From: **Peter Turner** <peter.turner.home@gmail.com>
Date: 26 March 2014 14:31
Subject: Fwd: report and photographs of visit to Waratah rivulet February 13
To: chris.armstrong@chiefscientist.nsw.gov.au
Cc: leah.schwartz@chiefscientist.nsw.gov.au

Hi Chris, FYI below and attached; will send the mentioned second email next.

Will also send the 2010 SCA water loss modelling review mentioned in the attached (obtained by GIPA, but you may already have it).

Re tomorrow's meeting, would you be able to provide a projector?

Cheers, Peter.

---------- Forwarded message ----------
From: **Peter Turner** <peter.turner.home@gmail.com>
Date: 26 March 2014 09:21
Subject: report and photographs of visit to Waratah rivulet February 13
To: S Haddad <sam.haddad@planning.nsw.gov.au>
Cc: Fiona Smith
<Fiona.Smith@sca.nsw.gov.au>, graham.begg@sca.nsw.gov.au,sally.barnes@environment.nsw.gov.au, chris.wilson@planning.nsw.gov.au, david.kitto@planning.nsw.gov.au, Jessie Giblett <jessie.giblett@planning.nsw.gov.au>, Howard Reed <howard.reed@planning.nsw.gov.au>, Kelvin Lambkin <Kelvin.Lambkin@sca.nsw.gov.au>

Dear Mr Haddad, please find attached a largely photographic report of a February 13 visit to the increasingly badly damaged Waratah Rivulet.

This will be followed by a second email with a set of photographs largely taken in 2012. There are some interesting differences.

Both documents will shortly be sent to relevant Ministers.

The two are too large to send as an attachment to one email.

Regards, Peter. .

Waratah Rivulet Visit February 13 2014 - A Brief Report

A group of academics, scientists and concerned community members visited the Waratah Rivulet on Thursday February 13 to view past and recent longwall mining induced subsidence damage to this important watercourse. Delivering more water than Woronora River, the Waratah Rivulet provides approximately 30% of the inflow to Woronora Reservoir during periods of good rainfall and up to 50% during dry conditions. The rest of the inflow to the reservoir is provided by direct rainfall and runoff. The reservoir provides drinking water to southern Sydney, including the 200,000 residents of Sutherland Shire, and the 5,500 residents of Helensburgh. The inner catchment for the reservoir is formally protected by the Schedule 1 Woronora Special Area, for which visitor access requires approval by the Sydney Catchment Authority (SCA); unauthorised access risks fines of up to $44,000. The Waratah Rivulet is entirely contained within the Woronora Special Area and constitutes 30% of the catchment for the Woronora Reservoir.

Given its importance as a source of water and the notably significant damage caused by longwall mining, the Waratah Rivulet has been the subject of detailed study by the SCA[1] and is presented as a subsidence impact case study by the NSW Parliamentary Library.[2] A report by the Total Environment Centre provides insight into the discovery of damage to the river and responses to that damage.[3] The impacts are not unique; they are reflective of underground mining impacts to watercourses across Sydney's drinking water catchment.[4] Longwall mining was listed as a Key Threatening Process under the NSW Threatened Species Conservation Act in 2005[5(a)] and alteration to the natural flow regimes of rivers and streams was similarly listed in 2002.[5(b)]

The group visiting the rivulet on Thursday February 13 walked between Pool A to Pool O (see attached maps) to view past and recent damage to this important watercourse. The roughly one and a half kilometre length traversed included sections of the river particularly badly damaged[2,3] by Longwalls 10 to 13 of the Metropolitan Colliery, which were extracted between 2003 and 2006, and the area recently damaged by Longwalls 20, 21 and 22, the first longwalls of the Metropolitan Colliery expansion project (see attached maps). The expansion project commenced with Longwall 20 in May 2010 and Longwall 22B (Longwall 22 is comprised of two parts; A and B), is currently approaching completion.

The group was particularly concerned by the complete draining of a substantial and otherwise essentially permanent pool referred to as Pool N (see attached photographs) by the mining company, Peabody Energy. There are several substantial pools along the length of the watercourse and these pools play important roles as drought resilient water stores and, depending on their location with respect to mining operations, aquatic habitat and water sources for animal and bird life.

With little recent rain, flow in the river at the time of the visit was relatively low; nonetheless water was flowing from upstream pools into the southern end of Pool N. Normally Pool N would be some two metres deep at its downstream, northern end (see attached photographs). As a consequence of recent mining activity however, water is now being lost into a bedrock crack across part of the southern end of the pool (see attached photographs). Substantial cracks are visible in the floor of Pool N, evidently caused by subsidence associated with longwall extraction some 400 metres below the stream. Water entering Pool N would normally bank up against a rockbar that acts as a natural dam. Known as Rockbar N, the rockbar has been shattered (see attached photographs) as a consequence of recent mining. While the mining company advised the Sydney Catchment Authority of the damage to Rockbar N and Pool N, it did not advise the Community Consultative Committee.

The mining company asserts that all water lost from the surface of the watercourse will nonetheless find its way into the Woronora Reservoir, either by returning to the surface downstream or by joining groundwater flows that terminate at the reservoir. Dr John Bradd, Senior Fellow in the School of Earth and Environmental Sciences at the University of Wollongong and Principal

Hydrogeologist of Hydrogeological Solutions Pty Ltd, expressed concern that there was no readily accessible data to measure, model and interpret surface water losses to groundwater and the subsurface flow-paths that may or may not re-enter the drinking water supply downstream. He comments "*From our observations on the day, it was clearly evident that surface water was being lost through rock fractures unrelated to the natural geological stress direction. The practical challenges of ascertaining where the lost surface water is going once underground makes it very difficult to quantify the real impacts on our drinking water supply and the ecosystems along the river. There is a disturbing lack of knowledge and understanding that needs to be addressed."*

A 2010 review undertaken on behalf of the SCA by Prof. Vazken Andréassian from the Université Pierre et Marie Curie Paris, finds water loss from Waratah Rivulet is likely and his report emphasises a need for better data and modelling to more confidently assess the cause and quantity being lost.[6] In 2012, in partnership with the University of New South Wales, the SCA applied for Australian Research Council funding to improve its understanding of water losses. The proposed project included the use of satellite imaging to develop a detailed catchment model. The application was unsuccessful. It's puzzling that the SCA would appear to have found it necessary to to apply to the ARC for funding to undertake what would be regarded as a core responsibility.

Noting that the Andréassian review was completed in 2010, Dr Peter Turner suggests any loss from the Woronora Reservoir catchment will have been made worse by subsequent mining. He comments "*The loss of Pool N is deeply disturbing and emphasises the risks and consequences of mining beneath Sydney's drinking water catchment. There's an urgent need to update and improve water loss estimates and the State government should ensure that the SCA has all the resources it needs to gather good quality data and comprehensively model and assess the impacts of mining the quantity of water reaching Woronora Reservoir both from Waratah Rivulet and Woronora River. The Precautionary Principle argues that mining should not be allowed to continue in the absence of such knowledge*". A better understanding of the impacts of mining on the Waratah Rivulet would have direct relevance to impacts on other watercourses in Sydney's drinking water catchment.

The mining company provides assurances that its remediation method has been effective, however the Sydney Catchment Authority has yet to agree that this is the case. Remediation is a requirement of the project approval and Peabody Energy has invested a very substantial amount of money injecting polyurethane resin (PUR) into two rockbars, (A and F) in an endeavour to stem upstream leakage. PUR is reported to have been used successfully for infrastructure repair in geologically stable situations, subsidence however takes years to settle and is reactivated by nearby mining. While a 'curtain' formed by injecting PUR into an amenable rockbar can be expected to force water back to the surface, it may also divert water in other directions, with the possibility of loss from the reservoir catchment. The curtain would have no effect on any upstream surface water diverted into groundwater flows that leave the catchment area.

The Metropolitan Colliery is regarded as a dry mine, suggesting that mining has not resulted in surface water entering the mine, directly or indirectly, to any significant extent. There are concerns however, that some of the water being diverted into subsidence cracks in the Waratah Rivulet joins groundwater flows that take water away from the storage reservoir, possibly via a geological discontinuity. The expansion of the mine will include mining beneath Woronora Reservoir. While the inevitable subsidence cracking on the reservoir floor may not result in catastrophic inflows to the mine, it may well result in water leaking into groundwater flows that leave the catchment.

In 2013 the SCA declared that it would oppose mining within the Dam Safety Committee's Notification Areas and accordingly advised those companies operating in the Special Areas. The next set of longwalls to be extracted at the Metropolitan Colliery partly intrude into the Woronora Notification Area (see attached map). The Department of Planning and Infrastructure is currently assessing Peabody Energy's proposed water management plan for the new longwalls. Whether the Department accepts and accordingly acts upon the SCA's opposition to mining in this area remains to be seen.

Dr Bob Young commented during the February 13 visit to the Waratah Rivulet that longwall mining accelerates streambed erosion and so increases the volume of sediment carried into the storage reservoir. Subsidence cracking breaks large blocks into relatively thin plates that can be picked up during heavy flow periods and carried tens of metres downstream. The plates break up during transport and become more easily carried downstream. Finally the plates break down into sand and gravel that's eventually deposited into the reservoir. As surface fracturing extends to 15 to 20 metres below the surface and occurs along the whole length of the undermined river, a substantial volume of broken rock and sediment is likely to move downstream. In the absence of mining, stream beds remain stable for thousands of years.

During the February 13 visit a gas assumed to be largely methane was found bubbling from two nearby locations a short distance upstream from Pool N. The emission was accompanied by a strong sulfurous odour. Methane emissions have been reported previously along the section of the river in the vicinity above the new longwalls.[7,8] The mining companies argue that methane emissions into streams reflect near surface biological activity. Little research has been undertaken however and the origin of the gas released above the mines beneath Sydney's catchment is largely unknown and may vary from site to site. Of note, the 2012 Annual Review (AR) for the Metropolitan Colliery advises "*monitoring indicates that all of the gas releases were generally comprised of 21% oxygen and 0.1 to 0.4% methane*".[7] Dr Turner suggests these figures would be consistent with a systematic sampling failure resulting in the captured sample being primarily air.

Of considerable concern was the almost continuous display of iron contamination effects along the one and a half kilometres or so of the Waratah Rivulet walked by the group. Iron and other metals are released when water passes over the freshly exposed rock faces of cracks caused by subsidence from mining operations. Water turns green with dissolved iron containing minerals and may develop a milky opacity as colloidal iron oxyhydroxides form before aggregating as floc that deposits onto and stains the bedrock orange-red. Other metals released include manganese, aluminium, zinc, barium and strontium and levels can exceed the ANZECC 95% protection of aquatic species trigger values. Adding to the alien landscape are heavy growths of orange-red iron oxidising bacteria and algal blooms. The Sydney Catchment Authority estimates that between February 2002 to August 2009 15.4 and 4.0 tonnes of iron and manganese respectively were added into the Woronora Reservoir[ref]; more will have been added since. Prior to mining the Waratah Rivulet is believed to have been a pristine stream.[1(b)]

Drs Bob and Ann Young commented that during five visits since November 2006, they have noticed sustained seepage of orange floc and staining of the water. The contamination is not short-term or trivial. Dr. Turner noted that the iron contamination was greater and more extensive between Pools H and N than he'd seen on previous visits and was surprised by the amount of iron oxidising bacteria observed along the watercourse. The presence of the bacteria is indicative of elevated levels of iron and manganese.

The bacteria grow orange-red sheaths comprised of iron and manganese oxyhydroxides that form mats that reduce the available habitat, hinder stream flow, reduce available food and light an adversely lower oxygen content.[1(b)] Loss of native plants and animals may occur as a result of very high iron levels, or smothering and loss of dissolved oxygen.

An examination[9] of the limited data in the 2012 Annual Review (AR) for the Metropolitan Colliery finds that the mining operations breached a project approval requirement that there must be no more than negligible change to water quality entering the Woronora Reservoir from Waratah Rivulet, where negligible is defined as "*small and unimportant, such as to be not worth considering*".[10] The 2012 AR advises that the projects water quality assessment benchmarks were exceeded but that overall there was negligible change to the quality of water entering the Woronora Reservoir. The Department of Planning is awaiting the 2013 review, due in April, before making an assessment

Dr Stuart Khan, Associate Professor in the School of Civil & Environmental Engineering at the University of New South Wales (UNSW), expressed surprise at the extent and intensity of the iron contamination; "*I was aware of recent concerns of elevated contamination being caused by the mine expansion, but didn't expect to find the Waratah Rivulet in such an appalling and alien state. The realisation that impacts of this kind occur above and around all of the mines in Sydney's water catchment is sobering. Metal contaminants will continue to be released into the water for decades and there's little likelihood of remediation. It's time for our community to carefully consider whether the benefits of this mining really outweigh this lasting legacy in our rivers and drinking water catchments*".

Dr Melissa Haswell, Associate Professor of Public Health at UNSW, commented on the long-term implications of mining damage for Sydney's growing population. "*The bottom line is, there is no more important requirement for health than a clean, affordable, sufficient and reliable source of water. We can look at many countries today that are already struggling without enough safe water for its people and food production; these countries are carrying a terrible burden of ill health. In developed countries, we are increasingly seeing a situation where precious water sources, such as Sydney's catchment area, are being threatened by invasive human activities, most notably, coal and unconventional gas mining. This is even more concerning at a time when urban populations are increasing and longer and more severe droughts are expected. Hence, while 4.5 million people in the Sydney area can be assured that what comes out of the taps today is of high quality, plentiful and low cost, this may not be the case in future years if there is continuing damage to our water catchment. I'm sure most people would agree that our water catchments deserve the highest level of protection now and into the future. It is a public health priority that must come first*".

In reviewing the proposed water management plan for the next set of longwalls of the mine's expansion project, Longwalls 23 to 27, Dr Turner has suggested to the Department of Planning and Infrastructure that the method used by the mining company to determine a benchmark value against which to assess changes to water quality is statistically flawed. He also finds that the value used to assess iron concentrations changes is too high to be consistent with the requirement for negligible change in water quality.

Annual reviews typically present only a small subset of monitoring data and that's usually in graphical form. This limits as assessment of mining impacts. Unless requested, companies do not provide the data behind the information presented in the annual review to the Department of Planning and Infrastructure. While mining companies are obliged to collect environmental data in the public interest, they are not obliged to make that data available to the public; either openly via the Web or upon request. Peabody Energy for example have refused several requests for access to data made at Metropolitan Colliery Community Consultative Committee meetings by Dr Turner. Compounding this lack of transparency, the data analysis and consequential recommendations are undertaken by consultants selected and funded by the mining company. A 2010 Planning Assessment Commission Panel report[11] recommended that the Department address this problem. The Department has not acted on this recommendation.

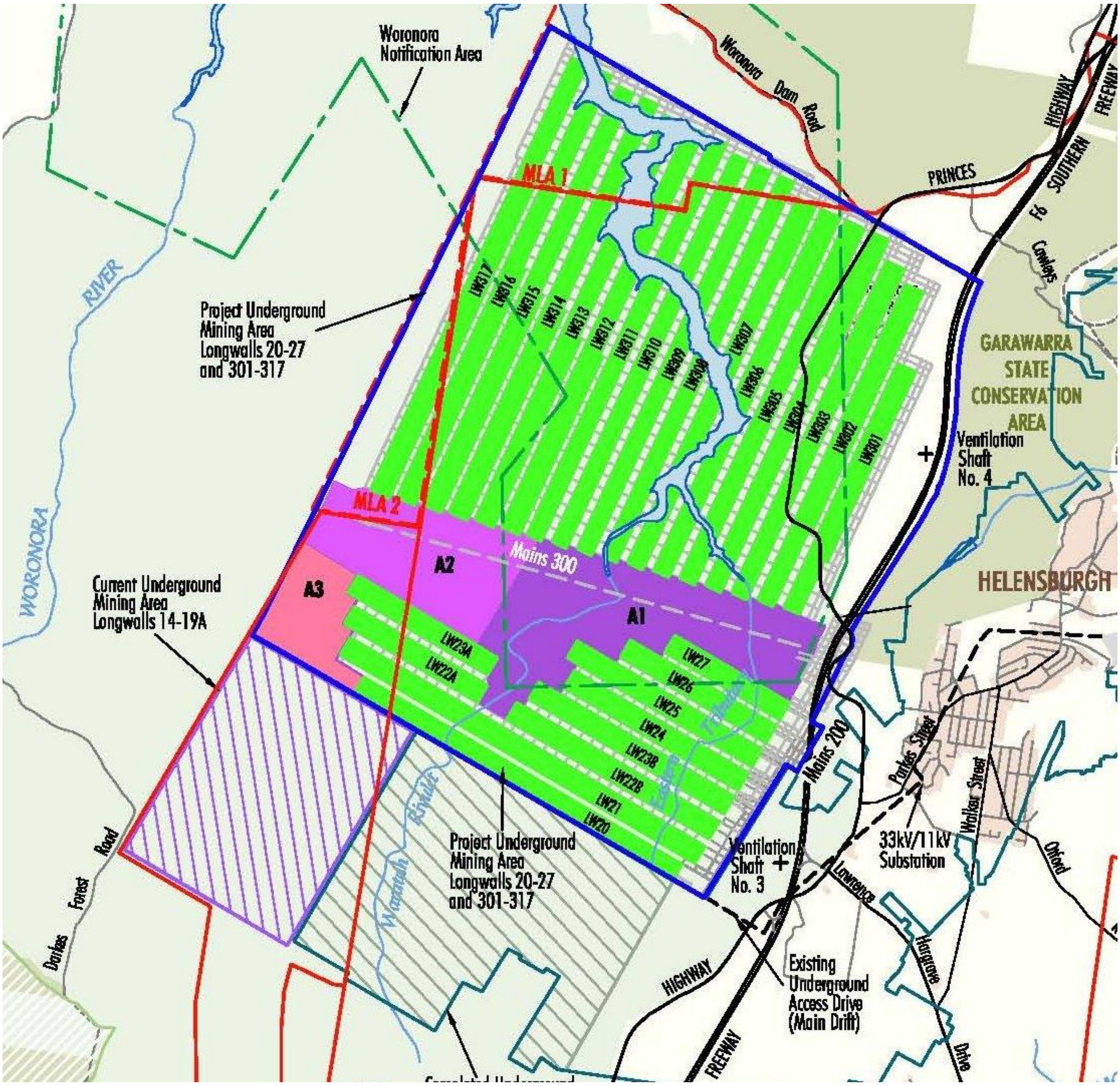
The views of the group were summarised by Sharyn Cullis from the Georges River Environmental Alliance; "*A genuinely independent review is urgently needed to establish that any further mining will satisfy the project approval standard of 'negligible environmental consequences' and ensure that there will be no further significant damage to the catchment of the Woronora Reservoir*".

Participants

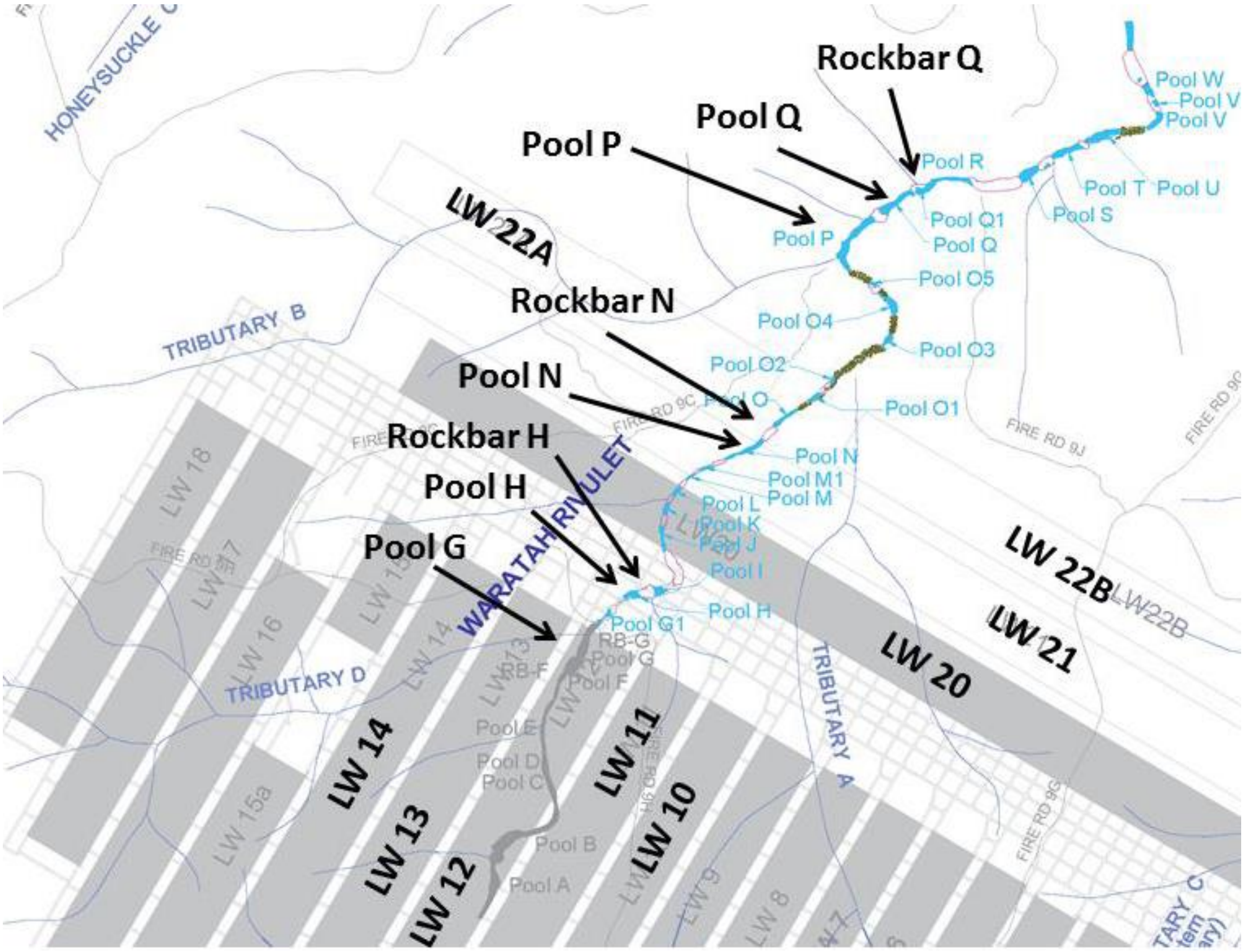
Dr John Bradd, Dr Paul Brown, Ms Sharyn Cullis, Dr Melissa Haswell, Dr Stuart Khan, Dr Peter Turner, Dr Ann Young, Dr Bob Young.

References

1. **(a)** Jankowski J & Knights P,'*Surface Water–Groundwater Interaction in the Fractured Sandstone Aquifer Impacted by Mining-Induced Subsidence; 1. Hydrology and Hydrogeology*'; 2010 IAH Congress, published in Biuletyn Pañstwowego instytutu Geologicznego 441: 33–42, 2010 R **(b)** '*Surface Water–Groundwater Interaction in the Fractured Sandstone Aquifer Impacted by Mining-Induced Subsidence; 2. Hydrogeochemistry*'; 2010 IAH Congress, published in Biuletyn Pañstwowego instytutu Geologicznego 441: 43–54, 2010 R.
2. Smith S., '*Mining and the Environment'* NSW Parliamentary Library Research Service Briefing Paper No 6/09, 2009, ISBN 9780 7313 18520.
3. Total Environment Centre, July 2007, '*What Happened to the Waratah Rivulet? A Case Study of the Failure to Protect Streams from Longwall Mining*'.
4. **(a)** Krogh M., '*Management of Longwall Coal Mining Impacts in Sydney's Southern Drinking Water Catchments'*, Australasian Journal of Environmental Management, Volume 14 Issue 3 Sept 2007. **(b)** Total Environment Centre 2007 '*Impacts of Longwall Coal Mining on the Environment in New South Wales*'.
5. **(a)** http://www.environment.nsw.gov.au/determinations/LongwallMiningKtp.htm **(b)** http://www.environment.nsw.gov.au/threatenedspecies/AlterationNaturalFlowKTPListing.htm
6. Andréassian, V., '*A review of the surface water hydrology studies carried out on the Woronora catchment'*, Sydney Catchment Authority, 2010.
7. *Metropolitan Coal 2012 Annual Review*, Peabody Energy, Project No. MET-08-08/8.1 Document No. 00482778.
8. http://www.smh.com.au/environment/water-issues/catchment-gas-leak-as-coalmine-cracks-20110308-1bmo9.html
9. Letter to the Director General of the Department of Planning and Infrastructure Sam Haddad from Peter Turner, October 31 2013.
10. Project approval for the Metropolitan Coal Project, Department of Planning, 2009.
11. NSW Planning Assessment Commission (PAC) July 2010 '*Review of the Bulli Seam Operations Project*', ISBN 978-0-9806592-6-9.



Location of the Metropolitan Colliery Longwalls. Note that Longwalls 23 to 27 are within the Dam Safety Committee's Notification Area; in 2013 the SCA declared its opposition to mining in the notification areas.



Location of the Pools and Rockbars on Waratah Rivulet and the Longwalls Below. Longwalls 21, 22A and most of 22B have now been completed.

The photographs within were taken by Peter Turner unless otherwise indicated.

Dr. Bob Young standing on the drained floor of Pool N, Thursday February 13 2014. The pool is approx. 150 metres long, up to 15 metres wide and up to 2 metres deep. The rocks in the foreground are piled up against Rockbar N and would normally be underwater. Photograph taken by Assoc. Prof. Stuart Khan.

Ass. Prof. Melissa Haswell standing on the drained floor of Pool N, photographed from Rockbar N Thursday February 13 2014. Rockbar N is approx. 2 km from the entrance to Woronora Reservoir. Upstream water flows between full pools; <u>only Pool N was dry</u>.

Subsidence induced cracking snakes across the floor of Pool N looking 'upstream' on the Waratah Rivulet, Thursday February 13 2014.

Short distance 'upstream' from the crack at the southern end of Pool N into which water was draining, February 13 2014. A layer on the river bed has been pushed upwards (upsidence).

Cracking and uplifting (upsidence) on the floor of Pool N, February 13 2014.

Crack into which water entering the southern 'upstream' end of Pool N is lost from the surface, February 13 1014. Photograph taken by Assoc. Prof. Stuart Khan.

Looking upstream along a full Pool N from Rockbar N in September 2012. The rocks exposed in the 2014 photographs are submerged. By September 2012 Rockbar N had been shattered and was leaking (see photographs in 2012 report).

Looking downstream along a full Pool N towards Rockbar N in September 2012. The water is green and milky reflecting dissolved iron and colloidal iron oxyhydroxides.

Google Earth view of a full Pool N in October 2009. Water runs over Rockbar N, providing a waterfall into Pool O on the far right. Pool N has since been drained, the rockbar shattered and the waterfall broken (see below and the 2012 photos).

Shattered northern 'downstream' waterfall face of Rockbar N (see also 2012 photos).

Cracking and uplifting (upsidence) to the east across the surface of Rockbar N. The extent of the cracking has increased since October 2012.

Dried up iron spring seep at the base of Rockbar N. The spring formed when the rockbar was shattered in 2012 (see 2012 photos) and began leaking water from Pool N. With the loss of Pool N the spring has dried.

Heavy iron oxidising bacteria growth and iron oxyhydroxide floc between Pool L and Pool M a short distance upstream from Pool N, Thursday February 13 2014. There is an almost constant display of iron contamination effects along a roughly two kilometre stretch upstream from Pool N.

Looking downstream to Pool H, February 13 2014. The water in Pool H has a very unusual murky orange-brown-green colour. Rockbar H is in the background; Rockbar H which is about 600 metres upstream from Rockbar N.

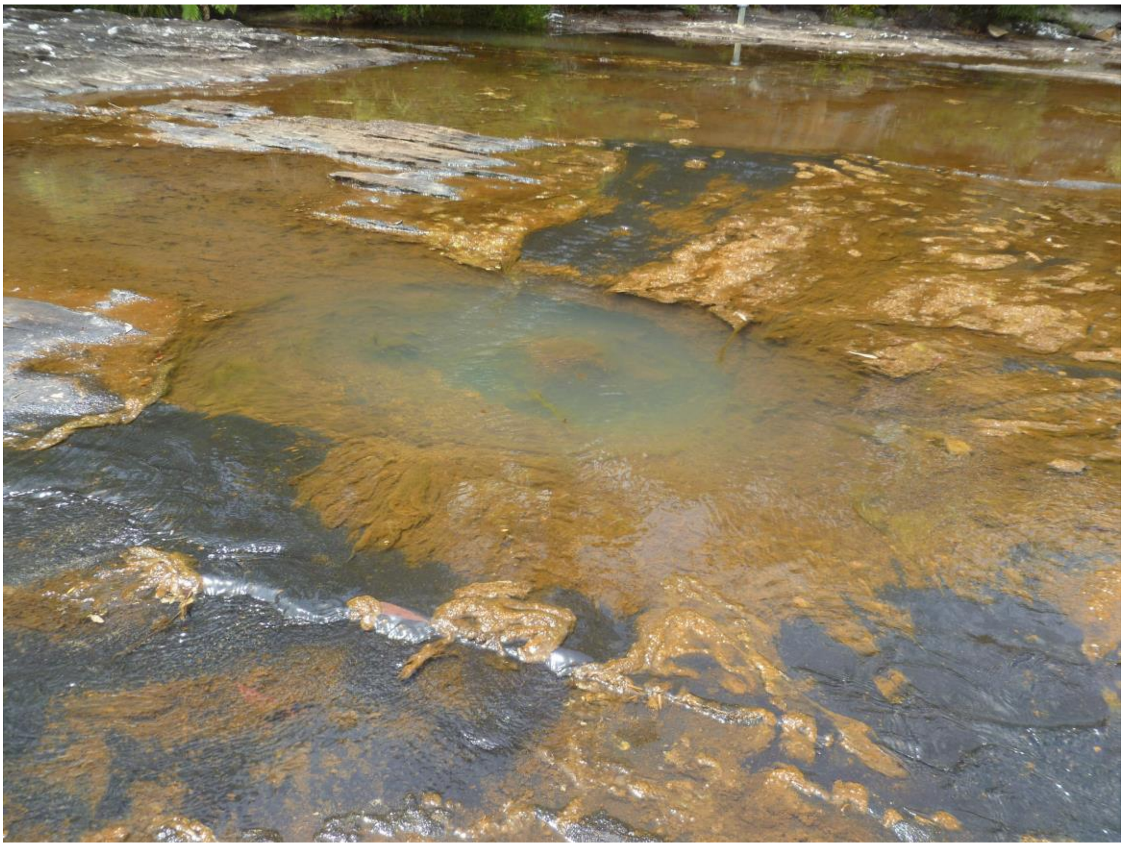
Looking into Pool H from immediately downstream, February 13 2014. The water in Pool H has a very unusual murky orange-brown-green colour, evidently reflecting an upwelling of contaminated ground water into the pool. The pool had the same appearance when visited on December 12 2013, it was green however on previous visits (see 2012 photos). There is heavy iron oxidising bacteria growth in water on Rockbar H. The water runs onto Rockbar H from the bottom right.

Green milky water flowing onto Rockbar H from Pool H; Pool H is the background.

Heavy iron oxyhydroxide floc and oxidising bacteria growth in milky green water running off Rockbar H. Pool H is in the far background. February 13 1014.

What appears to be a mixture of heavy iron oxyhydroxide floc and iron oxidising bacteria growth on the downstream side of Rockbar H, which is about 600 metres upstream from Rockbar N.

Looking downstream from Rockbar H into the milky green water of Pool I, February 13 2014.



Shallow milky green water, iron oxidising bacteria and algae between Pool I and Pool J

Substantial iron oxidising bacteria and algal growth upstream from Pool N, Thursday February 13 2014. Photograph taken by Sharyn Cullis.

Methane release a short distance upstream from Pool N, Thursday February 13 2014. Photograph taken by Assoc. Prof. Stuart Khan.

Green water looking upstream from Rockbar A, referred to as WRS3 by the SCA.

Heavy iron oxidising bacteria growth on the downstream side of Rockbar A, which is also known as WRS3. This rockbar is approximately 1.5 km upstream from Rockbar N and 850 metres upstream from Rockbar H.

Milky green water in a 'pothole' surrounded by iron oxidising bacteria on the downstream side of Rockbar A (WRS3).

What appears to be unusually heavyily iron oxide encrusted sheaths of iron oxidising bacteria colonies in a pool on the downstream slope of Rockbar 1 (WRS3), February 13 2014

'Stranded' iron oxidising bacteria sheaths drying out on the downstream side of Pool A (WRS3).

Milky green water in Pool B below Rockbar A

Thin film on water between pools C and D. The film is the 'extracellular polymeric substance' secreted by iron oxidising bacteria.

Green water in Pool F, looking upstream.

Green water looking upstream along Pool F from the edge of Rockbar F (WRS4). Note the large displaced bedrock fragments from the subsidence impacted river bed.

Water trickling out of Pool F is being lost into a cracked pothole; the pothole is behind a 'curtain' of polyurethane injected into the rockbar by Peabody Energy in an attempt to retain water in Pool F. While the company asserts the remediation has been successful, our understanding is that it has not met the SCA's performance criteria.

From: **Peter Turner** <peter.turner.home@gmail.com>
Date: 26 March 2014 14:36
Subject: Fwd: photographs of Waratah Rivulet and nearby streams
To: chris.armstrong@chiefscientist.nsw.gov.au
Cc: leah.schwartz@chiefscientist.nsw.gov.au

Chris, the second set of Waratah R. pics. Most of these are Sep-Oct 2012, though some in December 2013. Have shown or sent you many of these before I think. There are significant differences between the 2012 and the Feb 2014 photos (previous email) of Pool H, Pool N and Rockbar N.

Cheers, Peter.

---------- Forwarded message ----------
From: **Peter Turner** <peter.turner.home@gmail.com>
Date: 26 March 2014 09:43
Subject: photographs of Waratah Rivulet and nearby streams
To: S Haddad <sam.haddad@planning.nsw.gov.au>
Cc: Fiona Smith <Fiona.Smith@sca.nsw.gov.au>, graham.begg@sca.nsw.gov.au,sally.barnes@environment.nsw.gov.au, chris.wilson@planning.nsw.gov.au, david.kitto@planning.nsw.gov.au, Jessie Giblett <jessie.giblett@planning.nsw.gov.au>, Howard Reed <howard.reed@planning.nsw.gov.au>, Kelvin Lambkin <Kelvin.Lambkin@sca.nsw.gov.au>, Mark Bethwaite <mark.bethwaite@gmail.com>

Dear Mr Haddad, please find attached photographs of Waratah Rivulet taken in 2012, together with photographs of nearby watercourses taken in December 2013.

I note that the 2012 Annual Reports provided by Peabody Energy conveys little of the impact shown in these photographs and those I sent earlier today.

I also note that Peabody Energy made no mention of the shattering of Rockbar N (see attached photographs) at the February 2013 CCC meeting at which the 2012 Annual Review was summarised. The presentation given to the meeting included a photograph of Rock Bar N, but taken from a position where the damage could not be seen. As far as I'm aware, the CCC was not informed of the subsequent draining of Pool N.

It seems to me, and others, that the limited and selective nature of the reporting renders it insufficient for the Department and concerned members of the community to properly assess the impact of mining in Sydney's drinking water catchment.

These photographs, and those sent earlier, will also be sent to the office of the NSW Chief Scientist.

Regards, Peter.

Dr Peter Turner
Helensburgh 2508

Some Photographs of the Waratah Rivulet and Iron Springs at Swamps 20 and 21

The photographs within of the Waratah Rivulet were taken in late September and early October 2012, while the swamp photographs were taken in December 2013.

An earlier visit to the Waratah Rivulet in December 2011 found more flow and the water less green than in 2012. Rockbar N was then intact and water was flowing over the rockbar, which acted as a waterfall.

Longwall 21 passed below the Waratah Rivulet near Rockbar N sometime in January 2012.

The water in the Waratah Rivulet is green from rockbar WRS3 to sampling site WRWQ9 in Pool Q, which is used by Peabody to gauge the concentration of contaminants in water entering the Woronora Reservoir. This is a distance of about 2.2 kilometres.

The stream water is coloured green by dissolved ferrous ions. The milky opacity is caused by colloidal iron oxides formed as the ferrous iron is oxidised to ferric iron. This is noted in the quote below from the 2009 Director General's Environmental Assessment report for the approval of the Metropolitan Colliery expansion project. The colloidal iron aggregates and changes colour before settling to cause orange-red staining on the bedrock.

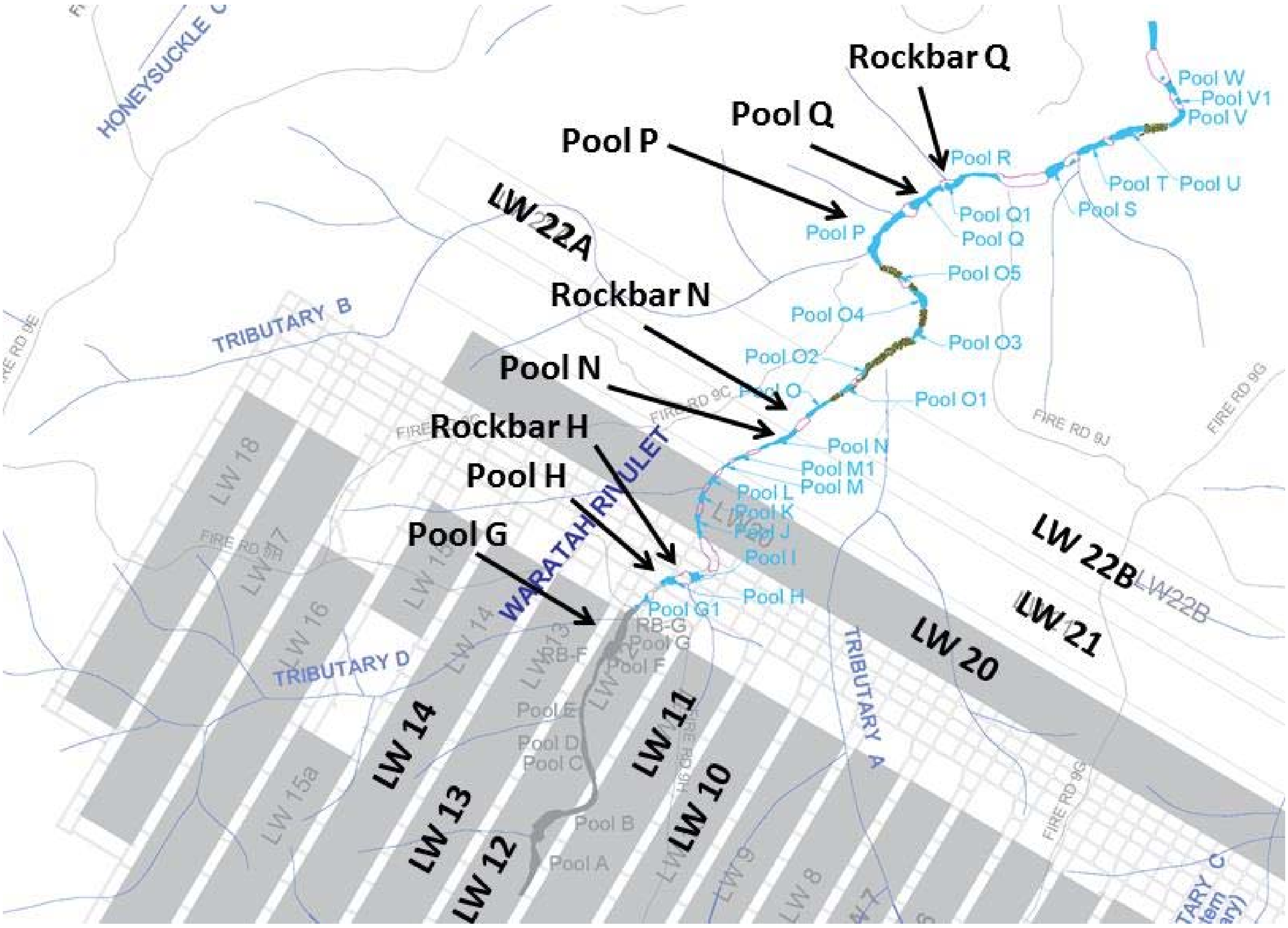
The Director General's June 2009 Environmental Assessment report comments on iron springs on the Waratah Rivulet:

"*Large areas of rocky substrate in the Waratah Rivulet and other watercourses have been observed to be covered by orange-red iron staining for many hundreds of metres downstream of mine subsidence fractures. If the iron concentration is sufficiently high, and the aquatic environment is suitable, then orange, bacterially-based iron flocs may also form in ponds. Potential ecological effects of such flocs are reported to include smothering of benthic habitat and biota and reduced light available for aquatic plants. Bacterially-catalysed oxidation of iron also consumes dissolved oxygen from the water column. In addition, the water in many pools appears to be stained by a generally pale-green milkiness or opacity. This is commonly associated with either iron staining on the substrate or iron flocs. In response to the PAC's Query No 36, HCPL provided information that this opacity was caused by colloidal ferric iron precipitating in the water column. The colloidal iron (as with the iron staining and iron flocs that it leads to) derives from ferrous iron, which is mostly leached from freshly-fractured rock by upwelling, oxygen-poor groundwater.*"

The 2010 PAC Panel report for BHP-Billiton's Bulli Seam Operations proposal notes "*Panel members have also noted water to be discoloured and opaque for considerable distances downstream of mine workings, but not upstream. The Panel inquired into this when assessing the Metropolitan Coal Project and was advised the dissolution of marcasite or iron oxy-hydroxides can lead to green opacity of water and algal blooms in rock pools accompanied by dissolved oxygen and related eco-toxic impacts*". That is, the algal blooms constitute a mining impact.

The Director General's report for the Metropolitan Colliery expansion project describes Pool P as being "*characterised by very clear water and a healthy and abundant population of a variety of aquatic macrophytes, with no iron staining present*". That may no longer be the case; though more dilute than further upstream, the photographs within show milky green water in Pool Q and what would appear to be iron staining on Rockbar Q. Pool Q is downstream from Pool P.

Map showing Waratah Rivulet, LWs 20 and 21 and the earlier longwalls



Iron spring emission, oxidising bacteria and algae in stream from Swamp 20 - 12/12/13. The stream supplies Waratah Rivulet.

Iron spring emission in stream from Swamp 20 - 12/12/13. The stream supplies Waratah Rivulet.

Iron floc and iron oxidising bacteria below Swamp 21, on Tributary A.

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Iron floc and iron oxidising bacteria below Swamp 21, on Tributary A - which supplies Waratah Rivulet

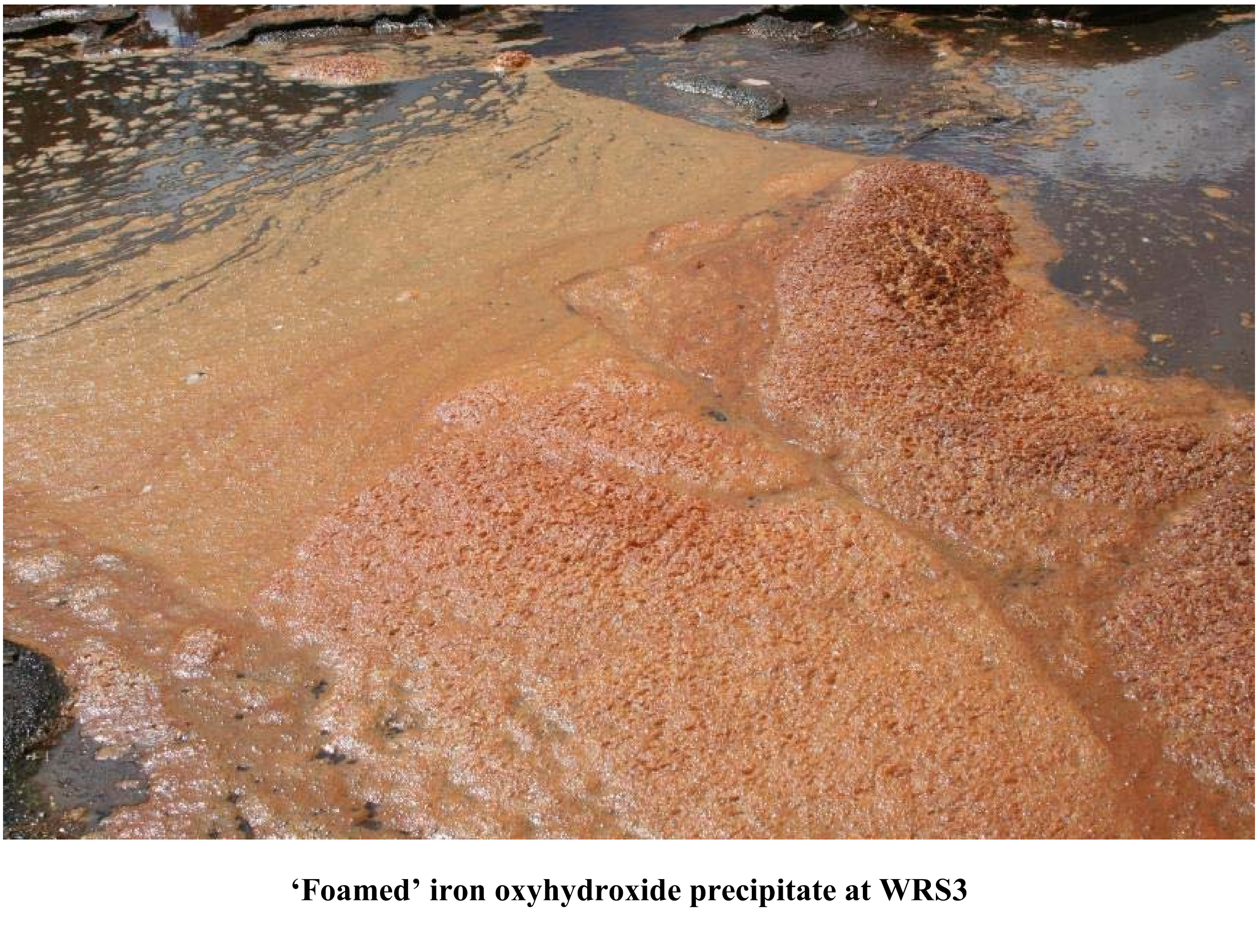
Iron oxidising bacteria and algal growth below Swamp 21. The stream supplies Waratah Rivulet.

Unexpectedly dry pool on Tributary A below Swamp 21, at the intersection with the stream from Swamp 20. There had been recent heavy rain and there was flow over the crossings at Eastern Tributary and Waratah Rivulet. The high water mark shows the capacity of the pool. Perhaps the lost surface water joins groundwater flows that reach Woronora Reservoir - or perhaps it doesn't.

Waratah Rivulet Visit Late September and early October 2012

Looking upstream at Rockbar WRS3 on the Waratah Rivulet. The water is green with dissolved iron and manganese from subsidence facture and the river bed is lined with orange-brown iron oxidising bacteria and algal growth.

WRS3 where remediation work has taken place in 2011-12



'Foamed' iron oxyhydroxide precipitate at WRS3

Milky-green water looking downstream from WRS3

Milky green water at Pool G - the increased opacity may be suspended algae and/or increased colloidal iron oxide

Iron oxidising bacteria film in Pool G

Iron oxidising bacteria along a channel across Rockbar H looking upstream to Pool H at Rockbar H - between northern end of old longwalls (LW 12) and Longwall 20 (new).

Iron oxidising bacteria in narrow channel from Pool H at Rockbar H.

Iron oxidising bacteria at the edge of Rockbar H

Iron oxidising bacteria and iron oxide deposits at Rockbar H

View downstream from Rockbar H

Crack across iron stained rockbar Rockbar H

Iron staining across the downstream side of Rockbar H

Iron staining looking upstream towards Rockbar H

Iron oxidising bacteria, staining and algal growth on riffles between Rockbar H and Rockbar N

Upstream from Rockbar N (WRS5)

Milky green water in Pool N behind Rockbar N (looking upstream)

Broken waterfall of Rockbar N (WRS-5) - water from Pool N leaks through about halfway down the broken face of the waterfall. The waterfall was intact when visited in December 2011, with water flowing over the top of the rockbar.

Water leaking through the now broken Rockbar N (WRS-5) from Pool N

Water leaking through a broken Rockbar N (WRS5) from Pool N

Fractures across Rockbar N and its waterfall face

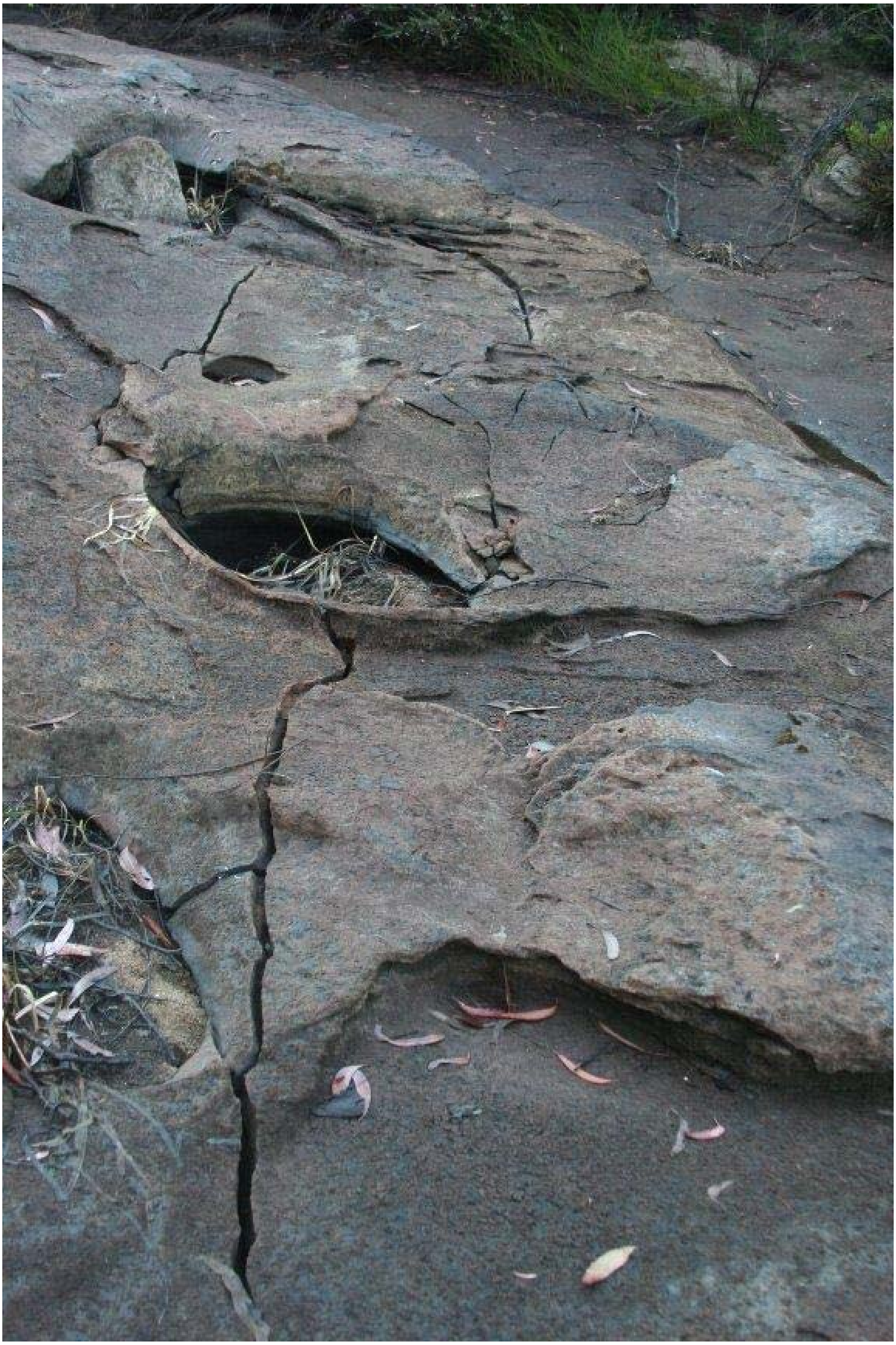
Fracturing across the face of the broken waterfall of Rockbar N

Large and precariously balanced fragment

Water leaks through a crack on the top of Rockbar N (WRS5) just behind the edge of its broken waterfall. The rockbar was intact in December 2011 and water flowed over its top.

Upsidence impacts on the surface of the shattered rockbar Rockbar N (WRS5)

Upsidence impacts on Rockbar N (WRS5)



Cracks run across the top of Rockbar N (WRS5), behind the broken waterfall. Intersected pot holes are drained.

Milky green water in Pool O below the broken waterfall at Rockbar N (WRS5)

Crack at the base of the broken waterfall at Rockbar N (WRS5)

Iron spring at the eastern side of the base of Rockbar N

Iron oxide emerging into water from a rock shelf at the base of the broken waterfall at Rockbar N

Iron oxide emerging into water from a rock shelf at the base of the broken waterfall at Rockbar N

Iron spring at the eastern side of the base of Rockbar N

Iron spring at the eastern side of the base of Rockbar N

Iron spring at the western side of the base of Rockbar N

Iron spring at the base of Rockbar N

Cliff fragments stacked like fallen dominos, approximately 150 metres downstream from Rockbar N

Milky-green water at sampling site WRWQ9 in Pool Q - near the entrance to Woronora Reservoir and approximately 2.2 km downstream from WRS3

What appears to be iron staining at Rockbar Q