PICCANINNIE PONDS COLLABORATIVE RESEARCH PROJECT

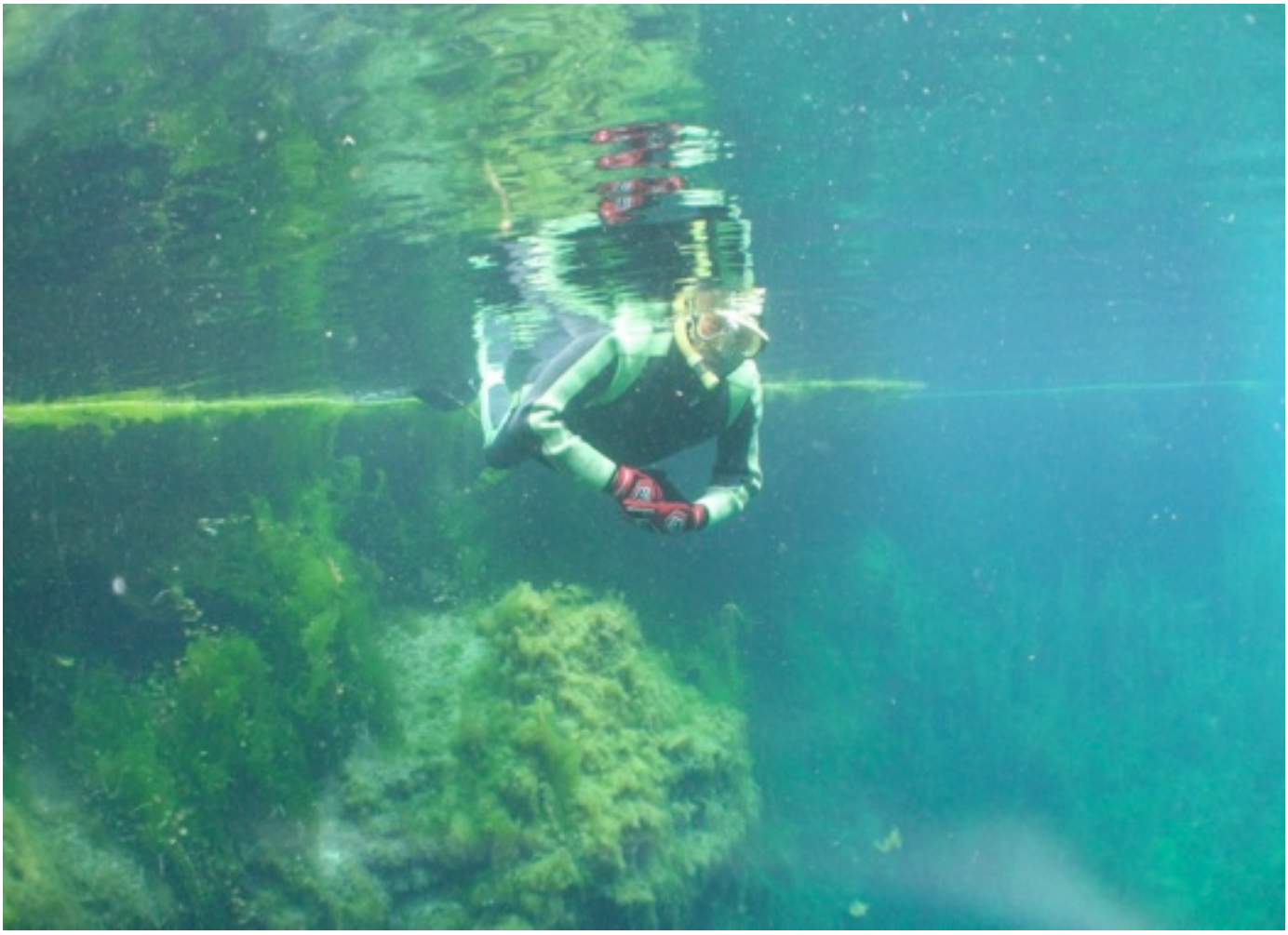
Peter Horne and Dr Richard Harris

BACKGROUND
by RICHARD HARRIS

Piccaninnie Ponds Conservation Park in South Australia's lower southeast is the home of a unique wetland and subaquatic cave system locally referred to as "Pics". The cave system in the conservation park is interesting in many respects, not least because it is one of the few coastal spring-fed features in the area with morphology that varies greatly from the classical solution-collapse cenotes that are endemic to the Mount Gambier karst. As a possible anchialine cave (i.e. an inland cave with probable subterranean connections to the ocean), it also represents a unique ecosystem with enormous biodiversity.

Piccaninnie Ponds was one of the first caves to be extensively dived in the region during the early 1960s, and rumours very quickly developed of the presence of a near-bottomless chasm. Unfortunately it was also the site of three fatalities during the early days of Australian cave diving and so it was soon regulated by the then National Parks and Wildlife Service with a permit system and a maximum allowed diving depth of 36.5 metres for qualified members of the Cave Divers Association of Australia (CDAA) Inc. Over the years, most divers who have visited Pics no doubt wondered what secrets lay in the depths of the cave. It is also likely that many clandestine dives were made to explore the deeper sections, and in more recent times with the advent of mixed gas diving, rumours of a passageway at over 90-100m have been propagated. However by making illegal dives, individuals risked not only their own lives but also the access rights of the law-abiding divers who represent the vast majority of the divers in the Association.

Like everyone else, I for many years wanted to explore the bottom of Pics. Finally in 2006, I put together my



Peter Horne in the very picturesque First Pond

first proposal for a mapping and research project using mixed gas technology. Not surprisingly, the CDAA was initially not enthusiastic about the concept; I learnt that other groups had put forward similar proposals in recent years and all had been rejected. Not being one to give up easily, I decided I needed to find more information to support my quest, so the next two years were spent on a fact-finding mission, reading up on the hydrology, geology and biodiversity of the region. Soon my simple "quest for the bottom" was replaced with a genuine interest in answering many of the mysteries of the ponds ... Where did the water come from? How was the cave formed? Was there a connection with the ocean, and what undiscovered life-forms might live deeper in the system?

(L-R) Team members Richard "Harry" Harris (Project Coordinator), Grant Pearce (Project Manager), Gary Barclay, Linda Claridge, John Dalla-Zuanna and Ian Lewis discuss the dive plan on the walkway to the First Pond. Photo: Peter Horne

With this renewed interest I approached the Department for Environment and Heritage (DEH). At that time there was increasing interest in groundwater use and the potential impact of industry and agriculture on the aquifer; Piccaninnie Ponds was already showing signs of stress and there were plans afoot to study these changes.

Suddenly the idea of deep-water sampling and tracking of water flow became much more appealing to the DEH; the development of the National Water Initiative also meant that water was politically red hot with monies becoming available for research. It would, however, take a further 18 months of negotiations, and with the assistance of local cave diver and environmental scientist Grant Pearce the final permissions were granted in early 2009. The last issue was resolved when the CDAA kindly agreed to indemnify the dive activities as a Special Project.

PROJECT GOALS
by PETER HORNE and RICHARD HARRIS

With the intention of commencing the first-ever collaborative project between the DEH and volunteer cave divers, it was important to have some clear goals. Good baseline studies of such variables as water quality ("nutrient flux"), flow rates and sources, biodiversity and temporal trends had been performed in the Piccaninnie Ponds complex during the last 30 years, and the DEH expressed their desire to further develop a better understanding of all facets of the hydrology of the system.

None of the above issues could be studied without understanding the morphology of the site, so the production of a map of the complex was the first task. A mapping project coordinated by fellow project team member Peter Horne had been undertaken in 1984/5 and this provided good detail to a depth of approximately 50m in the chasm and 40m in the Cathedral, so the

Grant Pearce and John Dalla-Zuanna preparing to dive with Colleen Bernie in the background. Photo: Ken Smith

current research team thus aimed to provide detail from greater depths, along with information about temperature, water flow, geology and any fossils or fauna seen.

TRIP 1 PROJECT ACTIVITIES: 2-4 MAY 2008

The divers involved in the initial dives were Richard "Harry" Harris, Grant Pearce (Access Coordinator, mapping & support) and John Dalla-Zuanna (aka "JDZ", taking video). Before the diving commenced, a shot line was placed in the Chasm with emergency and

Looking down along the Sandy Track

decompression gases attached; careful placement also ensured that there was minimal disturbance to the aquatic plants. The dives are described below to give readers a feel for how the discoveries unfolded.

Friday 2nd May

Grant (on open-circuit trimix) first performed a dive in the "Bathtub" area at the bottom of the "Cathedral" in order to search for reported leads into deeper sections of the cave, and several potential areas for further exploration were identified. JDZ and Harry (both on trimix rebreathers) dived in the "Chasm", laying a line from the tie-off peg at approximately 36m down the "Dog Leg" to the "Saddle" at 53m. At this point the Dog Leg passage narrowed and they had a choice of two holes, right and left. The right hole dropped into a small chamber that connected laterally to the space beneath the left, while the left hole continued down and further left (east) into a vertical slot at 56m. Through that slight restriction they entered "The Sandy Track"; a more gently-sloping, tube-like passage one to two metres across and about a metre high with a silty rock floor (which also contained a number of very old, discharged photographic flash bulbs).

This passage continued down to the south-east at a slope of about 45 degrees to a depth of 70 metres, where they entered a small room running approximately north-south. The floor here was at a depth of 73 metres, and to the right, a narrow fissure ("The Cascades") dropped to 80 metres.

JDZ paused here while Harry entered the fissure. At 80 metres, a white guideline was found tied off to the wall, and a large mass of loose line caused him some delay with his descent while he gathered it up before dropping towards the bottom of the fissure. Harry then followed the white line to a depth of 90m in a more open but very silty chamber (probably the long-rumoured "Subway Station").

The Cascades at about 70 metres. This is like a miniature version of the Saddle in the Dog Leg. The way on is via the tight fissure on the right.

At this point, the dive was turned and they both surfaced safely after their decompression at 180 minutes. JDZ also recorded a video of this dive, and on reviewing this it appeared that there was definite flow coming up out of the fissure at 75m, where rising silt could be seen.

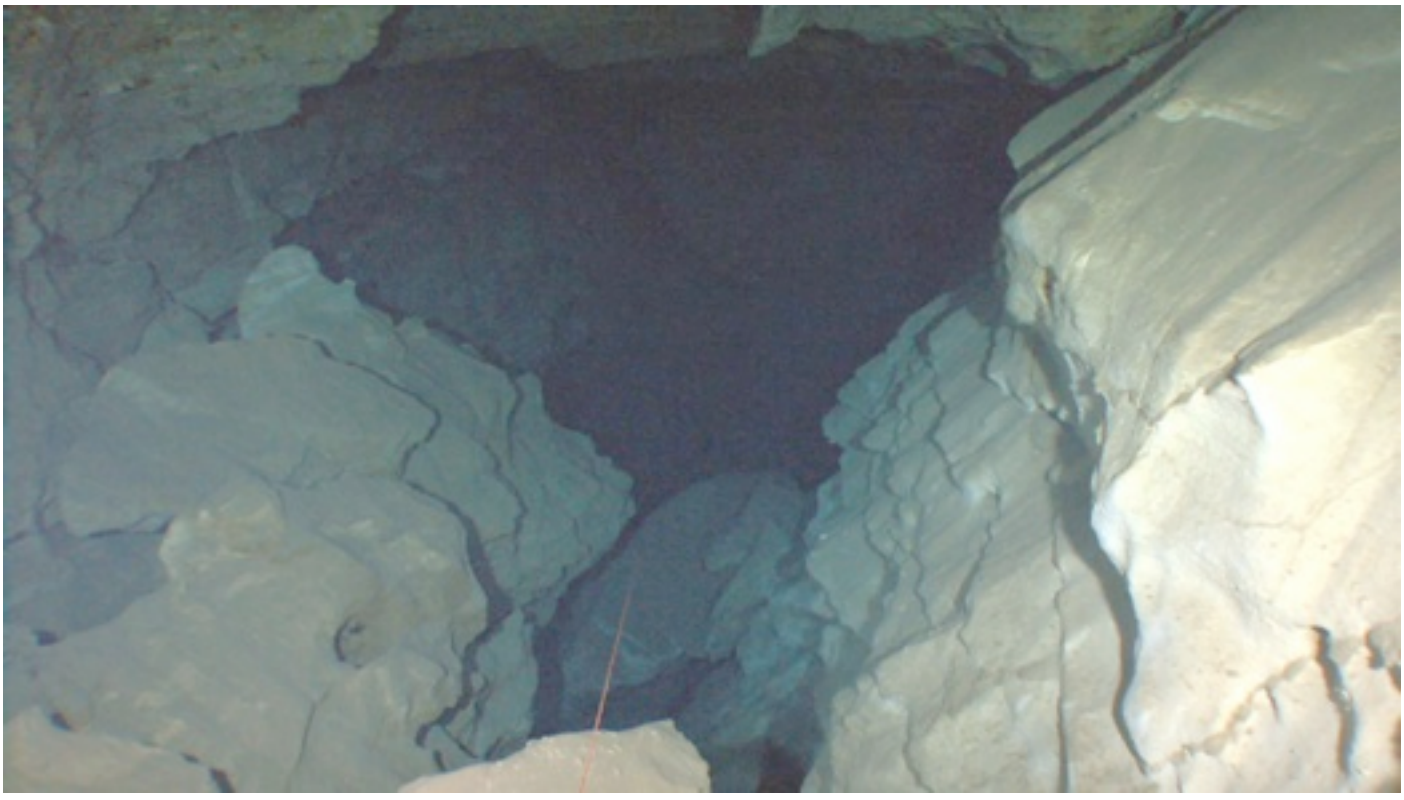
Saturday 3rd May

JDZ and Harry dived in the Chasm again and quickly followed their line to the top of the fissure at 74m. Harry dropped through the fissure to the old white line and followed it down to 90m noting a horizontal passage approximately 15m long heading west towards the Cathedral side of the system. At 90m the white line ended in a tie-off on the eastern wall. No other line was found in this area, so after tying off a new line Harry pushed down and to the west slightly until at a depth of 105 metres the floor came into view, containing several holes roughly 2 x 1m across. Harry dropped into the last of these, but the very friable chalky silt quickly enveloped him and all visibility was lost. He did, however, note that the soft silt floor was at a maximum depth of 110m.

Looking straight down into the deepest known area of Piccaninnie Ponds (110 metres) in several silty holes in the floor of the Subway Station.

Rising above the silt, Harry then noticed that any further exploration to the west appeared to be blocked by a large boulder. However as he ascended he realised that there was a passable gap between the top of the boulder (which he called "Sentinel Rock") and the ceiling of the Subway Station room. Swimming over the top at a depth of 96 metres, he entered clear water again and the gap between floor and ceiling increased. Suddenly, Harry found himself "...staring into space, my light barely illuminating the opposite wall of a large chamber! For me, this was a once-in-a-lifetime moment of pure joy as all the work of establishing the project was rewarded, with interest!" This fabulous room is now known as the "Chamber of Secrets".

With the clock rapidly ticking towards his maximum bottom time, Harry reeled out approximately 30m across the chamber, intermittently tying off on the silty floor boulders. The chamber curved to the right before slowly narrowing and ending in a sheer wall. The maximum depth at the end of the chamber was 107m, and several promising leads were noted around the perimeter. At exactly 30 minutes he made his final tie-off and swam out of the cave, surveying the line on the way out. In places, fossil scallop shells were noted embedded along the walls, and what looked like large "yabbie" tracks (?



Harry's first glimpse of the Chamber of Secrets took his breathe away!

John Dalla-Zuanna at the end of the Chamber of Secrets.

Cherax sp.) were also noted in the floor silt. There were no signs that anyone had ever visited this area of the cave previously (although naturally this possibility cannot be completely ruled out), and Harry's total dive time, like many of the dives to follow, was around four and a half hours.

Sunday 4th May

JDZ and Harry again visited the deep section at the bottom of the Dog Leg, with the intention of taking water temperature measurements in different areas of the cave and to video the new sections. JDZ led while Harry followed with the video-camera, and with a permanent line now installed, the dive to the end of the new large chamber was easily completed in 20 minutes. Grant also dived to 80m and collected some water samples in the cave.

The outcomes from these first very exciting dives clearly showed that further dives and more detailed mapping involving the use of RDF "pingers", tapes and compasses was required to enable us to better understand the geomorphology of the Piccaninnie Ponds system. Some promising leads were found in the Chamber of Secrets, the Subway Station and at the bottom of the Cathedral, and along with more water sampling and biodiversity studies a detailed evaluation of the water flows in the Cathedral and the 75m fissure also needed to be carried out.

SUMMARY OF INITIAL FINDINGS

1. A significant amount of deep passage and chambers were found to exist beneath the chasm, trending in the general direction of the Cathedral. Video and preliminary survey data was also recorded.

2. There is apparent flow into the cave at depth, and this water may be welling up through the fissure into the Chasm and hence supplying much of the pond system. A point source has not yet been located.

3. The cave is extremely tight and silty in parts below a depth of around 74m, with the walls and rocks all covered in a thick coating of very friable "cheesy" silt. Much of the dive between 74 and 95 metres is spent in very low or zero visibility.

4. Fossils were found below 90m.

5. Tracks (most likely "yabbie", Cherax sp.) were observed in silt at approximately 105m.

6. Water temperature was recorded via depth gauge-mounted digital thermometers as being a consistent 16 degrees C from just below the surface to the maximum depth of 110m.

7. While some researchers have speculated that a seawater-based halocline may have infiltrated the deeper areas of the Chasm, no related changes in water visibility were observed anywhere in the system.

Figure 6: Harry's preliminary extended section sketch of the new deep sections found at the bottom of the Chasm in Piccaninnie Ponds.

TRIP 2 PROJECT ACTIVITIES: 27-29 JUNE 2008

The divers involved in the second mapping and research trip formed two teams: Team One (the "deep" team) comprised May 2008 project members Richard "Harry" Harris, Grant Pearce and John "JDZ" Dalla-Zuanna as well as Linda Claridge (mapping & support) and Ken Smith (mapping, support & photography) who utilized both rebreather and open-circuit (scuba) trimix technologies to explore the deepest areas of the Chasm and Cathedral areas of the Ponds, and Team Two (the "air" team) comprised Ian Lewis (mapping & support/ geomorphological documentation) and the author (mapping & support/video & photography), who undertook other mapping and research work in the shallower areas using scuba (air only). Gary Barclay was unfortunately unable to dive, but he still provided an invaluable support role in many ways (as did his partner Linda), including refilling scuba cylinders and supplying much-appreciated heat-packs and warm drinks for the often-chilled members of the dive teams.

The key objectives during this trip included:

• the continuation of the exploration and mapping of the deepest areas of the Chasm (The Chamber of Secrets etc), incorporating Ken's radio-location "pingers"

• videotaping these areas to aid both mapping and research activities

• exploring and mapping the deeper areas underneath the Bathtub in the Cathedral

• evaluating possible water flow areas (including a "Hot Spot" previously reported in the Cathedral) and recording temperatures etc of same

• collecting samples of water, rock and silt from specific areas

• noting and sampling fossils and general biodiversity aspects, and

• linking the 1985 "shallow" survey to the new "deep" survey.

SUMMARY OF SECOND WEEKEND FINDINGS

These dives resulted in a number of very interesting observations. Perhaps most importantly, the deepest areas of the Dog Leg passage (i.e. the Chamber of Secrets etc) were more thoroughly explored and visually-captured for the first time on high-quality (three-chip CCD) videotape, and it was determined that no major passages were found leading off or going deeper than the presently-known Piccaninnie Ponds system, although numerous possible leads still await further exploration The observations of apparent water flow and temperature variations in the system, especially in the Cathedral and the Hot Spot, require much more extensive investigation

The unexplored main rift in the NW corner of the Chamber of Secrets with its interesting strata and morphology.

using a range of techniques to measure these aspects. A number of aspects requiring more detailed mapping in relation to omissions made during the 1985 project (e.g. the northern wall of the Chasm being much more complex and ragged than has been recorded previously) were also noted.

The team was also very fortunate during the weekend to (literally) receive a "drop-in" visit by internationally-renowned cave diving explorer and film maker Andrew Wight, who parked his sleek blue helicopter in the paddock at the end of the carpark track and very kindly took Ian, Linda and Peter for an extended flight over the entire wetlands system. This valuable excursion resulted in the discovery of a number of interesting pools and lakes which Peter videotaped using Harry's video-camera so that they could be accurately located and explored later in this study.

TRIP 3 PROJECT ACTIVITIES: 29 OCT – 1 NOV 2009

The third trip once again involved a considerable amount of research and other work. The party on this occasion comprised Richard "Harry" Harris, Grant Pearce, John "JDZ" Dalla-Zuanna, Ken Smith, Ian Lewis and Peter Horne, along with new team members Liz Rogers, Chris Edwards, Dean Chamberlain and Jim Arundale, and (non-diving) Department of Water, Land and Biodiversity Conservation (DWLBC) staff Dave Sturges, Paul O'Connor and hydrogeologist Claire Harding. Grant's son Aaron also helped in various ways, including shuttling gear to and from the pontoon.

Because so much new information and mapping data had been collected about the deeper areas of the Piccaninnie Ponds system, JDZ was able to produce a stunning computerised 3D representation of the known system which not only enabled the research team to showcase Pics to members of the CDAA but also to the Department for Environment and Heritage and scientists/resource managers at the Department of Water, Land and Biodiversity Conservation. Very importantly, Grant was also able to utilise this new information to plan the placement of hydrogeological monitoring devices by the team's divers to facilitate a longitudinal study of electrical conductance at three locations in the system, and it is hoped that the data obtained from these instruments over the next few years will greatly increase our understanding of this important groundwater-dependent ecosystem.

The primary goals of this 4-day diving period included:

• the installation of three hard-wired water quality data-loggers in areas that best represented possible water outflow and mixing areas in the spring system;

• obtaining temperature, pH and EC data from multiple levels using a water sampling device drawn through the water column, and obtaining water samples from different locations and depths for more detailed analysis;

• continuing the exploration and mapping of the Cathedral side of the system; and

• exploring and assessing selected areas of the surrounding swamps and wetlands for undocumented yet potentially significant flooded karst features.

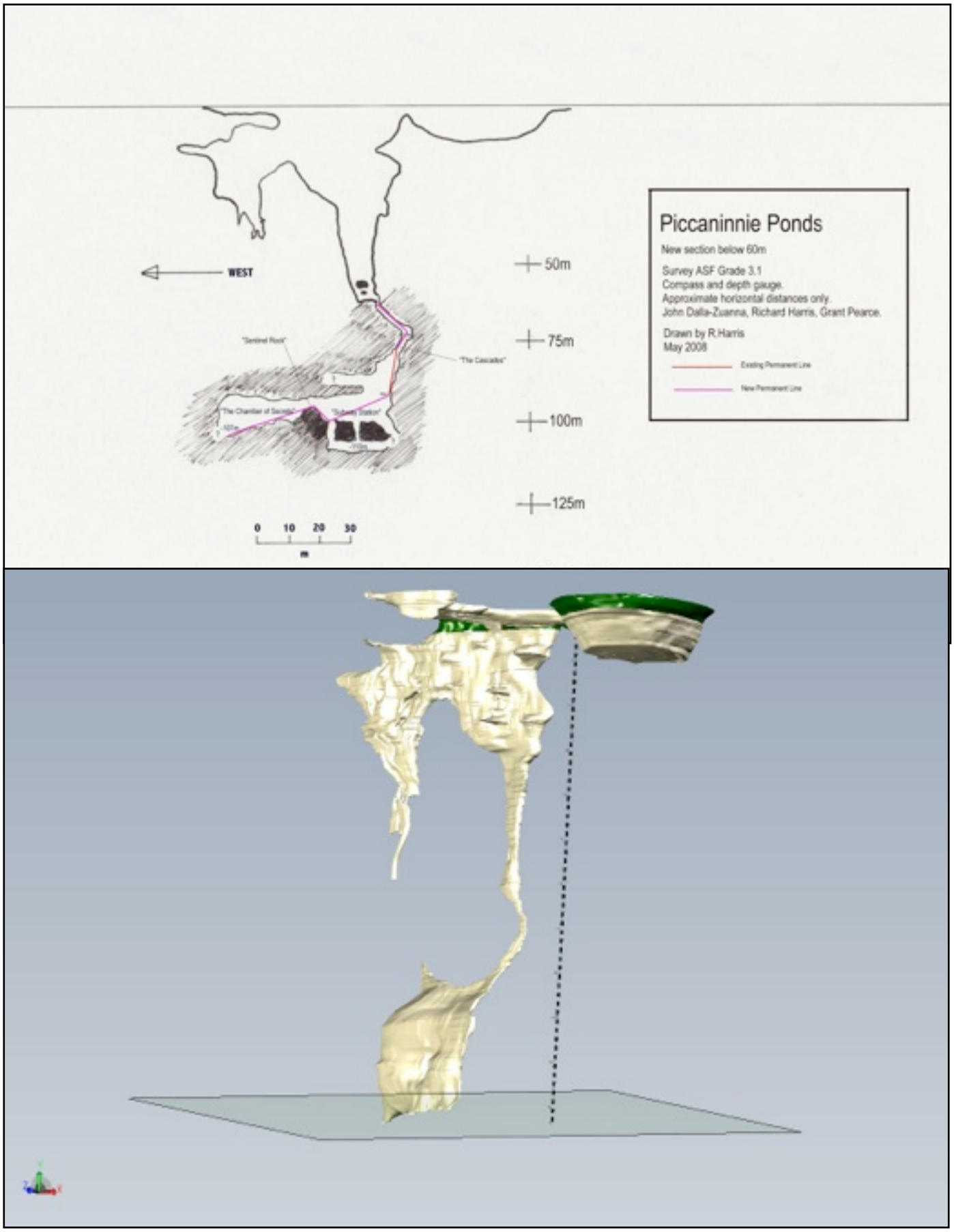
CONCLUSIONS

This first paper describes the cave diving research activities in Piccaninnie Ponds which were undertaken in 2008 and 2009. For the study participants, the opportunity to start to unveil some of the secrets of this world-class groundwater dependent ecosystem has been tremendously exciting. As with many such projects, every answered question and every new discovery has led to even more questions and more theories about the genesis of this unique site. We are just scratching the surface in terms of understanding the hydrogeology of the Piccaninnie Ponds spring system and we await with eager anticipation the results of the many water and rock samples that we have helped source.

Ian Lewis also utilised his geomorphological knowledge and experience during this project to more thoroughly record the physical structure of Piccaninnie Ponds. From underwater observations and measurements he made of wall features as well as our underwater images, Ian found that significant water level fluctuations and flow regimes appear to have occurred over at least 20,000 years, reflecting sea level changes and some past climatic indicators. Furthermore it is possible that the system contains old water level features and some geological features that extend back more than 125,000 years (perhaps to 220,000 years) which are the two lowest Ice Age sea levels prior to the most recent episode.

As this first phase of the study concludes, we embark on the second phase which should prove equally productive. The longitudinal analysis of water chemistry now commences thanks to the positioning of the data loggers in the spring, and ongoing maintenance of this equipment will provide the opportunity for further dives. Numerous parts of the system also require further exploration, including the Bathtub area of the Cathedral, the horizontal rifts between 85m and 100m in the bottom of the Dog Leg, and some small karst features in the surrounding wetlands. Ian and Grant also feel that these features may hold vital clues to the possible volcanogenic genesis of the system.

This study has also been groundbreaking for CDAA divers from the point of view of collaborative research with government departments. A great deal of effort has gone into organising a framework within which volunteer divers can work alongside the DWLBC and DEH, and we hope this may open the door for other similar collaborative studies in the future. Deep technical cave diving carries a small but real risk, and it is a credit to the CDAA's training proficiency and to the professionalism of all the divers that the project has been conducted without any significant incident.



A sketch of the new deep section of Piccaninnie Ponds and a 3D version produced by John Dalla-Zuanna