

Carlsbad Caverns National Park --Trip Report

Study # CAVE-00077 Permit # CAVE-2009-SCI-0001

Principal Investigator : Paul R. Jorgenson KE7HR

Date: 30 to 31 May 2009

Cave: Carlsbad Caverns

Specific Area: Left Hand Tunnel

Team Leader: Paul Jorgenson KE7HR

Team Members: Ray Keeler KE7CPI, Rich Bohman K7RRB, Aaron Hicks KA3UPL, Glenn Tooley K7GET, Teresa Gerrity KF7AEM

Total Number of people times Number of Hours : 6 x 10 = 60 person hours.

Purpose of trip: Science: Study amateur radio high frequency voice communications from in cave to in cave and in cave to the surface.

Condition of gate: Good.

Background:

The use of amateur radio (ham radio) communications in caves has been an on going, but not often publicized, process for decades. Reports in *SPELEONICS* record experiments (by Reid, Halliday, and Jorgenson - among others) that used the lower High Frequency (HF) bands for successful voice communications. Advances in technology have miniaturized and made more robust (field friendly) the radios commercially available to hams. Using this newer, commercially available, equipment we have demonstrated the ability to use wireless voice communications in caves in Arizona, Alabama, Missouri, and Indiana up to depths of about 450 feet of overburden over several years. The desire was to test this voice communications equipment in the Guadalupe limestone as a proof of concept for possible use in other caves in the area.

The Left Hand Tunnel in Carlsbad Caverns is an ideal place to test this communications system due to the depth of the passage below the surface, the level passage character, the lack of electrical wiring or other metal associated with the more accessible tourist parts of the cave, and easy access by elevator.

Testing:

A team of six cavers with FCC General Class or Extra Class amateur radio licenses (required for the frequencies to be used) drove to the Park from Phoenix, Arizona on Friday, May 29, 2009 and stayed in the Research Huts in the Park. On Saturday, May 30th, about 8 AM, we met with Cave Specialists Stan Allison and Tom Bemis (incidentally, both also hams) to complete the required paperwork and go over our plan of operations for the day.

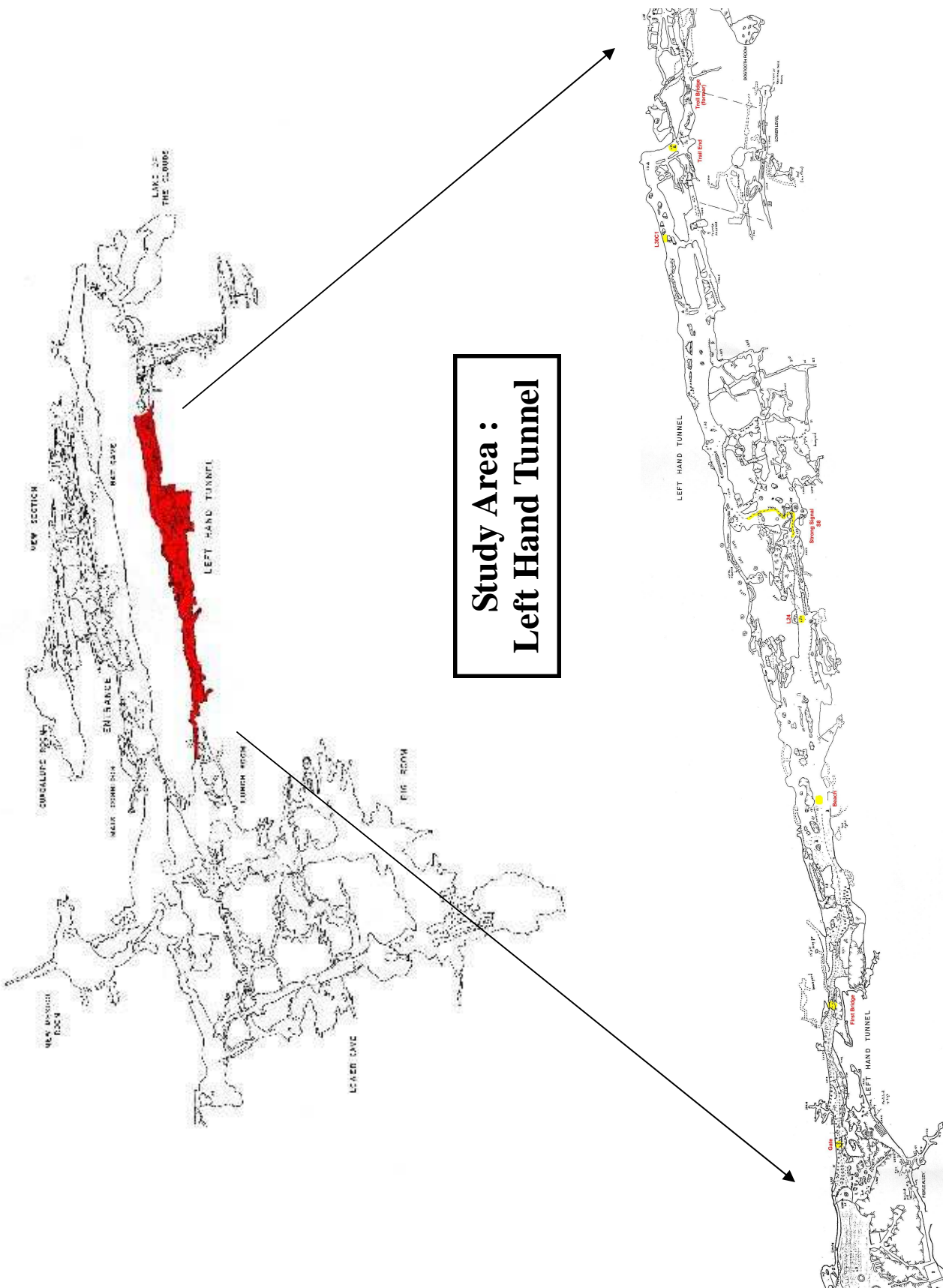
After breakfast, we proceeded down the service elevator and to the Left Hand Tunnel gate. Stan Allison and Tom Bemis accompanied us to the gate, with Tom staying with the radio crew while Stan returned to the surface. We proceeded to the "Beach" (survey station: BMLHT1) area of the passage and set up our first radio (Yaesu FT-817ND) and antenna (100 foot random wire laid on the ground and MFJ antenna tuner). A second and third radio were set up to be mobile down the passage, initially further into the cave and secondarily back towards the entrance. Several locations along the passage were tested to try and determine what the maximum distance possible between two of the low power (5 watts maximum) stations was possible. The antennas exhibit an "end fire" radiation pattern with the maximum signal off of the far end of the wire, so the antennas were oriented to be "aimed" at each

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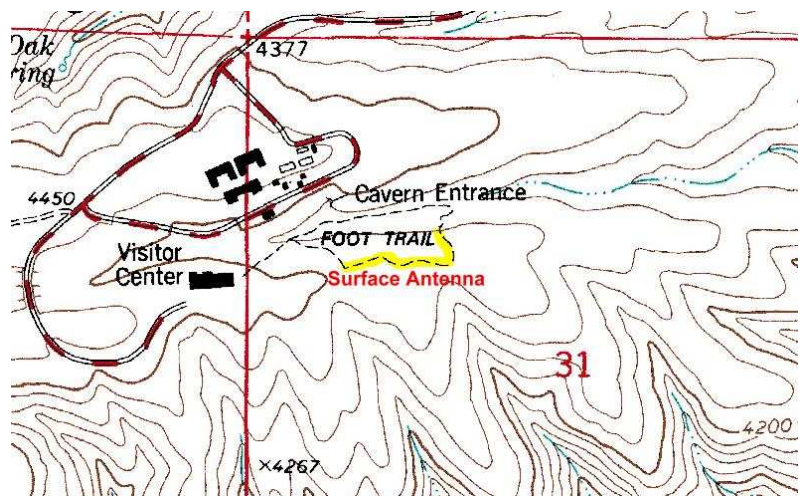
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other along the confines of the flagged trail. The station that went towards the entrance got to the "First Bridge" area (survey station: DA*2) and tried both possible orientations of the antenna (within the confines of the flagged trail) with the expected results - the signals from further in the cave were stronger with the antenna pointed into the passage.

Reliable SSB (single sideband) voice communications were established from the First Bridge area to the Beach and beyond to a point in the passage at survey station L30C1. The signal levels for these radios is given in "S" units, ranging from S0 (no indicated strength) to S9 (a very strong signal). Signal levels above S9 are in decibels above the S9 reading. The signals between the Beach and the L30C1 area were in the S2 range - very good, 100% communications quality.

A rough distance survey with a Disto laser distance meter along the passage yielded an approximate 1100 feet of separation between the stations on each end of the passage. This appeared to be enough propagation of the radio signal through the rock to allow a surface to cave communications test. The team returned to the surface to set up the surface station and plan for the second trip, at about 12 PM.

The Park has a linked repeater radio system on VHF that should allow communications from the surface through this system to the gate area of the Left Hand Tunnel. A Park radio was given to the surface team along with procedures for proper use to coordinate the start of the next experiment. The long wire antenna for the surface radio consisted of two 500 foot lengths of #14 wire that could be linked together to form one 1000 foot antenna and a MFJ tuner. The antenna was laid out along the Nature Trail south of the Caverns entrance. The Nature Trail conveniently very nearly aligns over the passage of the Left Hand Tunnel below. The wire was longer than the trail was straight, so the eastern end (far end from the radio) was bent to follow the trail. The surface radio was a Yaesu FT-857D which has additional DSP filtering not available on the underground radios. This was somewhat important due to thunderstorms in the distance (estimated 20 to 30 miles at the closest) creating static and lightning discharges that were peaking up to a S8 signal strength.



Two underground teams went down the elevator, at about 1 PM. One team was going to go ahead to the Beach while the other team stayed near the Gate to be able to coordinate the start with the Park repeater radio. For some reason the Park VHF repeater was not functioning but SSB HF communications were established anyway. We were talking on a wireless radio through nearly 800 feet of rock with only 5 watts of radio power! The signals were at a bare minimum of usability with no indications on the S meter and distant thunderstorm static. An error in connecting the antenna tuner on the surface was found and corrected. The signals went up by nearly 100% in strength and intelligibility but still was not moving the S meter. We had achieved an acceptable level of communications to pass messages between the underground passage and the surface with a voice radio!

The Gate team moved to the Beach and the Beach team went further into the cave to test at various locations along

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the passage as directed by the surface station. The team got as far as the end of the flagged trail (survey station: L32A1) where we still had acceptable communications with the surface and the Beach area station. The Beach station went back to near the First Bridge and established communications with the surface and the Trail End station before going back to the Beach for better signal strength. The surface antenna was switched between 500 and 1000 feet as the underground stations gave signal reports. Little difference was noted between the two lengths. The Trail End station started back towards the Beach stopping along the way to see if any better signal strength could be achieved with the surface.

We had done all of the communications on the frequency of 3.905 MHz (75 meters) and tried a session at 1.975 MHz (160 meters) at survey station D349 with acceptable results. The antenna tuner in the cave was not able to achieve a good match at this frequency so we returned to 3.905 MHz to finish the experiments for the day.

The Beach station also tried a commercial antenna from MFJ which is a base loaded vertical and also used a 50 foot counterpoise (ground) which acts quite a bit like the random wire the other underground station was using, in effect the counterpoise wire has an “end fire” effect with the strongest signals off of the far end of the counterpoise. Various angles of the short vertical were tried with little to no effect on signal strength on either end of the path.

As the Trail End station moved back towards the beach trying different locations, a zone of greatly enhanced signal strength was encountered near survey station D351. The signal strength jumped from not moving the S meter at all to a very robust S8 signal! This equates to a power increase of 35dB! Since we had such good signal strength at 5 watts, the power was reduced all the way to 1/2 watt and we still had a signal strength of S2 from the Left Hand Tunnel about 800 feet below the surface! Wow! A vertical orientation of the antenna underground was tried by letting the wire go down a vertical crack but no real enhancement of the signal was noted. Tom Bemis even made a contact with the surface from the S8 area. After doing a “happy dance”, the S8 station kept moving back towards the Beach and the signal went back to S0 by survey station L24. Back at the Beach, the experiment was over and the underground stations packed up and came up to the surface, just as distant stations were starting to use the frequency. The underground teams could not hear either the thunderstorm static or the distant stations.



S8 signal from 780 feet below!

The surface antenna and station were packed up and brought back to the research huts, at about 5 PM.

On Sunday, May 31st, we coordinated with Stan Allison (and returned the Park radio to him), at about 7:30 AM, for our reentry into the cave, before the tours started, to take photos of the character of the passage and attempt to see if there might be any clues for the zone of enhanced signal strength. There is a ceiling joint along the passage length but no other obvious physical indications of why there should be such a zone of higher signal strengths.

We exited the cave about 9:30 AM, cleaned up the huts, finished the paperwork with Stan and then did a “tourist trip” down the natural entrance of Carlsbad Caverns. Even though we had all done this many times, the trip is always special. Reaching the elevators, we rode up again to the surface to depart for home.

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Conclusions:

Using “off the shelf”, commercially available, amateur radio equipment we were able to establish acceptable SSB voice communications along a significant length of the Left Hand Tunnel and to the surface from the underground.

An area of greatly enhanced signal strength was noted. Theories about this zone need to take into account the possible antenna orientation of the surface to underground antenna, but not far from the enhanced zone the signal strength went down considerably with little change in antenna orientation. The possibility exists that there is an unknown void, probably a large one, between the Left Hand Tunnel and the surface above. The signal strength at the enhanced area is similar to caves in Arizona where we only had about 150 feet of overburden instead of nearly 800 feet. A future trip will be done to try and resolve this area more exactly.

Distances achieved, as measured in the program Compass using the Park data file for Carlsbad Caverns:

End of Trail (L32A1) to First Bridge (DA*2) = 1620 feet (.307 mile or 494 meters)

End of Trail (L32A1) to Beach (BMLHT1) = 1250 feet (.237 mile or 381 meters)

Depth achieved, with passage elevation derived from the Park data file for Carlsbad Caverns and the location of the Nature Trail on the USGS 1:24000 topographic map:

Surface = 4380 feet Left Hand Tunnel = 3600 feet for a depth of 780 feet (.148 mile or 238 meters)

Future:

This amateur radio system may currently be capable of establishing voice communications to key areas of other caves in the Park such as the Lechuguilla EF Junction with about 550 feet of overburden. Licensing restrictions (current system requires a General Class or higher FCC amateur radio license) or possibly a National Park Service authorized frequency in the lower HF band could be used for deep communications in wild caves in the Park.

Further testing in Carlsbad Caverns to try and determine the nature of the signal enhancement zone will be done at a future date. Different antennas and antenna configurations will be used to try and fine tune the system for even better performance. Also, when the Lake of the Clouds area is free from the bat restriction, a maximum depth trip will be undertaken.

Supporting Graphics:

“At the Beach” Left: Rich and Teresa Right: Ray



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Tom Bemis watches Paul adjust the tuner during testing.



Paul at the Surface station on the Nature Trail.



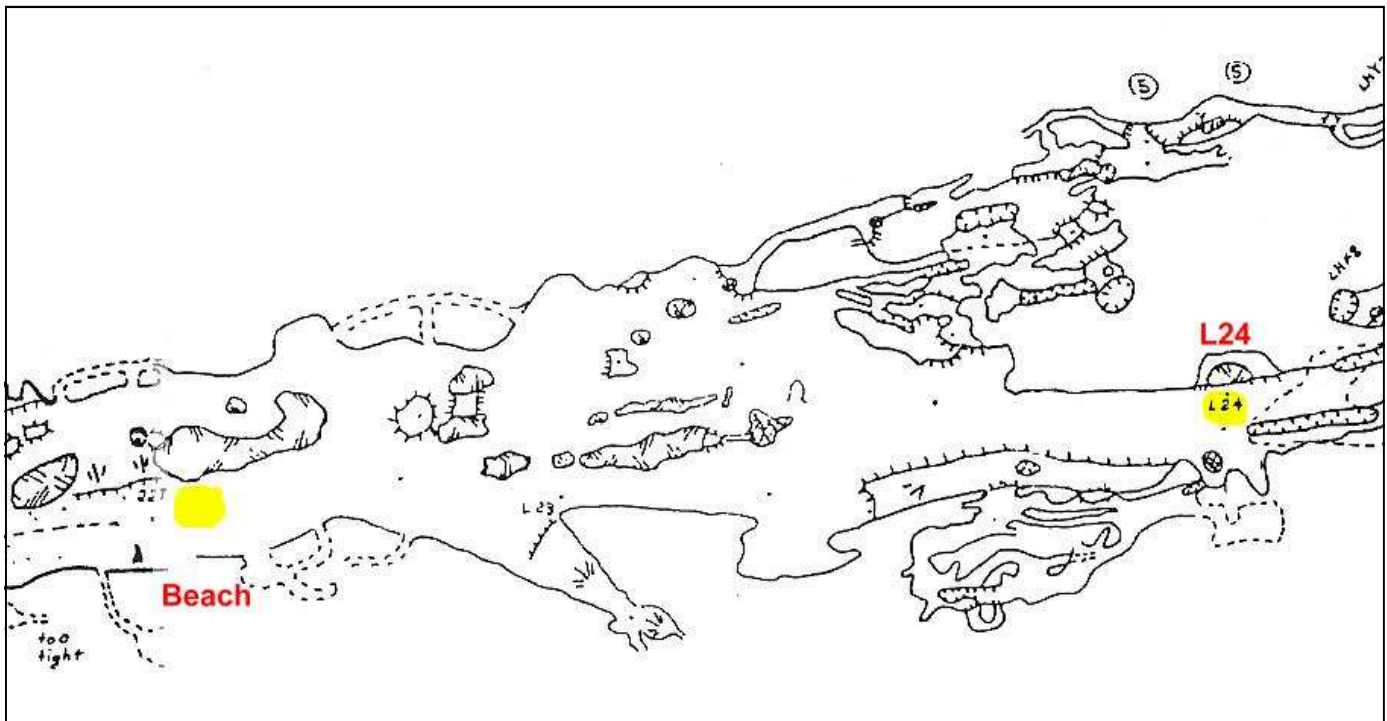
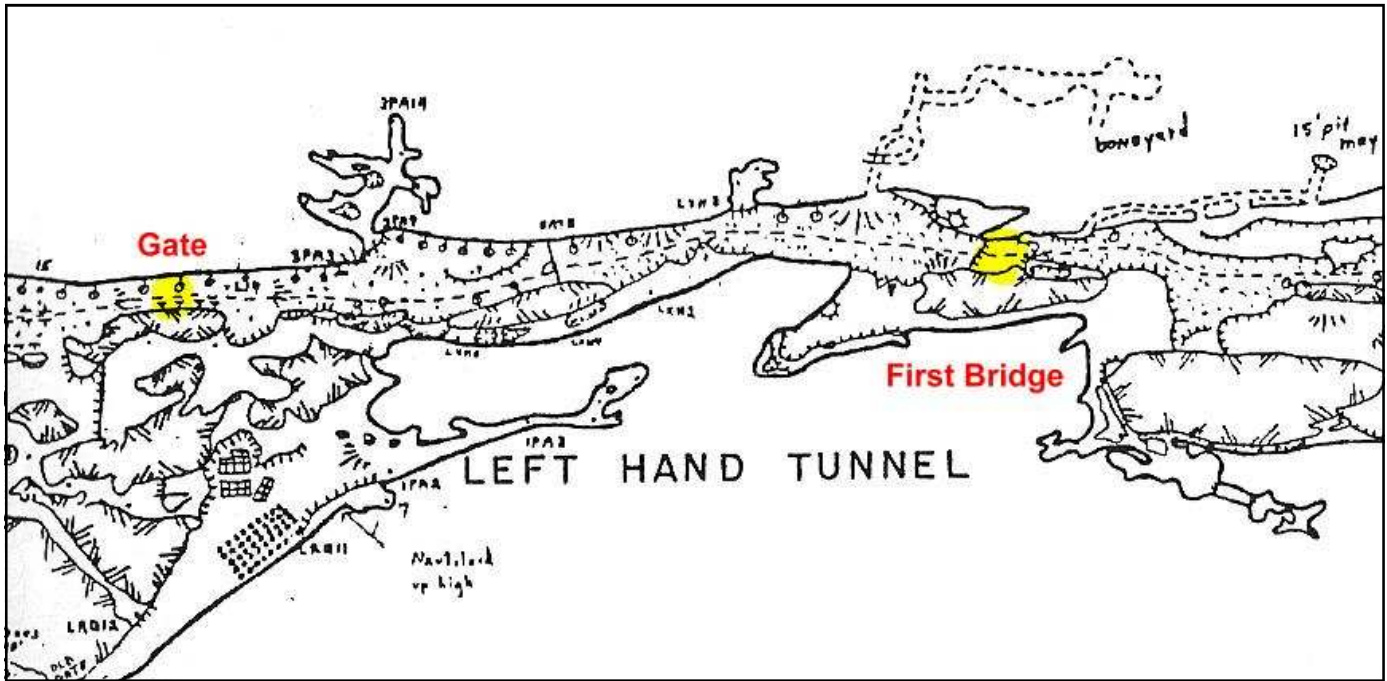
Surface Station Setup

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Testing and other noted locations.

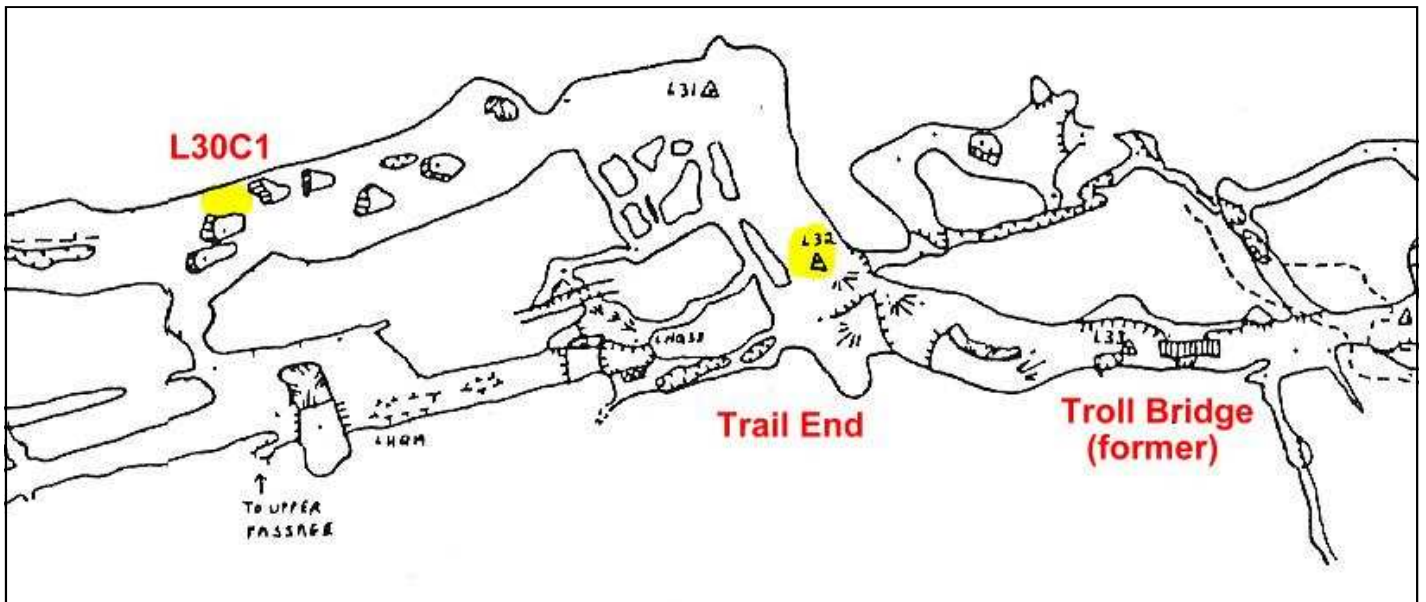
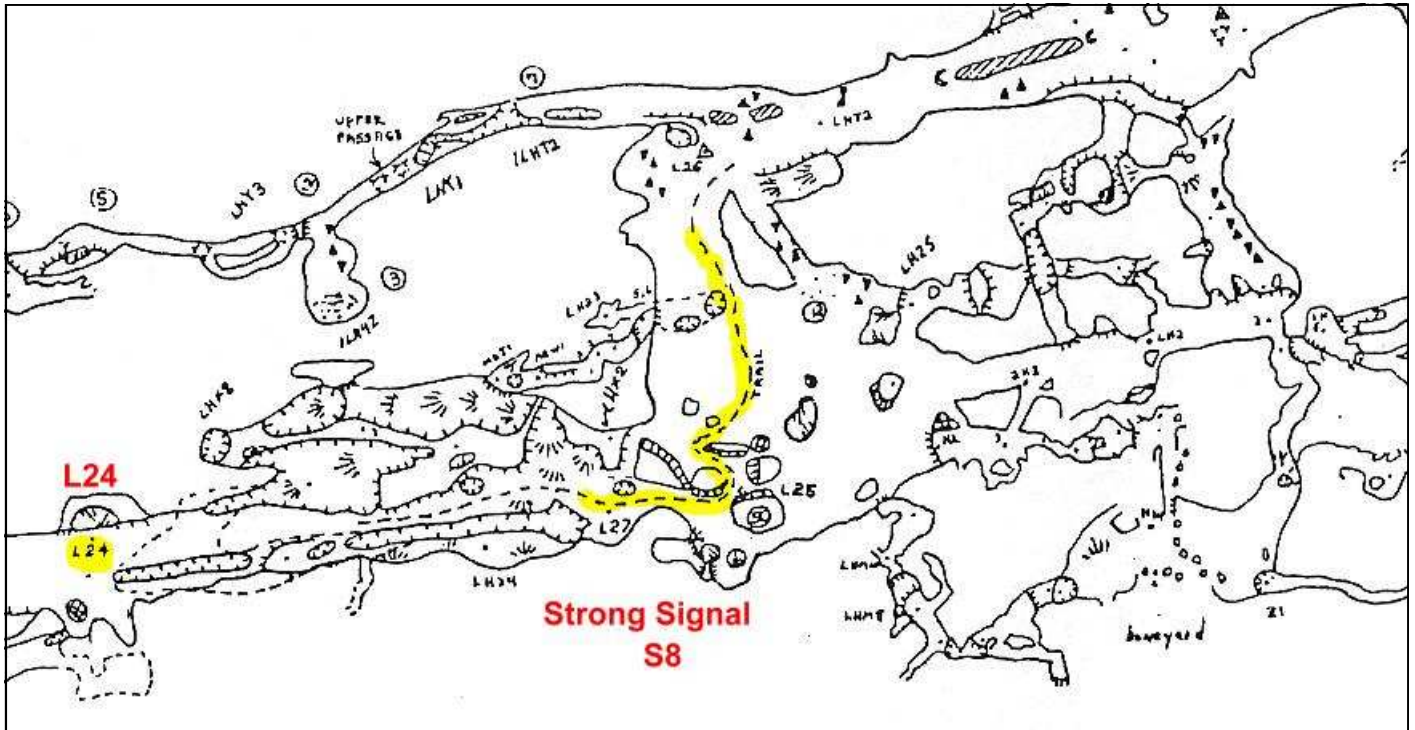


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Passage Character Photos - Left Hand Tunnel

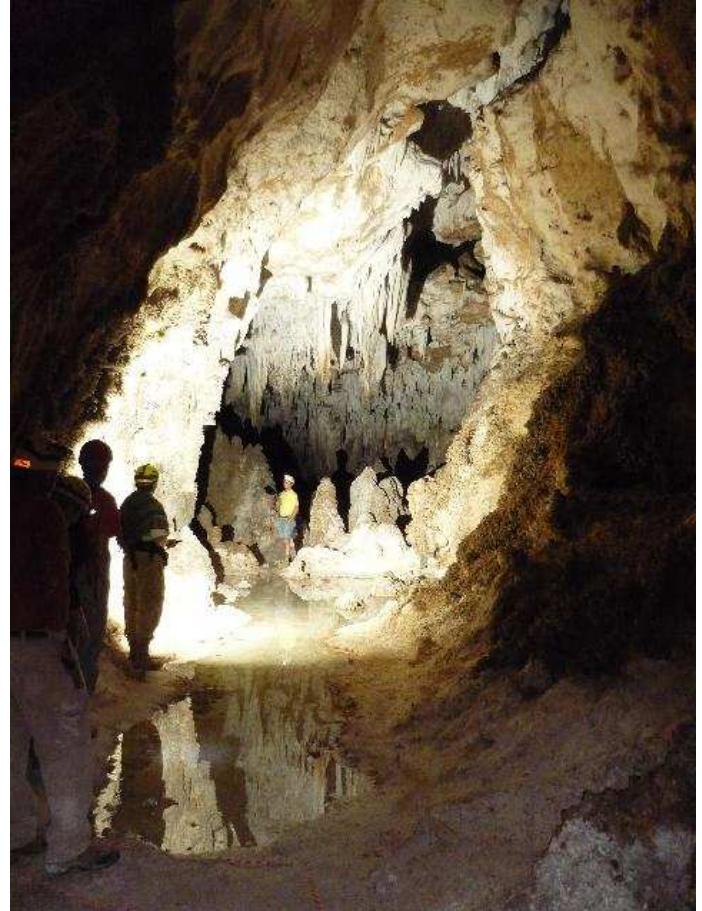


Photo Credits:
Paul Jorgenson (page 4, 6, 9, 10)
Rich Bohman (page 5)
Aaron Hicks (page 5, 6)

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Radio Cavers: (back - left to right) Aaron Hicks KA3UPL, Glenn Tooley K7GET, Ray Keeler KE7CPI, Rich Bohman K7RRB, Teresa Gerrity KF7AEM (front - kneeling) Paul Jorgenson KE7HR