REDEFINING SOUTH EAST QUEENSLAND'S WATER SUPPLY OPTIONS

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ABSTRACT

The opportunity to closely examine water rights and water supply arrangements in the Brisbane region has been enabled through the rollout of Queensland's statutory water planning processes. This is during a time of significant change and investment in water management, including the imminent addition of purified recycled water to Brisbane's main water storage, "Wivenhoe Dam".

Moreton Basin, located within a sub-tropical climatic zone, relies on infrequent, but high volume inflows into Brisbane's water supply scheme. An operational and water entitlement system that is in accord with this climatic variability has been proposed and modelled using the Water Resource Plan (WRP) hydrological model (Integrated Quantity Quality Model (IQQM)) supplied for this purpose.

The flexibility of the system is achieved through alignment with storage performance, whereby during periods of low water availability supply is curtailed. Accordingly when the storage increases in volume, additional water is made available to water users.

The operation rule proposed by the Queensland Bulk Water Supply Authority uses releases from Wivenhoe Dam as a function of storage level, instead of a fixed entitlement of 286,000 ML, as set in the WRP model. The annual take of water was optimised to rise up to 355,000 ML per year in accordance with the flow in the system. Through optimisation the annual maximum water take under the proposed operational regime equals or exceeds the current allowable take throughout the entire historical sequence of climatic data (1889 – 2000) available for testing.

The proposed adaptive system will provide benefit to urban and industrial water users, and the methodology has the potential and support to be applied within irrigation areas.

INTRODUCTION

The timeless and resonant words of Dorothy MacKellar (1904) "*A land of sweeping plains, of rugged mountain ranges, of droughts and flooding rains*" ring as strong and true now, as ever before. The consequential variability and differences in storage performance across Australia will be demonstrated through a comparison of Lake Wivenhoe in Brisbane and Lake Eildon in the upper Goulburn catchment.

The state of Queensland has a water resource planning framework defined through the *Water Act 2000*. This framework requires that clearly specified performance objectives must be met through the operations of each water supply scheme. Based on an analysis of the cyclical performance of Lake Wivenhoe, a water sharing system that is consistent with the performance objectives specified under the *Water Act 2000* has been developed.

Sensitivity to, and alignment with the performance of water storages will provide significant advantage and opportunity to the urban and rural residents of the greater Brisbane area. Furthermore, being able to operate under a system that is straight-forward and simple to understand, and that allows for forward planning, will give greater confidence to the water customers.

A major step forward by using a system that is compatible with the performance of the storage is that it overcomes the dulling or damping down of system performance that occurs through the use of gross averages. It also accepts that historic sequences, while informative, should not be given significance in driving operating arrangements.

PHYSICAL CHARACTERISTICS OF TWO MAJOR AUSTRALIAN STORAGES

The upper Brisbane River catchment above Lake Wivenhoe drains an area of approximately 7,000 square kilometres. The Brisbane River rises in the Brisbane Range which is located some 40 kilometres east of Kingaroy. Major tributaries of the upper Brisbane River include Cooyar, Emu and Cressbrook Creeks which all enter the river from the east and travel in a southeast direction eventually passing through into Wivenhoe Dam. Its major tributary, the Stanley River, rises in the Conondale Ranges southeast of Maleny and travels in a southwest direction through one of the heaviest rainfall areas in Australia and into Somerset Dam and then eventually into Wivenhoe Dam.

Lake Wivenhoe (Wivenhoe Dam) is the largest dam in South East Queensland and major water supply for the greater Brisbane area, which is undergoing rapid population growth. Lake Wivenhoe is located on the Brisbane River, with a water storage capacity of 1,165,000 ML at full supply level, approximately 60 km north-west of Brisbane. In addition to urban water supply requirements, approximately 130 irrigators are supplied from Lake Wivenhoe.

The Goulburn Broken catchment is in central northern Victoria and comprises the catchments of the Goulburn and Broken Rivers. The catchment covers a total area 23,915 square kilometres or 10% of the Victorian total land area. The rainfall pattern (average annual) varies between 1600 mm in the south east to 450 mm in the far north of the catchment. Lake Eildon (Eildon Dam) was built to supply more than half of the water used in the Shepparton Irrigation Region with the present capacity being 3,390,000 ML. Lake Eildon is located on the upper catchment of the Goulburn River in northern Victoria. The Goulburn catchment produces on average 1.8 ML/ha/yr while the Brisbane catchment produces 1.17 ML/ha/yr.

Heavy rains in the upper reaches of the Brisbane River, particularly the Stanley River catchment, may result in significant local flooding of low lying areas. However Somerset and Wivenhoe Dams have significantly reduced the frequency of flooding in the lower Brisbane River catchment to Brisbane City, where major flooding can still occur from local area run-off.

The mean annual rainfall for Lake Wivenhoe is 911mm with the associated mean annual flow being 820,708 ML/a. The mean annual rainfall for Lake Eildon is 852 mm with the associated mean annual flow being 1,520,460 ML. While informative at the broad level, these statistics do not provide any insight into optimising operations for the dams.

An alternate, more refined way to look at dam performance is through using a 10-year rolling average for the inflows, as illustrated in Figure 1.

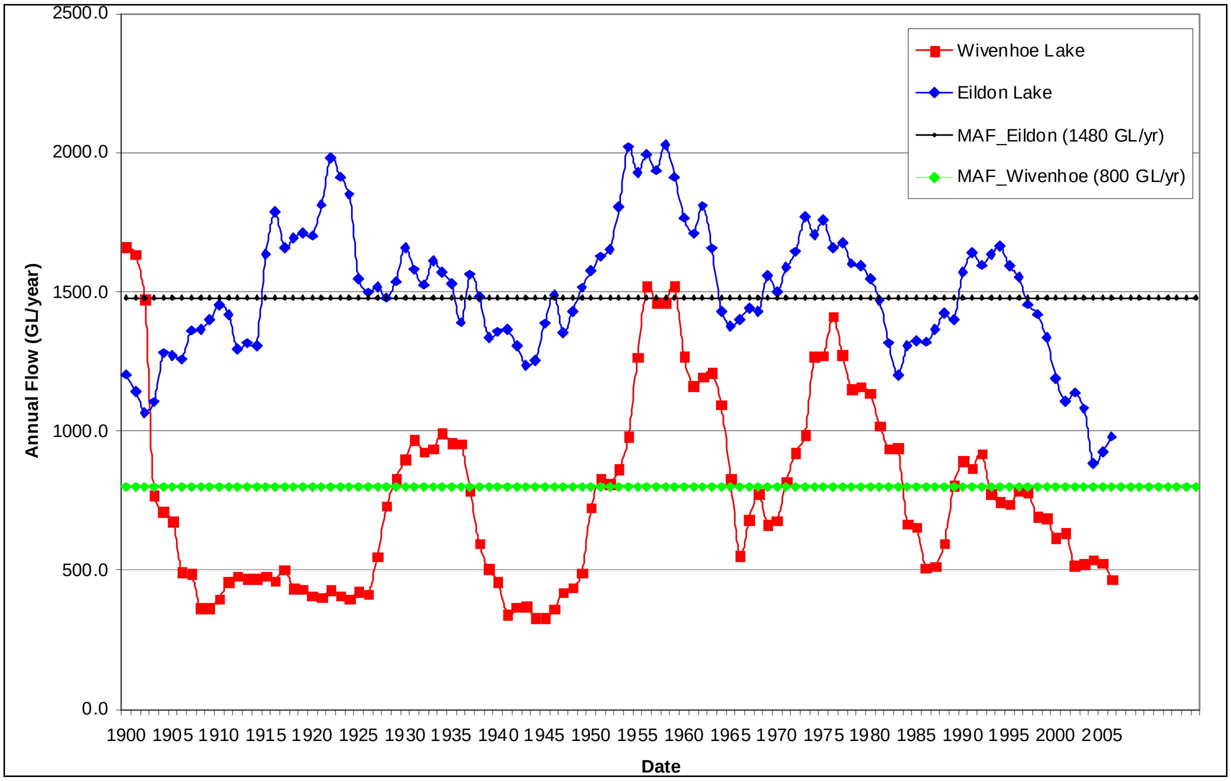

Figure 1: Mean Annual Flow and rolling 10-year average for Lake Eildon and Lake Wivenhoe (Based on or contains data provided by Goulburn-Murray Water [2008] and the State of Queensland (Department of Natural Resources and Water) [2007]).

The long term (1891 - 2006) moving 10 years average streamflow as inflow into Lake Wivenhoe and Lake Eildon is shown in Figure 1. The moving 10 years average plots for both storages show that both systems operate in a generally cyclical pattern of wet or dry sequences, with Lake Wivenhoe having the more pronounced episodes. The standard deviation for the streamflow into the Eildon and Wivenhoe Dams are 683.37 GL and 960.96 GL respectively. The largest and smallest annual flow for Eildon and Wivenhoe Dams are 4058.5 GL and 200.7 GL for Eildon Dam and 7491 GL and 64.5 GL for Wivenhoe Dam.

The variation in annual streamflow for the Brisbane River at the Wivenhoe Dam is shown in Figure 2. The annual streamflow for the Brisbane River has positive skewness, which means that the data is not symmetric around the mean or median. The mean is biased toward the very large flows; however these flows are greatly exceeded in number by flows of less than the mean.

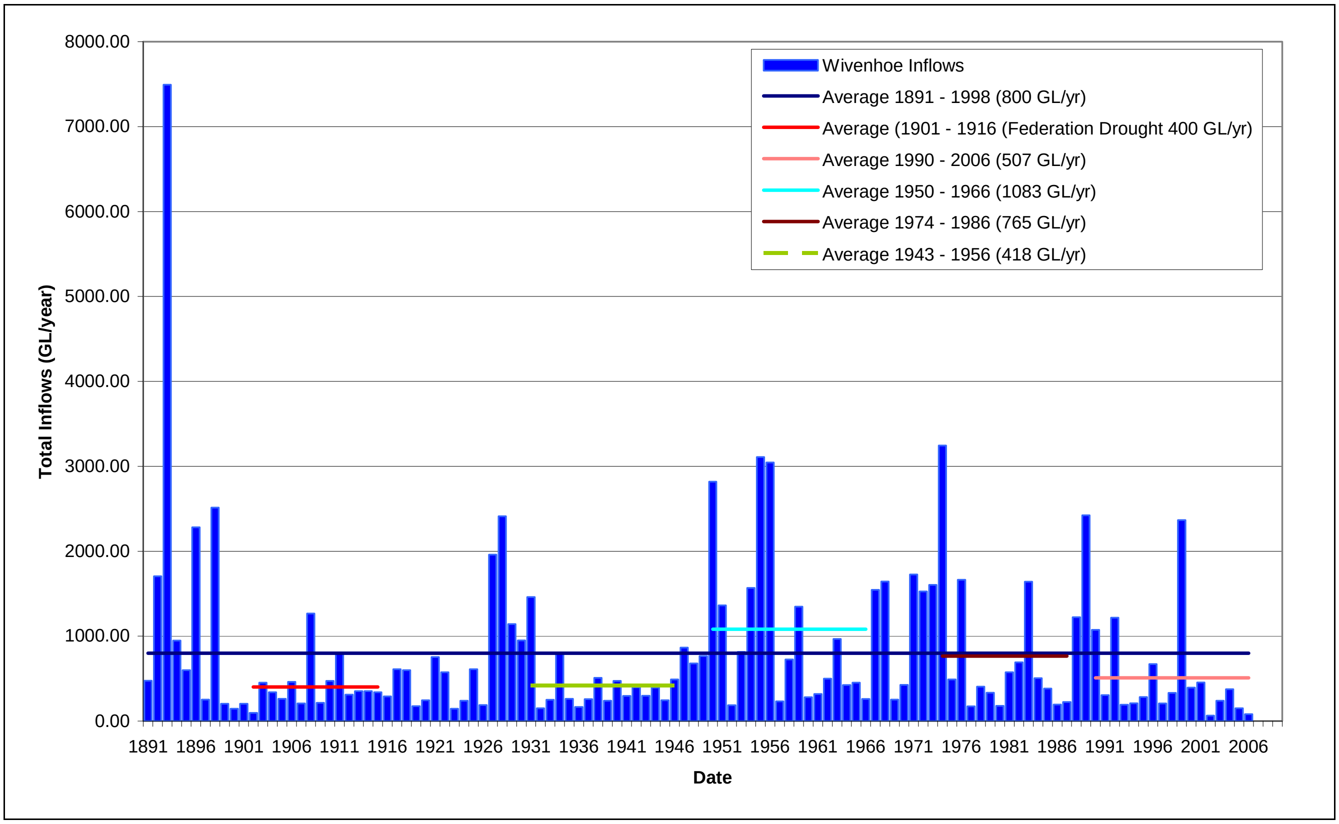

Figure 2 Annual flow into Wivenhoe Dam

Variable annual flows into Lake Wivenhoe and Eildon are driven by a changeable climate, which is a characteristic of Australian rivers. Flow variability can be described by the coefficient of variation of annual flows (Cv), calculated as the standard deviation divided by the mean (Cv = 0.46 for Lake Eildon and 1.2 for Lake Wivenhoe). The Brisbane catchment with a Cv of 1.2, is nearly three times the Goulburn catchment and four times the world average of 0.33. As well as more variable flow, extreme floods occur more often in Brisbane catchment than in Victoria or most of the rest of the world.

Highly variable flows have important implications for water supply management as shown in Figure 2. Two droughts (~400 GL/yr) and the recent 2001 -2006 (~500 GL/yr) drought were recorded in the period of 1891 – 2006 as shown in Figure 2. The high run-off variability and extreme flood pattern influenced the statistical mean annual flow for any periods in the streamflow records. The level of demand and reliability expected by water users, combined with the high levels of storage losses (evaporation + seepage) in Lake Wivenhoe, has led to optimisation of the operating rules in the Central Brisbane Water Supply Scheme.

A further assessment of Lake Wivenhoe shows that the quantum of inflows is dominated by low-flow events. However, while many small inflows occur, their contribution to the volume in storage is minor when compared to the yield provided by less frequent, but large inflows, such as are associated with cyclonic driven events. The frequency and relative contributions of small and large inflows to Lake Wivenhoe are illustrated in Figure 3.

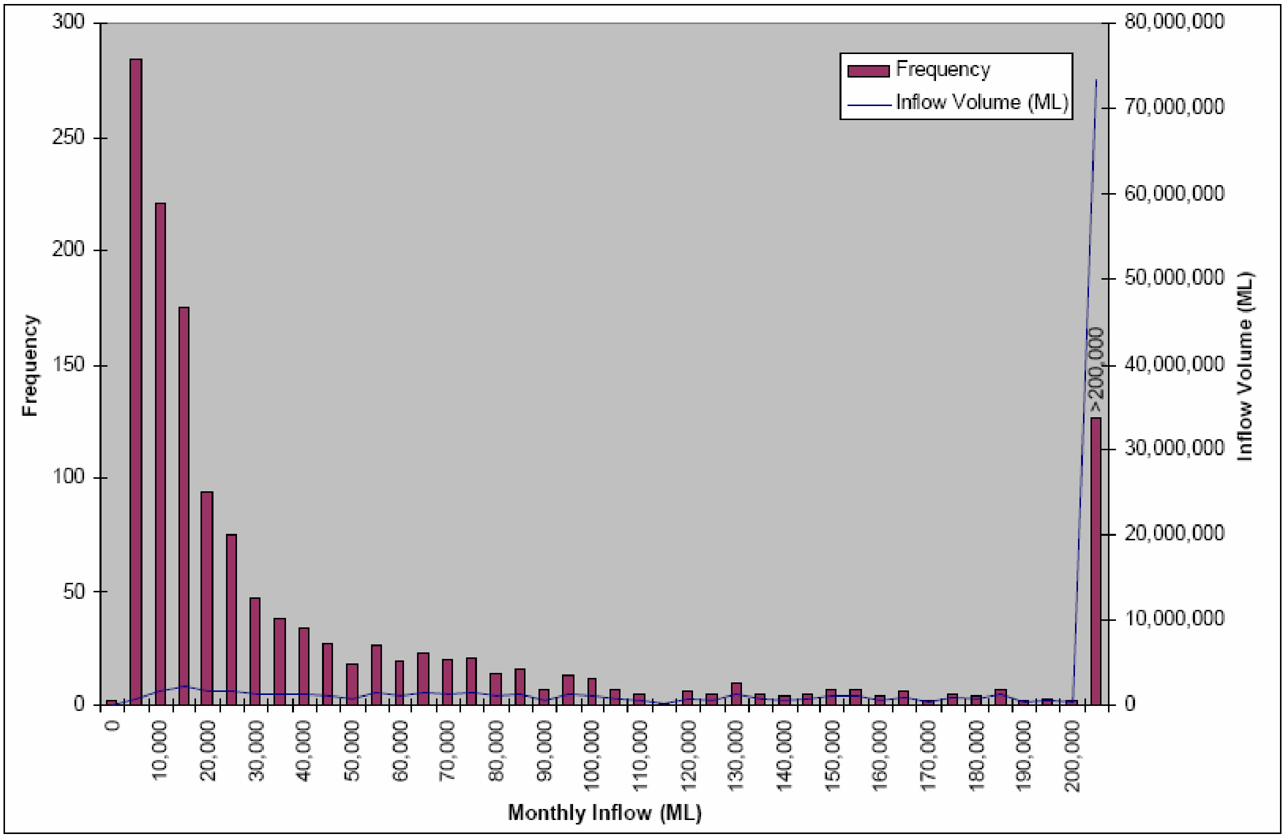

Figure 3 Frequency and volume of monthly Lake Wivenhoe inflows (1889 – 2005). Based on or contains data provided by the State of Queensland (Department of Natural Resources and Water) [2007].

CLIMATE VARIABILITY

Climate variability is a fundamental driver of the water cycle. It determines how much water is available and how much water we can take in the short and long term. Climate variability is highly complex, and therefore it is inappropriate to simply extrapolate past trends to predict future conditions. It is widely recognised that water management must be able to adapt to the changing climatic conditions that are being experienced (Pittock, 2007). The Intergovernmental Panel on Climate Change has warned that Australia can expect increased drought and fire, as well as increases in the severity and frequency of storms (IPCC, 2007).

The latest climate model from CSIRO (Mark 3) simulated slight increases in annual rainfall, although these results must be considered experimental. The BOM model, on the other hand, has shown that rainfall has been declining in the non-summer months and increasing in the summer months. For strategic decision making, consensus scenarios should be preferred. Because of some disagreement between the projections of different climate models, the range of projected rainfall changes over Queensland is large. Climate variability was therefore taken into account in the optimisation undertaken.

The extreme weather conditions and variability we face are characterised in the following excerpt from Brisbane's main newspaper; the Courier Mail.


SIZZLE SIGNALS END OF SUMMER

IT'S the heatwave we had to have. After months of drenching rain and wild seas causing beach erosion, like this at Duranbah, the last weekend of summer is going to be the hottest. Sweltering conditions are predicted for the south-east with temperatures hitting 36C. The craziest thing of all is that even though 82 per cent of the state is flood-affected, 62 per cent remains drought-declared. Report>>P5

Figure 4: Newspaper clipping, 22 February 2008

The simultaneous state of being both flood-affected and drought-declared epitomises the climatic challenges we face. A flexible and responsive water management system is therefore needed to cope with these extremes. In addition to addressing the variability of our climate (Neal and McMahon, 2007), it has also been clearly identified that more research is required into optimisation of storage management.

PROPOSED OPERATION OF LAKE WIVENHOE

In accordance with state water resource planning requirements, the Queensland Bulk Water Supply Authority (QBWSA) has the opportunity to design a preferred operational regime for the Central Brisbane Water Supply Scheme, fed by Lake Wivenhoe. The over-riding criteria in development of proposed arrangements are that statistical performance measures for environmental and reliability requirements must be met. Proposals are assessed against a baseline level of performance determined by the Department of Natural Resources and Water, which currently allows annual extractions of up to 286,000 ML.

QBWSA has endeavoured to define a flexible and sustainable conforming system that maximizes the volume of water available to be taken over the longest periods. In recognition of the cyclical performance of Lake Wivenhoe, and strong climatic influences, a straight-forward Advanced Water Sharing (AWS) system has been devised where the rate of take is a function of the storage volume of Lake Wivenhoe. Essentially the more water there is in storage, the higher the permitted rate of take can be. The system is capitalising on the wet sequences that occur at Lake Wivenhoe, by drawing more during periods of sustained high inflow, so that greater replenishment, and less overflow occurs. Table 1 shows the extraction rates that can be achieved from Lake Wivenhoe under this regime.

Wivenhoe Dam Level EL m AHD	Wivenhoe Dam % Full	Storage Capacity (ML)	Maximum daily extraction rate (ML/d)	Maximum annual extraction (ML/yr)
67.0 – 65.0	100 – 82.8	1,165,200	975	355,000
65.0 – 63.0	82.8 – 68.2	965,200	858	328,925
63.0 – 60.0	68.2 – 50.1	794,560	819	300,320
60.0 – 53.25	50.1 – 21.4	583,930	780	286,000
< 53.25	< 21.4	250,000	702	257,000

Table 1: Optimised extraction regime for Wivenhoe Dam

With the maximum annual take ranging between 22-30% of full supply, when operating from the higher storage levels, the minimum permitted level of extraction is known for over a three year time horizon. Having certainty over this timeframe will be invaluable in forward planning, efficient water use and scheduling of business activities. The potential to access previously uncropped lands through temporary availability of additional water can also be realized through AWS.

CONCLUSION

Greater versatility and adaptability are strong imperatives for future Australian water management. Against the historic background of water management systems being based on coarse averages, a system has been designed that accommodates and can benefit from variability in system performance.

Multiple water sources, such as desalinated or recycled water are rapidly being embraced by the Australian population. In terms of efficient and economic water supply, maximizing use of the cheapest water source, namely from rainfall dependant storages, is an obvious course to follow. In this regard QBWSA has designed a water supply system that will meet the needs of the future, with low administration requirements, without compromising the environment.

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