

(Paper presented by Department of Sustainability and Environment to Broken System Water Users Meeting - 30 June 2005)

Decommissioning Lake Mokoan

Determining Existing Reliability of supply in the Broken System

Purpose of this Paper

The purpose of this paper is to confirm a reliability of supply to the Broken system irrigators. The effectiveness of offsets can then be assessed in terms of achieving this reliability of supply for the Broken system after Lake Mokoan is decommissioned. .

White Paper Commitment

The White Paper, *Our Water Our Future*, contains the basis for decommissioning Lake Mokoan. Included in this basis is a commitment to Broken, Goulburn and Murray irrigators “that their existing reliability of water supply will be unaffected.” *Our Water Our Future* also identifies benefits to irrigators of improved water quality, which arise from this decision.

System Operation History

Design Intent

Lake Mokoan was designed and constructed to serve the Broken, Goulburn and Murray irrigation systems. The original intent was “the additional water made available is used to support the existing Goulburn and River Murray systems as well as providing a measure of local benefit.”¹ The intent was to minimise storage in Lake Mokoan and therefore minimise evaporation losses.

Lake Mokoan was completed and operational in 1972. The diversion works to transfer water to the East Goulburn Main (EGM) were not provided at this time because the immediate need was maintaining reliability of supply to the River Murray irrigation areas. After 1978, with the completion of Dartmouth, the EGM diversion works could be further considered.

In 1982 and 1984, Parliamentary Committees reaffirmed that the prime function of Lake Mokoan was to provide water to the Goulburn irrigation system.

In the late 1980's², the Rural Water Commission undertook a review of requirements to serve the Goulburn irrigation system. This review considered the impacts on recreation, irrigation and habitat related to providing for an average of 67,000 ML/year (800 ML/day maximum) pumped supply from the Broken River into East Goulburn Main.

¹ 1963, Parliamentary Public Works Committee, Progress Report No. 3, pg 10.

² 1989, Ministry for Planning and Environment, Assessment of Environment Effects, pg 5.

The infrastructure to transfer water from the Broken River into EGM was never built because of the uncertainty related to Blue-Green algae (BGA) occurrence. Hence, the Lake was not fully utilised as intended.

Blue-Green Algae Impacts

BGA has presented a constraint on the operation of Lake Mokoan since the 1982/83 drought, although the problem did not become chronic until the early 1990's. Since 1991, when formal monitoring began, very high BGA counts have been regularly recorded resulting in closure of the storage to protect water quality and river health in the Broken, Goulburn and Murray Rivers.

Recently, as part of the BSRRC process, G-MW³ has reviewed the pattern of BGA alert levels and resulting Lake Mokoan closures. This review shows that the lake was open in the 2nd half of the irrigation season in only four of the 13 years since monitoring commenced. Three of these four years are 2002 to 2005. In December 2003, closure came close with an Alert 3 level recorded briefly and Alert 2 levels recorded in three months and Alert 1 level in one month of the same irrigation season.

Current Operation Rules

The operational rules currently applying to releases from Lake Mokoan reflect priority of existing use, water quality constraints and to a more limited extent the original design intent. These rules are:

- Maximum rise and fall rules, which are aimed at minimising the likelihood of a BGA outbreak.
- Lake Mokoan is open at least during July to December in all years and closed for varying periods over January to June depending on operational decisions made in response to BGA alert level recordings.
- Allocation to the Goulburn when Broken allocation is at 170% and Goulburn allocation is at or less than 100% and when Mokoan is ruled open with respect to BGA level.
- Allocation to the Murray when Broken allocation is at 170% and Murray allocation is less than 200% and there is no off-quota.

Estimates of System Reliability

Modelling the System – for the Bulk Entitlement (BE) Conversion

REALM modelling undertaken for the Bulk Entitlement Conversion assumed a pattern of BGA constraint on the use of Lake Mokoan for the Broken system supply, based on a review by G-MW (Ballard, March 2001) of historical closure of the lake. The BGA rules for the “base” BE run are:

- Lake Mokoan is on-line (available for releases) in all years from June to January inclusive;
- Lake Mokoan is on-line every second year from February to May inclusive when flow into Lake Nillahcootie is less than the flow at 90% probability of exceedance (14,800 ML/year).

³ *Modelling of Broken System Operation Rules*, Broken System Reliability Reference Committee, Meeting No. 6 may 2005, Discussion Paper.

- Lake Mokoan remains off-line in all other years from February to May inclusive.

The intent of this base run was to provide a reference point for consideration of the impact of introduction of environmental flows and increased usage due to sleeper licence activation.

The estimated reliability of supply to Broken system irrigators was 80%. The BE was signed in December 2004, following a five year period of stakeholder consultation.

Modelling Refinements – post the BE and decision to decommission Lake Mokoan

In the 2nd half of 2004, DSE in conjunction with G-MW undertook model re-calibration to better reflect improved water delivery measures implemented in the period 1997 to 2002 in response to drought conditions. For this period, the system operating losses were adjusted to reflect the improved delivery performance. Re-calibration was achieved by adjusting transmission losses to “fit” the Lake Nillahcootie storage level variation. For the calibration, inflows to and releases from Lake Mokoan replicated exactly.

The model was then re-run over the entire 112 year climatic period of record incorporating the BE derived BGA rules, the reduced operating losses and a 1.85 metre rise and fall rule.

The estimated reliability of supply to Broken system irrigators was 91%.

More recently, G-MW⁴ has modelled the impact of changing the BGA release rules from those assumed for the BE Conversion. A total of four additional options consisting of more relaxed release rules were assessed which provide an increase in reliability from 93% to 97%.

Issues of Consideration in Determining System Reliability

There are a number of issues, which should be considered in determining existing system reliability. These are:

- **Variation in operating conditions** – since 1971 when Lake Mokoan first began to operate, the operating conditions have varied significantly in response to changing priorities and to the BGA constraint. Hence, determining what might be regarded as “normal” conditions is a difficult exercise.
- **Blue-green algae** – from 1991 to 2001, BGA outbreaks have been a major problem and constraint to releases from the lake. Since 2001, the lake has remained open all year. The BSRRC⁵ suggest the BGA problem is abating and has been corrected by shoreline restoration and upper catchment improvements. However there is insufficient evidence to confirm this view. Whilst BGA occurrence has not been a problem in the last few years, this may be more related to normal climate variation than to any permanent change. BGA is attributable to a number of physical and chemical conditions, which are related in a complex way that is not clearly understood. BGA is discussed in more detail in **Attachment A**.

⁴ Modelling of Broken System Operation Rules, G-MW for BSRRC, Meeting No. 6, May 2005 (Fig 1)

⁵ Analysis of Technical Information, System Reliability, Broken System Reliability Reference Committee, May 2005 – Section 4.1.

- **Modelling of the impact of BGA on reliability of supply** - The impact of BGA on reliability of supply has been estimated by using annual inflow to Lake Nillahcootie as a trigger for whether Lake Mokoan is on-line or off-line over the period February to May (on-line during all other months). This is an overly simplistic prediction of the likelihood of BGA occurrence and should only be interpreted, if at all, in a precautionary manner. G-MW compared four options of trigger flow rule to show reliability could be in the range of 91% to 97%. These options are also discussed in Attachment A.
- **Improvements in operating efficiency** – the improvements in operational efficiency from 1997, in response to drought conditions, had a significant impact on the reliability of supply. The extent that this improvement is “permanent” is uncertain without the improvements in monitoring and local storage provision which may be provided as an offset package.
- **Inter-basin share of the water resource** – the existing operating rules have been developed over a number of years to reflect the known BGA constraint. If, as suggested by the BSRRC, the BGA constraint is lessening, it cannot be assumed that the increased availability of water would go solely towards improving reliability of supply to Broken irrigators. To assume so, implies an operating policy for Lake Mokoan that is a significant departure from the original design intent which was to minimise the evaporation losses from the lake by drawing down to met Goulburn demand where possible.
- **Period of assessment** – the reliability has been assessed based on a 112 years of record (1892-2003) rather than the 33 years since Lake Mokoan has been operating. Over this more recent period, Broken irrigators have had 100% or greater allocation. The model results closely replicate this experience for the same period. However over the longer period, the modelling shows that in nine years allocations were less than 100% because climate conditions. During “big” drought of the 1940’s there were five years when allocations were less than 100% of which four years were less than 40% allocation Hence, based on the recent experience, there is a perception that reliability is greater than it is when the longer period is considered.

Conclusions and Recommendations

Conclusions

The conclusions of this paper are:

- Determination of a reliability of supply for the Broken system users is difficult in view of the changes in operating conditions over the last 30 years.
- The estimate of the impact of BGA on reliability through the use of a trigger flow is a very simple representation for what is a much more complex relationship and therefore, should only be used in a precautionary and comparative manner.
- The conclusion reached by the BSRRC, that BGA is improving in recent years is not strongly supported in terms of factors known to be significant in the generation of BGA blooms. Whilst the last three years of record have not resulted in a sustained Level 3 alert, this is more likely to be attributable to climate conditions rather than measures taken to reduce nutrient inflow. On the basis of available information, prediction of permanent BGA improvement should be regarded as speculative.

- The view that reliability is high (100% allocation or greater) during the 33 years experience since Lake Mokoan commenced operation is confirmed by the model results. However the modelling of a much longer period, which includes the 1940's "big" drought shows nine years had allocations less than 100%. A primary function of the water resource allocation (REALM) model is extension of the record period as far as is possible. This is normal practice in water resource planning.
- The *Base Case* estimate of reliability (91%) is precautionary with respect to the BGA trigger flow and optimistic with regard to operating efficiency. Options B (93%) and D (93%) are more optimistic with regard to both BGA trigger flow whilst having the same operational efficiency as the Base Case. The BSRRC adopted Option C (97%) is considered highly optimistic with regard to BGA rule with the same operational efficiency as the Base Case.
- The modelling of options with significantly improving BGA conditions do not include any adjustment in the entitlements to go to the Goulburn and Murray irrigations systems but only improving Broken system allocation. Some sharing of the increased water resource availability would be expected.
- A reliability of supply of 91% is considered a reasonable and responsible estimate of Government's commitment under *Our Water Our Future*. Whilst considered precautionary with regard to BGA trigger flow to move off-line, it is optimistic in terms of assumed operational efficiency.
- Increasing the reliability of supply to greater than 91% is taking it beyond the Government's White Paper commitment. This should only be done with consideration of the likely costs, benefits and impact on irrigators related to the operation of a reconfigured system and the increased likelihood that offsets will need to include entitlement purchase. This would require G-MW support in terms of the future operation of the Broken System.

Recommendations

It is proposed that the BSRRC and Broken system irrigators:

- Acknowledge the DSE determination of an existing reliability of supply of 91%.
- Agree to work with G-MW and DSE to achieve the maximum possible reliability of supply through cost effective use of the committed government funding and if necessary G-MW support.
- Acknowledge that the strategy for reducing demand will focus on water savings infrastructure but where necessary and appropriate, both transfer and purchase of entitlement will be considered in formulating the final package of offsets.

Major Projects Division

Water Sector Group

Department of Sustainability and Environment

Attachment A – BGA Occurrence and the Modelling of BGA

Introduction

This attachment considers the information available regarding BGA occurrence in Lake Mokoan and whether this can be used to determine reliability of supply which reflects current conditions.

Investigations

In July 2000, AWT reported⁶ on investigations and a workshop, which related to the occurrence of BGA in Lake Mokoan. The report identified a number of key “triggers” influencing the development of cyanobacterial (BGA) blooms. These triggers were wind and the impact of wind on mixing, turbidity, stratification, benthic BOD and nutrients. The report suggests that wind and likelihood of mixing are particularly significant as are turbidity, benthic BOD, DO and temperature.

In summary and of relevance to the determination of reliability of supply, the report suggests that:

- The relationship between the key triggers is complex and requires further investigation before it is clearly understood;
- The significance of nutrients derived from inflow, compared to those derived from benthic deposits, is not clearly understood.

The G-MW modelling report (May 2005) documents the BGA alert levels, Lake Mokoan release status (open/closed) and inflow to Lake Nillahcootie for the period July 1992 to March 2005. It also provides details of the results of running the REALM model under a range of BGA rules and alternative rise and fall rules.

Interpretation of BGA Occurrence Alert Levels

The BSRRC⁷ propose that the BGA problem has reduced over the last five years attributable to shoreline restoration and upper catchment improvements. However, this conclusion is based only on observation of event frequency without consideration of any of the other factors highlighted in the AWT report of being significant with regard to BGA occurrence.

Observation of event frequency is insufficient information to judge, as the BSRRC have, that the BGA situation of the late 1980s to late 2000s is an “aberration” with respect to the long term.

A comparison was done of the BGA “events” (level 3 and levels 1, 2 & 3) since 1991 and annual inflow to Lake Nillahcootie. This comparison suggests some relationship between the two variables and therefore a relationship between the occurrence of BGA and climate. However the relationship is not a strong one ($R^2 = 0.54$ to 0.67). This is consistent with the understanding that BGA occurrence is dependent on a more variables and a more complex relationship between these variables than this simple relationship.

⁶ AWT, Investigation of Factors Influencing Cyanobacterial Blooms in Lake Mokoan, July 2000.

⁷ Analysis of Technical Information, System Reliability, Broken System Reference Committee, May 2005 – Section 4.1.

Hence, there is no firm basis to suggest that the BGA problem is disappearing or even in significant decline.

Modelling Results for BGA Rule Options

Table 1 of the G-MW report shows the performance of the four options in terms of actual Lake Mokoan open/close status. At one level, the conclusion with respect to the best match would be Option D with only 2 “errors” compared with the 3 “errors” of all the other options. However, the difference between the four options is so small and the basis of comparison quite coarse (i.e. simple open or close which does not give any guidance with respect to the possible near “misses” such as 2003/04).

In view of the limitations of this comparison, the following points on the relative merits of the four options are presented:

- The Base Case (91% reliability) - regarded by the BSRRC as too conservative from a BGA perspective. It is optimistic in terms of water delivery efficiency.
- Options B and D (93% reliability) – is less conservative than the Base Case having a BGA rule with the lake open every low flow year rather than every other year as for the Base Case. These options are optimistic in terms of water delivery efficiency.
- Option C (97% reliability) – is the most optimistic with a BGA rule having the BGA rule with the Lake Mokoan open during February to May in half of all years. This option is heavily weighted to the last three years and in particular 2003/04 despite this year being very nearly a “closed” year. Hence it is regarded as highly optimistic in terms of the BGA rule. It is optimistic in terms of water delivery efficiency.

Conclusion

Interpretation of BGA occurrence using such a simple relationship as annual inflow is a surrogate only and does not have a scientific basis. It is not a strong basis for determining reliability of supply.

At best, the comparison of a range of BGA rules options is considered useful in determining how sensitive the model is to changing the rules of release from Lake Mokoan.