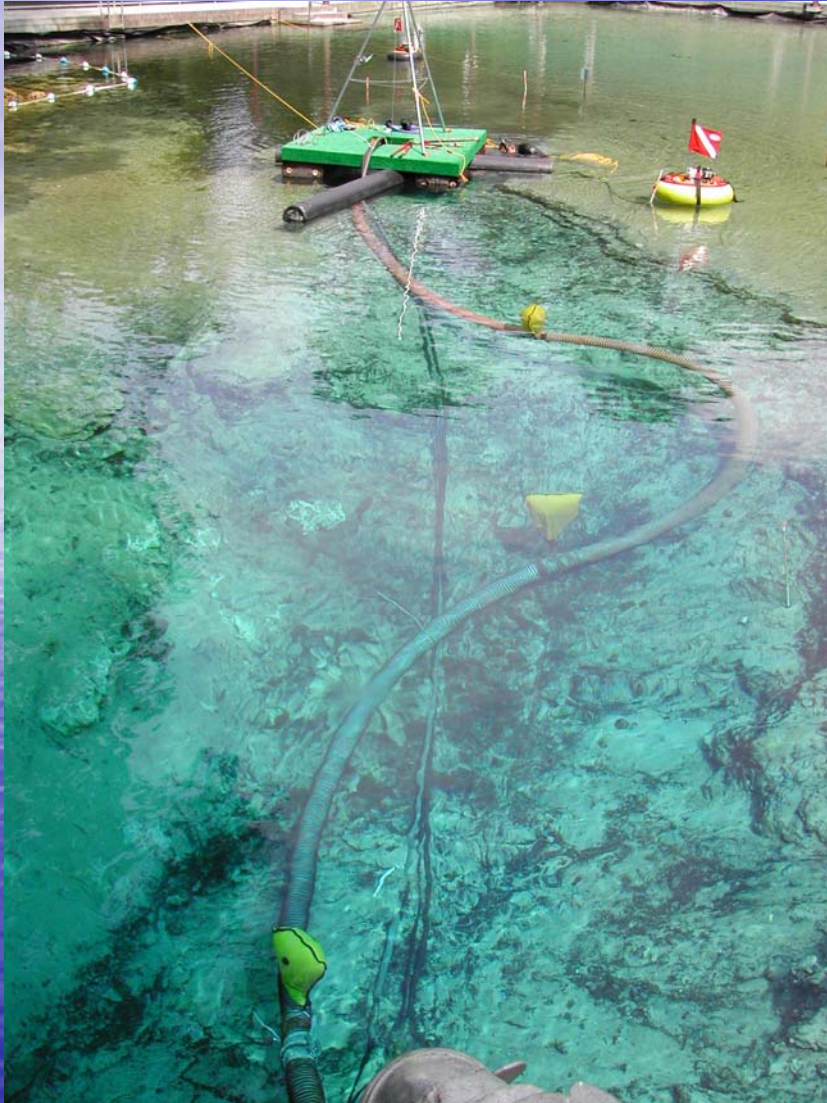
Education and Public Outreach

- Bulletin 31 Revision
- Water's Journey Video
- County Commission Video
- Springs Initiative Video
- Spring Website:
www.floridasprings.org
- Homeowner Lawn Care Booklet
- Lawn Care Provider Brochure
- Spring Working Groups
- Spring Basin Signs
- Spring Conference
- Spring Basin Brochures
- Local Government Workshops
- BMP Manuals
- Spring Posters
- Underwater Photographs
- Spring Recharge Area Planning Reports
- State Fair Exhibits

Landowner Assistance

- Lafayette Blue Restroom Drain field Relocation
- Nutrient Reduction in the SRWMD.
- Ichetucknee recharge Area Protection
- Jackson Blue Recharge Area Mobile Irrigation Lab
- Rainbow Spring – Golf Course BMP's
- Sinkhole and Karst Feature Mapping in Wakulla Spring Recharge Area.
- Sinkhole Clean-up Program





Restoration

- Troy Spring Erosion Control
- Fanning Spring Restoration
- Ichetucknee Headspring Restoration

Land Acquisition

- The Florida Springs Initiative Does NOT Fund Land Purchases
- Land Purchasing is Done Through Florida Forever (DEP Division of State Lands)
- Initiative DOES Submit Boundary Amendments for the Purchase of Land in Springsheds.
- Ichetucknee Trace: Two Limestone Mines, Rose Sink, and Ichetucknee Sink.
- Wakulla Springs Protection Zone: 3800 Acres from St. Joe, 3300 Acres from Nemours Foundation, and 26 Acres at Kirtons Corner.

Using the Springs Initiative as a Model for Cave Resource Management – Our Tasks:

- Define and illustrate the socio-economic benefits of caves to Florida – focus on real world examples.
- What are the politics surrounding cave management – how do we overcome political obstacles and identify funding sources?
- What is the role of State and local government?
- How to improve land-owner relations?
- What is the relationship between water resources and ecological management?
- Define an ideal cave study to implement new ideas in this field.

Socio-economic Benefits



- Tourism Dollars
- Drinking Water Quality
- Wildlife – Unique Ecosystems with Endangered Species



Politics of Protection and Funding Sources

- How do We Influence the Political Policy Makers?
- Political Obstacles???
- Where Can the Money Come From?



Role of State and Local Government?

- Land Acquisition and Management
- Funding Sources
- Regulators



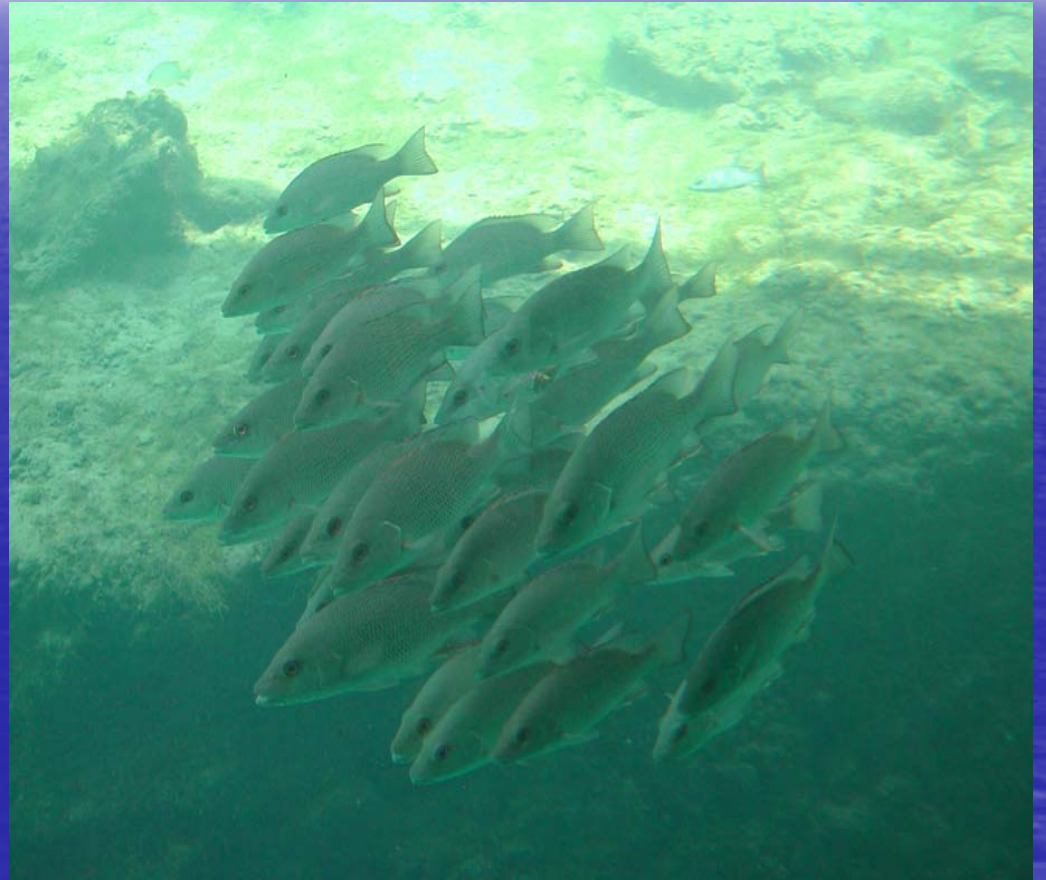
Improving Land Owner Relations

- More Education
- Including the Public in the Decision Making Process
- Monetary Assistance
- Communication



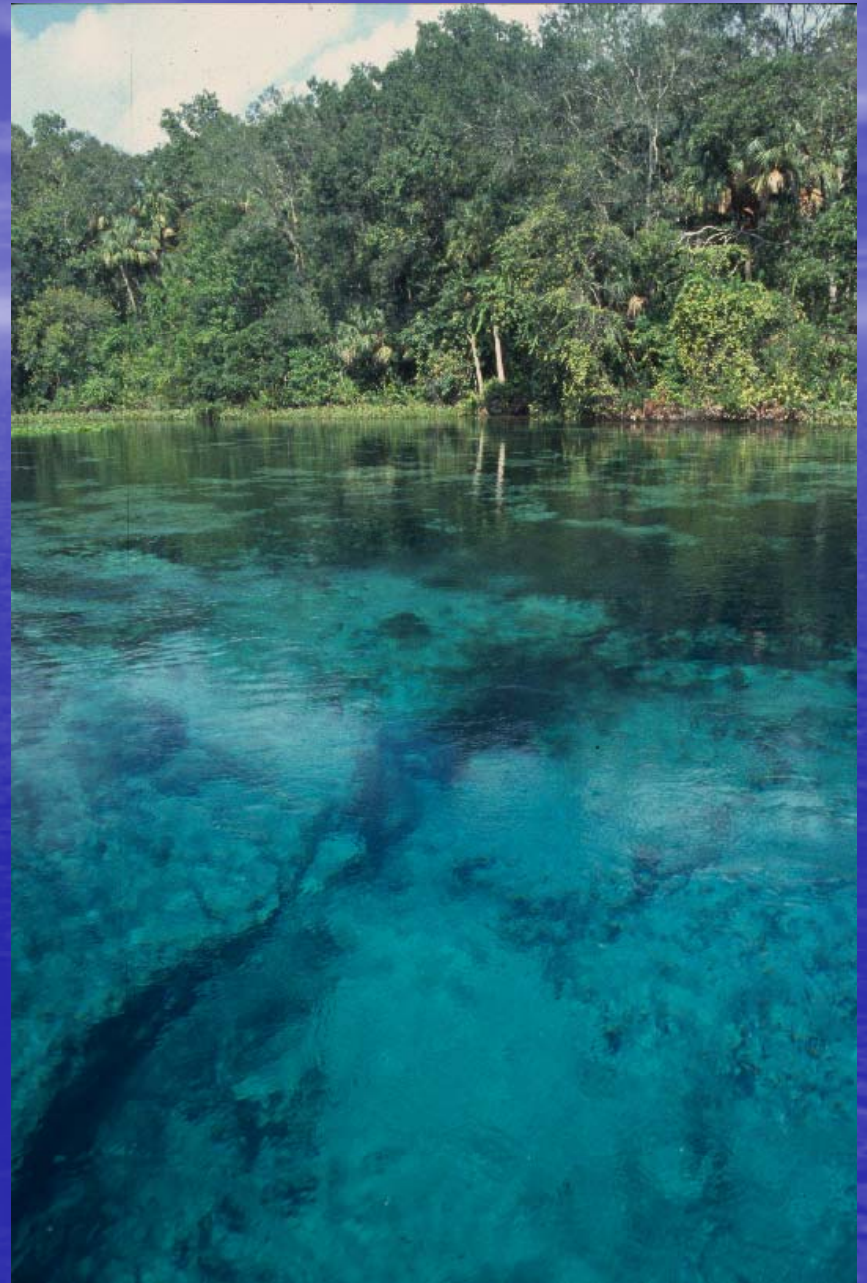
Water Resources and Ecological Management

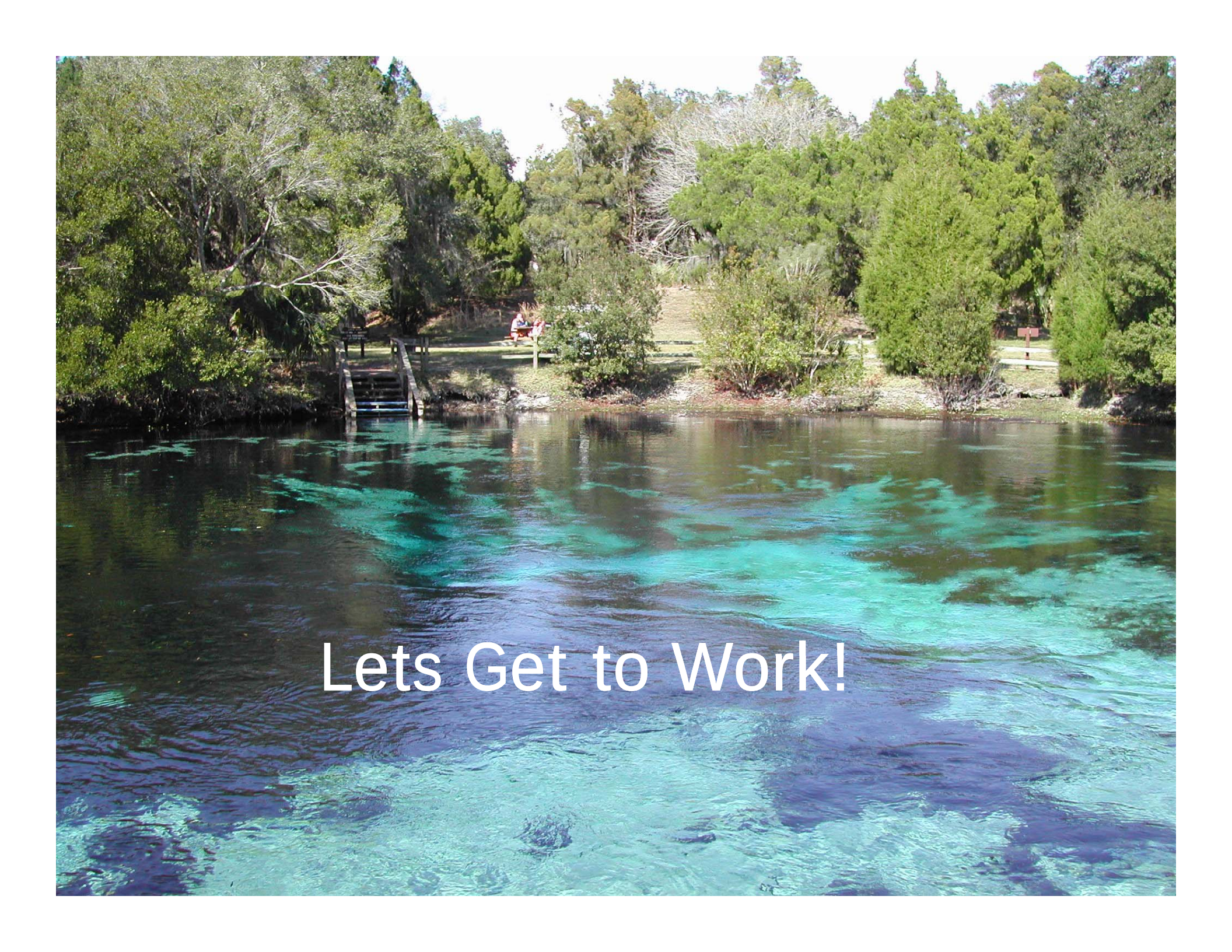
- The Ecology Declines when the Water Resource is Degraded
- Need to Consider the Entire Ecosystem – Cave Systems are Complicated
- Need Further Study



Ideal Cave Study

- Must be Multi-disciplinary in its Approach
- Geology, Biology, Chemistry, Ecology, Economic, Political, etc.
- Must be Implementable
- Cost??





Lets Get to Work!

Caves are a critical component of
the spring/watershed

Why?

- Contain/support sensitive biota
- Contain/support archeological and cultural artifacts
- Can act as priceless laboratories for medical, biological, geological, and hydrogeological and scientific studies
- Are valuable tools for understanding groundwater flow and contamination transport in karst systems
- The above items significantly impact local and state wide economy

Potential Threats

- Resource extraction – including, but not limited to mining, blasting, and drilling
- Subsidence
- Development, infrastructure construction
- Leaching from leach fields including but not limited to septic tanks, fertilizer, and pesticides
- Direct and indirect runoff
- Toxic waste
- Landfills

Potential Threats (con't)

- Overgrazing (erosion)
- Borrow pits, percolation ponds, storm water retention ponds, drainage wells, flood control ponds
- Inadequately educated cavers
- Anthropogenic alteration
- Ambiguity of ownership
- Depletion of groundwater (due to over-withdrawal)
- Inadequate enforcement of existing laws

What should be done?

- Establish management policies for surface and subsurface environments
- Recognize caves are karstic systems that need special consideration and management practices
- Identify involved agencies including federal, and state agencies, professional organizations, and citizen groups

Create an inventory of known caves that provides the following

- Location
- Geographical makeup
- Morphology
- Supported biota
- Ownership
- Access
- Vulnerability to contaminants
- Vulnerability to structural changes
- Zone of contribution
- Air and Water quality
- Paleo/archeological/cultural value
 - Information about discharge

- Seek to develop consistent approach when feasible when managing caves
- Conduct research and monitoring efforts to better understand these systems and their role in maintaining the integrity of the watershed
- Encourage volunteerism
- Promote awareness through education and public outreach
- Develop system of classification of caves on basis of vulnerability to degradation and/or damage

- Review another classification system in this or other countries in order to select system that with some modification could serve as Florida's classification system
- While certification systems are adequate in regard to safety, need improvement for environmental education
- Educate decision makers at local and state level on significance of caves
- Exempt certain locations and ownership data from Freedom of Information Act

- Incorporate land development regulation designed to protect caves and springs into local government comprehensive plans
- Amend cave protection statute to better prevent cave destruction by private landowners

Bridging the Gap Scientists/Cavers

- Buried Issues
 - How are views of the world of cavers and scientists different; the same?
 - Open communication between the two groups
 - Develop training sessions
 - Scientists to cavers; Cavers to scientists

Evolution

General to Specific

- 1970s
 - WMD hydrogeologists interested in general concepts; just learning
- 2000s
 - Can put “arms around springshed”
 - Can put “fingers around mapped caves”
 - No further discussion

Data Form and Training

- Develop more complete data form to be used by divers
- Scientists/cavers develop form
- Divers collect data, fill out form, supply scientists with data
- FGS agreed to take lead

QA/QC Issues

- Associated with form and data collection

Land Owner Confidentiality

- Property rights and protection

Need for Additional Glossary

- Is it needed?
- If so, what terms need to be included?

Role in Watershed Management

- How do we incorporate cave data?

Ideal state study site “block of Rock”

- If needed, what would it look like and where would it be located

Issues not yet discussed

- Continued development of database
- Future technology
- Potential to fund divers to collect data
 - Associated liability

Buried Issues (Better Interaction)

– Educational Outreach

- Scientists/cavers Cavers/Scientists
- Organize meetings between groups
- FGS to take lead

Develop “speakers bureau”

- Scientists to attend Caver meetings
- Scientists need to become more “entertaining”
- FGS will try to coordinate

Buried Issues

- Develop message board
 - FGS to try to take lead (a workload?)

Data Form

(To be filled out by willing cavers)

- General
 - Time, date, weather
- Physical (possible items; not all items)
 - Conduits/caves – size and shape
 - Features/morphology
 - Depth (ave, max)
 - Dist. of cave conduits
 - Mapping coordinates

Data Form

- Sediments (sand, clay, mud)
- Photographs
- Geological formations (to some extent)
- Fossils & Artifacts occurrence
- Modern artifacts
- Mineralization
- Colors/staining
- Breakdown
- Cohesiveness of cave material
- Domes and chimneys, vents and rooms
- Trib. Arrangement

Data Form

- Flow
 - Stage (relative); in/out
 - Velocity (dist/time)
- Quality
 - Clarity/turbidity
 - Water color (blue, black, green, milky, “mung”)
 - Stratification
 - Location of temp, color, WQ, Halocline change

Data Form

- Metered analytes (need meter)
 - pH, T, cond, DO, density (?)
- Water sample (need training)
- Biological
 - DEP “form”
 - Vegetation at entrance

Form

- Miscel
 - Sample – who for and what project
 - Location of sample collection
- Training
 - Scientists will need to train cavers
 - Cavers/Scientists go to each others meetings
 - Caver meeting May 2004

QA/QC

- Adherence to QA/QC or sampling plans
- Training by scientists needed
- Keep divers “chain of command” to a minimum

Glossary

- Use current glossary (scientists to cavers)
- Develop a second glossary (cavers to scientists)
- As form develops into electronic format, a translator will be developed (S - C; C - S)

Ideal Site

- Goals and properties of site
 - Test diving and science tech.
 - Adequate previous knowledge of system
 - Access to site somewhat controlled
 - Located near to cavers/researchers
 - Begin in one area and later move to others
 - Woodville Karst Plain (FGS define area)

Other Sites

- | | |
|----------------|-------------|
| • Man/Fan | Eagles Nest |
| • Troy | Weeki |
| • Itch | Sulphur |
| • Madison Blue | Wekiwa |
| • Peacock | Rainbow |
| • Beacon Woods | Silver |

Role in Watershed Man.

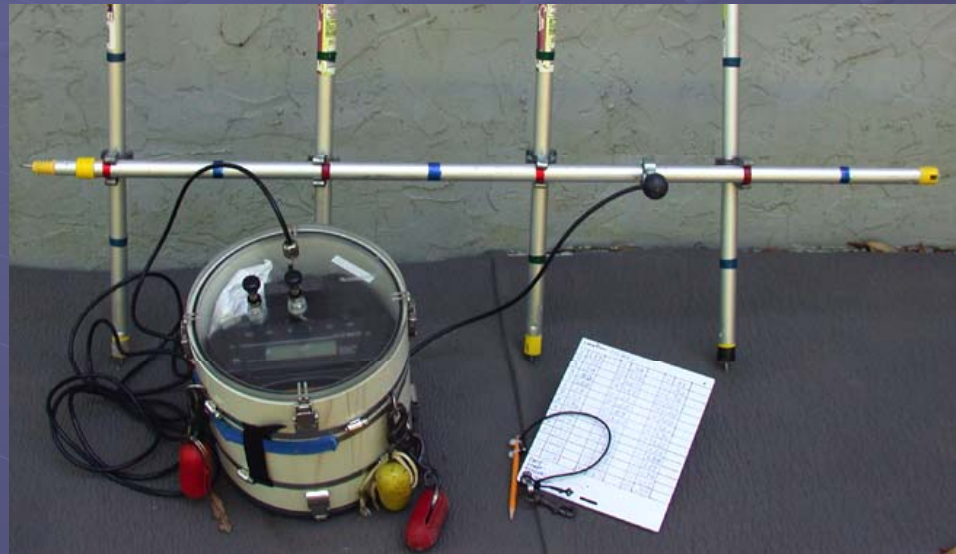
- Information from cavers is critical
- Incorp. Locations of caves into WM Plans
- Incorporate Caver Maps into “Science”
 - Will need QA

Confidentiality

- Need letters of support for a legislative bill to protect land owner confidentiality
- Panel developed draft letter of support
- Other possible supporters
 - Hydroconsortium,
 - FAPG
 - NSS-CDS
 - Fla Museum of Nat. Hist.?

Future Technology

MAKING DISCHARGE MEASUREMENTS WITHIN SUBMERGED CONDUITS



PRESENTED BY:

PETE BUTT

KARST ENVIRONMENTAL SERVICES, INC.

METHOD GOAL

Produce the most accurate discharge estimate possible by measuring a series point velocities within a selected submerged passage cross-section.



APPLICATIONS

- **Measure discharge of a spring vent lying beneath a surface water body.**
- Determine proportion of flow contribution of multiple/tributary conduits within a cave system.
- Measure discharge/velocities at a discreet passage locations in support of other studies (dye trace, biological studies, etc.)

METHOD SYNOPSIS

- 1) Select suitable passage cross-section.
- 2) Fit support poles into cross-section.
- 3) Record relative positions of poles, walls and measurement stations.
- 4) Make and record as many point velocity measurements as practical (near-wall points are critical).
- 5) Plot support pole, wall and station data (X & Y points).
- 6) Use contouring program to process spatial and velocity data (X, Y & Z points).

CHALLENGES

ENVIRONMENTAL

- Depth
- Visibility
- Sediments
- Bottom Time
- Flow
- Passage Configuration/Shape

PERSONAL

- Patience
- Temp. Tolerance

TECHNICAL

- Instrumentation
- Instrument Support Design and Set-up
- U/W Communication
- Experience/Training
- Number of Stations
- Level of Detail: Stations and Walls
- Data Processing

Standard Flowmeter Configuration



Equipment Development



FLOWMETER

- Marsh-McBirney Model 2000 Flowmeter
- Underwater Housing w/ controls
- Weights
- Data Slate

SETTINGS

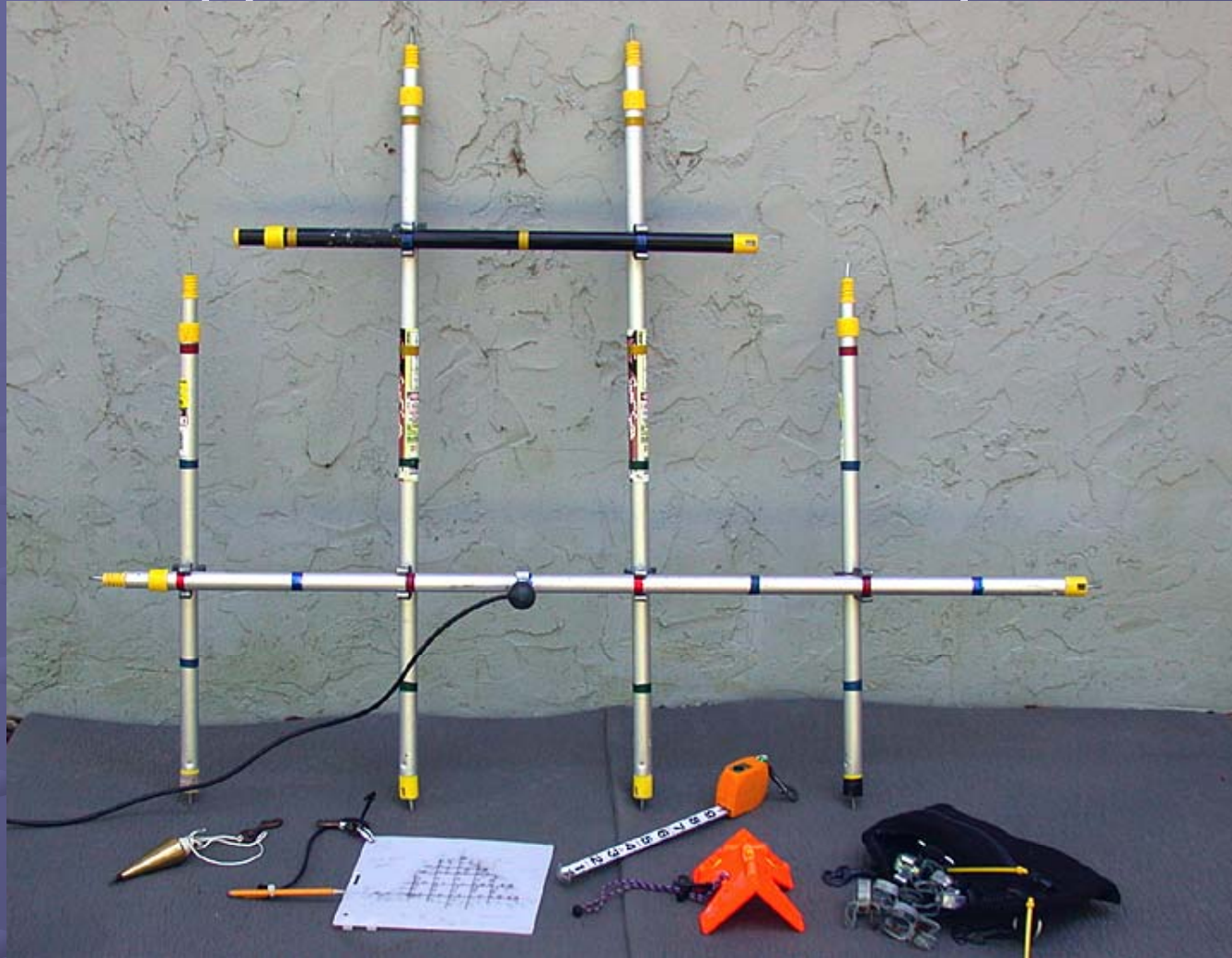
- Fixed Point Averaging used.
- 60 second periods used.



Underwater Flowmeter Controls Detail



Support Poles and Set-up Gear



Telescoping Poles w/marks

Post level, plumb bob

Spring clips

Pocket Rod Tape

Set-up/drafting slate

Probe Clamp and Pole



Grid Setup:

1) Install and Level Horizontal Poles



Grid Setup:

2) Install and Square-up Vertical Poles

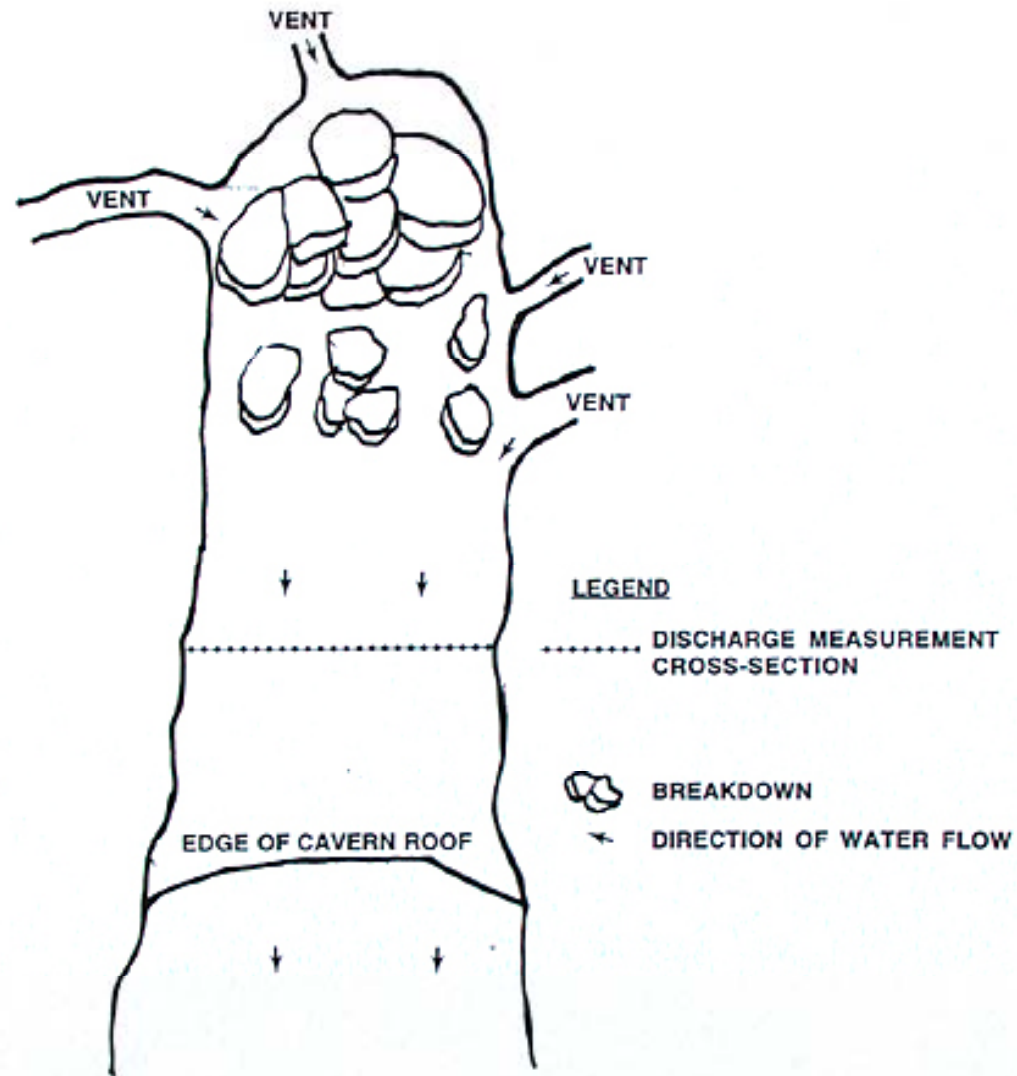


Grid Setup:

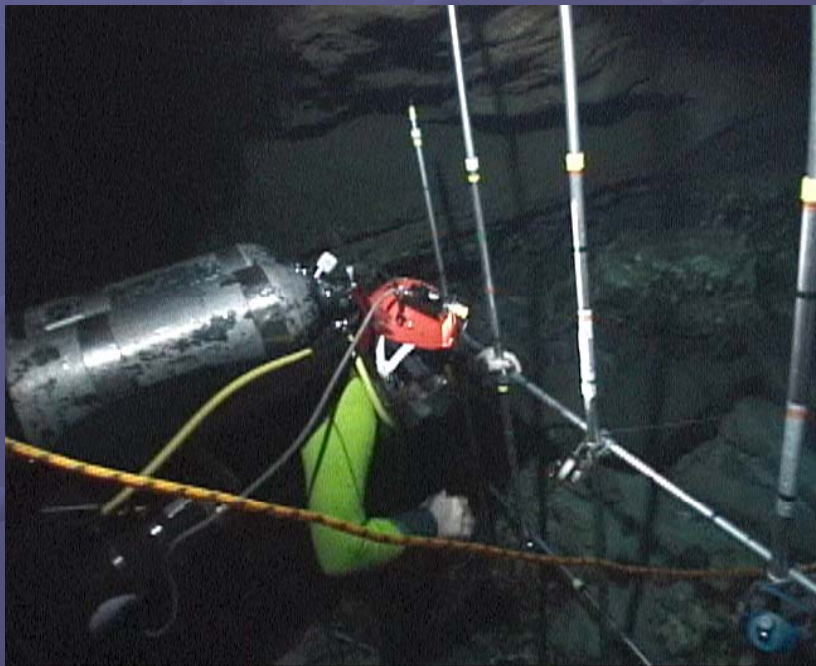
3) Measure Wall and Pole Positions, Begin Flow Measurement



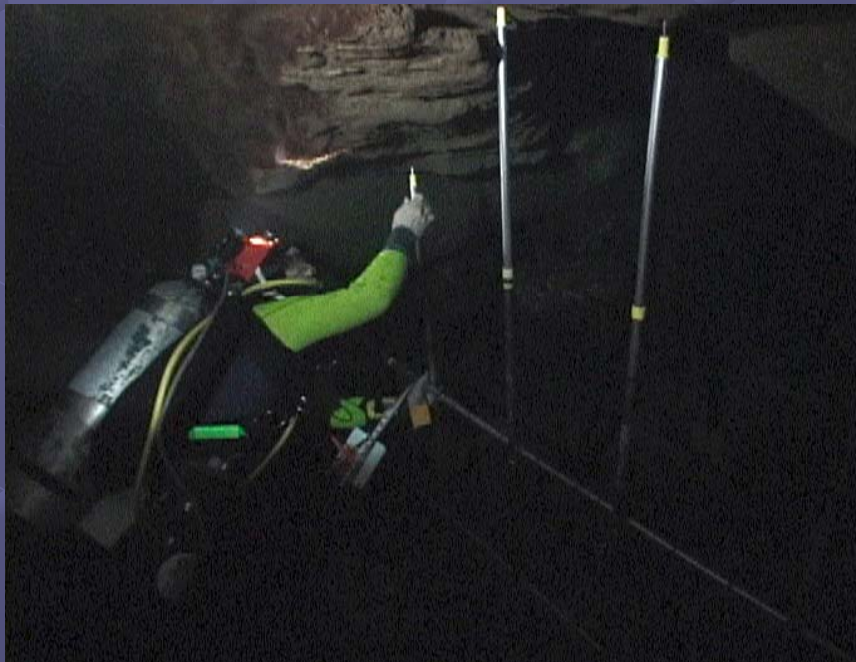
Croaker Hole



Grid Set-up I



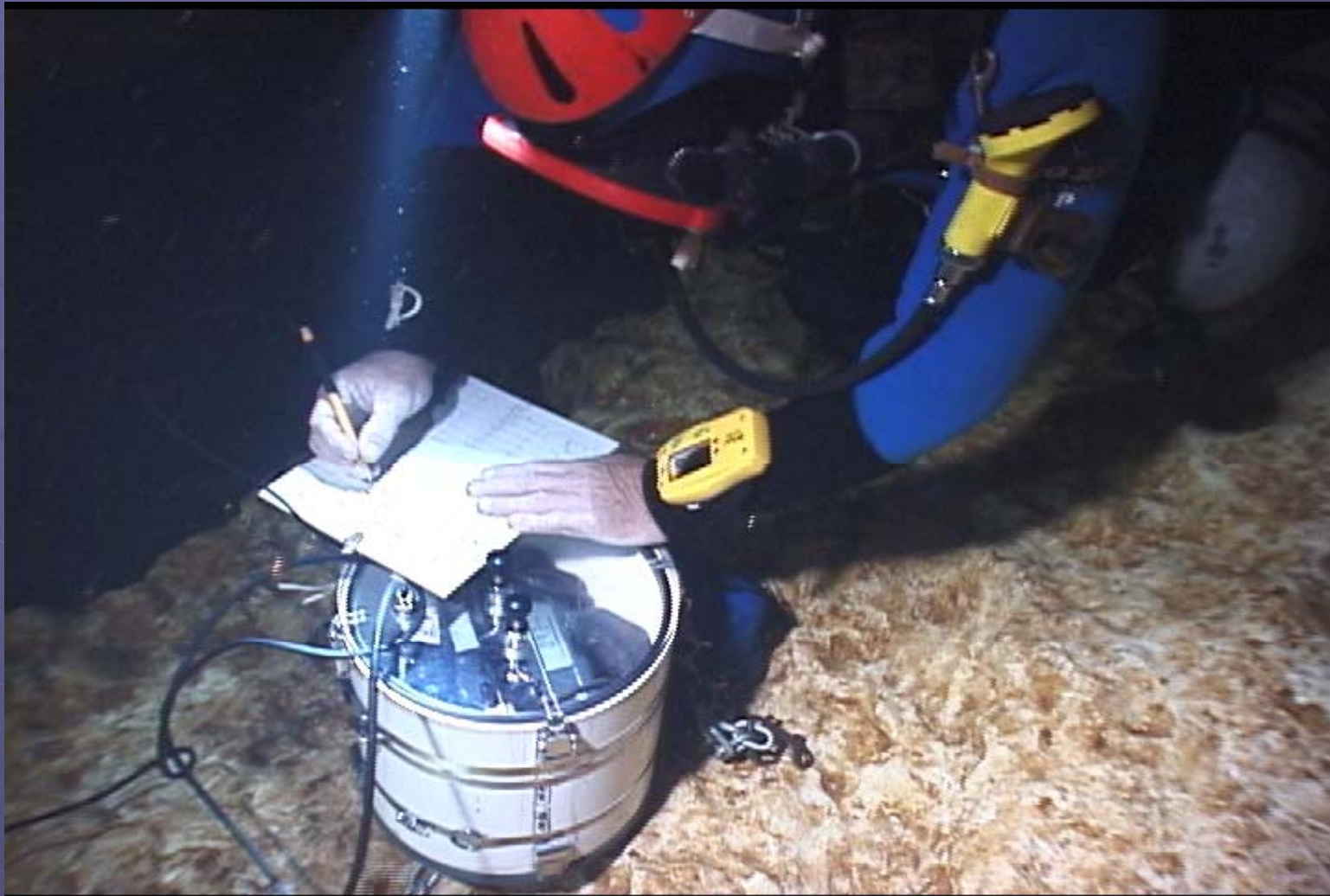
Grid Set-up II



Finished Cross-section Grid Set-up



Flowmeter/Housing in Operation



Underwater Data Recording



UNDERWATER TASK COMPLETION TIMES

- New support set-up:
50-70 minutes
- Subsequent visit set-ups:
20-50 minutes
- Take velocities at 55-60 stations:
100-130 minutes
- Optimal maximum operating depth based on
above:
60 - 70 feet

Method Development

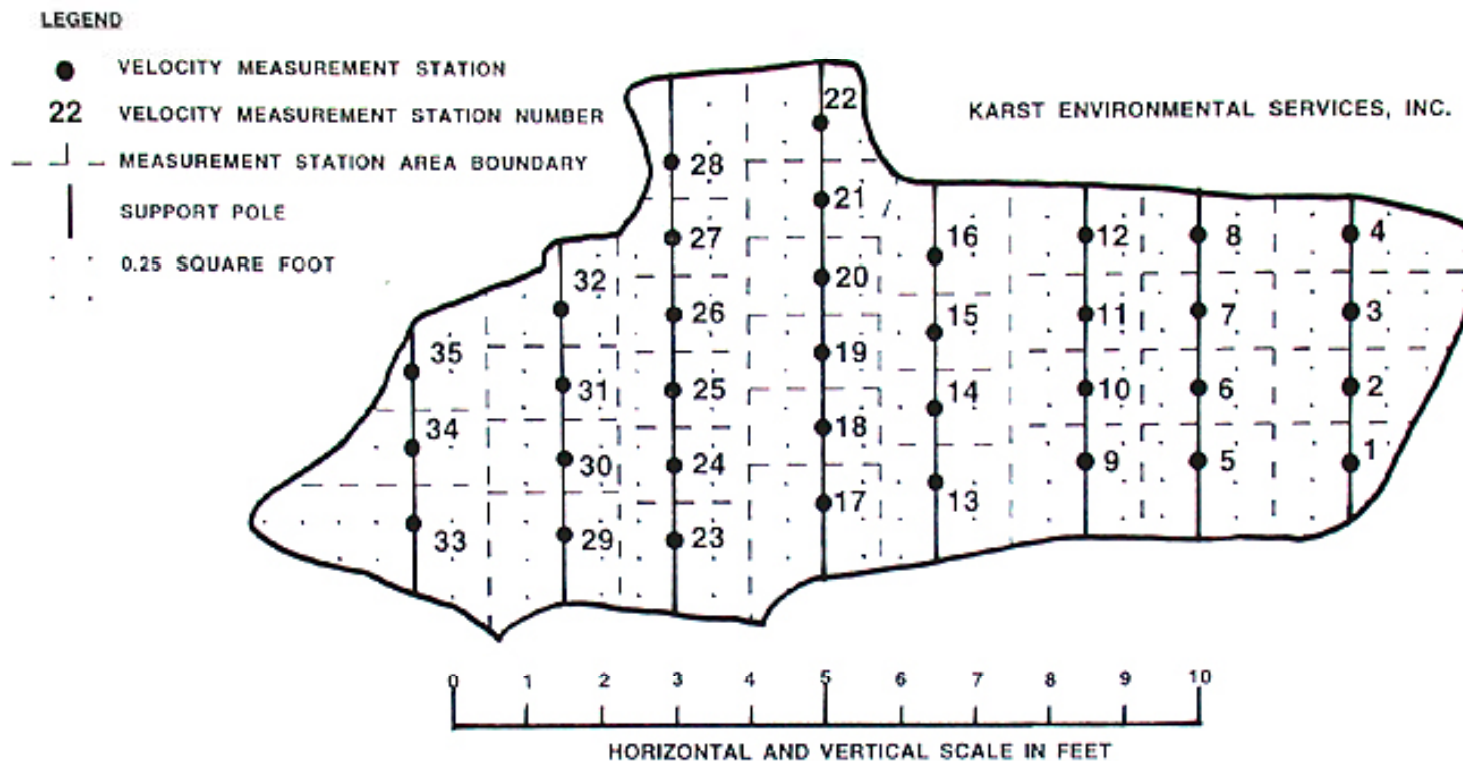
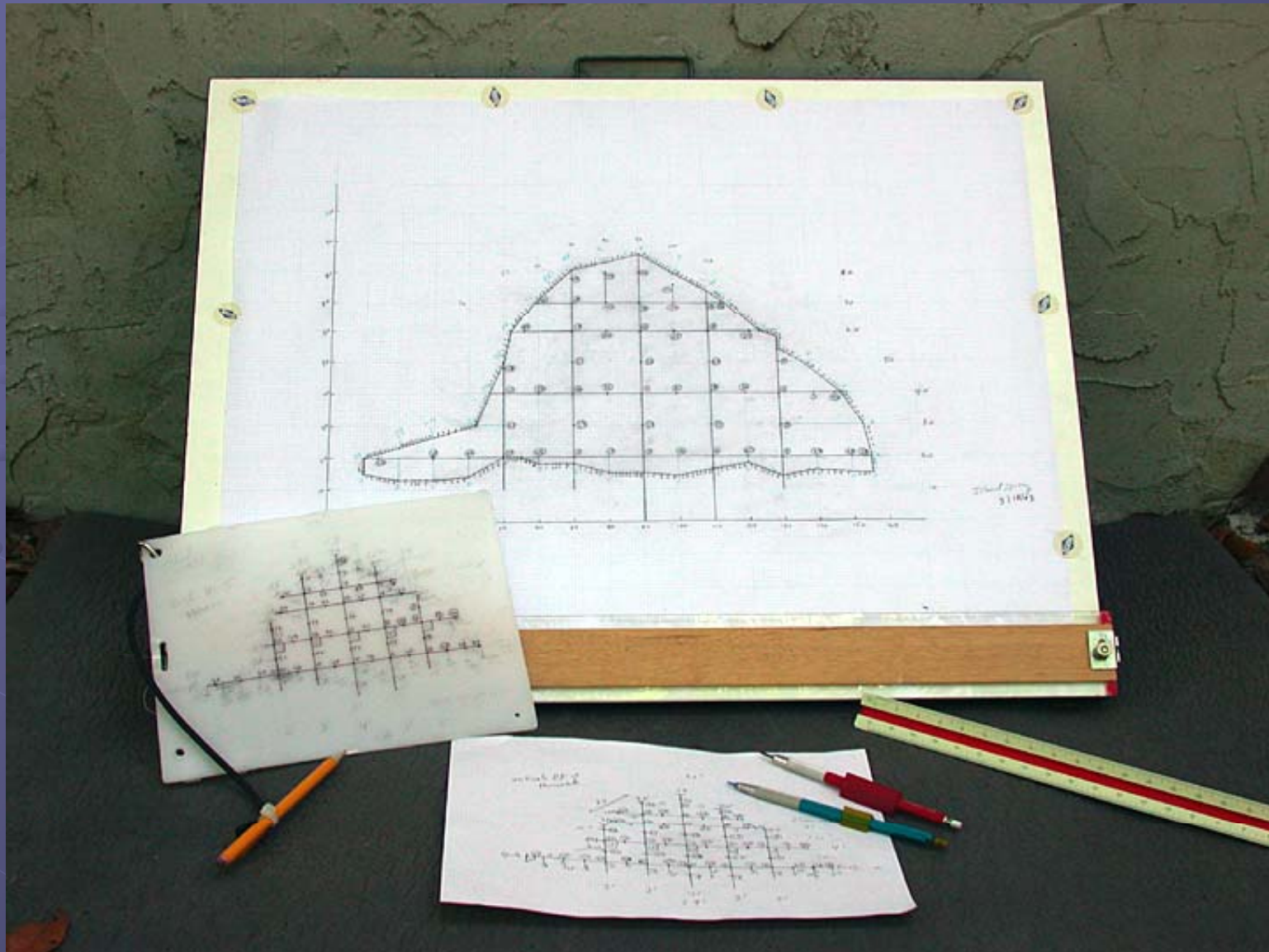


Figure 1. Discharge measurement cross-section; Lake Apopka Gourdneck Spring, Lake County, Florida, June 19, 2001 measurement. Cross-section is viewed to the upstream of observer, and is located between the 53 and 57 foot depth levels. Numbered velocity measurement stations are shown, along with assigned area boundaries. See Table 1 for station velocities and station areas. See Figures 2 and 3 for location of measurement cross-section in spring.

Field Data Layout and Input



CROAKER HOLE SPRING

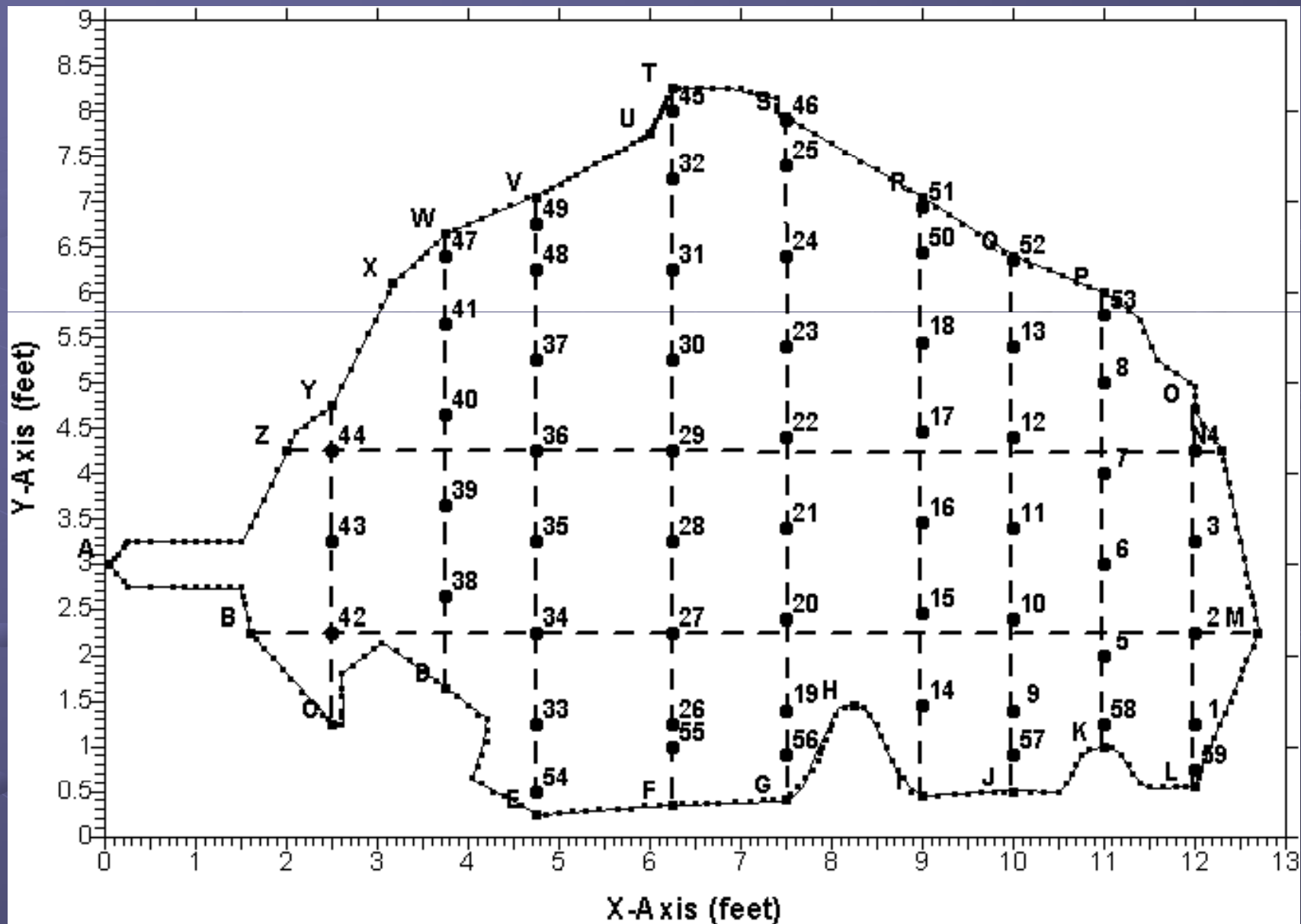
X,Y & Z Data Spreadsheet for Surfer 8

Table 3. Croaker Hole XYZ Grid Data December 11, 2002.

	X	Y	Z (Velocity)	Station #	FROM HAND PLOT:	
					X Plot	Y Plot
	12	1.25	0.67	1	240	25
	12	2.25	0.72	2	240	45
	12	3.25	0.69	3	240	65
	12	4.25	0.76	4	240	85
	11	2	1.28	5	220	40
	11	3	1.24	6	220	60
	11	4	1.22	7	220	80
	11	5	1.18	8	220	100
	10	1.4	1.36	9	200	28
	10	2.4	1.49	10	200	48
	10	3.4	1.54	11	200	68
	10	4.4	1.54	12	200	88
	10	5.4	1.66	13	200	108
	9	1.45	0.89	14	180	29
	9	2.45	1.37	15	180	49
	9	3.45	1.61	16	180	69
	9	4.45	1.72	17	180	89
	9	5.45	1.67	18	180	109
	7.5	1.4	0.95	19	150	28
	7.5	2.4	1.22	20	150	48
	7.5	3.4	1.61	21	150	68
	7.5	4.4	1.8	22	150	88
	7.5	5.4	1.98	23	150	108
	7.5	6.4	1.66	24	150	128
	7.5	7.4	1.5	25	150	148
	6.25	1.25	0.81	26	125	25
	6.25	2.25	1.16	27	125	45
	6.25	3.25	1.66	28	125	65
	6.25	4.25	1.76	29	125	85

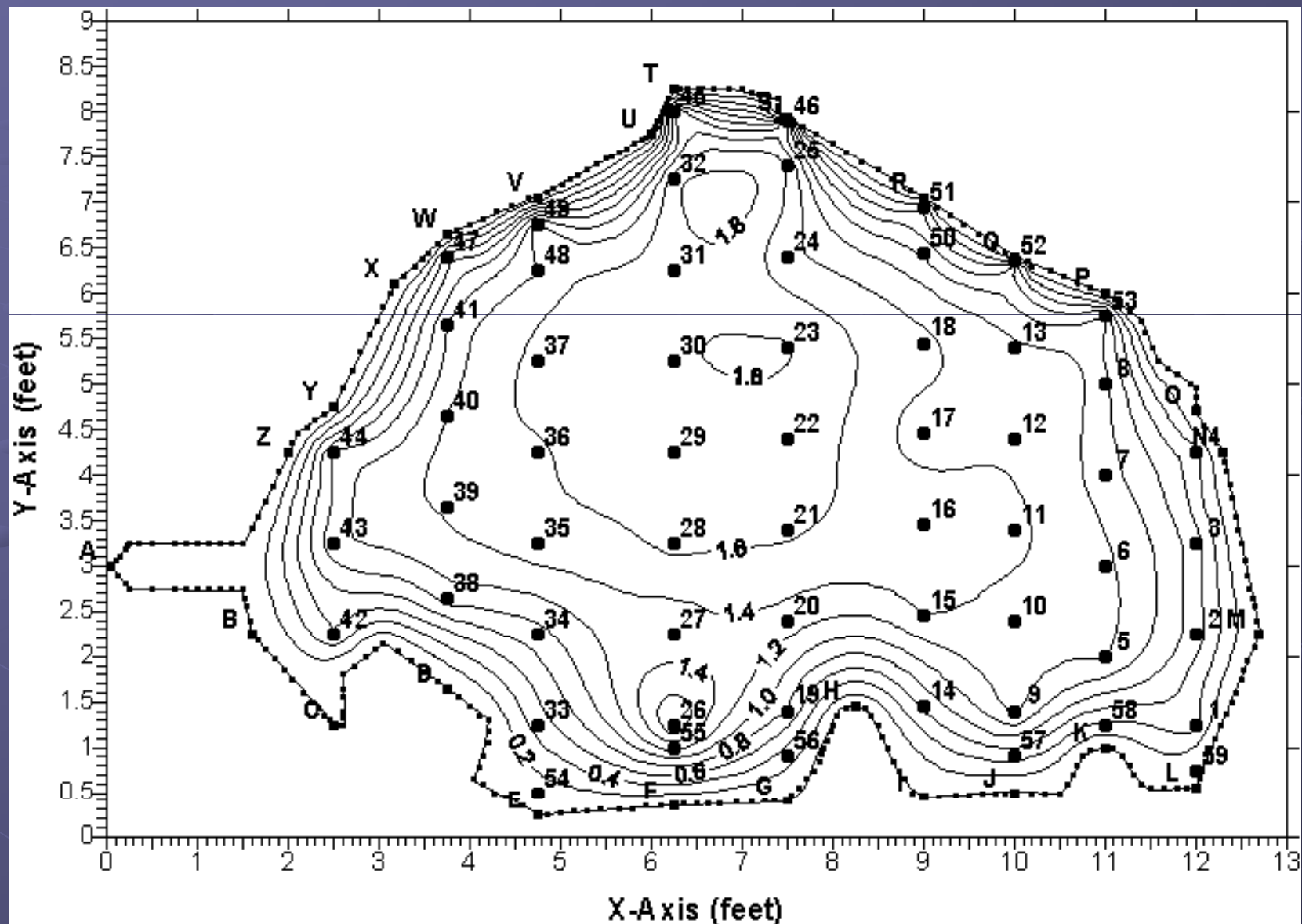
CROAKER HOLE SPRING

Station Positions (X,Y) for Surfer 8



CROAKER HOLE SPRING

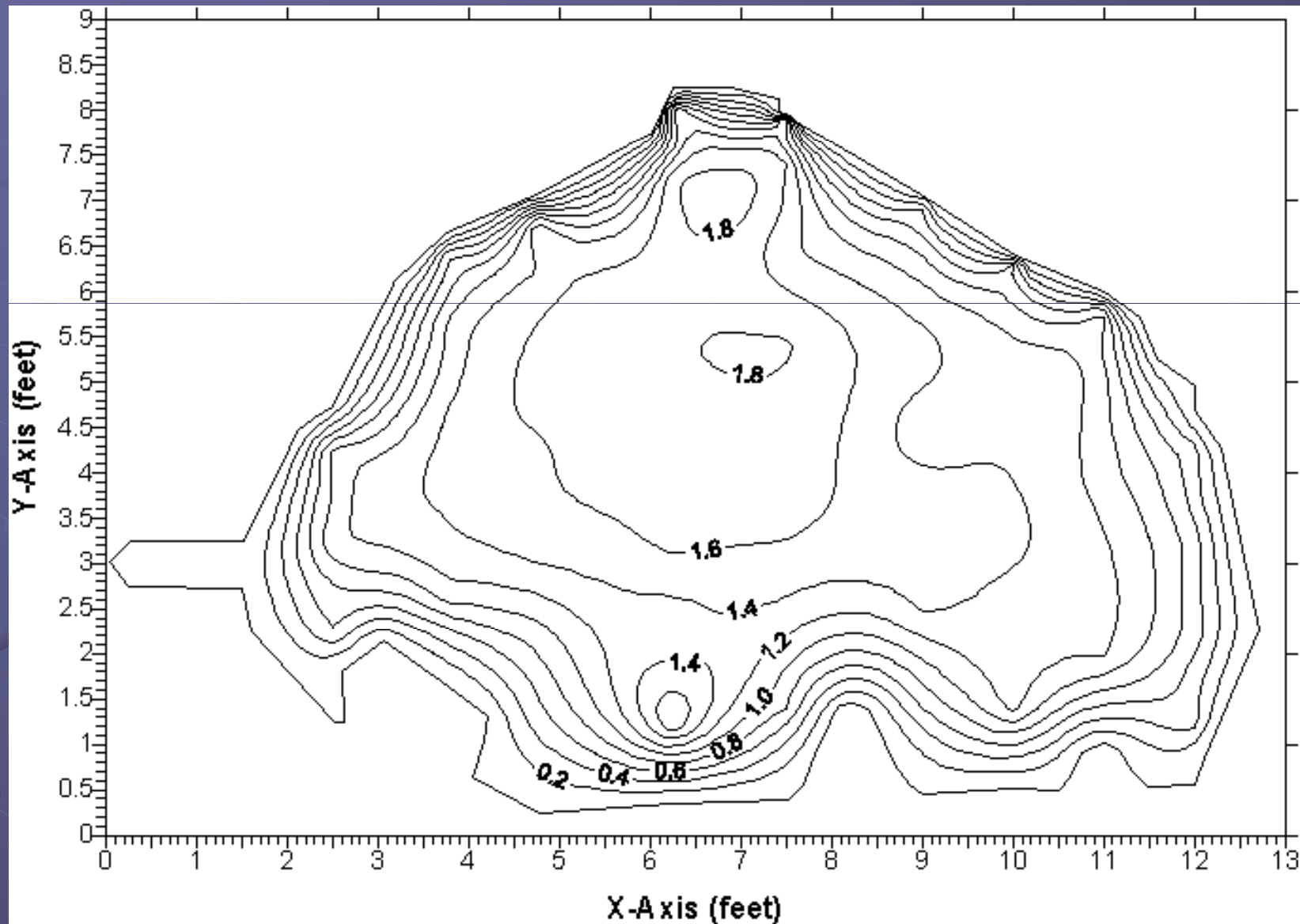
Stations & Surfer Velocity Contours (X,Y & Z)



CROAKER HOLE SPRING

Final Surfer Contour & Q

(December 11, 2002 Measurement: 73.077 CFS)



CROAKER HOLE SPRING

Surfer 8 Grid Volume Computations

TABLE 2. CROAKER HOLE SPRING, DECEMBER 11, 2002.
SURFER 8 GRID VOLUME COMPUTATIONS AND GRIDDING REPORT

UPPER SURFACE

Grid File Name: C:\PROJECTS\KARST ENVIRONMENTAL\Croaker Hole\Dec 02\Croaker Hole 12-02 SURFER XYZ T3 BLF.grd
Grid Size: 171 rows x 261 columns
X Minimum: 0
X Maximum: 13
X Spacing: 0.05
Y Minimum: 0
Y Maximum: 8.5
Y Spacing: 0.05
Z Minimum: -2.5844752260964
Z Maximum: 1.9800000003393

LOWER SURFACE

Level Surface defined by Z = 0

VOLUMES

Z Scale Factor: 1
Total Volumes by:
Trapezoidal Rule: 35.35272110147
Simpson's Rule: 35.355601171423
Simpson's 3/8 Rule: 35.356562172955

CUT & FILL VOLUMES

Positive Volume [Cut]: 73.07652220024 <<<<<Flow Rate in CFS

Negative Volume [Fill]: 37.723813416579

Net Volume [Cut-Fill]: 35.35270878367

AREAS

Planar Areas

Positive Planar Area [Cut]: 62.726887496134 <<<<Cross-section area in Square Feet.

Negative Planar Area [Fill]: 47.773112503866

Blanked Planar Area: 0

Total Planar Area: 110.5

Surface Areas

Positive Surface Area [Cut]: 86.447048590834

Negative Surface Area [Fill]: 60.06126081369

UNDERWATER DISCHARGE MEASUREMENT

Location: **CROAKER HOLE SPRING**

Putnam County, Florida

Date: **December 11, 2002**

Time Start: 14:22

Personnel: Peter Butt, Tom Morris, Mark Long

Time End: 15:55

Method: Grid within irregular conduit

Instrument: MMB2000 FLO-MATE in U/W case, probe on support poles

Analysis Method: Surfer 8 with kriging

Island Spring Total Discharge:

CFS 73.077

MGD 47.231

GPM 32799

Total Cross-sectional Area: 62.73 square feet

Avg. Station Point Velocity: 1.248 feet/second

Cross-section Depth: 44-51 feet deep

Msmt. Periods: 60 seconds

Velocity Reading by Station: (All velocity readings in feet per second.)

Station #	Point Velocity	Station #	Point Velocity
1	0.67	31	1.81
2	0.72	32	1.72
3	0.69	33	0.59
4	0.76	34	1.05
5	1.28	35	1.63
6	1.24	36	1.59
7	1.22	37	1.71
8	1.18	38	1.2
9	1.36	39	1.48
10	1.49	40	1.54
11	1.54	41	1.35
12	1.54	42	0.82
13	1.66	43	1.27
14	0.89	44	1.15
15	1.37	45	1.88
16	1.61	46	1.55
17	1.72	47	1.08
18	1.67	48	1.56
19	0.95	49	1.3
20	1.22	50	1.26
21	1.61	51	0.26
22	1.8	52	0.94
23	1.98	53	1.02
24	1.66	54	0.52
25	1.5	55	0
26	0.81	56	0.5
27	1.16	57	1.02
28	1.66	58	1.13
29	1.76	59	0.18
30	1.83		

IMPROVING ACCURACY

- Increase number of stations.
- Take velocity readings closer to walls, especially in high velocity areas.
- Investigators should stay out of conduit's flow path as much as possible.
- After initial visit, replicate support grid with improvements and more measurements.

LAKE AOPKA GOURDNECK SPRING

Lake County, Florida

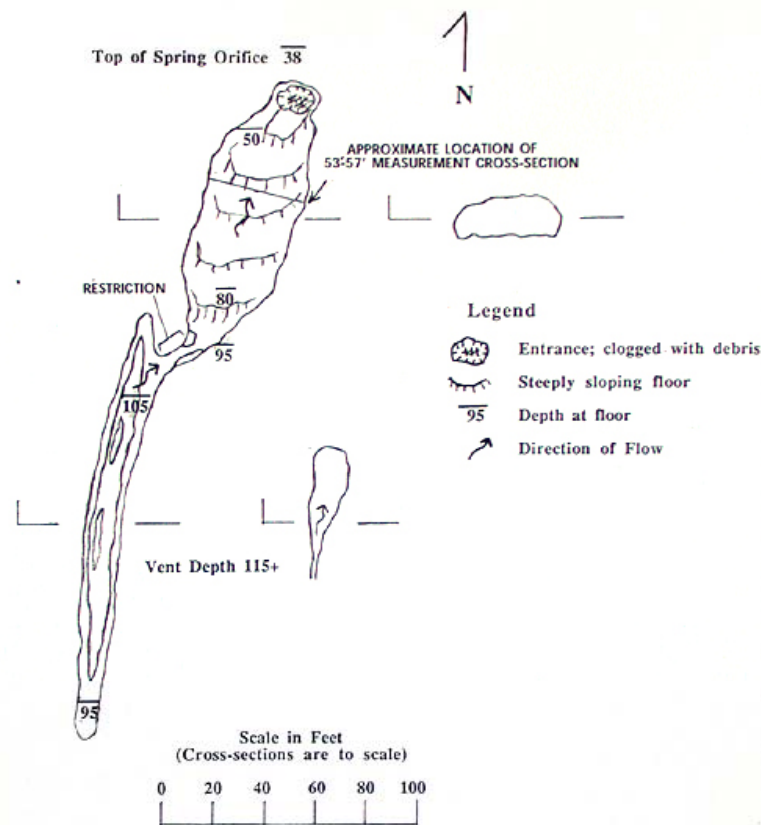


Figure 2. Lake Apopka Gourdneck Spring Cave, Lake County, Florida. Plan view with cross-sections. Entire cave is underwater.

Survey and Sketch of Apopka Spring:
Peter Butt and Tom Morris, Karst Environmental Services, Inc. 1993

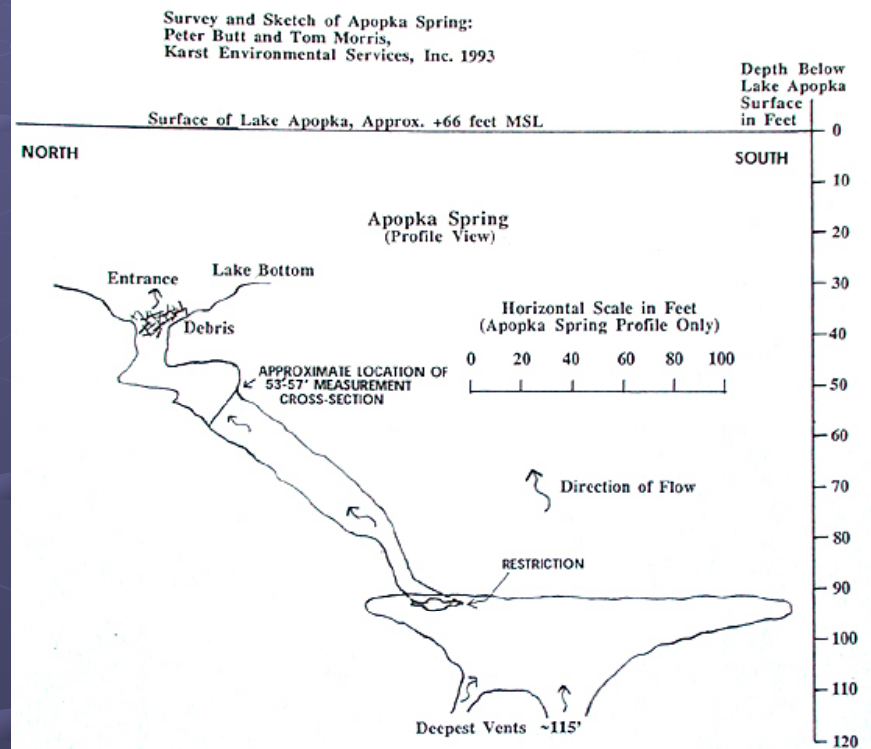
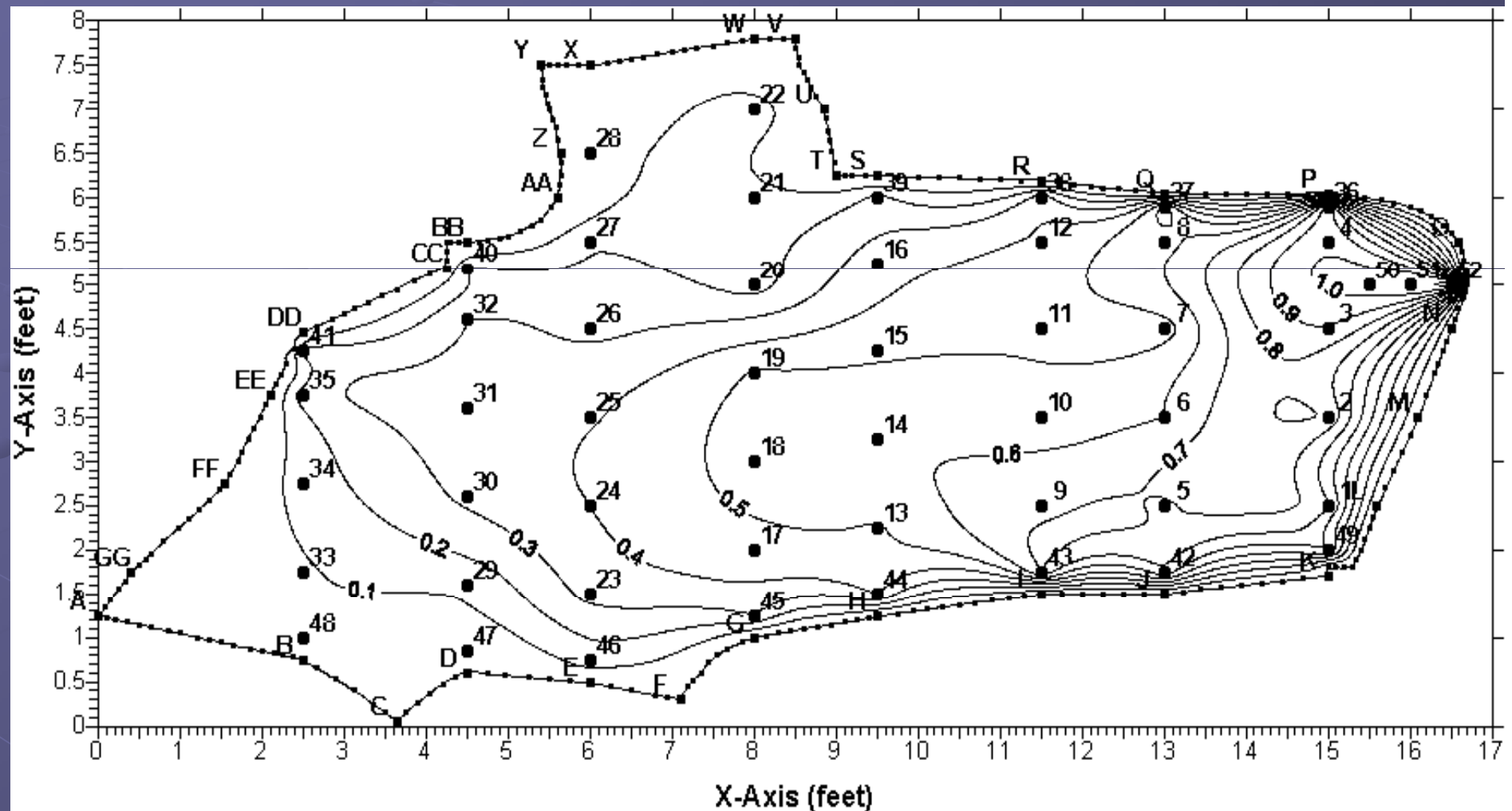


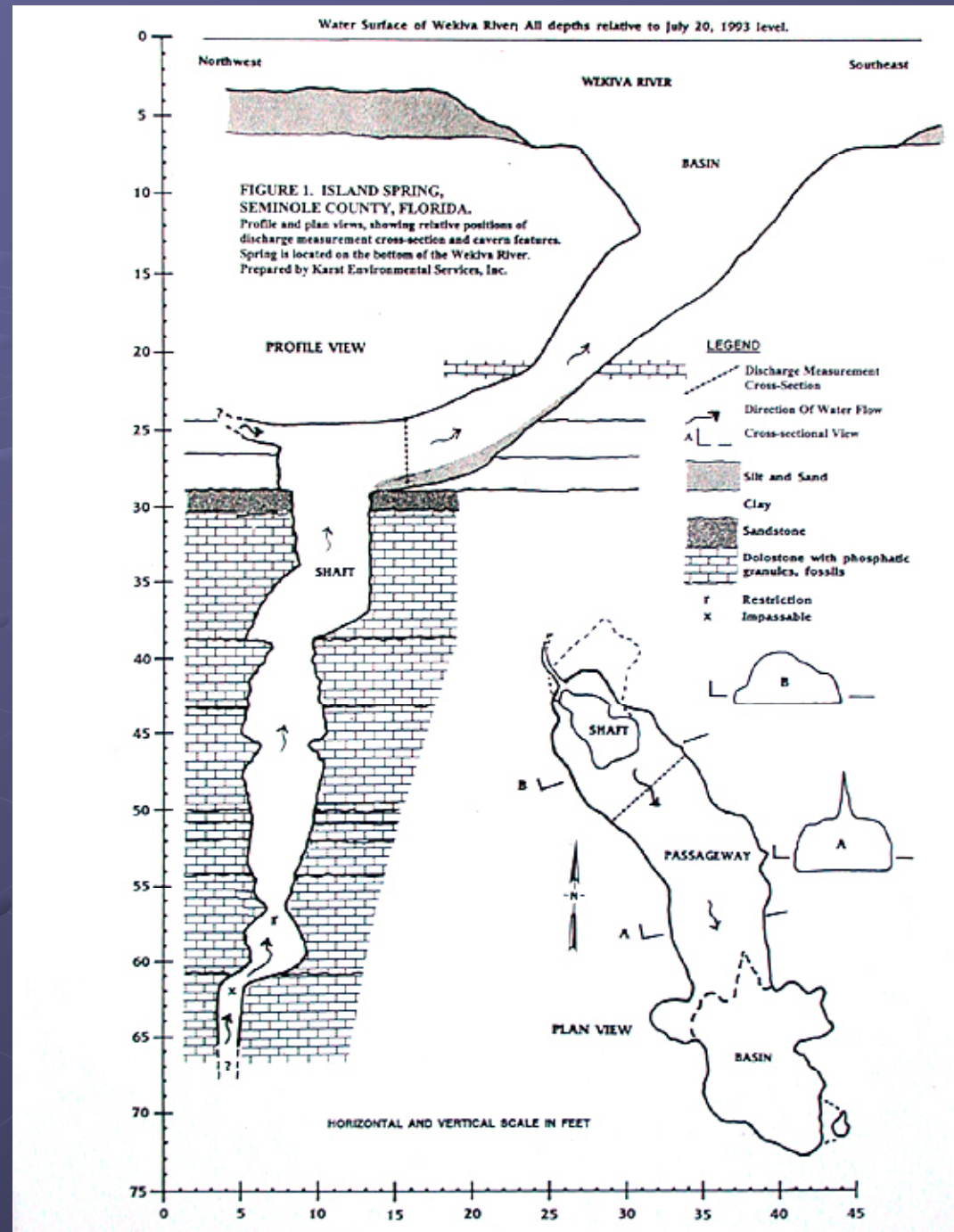
Figure 3. Lake Apopka Gourdneck Spring Cave, Lake County, Florida. Generalized profile view of cave.

LAKE APOPKA GOURDNECK SPRING

Lake County, Florida

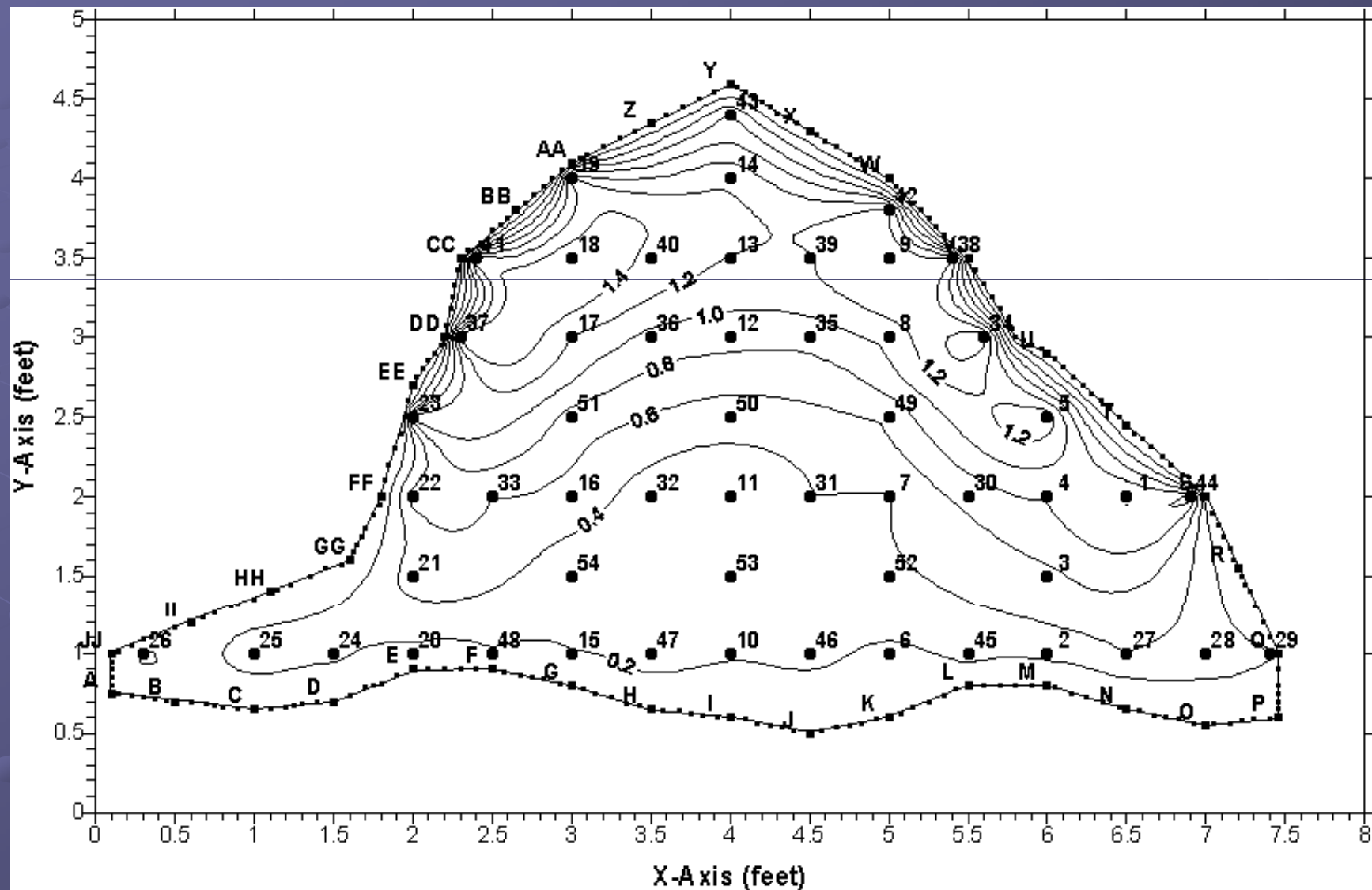


ISLAND SPRING Wekiva River, Seminole County



ISLAND SPRING

Wekiva River, Seminole County



WEKIVA FALLS RESORT

Lake County, Florida



WEKIVA FALLS RESORT

Lake County, Florida

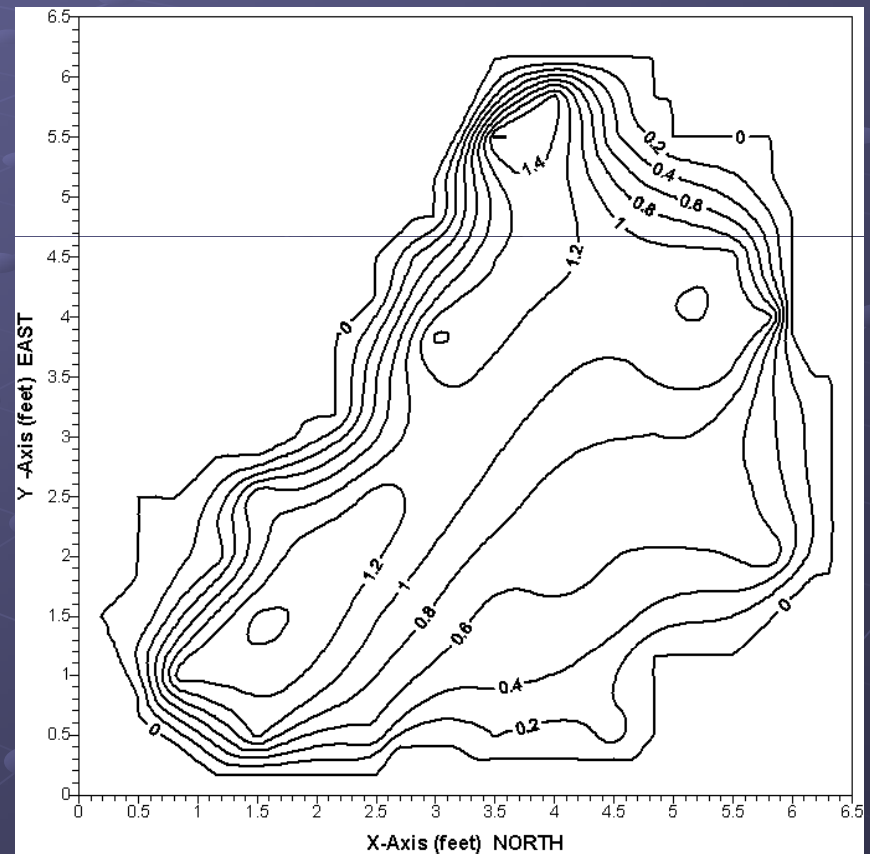
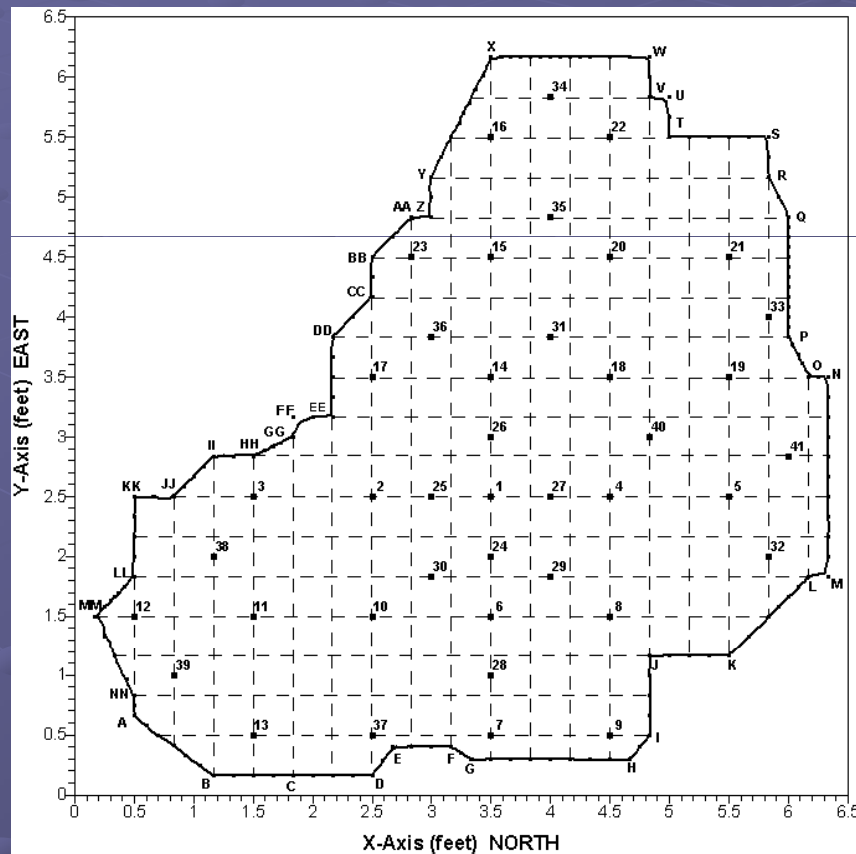


Horizontal Wire Grid Support



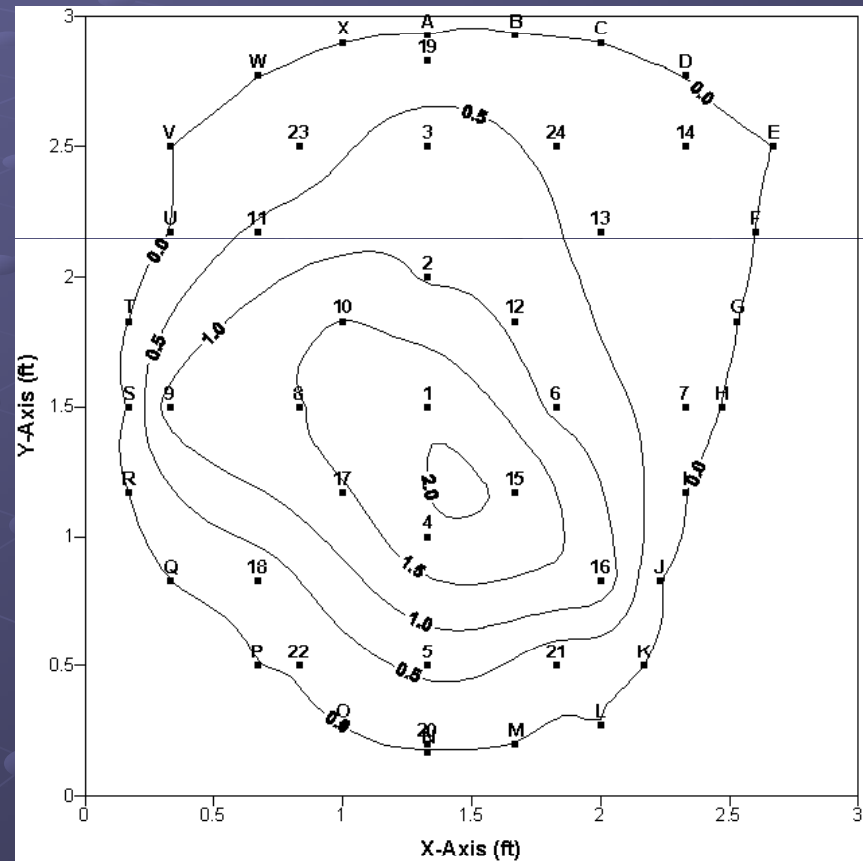
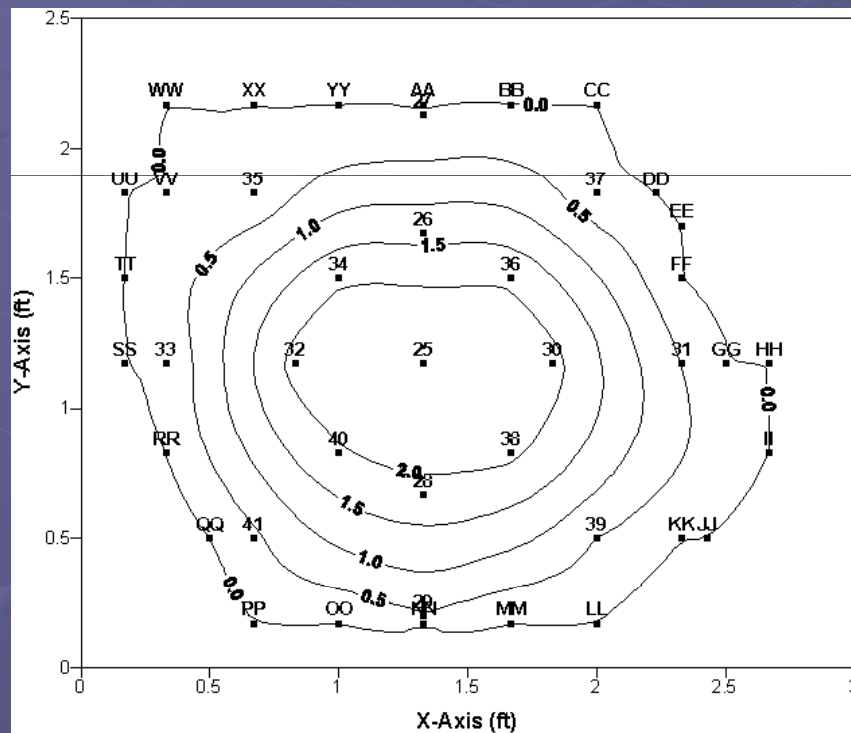
WEKIVA FALLS RESORT

Lake County, Florida



WELAKA SPRING, Putman County, Florida

North and South Vents



BLUE SPRINGS STATE PARK

Volusia County, Florida



Movable Horizontal Support Pole



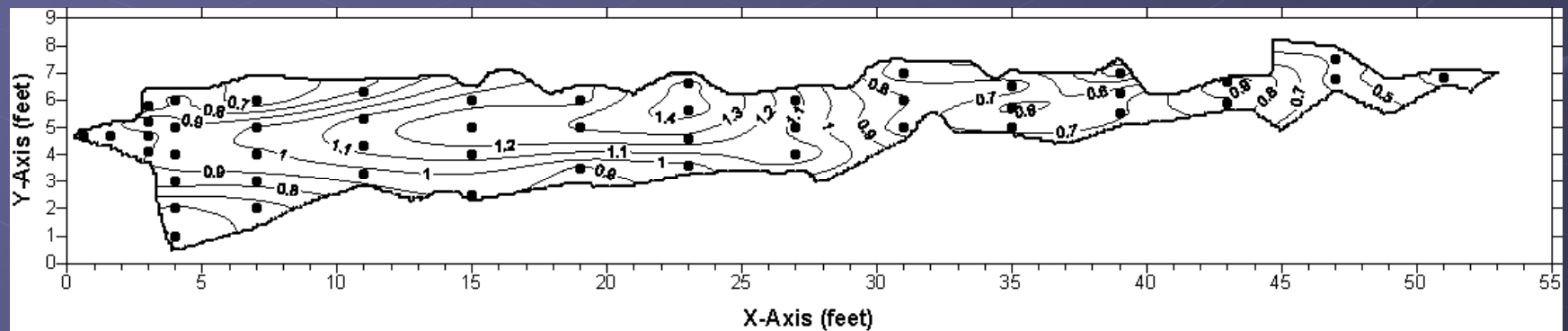
BLUE SPRINGS STATE PARK

Volusia County, Florida



BLUE SPRINGS STATE PARK

Volusia County, Florida



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