Appendix E

Potential implications for the London Bridge natural arch and karst

Environmental impact statement

Murrumbidgee to
Googong Water Transfer

Potential implications for the London Bridge natural arch & karst

A report to GHD from
Optimal Karst Management
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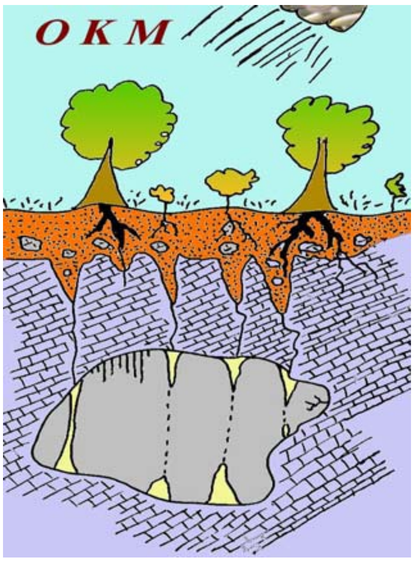
April 2009



1. Introduction

1.1 Purpose of this report

ACTEW Corporation Limited (ACTEW) proposes to undertake the Murrumbidgee to Googong Water Transfer Project (referred to in this report as ‘the project’). This report has been prepared to provide an assessment of the potential impacts of the project on the London Bridge natural arch and associated features as an input to the environmental impact assessment. The environmental impact assessment is being prepared in accordance with the requirements of Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and the ACT *Planning and Development Act 2007.*

The report addresses the requirements of the Director-General of the NSW Department of Planning (the Director-General’s Requirements) dated 7 October 2008 and the Final Scoping Document prepared by the ACT Planning & Land Authority (the Scoping Document) dated 16 December 2008.

1.2 Project overview

In recent years the Australian Capital Territory (ACT) region has been experiencing severe drought conditions coupled with increased demand for water. Canberra and Queanbeyan have been subject to level three water restrictions since 2006. The current drought, together with predicted climate change and population growth, is driving the search for a more reliable water supply for the ACT. In response to this need, the ACT Government developed the Water Security Program, which identified a range of new water supply projects.

The project is one of the preferred options for delivering improved security to the ACT’s water supply. It involves pumping water from the Murrumbidgee River (within the ACT) and transferring it via a pipeline to the Googong Reservoir via Burra Creek (in NSW). The Googong Reservoir supplies water treated to drinking quality standards to the ACT.

The project involves construction and operation of infrastructure required to transfer approximately 100 ML/day of water a distance of approximately 13 km from the Murrumbidgee River to Burra Creek.

The infrastructure required to transfer the water includes an intake/low lift pump station; a high lift pump station; an underground pipeline; a discharge structure and a power supply.

1.3 The location of the project

The intake/low lift pump station would be located on the east bank of the Murrumbidgee River, in the ACT, approximately 34 km south of Canberra. It would be located in an area known as Angle Crossing, approximately 4 km west of Williamsdale on the Monaro Highway.

The high lift pump station would be located within the ACT, approximately 290 m to the east of the intake/low lift pump station.

The pipeline would cross rural land in an east/north-east direction for approximately 13 km. It is located in the vicinity of Williamsdale and Burra Roads, within the districts of Williamsdale and Burra. The majority (approximately 10.2 km) of the pipeline would be located in NSW, with approximately 2.8 km located in the ACT.

The pipeline would discharge to the discharge structure, located on the banks of Burra Creek, just downstream of an existing flow measuring station approximately 10 km south of Googong Reservoir. The discharge structure is located within land know as the Googong Foreshores, which is Commonwealth land within NSW.

This report, commissioned by GHD on behalf of ACTEW, discusses some of the issues for increased water flows at the London Bridge natural arch. Others will be reporting on geomorphological, palaeontological, anthropological and archaeological issues.

It appears that the proposed 100 ML/day transfer will not appreciably change hydrological regime for other than low flow conditions ACTEW 2008a, 2008b). From a geomorphological perspective Burra Creek has encountered dramatic changes in environmental regimes from 'Ice Age' to 'modern' conditions – and back again. Mankind - Aborigines and Caucasians - have also influenced the setting and geomorphology of the site. The task here is to evaluate whether the proposed M2G bulk water transfer will adversely impact on London Bridge, its karst features and processes, its Aboriginal and European resources and cultural attributes, its biota and palaeontological features.

Although London Bridge natural arch is not within the Australian Capital Territory it as managed as if it was part of the Territory as part of the Googong Foreshores (ACT Government 2007) under water-sharing arrangements between the Commonwealth, the Territory and New South Wales under the *Canberra Water Supply (Googong Dam) Act 1974.* A 150-year lease was signed in September 2008, giving the ACT Government control of the dam and its foreshores.

A variety of statements about the aesthetic, historic, scientific and cultural values reactions of visitors and researchers are attached as Appendix 1.

2. NSW Director Generals' and ACT Government Reporting Requirements

The Director-General's requirements of the various state and territory departments, local government and the Murray Darling Basin Commission have been reviewed for the preparation of this report. Only those of the Department of Environment and Climate Change appear to be of direct relevance to London Bridge itself. Some of the statements made in this Department's letter are incorrect – these have been addressed in the discussion below.

3. Natural and cultural heritage values and listings

The feature is listed on the now-frozen Commonwealth Register of the National Estate[1]. That register describes the site as follows:

> ***Statement of Significance:*** *The London Bridge area is a good representation of, and illustrates well, the development of caves and an arch as meander cut offs, and the eventual abandonment of the meander channel. The caves contain rich Pleistocene deposits of small mammals, and Pleistocene bone breccia of large mammals, is embedded in flowstone on the floor of the two main caves.*
> *The arch is a large attractive natural bridge of aesthetic value. The karst features displayed at London Bridge, its close proximity to Canberra, and the cave deposits containing Pleistocene mammal fossils, make the area an important teaching and research site.*
> *The Commission has determined that this place has Indigenous values of National Estate significance. The Commission is currently consulting with relevant Indigenous communities about the amount of information to be placed on public record.*
>
> ***Description:*** *London Bridge is a natural limestone arch, which developed, along with several small caves, as a meander cut off on Burra Creek.*
> *The now abandoned incised meander is clearly visible just east of Burra Creek.*
> *The limestone which contains the arch and caves is a small lens (about 50m x 150m) developed in the late Silurian Cappanana Formation.*
> *The arch is 34m long, about 12m-18m wide and 5m high, while 5m-7m vertical cliffs occur above both entrances to the arch. Two through caves, containing patches of flowstone and Pleistocene fossil deposits, occur in the limestone, above the level of the arch.*
> *These caves are older Burra Creek passages. Several small caves and shafts also occur in the limestone.*

[1] The Register of the National Estate was "frozen" in February 2007 and now only exists, nationally, as an archival register titled the 'Australian Heritage Places Inventory'.

The above statement and description is adequate but perhaps overstates some values and underplays others – however these are not significant in the context of this report.

London Bridge is also listed on:

- the heritage register of the Palerang Council;
- the Geological Society of Australia's ACT Division's 1998 report *Geological Monuments in the ACT*; and
- the National Capital Development Commission/National Capital Planning Authority's Technical Paper 56 *Sites of Significance in the ACT.*

London Bridge also appears an outstanding example of its geomorphic type and origin in two internationally recognised scientific texts (Jennings 1971, Jennings 1985) and in one substantive peer-reviewed scientific paper (Jennings et al 1976). It is one of 28 geological excursions listed for the ACT and wider region in the new guide to the geology of this area (Finlayson 2008).

4. Values of the place and potential impacts from changes in Burra Creek flow regimes and water quality

4.1 Aesthetic values

The aesthetic values of the site have been recognised by European visitors and scientists since 1823 (see Appendix 1 for quotations from the literature). The area is visited by many people – largely for its aesthetic qualities but also as a scientific curiosity and for the easily explored, if very small, caves. Visitor numbers may rise after the publication of the new geological guide to the ACT and region (Finlayson 2008).

Higher water levels arising from the proposed M2G bulk water transfer should not affect the visual qualities of the site and might well add to its attractiveness – especially in very low flow conditions where pools may be stagnant and unappealing.

Figure 1. Vertical view of London Bridge (2008)

Figure 2. Southern (upstream) side of London Bridge (2008)

Figure 3. Northern (downstream) side of London Bridge (2008)

4.2 Archaeological and historic values

These values will be examined in depth by others more qualified than I (Navin Officer and Associates). Suffice to say that a brief review of Appendix 1 below which documents European reactions to London Bridge demonstrates that it has been appreciated since at least 1823. Boot and Cooke (1990) provide the best review of the archaeological and historic values and controversies surronding the site. Spate (1993) also touches on these. Appendix 1 should be consulted in regard to the existing documentation of the so-called 'London Bridge Mystery'. In spite of Boot and Cooke's review of the historical material I believe that this 'mystery' is not resolved – there are many inconsistencies even from one reporter such as John Gale. Any discoveries of Aboriginal or European skeltal material in the 19th Century need not necessarily come from the caves at London Bridge itself as there are others on the former large London Bridge estate and nearby in the Burra Creek Valley.

The proposed M2G water transfer will not in impinge on the sediments of Douglas Cave or on the Burra Shelter 1 site excavated by Boot and Cooke (1990) immediately upstream from Burra Cave. At the time of Boot and Cooke's excavations in Douglas Cave, Burra Creek was 'considerably deeper than this (the normal 5-10 cm cited in Nicoll and Brush 1976, p 17-18), up to a metre deep in some places, and had been so for over a year, according to rangers and local residents'. A one metre increase in depth above the level shown on Nicoll and Brush’s maps and sections is still 1.5 m below the lower entrance to Douglas Cave and at least 5.5 m below the bottom of Boot and Cooke's excavation. A similar comment applies to the Burra Creek 1 shelter excavation with the floor of that excavation being about 2.5 m above the creek level plus the metre referred to by Boot and Cooke.

4.3 Geology

The geology of the London Bridge limestone is described best by Veevers (1953) and Jennings et al. (1976). The limestone is part of the Capannana Formation which is of Late Silurian age. The limestone generally dips westwards at about 40^o although there are variations and minor folds. Burra Creek flows along the line of strike (roughly north-south) and the Queanbeyan Fault. The limestone itself extends patchily many kilometres up- and downstream of London Bridge. The bedding planes and jointing (including some well-developed and beautifully curved unloading joints) have provided initial partings for solution of the limestone and subsequent stream capture and cave development. The limestone is fossiliferous in parts but there it seems that there are no taxa which are only found at London Bridge itself.

The M2G proposed water transfer will not significantly affect the the geological values of London Bridge.

4.4 Geomorphology

The geomorphology of the site was touched on, perceptively, by Mahony and Taylor (1913), Veevers (1953) and, most substantively, by Jennings et al. (1976). GHD (2008) does not comment substaantivlely on the geomorphology of London Bridge itself but rather on the fluvial geomorphology of the whole of Burra Creek. Jennings et al. (1976) provide evidence on the development of the caves, London Bridge arch itself, and on the meander in Burra Creek. The abstract to that paper reads as follows:

> London Bridge spans Burra creek in the Southern Tablelands. It was formed by the development of an underground cut-off through a limestone lens in the waist of a meander spur and controlled by the strike of the limestone and dip and unloading joints. The meander loop is occupied by a tributary alluvial fan, which may have been a dynamic factor in forming the cut-off, not simply a consequence of it. Abandoned caves along the strike at higher level represent earlier cut-offs. Descending profiles in these caves were caused by a rejuvenation head, held at the meander by resistant greywacke. London Bridge combines scientific interest and natural beauty to such a degree that it should be preserved as a geologic monument. (p 238)

The caves themselves at London Bridge are more fully described in Nicoll and Brush (1976).

Figure 4. London Bridge cave maps, and cross and long sections. After Nicoll and Brush (1976).

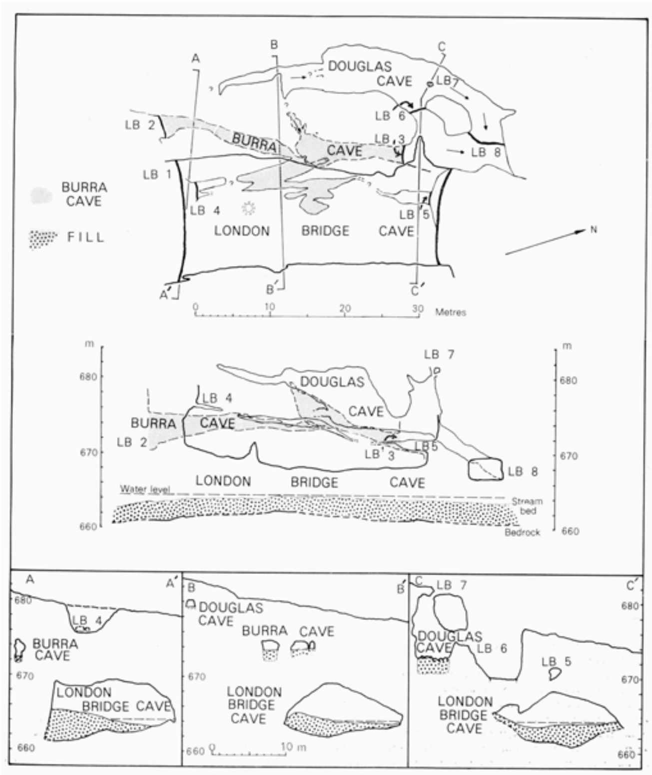


Figure 5. Interior of Burra Cave (2008)

Figure 6. Lower entrance of Douglas Cave (2008)

It is interesting to note that Burra Creek, about 1.1 km upstream from London Bridge (at about GR 55H 705270 E; 6066710 S; GDA 94), appears to be eroding the same limestone strata in a similar fashion to that which lead to the development of the Bridge. However, even is this observation is correct, a 'new London Bridge' will not be available for many thousands of years!

The M2G proposed water transfer will not significantly affect the geomorphological values of London Bridge.

4.5 Cave-dependant invertebrates

Eberhard and Spate (1995) reviewed the literature and conducted surveys of the invertebrate cave fauna across New South Wales. The London Bridge caves were not included in the survey as they are small and have been heavily disturbed by visitors over the years. No literature references to cave fauna here were found. Brief inspections carried out in the course of this study revealed no terrestrial inhabitants with any cave-dependant features. As there are almost certainly water-filled fissures or solution features in the limestone there is a possibility that there maybe groundwater dependent species at this site but again the small scale of the site and thus its phreas[2] suggests that isolation from surface waters is unlikely that stygofaunal communities have developed.

The proposed M2G bulk water transfer will not affect the terrestrial cave spaces. It is probable that any cave-adapted stygofaunal species present have coped with greater environmental change through glacial/interglacial conditions and the changes in land use consequent on European settlement (and possibly on changed fire regimes, and hence, vegetation conditions, as a consequence of the arrival of Aboriginal people).

4.6 Cave-dependant vertebrates

It is clear that the caves have been used by cave-dwelling bats through time. Species that may have used the caves in the past include *Miniopterus schreibersii oceanensis* (Eastern Bentwing Bat), *Myotis adversus* (Large Footed Myotis) and *Rhinolophus megaphyllus* (Eastern Horseshoe Bat). The first two species are listed as *Vulnerable* under the NSW Threatened Species Protection Act 1995. There does not appear to be substantive ongoing use of the caves by bats species. The nearest known substantive roost of *M. s. oceanensis* is in a concrete tunnel in the base of Googong Dam itself. In this region this species is dependent on the maternity cave at Wee Jasper from which bats disperse to the coastal ranges following summer breeding. In caves such as those at London Bridge the use by *R. megaphyllus* is often demonstrated by the presence of large moth wings as 'calling cards' – none have been observed.

That the caves are still used occasionally by bats – probably *M. s. oceanensis* – is demonstrated by a very thin, and discontinuous layer of faecal pellets across the floor of Douglas Cave. The youth of this layer is demonstrated by its deposition across the surface of the excavation conducted in 1990 (Boot and Cook 1990). The limited size of the caves, together with their openness to the outside atmosphere, suggests that they are not critically important for cave-dwelling bats. Modern visitor pressures will also have reduced the use of these caves by bats.

In October-November 2008 a small raptor (of unknown species) was nesting and raising young on the cliffs outside Douglas Cave.

The proposed M2G bulk water transfer will not significantly impact on the use of the caves by cave-dwelling bats. In fact, the converse may well be true – higher water levels may reduce human visitor pressures on Douglas Cave in particular and thus produce more equitable conditions for bats.

4.7 Sub-fossils

Hope (1976) and Boot and Cooke (1990) have investigated the sub-fossil material from London Bridge; the latter workers report at least 27 species present with rabbits and mice being the only introduced species. There is no doubt that it is a valuable site with nine locally or nationally extinct species recovered. Changes in species composition may reflect changes in the local climate and vegetation since the Last Glacial Maximum (~18,000 years ago). Much of the smaller-size bone material has been insufficiently studied (Boot and Cooke, p 99). It appears that many, if not all, of the small mammal remains found at London Bridge were the prey of owls which roosted in the caves. There appear to be no modern reports of owls using the caves.

However, the comment in the Department of the Environment and Climate Change's Director-General's Requirements (letter DECC to Department of Planning, 16 September 2008) that the bone deposit is “massive” cannot be supported – it is not particularly extensive even in the southern New South Wales context. Neither can the statement ‘the deposits have been dated to more thaan 20,000 years’. The oldest date reported by Boot and Cook (1990, p 96) is 12,920 +/- 250 BP – ANU-7464).

The following are the most important species recovered by Hope (1976) and Boot and Cooke (1990):

- *Conilurus albipes* – white footed rabbit rat – extinct since 1840;

[2] Phreas = the saturated zone below the watertable.

- *Mastacomys fuscus* – broad toothed rat – locally extinct;
- *Rattus lutreolus* – swamp rat – locally extinct;
- *Pseudomys fumeus* – smoky mouse – locally extinct;
- *Pseudomys oralis* – Hastings River mouse – locally extinct;
- *Pseudomys novarhollandiae* – New Holland mouse – locally extinct;
- *Bettongia gaimardi* – Tasmanian bettong – extinct on the mainland;
- *Burramys parvus* – mountain pigmy possum – locally extinct; and
- *Dasyurus viverrinus* – eastern quoll – extinct on the mainland.

The proposed M2G water transfer should not impinge on the sediments of Douglas Cave or on the Burra Shelter 1 site immediately upstream from Burra Cave. At the time of Boot and Cooke's excavations in Douglas Cave, Burra Creek was 'considerably deeper than this (the normal 5-10 cm cited in Nicoll and Brush 1976, p 17-18), up to a metre deep in some places, and had been so for over a year, according to rangers and local residents'. A one metre increase in depth is still several metres below the lower entrance to Douglas Cave which in turn is several metres below the bottom of Boot and Cooke's excavation. A similar comment applies to the Burra Creek 1 shelter excavation.

5. Channel changes at London Bridge

A variety of evidence is available examine changes in the channel morphology at London Bridge over the period ~1927 to 2009. GHD (2008) has also discussed channel changes throughout the length of Burra Creek. We also have a few, not very adequate, descriptions dating from 1823 to 1913. Currie (1825) remarked on his “one perfect Saxon arch”. There must have been channel incision at that time to allow him a view of an arch. If the upper level of the current level alluvial terrace is projected toward the apex of the arch – that is, assuming that the terrace was not incised in 1823 – there would have been a very sorry arch indeed in view - hardly rising above the water at all. Lampert (pers.comm) suggests that there is perhaps 50-100 cm of post-European sediment deposition on the terrace. Even if one metre is subtracted from the modern terrace level and that level projected against the arch the span would not seem to be spectacular enough to generate the 'perfect Saxon arch' comment.
Moore (1981, p 58) states:

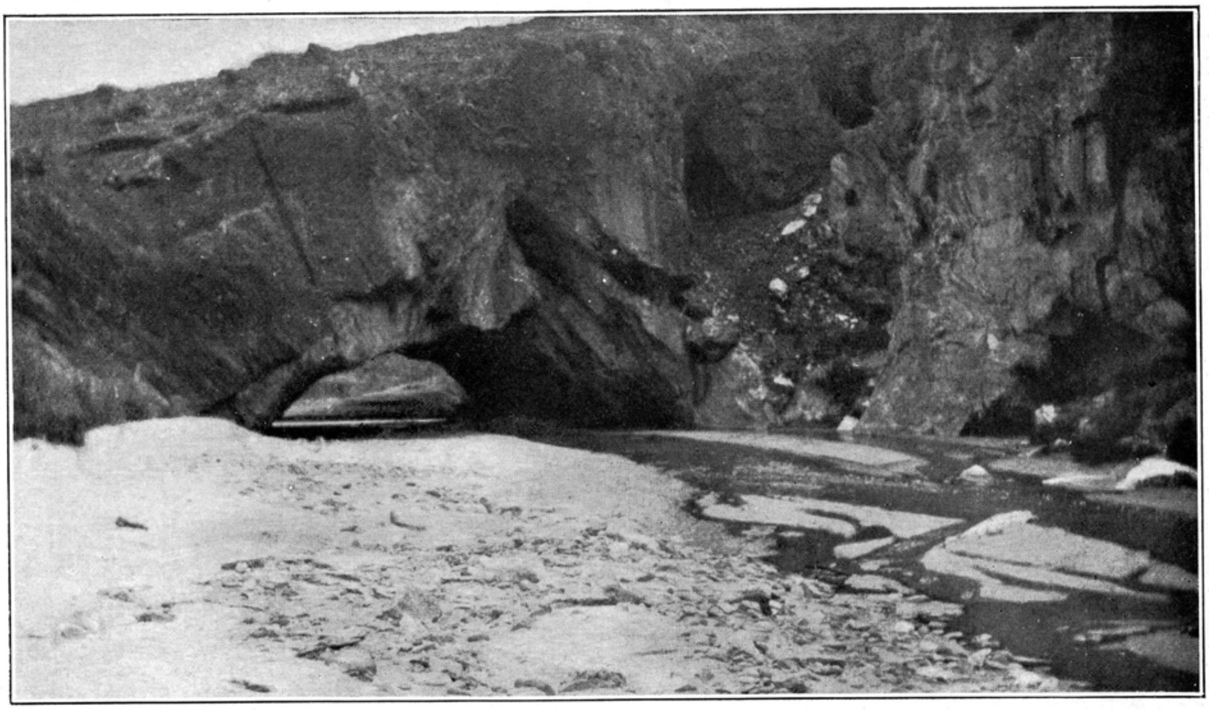
> Soil erosion hardly existed whilst the country remained in its native state. Surveyor Larmer's plan of the Church Land back in 1835 shows the Burra Creek as a string of waterholes between which the waters flowed after rain. A creek with defined banks did not exist at that time.

As discussed previously a creek without defined banks seems unlikely at London Bridge – even if just above and below the arch itself. Some measure of incision seems likely before it would be reported as a 'perfect Saxon arch'.

Flow conditions through the arch would likely by changed by a reduction in 'roughness' and possibly by increased velocity through 'pipe flow' conditions. Thus channel incision above (and below) the arch appears likely – suggesting that the arch would have been a 'pond' in the common Southern Tablelands minor steam situation of ‘chain-of-ponds' creeks.

Perhaps more importantly, we have a series of photographs from ~1927 to present which show that the channel conditions at London Bridge display variable conditions with the current heavily vegetated conditions at the Bridge as being 'abnormal' (Figures 7-9). The increase in vegetation is probably the result of relatively long-term low flow conditions through the last decade of drought – perhaps with the reduction in grazing pressures since around 1976. 'Normal' conditions from ~1927 until 1976 (that is, natural conditions that will have been modified by land use changes from 1823 to 1976) seem to be of a much less vegetated channel.

Figure 7. Downstream view of London Bridge at or prior to 1927 (Gale 1927, opposite p 59)



London Bridge: A Natural Archway Spanning Old Burra Creek.

Figure 8. Downstream view of London Bridge in 1976

Figure 9. Downstream view of London Bridge in 2008

6. Water levels during the proposed pumping regime

Increased water levels at the proposed 100 ML/day are unlikely to alter the channel conditions radically as they do not significantly increase stage or velocity. Natural flood flows will be those that change channel condition. The following two figures (Figures 10 and 11; from BWA, 2009) show modelled flows through London Bridge itself for low flows (5ML/day), for the proposed pumped flows of 50 and 100 ML/day and for three month and two year annual recurrence interval (ARI) flows with and without the proposed pumped flows. Either of the proposed pumped flows will raise water levels through the Bridge by less than 0.40 m above the low flow stage. Three month ARI flows are about 0.8 m above low flow and two year ARI flows are about 1.9 m above low flow – this level is about 2.2 m below the roof-line at the downstream side of the Bridge. Figures 10 and 11 show that the addition of the proposed pumped flows to Burra Creek do not significantly raise creek levels above natural flow regimes. Figures 12 and 13 show upstream and downstream flood flows in Burra Creek in November 1976. The flood is of unknown recurrence interval but at this stage is probably roughly comparable (by eye) with the modelled two year ARI flows.

The water levels predicted in a two year ARI storm plus a pumped discharge of 100 ML/day is still lower than the floors of Douglas and Burra Caves and Burra 1 shelter. Thus there would be no impact on the sediments in this situation.

Figure 10. Computed Water Surface Profiles along Burra Creek through London Bridge (from BWA, 2009). The grey shaded area shows the longitudinal extent and roof-line of the underside of London Bridge. Flow is from right to left.

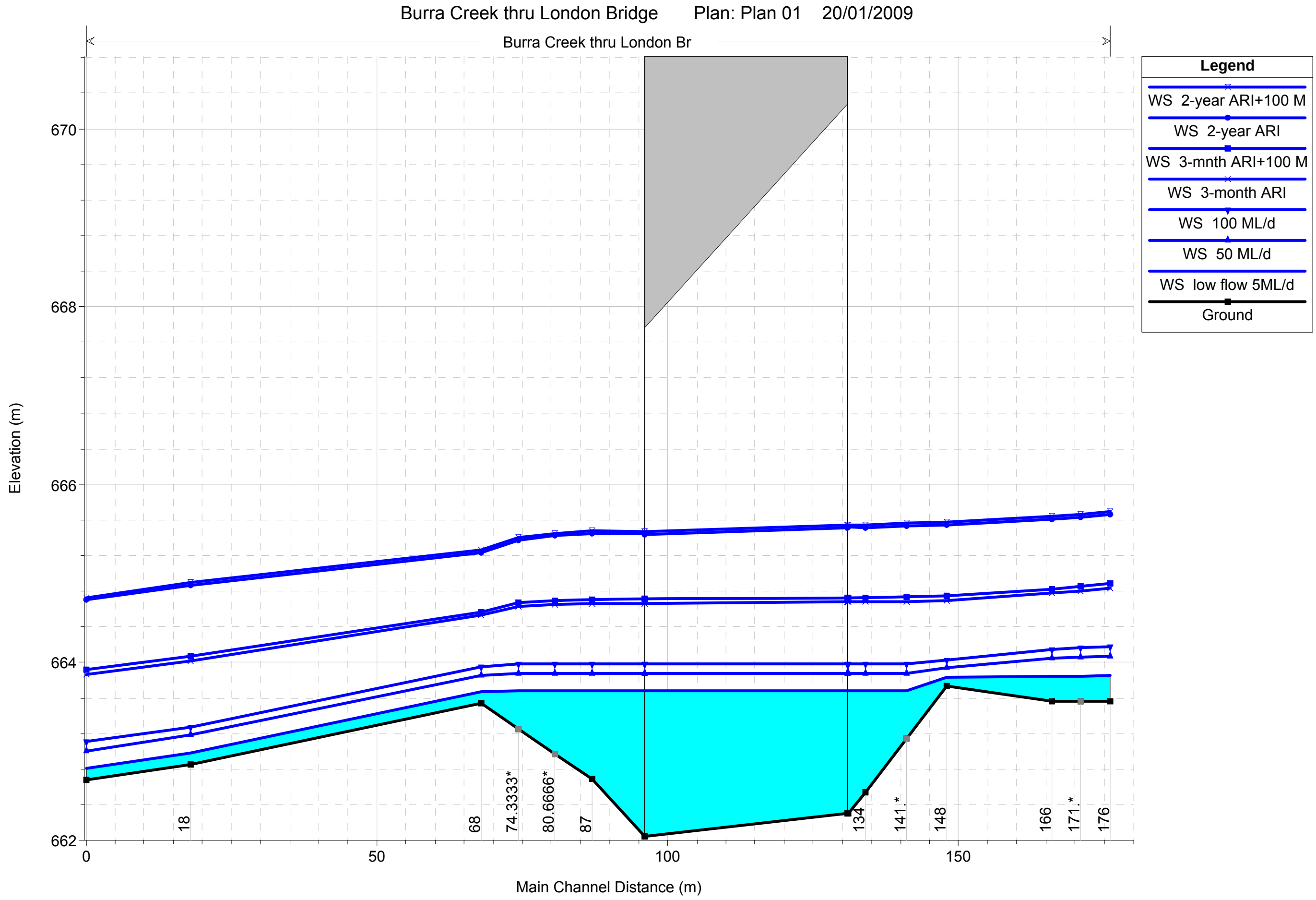


Figure 11. Computed Water Levels at RS 96 (downstream end of London Bridge – from BWA, 2009)

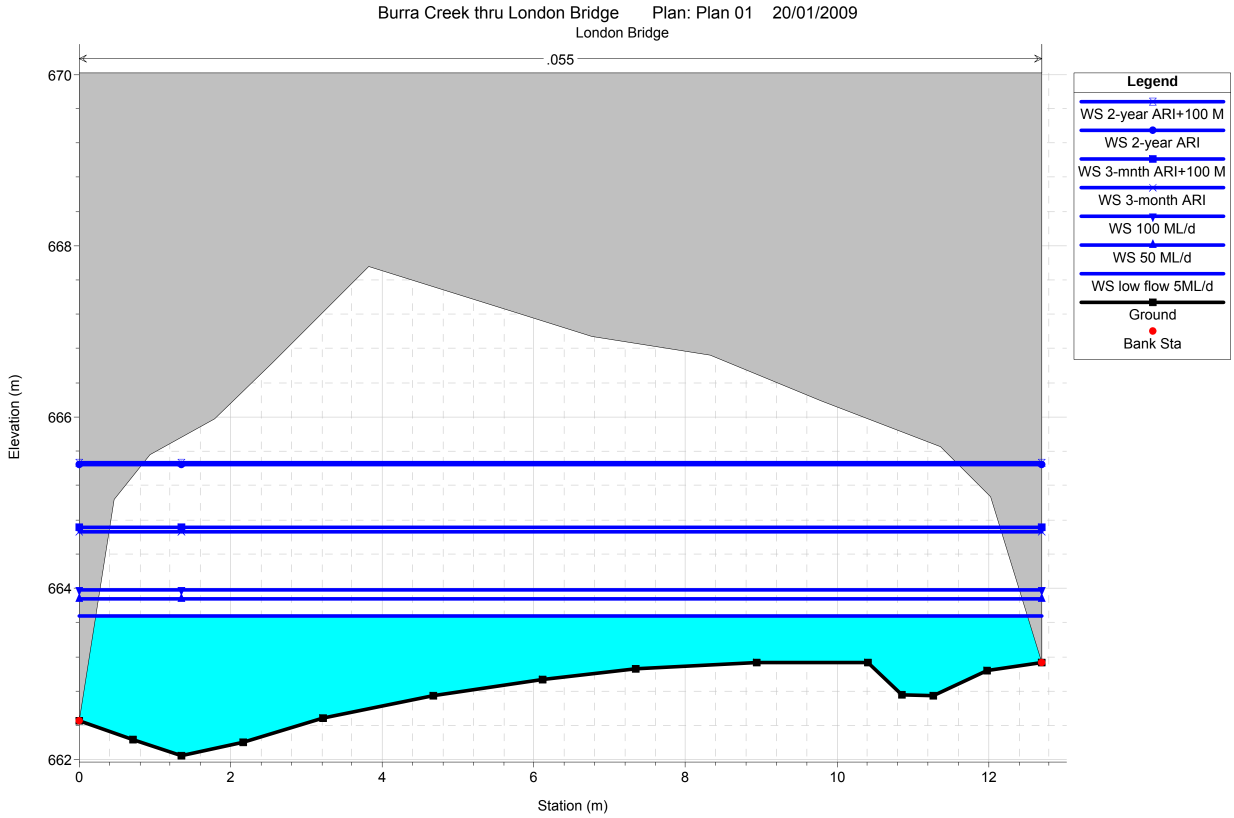


Figure 12. Upstream side of London Bridge during the falling limb of a flood in November 1976

Figure 13. Downstream side of London Bridge during the falling limb of a flood in November 1976

7. Water quality changes at London Bridge

The chief concerns for this report are on limestone solution at the Bridge and on conditions for cave-dependant stygofauna. This latter concern has been discussed above.

From the limited data set available (Actew, 2008) the Murrumbidgee River at Angle Crossing is under-saturated with respect to carbonate any thus would be capable of dissolving the limestone of London Bridge. Based on about 50 samples taken over the period 3 January 2007 to 11 November 2008 hardness (expressed as calcium) ranged from 7 to 64.9 mg/L – well below saturation. Given the small proportion of carbonate rocks in the catchment above Angle Crossing these low carbonate values are expected. The acidity (pH) of the Murrumbidgee River is generally slightly alkaline as shown in the following table.

Acidity (pH)	Value
Mean	7.40
Standard deviation	0.373
Coefficient of variation %	9.9
Number of samples	54
Range	6.2 > 8.1
Samples below pH 7.0	6 samples (6.6, 6.6, 6.9, 6.2, 6.7, 6.9) mean pH 6.5

Based on these values there are very few occasions when the Murrumbidgee River waters are aggressive. On the few occasions when higher flows in the Murrumbidgee coincided with pH determinations the values were always greater than pH 7.0 and thus non-aggressive. However, it must be noted that the data set only applies to a period of less than two years in a dry period and the higher flows in this period were not large.

No appropriate water quality data is available for Burra Creek so the assessment below is made on the basis of Murrumbidgee River water quality as the samples are taken from the backed-up waters of Googong Dam and not from the free-flowing Burra Creek (Actew, 2008). It is also assumed that bulk releases from Tantangara Reservoir will not affect water quality in the Murrumbidgee River at Angle Crossing – this may not be a safe assumption. It is probably safe to assume that in times of low flow, Burra Creek does have a high carbonate concentration (but there is little or no evidence of carbonate deposition so under-saturation is also assumed). Addition of weakly acidic waters from the Murrumbidgee to Burra Creek at times of higher flows in the former should thus be buffered to some extent by Burra Creek water.

Long-term determinations of limestone erosion rates conducted at Cooleman Plains and at Yarrangobilly indicate that the rate of erosion by under-saturated surface streams is of the order of 0.051-0.200 mm/year (Spate et al., 1985, Smith et al., 1995). The higher figure is based on a site where abrasion is probably dominant over solution in limestone erosion. Determinations of erosion rates at Cooleman and Yarrangobilly have been correlated with measurements at Ginninderra and thus it is probably valid to use these data to estimate the impact of increased flows at London Bridge. Assuming that increased artificial flows operate for 365 days a year, enlargement of the Bridge might increase on each limb of the arch by ~0.05-0.2 mm/year in the region where increased water levels operate. It is believed that the actual operating regime will be less than 365 days (ActewAgl, 2008) and higher flows during non-operational flows will be eroding the arch at a natural rate (albeit one modified by land use changes sine the early 19^{th} Century).

Changes in water quality arising from the proposed M2G water transfer will not be a significant issue on the karst and associated values at London Bridge.

8. Conclusions

The major conclusions to be drawn from this report are that:

- The proposed pumped flows to Burra Creek will not significantly impact physically upon the geomorphology, archaeology, zoology and other values of the London Bridge natural arch.
- The water quality issues created by the proposed flows are more open to question but changes in water quality are most unlikely to have any significant impact upon the Bridge.

The higher water levels may well provide benefits to the sediments in Douglas Cave and to bats using the downstream portion of Burra cave and in Douglas Cave by restricting public access to those caves. In fact, in the words of John Gale (1927, 9 60), ‘The water passing through the archway is but a small stream in its ordinary flow, but in flood-times the increased volume must add considerably to the charm of the scene.”

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Appendix 1 – Historical reactions to London Bridge

The history of European reactions to the site is demonstrated in the following paragraphs:

Currie 1825

p 39. In one place the rock formed a natural bridge of one perfect Saxon arch, under which the water passed. [8th June 1823 – entire diary entry referring to London Bridge]

Brennan 1907

p 208. 'In January, 1874, I discovered on the London Bridge Estate, the property of Mr. John McNamara, a veritable catacomb on a small scale, wherein were found many hundreds of human bones and skulls, centuries old. I had several bags of them conveyed to Queanbeyan, where they were carefully inspected by three surgeons, including Coroner Morton, who pronounced them to be the skeletons of the Aborigines of former times.'

'The London Bridge is a natural limestone formation spanning the Burra Creek; beside it is a very spacious cave, which bore traces of having been used in early times by Aborigines.'

Mahony and Taylor 1913

p 36. London Bridge is a locality that takes its name from a natural arch of rock spanning Limestone or Burra Creek, a tributary of the Queanbeyan River about 12 miles south of Queanbeyan township and 6 miles east of the Federal boundary. Several limestone deposits occur in this neighbourhood.

The natural bridge forms a huge arch rising about 40 feet above the stream; the opening through which the creek flows clears the water by about 15 feet and is some 50 yards across. The bridge is about 30 yards wide and could easily be crossed by a vehicle if the surface were more level. There is a sheer drop to the water on the northern side, but on the south there is a more gentle as shown in the photographs (No. 12). This very remarkable natural feature is formed in beds of limestone with some shale striking N. 15o E. in the direction of the creek, and dipping westerly at 65o. It has evidently been formed by solution of the limestone, possibly along a fissure or other line of weakness, for there is evidence to show that the creek once flowed round the eastern foot of the spur it now pierces.

The total width of the limestone beds is 90 yards including some interbedded shales and the length along the strike is short.

Within a distance of about 2 miles up Limestone Creek, 5 other outcrops of limestone were visited, but none of them were of any great extent.

Owing to the rugged nature of the country and the ensuing difficulties of transport, it is very unlikely that these deposits will ever be of any commercial value; and it would, indeed, be **vandalism to interfere with so remarkable a feature as London Bridge**. [emphasis mine]

Gale 1927

p 19. Quotes Currie's diary entry as: In one place the rock formed a natural bridge of one perfect Saxon arch, under which the water passed. [8th June 1823]

p 59-60. London Bridge.

Situated on the Old Burra Creek, about 20 miles south of Queanbeyan, stands this natural curiosity. Captain Currie has given but a meagre description of it. There is a roadway over it – not of man's construction – but, as the arch is, itself, formed by nature, and wide enough for two vehicles to pass each other with ease. From the keystone of the arch (though it has none, I employ the word figuratively) is a distance 10 or 12 feet, and a about half-way down appears an opening as into a chamber. This it literally is. It is said that it has been explored by bushmen with a taste for discovery, and that it has been used in bygone times as a burial-place by the aboriginals, and was found to contain some crumbling remains of the native blacks, with their belongings, which had, according to custom, been interred with them. The water passing through the archway is but a small stream in its ordinary flow, but in flood-times the increased volume must add considerably to the charm of the scene.' [He then goes on to quote Brennan *op cit*.]

Moore 1981

p 4. They [Currie and party] discovered London Bridge on 8th June, 1823, which Currie noted in his journal as being - "A fine roman arch and one of natures's marvels."

p 52. Misquotes Currie again 'a fine Roman arch and one of nature's marvels.' 'The bridge proved a crossing well above flood level and was often used in this respect. Together with the caves it is well known to local residents of the Burra Valley and many outsiders have inspected this marvel of nature.' [Moore infers this knowledge extended from 1837 on].

[Moore discusses the "London Bridge Caves' case" of 1875 under the heading of 'The London Bridge Mystery'. European bones in a 'cave abt four feet deep and in width a little more than would admit the body of a man'. 'The cave was a short distance from 'the Old Monaro Road.']

Jennings et al 1976

p 248. It is also a beautiful piece of natural architecture as was recognized more than a century and a half ago. Therefore a strong case exists for the preservation of London Bridge as a geological monument.

Owen et al 1988

p 45. London Bridge is of outstanding geomorphological value, both as a scientific and educational locality, and is also of appreciable value. It is also of some historic interest ...

Boot and Cooke 1990

p 100. As we have stated above the London Bridge Karst formation has long been recognised as an excellent eaxample of natural bridge formation by stream self capture … The site also has important aesthetic qualities. On this basis alone we would argue that London Bridge is of national and international significance. [They go on to list other values.]

9 101. London Bridge is of significance for many reasons and at many levels, and therefore an ubusual site which should be protected and managed with great care. This range of levels of significance at one site is so rarely encountered in Australia that this situation must add further unquantifiable significance of the place.

ACT Government 2007

p 63. A significant geomorphological feature known as London Bridge is located on Burra Creek (included in the Register of the National Estate ...). This is a natural arch in limestone containing fossils of brachiopods, corals, crinoids and trilobites. Several small caves and shafts also occur in the limestone.

P 68. London Bridge Natural Arch is included on the Register of the National Estate as a Natural place that also has Indigenous values (Place ID 1182). The arch is an important component of the natural heritage of Googong Foreshores ..., but also has cultural heritage value. The feature has long attracted interest since first being described by explorer Mark Currie, who was directed there by an Aboriginal guide*. Currie described it as 'a natural bridge of one perfect Saxon arch, under which the water passed'. The arch has elements of all the values that make up cultural significance ... and features widely in tourist information about the region.

* Currie's diary does not suggest this.