Russell Latter in Ewens Ponds in 1985. Photo by his uncle, Ian Saunders using a Nikonos III. Russell was 15.

Cave Divers Association of Australia

C.D.A.A. Newsletter

No. 151 - MARCH 2020

GUIDELINES

CAVE DIVERS ASSOCIATION OF AUSTRALIA

(Incorporated in South Australia)

Print Post No. PP 100023987

CONTENTS

Editorial - Meggan Anderson	5
National Committee Updates	6-9
Instructor List	35

Articles...

Junee Cave Expedition, Pt2 - Stephen Fordyce	10-17
Thai Cave Rescue Re-enact - Stephanie Looi	18-20
Vertical Access Workshop - Tim Featonby	22-23
High Altitude Decompression - Beat Muller	24-34

Cover:

Steven Fordyce Sump No. 2.

Photo by Stewart Donn

CAVE DIVERS ASSOCIATION OF AUSTRALIA

ABN 65 062 259 956

P.O. BOX 544, Mt Gambier, SA 5291

GUIDELINES is a newsletter of the Cave Divers Association of Australia. All articles for the following issue are to be sent to the Publications Director, Email: publications@cavedivers.com.au

CONTACT LIST

Please contact the most relevant person or, if unsure write to:
C.D.A.A. P.O. Box 544 Mt Gambier SA 5291 www.cavedivers.com.au

NATIONAL DIRECTOR - Peter Wolf
Email: national@cavedivers.com.au Mobile: 0413 083 644

Science Officer – Ian Lewis Mobile: 0427 284 051
Email: science@cavedivers.com.au

Media Contact - Peter Wolf
Email: media@cavedivers.com.au Mobile: 0413 083 644

Risk Officer – Peter Wolf Mobile: 0413 083 644
Email: risk@cavedivers.com.au

Search & Rescue Officer - Richard Harris
Email: sar@cavedivers.com.au Mobile: 0417 177 830
Phil Croker 0423 393 347

STANDARDS DIRECTOR - Joseph Monks Mobile: 0409 792 480
Email: standards@cavedivers.com.au

Quality Control Officer - Joseph Monks Mobile: 0409 792 480
Email: quality@cavedivers.com.au

BUSINESS DIRECTOR - Mary-Anne McLeod Mobile: 0401508838
Email: business@cavedivers.com.au

CDAA Products - Victoria Hudson Mobile: 0439 558 700
Email: products@cavedivers.com.au

Bookkeeper - Vacant
Email: accounts@cavedivers.com.au

SITE DIRECTOR - Kelvyn Ball Mobile: 0428 842 259
Email: site@cavedivers.com.au

Mapping Officer - Tim Payne
Email: mapping@cavedivers.com.au Mobile: 0448 147 927

Tank Cave Booking Officer - Noel Dillon
Email: tankcave@cavedivers.com.au Mobile: 0407 530 103

Kilsbys Booking Officer - Craig Larkin
Email: kilsby@cavedivers.com.au Mobile: 0418 821 191

Lady Nelson Booking Officer - Adam Hair
Email: ladynelson@cavedivers.com.au Mobile: 0418 333 718

Shaft Booking Officer - Gary Barclay
Email: shaft@cavedivers.com.au Mobile: 0407 527 921

Bakers Booking Officer - Matthew Skinner
Email: bakerscave@cavedivers.com.au Mobile: 0401 007 094

Little Blue Booking Officer - Victoria Hudson
Email: littleblue@cavedivers.com.au Mobile: 0439 558 700

PUBLICATIONS & RECORDS DIRECTOR - Meggan Anderson
Email: publications@cavedivers.com.au - Mobile: 0415 291 904

Records Officer - Brendan Moore Mobile 0407183522
Email records@cavedivers.com.au

Guidelines - Graphics & Advertising - David Bryant
Email: guidelines@cavedivers.com.au - Mobile: 0417 125 710

Webmaster: Rowan Stevens Email: web@cavedivers.com.au Mobile: 0417 550 509

STATE REPRESENTATIVES

ACT: Alasdair BLAKE. Mob: 0404 823 007 Email: actrep@cavedivers.com.au
NSW: Ryan DUCHATEL. Mob: 0419 268 714 Email: nswrep@cavedivers.com.au
N.T.: Jeffrey SWANN. Mob: 0419 561 515 Email: ntrep@cavedivers.com.au
QLD: Ben SHIELD. Mob: 0405 260 276 Email: qldrep@cavedivers.com.au
SA: Damian BISHOP. Mob: 0433 345 743 Email: sarep@cavedivers.com.au
WA: Geoff PAYNTER Mob: 0407 445 112 Email: warep@cavedivers.com.au
VIC: Benn Walton Mob: 0412 751 873 Email: vicrep@cavedivers.com.au

Public Officer - Andrew Seifried Mob: 0404 275 637
Email: publicofficer@cavedivers.com.au

CDAA INSURANCE

Web Site PDF: http://www.cavedivers.com.au/public-documents
Policy Type: Affinity Combined General & Products Liability Policy – LIU-CAS-AEAL-14-01
Insurer: Affinity Insurance Brokers Level 1, 1265 Nepean Highway, Cheltenham. VIC 3912.
Underwritten by Liberty International Underwriters ABN: 61 086 083 605.
Incorporated in Massachusetts, USA.
Name Insured: Cave Divers Association of Australia Inc. **Policy#** 441680
Public Liability: $20,000,000 any one claim. **Expiry:** 30th September 2020.

Dear Members

Happy New Year and welcome to the first Guidelines issue for 2020. I want to thank everyone who contributed to this issue, having a lot of material meant that it was less time consuming getting this issue together. Please keep those contributions coming in 2020 and that includes photography for the cover!

On the records front it has been business as usual along with trying to keep the website and system ticking along. The year has only started and we've already issued three visitor permits, if you have friends from overseas coming over, make sure you tell them to get their applications in early as they do need to be assessed and approved by the whole of the National Committee. If you're a sponsor, please also check your responsibilities in the Regulations.

After this issue it won't be long before our busy membership renewal period starts, if you want to help us out by getting in early that would be great! I've noticed a few of you have already got your renewals in so thanks for that.

Until next time

Meg

Publications and Records Director

Meggan Anderson #4942 | *Publications and Records Director*
M: 0415 291 904 | E: publications@cavedivers.com.au

Articles for Guidelines June 2020 - Deadline is May 10th

- **Send articles and jpeg images by email to guidelines@cavedivers.com.au**

Did you know?

You can opt for an electronic copy of Guidelines rather than a paper copy. ***Simply login to your CDAA online account***, select the dropdown menu under the My Records tab and click on Update My Details. Handy for those who have multiple CDAA members in their household or for those wanting to do their bit for the environment!

For much of the CDAA's 47-year history, our members have shared a "symbiotic" relationship with the regional communities around "cave-country". One of the most obvious examples of this is, of course, Mount Gambier.

Working alongside landowners and managers, the CDAA, a not-for-profit volunteer-run Association, has facilitated access for over 5300 cave divers it has certified in Australia, to caves around Mt Gambier and across the Lower South East for nearly five decades.

As a result, CDAA members have visited the region in significant numbers each year, with many of the CDAA's current 700-plus members making numerous return trips annually, typically staying for 3-4 days (and often longer) each time. During its lifetime, the CDAA has also introduced many international cave diving visitors to these regions.

It has been a wonderful, mutually beneficial relationship. The surrounding communities have benefitted as our members have travelled across the country to spend their hard-earned money on accommodation, air-fills, at shops, pubs, petrol stations, restaurants, cafés and across many other local businesses. In return, CDAA members have been granted the privilege of accessing, exploring and enjoying the amazing natural cave features in these areas, for the most part, free of charge. In the background, the CDAA has developed the booking systems, maintained the procedures and upheld the standards to ensure that it all happens without any hiccups.

However, over the last few years cave diving associated activities around Mt Gambier have attracted an unprecedented level of commercialisation. It is inevitable that the CDAA would eventually be impacted by this changing landscape.

Last month we were notified that from July 1st, Forestry SA will be charging CDAA members for access to Forestry dive sites. This charge will most likely be applied on a per-dive basis. It is our understanding that at least one other land manager is also considering introducing a similar fee structure.

Historically, the application of fees at cave diving sites has resulted in significant drop-off in visitation. Most recently we observed this first-hand at Tank Cave, despite it being one of Australia's most extensive and amazing cave diving sites. The stagnating visitation was one of the primary reasons this committee abolished the fees there a little over a year ago. Since this time the number of divers visiting Tank Cave has increased dramatically.

This type of drop-off is something we would all like to avoid. However, for the many CDAA members who visit the Mount Gambier region numerous times per year, undertaking several dives-per-day over multiple days, it is likely that the introduction of fees per-dive will make it unviable to maintain the same frequency of visitation.

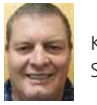
As Forestry sites are also a staple for CDAA Cave and Advanced-Cave level training, how such fees might impact course costs as well as future student numbers will also need to be taken into account.

Fortunately, Forestry SA have graciously provided the CDAA with an opportunity to discuss the terms of their proposal, and these are just some of the issues we will need to work through over the next few months. As always, we will advocate for our members to ensure that their interests as well as those of other stakeholders are taken into consideration.

Warm Regards, Pete
CDAA National Director

On behalf of the National Committee


Mary-Anne Mcleod, Business Director


Kelvyn Ball, Site Director


Joseph Monks, Standards Director


Meggan Anderson, Publications and Records Director

The first quarter of the year is a relatively quiet time for Business Director which has given me the opportunity to ensure the accounts are up to date, further review financial controls including the Paypal setup and streamline processes.

Victoria has been investing some time reviewing the Products portfolio and is currently working on a range of merchandise that will be available to members. Keep a look out for the opportunity to place an order!

It is now time to start the planning for the 2020 AGM that will be held in Mount Gambier in late October. We are currently scoping ideas for speakers, so please get in contact if you have suggestions or contacts. Further, if any members would like to assist in the planning and co-ordination for the day let me know, your help would be much appreciated.

Mary-Anne McLeod #5011
Business Director

Hello Team,

I hope everyone has had a great break over Christmas and a fantastic start to the new year. We have had a number of courses conducted over the break, with the instructor body working closely with new members who are beginning on their paths as cave divers and for others who are advancing. Hats off to all the instructors, thanks.

Over the past few months I have been unable to dedicate the usual amount of time to CDAA projects as a lot of my time has been eaten up through focussing on dealings with some individuals who seem to feel that they are outside of any accountability. Please remember that open communication is always invited and encouraged within the CDAA, this is beneficial for everyone.

As mentioned previously, we have had past members re-joining the CDAA, this is great to see. We all know that life can take us a different path but the CDAA has been around for over 40 years and will be around for many more. We have also had enquiries from people overseas doing cross overs as they appreciate the site related skills/access that we incorporate into our courses and aspire to dive the Australian caves in the safest way possible.

Tim Featonby #3372 conducted a free climbing workshop incorporating a clean-up day at Hells Hole. The member turn-out was great and from all accounts it was a big success. Thanks Tim Featonby for organising this great opportunity for the members.

I would like to congratulate Ryan Duchatel #4983 for starting his Basic Cave intern, Chris Edwards #2247 for starting his Cave intern and Josip Bicanic #4691 for Advanced Cave intern. You are all fantastic ambassadors for the CDAA, and I look forward to seeing you finish so you can pass on the knowledge to a fresh bunch of cave divers.

I would also like to take this opportunity to thank the current instructors. As many of you will know, to become an instructor you are required to complete two internships with current instructors. It falls to the instructor body, not the National Committee, to assure the quality of the candidate as they are the experts in this area. I would encourage any instructor to give an intern a chance, even if you do not know them.

Thanks team!

Dive safe and within the standards,

Joseph Monks #4653
Standards Director

Welcome to the New Year! Ready for another year of diving our incredible sites?

In January I visited quite a few of our landowners for a catch up on how things are going and received a very happy response. Some of the landowners/staff that don't dive, enjoyed a good chat about the things we see in our underwater world.

Also in January, I and a lot of enthusiastic divers joined Tim Featonby in a climbing course he was running. A lot of new skill sets were setup for attendees to challenge over 2 days. Some of the dive sites we used for training was a sinkhole near Piccanninie Ponds and Caroline Sinkhole and the other was Hell's Hole which we used for training and a clean up in the site on the second day.

Three Sister's - I attended a meeting on site at Three Sister's with Grant City Council on Feb 7, 2020 about regaining access to this site. Discussions re parking, track access and how to set up A Frames etc to get divers in and out safely. Hopefully an outcome soon.

FYI Just a heads up that Forestry's have proposed putting a price on their dive sites as of July 1, 2020. More information to come.

Qld State Rep changeover. Joseph Monks has stepped aside and endorsed Ben Shields to takeover this role. Thank you Joe for all the time and effort you have put into running events in the Qld state. Welcome Ben.

Finally, just a general reminder to stay safe, clean up and be fire safety aware whilst attending CDAA sites.

Catch you in the next quarter!!

Cheers Kelvyn Ball – Site Director

JF-8 Junee Cave, ASF Diving Expedition Report

PART 2.

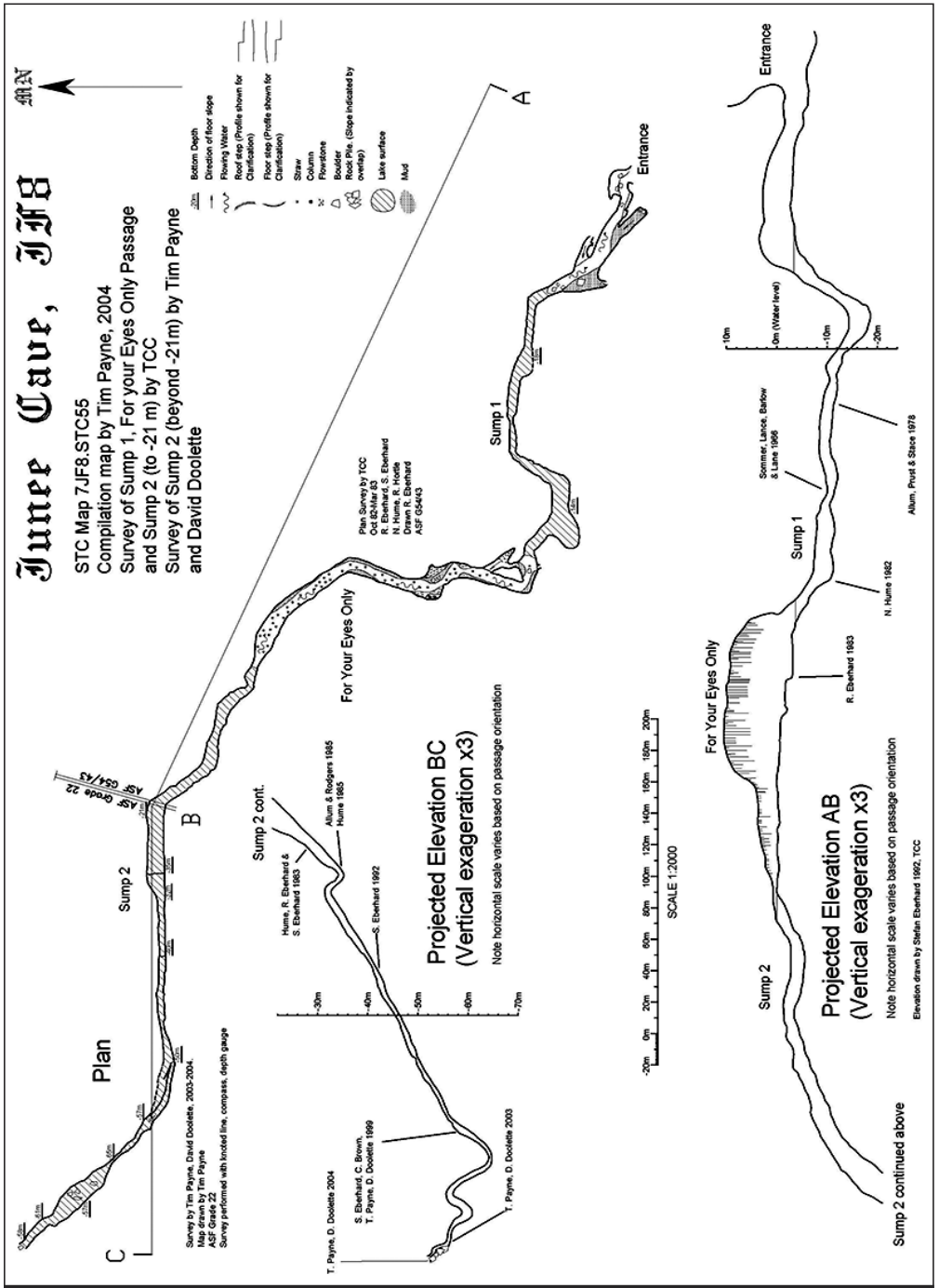
By Stephen Fordyce (with input from other team members), January 2019.

Recap of Part 1:

A crew from 4 states (3 Victorians, 1 South Australian, 1 New South Welshperson and divers from both from southern and northern Tasmania) assembled in the height of summer with the goal of making an assault on Junee Cave (JF-8). This is the resurgence of just about all the caves in the Junee-Florentine karst, lying under Mount Field, which includes such well-known caves as Growling Swallet and Niggly Cave (the deepest cave in Australia). The cave is at the centre of the Junee Cave State Reserve, managed by the Tasmanian Parks and Wildlife Service. It's well known for flooding, and even summer weather can include snow and torrential rain in the mountain catchment above. While we were lucky to enjoy mostly rain-less weather, the nearby bushfires had to be carefully monitored and planned

The end of Sump 2 has been pushed by multiple very capable people, so it was always going to need something special to yield anything new. A good start to giving a push the best shot is to give it lots of shots, and knowing this, our dives could be incrementally increased in duration and productivity. A major advantage in the use of rebreathers is to reduce the amount of gas consumed each dive to almost nothing in comparison to "open circuit", which also made the logistics of multiple dives much easier. Rebreathers are also warmer than open circuit, a major advantage in cold water. Backup "bailout" tanks are still required against the possibility of rebreather failure, but by staging these through the sump and leaving them for the entire project, the amount carried on each dive is minimised without compromising safety. This also means that the overall amount of bailout tanks can be limited to those required for the small number of divers in the water at one time, rather than a set each for the entire team.

Our early dives focussed on staging bailout cylinders, identifying (and videoing leads), checking exposure tolerance and adjusting thermal protection, laying and surveying knotted line, and fixing existing line, with little time spent at the end. Intermediate dives saw the end reached quickly and smoothly, for maximum time pushing. The final "cleanup" dives were for the retrieval of gear, line and bailout.



Existing map of Junee Cave - compiled by Tim Payne, including original survey from entrance to 17m depth in Sump 2 by Tasmanian Caverneering Club

Much time was spent and technology used in Sump 2 (my dive log records 14 hours in there across five dives) and some progress was achieved. Sump 2 meanders up and down a bit until dropping to 18m or so, and then heads steeply down until hitting 64m maximum depth after 200m. The deep section meanders along at 54-58m depth for 100m and then ends in a rockpile which blocks the (upward trending) passage.

Descriptions from previous trips matched the video and my impression of the end quite well. An open and well-defined tunnel of perhaps 6m wide and 3m high was trending up and then blocked by rockfall. Straight ahead, in the middle of the tunnel was a triangular shaped hole at 55.5msw with an enticing void behind it, but no chance of getting through. Definite flow coming out, although not a gush. 2m to the left of the centre lead, was a dubious looking lead 1m lower and heading horizontal (ie. most likely further into the rockpile) that would require some serious wriggling in sidemount or no-mount gear. Flow not noticed, but not really checked either.

To the right, the passage trends around the rockpile and up for a surprising few metres more - to 53msw. There is then a horizontal lead which might be negotiable in sidemount gear, and upwards in the rockpile would be worth another look. Of particular interest are many blocks of black/ribbed thinly-bedded Benjamin Limestone (kettle to microwave size) which do not match the bedrock walls and ceiling (which are formed in the thickly bedded, lighter coloured Cashions Creek Limestone), and appear to have rolled down from higher up. The presence of these erratic boulders of Benjamin Limestone, which are the next strata in the geological sequence heading north, lend optimism to the prospect of an upwards trending continuation of the sump. Flow not observed, but not really checked either.

The centre and right-hand leads were most prospective, and in fact the rest of the trip was dedicated almost entirely to the centre lead and to accessing the void behind it. Two subsequent dives were dedicated to careful and painstaking gardening (as well as some other jobs like surveying), and making a way to access what was named the "Armageddon Room" up and around to the left. The push dive was a tricky one, and involved a great deal of planning - if things went well, the cave would open up, mirror the other side, and a barrelling tunnel would head towards an airspace and dry cave. This would allow a break out of the water, and more importantly - a reset of thermal and decompression obligations. While very optimistic, it would be a shame to have the time and motivation to achieve this if opportunity presented, but lack a thorough plan or some small but crucial piece of gear. To this end, even a stick of salami was carried, for energy while exploring dry cave on the other side.

The trouble was, if things didn't go so well, and the theorised air chamber couldn't quite be reached, a brutal decompression obligation and extended exposure would be experienced due to having to go back down to depth and return to the known surface at the start of the sump. In reality it was acknowledged as unlikely that a remote airspace would be reached on this dive, and that a careful decision would need to be made according to what the dive presented.

Getting into the Armageddon Room was via the "Fridge Restriction" and required removal of butt-clipped reels and suit inflation cylinder, and a bit of wriggling, which took some time. Even at this early point in the push dive, the possibility of surfacing in a new air chamber was quickly evaporating. The enticing void beyond the triangle hole was found to be a squalid, nasty thing (although trending up a slope), with enough space to turn around and tie off the reel but not much else. The highest

Impressively proportioned and decorate passage in For Your Eyes Only. Photo by Stewart Donn

Steve getting ready for a dive in Sump 2. Photo by Stefan Eberhard.

Historical Chris Brown reel (from the 1999 expedition) sees the light of day again. Photo by Stephen Fordyce

point reached was 52msw, a couple of metres beyond the tie-off point, with rubble and rockpile pinching off to the ceiling.

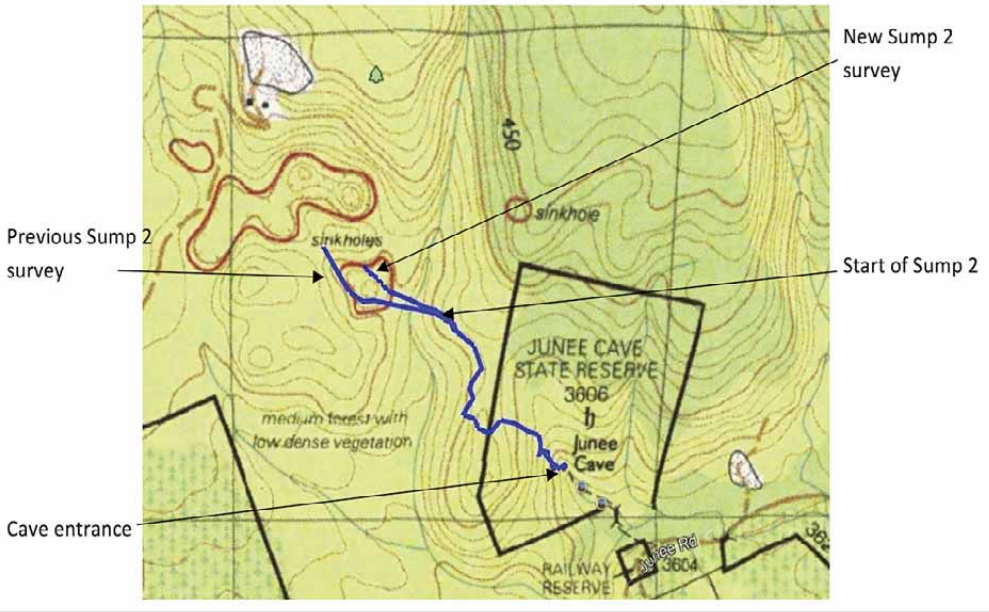
While a second set of eyes never hurts, I sadly pronounce the centre lead a "no go". Getting in, and then out again is not a trivial exercise and would only be possible for an experienced sidemount diver. About 10m of 3mm orange line was added (not surveyed) and left in place - it will be interesting to see what this does after some time in higher flows. Compared to other parts of the cave, more flow would have been expected - most likely this is just due to flow filtering through small gaps in the rockpile, but it's also possible there may be a bypass and another way on. Other sump dives further upstream in the master cave system have been in relatively small, uncollapsed passages that I feel may be recent bypasses of more ancient collapses and rockpiles.

Near the end of the right hand lead - black/ribbed Benjamin Limestone block against Cashions Creek Limestone walls and floor rubble. Photo (GoPro still) by Stephen Fordyce

Black rock characterises much of the cave, including the Sump 1 home side pool. Photo by Stewart Donn

In the spirit of leaving the cave environment in better condition than we found it, a good deal of old line was retrieved from Sump 2 and brought out - particular kudos goes to Dave for the time he spent on this task. Alas the deep section still has as many as 4 lines running in parallel! Also recovered was a reel with "Harry" on it (the day before he became Australian of the Year - it's no doubt now worth millions) of vintage approximately 2009,

Near the end of the right hand lead - black/ribbed Benjamin Limestone block against Cashions Creek Limestone walls and floor rubble. Photo (GoPro still) by Stephen Fordyce



Overlay of the cave showing old and new surveys. By Stephen Fordyce.

The obligatory team brag pic. Left to right: Stefan Eberhard, Stephen Fordyce, Patrick Fitzgerald, Grant Pearce, Andrea Russo, Steward Donn, Dave Apperley
Photo by Stefan Eberhard

and a Chris Brown reel/heirloom dating back to the 1990s. Nothing was left in the cave apart from some of the "clotheslines" set up to help keep the large amounts of gear tidy/out of the way. We were careful to stay in the stream or below the winter high water marks (with a few already well tracked exceptions), and were confident that our impact was minimal. Three discrete signs were placed in three areas with sensitive mud banks in For Your Eyes Only. The signs are small plastic plant tags about 50mm x 40mm, marked with permanent ink asking visitors to avoid the mud banks. No other protective measures were considered necessary.

In what turned out to be a supreme team effort, knotted line was laid, surveyed, and retrieved, as most of the Sump 2 had previously only been surveyed via ready reckoning. The result is not perfect, but a reasonably accurate survey is claimed and we have in fact reduced the length of the cave. Gathering more survey data should be on the list of future visits. Anaspides eberhardi (a species of cave-adapted Tasmanian mountain shrimp) were everywhere in both sumps, and pale native fish with eyes (Galaxias truttaceous) about 20cm long were spotted, including near the far end of Sump 2. A lot of video footage was taken with a Sony A7iii and Keldan lights in FYEO and Sump 1 (although it was quite silty when filmed) and while there is rather average GoPro footage available of all of Sump 2, it would be fantastic to film it with a better camera and video lighting - this would take some co-ordination and a bit of luck. Sump 2 didn't start crystal clear, and silt was disturbed easily, although visibility was never low enough to be a big worry (either in or out). At this stage, a return has not been written off, but is not planned either. There are still things to do and leads to check and push - best of luck to any who venture there.

Thanks again to everyone on the team, and to the ASF for their generous support. A special thanks to Andrea (with assistance from Stewart) who overcatered so drastically that the entire team was fed a delicious dinner on more than one occasion. Honourable mention goes to the owner of our accommodation, for leaving a slab of beer in the fridge for us.

Further details (dive profiles, gas mixes, schedule, thermal considerations, and more) are available in the Addendum to this report.

Party:
Stephen Fordyce
Patrick Fitzgerald
Stewart Donn
Andrea Russo
Stefan Eberhard
Grant Pearce
Dave Apperley

CDAA members re-enact the Thai Cave Rescue for TV

By Stephanie Looi CDAA #4971. Photos by Dean Cropp #4899

It all started with a random phone call from Tim (Featonby). 'So, Steff, I've got one for you… I need a cave diving dummy, and the first person I thought of was you. Craig and Harry are talking to Sunday Night about the Thai cave rescue and they want a re-enactment. I need a small person that I can tie up, and drag through a cave underwater while they pretend they're unconscious.' Well, how could I resist an invitation like that? I organised some babysitting and told my boss I was off to Jenolan to be a stunt double. The day of filming arrived, and we got up at a wholly unrespectable hour to make the 3 hour drive by 0800. Jenolan, for those of you who may be unfamiliar with it, is one of the world's oldest cave systems and spectacularly decorated, located west of Sydney. Apart from the diving, it is also an iconic tourist location.

On arrival, I met up with Tim, Dean Cropp and Franziska Link, who were the brains behind the caper, as well as Michael Collins, a Jenolan guide and cave diver who was there to keep us out of trouble. As we unloaded all our gear, we realised that between us we had way too much gear, and probably enough tanks to do several days of diving without requiring a compressor. We did a bit of a gear rationalisation, and I unloaded pretty much all my dive gear, including fins, BCD and regs, leaving me feeling a little naked.

Our destination was the Pools of Cerberus, in Cerberus cave, so named because when you shine a light on the pool it looks like a three headed dog. To get there, we walked 400m through a spectacular show cave. Whilst the walk is all on concrete, the steep stairs, low crouches and steep inclines are a little different from the entrance to say Pines or the stroll out to Pics. My baby 7s were definitely much nicer to lug in than the backmount 10s Dean was using.

Once we got there, we had a good look at the pool and decided an approach. The general plan was for me to act dead (well, unconscious… but I'm not much of an actor), use a full face mask, and have my hands and feet tied while Tim dragged me through the cave and Dean and Francesca filmed the entertainment. There were lots of discussion about how to make it look good enough for the camera, but maintain a level of safety that we were all comfortable with. In particular, we discussed things like how to stash normal safety gear we all carry on our cave dives, and how to hide a redundant air source. As my freediving wetsuit doesn't include any pockets, this feat involved some creative stuffing and bungeeing gear into strange places. We also talked about a way we could make it look like my hands and feet were tied, but that I could still Houdini out in an emergency. After trying multiple options, we settled on cutting up an old occy strap, and cable-tieing it together with enough elasticity I could break out if needed. Finally, I had a lesson on using a full face mask – something I'd never tried before. It looked quite Darth Vader, and I have to confess I may have said quietly "Luke, I am your father" as I pulled the straps tight.

After all of this, we geared up, and Dean and Tim swam off to get some footage of Tim looking like a hero. As I watched, I saw clouds of silt descending from the roof, where their exhale bubbles were knocking it off the ceiling and walls. The beautiful blue pool soon became coffee coloured murk.

I have to confess I had a few moments of trepidation as I sat on the bank and strapped on the full face mask. Although we didn't technically violate any of the 5 golden principles, I do feel that preparing to go into a cave you've never seen before with your hands and feet tied together, with no fins or BCD would probably have had Sheck Exley raising an eyebrow. Having just finished Advanced Cave, the irony wasn't lost on me that my first dive post course would be being dragged through a cave in an iconic location like Jenolan as a piece of meat.

By the time Tim swam back, the pool looked like Gouldens after multiple students have attempted the stress test. Due to the level of silt, neither of us were super comfortable with the idea of traversing the tunnel between the two pools without both of us having a hand on the guideline. We elected instead to leave my hands untied, and just swim through the tunnel. Well, I use the term "swimming" with some poetic license. There's only so much swimming you can do with one hand on the guideline, your feet tied together, negatively weighted without BCD or fins. We realised then that my wetsuit and minimalistic harness (ie a piece of bungy and a weight belt) had a conspicuous lack of handholds which would have made the job easier. I stifled giggles as Tim shouldered and shoved me through a 10 or so metre tunnel which felt way longer and tighter than it really was.

As we neared the end of the restriction, we put

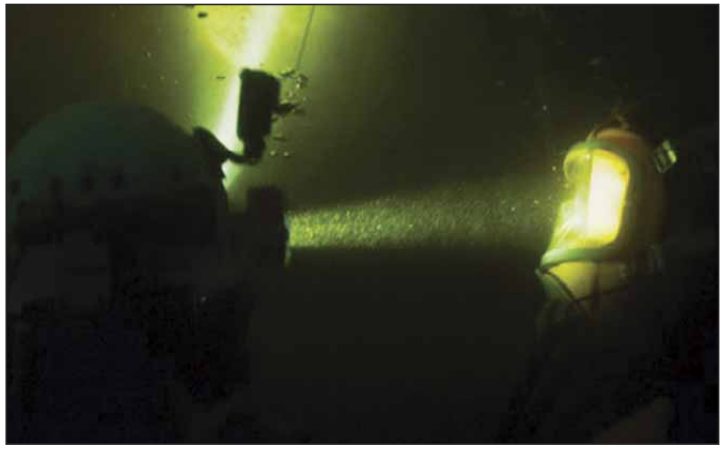
Rimbach to good use. 2 squeezes on a random body part, "OK?" followed by 2 squeezes on what I think was Tim's arm, I proceeded to close my eyes and pretend I was in the first stage of the lost line drill (the bit where your instructor takes your hands off the line and turns you round and round upside down). I concentrated on trying to remain floppy and not giggle as I got swum up, down and around as well as a fair bit of pushing, pulling, bumping on rock, and random light shining and mask tapping. I also discovered the joys of trying to equalise in a full face mask when you aren't sure if you're going up or down.

After surfacing and realising just how hard it is to maintain positive buoyancy when negatively weighted and without gear, we had a chat and went in for another round of being swished round the pool to get the shots Dean was after. We then returned through the tunnel. By this stage we had stirred the silt up gloriously, and I yearned for the clarity only achieved after attempting to buddy breathe through a restriction with a new partner. The vis was about the quality of looking through chocolate milk, not aided by the fact my mask had fogged up and I wasn't willing to figure out how to unstrap and clear it underwater. The couple of arrows that had been preplaced for this contingency were definitely welcome as I mostly slithered and humped through the silt with Tim attempting to be helpful (or perhaps just being impatient with my slowness) shoving me from behind.

After this, it was time to get random other shots that Dean and Francesca had in mind: Tim looking intrepid, Tim doing his best Blue Steel impersonation, Tim rising slowly out of the water, like a weird swamp creature and glaring at something slightly off camera before sinking slowly into the murky depths of waist deep water. Tim trying to swap helmets to look like someone else and realising it was about 2 sizes too small to fit over his hood meaning he resembled an emergency stop button.

Then, I got to play dead again for more shots of me being repeatedly dunked and resurfaced. By this stage I was starting to get cold. Instead of my drysuit, I was "diving' in a 3+5 wetsuit barefoot, and even my fancy new heated vest wasn't enough to keep the cold at bay with all the lying still. After this came the most dangerous part of the whole day as I am pretty sure I weigh a fair bit more than your average 10 year old, and there were no Work Safe lifting practices employed as Tim dragged me up onto a muddy bank and back into the water, over and over and over again. I'm pretty sure by the end of it, he wished he'd asked someone lighter!

Finally we got out and warmed up while Dean and Francesca reviewed the footage. Thankfully they decided they had enough that we could call it quits. We packed up all the gear and lugged it out. We definitely got a few stares as we emerged into the sunlight in wet wetsuits and bare feet out through the crowd of tourists waiting to be taken on their tour.



After stripping off and marvelling at how much silt I'd managed to accumulate, the only thing left to do was stuff all the wet gear into the car, tell some poor taste jokes about being tied up and dragged unconscious through the water, and reverse our trip home to Sydney.

Vertical Access Workshop

By Tim Featonby. Photos by Helen Spencer.

A vertical access workshop was conducted by Tim Featonby in Mount Gambier in January of this year. The two day workshop proved very successful with eighteen of our members attending the two days of training.

Day One started with some theory about the different types of equipment used in caving; their uses, limitations and the differences compared to working at heights, gym or rock climbing and rappelling. This was followed by setting up gear and running through some dry practices on the ground. The group then moved on to a local sinkhole to run through the Level 1 Vertical Access requirements. This consisted of being able to rappel down a cliff edge, climb a steel wire ladder and belay a person or equipment. These skills were originally part of the Deep Cavern course and allowed members to have the basic skills to turn up and safely enter sites such as the Shaft and Bakers Cave. We then moved on to another dry sinkhole that was a little larger where we went through the basics of Single Rope Technique (SRT). This involved climbing up a single rope with the use of various types mechanical devices such as foot loops, ascenders and cows tails (no cows were hurt in the process of the course). The participants were required to ascend up a rope from the ground while passing a knot in the rope, change over from ascent to descent to come down negotiating the knot again. The day's skills were finished with members being required to conduct a rescue by rappelling down a rope to a stuck climber, attaching the climber to the rescuer while removing them from their own rope then safely descending to the ground with them. This led to some interesting positions, comments and new friendships, but, what happens in a cave stays in a cave. The day finished with a debrief, bbq and a few beers back at Tim's place.

The second day everyone went to Hells Hole for a dive. It didn't start well with most divers saying it would have to be called off due to the horrible conditions in Hells Hole. It seems that many weren't around when Pines was full of duck weed or have forgotten what it looks like. Ropes were configured to lower gear and some brave volunteers went in first to find that the duck weed was easily moved out of the way and that the water was crystal clear below the duck weed. Members rappelled in to dive or snorkel then ascend back out while rigging was also set up to rescue people if needed and to remove gear. Members also removed garbage from the hole helping to keep our sites clean and assisting Forestry in the process. This completed the Level 2 Vertical Access that is intended to allow members to be able to safely access sites such as Pannikin Plains cave or the Three Sisters.

In all it was a great weekend enjoyed by all. It was a free workshop, however, everyone donated some money towards the instructors time which went into purchasing more equipment for future courses and it was recommended that there should be a small nominal fee in the future in order to contribute to continuation of the training. There was lots to learn regardless of what level people came in at and it showed that there is still lots to learn. Hopefully it went some way to filling the gap in knowledge of our members left by the removal from the basic course. Maybe we might be able to get it back in and have Level 2 incorporated into the cave course with enough support.

Stay tuned for the next workshop and be safe.

High Altitude Decompression Research and Diving Tables

By Beat A. Müller MSc Mech. Eng. ETH

Key words:
decompression research, high altitude diving, dive tables, decompression modelling, hyperbaric facilities, Bühlmann table.

This paper is completely focused on the "high altitude testing phase" of the Bühlmann '86 Air Diving Tables and the background of their calculation & "design". Five special events during this process are presented more in detail (Lake Silvaplana, Lago di Lucendro, Muttsee, Lake Titicaca, and Mount Kenia).

It does not cover any other of the many more test dives in the chamber or during real open water dives, which were duly recorded, analyzed and used for further refinement of the ZHL-16 system.

The paper is also a tribute to late Prof. A.A. Bühlmann (†1994), Dr. M. Hahn (†2000) and Dr. K. Meier-Ewert (†1989) for their relentless work in the field of decompression research and modelling and their support to the author.

A tribute to Prof. Bühlmann

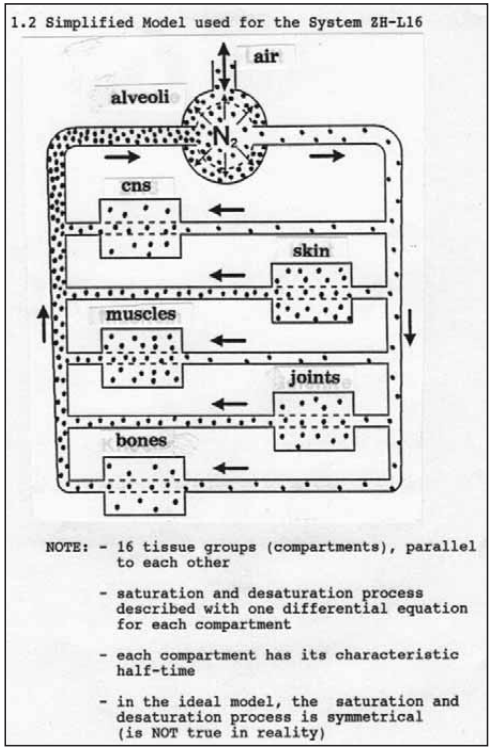
At the Diving Officer Conference of the Irish Underwater Federation in 1991, the author made the following statement:

"In the person of Prof. Dr. A.A. Bühlmann, Switzerland as a country with no access to the sea is lucky enough to have an expert of world-wide reputation, accepted as a leading scientist in the field of hyperbaric research not only by the vast diving community and scientific organizations, but also by many governmental bodies."

The author therefore still feels that the opportunity to work together with Prof. Bühlmann during more than 5 years was a unique chance, a lifelong lasting experience and some kind of undeserved luck.
Today, the author thinks that this still holds true.

About the Model behind (pic to right)

All the ZHL-models are neo-Haldanian, perfusion-based compartment models consisting of 12-16 compartments (tissue groups), grouped in parallel, characterized by their half-times and with an assigned pair of coefficients. These coefficients describe the relation between the actual inert gas tissue pressure and the tolerated ambient pressure. This relation is linear, in other words, the two coefficients define a straight line.
Denomination: ZH=Zurich, L=linear, 16 no. of tissue groups/pairs of coefficients
It is a pure perfusion model, which does not account for diffusion processes. It assumes that the inert as is hold in solution as long as a critical super-saturation threshold is not exceeded. The beauty of this model is its mathematical simplicity: as the entry state of each compartment is the same and independent of its neighbor compartments, the saturation and desaturation process can be described with one differential equation for each compartment. Saturation and desaturation is mirror-like to each other (which does not exactly reflect true biological "behavior".
Other models with compartments aligned in series (serial models) like the Canadian DCIEM show an asymmetrical saturation/desaturation process, but lead to a number of coupled differential equations. This is because the output state of the former compartment directly influences the input state of the following compartment.
However, in mid-80s, the cycle time of the processors (e.g. Z80) did not allow for this much more complicated and more time-consuming iterative calculation. Today, one can calculate such iterative processes with a simple excel-sheet….
For the table calculations, we started with the ZHL-12 model and coefficients, but in the course of development (and with the rapidly growing test results) recalculated all major values with the ZHL-16B coefficients. In some rare cases, if a difference was within a minute (or less) and the delta insignificant to the basic value (and may be, looked "nicer" on the graph), the former value left unchanged.



High Altitude Diving Trials of the Swiss Army 1969 (tables of 1973/76)

The Swiss Army performed first trials with recruits of a "combat frogmen" during a training course that was held at Lake Silvaplana, Switzerland at 1800m a.s.l. while using the French GERS table (originally designed for sea level). Disastrous results: 2 out of 8 divers developed severe forms of DCS.

This was just another one - but very strong - trigger event to put more efforts in high altitude decompression research. First result: the famous tables of 1976 arranged in 5 sets for 5 different altitude ranges (0-700m / 701-1500m / 1501-2000m / 2001-2500m / 2501-3200m a.s.l.) and one more table accounting for altitude adaption.

The `86 Air Diving Tables

In a kick-off meeting between Prof. Bühlmann, Dr. M. Hahn, and representatives of the Swiss Underwater Sports Federation (incl. the author) was held on 08.05.1986. In the course of this meeting, all necessary specifications (such as altitude ranges and their associated ambient pressures, depths increments, max. depths, bottom times, safety margins, composition of breathing gas, ascent/descent rates) of the "new" table had been established. Originally, it was decided that Dr. Hahn would calculate the 0m-700m asl altitude range, the author the range from 701m to 2500m a.s.l. .

However, after very short time, it was evident that the requirements of the German Federation were different of those of its Swiss colleagues. Thus, it was decided that Dr. Hahn would independently calculate the German tables and the author both tables for the Swiss Federation.

It is not known and has never been communicated openly to the public, whether Dr. Hahn used the same safety margins and parameters for his calculations as we did.

For the lower table range (0-700m a.s.l.), full adaption of all compartments to the inspired inert gas pressure at sea level immediately before the dive was assumed.

For the upper range table, full adaption at the lower altitude /00m a.s.l. was assumed, followed by a more or less continuous transit of 1hr to the upper range limit (2500m a.s.l.), immediately followed by the dive (situation of already equipped special forces divers brought by air transport to the dive site and jumping directly into the water).

For this "ascent ramp", the inert gas saturation and desaturation was calculated with the exact solution of the differential equation, not with the "simple" one for a rectangular (timeless) pressure change.

Two sets of tables were developed for printing on paper. Each set hat (on its reverse side) the same Surface Interval-, RNT- and Waiting Time for Flying table. It was decided that the RG "H" (and its related values) was the longest one to be presented. It is about the edge for recreational sport diving with air.

In addition, for more practical on-site use, two sets of plastic tables were also developed (one for each altitude range), with a distinctive color assigned for each range (blue for 0-700m, yellow for 701-2500m). Compared to the printed-paper version, due to lack of space, the depth range was slightly reduced. The calculation and "design" of the new tables are discussed in detail in the following paragraphs.

Physical Constants

Ambient pressure at sea level: 1.013 bar

Ambient pressure at altitude: accord. To ISO/IATA altitude formula for standard atmosphere: with Ambient pressure for aircraft cabin: 0.58 bar

Pressure gradient for water: 1.0 bar / 10m (corresponds to a H2O density of 1.019 kg/liter and 1 bar = 10^5 N/m2

Fraction of O2, N2 in air: The inspiratory partial pressure were calculated with fractions of 0.21 (O2) and 0.79 (N2) respectively

Physiological Constants

Alveolar water vapor pressure: 0.0628 bar

Alveolar CO2 partial pressure: 0.0533 bar

Respiratory coefficient: 0.80

All tissue calculations were carried out with the correctly calculated alveolar partial pressures of the inert gas fraction.

Pre-dive adaption

0-700m altitude range: all tissues fully adapted at sea level (0m a.s.l.), followed by "timeless" ascent to 700m a.s.l., immediately followed by the dive -> no adaption for this altitude.

701-2500m altitude range: all tissues fully adapted at 701m a.s.l., followed by a steady ascent to 2500m a.s.l. within 1 hour, immediately followed by the dive. Consequence: first two half-times almost completely adapted, remain half-times in various states of adaption. t

The desaturation of all compartments during this steady ascent was executed with the strict solution of the differential equation (the Schreiner eq.).

Such ascents by car to altitudes are very often made in Switzerland by just "ordinary" divers (e.g. drive from Zurich to Gotthard region etc.) and are nothing extraordinary.

The immediate dive upon arrival at altitude reflected the situation of police and military divers which were transported to altitude by other means and were already partly or fully equipped for quick action.

Repetitive Group Codes

Each compartment (=ea. half-time) has an assigned letter code (Repetitive Group, RG), starting with #1 "A" and ending at #16 with "P" (which is not on the printed tables).

The letter at the end of each dive is the RG letter of the "leading tissue", that means of the compartment that was at its threshold at the time of surfacing, thus was determining either the NDL or the time of the shallowest deco stop.

If at the time of surfacing the compartment with the next longer half-time was also saturated to 95% or more, then this RG letter was taken to be printed.

No Decompression Limits (table below)

After almost all specifications had been agreed upon, the calculation of the new table started with determining the no-decompression limits (NDL).

For each of the two altitude ranges and for all depths (with 3m/10ft increments) the NDL was calculated for each compartment and the least value taken for each depth.

Within a parametric study, a large series of descent/ascent rate combination was analyzed. Finally, for depths down to 15-18m and with the analysis of the parametric study in the background, a rectangular profile was used. For deeper depths, a fixed ascent rate of 10m/min was used.

Again, as with the RNT table, the results were plotted onto a diagram for a visual inspection, and again (if deemed necessary) a mathematical spline function was used to "smooth" the curve, of course to the safe side. The Spline Functions used for the different sections were mostly polynominal functions of third order, with the condition at the segment boundaries that they are twice continuously differentiable at the segment borders (s. RNT table).

A) NULLZEITEN — ***No-deco Limits Table***

Tabelle

Tiefe [m]	US-Navy 1957	GERS 1965	RNPL 1972	Bue76 1973	DCIEM 1983	Bue86 1987	PADI 1988	BSAC 1988
	Meer	Meer	Meer	0-700	Meer	0-700	Meer	0-250 6m-St.
9	--	--	--	--	380	335	>205	243
12	200	--	137	200	175	125	140	122
15	100	>120		75	75	75	80	74
18	60	75	57	50	50	51	55	51
21	50				35	35	40	37
24	40	45	32		25	25	30	30
27	30				20	20	25	24
30	25	30	20	20	15	17	20	20
36	15	25	14		10	12	13	14
42	10	10	10		7	9	8	12

For all ascents with a real ascent rate, the strict solution of the differential equation (the Schreiner eq.) was applied.

Dive Profiles

In a second step, the profiles for the defined depths were calculated up to the point where the leading repetitive group at the time of surfacing was "P" #16).

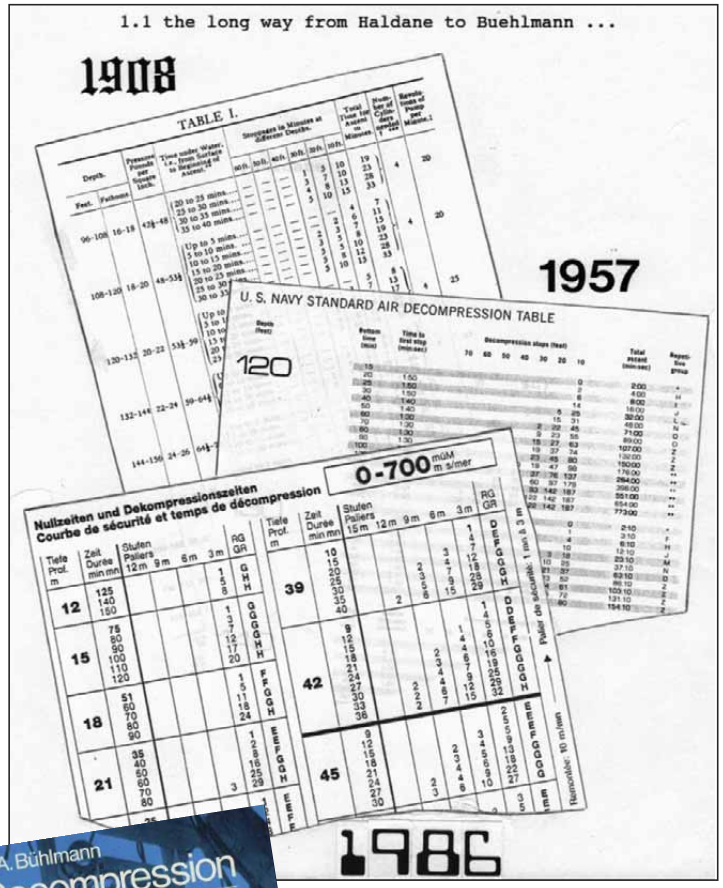
The descent time was either assumed as timeless (down to 15-18m), or, for deeper depths, 30m/min was chosen (which can be practiced in reality).

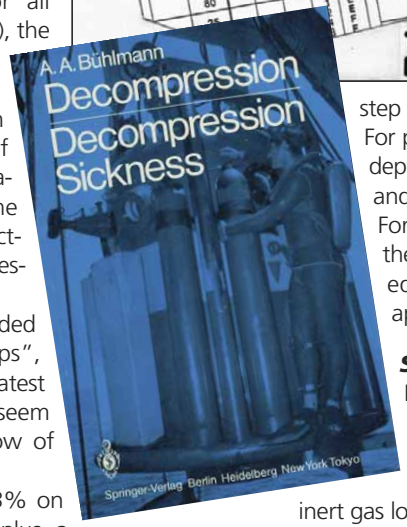
Ascent time to deepest stop was calculated with the fixed ascent rate of 10m/min. For the printed table version, the exact ascent time was rounded to the next full minute for easier handling. For all ramps (down and up), the inert gas saturation and desaturation was calculated with the exact solution of the differential equation, not with the "simple" one for a rectangular (timeless) pressure change.

There were no included so-called "deep-stops", which – following latest research results – seem not to be the "yellow of the egg".

A safety margin of 3% on the running depth plus a fixed 1m was added to all depths, with the exclusion of the decompression stages.

In addition, the calculated stop times for each step included the ascent time to the next higher step (shallower depth).





For practical and legal reasons, maximum depth was limited to 54m (57m resp.) and to RG "H".

For all ascents with a real ascent rate, the strict solution of the differential equation (the Schreiner eq.) was applied.

Surface Intervall (SI) table

For determining the indicated times at surface to switch from one half-time (RG) to a shorter half-time (e.g. from "H" to "C") the overall tissue inert gas loading which is implicitly behind every RG had to be compared, and this for all table depths and for all half-times (all RG or compartments), which was a very time-consuming and tedious process.

For the calculation of the time from the maximum tolerated inert gas pressure for each compartment to (almost) complete desaturation (RG "0"), we took a target inert gas pressure which is 5% above the alveolar inert gas pressure at surface (otherwise the time to complete desaturation would last eternally). For the waiting times for Flying after Diving, please refer to the corresponding paragraph in this abstract.

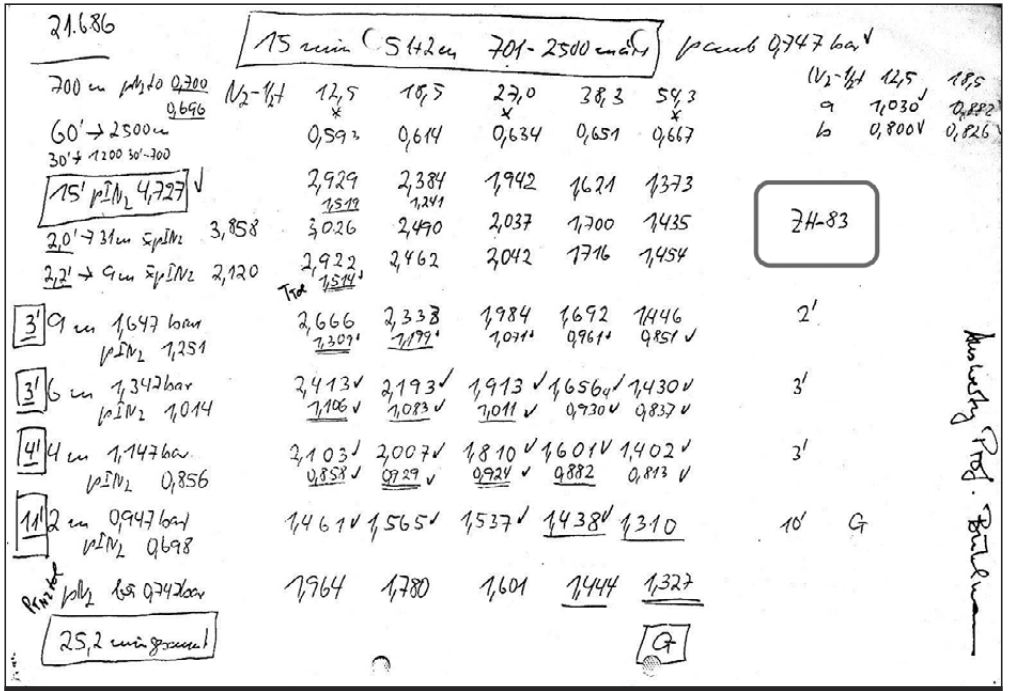
We did not include any forms of the shunt effect; at that date, there were just not enough reliable data for a serious mathematical modelling. However, the effects of the shunt were (at least partially) counteracted by the applied rounding rules and the requested handling rules. By always taking the highest values of both altitude ranges and the repeated rounding process as well as the handling rules, many of those shunt effects have been masked as a side-benefit. This process was repeated for both altitude ranges and the highest values taken into the table. Those values were plotted onto a diagram for a visual check. As a last measure, all curves have been "smoothed" with a mathematical spline function, of course always to the safe side.

Residual Nitrogen Time (RNT) table

Here, for all depths (9m to 57m) and the range of repetitive groups ("A" to "G", resp. "H") the bottom times needed to achieve the maximum tolerated inert gas tissue pressure for each depth-RG combination had to be calculated and to be plotted for a better visual overview.

In addition, all values had to be compared against the values for the "normal" dive profiles. In some cases, some minor adaptions had to be done for the reason of a coherent system.

Finally yet importantly, a "smoothing" with a mathematical spline function had been executed, to the safe side of course. The Spline Functions used for the different sections were mostly polynominal functions of third order, with the condition at the segment boundaries that they are twice continuously differentiable at the segment borders (s. NDL values).



Dr. A.A. Bühlmann's own handwriting... He was said to be a numercial wizard... but he did all his calculations with a hand-held calculator

Flying after Diving in pressurized cabins (see below)

While ascending to cruising altitudes of 35'000 to 40'000 ft at a climbing rate of 1500-2500ft/min, the cabin pressure is also continuously reduced to a final "cabin altitude of 7000-8000ft (2134m-2438m or 0.784-0.756bar).

A pressure of 0.60bar is regarded as the maximum (accepted) technical deviation. At 0.54bar, the oxygen masks are released. As the longest waiting times were requested if the preceeding dive was made at sea level, we took the final tissue values from each dive profile of the 0-700m table up the RG="H".

For the calculation we assumed that the ascent rate is indefinitely (rectangular profile, like an explosive decompression to cabin pressure). So the normal ascent time of 15-20min to cruising altitude (and the resulting desaturation) is neglected. The reference pressure cabin pressure was finally assumed to be 0.58 bar.

Normal ascent rate of a passenger aircraft is approx.. 1500-2500 ft/min (depending on aircraft type and altitude), however the cabin pressure reduction is never more than 1000ft/min.

Parametric studies showed that the higher to diving altitude, the lesser the waiting time for flying. Also it was shown that after one hour of waiting time the diver can ascend from sea level to at least 2000m asl for all repetitive groups up to "H".

Nevertheless, we set a lower limit of 2 hours; after this waiting time all compartments up to a half-time of 20min are desaturated to more than 97%. This minimum time is still 2-3 times shorter than what is possible in reality (storing diving equipment, packing, drive to the airport, check-in, security, boarding, delayed departures, ascent to cruising altitude, etc.).

The often requested waiting times of 24hrs are just greatly exaggerated (s. report by Nishi) and not scientifically founded but more the result of fear about a law suit.

Crossing a pass and flying in non-pressurized cabins

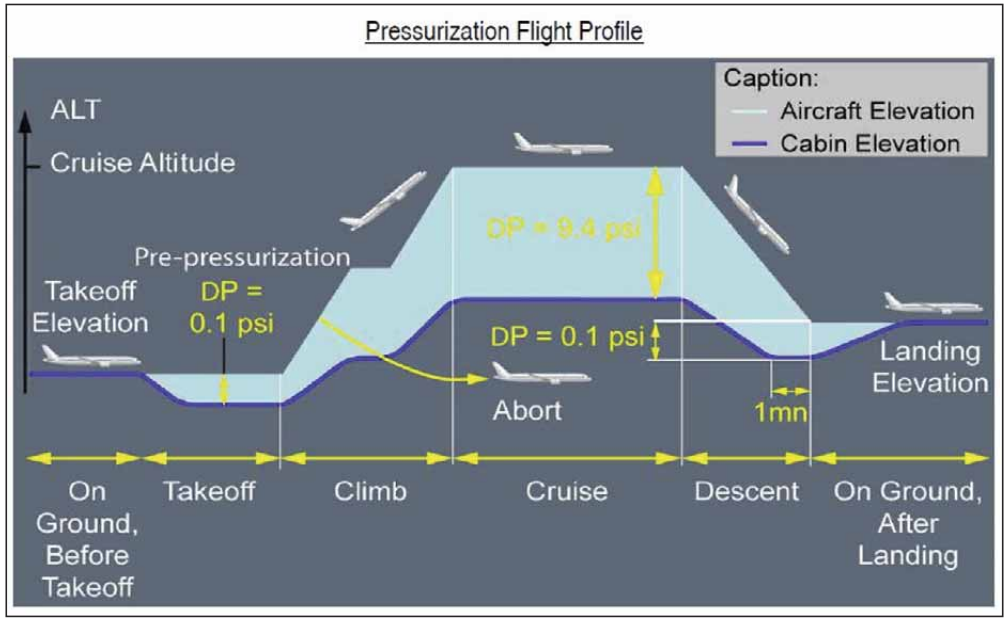
The problem is the same as for flying: with increasing altitude, the ambient pressure decreases. For a selected range of altitudes in 500m increments, the corresponding pressure was calculated according to the ISO/IATA formula for standard atmosphere up to 4000m a.s.l., which is 0.615bar

For all repetitive groups from A to H and for each depth/bottom time combination, the maximum attainable altitude was calculated on their basis of a timeless ascent (rectangular profile). For being on the safe side, this calculation was repeated for any upper altitude range (700m asl and 2500m asl). Not surprisingly, the higher the diving altitude, the shorter the waiting time for a follow-up ascent to a same altitude as from the lower altitude table range .

One safety rule was added: the diver has to stay for at least 1 hr on the altitude of the dive site, before starting a more or less steady ascent to the target altitude. This time is mostly needed for coming out of the water, changing cloths, stowing the equipment, cleaning-up the dive-site and debriefing. The arrival at the target altitude should not be before the end of the indicated waiting time. Waiting times are always rounded to the next half hour, another built-in safety margin.

In consistency with flying after diving, the waiting time for 4000m asl for RG H is 7hrs, the same value as for flying in a pressurized cabin. Due to the assumed slightly higher target ambient pressure for RG "H" (0.615bar instead of 0.58bar), even an ascent to 4500m asl would be allowable, but we decided to cut it down to 4000m.

It must also be said that it is very rare to find a lake at 4000m+ altitude.



Tools and Technical Support behind

Most calculations were done with then-desktop computers such as HP-97 with 224 programmable steps in revers Polish notation. This was barely enough for one tissue and one point (waypoint) of a dive profile. So for each tissue and each such waypoint of a dive profile one calculation was needed.

Later on, a program was written in Turbo Basic and run on a Compaq Portable III computer.

Independently a third calculation for the same profiles was executed with an Assembler program on a big IBM mainframe computer. Thus, any deviation was immediately visible and was analyzed.

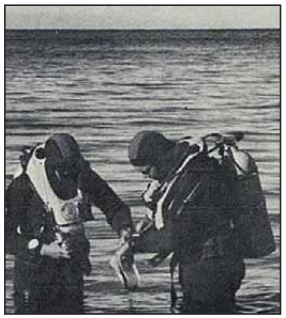
Ultimate authority was still Prof. Bühlmann: he made all calculations for each tissue on a little "handheld" calculator.

Most depth/time combinations on the table requested one or more iterations until all involved persons agreed or deviations were clearly explained and accepted.

Lake Titicaca Trials (1987; 3800m a.s.l.)

Diving expedition of a diver- and scientist group of the British Rhine Army. 17 divers made 290 dives in just 3 weeks. Divers were fully adapted at this altitude.

Dives were single and repetitive dives. Bottom time were from 11-52min, depths from 5-39m.



A set of special tables was calculated for an operational range from 25021m to 4500m a.s.l. Thus, even a probable helicopter evacuation was included in the worst case scenarios. Other parameters were identical to those of lower altitude rages, including an ascent rate of fixed 10m/min.

Dive computers Aladin (specially programmed) and Deco Brain were extensively used. Not one single DCS related incidence was reported.

Lago di Lucendro Trials (1984-88; 2134m a.s.l.)

Those tests were usually included in the training program of T*** divers, offered by the Swiss Underwater Sports Federation SUSV. "High Altitude Diving" is a standards training part for any serious training agency in Switzerland.

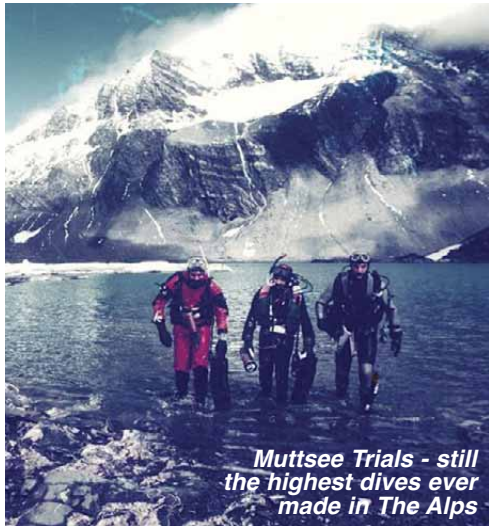
From 1984 to 1988, approx. 50-60 divers (approx. 10-15 per year) made 50-60 dives, normally in the 30-40m depth range. On the event of 23.8.1986, 14 divers made 16 dives (2 repetitive), 15-18min, and depths 29-37m.

Table used: the then-provisional table for 701-2500m a.s.l., Deco-Brains P2-2 and P2-3, as well as Aladins.

Dives were single and repetitive dives. Due to short stay at altitude, divers were only partially adapted in best case.
Not one single DCS-related incidence was reported during this period, despite the fact that executed stop time were much shorter than requested by 76—and 86 tables.

Muttsee Trials (1988; 2500m a.s.l.)

Reconnoiter dives (3 divers) in August 1987, with 4 dives (non-adapted), of which 2 first dives, rest repetitive dives, depths 33-39m, bottom times 15-21min; no symptoms.
The real tests later in October: 15 divers during 2 days. 56 dives (of which 52 recorded for the tests). Of these 52 dives, 28 were first dives, 28 repetitive dives. Depths were from 24-58m, bottom times from 12-25min. Adaption time approx. 4 hrs on the first series of dives to one full day.
Tested were tissue groups with half times around 18, 38, 54min (skin, muscles)
Tables used: a "shortened" version of the ZHL-16 table, but without almost all safety margins
4 cases of relatively mild skin symptoms and muscles. One of the person was put on pure O2 and flown down into the valley by helicopter. One day later some of the symptoms returned and he went into the chamber. Afterwards total relief and no persisting symptoms.
Skin symptoms faded away after some normobaric O2 breathing. No further actions taken.


Muttsee Trials - still the highest dives ever made in The Alps

Practical Applications and special Environments

Today, dozens of diving computers are in widespread use worldwide, in various forms (non-adaptive, adaptive), 6-16 tissue groups, w/o gradient factors and further included parameter (temperature, workload). The ZHL-system is especially popular for nitrox and trimix dives.
It was also extensively used during the cave diving exploration of the Doux-de-Coly (Dept. du Lot, France) by world-class Swiss cave diving explorer Olivier Isler in 1988/89 with open systems (penetration distances up to 4000m, max. depth 65m; extensive use of O2, trimix and nitrox).
Another field is space: while the very first space crafts had been run on a interior pressure of 5 psi (Mercury, Gemini, Apollo) with a pure O2 atmosphere, todays space crafts (incl. ISS) retain a "normal" atmosphere of 14.6 psi (1 bar).
However, the space suit can only hold an inside atmosphere of 4 - 7 psi with pure O2, so is heavily sub atmospheric! A switch from ISS into the suit creates an inert gas pressure drop ratio of approx. 2.87 (14.7*0.78 : 4 to 5) which is way above what our longest half-times tolerate (approx.: 1.27). Thus, such a drop would create severe cases of DCS. Therefore, a "pre-breathe" session of 30min to 1 hr on pure O2 at 1 bar is requested before leaving the station (s. report of University of Maryland).

Mount Kenia dives (1988; 4780m a.s.l.)

Organization strictly on a private basis, 2 Swiss divers, one living in the area at 1800m a.s.l., one coming directly from the lowlands, Ascent carried out in 2 phases with a short stop at approx. 3500m a.s.l., 18 dives on 4400-4780m, bottom times from 10-20min, depths 10-15m. Decompression according a customized Aladin (ZHL-6 or /8) from the then-manufacturer; no symptoms but exhaustion due to lack of O2 at this altitude.


Mt. Kenia

Excursion: Bühlmann table with Deep Stops

At some period of time there was a hype towards introducing "deep stops" of the tables. Those attempts mostly came from non-scientific parties with no truly approved data behind.
Prof. Bühlmann was not a friend of those procedures which he called "unscientif" and "amateurish". Already then he pointed to the fact that a) for deeper dives, tissues with shorter half-times would be more saturated during these stops and b) that his numerous deep diving trials (200-300m range) in the 60' and 70' clearly proofed that such stops are unnecessary.
Finally, the Swiss Underwater Sports Federation decided against such a "modified" table. Today, with reference to the NEDU study (NEDU TR11-06, July 2011, Doolette, Wayne et al.) we definitely know scientifically that in most cases such deep stops are of dubious benefit to the diver.

Results and consequences

The systems ZHL-12 and ZHL-16 have been tested and proofed over an extremely broad range of diving candidates, breathing gases, physical activities and environments. Resulting tables have been calculated under the assumption of various worst-case scenarios and with many integrated safety margins.
The testing and operational "envelope":

- Altitudes from 0 to 4780m a.s.l. (chamber: 4200m).
- Single and repetitive dives (up to 3 consecutive dives); surface intervals from 10-120min.
- Tests done with drastically reduced stop times and safety margins of the published tables.
- A great number of chamber dives and real open water dives.
- From icy cold fresh water lakes to warm tropical salt water of the sea.
- Depths down to 500m and even 575m (chamber).
- Bounce dives and saturation dives (30m – 220m).
- Recreational dives and hyperbaric work, from minutes to hours.
- Tables and computer in use worldwide with several 100'000 real and symptomless dives.
- Used with air, nitrox, heliox, other mixed-gases and for O2 decompression.
- Extremely reliable and in use for multi-gas diving and adaption.
- Exact copies in use in Ireland, Switzerland, Austria, Portugal, Spain, Algeria, Bolivian and Peruvian Navy.

A variety of slightly different tables, based on the ZHL-16, have then been designed such as Bühlmann/Hahn 92, Deco 2000, tables of the British Subaqua Association.
Other training agencies such as PADI, NAUI etc. have other tables in use; however, they treat it as a blackbox to the public. On a pure scientific view, with no knowledge on their background, they cannot been trusted.
In the case of the 86 tables, it was a very lucky coincidence that Prof. Bühlmann not only was involved in the very deep diving research together with the offshore oil-industry with the laboratory as the dominant tool behind, but also strongly involved in the high altitude diving research. Finally yet importantly, he managed it to develop a very strong and fruitful cooperation with physicists, engineers and the general diving public.

Current and future developments

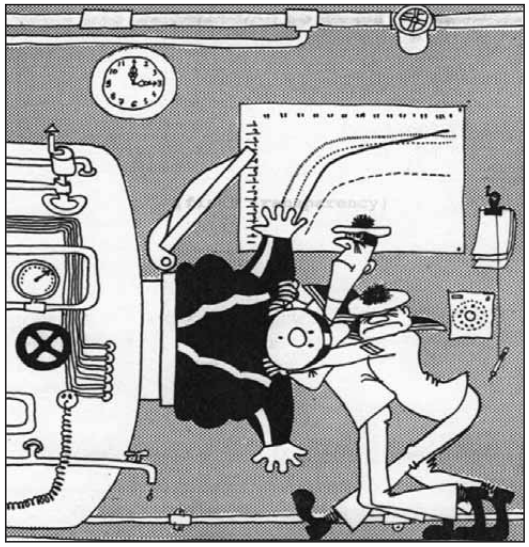
Some refinements have been incorporated in the saturation/desaturation algorithms in some of the computer software such as physical activities (via breathing rate), water/skin temperature and shunt effects during surface intervals. Even the pulse rate could be permanently measured and used.
A mathematical method, called "gradient factors" has been developed by E. Baker, which is nothing but reducing the maximum tolerated inert gas overpressure for each tissue by a certain amount (expressed in % of the original value given by ZHL-16 et. al.; 100% means orig-

inal value). The main effects are deeper and longer stops.
Various computer models also use systems for the desaturation part that are based on modelling bubble mechanics, so-called diffusion models (Variable Permeability Model VPM; Reduced Gradient Bubble Model RGBM). They also work well. However, there is no true and proven special benefit of one over the other.
Some of the computer software allows the diver to choose the system for calculating the decompression: Bühlmann, RGBM, VPM or any other.

About the author:

Born on 03.01.1953 in Bern (Switzerland), having a M.Sc. in Mech. Eng. from the Swiss Federal Institute of Technology (ETH), with specialization in Thermodynamics and Unsteady Flow Dynamics, he has been working nearly 20 years in the computer science industry. From 2010 to his retirement in January 2016, he was working as a project manager in one of the biggest Swiss Enterprises, with focus on energy procurement.

Beat Müller holds a certificate as a National Instructor (I **** CMAS) and numerous other instructor certifications from CMAS, NAUI, PADI, FASSAS and SCD. Appointed Staff Instructor Cave Diving by cmas.ch in 2004, he looks back on approx. 4500 dives all over the world.
In the mid-eighties, cooperation with Prof. Dr. A.A. Bühlmann in Zurich, with his direct involvement in the high altitude diving research- and test-program up to 2500m a.s.l. He was the responsible software engineer who wrote the software for the famous '86 Bühlmann air-diving tables, as well as the high altitude dive tables for the diving expedition of a group of divers of the British Rhine Army at Lake Titicaca at 3800m a.s.l. He also gave contributions to publications such as "Decompression – Decompression Sickness (Bühlmann) and "Deeper into Diving" (J. Lippman) and numerous training aids of the Swiss Federations SUSV and cmas.ch.
Other activities:2004 – 2008 Vice President of the Technical Committee of CMAS International, 2000-2013 Member of the Commission of Technical Diving of cmas.ch, from 2004 – 2013, Head of the Cave Diving Working Group in the Technical Committee of CMAS International. Working as an international ITC CMAS Course Director in Turkey, North Africa and Ireland. He is the author of the Cave Diving Standards and Training System of CMAS International and of Swiss Cave Diving.
Together with Fritz Schatzmann, he is the author of the European reference book „Höhlentauchen" (engl. "Cave Diving"), and "Cavern Diver".
He is also a founding member and former president until 2015 of the largest European cave diving association "Swiss Cave Diving" and co-owner of the registered trademarks "Swiss Cave Diving", "Swiss Cave Diving Instructors" and "Swiss Cave Divers". He is still working as a member of the board in the position of a Director of Standards.
Since 2006, he acts as the webmaster of the most visited cave diving website in Europe, www.swiss-cave-diving.ch. He lives with his wife in the greater Zurich area. He has given numerous presentations on decompression modelling and on Prof. Bühlmann's work in Switzerland, many other European countries, North Africa and Overseas. ■



CDAA INSTRUCTORS

NAME	Basic Cave	Cave	Adv. Cave
NEW SOUTH WALES			
 FEATONBY, Tim (CDAA 3327) Worrowing Heights, NSW Mob: 0402 129 253 E: tim.featonby@hotmail.com	Yes	Yes	Yes
SOUTH AUSTRALIA			
 PAYNE, Timothy (CDAA 2640) Mob: 0448 147 927 E: Tim@diveessentials.com	Yes	Yes	Yes
VICTORIA			
 ALLEN, Terri (CDAA 3483) Mob: 0419 176 633 E: terri.allen@monash.edu	Yes	Yes	Yes
 BARCLAY, Gary (CDAA 1735) Mob: 0407 527 921 E: garinda@bigpond.com	Yes	Yes	Yes
 BOWMAN, Jane (CDAA 1880) Mob: 0407 566 455 E: janelbowman@hotmail.com	Yes	Yes	Yes
 CLARIDGE, Linda (CDAA 2214) Mob: 0408 052 070 E: garinda@tpgi.com.au	Yes	Yes	Yes

NAME	Basic Cave	Cave	Adv. Cave
VICTORIA Continued			
 DALE, Steve (CDAA 3926) Mob: 0468 417 211 Email: info@extremewatersport.com.au	Yes	Yes	
 EDWARDS, Chris (CDAA 2247) Mob: 0417 116 372 Email: chrisedwards01@me.com	Yes		
 MONACO, Rubens (CDAA 1731) Mob: 0413 429 533 E: info@idcscuba.com.au	Yes	Yes	Yes
WESTERN AUSTRALIA			
 PAYNTER, Geoff (CDAA 3784) Mob: 0407 445 112 E: gpaynter60@bigpond.com	Yes	Yes	Yes