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# The Carroll Cave Digs by Rick Hines

## Introduction

Carroll Cave, located in Camdenton County, in south-central Missouri, is one of the most significant caves in Missouri with over 12 miles of mapped passages and over 100 known, but unmapped, side passages.

Most of the mapped passage of Carroll Cave consists of two major river passages, the Carroll River passage and the Thunder River passage. The DL7 passage is an exception that enters on the left side of the lower Thunder River passage. The Carroll River is a small, slow flowing stream that flows out of the natural entrance. The Thunder River carries a much larger flow of about 1,000,000 gallons a day and feeds Toronto Spring that is located about 3.5 miles northwest of the natural entrance. Much of the current volume that moves through the Thunder River passage, in an earlier geological time, flowed out the natural entrance, before finding its way to the lower elevations of the Thunder River. The junction of the two river passages is known as the T-Junction.

The current owner of the natural entrance (and only known entrance) will not grant permission for anyone to enter the cave. The Carroll Cave Conservancy has leased land over the cave from a cooperative landowner and is working to dig a new entrance.

## Where Should I Start?

Where should I start on this project that has been a passion of mine for most of my life:

My first trip into the cave in 1970,

The early 1990's breakdown of the originally excellent landowner/caver relations as the entrance ownership moved to a new generation and grottos squabbled for control,

My search for a new entrance or a point to dig a new entrance that started in earnest in October 1994 with a fact-finding trip to the area to try to meet with all the owners of land over the known cave,

The sinkhole dig that started November 18, 1995 and was reluctantly abandoned after five years and over 1000 man-days of digging, due to safety concerns,

The formation of the Carroll Cave Conservancy in January 1998 "to manage Carroll Cave in a manner that minimizes damage to the cave and its fauna while providing access for scientific study and exploration by responsible cavers,"

The T-Junction dig that started with the drilling of a nine-inch pilot hole into the cave 118.5 feet below on November 10, 2000,

The first explosive blast at the T-Junction dig on October 14, 2001 that started the relatively efficient process that has moved us to within in 52 feet of our goal?

Well, this is a publication for diggers so I will assume I have already said enough about ancient history, landowner relations and cave politics.

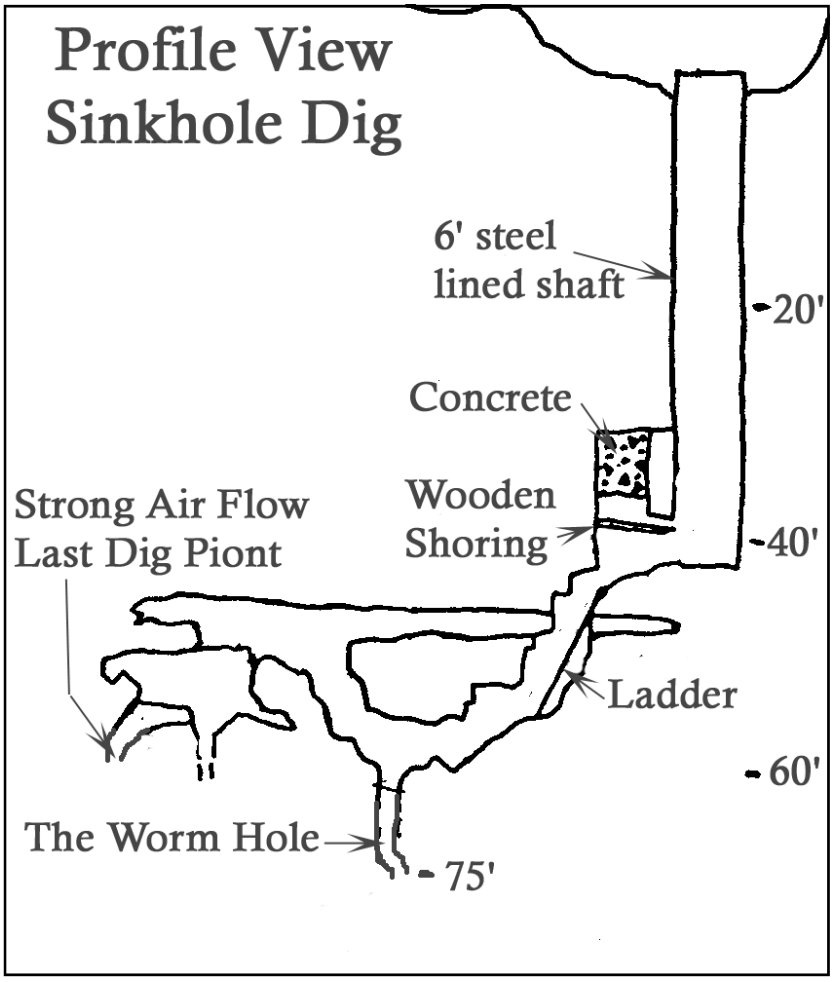
I will briefly summarize the sinkhole dig and then describe in a little more detail the T-Junction dig that is much more promising.

The sinkhole dig is located over a breakdown choke that was once thought to be the end of the Upper Thunder river passage. It is located approximately 2.5 miles west of the natural entrance. I found the sink as a result of my October 1994 visit when I met a 93-year-old gentleman, Mr. Chris Danuser, who pointed me to the sink. Plotting the GPS coordinates of the sink on my Carroll map confirmed my suspicion that the sink was directly over the upper end of the Thunder River Passage. The point is over a large breakdown pile known incorrectly as the Collapsed End. (Hard core cavers have pushed through the breakdown and traveled over 1500' beyond the collapsed end before turning around in a large bore hole passage!)

The original name for the sinkhole dig was the Trash Dig. Enthusiasm was high on the first dig. We hoped to remove a few loads of trash, discover a deep pit and drop into Carroll. After a dozen truck loads of trash and at least that many refrigerators were hauled to a more ecologically-stable resting place a couple miles away, it became clear that our goal would not be reached with a one day effort.

Three trucks rotated between the sink and the more ecologically-stable resting place. Greg Fry, Chris Danuser's grandson (one of two grandson's who own most of the land over the cave) worked with us all day. His four-wheel drive truck was the only one of the three with enough traction to drag the refrigerators from the pit. A human chain ferried five gallon buckets of glass, cans and plastic to the waiting trucks. We entertained ourselves by dating the artifacts uncovered. We estimated the age of everything from pop cans to bed pans. I was amazed at how well some of the plastic items had survived. A nicely preserved plastic water gun, plastic Santa and a bright yellow ball bat were found. As the yellow ball bat was thrown to the surface, Greg was heard to say, "you must be getting close, I just saw **a bat fly out!"** Well, Greg's humor continues to this day but it got harder to find anything humorous about the sinkhole dig as we continued digging nearly every month for five years.

The dig soon became too deep for the bucket brigades to effectively move material to the surface. Two runs of a 1" polypropylene rope were strung horizontally between two trees on opposite sides of the dig. A 4-to-1 block and tackle system was rigged from the poly rope and dropped directly into the dig. A board, approximately 2 feet by 3 feet with a chain in each corner was hung from the block and tackle system. Five-gallon plastic buckets would be filled with mud and rock and placed on the board. The board and buckets would be raised to the surface and the buckets carried to the sides and dumped far enough a way so that the material would not wash into the dig.




As we moved deeper it became necessary to line the hole to prevent material from washing in as fast as we could remove it. As we searched for a steel tank to shore up the dig we were fortunate to meet Danny Schupbach at a local construction company. Danny had access to some salvaged 6' diameter pipe that he donated to the cause. Danny has remained a strong supporter of the CCC, providing much needed material and equipment.

The first shoring to go in to the dig was an 11-foot long section of the 6-foot diameter 5/16-inch wall pipe. This section weighed about 2700 lb.

We moved straight down 42 feet through loose breakdown and mud. We cut up pieces of the 6-foot steel pipe and lowered them down the hole and welded them in place as needed to shore up the lose sidewalls. Progress was not easy. Often we would arrive for a dig and find that a heavy rain during the prior month had washed in more mud and rock than we had removed in the prior six months. I have a feeling that we dug some of the same mud and rock four or five times.

However, there were some very encouraging signs associated with the dig. In December 1997 we reached 32 feet and felt a good airflow between the rocks. Soon a bat crawled out and flew away. An hour later a second bat emerged. Yes real bats, not plastic.

As we continued down we had strong airflow. Velocities up to 800 feet per minute(10 mph) were measured. We followed the air straight down to 42 feet with our 6-foot shaft and then horizontally for 10 feet. The floor of the 10-foot long alcove trended down and under a bedrock wall.

On Sinkhole Dig 34 on July 17, 1999, we opened a small hole at the end of the horizontal shaft. As we dug the gravel and mud started falling into a cave below. A strong breeze was flowing into the cave. Our spirits were high as we slid through the small opening, down a steep gravel bank, to the cave below. We found ourselves in a room, 15 by 25 feet, with a ceiling height of about 5 feet in the center. Following the air we picked our way into an even larger cave room about 50 feet long. A small corkscrew passage dropped down about 12 feet below the floor of the second room to a total distance of about 75' below the top of the steel pipe and only 45 or 50 feet above the estimated depth to the Thunder river.

For several months we continued to dig at the far end of the second room. We tried to follow a bedrock wall down. We had very strong airflow and a clean fist size opening between the rocks.

We also had a very unstable cave. Most of the walls consisted of a loose stack of crumbling bolder. Large slabs of rock hung precariously from the ceiling. At the back wall where we were digging, we placed screw jacks to prevent a large rock from sliding in.

After Dig 39 in December 1999, we decided that additional work in the sinkhole dig could only be continued safely if a great deal of additional shoring were put into place in the small cave. The shoring would be difficult and time consuming. We decided it was time to put the sinkhole dig on hold and look at other options.

## Drill a 36" Shaft

We contacted several companies to determine the cost of drilling a 36" diameter hole in to Carroll. Estimates ranged from $20,000 to $100,000. The only catch with the $20,000 bid was that the driller's equipment could drill through no more than 80 feet. We spent several months surveying on the surface to locate a point over the cave with less than 80 feet between the cave ceiling and the surface. Most of the surveyed Carroll passage lays about 120 to 140 feet below the surface. We found one spot that might have worked. The landowner would allow us to drill and would give us access but he did not want to do it formally with a long-term lease. In order for the CCC to maintain our 501 (c) (3) status, however, we needed a lease on any property in which we invested tax-free dollars.

Steel Going In

The Board

Harley in Water

Looking Down

From Dig to Small Cave

## Drill a Pilot Hole and Jackhammer

The next approach considered was to drill a 9-inch diameter pilot hole into the cave and then open the hole to 30" using a jackhammer. We could have a 9-inch hold drilled for less than $1000 and we recently had an industrial strength air compressor and jackhammer donated.

With depth not as critical a factor, we then focused on finding the best spot for a new entrance with out worrying about the depth. This brought us to the T-Junction. The T-Junction is where the Carroll River Passage Ts into the Thunder river passage. Ceiling heights are as much as 40-feet and the room volume can easily accept the volume of material in the planned entrance shaft. The obvious advantage of the T-Junction entrance is three directions to explore from a central point. Other advantages include a large room to target for drilling, a good area for an in-cave base camp, a surface point with access to AC power, avoiding traffic through areas with high bat populations, and avoiding much of the nasty mud and water that Carroll is infamous for.


Drilling 9" Pilot

## The T-Junction Dig

We carefully surveyed to locate the drill point. We hired a local well driller to drill a 9-inch hole. We estimated the depth to the ceiling to be 120 feet. On the first try we broke into the cave at 118.5 feet. The T-Junction dig had started!

After Drilling the 9-inch pilot hole we hired a backhoe to dig down to bedrock. We hit bedrock at 9 feet.

We were eager to try jackhammering. But the donated air compressor would not run and the repair work was going slowly. We rented a compressor and jackhammer to test the process. The first 4 inches of rock was difficult to get through even though the layer below was soft and crumbly. When we got into the crumbly material we forced it into the 9-inch pilot hole too fast and plugged the hole. We eventually got the hole unplugged by probing with a ½-inch steel pipe.

Before trying additional jackhammering we needed to stabilize the 9 feet of overburden, which was tending to wash in with every rain. We obtained an 8-foot diameter by 16-foot tall steel tank. We cut a 4-foot diameter hole in the bottom of the tank at the perimeter of the tank (not centered). With the help of a backhoe we lowered the tank into place. The tank extends 9 feet below the surface. The top of the tank was cut off leaving about 3 feet above ground for a safety rail.

A 20' tall tripod was centered over the 9" hole and welded to the steel tank. Doors were cut and hung to provide access. A 4 to 1 block and tackle system with 600 feet of 7/16 nylon climbing rope is attached between the tripod and the "elevator." The elevator moves the digger in and out of the 30-inch shaft. The elevator consists of two 16-inch diameter boards separated by 3 lengths of 7-foot chain. One stands on the lower board and the top board provides some protection from anything that might fall from above.

## Let's Blast

Our first jackhammer experience led us to consult with others and consider additional options. One option to speed up the process was to drill, set explosives and blast. Others around the country had had success with several variations on the blasting approach. The 9-inch pilot hole and large cave room below provided an opportunity to safely remove the blast debris without hauling it out overhead. Two things were needed before we could test blasting. We needed access to explosives and we needed expert help. As I searched the internet for information on explosives I stumbled on to The University of Missouri Explosives Lab at Rolla (http://www.umr.edu/~explosiv). The web page mentioned the director of the lab, Dr Paul Worsey. I emailed Dr. Worsey and asked his advice. He promptly got back with me and to my surprise I found that he was already familiar with the dig. One of Dr. Worsey's students is a caver and had been following our progress. Paul is also a caver with most of his experience in his native England.

**8' Steel Tank to Bedrock**

Paul has turned out to be a very valuable resource. Paul has trained CCC people on site. Additionally the CCC sponsored one of our members at a blasting seminar taught by Paul. Paul has obtained donations of blasting caps and the main charge explosive, and he has provided several students to help the dig by transporting explosives from and to Rolla.

One of Paul's students, Ryan Freeman, is doing a project on our dig and is conducting experiments to develop an optimum drilling and blasting process. Seismographs are being used to measure shockwave velocities so that explosives charges can be reduced to the appropriate levels to minimize damage to the cave as we get closer to the ceiling.

With Dr. Paul Worsey's help we set of the first blast on October 14, 2001. As of December 23, 2001, we had completed 33 blast cycles and had moved the bottom of our 30-inch diameter shaft to within 52 feet of the ceiling of Carroll Cave.


A blasting cycle consists of the following:

1) drilling 1.5-inch diameter holes,
2) placing non-electric caps in the main charge explosive,
3) loading the explosive into the drilled holes (typically eight),
4) taping the "non-el" shock tubes to an electric cap,
5) moving to a safe distance,
6) detonating the blast,
7) starting exhaust air to clear the shaft,
8) working the debris down the pilot hole,
9) scaling the walls of loose rock and squaring up the bottom of the hole with a pneumatic chipping hammer,
10) setting a drill template,
11) measuring the distance to the template and to the debris cone in the cave,
12) Start all over!

We have experimented with a number of variables in the blast cycle and have learned a lot but may never have the optimum recipe.

We have learned that for the 1.5-inch holes we are drilling, the 7/8 inch drill stem gets stuck in the hole less often than with the 1-inch drill. We have drilled holes from 2 feet deep to over 4 feet deep. The deeper holes take longer to drill but the depth gained per day is larger. Well I guess the list of things we know with a high degree of confidence is fairly short.

The list of things we think we know, debate, and test is longer. We have experimented with the amount of explosive loaded in each hole. Our friends at Rolla are interested in finding the minimum amount necessary to do the job. My feeling is the more the better. We use a metal template with 6 equally-spaced holes on a 28-inch circle to locate the start of the drilled holes. We drill away from the center with about a 6-degree angle from vertical so that the shaft ends up at about 30 to 34 inches in diameter. We are currently

using an 8-hole pattern that adds 2 holes nearer to the 9-inch pilot hole. The 8-hole pattern is the currently preferred pattern. When the 8-hole pattern is used the 2 holes near the pilot hole are loaded with zero delay detonators. Two of the neighboring outer holes have an intermediate delay and the remaining four charges go off last. The first explosion opens a hole for the next blast that in turn opens a hole for the material from the final blast.

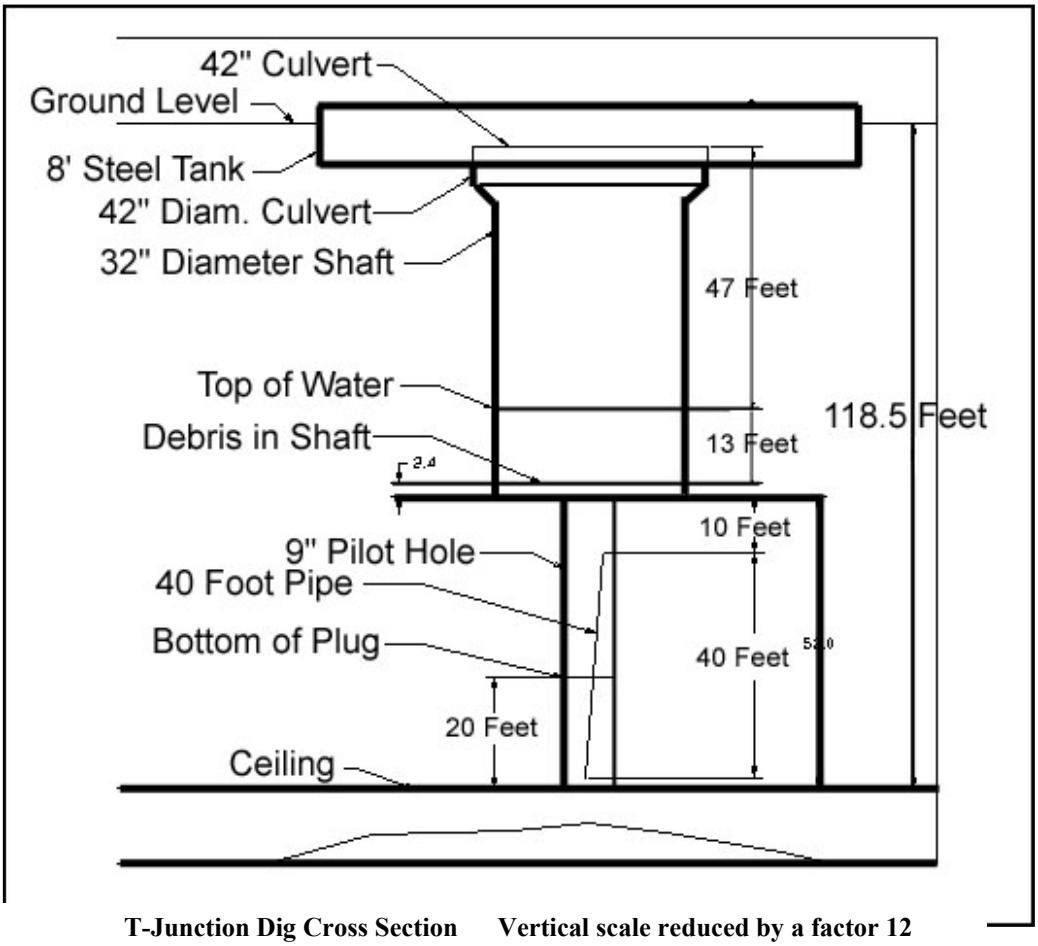
We have had problems clearing to the bottom of our drilled holes. We sometimes leave a step at the bottom that requires jack hammering or a second round of explosives to square up. Variations in the rock are a factor. We hit one layer where quartz grains had replaced all or nearly all of the limestone. It took three blasts to clear the foot thick layer.

By far the biggest problem we have encountered is plugging the pilot hole. A plug tends to occur when too much material flows down the 9-inch hole too fast. We have tried to control the rate by hanging a 4-inch pipe or an I-beam in the pilot hole and we have never had a plug occur with this system. The pipe or I-beam is about 8 feet long and is suspended in the 9-inch hole so that the bottom of the steel is near the bottom of the drilled holes. The steel prevents the debris from the blast from falling down the pilot hole until the steel is wiggled. With this method the debris can be slowly worked down the 9-inch hole at a rate that prevents plugging. Although this process works, it is not without problems. It is difficult to thread the steel down the hole with 8 non-el tubes crossing over the hole. Each blast severely deforms the steel limiting its life and making it more difficult to thread it into the hole.

Because of the problems associated with hanging a pipe or I-beam in the hole, we have tried other systems as well. We thought with the 8-hole system with delayed blasts, the material would flow down the hole in an orderly manner. That seemed to work for a while but then we plugged the hole. We tried several lengths of a heavy chain and that seemed to work for a while but again we plugged the hole. The chain may still work if it is hung deeper into the hole to prevent it from being lifted out with the upward moving debris from the zero delay dets.

As of February 2002, the pilot hole is plugged with 13 feet of water over the plug. We have constructed a 63-foot long drill stem by welding ¾-inch pipe together. With air, rotation and hammering provided by our pneumatic drill we hope to break through the plug. If we can get it started moving the water pressure should flush it into the cave below. When the weather improves we will try again. You can follow our progress at

[www.carrollcave.org](http://www.carrollcave.org)




**T-Junction Dig Cross Section  Vertical scale reduced by a factor 12**

## Thanks


I would like to thank all the people who have made this project possible.

Greg Fry: Owner of much of the land over the cave and manager of the cattle ranch where the dig is located. Greg tolerates us, encourages us, and even helps pull rope.

Chris Danuser: Owner of the land the dig is on. Chris has given the CCC a lease on the property at the dig site.

Bill Hays: Our pro bono attorney

Danny Schupbach: Has provided steel for both digs and loaned us a compressor and pneumatic drills.

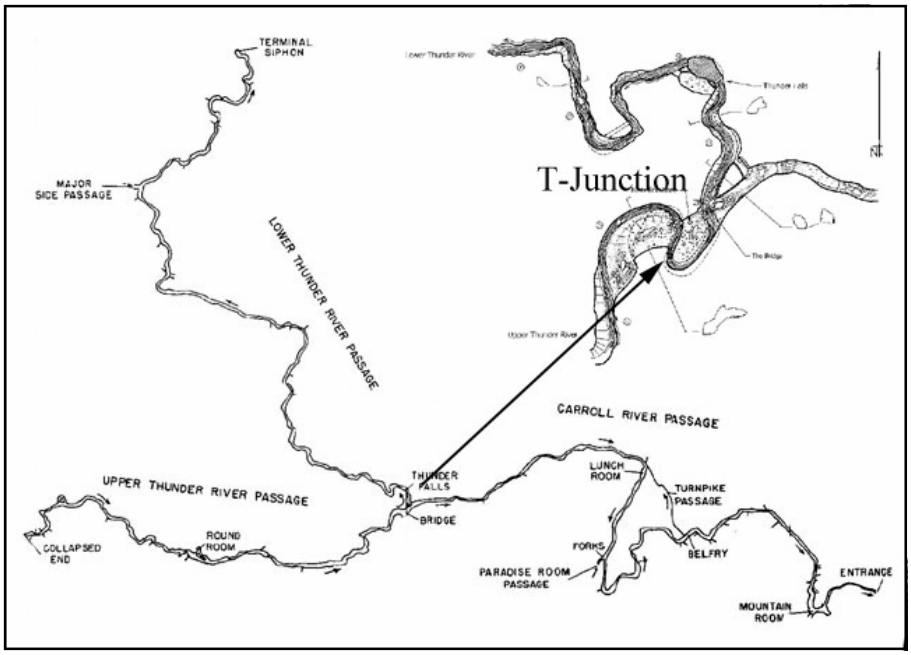
Paul Worsey: Explosive expert, that has arranged the donation of explosive for us.

Ron Jaeger: Has made substantial cash donations.

Jason Percival: Backhoe operator who has donated his services.

Jim Stamper: Well driller who drilled the 9-inch hole at a reduced cost.

Kay Hines: My wife who has put up with me being at the dig for a "few" weekends.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