Department of Planning and Environment

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Hydrologic analysis of options for the Border Rivers Regional Water Strategy

Regional Water Strategy Program

June 2022

Acknowledgement of Country

The NSW Government acknowledges Aboriginal people as Australia's first people and the traditional owners and custodians of the country's lands and water. Aboriginal people have lived in NSW for over 60,000 years and have formed significant spiritual, cultural, and economic connections with its lands and waters. Today, they practise the oldest living cultures on earth.

The NSW Government acknowledges the Bigambul, Githabul Gomeroi, Kambuwal, Kwiambal and Ngarabal people as having an intrinsic connection with the lands and waters of the Namoi Regional Water Strategy area. The landscape and its waters provide the Bigambul, Githabul Gomeroi, Kambuwal, Kwiambal and Ngarabal people with essential links to their history and help them to maintain and practise their culture and lifestyle.

The NSW Government recognises that the Traditional Owners were the first managers of Country and that incorporating their culture and knowledge into management of water in the region is a significant step for closing the gap.

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Executive summary

The NSW Government is developing 12 regional water strategies that bring together the best and latest climate evidence, with a wide range of tools and solutions to plan and manage each regions water needs over the next 20 to 40 years. The Border Rivers Regional Water Strategy is one of 12 strategies being developed across NSW to meet this commitment.

The draft Border Rivers Regional Water Strategy, including a long list of options, was released in October 2020[1]

This report provides the outcomes of hydrological assessment that was undertaken to understand the impact of options that influence the supply or demand of water in the Border Rivers catchment, as well as to feed into the economic and environmental assessment of potential options.

Assessment of the water security and changes in the flows regime in the Border Rivers valley has been undertaken for three climatic regimes:

- historically based (130 years) assessment of existing system and defined list of options to provide initial insight into current water supply performance and risks, potential improvements under augmentation options and relative benefits between defined options
- long-term stochastic (10,000 years) assessment of existing system (using the stochastic climate data generated based on paleoclimatic information and projected climate change) and defined list of options to provide water security outcomes of precision relevant to high-value industries such as mining and power generation
- stochastic hydro-economic assessment (30-year forecast assessment) of selected and defined strategic water supply options, with integration into financial and economic modelling — incorporating capital and operational expenditures and benefits. Assessment was undertaken for a list of options consistent with those of the long-term stochastic assessment.

Eight options from the draft Border Rivers Regional Water Strategy were modelled. For some of these options a number of different scenarios were assessed.

[1] The draft Border Rivers Regional Water Strategy and long list of options can be viewed at: https://www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/what-we-heard/border-rivers-regional-water-strategy

Option name	Description of options assessed
Option 1. New dam infrastructure on the Mole River	Option 1a- Mole 100GL - All NSW -existing licences only (translucency release) with growth in use (supplementary shares reduced by 50% to achieve base case diversions) Option 1b — 100 GL Mole River dam — 27GL new high security shares on Mole (with delivery loss and Mole translucency release) and supplementary shares reduced by 60% to achieve base case diversions. Option 1c — Mole 150 GL — 34 GL high security on Mole (30% delivery loss, 30% reserve, translucency release) with growth in use (supplementary shares reduced by 70% to achieve base case diversions).
Option 2. Raising Pindari Dam full supply level	Option 2a — Raise Pindari Dam by 5 m — supply existing users — growth in use applied supplementary shares reduced by 20%. Option 2b — Raise Pindari Dam by 10 m — supply existing users — growth in use applied supplementary shares reduced by 30%.
Option 3. Raising Mungindi Weir	Option 3 — Raise Mungindi weir by 5 m — Full Supply Level 1,480 ML Supply Existing Users — Growth in Use applied, supplementary shares reduced by 10%.
Option 4. Piping water to stock and domestic users in the unregulated section of the Boomi River	Option 4 — Boomi pipeline (essential supply delivery) losses in resource assessment reduced by 10 GL/year with 7% reduction in supplementary growth in use response.
Option 8. Inland river diversions from the east	Option 8a — small diversion: base case (actual permitted take model with CLA_11 transfer from Clarence (Mann River Dam full supply volume 49GL @ 13GL/yr to Pindari). Option 8b — large diversion: base case (actual permitted take model with CLA_7 transfer from Clarence straight into Mole River) with new 49 GL high security demand at Boggabilla.
Option 23. Improve connectivity with downstream systems	Option 23 — Additional Mungindi 100 ML/day target (NSW ownership).
Option 30. Review of regulated river water accounting and allocation processes	Option 30 — Increase the system storage reserve in Pindari and Glenlyon dams from 41.1GL (18 months reserve) to 62.2GL (two-year reserve).
Option 31. Investigation of licence conversions	Option 31a — general security A and general security B reduced by 100% (242.12GL), 85 GL high security created at Boggabilla. Option 31b — general security B reduced by 16GL, 4GL high security created using conversion rate from option 31a.

Option name	Description of options assessed
Combined option 1	Combination of • Option 1c — Mole 150 GL — 34 GL high security on Mole (30% delivery loss, 30% reserve, translucency release) with growth in use (supplementary shares reduced by 70% to achieve base case diversions). • Option 31a — general security A and general security B Reduced by 100% (242.12GL) 85 GL high security Created at Boggabilla.

All hydrologic and water supply assessment modelling was undertaken using the eWater Source river system model. The Source model was developed as a tool for planning and evaluating water resource management policies at the river-basin scale. This model can be applied to regulated and unregulated streams and is capable of addressing water quality and environmental issues, as well as water quantity issues.

1. Introduction

This report outlines the hydrologic modelling undertaken to understand the how infrastructure and policy options that change the supply, demand or sharing of water will impact on different water users, licence holders and flows in the Border Rivers catchment Hydrological modelling is a key input to the development of the final Border Rivers Regional Water Strategy. Hydrological assessment has been undertaken on the infrastructure and policy options that may change the demand, supply or allocation of water identified in the Draft Border Rivers Regional Water Strategy – long list of options[2]. The modelling has been done to further our understanding of the impact of the options on existing water supply risks to the range of water users in the Border Rivers catchment, as well as to feed into the economic and environmental assessment of potential options. The modelling provides part of the evidence for options being included in the proposed shortlist of actions identified in the *Border Rivers Regional Water Strategy: shortlisted actions consultation paper*[3]

Hydrologic modelling of options for the Border Rivers has been undertaken using the Border Rivers eWater Source river system model. Eight options were modelled:

- Option 1: New dam infrastructure on the Mole River
- Option 2: Raising Pindari Dam full supply level
- Option 3: Raising Mungindi weir
- Option 4: Piping water to stock and domestic users in the unregulated section of Boomi River
- Option 23: Improve connectivity with downstream systems
- Option 30: Review of regulated river water accounting and allocation processes
- Option 31: investigation of licence conversions

Modelling results for a number of different scenarios under each option are presented in the following sections.

[2] https://water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/what-we-heard/border-rivers-regional-water-strategy
[3] . https://www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/public-exhibition/border-rivers

2. Background

Border Rivers region

The Border Rivers catchment is split between NSW and Queensland

The Border Rivers valley comprises the catchments of the Dumaresq, Severn, Weir, Macintyre and Barwon rivers. These catchments drain from the Great Dividing Range between Inverell in Far North NSW and Warrenbayne in Southern Queensland. It has an area of approximately 49,500 km^2, of which just under half (about 24,500 km^2) is in NSW. Grazing and dryland cropping are the major agricultural land uses in the valley, covering about 90% of the area; irrigated agriculture, mainly cotton, covers less than 3% of the NSW Border Rivers valley area.

The valley sits in a sub-tropical climate zone. Average annual rainfall across the valley decreases from east to west, from over 1000 mm in the eastern ranges around the Great Dividing Range, to around 500 mm in the west at Mungindi. The rainfall is strongly seasonal — the highest volumes occur during the summer months during summer storm activity.

Annual evaporation has a strong east–west gradient across the valley, with average Class A pan evaporation exceeding the average rainfall across the entire valley. Annual evaporation is around 1200 mm in the eastern ranges, and over 2000 mm in the far west of the catchment at Mungindi. Mean daily evaporation at Inverell ranges from 2 mm/day in winter to 6.5 mm/day in summer.

The river network is made up of the main river and its tributaries, effluents and breakouts, with a complex series of branching channels at the lower end of the valley. The main tributaries entering NSW draining from Queensland are:

- Pike Creek and Macintyre Brook, which enter the Dumaresq River
- Weir River, which enters the Macintyre River.

The junction of the Weir and Macintyre rivers marks the start of the Barwon River, and the town of Mungindi on the Barwon River marks the downstream end of the Border Rivers valley. Approximately 450 km of the border between NSW and Queensland is formed by (from upstream to downstream) sections of the Dumaresq, Macintyre and Barwon rivers.

Climate (rainfall and evaporation) and geography directly affect the volume of run-off generated within the valley, and how, when and which crops are grown. The characteristics of the river network affect how run-off accumulates as streamflow through the system, including how some flow breaks out of the main channel into the floodplain zones, where most of the irrigation farms are located. This requires representing how water flows through the system — including the large volumes stored behind headwater dams, released in response to downstream demands.

Managing water in the Border Rivers region

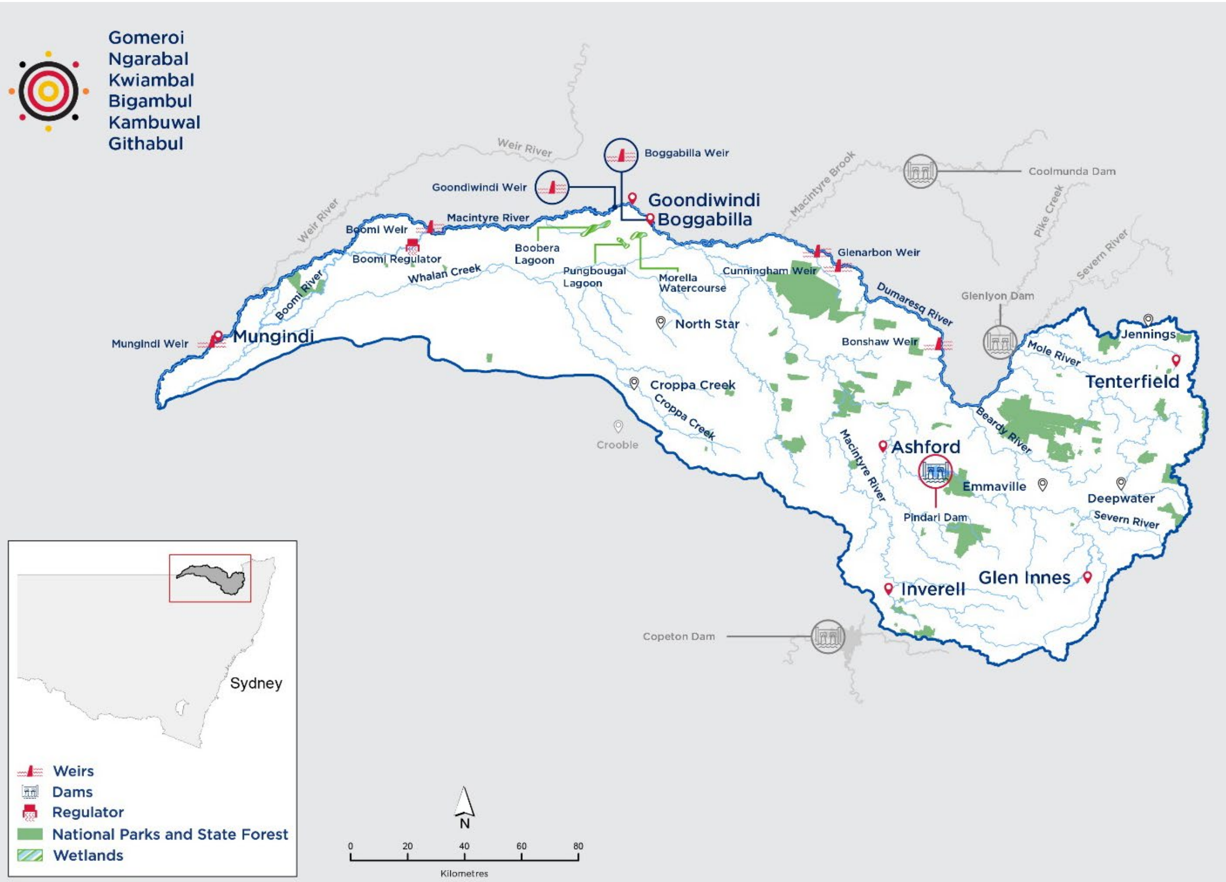
The catchment is regulated using three storages

Water in the valley is regulated through three major public water storages — Glenlyon Dam on Pike Creek (Queensland), Coolmunda Dam on the Macintyre Brook (Queensland), and Pindari Dam on the Severn River (NSW), and several weirs that regulate the flow pattern and availability of water in the system (Figure 1).

The construction of these major dams and the regulation of river flows has enabled the NSW and Queensland governments to deliver water to water users, and issue licences for the supply of water according to their respective legislation.

Access to regulated water is through licences. Water from unregulated rivers (for example, in tributaries and headwater streams) can be accessed under certain conditions, as can groundwater and floodwater. Under natural conditions, the river system would exhibit high flow variability in response to climate variability. However, regulation of the river has reduced this variability.

Figure 1: NSW Border Rivers Surface water sources and infrastructure



Water users include urban areas, irrigators, the environment, and water for stock and domestic supply. The largest water demands are from the irrigated farm properties in the floodplain areas between Goondiwindi and Mungindi, downstream from the junction of the Dumaresq River to upstream from the junction with the Darling River. These areas are principally used to grow cotton.

Water resources planning and management is shared between NSW and Queensland

The *New South Wales–Queensland Border Rivers Act 1946* and the Continuous Accounting of the State's Shares of the Inflows to Glenlyon Dam and the Border Rivers Regulated Flows: Standing Operating Procedure 2009 establish the sharing of water between the two states.

The New South Wales–Queensland Border Rivers Intergovernmental Agreement 2008 is an agreement between NSW and Queensland to manage their respective shares of the river flows to ensure key environmental outcomes are achieved, and to provide a consistent approach to managing water use and trade.

Other NSW policies and legislation include the:

- NSW Water Management Act 2000 No. 92
- Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2009
- Natural Resources Access Regulator Act 2017
- Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources 2012
- Floodplain Management Plan for the Border Rivers Valley Floodplain 2020
- NSW Floodplain Harvesting Policy 2013 (revised 2018).

The Border Rivers Source model: nationally adopted and evidence-based

The models that are used by the department to underpin water management in NSW are quantitative simulation models. Simulation models are widely used in water resources management to improve understanding of how a system works and could behave under different conditions.

The department, along with other Australian water agencies, uses or will use the Source software platform, which has been adopted as Australia's national hydrological modelling platform. Source was developed by a consortium of Australian research and industry partners to provide a consistent hydrological and water quality modelling and reporting framework to support integrated planning, operations and governance at scales from urban to catchment to river basins.

Use of a common platform facilitates collaborative and consistent modelling, analysis and policy development across the Murray–Darling Basin, including the accreditation of water resource plans under the Murray–Darling Basin Plan.

Source is designed to simulate flows through a system — whether those flows are water, sediment, contaminants, water accounts or water trade. It provides sufficient functionality to simulate the process of water moving out onto floodplains. Source models are built from components that are linked, by adding nodes and links, to represent the system to be modelled. There are many types of nodes to represent places where water can be added, diverted, stored and recorded (for reporting) in a model, including:

- water sources (supply) such as inflows and storages
- water users (demand) such as crops, towns, industries and the environment

- reporting points such as gauges and environmental assets.

Links connect, store and route water passing between nodes.

Source also contains models (‘component models’) that can run together to simulate multiple processes within the system. For floodplain harvesting modelling, these include:

- rainfall and run-off models that convert rainfall into run-off across the landscape
- irrigated crop models that simulate the crop growth cycle and subsequent water demand
- storage models that simulate the management of storage water.

The model was built by connecting Source node and link components (in-built or coded by the model developers) to represent a full river system, including its floodplains. These components were then populated with data. In most cases the data was specific to the Border Rivers, and where local data was not available, from other parts of NSW and technical literature.

The model enables a water balance assessment accounting for inflows and outflows at multiple scales (daily, seasonal and annual; property, river-reach and whole-of-valley). Details relating to calibration of the Border Rivers model can be found in the NSW Department of Planning, Industry and Environment report[4].

[4]NSW Department of Planning, Industry and Environment 2020, *Building the river system model for the Border Rivers Valley regulated river system*
www.industry.nsw.gov.au/water/plans-programs/healthy-floodplains-project/water-sharing-plan-rules/border-rivers

3. The assessment framework

Modelled options

Hydrological assessment has been undertaken on the Border Rivers Regional Water Strategy's 'long list' of infrastructure options[5]. The modelling has been done to further understand the impact of the options on existing water supply risks to the range of water users in the Border Rivers catchment, as well as to feed into the economic assessment of potential options for water supply system augmentation and development.

The options from the Border Rivers long list of options that were modelled are provided in Table 1, whileFigure 2, shows the location of these options. To enable a more complete assessment for some of these options, a number of different model runs were done to enable assessment of different approaches to implementing the option. These included adjusted options to maintain compliance with the system diversion limit and preserve the average end-of-system flow.

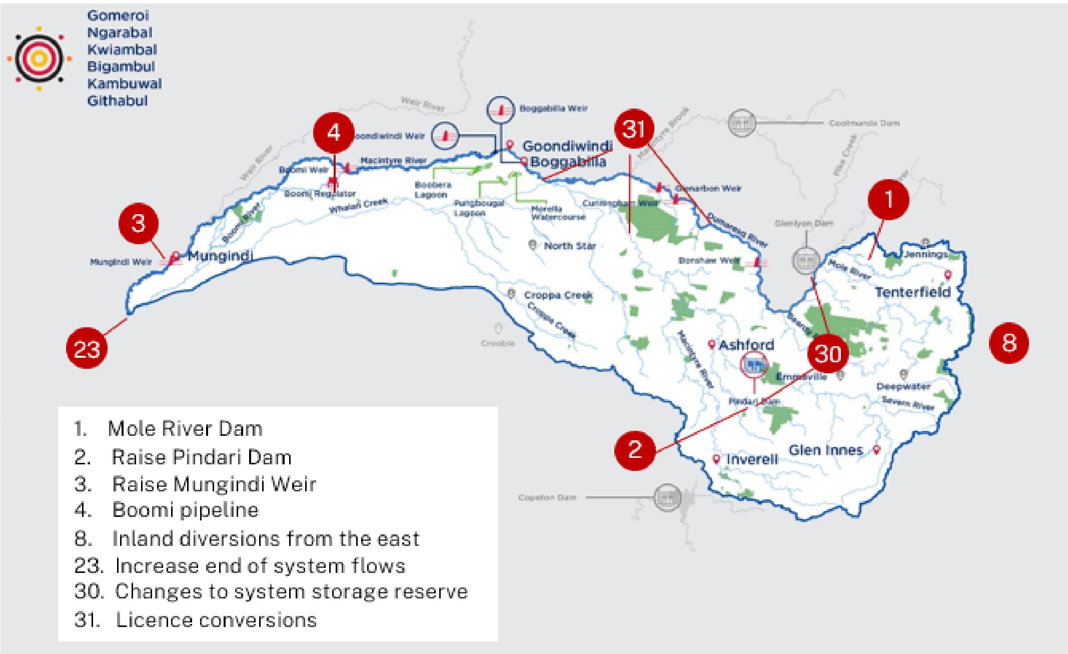
Table 1: Options assessed using hydrological modelling for the draft Border Rivers Regional Water Strategy

Option name	Description of options assessed
Option 1. New dam infrastructure on the Mole River	Option 1a- Mole 100GL - All NSW -existing licences only (translucency release) with growth in use (supplementary shares reduced by 50% to achieve base case diversions) Option 1b — 100 GL Mole River dam — 27GL new high security shares on Mole (with delivery loss and Mole translucency release) and supplementary shares reduced by 60% to achieve base case diversions. Option 1c — Mole 150 GL — 34 GL high security on Mole (30% delivery loss, 30% reserve, translucency release) with growth in use (supplementary shares reduced by 70% to achieve base case diversions).
Option 2. Raising Pindari Dam full supply level	Option 2a — Raise Pindari Dam by 5 m — supply existing users — growth in use applied supplementary shares reduced by 20%. Option 2b — Raise Pindari Dam by 10 m — supply existing users — growth in use applied supplementary shares reduced by 30%.
Option 3. Raising Mungindi Weir	Option 3 — Raise Mungindi weir by 5 m — Full Supply Level 1,480 ML Supply Existing Users — Growth in Use applied, supplementary shares reduced by 10%.
Option 4. Piping water to stock and domestic users in the unregulated section of the Boomi River	Option 4 — Boomi pipeline (essential supply delivery) losses in resource assessment reduced by 10 GL/year with 7% reduction in supplementary growth in use response.

[5] Department of Planning, Industry and Environment 2020, *Draft Regional Water Strategy: Border Rivers: Long List of Options 2020*.www.industry.nsw.gov.au/water/plans-programs/regional-water-strategies/public-exhibition/previously/border-rivers

Option name	Description of options assessed
Option 8. Inland river diversions from the east	Option 8a — small diversion: base case (actual permitted take model with CLA_11 transfer from Clarence (Mann River Dam full supply volume 49GL @ 13GL/yr to Pindari). Option 8b — large diversion: Base case (actual permitted take model with CLA_7 transfer from Clarence straight into Mole River) with new 49 GL high security demand at Boggabilla.
Option 23. Improve connectivity with downstream systems	Option 23 — Additional Mungindi 100 ML/day target (NSW ownership).
Option 30. Review of regulated river water accounting and allocation processes	Option 30 — Increase the system storage reserve in Pindari and Glenlyon dams from 41.1GL (18 month reserve) to 62.2GL (two-year reserve).
Option 31. Investigation of licence conversions	Option 31a — general security A and general security B reduced by 100% (242.12GL), 85 GL high security created at Boggabilla. Option 31b — general security B reduced by 16GL, 4GL high security created using conversion rate from option 31a.
Combined option 1	Combination of • Option 1c — Mole 150 GL — 34 GL high security on Mole (30% delivery loss, 30% reserve, translucency release) with growth in use (supplementary shares reduced by 70% to achieve base case diversions). • Option 31a — general security A and general security B Reduced by 100% (242.12GL) 85 GL high security Created at Boggabilla.

Figure 2. Location of options modelled



Climate datasets

Instrumental climate data

The instrumental climate refers to the period of available instrumental meteorological recordings (1 July 1889 to 30 June 2020) that are used as inputs into the rainfall-runoff models, required to generate runoff for river system models an as a direct climate input into river system model simulations. For option assessment, the performance of the option over this timeframe was compared to the outcomes of the historic period to provide a preliminary basis to evaluate options for shortlisting portfolios.

This climate data is referred to as 'instrumental' throughout this report. It is the building block for incorporating long-term and climate change data. This data set was used for all of the hydrologic options in this report.

Long-term historic climate projections (stochastic data)

The long-term historic climate projections (stochastic data) refers to the 10,000 years of stochastic-generated climate (developed using paleo climatic information by the University of Adelaide) that are used to evaluate the final viability of portfolios as well as define the base case. For option assessment, a thousand replicates of 40-year periods were sampled from this data to provide a comprehensive assessment of outcomes across many possible climate realisations.

This climate data is referred to as 'stochastic' throughout this report.

Dry climate change scenario (NARCliM) modelling

The 'dry climate change scenario (NARCliM modelling)' refers to the stochastic climate change data generated by multiplying the stochastic time series of 10,000 years with average monthly scaling factors derived from NSW and Australian Regional Climate Modelling (NARCliM) climate projections for 2060-2079 compared to the baseline period of 1990-2009 for each climate time series for every climate station used in the modelling. The average monthly scaling factors represented the mean of three regional climate models of CSIRO-MK3 GCM used in NARCliM 1.0.

This set of stochastic data with climate projections are used in conjunction with the stochastic data to evaluate the final viability of options, as well as to define future base cases. For options assessment, 1000 replicates of 40-year periods were sampled from this data to provide a comprehensive assessment of outcomes across many possible climate realisations.

This source of data is referred to as 'stocahstic+NARCliM' throughout the report.

Outputs for option assessment

The performance metrics presented in Table 2 were used to interpret the performance of each option. Streamflow locations were selected to represent the point of maximum flow (Goondiwindi), and the end of the system (remaining stations).

Table 2 Performance metrics

Category	Component
Annual NSW diversions	• town water supply • general security diversion • supplementary diversions • floodplain harvesting • rainfall harvesting
Annual Queensland diversions	• high priority water allocations (town water supply) • medium priority water allocations • off-allocation • water harvesting • overland flow take
NSW allocations	• existing high security 1/7 • existing high security 30/6 • general security A 1/7 • general security A 30/6 • general security B 1/7 • general security B 30/6
Storage behaviour	Percent of time that Pindari Dam storage volume is: • at full supply level (312.3 GL) • below 50% • below 10% • below 5% • below dead storage volume (0.5 GL)
	Percent of time that Glenlyon Dam storage volume is: • at full supply level (254.3 GL) • below 50% • below 10% • below 5% • below dead storage volume (0.2 GL)
	Percent of time that Coolmunda Dam storage volume is: • at full supply level (69.1 GL) • below 50% • below 10% • below 5% • below 0.2 GL
	Percent of time that total system storage volume is: • below 500GL • below 10GL
Mean annual streamflow	• Macintyre River at Goondiwindi (416201a): downstream flow • Gauge: 0112 M Barwon River at Mungindi (416001): downstream flow • End of system

4. Mole River dam

Option description

Option 1 in the draft Border Rivers Regional Water Strategy was to prepare a business case for the construction of a new dam on the Mole River, approximately 20 km south-west of Tenterfield. Modelling was done for two different storage capacities: 100 GL and 150 GL. Modelling was also done on using the dam to augment existing entitlement or to create new high security entitlements. Options modelled are described in Table 3.

Table 3. Mole River Dam option descriptions

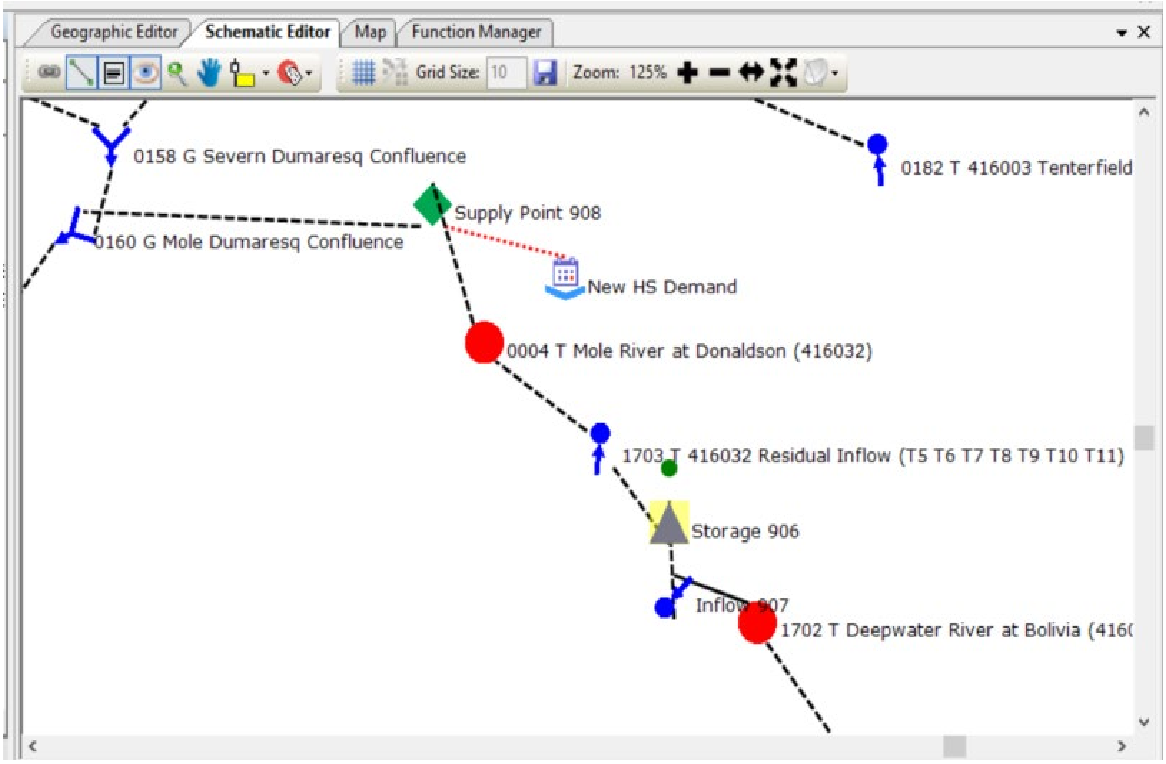
Option	Description
Augment supply of existing entitlement options	
1a	100 GL Mole River Dam - All NSW - Existing Licences Only (Translucency release) with growth in use applied (supplementary shares reduced by 50% to achieve base case diversions)
Create additional high security options	
1b	100 GL Mole River Dam - All NSW - 27GL new high security entitlement on Mole (30% delivery loss, 30% reserve, translucency release) with growth in use applied (supplementary shares reduced by 60% to achieve base case diversions)
1c	150 GL Mole River Dam - All NSW - 34GL new high security entitlement on Mole (30% delivery loss, 30% reserve, translucency release) with growth in use applied (supplementary shares reduced by 70% to achieve base case diversions)

Model configuration and assumptions

Model configuration

The base case Source model of the Border Rivers catchment developed by DPE has been used for this analysis. The model has been modified to include the proposed storage as shown in Figure 3. Residual catchments' inflows between the gauges 416023 (Deepwater River at Bolvia) and 416032 (Mole River at Donaldson) have been split in the ratio of 81:19, because 81% are upstream of the proposed storage and 19% are downstream.

Figure 3. The base case Source model has been modified to include the storage from the proposed Mole River dam



Model assumptions

Ownership

Border Rivers water arrangements include sharing with Queensland as per the New South Wales–Queensland Border Rivers Intergovernmental Agreement 2008. All options evaluated make a simplifying assumption that the storage and any upstream inflows into it are completely owned by NSW for the purpose of understanding the maximum possible benefit the dam could provide for the NSW water users.

Growth-in-use response

The introduction of an additional storage in the Mole River has the potential to result in total diversions in the system that exceed the water sharing plan's long-term average annual extraction limit. Consequently, modelling has incorporated a growth-in-use response if required to ensure long-term average annual diversions do not increase beyond the base case. This has been achieved through a uniform reduction in supplementary shares across the valley.

Delivery losses

The majority of options assessed have been configured so there are no delivery losses associated with supply and as a consequence no loss reserve has been set aside within the storage. This approach was chosen because results provide a 'bookend' to mark the highest and lowest points of the maximum water security benefits that the option may produce. It effectively represents a water use demand immediately below the dam wall.

Including delivery losses and the corresponding creation of an associated storage reserve will reduce the amount that can be supplied from a Mole River dam and, in turn, will reduce benefits.

Where delivery losses have been assumed, the losses required to be set aside have been set at a third of the entitlement volume of the product created. Transmission losses have been set at the same volume as the proportion of water set aside in the storage for conveyance — spread uniformly across the year.

Storage characteristics

The model's assumed storage dimensions, and spillway and valve relationships, are in Appendix 1.

Zero Mole River dam dead storage has also been assumed in all the option modelling undertaken at this stage. Seepage from the dam has been assumed to occur at a rate of 0.821 mm/day.

The valve capacity not a constraint in the delivery of orders. For the zero loss runs the spillway discharge relationship has been based upon a broad-crested weir assumption. A spillway width of 59 m and a coefficient of 1.8 m has been assumed. In runs where delivery losses and environmental releases have been considered, the relationship has been updated on the basis of dam design criteria. This is presented in Appendix 1.

Assumed allocation, accounting rules and harmony storage operation

For 'bookend' options where water is delivered and used in the Mole River without any delivery loss, a separate, independent annual allocation system has been adopted in the modelling. Because the model was configured to supply a single 'lumped together' user from a Mole River dam, no reserve assumptions for subsequent years were required in the resource assessment.

For options where water was delivered from the Mole River to a location on the Macintyre River, we had to apply assumptions in relation to how the storage is operated in conjunction with other storages in the system.

When evaluating supply for existing entitlements from a Mole River dam, the modelling has assumed that joint operation of Glenlyon and Mole storages is identical to that of Pindari and Glenlyon in the base case modelling. For these types of options, further optimisation of harmony operation[6] of the three storages is likely to produce additional benefits to general security licence holders beyond those presented in this assessment. Additional existing Border Rivers allocation and accounting arrangements have been applied.

New demands

Any new high security demands have been represented at 100% allocation use, with demand distributed uniformly over the year. This implies that users will seek to use all of their allocation every year either through trade or storage in on-farm infrastructure. Tributary use has been set to zero, with all supply coming from the Mole River dam.

[6] Harmony operation refers to coordination of releases of water from Glenlyon and Pindari dams to:

- minimise the likelihood of one dam filling before the other,
- ensure that each storage can supply commitments in river reaches where it is the sole source of supply

Environmental releases

The model included a translucency release rule with a similar form to that used for Pindari Dam. The rule is structured as follows:

- The required release flow is up to 153 ML/day of Mole River dam inflows from June–August, and 40.5 ML/day in other months.
- If the Mole River dam inflow is less than 4.5 ML/day, then the release will be 4.5 ML/day.

Modelling results

Results in this section are presented for the key Mole River dam options listed above in Table 3.

Mole River Dam - augment supply of existing entitlements

Alterations in NSW and Queensland licensed diversions

Option 1a: 100 GL Mole River Dam - All NSW -Existing Licences Only (Translucency release) with growth in use applied (supplementary shares reduced by 50% to achieve base case diversions)

Option 1a evaluated the potential water security benefits to existing users through construction of a Mole River dam. Option 1a has a growth-in-use action implemented.

As stated in the key assumptions section of this report, the joint storage operational rules for Mole River and Glenlyon dams have been assumed to follow the same harmony relationship that applies to Pindari and Glenlyon dams in the base case. This is unlikely to be optimal and, therefore, any water security benefits presented in these options have the potential to be increased through further optimised joint storage operation. This has not occurred at this stage of option assessment.

Results in alterations to existing entitlement diversions as a result of Mole River Dam construction and operation are presented in Table 4, and Figure 4 and Figure 5. The results indicate that an additional 23 GL of general security diversions in the Border Rivers occurs as a result of a Mole River Dam if supplementary diversions are reduced by 25 GL through a growth-in-use action. Reductions in supplementary use as a result of the growth-in-use action in option 1a are shown in Figure 6.

Table 4. NSW and Queensland long-term average diversions by licence category — 100 GL Mole River Dam – general security entitlements (option1a) a

Mean annual water diversions	Base case	Option 1a
NSW diversions (GL/year)		
Ashford town water supply	0.10	0.20
Boggabilla town water supply	0.20	0.00
Mungindi town water supply	0.28	0.20
General security diversions	93.74	116.52
Supplementary diversions	70.49	45.62

Mean annual water diversions	Base case	Option 1a
Floodplain harvesting (excluding rainfall harvesting)	34.26	34.91
Rainfall harvesting	10.89	11.23
Total	**209.96**	**208.69**
Queensland diversions (GL/year)		
High priority water allocations (town water supply)	2.59	2.59
Medium priority water allocations	51.85	47.09
Off-allocation	91.96	91.72
Water harvesting	59.55	59.53
Overland flow take	17.23	17.00
Total	**223.18**	**217.94**

Figure 4. Base case existing general security B annual diversions

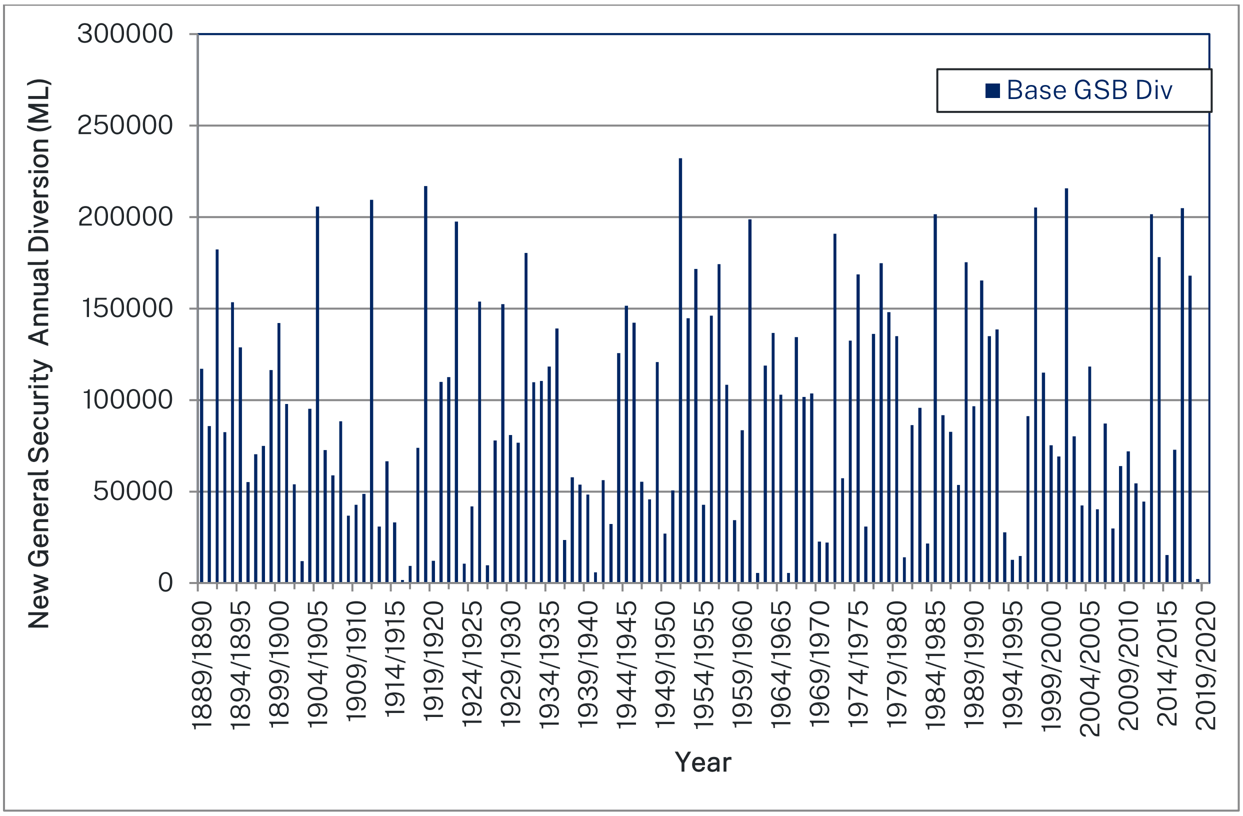


Figure 5. Option 1a — existing general security B annual diversions with additional supply from Mole River dam

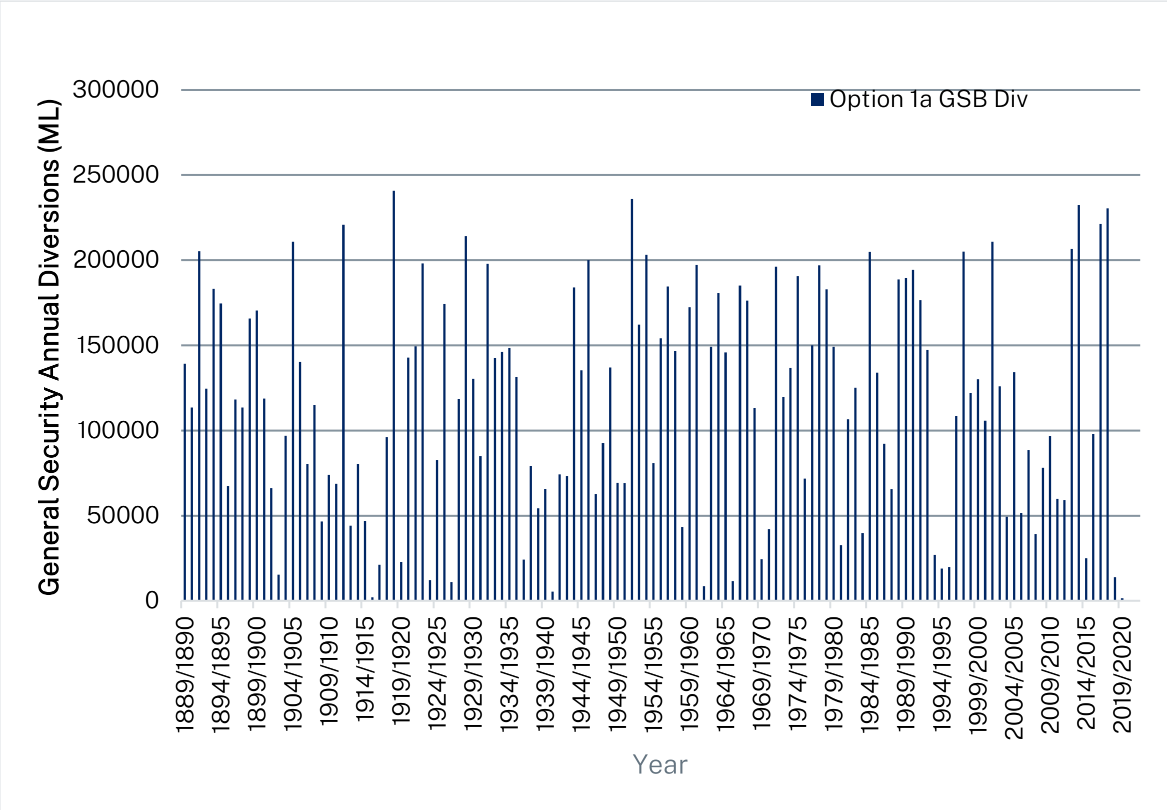
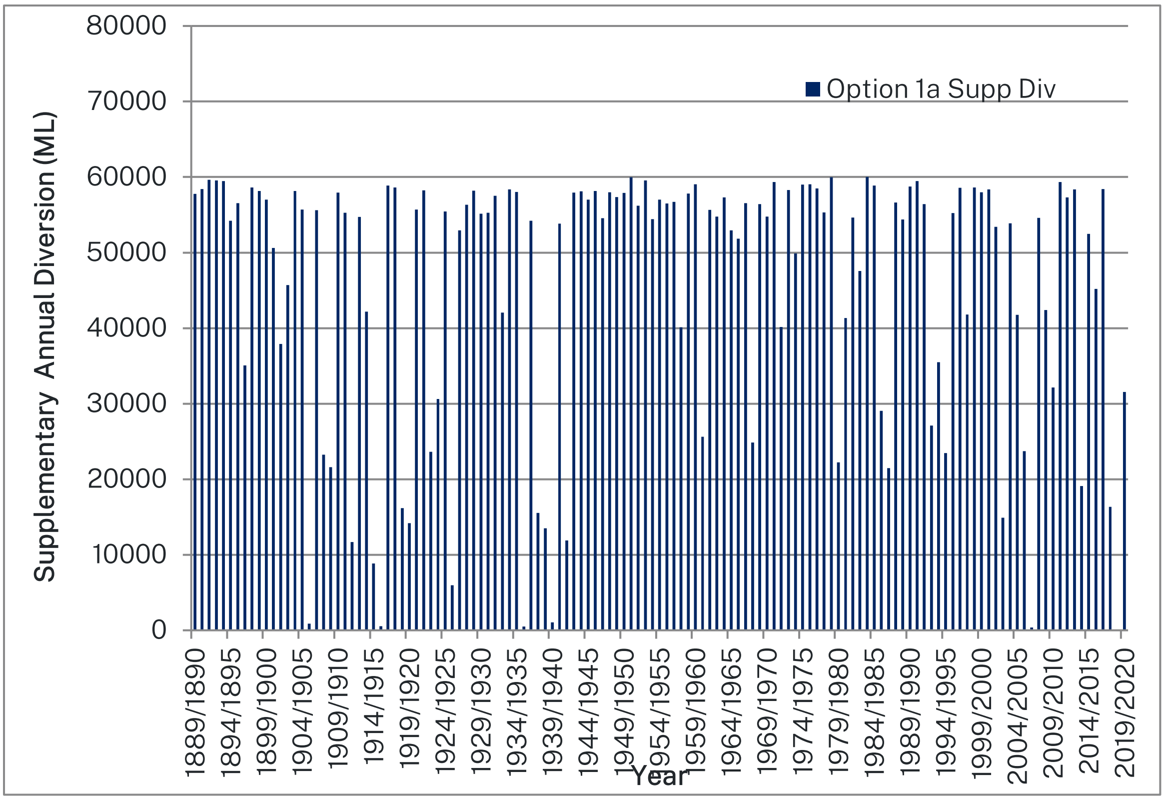


Figure 6. Option 1a — existing supplementary annual diversions with additional general security supply from 100 GL Mole River dam and growth-in-use response (option 1a)



Alterations in NSW allocation reliability

While existing general security users' diversions increase with a Mole River dam, allocations increase beyond what is likely be expected. As seen in Table 5, start and end-of-year average allocations for general security B increase substantially beyond the base case. As mentioned in the previous section, this is primarily a consequence of increases in general security diversion being constrained by existing planting behaviour of farmers and under-use of the Mole River storage due to non-optimised joint storage operational rules.

Table 5. NSW start (1st July - 1/7) and end-of-water year (30th June - 30/6) allocation reliability by licence category — option 1a (100 GL Mole River Dam – general security entitlements)

NSW effective allocation (%)	Base case	Option 1a
Existing high security 1/7	100.0	100.0
Existing high security 30/6	100.0	100.0
General security A 1/7	30.2	35.4
General security A 30/6	93.6	94.5
General security B 1/7	44.9	53.2
General security B 30/6	76.8	94.4

Alterations in storage behaviour

Alterations in storage behaviour for option 1a are presented in Table 6, Figure 7 to Figure 9. As shown, storage drawdown frequency increases — firstly, as a result of Mole River allowing additional supply of general security and, secondly, due to reduced supplementary access under a growth-in-use response.

Table 6. Storage behaviour — 100 GL Mole River Dam – general security entitlements (option1a)

Storage behaviour	Base case	Option 1a
Percent of time that Pindari Dam storage volume is:		
At new full supply level (FSL)		
At full supply level (FSL: 312.3 GL)	8.2%	7.8%
below 50%	66.0%	68.9%
below 10%	27.7%	30.6%
below 5%	20.1%	23.1%
below dead storage volume (0.5 GL)	0.7%	1.0%
Percent of time that Glenlyon Dam storage volume is:		
At full supply level (FSL: 254.3 GL)	3.8%	3.7%
below 50%	46.4%	45.6%
below 10%	0.2%	0.1%
below 5%	0.1%	0.0%
below dead storage volume (0.2 GL)	0.0%	0.0%
Percent of time that Coolmunda Dam storage volume is:		

Storage behaviour	Base case	Option 1a
At full supply level (FSL: 69.1 GL)	4.7%	4.7%
below 50%	57.6%	57.6%
below 10%	16.6%	16.6%
below 0.2GL	6.8%	6.8%
Percent of time that Proposed Mole River dam storage volume is:		
At 100 GL or more		14.3%
below 50 GL		59.7%
below 10 GL		2.7%
below 5 GL		19.4%
below 0.2 GL		9.5%
Percent of time that total system storage volume is:		
Below 500 GL	81.1%	75.0%
below 10 GL	12.9%	13.1%

Figure 7. Mole River dam storage behaviour — 100 GL Mole River Dam – general security entitlements (option1a)

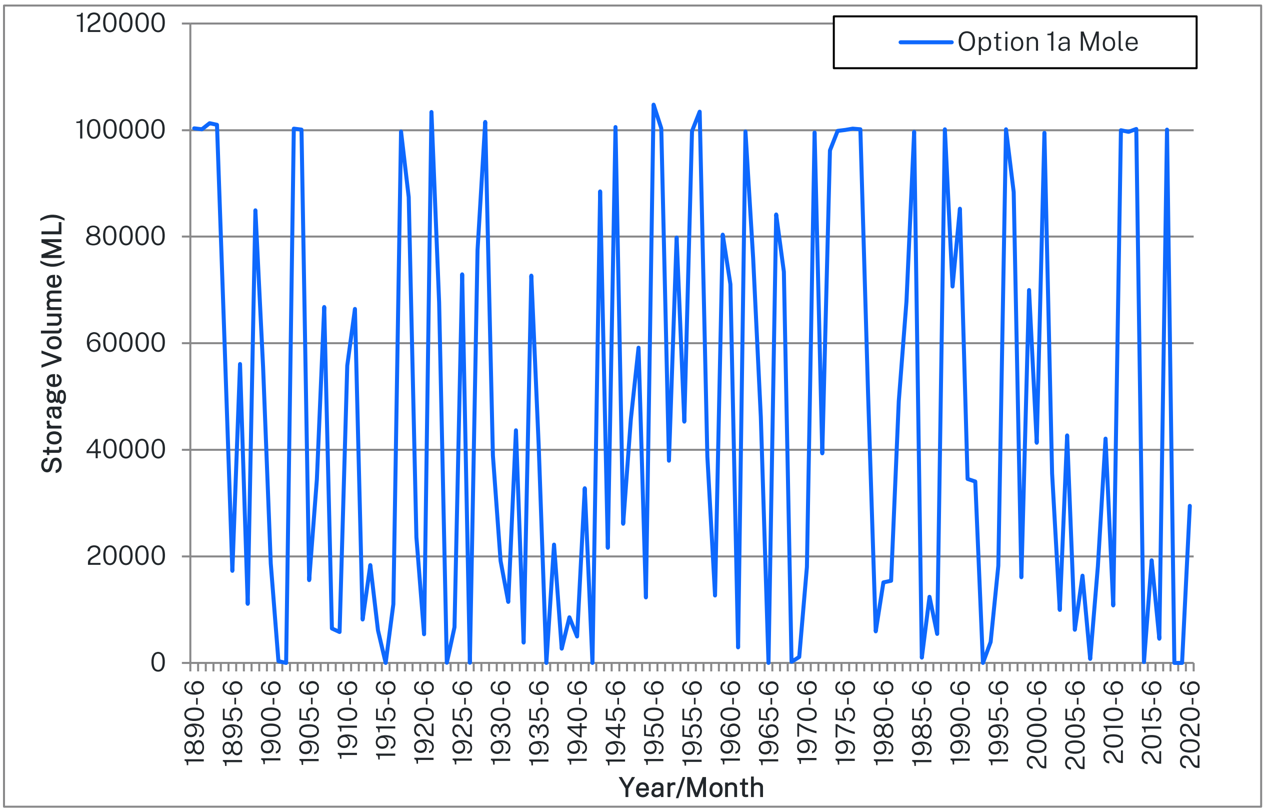


Figure 8. Pindari Dam storage behaviour base case — 100 GL Mole River Dam – general security entitlements (option 1a)

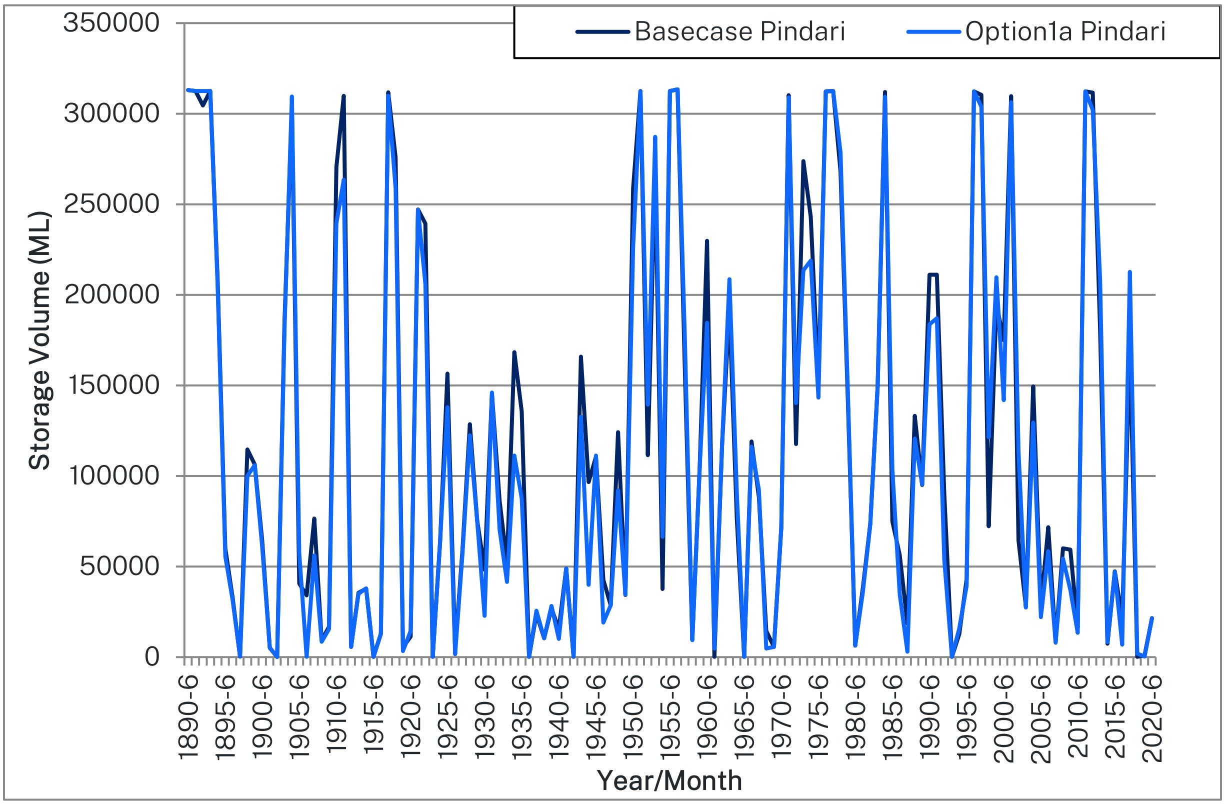
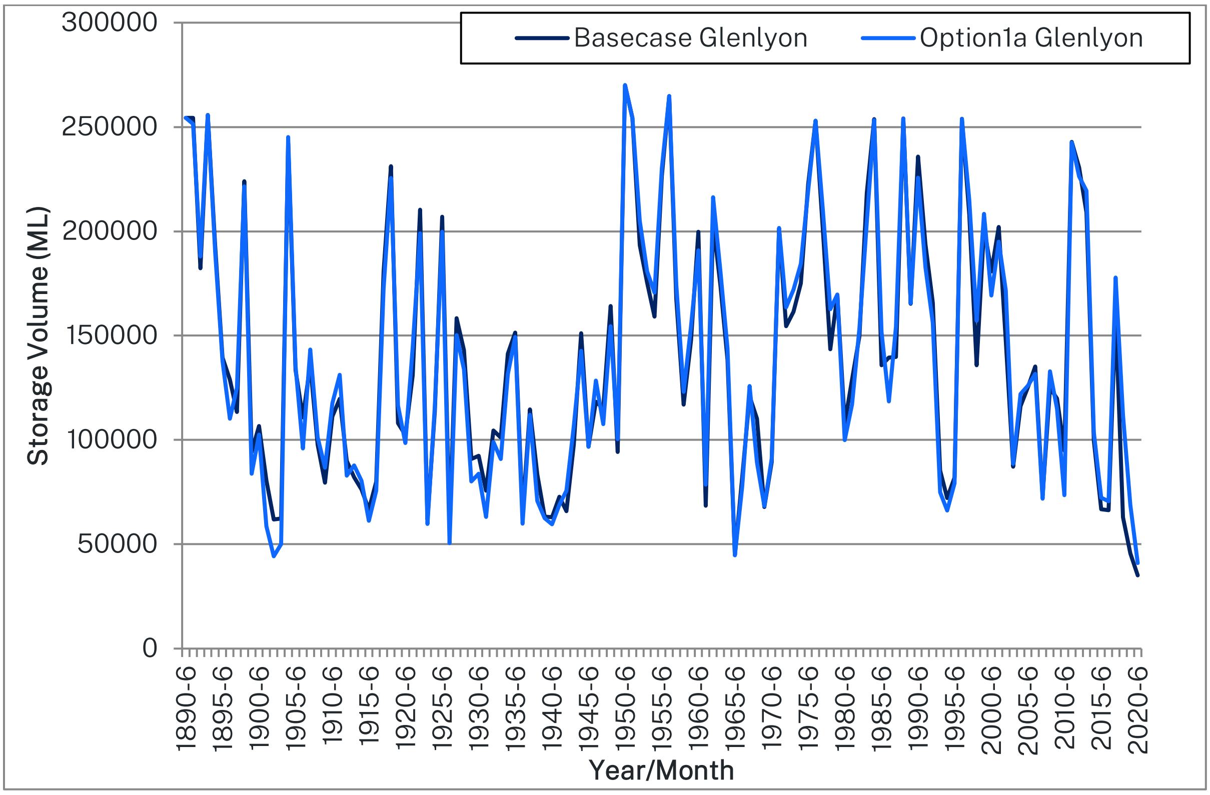


Figure 9. Glenlyon Dam storage behaviour base case — 100 GL Mole River Dam – general security entitlements (option 1a)



Alterations in river flows

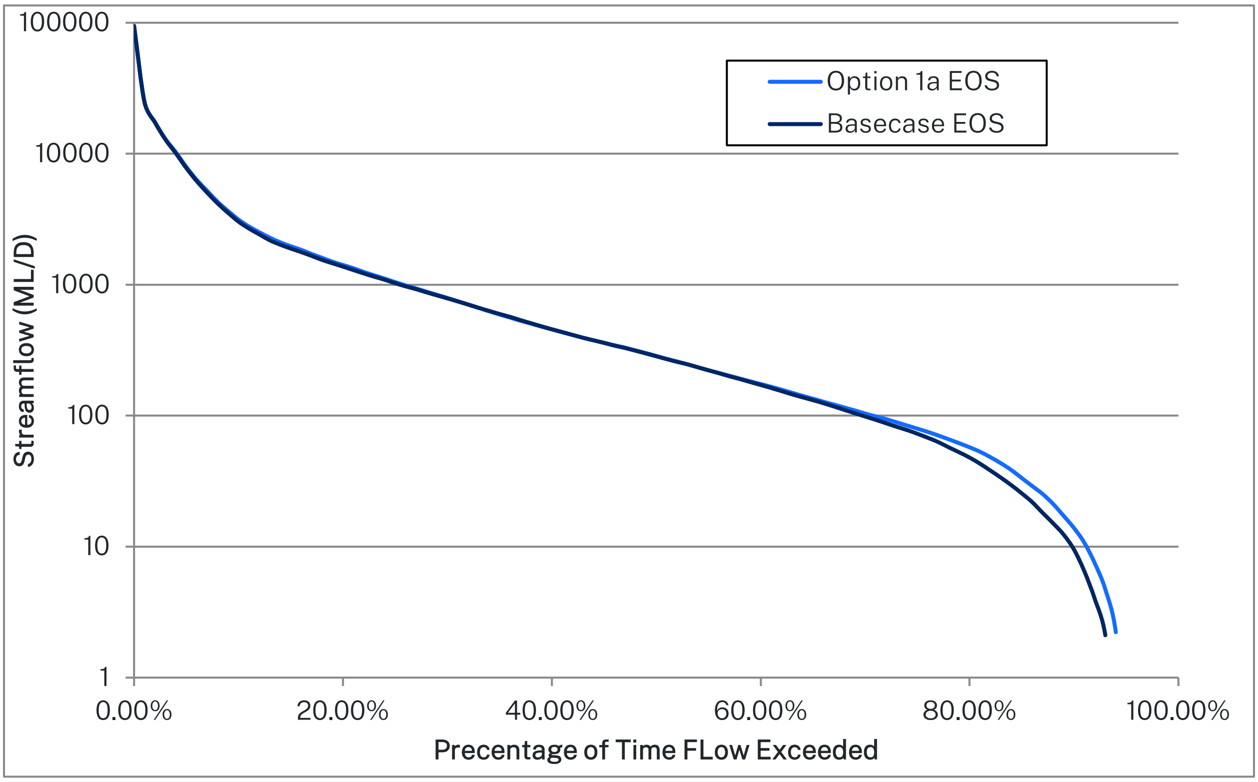
A detailed analysis of flow regime alteration has not occurred as part of the current assessment — although, as mentioned previously, such as assessment should include updating the river system model for the preferred valve and spillway discharge relationship.

Changes in the flow regime downstream of the proposed Mole River dam and at the Border Rivers end of system for option 1a relative to the base case are shown in Table 7 and Figure 10. The extent of flow change relative to the base case is minimal. This is due to the under-use of a Mole River dam in this option.

Table 7. Mean annual flow changes — option 1a (100 GL Mole River Dam – general security entitlements)

Mean annual streamflow (GL/year)	Base case	Option 1a
Macintyre River at Goondiwindi (416201a): downstream flow	794.5	794.5
Gauge: 0112 M Barwon River at Mungindi (416001): downstream flow	365.3	372.7
End of system	590.9	599.8

Figure 10. Border Rivers end-of-system flow behaviour base case, and 100 GL Mole River Dam – general security entitlements (option 1a)



Mole River Dam – creating additional high security options

Results in this section are presented for creation of high security licences from Mole River Dam of two different capacities - 100 GL and 150 GL(Table 8). These options have delivery losses and some low flow environmental flow releases added.

Table 8. Mole River dam options - create additional high security

Option	Description
1b	100 GL Mole River dam — 27 GL new high security shares on Mole (with 30% Delivery Loss and Mole translucency release) and supplementary shares reduced by 60% to achieve base case diversions.
1c	Mole 150 GL — 34 GL new high security on Mole (30% Delivery Loss, 30% Reserve, translucency release) with Growth in use (supplementary shares reduced by 70% to achieve base case diversions).

Alterations in NSW and Queensland licensed diversions

Construction of a Mole River dam and supply to NSW users only appears to have a negligible effect on Queensland diversions so long as a growth-in-use response is implemented.

Results for options 1b and 1c are presented in Table 9

The following findings have been made from the analysis:

- The amount of additional high security entitlements created by the Mole River dam was based on ensuring that full allocation volumes could be supplied in most years.
- Creating additional high security entitlements cannot occur without Border Rivers diversions exceeding the base case unless a growth-in-use response is applied.
- In the case of option 1b, including delivery losses and translucency rules results in creating 27 GL high security. This is also shown in terms of a comparison of option 1b and 1c with annual diversions in Figure 11 and Figure 12.
- Increasing Mole River dam storage volume from 100 GL (option 1b) to 150 GL (option 1c) only allows for an additional 7GL of high security entitlements to be created, while maintaining the same reliability. This indicates that the size of the storage is approaching the hydrologic capacity of the system.

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Table 9. NSW and Queensland long-term average annual diversions by licence category for 100 GL Mole River Dam – 27 GL high security (option 1b) and 150 GL Mole River Dam – 34 GL high security (option 1c)

Average annual water diversion	Base case	Option 1b	Option 1c
			NSW diversions (GL/year)
Ashford town water supply	0.10	0.10	0.10
Boggabilla town water supply	0.20	0.29	0.29
Mungindi town water supply	0.28	0.10	0.10
General security diversions	93.74	97.19	98.39
Supplementary diversions	70.49	37.58	29.66
Floodplain harvesting (excluding rainfall harvesting)	34.26	35.42	35.61
Rainfall harvesting	10.89	10.94	10.91
New Mole River high security		26.47	32.90
Total	**209.96**	**208.09**	**207.97**
Queensland diversions (GL/year)			
High priority water allocations (town water supply)	2.59	2.58	2.58
Medium priority water allocations	51.85	50.79	50.96
Off-allocation	91.96	91.76	91.66
Water harvesting	59.55	59.55	59.54
Overland flow take	17.23	17.08	17.08
Total	**223.18**	**221.75**	**221.8**

Figure 11. Mole high security diversions — 100 GL Mole River Dam – 27 GL high security entitlements (option 1b)

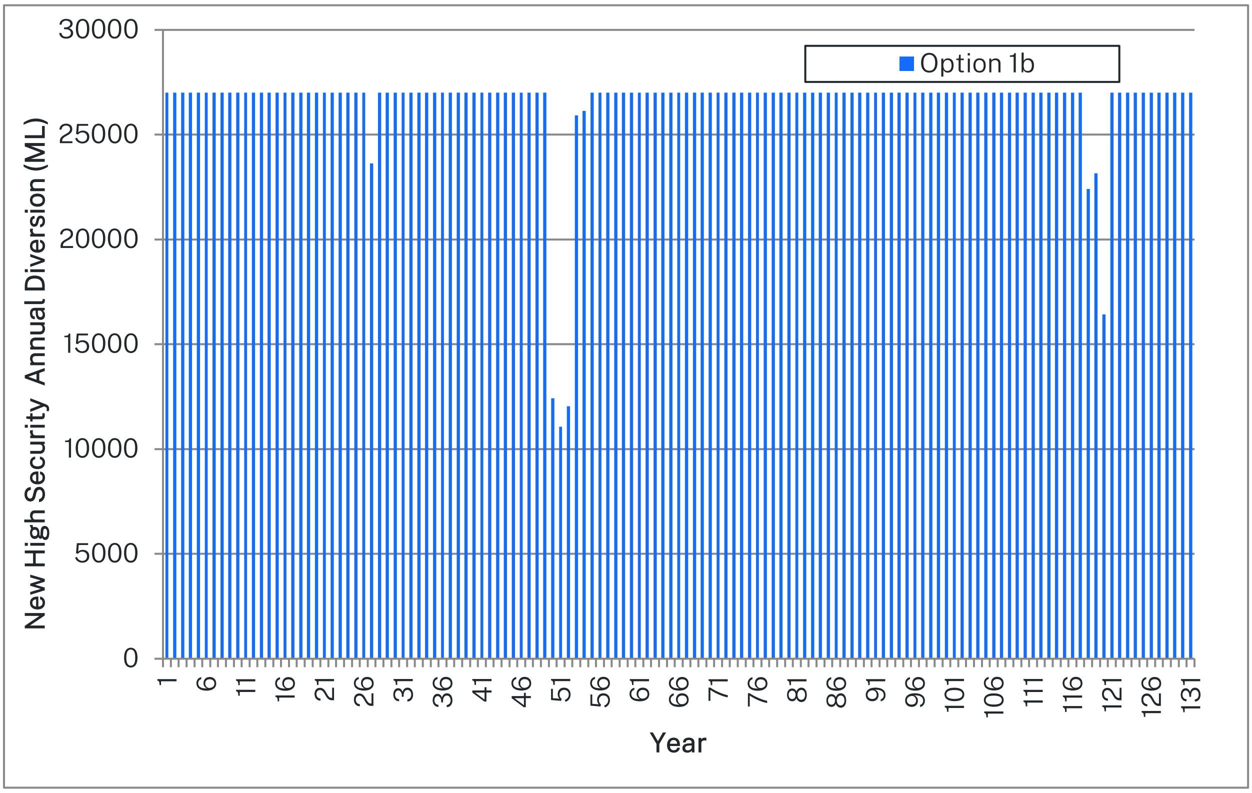
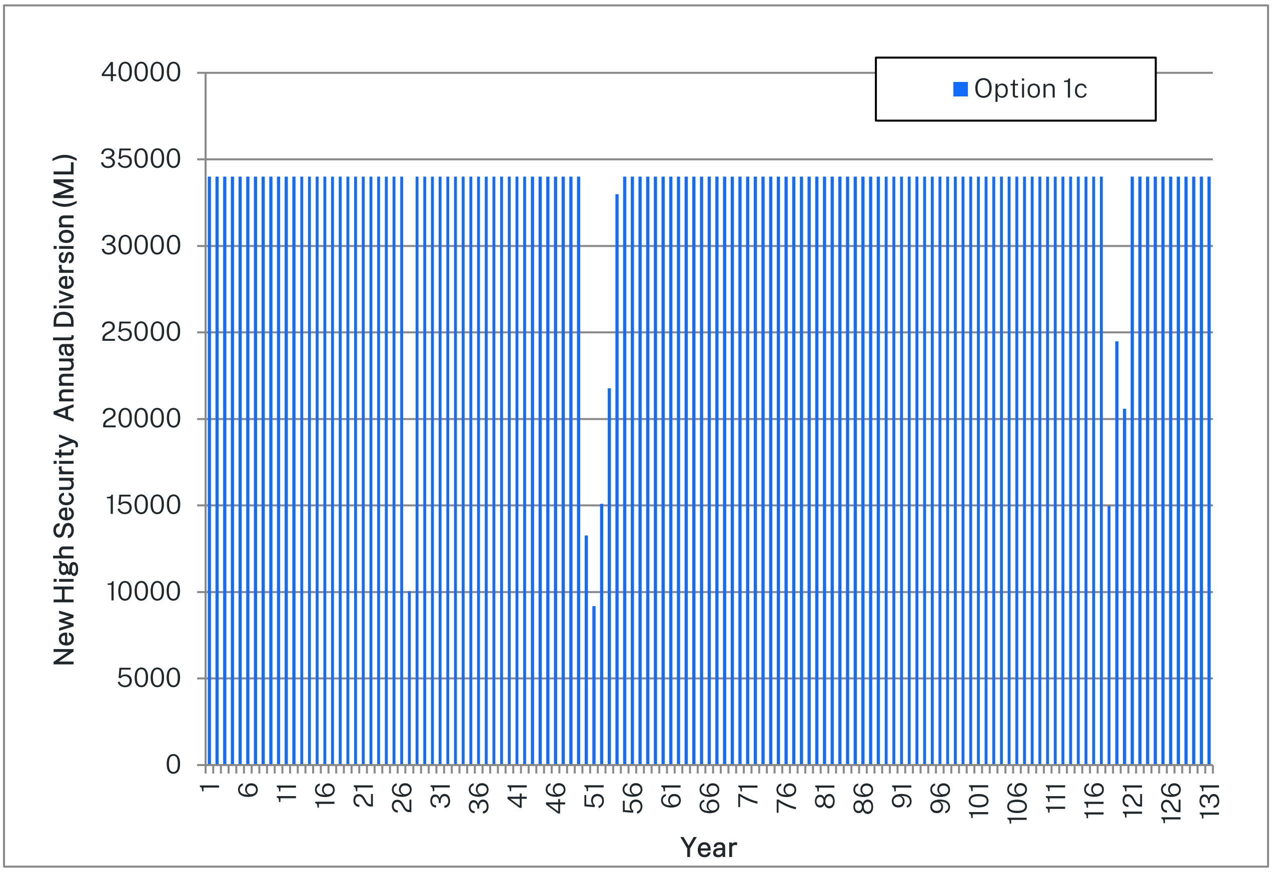


Figure 12. Mole High Security Diversions 150 GL Mole River Dam – 34 GL high security (option 1c)



Alterations in NSW Allocation Reliability

Changes in allocation reliability at the start and end of the water year are shown in Table 10 for each of the options.

Table 10 - NSW start (1st July - 1/7) and end of water year (30th June - 30/6) allocation reliability by license category - 100 GL Mole River Dam – 27 GL high security (option 1b) and 150 GL Mole River Dam – 34 GL high security (option 1c)

NSW Effective Allocation (%)	Basecase	Option 1b	Option 1c
New Mole River high security 1/7		93.6	92.6
New Mole River high security 30/6		98.9	97.5
Existing high security 1/7	100.0	100.0	100.0
Existing high security 30/6	100.0	100.0	100.0
General security A 1/7	30.2	27.3	26.8
General security A 30/6	93.6	92.2	92.4
General security B 1/7	44.9	40.7	39.8
General security B 30/6	76.8	73.9	73.4

Alterations in Storage Behaviour

Changes in storage behaviour are presented in Table 11. Monthly storage behaviour over the full model simulation period for Glenlyon, Pindari and the proposed Mole River dam are also presented for options 1b relative to the base case, in Figure 13 to Figure 15.

Table 11. Storage behaviour — 100 GL Mole River Dam – 27 GL high security (option 1b) and 150 GL Mole River Dam – 34 GL high security (option 1c)

Storage behaviour	Base case	Option 1b	Option 1c
Percent of time that Pindari Dam storage volume is:			
At new full supply level (FSL)			
At full supply level (FSL: 312.3 GL)	8.2%	7.1%	6.9%
below 50%	66.0%	70.8%	71.6%
below 10%	27.7%	31.0%	31.3%
below 5%	20.1%	22.1%	23.1%
below dead storage volume (0.5 GL)	0.7%	0.8%	0.9%
Percent of time that Glenlyon Dam storage volume is:			
At full supply level (FSL: 254.3 GL)	3.8%	3.3%	3.2%
below 50%	46.4%	52.9%	55.1%
below 10%	0.2%	1.1%	0.5%
below 5%	0.1%	0.3%	0.2%
below dead storage volume (0.2 GL)	0.0%	0.0%	0.0%
Percent of time that Coolmunda Dam storage volume is:			
At full supply level (FSL: 69.1 GL)	4.7%	4.7%	4.7%
below 50%	57.6%	57.6%	57.6%

Storage behaviour	Base case	Option 1b	Option 1c
below 10%	16.6%	16.6%	16.6%
below 0.2GL	6.8%	6.8%	6.8%
Percent of time that proposed Mole River dam storage volume is:			
At 100 GL or more		22.3%	73.2%
below 50 GL		16.0%	11.6%
below 10 GL		0.3%	0.1%
below 5 GL		0.1%	0.0%
below 0.2 GL		0.0%	0.0%
Percent of time that total system storage volume is:			
below 500 GL	81.1%	75.5%	71.2%
below 10 GL	12.9%	4.6%	3.4%

Figure 13. Mole River dam storage behaviour — 100 GL Mole River Dam – 27 GL high security (option 1b)

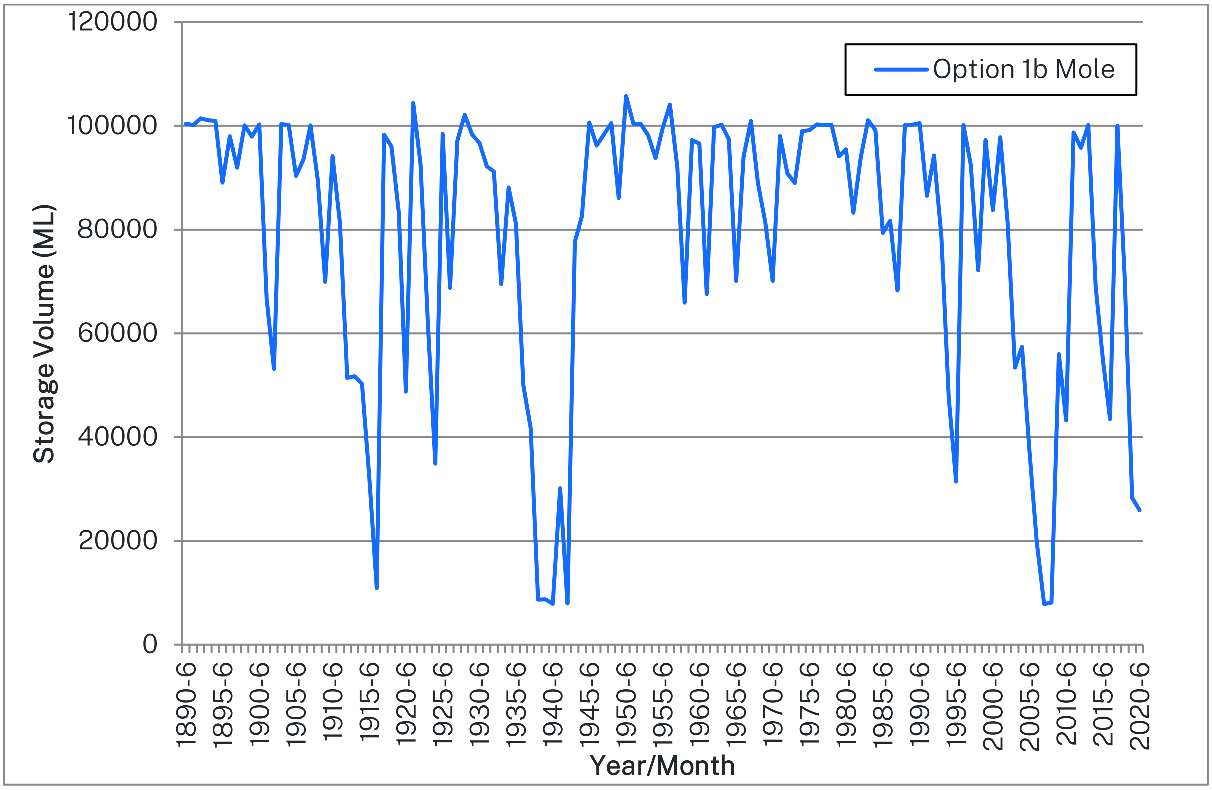


Figure 14. Pindari Dam storage behaviour base case — 100 GL Mole River Dam – 27 GL high security (option 1b)

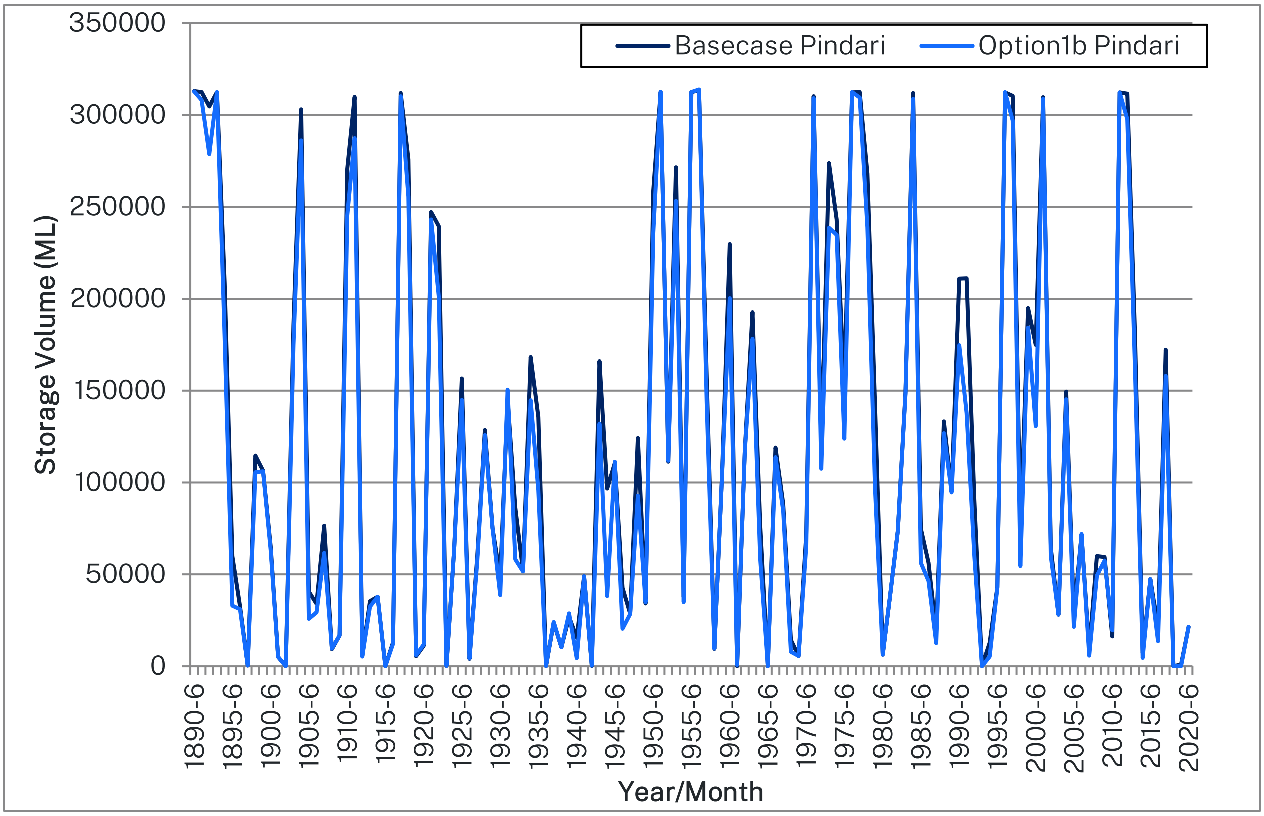
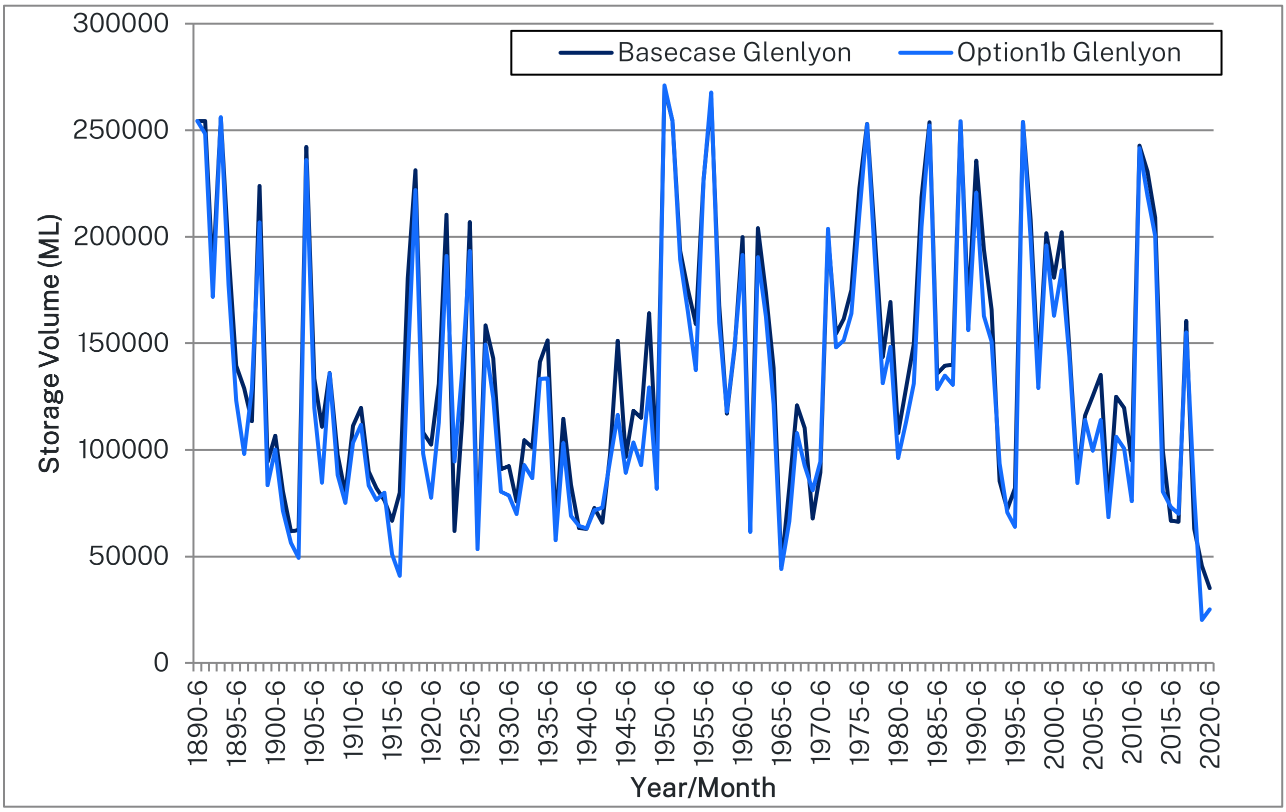


Figure 15. Glenlyon Dam storage behaviour base case — 100 GL Mole River Dam – 27 GL high security (option 1b)



The storage behaviour results indicate that the drawdown frequency for Pindari and Glenlyon dams increase for options 1b relative to the base case. This is due to the growth-in-use response reducing supplementary diversions and increasing general security demand.

Alterations in river flows

Changes in the flow regime downstream of the proposed Mole River dam, at the Mole River end of system after high security diversions have occurred, and at the Border Rivers end of system, for options 1b and 1c are shown for mean annual flows inTable 12, and by a flow duration curve for option 1b before and after high security extraction in Figure 16 and Figure 17.

As can be seen, from the figures, despite the introduction of the translucency rule the alteration in the flow regime downstream of the Mole River storage and at the Mole River end of system still appears to be substantial.

Table 12. Mean annual flow changes — 100 GL Mole River Dam – 27 GL high security option 1b) and 150 GL Mole River Dam – 34 GL high security (option 1c)

Mean annual streamflow (GL/year)	base case	option 1b	option 1c
Macintyre River at Goondiwindi (416201a): downstream flow	794.5	777.0	773.0
Gauge: 0112 M Barwon River at Mungindi (416001): downstream flow	365.3	372.5	374.2
End of system	590.9	600.4	602.4

Figure 16. Downstream of Mole River dam (before high security extraction) flow behaviour base case — 100 GL Mole River Dam – 27 GL high security (option 1b)

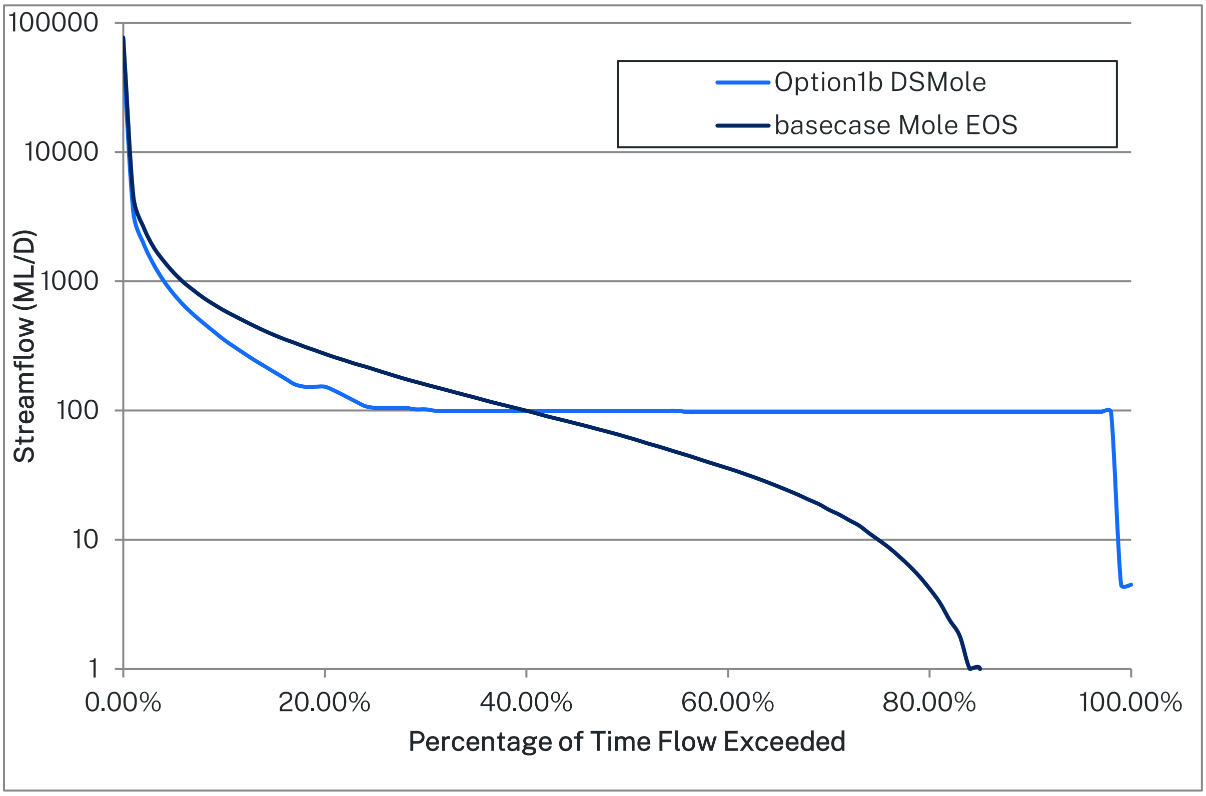
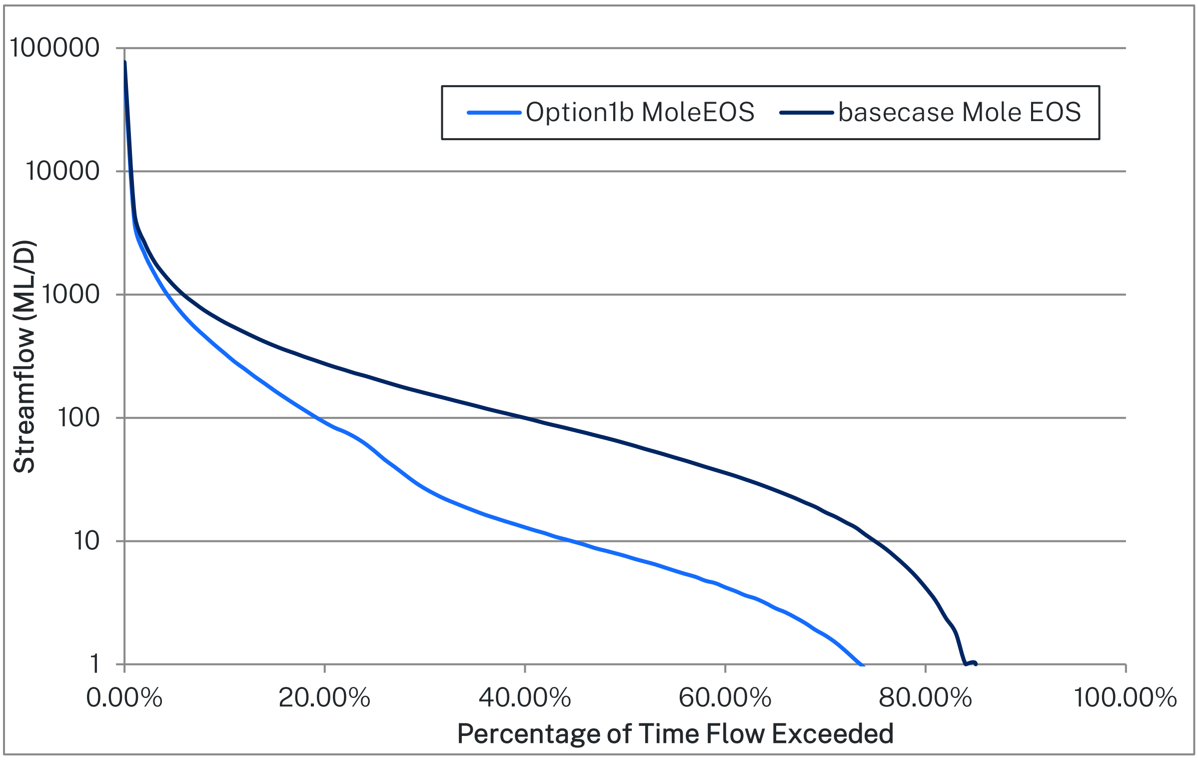


Figure 17. Downstream of Mole River dam (after high security extraction) flow behaviour base case — 100 GL Mole River Dam – 27 GL high security (option 1b)



5. Raising Pindari Dam

Option description

Option 2 in the draft Border Rivers Regional Water Strategy was to raise the Pindari Dam wall to increase the dam's storage capacity. Wall raises of 5 m and 10 m were modelled (see Table 13).

Table 13. Pindari Dam wall-raising option description

Option	Description
2a	Raise Pindari Dam by 5 m — Supply Existing Users — Growth in use applied, supplementary shares reduced by 20%.
2b	Raise Pindari Dam by 10 m — Supply Existing Users — Growth in use applied, supplementary shares reduced by 30%.

Model configuration and assumptions

Model configuration

Two model configuration changes were for analysis:

- reducing supplementary shares for growth-in-use actions
- changing Pindari storage characteristics.

Key assumptions

It is assumed that existing joint storage operational practices and irrigator behaviour remain unchanged during the model analysis.

Storage characteristics

The existing valve relationship contained in the model has not been changed, while the spillway rating has been shifted by 5 m and 10 m respectively to reflect increased wall heights.

Modelling results

Alterations in NSW and Queensland licensed diversions

Results of diversion changes as a result of raising the Pindari Dam full supply level in conjunction with a growth-in-use response are presented in Table 14. Raising the dam 5 m produces a 5 GL/year increase in general security diversions, while raising the dam 10 m produces a 9 GL increase.

Table 14. NSW and Queensland long-term average annual diversions by licence category — Pindari Dam 5m (option2a) and 10 m (option 2b) wall raise

Annual average water diversions	Base case	Option 2a	Option 2b
NSW diversions (GL/year)			
Ashford town water supply	0.10	0.10	0.10
Boggabilla town water supply	0.20	0.20	0.20
Mungindi town water supply	0.28	0.28	0.28
General security diversions	93.74	98.72	102.73
Supplementary diversions	70.49	62.70	57.84
Floodplain harvesting (excluding rainfall harvesting)	34.26	34.72	34.96
Rainfall harvesting	10.89	10.97	11.01
Total	**209.96**	**207.70**	**207.12**
Queensland diversions (GL/year)			
High priority water allocations (town water supply)	2.59	2.59	2.59
Medium priority water allocations	51.85	51.69	51.41
Off-allocation	91.96	92.20	92.25
Water harvesting	59.55	59.59	59.56
Overland flow take	17.23	17.17	17.09
Total	**223.18**	**223.24**	**222.90**

Alterations in NSW allocation reliability

Allocation increases as a result of Pindari Wall-raising are very small — the 5 m raise results in a 3.4% increase in general security end-of-year allocations, and the 10 m raise a 6.4% increase (Table 15). The small increases are primarily due to Pindari Dam spilling infrequently under the base case, meaning that the additional airspace created by the wall-raising is seldom used.

End of water year allocation reliability curves for the base case and options 2a and 2b are presented in Figure 18 and Figure 19. While allocation improvements occur for all allocations, low allocations improvements are greater for the 10 m raise. This is shown in Figure 19.

Table 15. NSW start (1st July - 1/7) and end of water year (30th June - 30/6) allocation reliability by licence category — Pindari Dam 5m (option 2a) and 10 m (option 2b) wall raise

NSW Effective Allocation (%)	Base case	Option 2a	Option 2b
Existing high security 1/7	100.0	100.0	100.0
Existing high security 30/6	100.0	100.0	100.0
General security A 1/7	30.2	32.2	33.3
General security A 30/6	93.6	94.5	94.1
General security B 1/7	44.9	46.4	47.8
General security B 30/6	76.8	80.2	83.2

Figure 18. End of water year (30th June) general security B effective allocation base case — Pindari Dam 5m (option2a) and 10 m (option 2b) wall raise

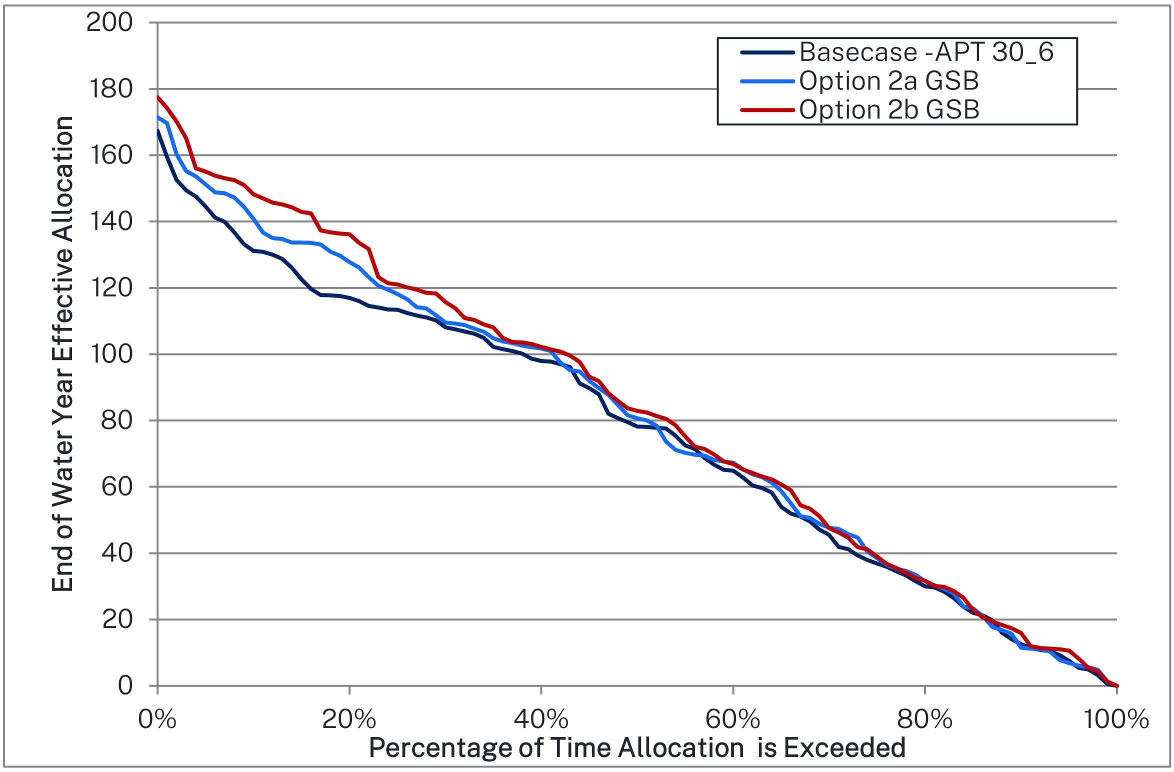
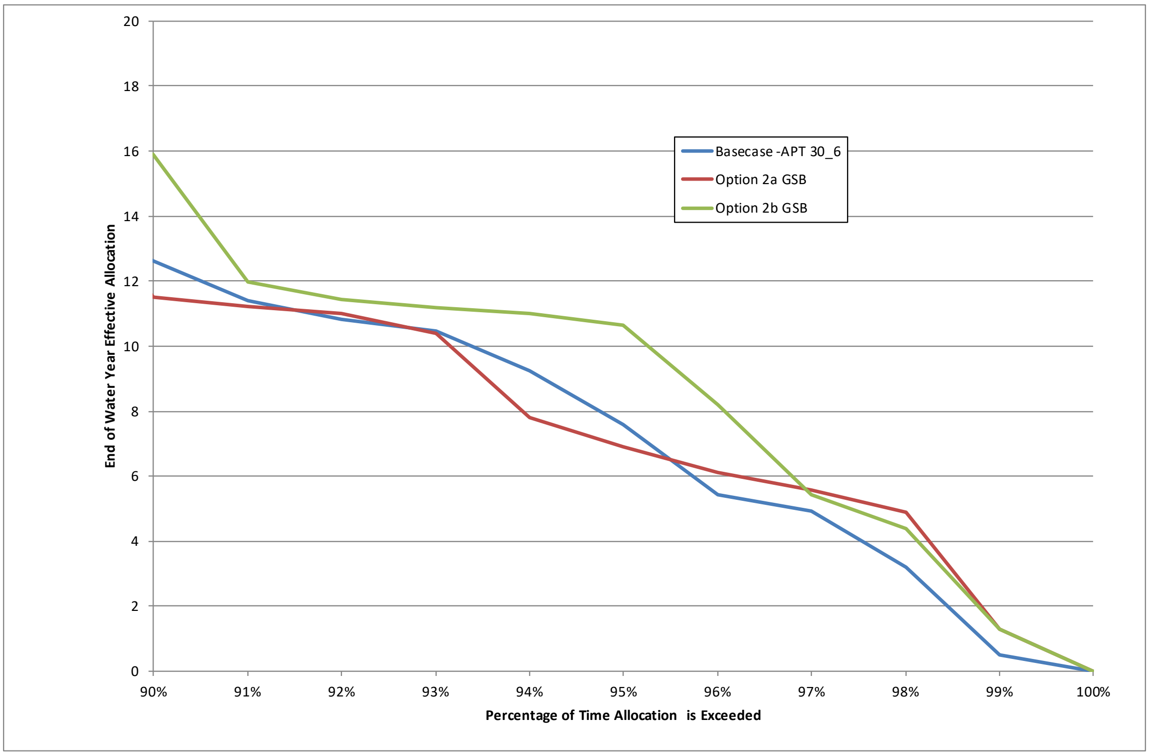


Figure 19. End of water year (30th June) general security B effective allocation base case — Pindari Dam 5m (option 2a) and 10 m (option 2b) wall raise (Allocations below 20%)



Alterations in storage behaviour

Alterations in storage behaviour as a result of wall-raising are presented in Table 16, and Figure 20 and Figure 21. As expected, wall-raising results in the dam sitting higher more frequently — although for the 5 m raise case below 35,000 ML, Pindari volumes appear to be drawn down slightly more frequently. This is most likely the effect of increased general security demand as a result of supplementary diversions reductions, when growth in use outweighs the additional resource created through wall-raising.

Table 16. Storage behaviour — Pindari Dam 5m (option 2a) and 10 m (option 2b) wall raise

Storage behaviour	Base case	Option 2a	Option 2b
Percent of time that Pindari Dam storage volume is:			
At new full supply level (FSL)		6.5%	5.5%
At full supply level (FSL: 312.3 GL)	8.2%	16.5%	18.6%
below 50%	66.0%	64.3%	63.4%
below 10%	27.7%	28.0%	27.4%
below 5%	20.1%	20.6%	19.6%
below dead storage volume (0.5 GL)	0.7%	2.0%	0.9%
Percent of time that Glenlyon Dam storage volume is:			
At full supply level (FSL: 254.3 GL)	3.8%	4.2%	4.3%
below 50%	46.4%	45.6%	45.0%
below 10%	0.2%	0.1%	0.1%
below 5%	0.1%	0.0%	0.0%
below dead storage volume (0.2 GL)	0.0%	0.0%	0.0%
Percent of time that Coolmunda Dam storage volume is:			
At full supply level (FSL: 69.1 GL)	4.7%	4.7%	4.7%
below 50%	57.6%	57.6%	57.6%
below 10%	16.6%	16.6%	16.6%
0.2 GL	6.8%	6.8%	6.8%
Percent of time that total system storage volume is:			
below 500 GL	81.1%	78.5%	76.7%
below 10 GL	12.9%	13.1%	13.3%

Figure 20. Pindari storage volume — percentage of time that volume is exceeded. Pindari Dam 5m (option2 a) and 10 m (option 2b) wall raise

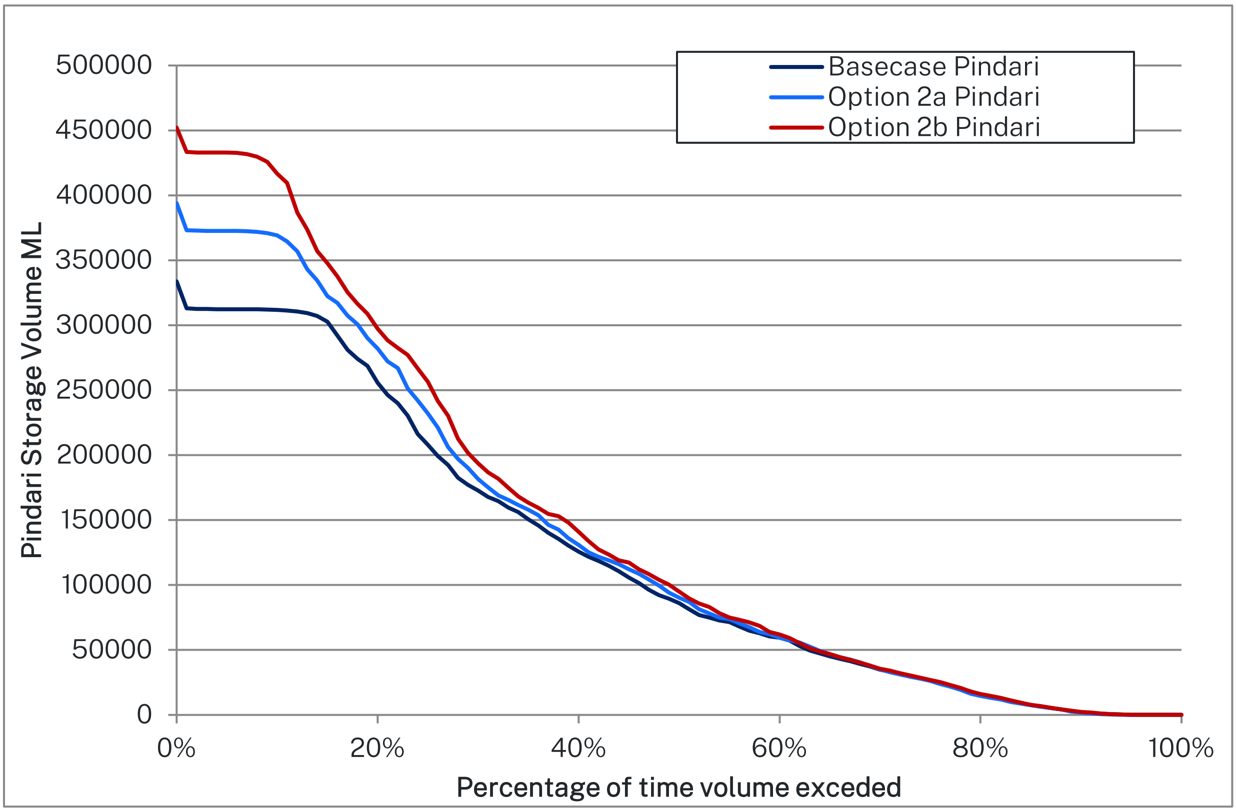
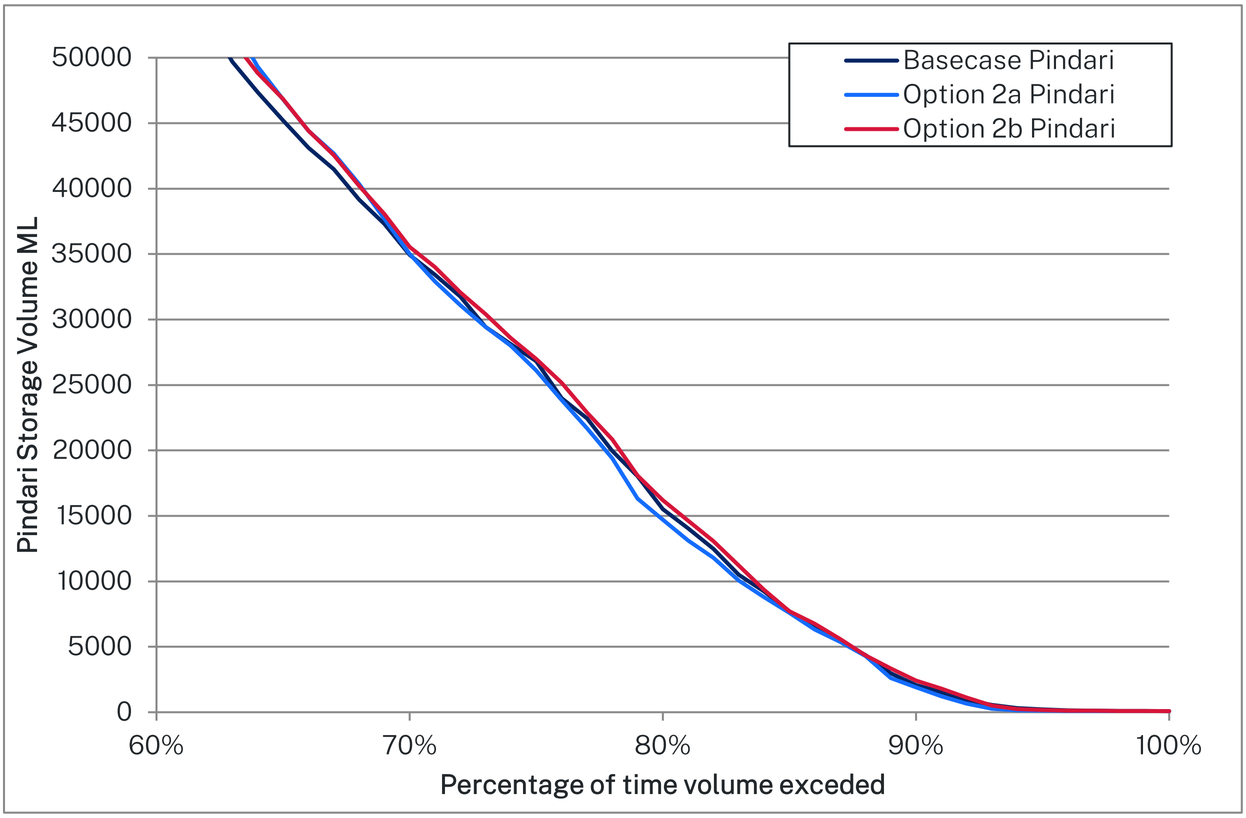


Figure 21. Pindari storage volume — percentage of time that volume is exceeded (for volumes below 50,000 ML). Pindari Dam 5m (option 2a) and 10 m (option 2b) wall raise



Alterations in river flows

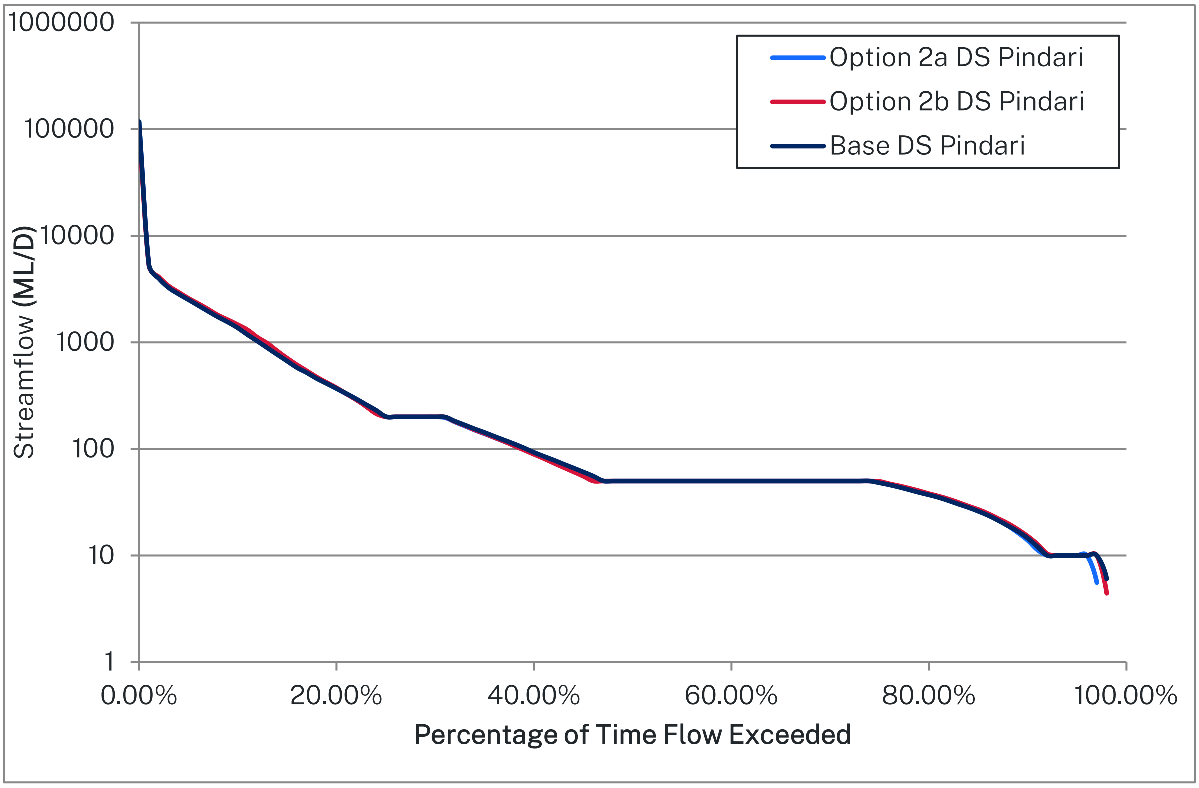
A detailed analysis of flow regime alteration has not occurred as part of the current assessment — although, as mentioned previously, such as assessment should include updating the river system model for the preferred valve and spillway discharge relationship.

Changes in the flow regime downstream of Pindari Dam and at the Border Rivers end of system for option 2a and 2b, relative to the base case, are shown Table 17 and Figure 22. Mean and low flows appear to increase slightly as a result of the redistribution of diversions from supplementary to general security.

Table 17. Mean annual flow changes — Pindari Dam 5m (option 2a) and 10 m (option 2b) wall raise

Mean annual streamflow (GL/year)	Base case	Option 2a	Option 2b
Macintyre River at Goondiwindi (416201a): downstream flow	794.5	794.3	794.3
Gauge: 0112 M Barwon River at Mungindi (416001): downstream flow	365.3	367.5	369.3
End of system	590.9	593.9	596.0

Figure 22. Downstream of Pindari Dam flow behaviour base case, and Pindari Dam 5m (option 2a) and 10 m (option 2b) wall raise



6. Raising Mungindi Weir

Option description

Option 3 in the draft Border Rivers Regional Water Strategy was to raise the Mungindi Weir to 5 m to increase the end-of-system storage capacity, improve system efficiency and improve delivery to water users in the lower reaches of the Macintyre River and the top end of the Barwon–Darling river-reach. The option evaluated is outlined in Table 18.

Table 18. Mungindi weir raising option descriptions

Option	Description
3	Raise Mungindi weir by 5 m — FSL 1480ML Supply Existing Users — Growth in use applied, supplementary shares reduced by 10%

Model configuration and assumptions

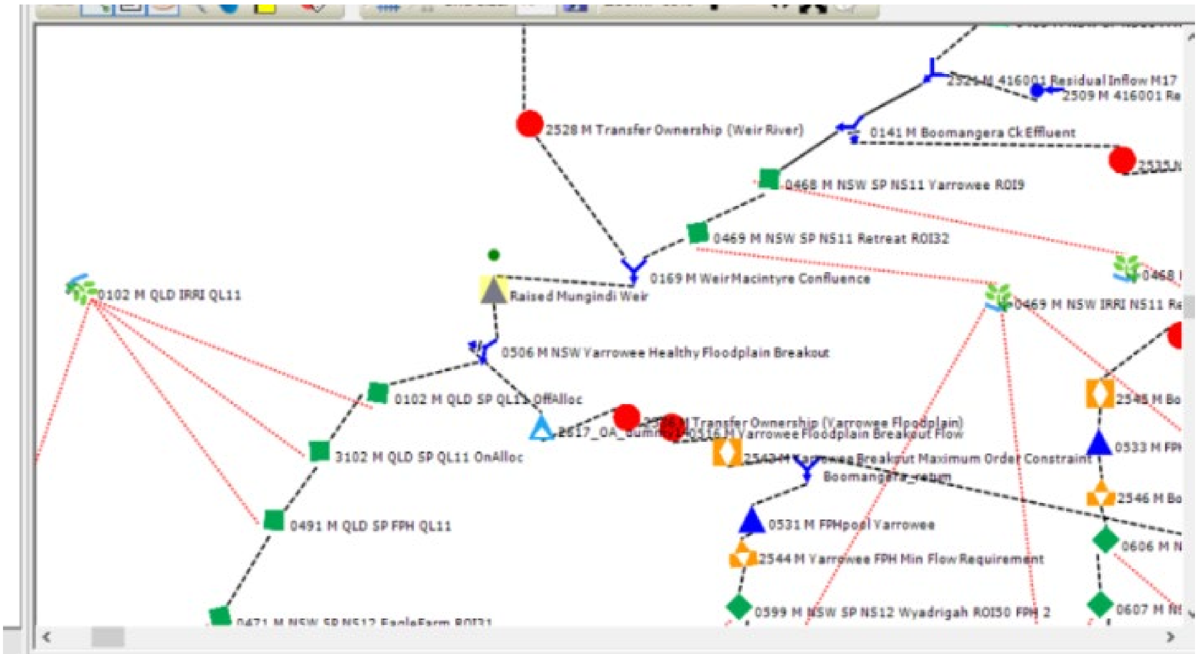
Model configuration

Two Source model configuration changes were required for the analysis:

- inclusion of Mungindi Weir
- reduction of supplementary shares for growth-in-use actions.

The model configuration changes are shown in Figure 23.

Figure 23. Raised Mungindi Weir schematic



Key assumptions

It is assumed that the weir pool can supply users up to the weir river confluence with the Macintyre River. Consequently, in the model, the weir was placed before these users.

Weir characteristics

The weir is 39 m wide and consists of five radial gates. Maximum discharge has been based on a broad-crested weir formula. The rating and storage dimensions of the weir are presented in Table 19 and Table 20. A storage volume of 1,480 ML has been assessed.

Table 19. Weir gated storage rating

Level (m AHD)	Minimum discharge (ML/D)	Maximum discharge (ML/D)
153	0	0
154	0	6065
155	0	17155
156	0	31515
157	0	48522
158	0	67812
159	89,141	89,141
165	252,129	252,129

Table 20. Weir storage dimensions

Level (m AHD)	Volume (ML)	Surface area (km^2)
153	0	0
156.6	730	0.08
156.7	740	0.08
156.9	800	0.31
157.2	910	0.42
157.5	1050	0.51
157.8	1220	0.6
158.1	1410	0.7
158.2	1487	0.733
158.4	1640	0.8
158.7	1890	0.91
159	2180	1.03

Modelling results

Alterations in NSW and Queensland licensed diversions

Results of diversion changes for existing entitlements as a result of raising Mungindi Weir in conjunction with a growth-in-use response are presented in Table 21. As can be seen, from option 3 raising the weir 5 m with a corresponding 10% reduction in supplementary shares to maintain diversions at the limit produces a 3 GL/year increase in general security diversions.

Table 21. NSW and Queensland long-term average annual diversions by licence category — Mungindi Weir full supply level 1480 ML (option 3)

Average annual diversions	Base case	Option 3
NSW diversions (GL/year)		
Ashford town water supply	0.10	0.10
Boggabilla town water supply	0.20	0.20
Mungindi town water supply	0.28	0.28
General security diversions	93.74	96.62
Supplementary diversions	70.49	66.82
Floodplain harvesting (excluding rainfall harvesting)	34.26	34.56
Rainfall harvesting	10.89	10.93
Total	**209.96**	**209.51**
Queensland diversions (GL/year)		
High priority water allocations (town water supply)	2.59	2.59
Medium priority water allocations	51.85	53.23
Off-allocation	91.96	92.09
Water harvesting	59.55	59.58
Overland flow take	17.23	17.25
Total	**223.18**	**224.73**

Alterations in NSW allocation reliability

Allocation increases as a result of Mungindi Weir raising are presented in Table 22. As can be seen, increases in allocation are very small — with option 3 resulting in a 1% increase in general security B end-of-year allocations.

Table 22. NSW start (1st July - 1/7) and end of water year (30th June - 30/6) allocation reliability by licence category — Mungindi Weir full supply level 1480 ML (option 3)

NSW effective allocation (%)	Base case	Option 3
Existing high security 1/7	100.0	100.0
Existing high security 30/6	100.0	100.0
General security A 1/7	30.2	28.9
General security A 30/6	93.6	94.9
General security B 1/7	44.9	45.2
General security B 30/6	76.8	77.8

Alterations in storage behaviour

Alterations in storage behaviour as a result of wall-raising are presented inTable 23. The results indicate that the Mungindi Weir raising results in minor alterations to storage behaviour at both an individual storage and system scale.

Table 23. Storage behaviour — Mungindi Weir full supply level 1480 ML (option 3)

Storage behaviour	Base case	Option 3
Percent of time that Pindari Dam storage volume is:		
At full supply level (FSL: 312.3 GL)	8.2%	8.2%
below 50%	66.0%	66.9%
below 10%	27.7%	26.4%
below 5%	20.1%	19.7%
below dead storage volume (0.5 GL)	0.7%	0.6%
Percent of time that Glenlyon Dam storage volume is:		
At full supply level (FSL: 254.3 GL)	3.8%	3.8%
below 50%	46.4%	42.4%
below 10%	0.2%	0.0%
below 5%	0.1%	0.0%
below dead storage volume (0.2 GL)	0.0%	0.0%
Percent of time that Coolmunda Dam storage volume is:		
At full supply level (FSL: 69.1 GL)	4.7%	4.7%
below 50%	57.6%	57.6%
below 10%	16.6%	16.6%
below 0.2GL	6.8%	6.8%
Percent of time that total system storage volume is:		
below 500 GL	81.1%	80.9%
below 10 GL	12.9%	10.9%

Alterations in river flows

End-of-system changes in the flow regime as a result of weir raising for option 3 relative to the base case are shown Table 24. Raising of the weir results in negligible changes to mean end-of-system flows.

Table 24. Mean annual flow changes — Mungindi Weir full supply level 1480 ML (option 3)

Mean annual streamflow (GL/year)	Base case	Option 3
End of system	590.9	590.3

7. Improved delivery of stock and domestic supplies in unregulated Boomi River

Option description

Option 4 in the draft Border Rivers Regional Water Strategy was to provide a piped supply to stock and domestic users in the unregulated section of the Boomi River in place of replenishment flow releases from Pindari Dam (Table 25). As such, 10 GL of the delivery losses set aside in the resource assessment can be reallocated to consumptive users to improve water security.

Table 25. Boomi stock and domestic supplies option description

Option	Description
4	Boomi Pipeline — Essential supply delivery losses in resource assessment reduced by 10 GL/year with 7% reduction in supplementary as a growth-in-use response.

Model configuration

Model configuration

The following model configuration changes were required for the analysis:

- the NSW high security reserve requirement in the model was reduced from 41 GL to 31 GL
- supplementary shares were reduced by 10% to ensure diversions remained within the diversion limit.

Modelling results

Alterations in NSW and Queensland licensed diversions

Results of diversion changes for existing entitlements due to supply to Boomi stock and domestic users via a pipeline in conjunction with a growth-in-use response are presented in Table 26.

As can be seen, from option 4, supplying users via pipeline and reducing essential supplies by 10 GL produces a 1.5 GL/year increase in general security diversions on average. This small increase is driven by not all of the extra 10 GL being used every year, and the losses associated with delivering this water to all existing users.

Table 26. NSW and Queensland long-term annual average diversions by licence category — Boomi pipeline (Option 4)

Annual average diversions	Base case	Option 4
NSW diversions (GL/year)		
Ashford town water supply	0.10	0.10
Boggabilla town water supply	0.20	0.20
Mungindi town water supply	0.28	0.28
General security diversions	93.74	95.22
Supplementary diversions	70.49	68.07
Floodplain harvesting (excluding rainfall harvesting)	34.26	34.46
Rainfall harvesting	10.89	10.91
Total	**209.96**	**209.25**
Queensland diversions (GL/year)		
High priority water allocations (town water supply)	2.59	2.59
Medium priority water allocations	51.85	51.93
Off-allocation	91.96	92.03
Water harvesting	59.55	59.56
Overland flow take	17.23	17.23
Total	**223.18**	**223.34**

Alterations in NSW allocation reliability

Allocation increases as a result of piping replenishment flows to Boomi users are presented in Table 27. As can be seen, increases in allocation are very small — resulting in a 1% increase in general security B end-of-year allocations.

Table 27. NSW start (1st July - 1/7) and end of water year (30th June - 30/6) allocation reliability by licence category — Boomi pipeline (Option 4)

NSW Effective Allocation (%)	Base case	Option 4
Existing high security 1/7	100.0	100.0
Existing high security 30/6	100.0	100.0
General security A 1/7	30.2	30.5
General security A 30/6	93.6	94.1
General security B 1/7	44.9	45.4
General security B 30/6	76.8	77.9

Alterations in storage behaviour

Alterations in storage behaviour as a result of piping replenishment flows to Boomi users are presented in Table 28. The results shown a small increase in Glenlyon drawdown storage behaviour due to increases in general security use.

Table 28. Storage behaviour — Boomi pipeline (Option 4)

Storage behaviour	Base case	Option 4
Percent of time that Pindari Dam storage volume is:		
At full supply level (FSL: 312.3 GL)	8.2%	8.1%
below 50%	66.0%	66.4%
below 10%	27.7%	28.8%
below 5%	20.1%	21.0%
below dead storage volume (0.5 GL)	0.7%	0.8%
Percent of time that Glenlyon Dam storage volume is:		
At full supply level (FSL: 254.3 GL)	3.8%	3.6%
below 50%	46.4%	49.5%
below 10%	0.2%	0.2%
below 5%	0.1%	0.1%
below dead storage volume (0.2 GL)	0.0%	0.0%
Percent of time that Coolmunda Dam storage volume is:		
At full supply level (FSL: 69.1 GL)	4.7%	4.7%
below 50%	57.6%	57.6%
below 10%	16.6%	16.6%
below 0.2 GL	6.8%	6.8%
Percent of Time that Total System storage volume is:		
below 500 GL	81.1%	81.7%
below 10 GL	12.9%	16.5%

Alterations in river flows

End-of-system changes in the flow regime as a result of piping Boomi replenishment flows are shownTable 29. The results show negligible changes to mean end-of-system flows.

Table 29. Mean annual flow changes — Boomi pipeline (Option 4)

Mean annual streamflow (GL/year)	Base case	Option 4
End of system	590.9	591.9

8. Inland river diversions

Option description

Option 8 in the draft Border Rivers Regional Water Strategy was to investigate potential diversion of rivers from east of the Great Dividing Range. Several alternate inland river diversion options into the Border Rivers have been modelled (see Table 30). Detailed results for the options are presented in the following sections.

Options have been taken from the 1982 Clarence Valley Inter–Departmental Committee on Water Resources report, ‘Possibilities for Inland Diversion of Water from the Clarence Valley’.

No optimisation of these options has taken place at this stage. Option 8a involves transfers from the Mann River in the Clarence Valley into Pindari Dam. Options 8b involves pumped and gravity diversions from the Timbarra River in the Clarence Valley into the Mole River in the Border Rivers valley.

Table 30. Inland river diversions option description

Option	Description
8a	Small diversion: base case (Actual Permitted Take Model with transfer from Clarence (Mann River Dam full supply volume 49GL @ 13GL/Yr to Pindari).
8b	Large diversion: base case (Actual Permitted Take Model with transfer from Clarence straight into Mole River) with new 49GL/Yr high security demand at Boggabilla.

Model assumptions

- Under option 8b an 897 GL storage in the Clarence valley transferring at an annual demand of 89 GL per year has been assumed.
- Under option 8a, a 49 GL storage in the Clarence valley transferring at an annual demand of 13 GL per year has been assumed.
- Zero dead storage has been assumed.
- No environmental flow releases have been assumed from the two Clarence storages.
- Existing Clarence River water users are not supplied from the new Clarence storages.
- No growth-in-use action is required due to diversion from external water source.
- The extraction limits from external water sources have not been considered.

Ownership

Transferred water into the Border Rivers is assumed to be owned by the NSW Government.

New demands

Additional high security demand has been created at Boggabilla. Because demand is serviced through a Clarence transfer, no adjustment to the reserve account in the Border Rivers was required.

Constraints

Two constraints were considered when creating additional high security volumes. These were:

1. end-of-year allocation reliability for other licensed products must not decrease below the base case
2. end-of-system flows must not decrease below the base case.

Modelling results

Alterations in NSW and Queensland licensed diversions

Results of diversion changes as a result of Clarence Transfers are presented in Table 31.

For option 8a, the transfer of 12.3 GL per year into Pindari Dam equates to a 4.7 GL per year increase in general security B diversions. Over half of the transfer appears to be consumed in delivery losses or remains as an unused allocation.

For option 8b, a transfer of 88.8 GL per year allows for creation of 49 GL of high security entitlements at Boggabilla. Further increases are constrained by the reductions in end-of-system flow below the base case.

Table 31. NSW and Queensland long-term average annual diversions by licence category — inland diversion scheme: small diversion (option 8a) and large diversion (option 8b)

Annual Average Diversions	Base case	Option 8a	Option 8b
Average Clarence transfer volume (GL/year)		12.3	88.8
NSW diversions (GL/year)			
Ashford town water supply	0.10	0.11	0.10
Boggabilla town water supply	0.20	0.20	0.19
Mungindi town water supply	0.28	0.28	0.29
General security diversions	93.74	98.12	94.20
Supplementary diversions	70.49	70.72	71.79
Floodplain harvesting (excluding rainfall harvesting)	34.26	34.35	34.35
Rainfall harvesting	10.89	10.92	10.86
New high security			48.92

Annual Average Diversions	Base case	Option 8a	Option 8b
Total	**209.96**	**214.69**	**260.71**
Queensland diversions (GL/year)			
High priority water allocations (town water supply)	2.59	2.59	2.50
Medium priority water allocations	51.85	51.16	54.76
Off-allocation	91.96	92.00	92.22
Water harvesting	59.55	59.55	59.58
Overland flow take	17.23	17.24	17.22
Total	**223.18**	**222.55**	**226.27**

Alterations in NSW allocation reliability

Start- and end-of-year average allocations for newly created high security allocations and any remaining and existing products are presented in Table 32. For option 8b, the transfer of Clarence Water into Pindari Dam increases end of water year allocations for both general security A and B. This indicates that under existing user behaviour, some of the transferred water is used.

For option 8b, start and end of water year allocations are largely unchanged. This is to be expected since transferred water is not being allocated to existing users.

Table 32. NSW start (1st July - 1/7) and end of water year (30th June - 30/6) allocation reliability by licence category — inland diversion scheme: small diversion (option 8a) and large diversion (option 8b)

NSW effective allocation (%)	Base case	Option 8a	Option 8b
New and existing high security 1/7	100.0	99.2	100.0
New and existing high security 30/6	100.0	99.2	100.0
General security A 1/7	30.2	30.2	29.8
General security A 30/6	93.6	95.9	93.2
General security B 1/7	44.9	46.6	45.6
General security B 30/6	76.8	80.2	77.7

Alterations in storage behaviour

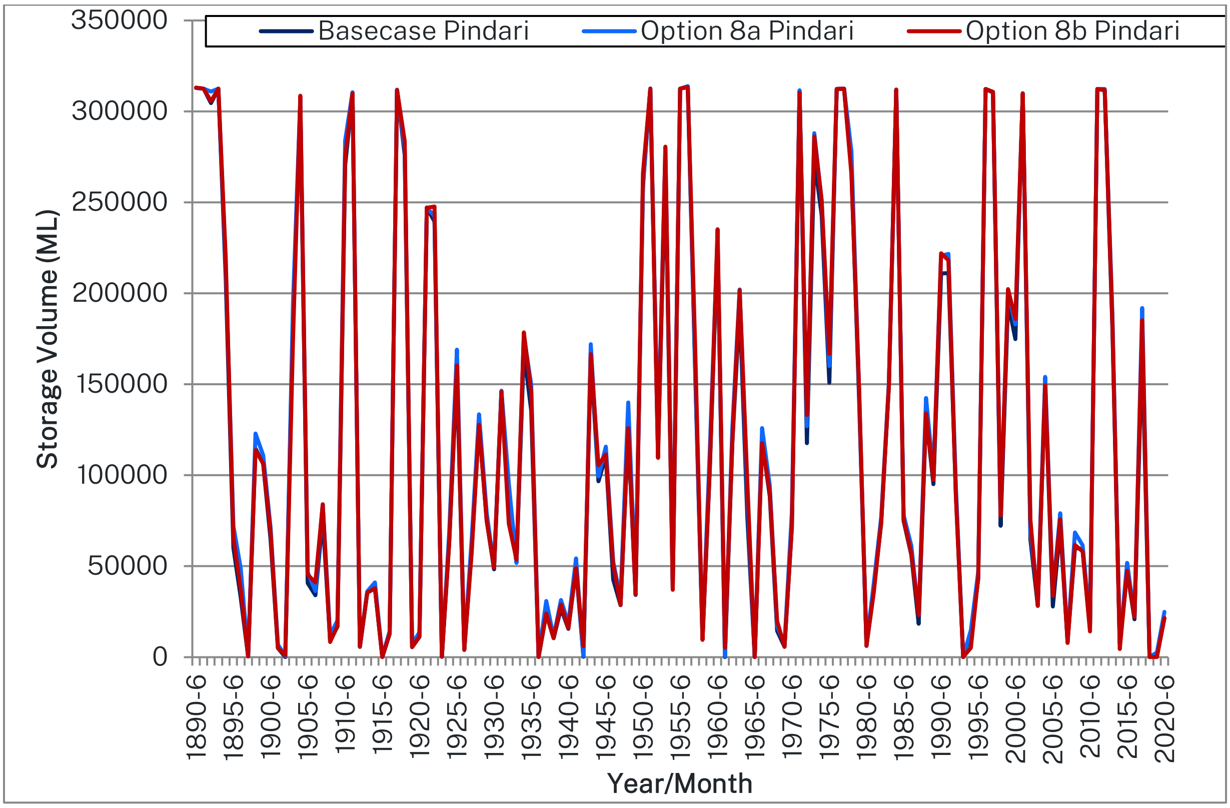
Alterations in storage behaviour as a result of transfers are presented in Table 33, and in Figure 24. For option 8a — as expected — Pindari Dam has greater stored volumes than under the base case. This reflects the under-use of transferred water.

For option 8b, there is very little change in storage behaviour from the base case.

Table 33. Storage behaviour — inland diversion scheme: small diversion (option 8a) and large diversion (option 8b)

Storage behaviour	Base case	Option 8a	Option 8b
Percent of time that Pindari Dam storage volume is:			
At full supply level (FSL: 312.3 GL)	8.2%	9.7%	8.6%
below 50%	66.0%	64.9%	65.2%
below 10%	27.7%	25.3%	26.7%
below 5%	20.1%	18.7%	19.5%
below dead storage volume (0.5 GL)	0.7%	0.0%	0.8%
Percent of time that Glenlyon Dam storage volume is:			
At full supply level (FSL: 254.3 GL)	3.8%	3.8%	4.0%
below 50%	46.4%	44.6%	44.0%
below 10%	0.2%	0.1%	0.1%
below 5%	0.1%	0.0%	0.0%
below dead storage volume (0.2 GL)	0.0%	0.0%	0.0%
Percent of time that Coolmunda Dam storage volume is:			
At full supply level (FSL: 69.1 GL)	4.7%	4.7%	4.7%
below 50%	57.6%	57.6%	57.6%
below 10%	16.6%	16.6%	16.6%
below 0.2 GL	6.8%	6.8%	6.8%
Percent of time that total system storage volume is:			
below 500 GL	81.1%	80.3%	80.0%
below 10 GL	12.9%	12.7%	12.3%

Figure 24. Pindari Dam storage behaviour base case — inland diversion scheme: small diversion (option 8a)



Alterations in river flows

End-of-system changes to the flow regime as the result of large and small inland diversion scheme are shown in Table 34. The results show a small increase of 2.2GL in the end-of-system flow as the result of the small inland diversion scheme. a reduction of 0.9 GL as a result of the large diversion scheme. The slight reduction in end of system flows in the large diversion scheme are a result of the volume of new high security created. A smaller volume would result in end of system flows being equal to or exceeding the base case.

Table 34. Mean annual flow changes — small diversion (option 8a) and large diversion (option 8b)

Mean annual streamflow (GL/year)	base case	Option 8a	Option 8b
End of system	590.9	593.1	590.0

9. Improve connectivity with downstream systems

Option description

The option was aimed at increasing end-of-system flows at Mungindi.

Table 35. Downstream connectivity option description

Option	Description
23	Additional Mungindi 100ML/day target (NSW ownership)

Model assumptions

Ownership

Water releases from storages to meet the end-of-system connectivity objective are from NSW supplies only.

New demands

A minimum flow requirement of 100 ML/day has been placed in the model at Mungindi.

Modelling results

Alterations in NSW and Queensland licensed diversions

Alterations in diversions are presented in Table 36. As can be seen, the introduction of an end-of-system flow target at Mungindi results in a significant reduction in general security use.

Table 36. NSW and Qld long-term average diversions by licence category — increase end-of-system flow by 100ML/d (option 23)

Annual average diversions	Base case	Option 23
NSW diversions (GL/year)		
Ashford town water supply	0.10	0.10
Boggabilla town water supply	0.20	0.19
Mungindi town water supply	0.28	0.29
General security diversions	93.74	72.35
Supplementary diversions	70.49	70.07
Floodplain harvesting (excluding rainfall harvesting)	34.26	34.11
Rainfall harvesting	10.89	10.58
Total	**209.96**	**187.69**
Queensland diversions (GL/year)	**Base case**	**Option 23**
High priority water allocations (town water supply)	2.59	2.56
Medium priority water allocations	51.85	54.12
Off-allocation	91.96	91.58
Water harvesting	59.55	59.55
Overland flow take	17.23	17.13
Total	**223.18**	**224.94**

Alterations in NSW allocation reliability

Average allocations at the start and end of water year for NSW licence categories are presented in Table 37. The results indicate that maintaining an end-of-system flow target of 100 ML/day leads to substantial reductions in NSW general security B allocation reliability.

Table 37. NSW start (1st July – 1/7) and end (30th June -30/6) of water year allocation reliability by licence category — increase end-of-system flow by 100ML/d (option 23)

NSW effective allocation (%)	Base case	Option 23
High security 1/7	100.0	99.2
High security 30/6	100.0	99.2
General security A 1/7	30.2	27.1
General security A 30/6	93.6	73.1
General security B 1/7	44.9	38.0
General Security B 30/6	76.8	62.7

Alterations in storage behaviour

Increased releases from storages to meet the downstream end-of-system flow target mean that both Pindari Dam and Glenlyon Dam are lower for longer. This is shown in the storage behaviour results of Table 38.

Table 38. Storage behaviour — increase end-of-system flow by 100ML/d (option 23)

Storage behaviour	Base case	Option 23
Percent of time that Pindari Dam storage volume is:		
At new full supply level		
At full supply level (312.3 GL)	8.2%	7.4%
below 50%	66.0%	69.4%
below 10%	27.7%	33.6%
below 5%	20.1%	24.9%
below dead storage volume (0.5 GL)	0.7%	1.4%
Percent of time that Glenlyon Dam storage volume is:		
At full supply level (254.3 GL)	3.8%	3.2%
below 50%	46.4%	59.6%
below 10%	0.2%	8.5%
below 5%	0.1%	4.6%
below dead storage volume (0.2 GL)	0.0%	0.1%
Percent of time that Coolmunda Dam storage volume is:		
At full supply level (69.1 GL)	4.7%	4.7%
below 50%	57.6%	57.6%
below 10%	16.6%	16.6%
0.2 GL	6.8%	6.8%
Percent of time that total system storage volume is:		
below 500 GL	81.1%	83.3%
below 10 GL	12.9%	22.8%

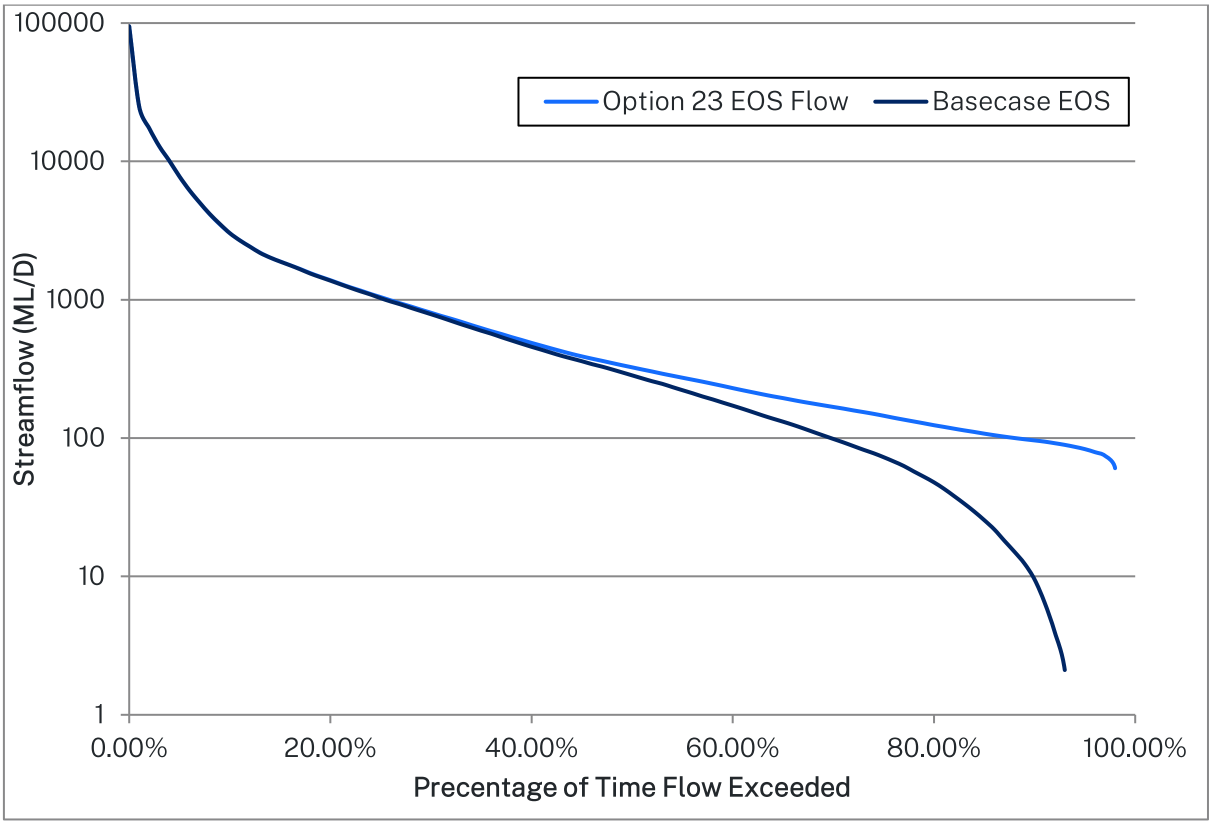
Alterations in river flows

Implementation of an end-of-system flow target at Mungindi results in increased flows along the entire length of the Border Rivers below Pindari Dam and Glenlyon Dam. This is shown by the changes in mean annual flows presented in Table 39, and the end-of-system flow duration curve comparison in Figure 25.

Table 39. Mean annual flow changes — increase end-of-system flow by 100ML/d (option 23)

Mean annual streamflow (GL/year)	Base case	Option 23
Macintyre River at Goondiwindi (416201a): downstream flow	794.5	803.6
Gauge: 0112 M Barwon River at Mungindi (416001): downstream flow	365.3	379.9
End of system	590.9	605.3

Figure 25. Border Rivers end-of-system flow duration curve— increase end-of-system flow by 100ML/d (option 23)



10. Review regulated river accounting processes (increase in system storage reserve for essential supplies)

Option description

Option 30 in the draft Border Rivers Regional Water Strategy was to review different settings of the water accounting and water allocation process. The component of this option that was modelled was to set aside additional reserves in the system to supply essential requirements for drought sequences that may exceed those that had been historically observed.

Table 40. Increases in system storage reserve for essential supplies option description

Option	Description
30	System reserve increase from 41.1GL (18-month reserve) to 62.2GL (two-year reserve)

Model configuration and assumptions

Model configuration

The following model configuration change was required for the analysis:

- the NSW high security reserve requirement in the model was increased from 41 GL to 62.2 GL.

Modelling results

Alterations in NSW and Queensland licensed diversions

Results of diversion changes for existing entitlements as a result of supply increasing the essential supply reserve are presented in Table 41. As can be seen, increasing essential supplies by 20 GL produces a minor 2.5 GL/year decrease in general security diversions on average.

Table 41. NSW and Queensland long-term average annual diversions by licence category — increase system essential needs reserve (Option 30)

Annual average diversions	Base case	Option 30
NSW diversions (GL/year)		
Ashford town water supply	0.10	0.10
Boggabilla town water supply	0.20	0.20
Mungindi town water supply	0.28	0.28
General security diversions	93.74	91.20
Supplementary diversions	70.49	70.55
Floodplain harvesting (excluding rainfall harvesting)	34.26	34.32
Rainfall harvesting	10.89	10.87
Total	**209.96**	**207.52**
Queensland diversions (GL/year)	Base case	Option 30
High priority water allocations (town water supply)	2.59	2.59
Medium priority water allocations	51.85	51.56
Off-allocation	91.96	91.95
Water harvesting	59.55	59.55
Overland flow take	17.23	17.26
Total	**223.18**	**222.91**

Alterations in NSW allocation reliability

General security B allocation decreases as a result of option 30 are presented in Table 42. As can be seen, end-of-year allocation decreases on average by 2.4%.

Table 42. NSW start (1st July - 1/7) and end (30th June – 30/6) of water year allocation reliability by licence category — increase system essential needs reserve (Option 30)

NSW effective allocation (%)	Base case	Option 30
Existing high security 1/7	100.0	100.0
Existing high security 30/6	100.0	100.0
General security A 1/7	30.2	29.2
General security A 30/6	93.6	93.5
General security B 1/7	44.9	43.5
General security B 30/6	76.8	74.4

Alterations in storage behaviour

Alterations in storage behaviour as a result of increasing the reserve are presented inTable 43. The results show that total system storage below 10,000 ML reduced from 12.6% to 5.6%. Most of this reduction is attributable to alterations in Glenlyon Dam storage behaviour.

Table 43. Storage behaviour — increase system essential needs reserve (Option 30)

Storage behaviour	Base case	Option 30
Percent of time that Pindari Dam storage volume is:		
At full supply level (FSL: 312.3 GL)	8.2%	8.5%
below 50%	66.0%	65.4%
below 10%	27.7%	24.4%
below 5%	20.1%	16.8%
below dead storage volume (0.5 GL)	0.7%	0.4%
Percent of time that Glenlyon Dam storage volume is:		
At full supply level (FSL: 254.3 GL)	3.8%	4.2%
below 50%	46.4%	32.8%
below 10%	0.2%	0.0%
below 5%	0.1%	0.0%
below dead storage volume (0.2 GL)	0.0%	0.0%
Percent of time that Coolmunda Dam storage volume is:		
At full supply level (FSL: 69.1 GL)	4.7%	4.7%
below 50%	57.6%	57.6%
below 10%	16.6%	16.6%
below 0.2 GL	6.8%	6.8%
Percent of time that total system storage volume is:		
below 500 GL	81.1%	80.1%
below 10 GL	12.9%	5.6%

Alterations in river flows

End-of-system changes in the flow regime as a result of option 30 are shownTable 44. The results show a slight increase in end-of-system flow as a result of higher reserves and reduced general security use.

Table 44. Mean annual flow changes — increase system essential needs reserve (Option 30)

Mean annual streamflow (GL/year)	Base case	Option 30
End of system	590.9	592.0

11. Investigate licence conversions

Option description

Two scenarios for creating additional high security at the expense of other licence products were evaluated. In option 31a all general security licenses are converted to 85 GL of high licenses. In option 31b, 16 GL (7%) of general security B licence is converted to 4 GL of high security. The conversion rate in option 31b is based on value obtained in option 31a.

Table 45. Licence conversions option description

Option	Description
31a	General security A and general security B reduced by 100% (242.12GL), 85 GL high security created at Boggabilla.
31b	General security B reduced by 16GL (7%), 4GL high security created using conversion rate from option 31a.

Model configuration and assumptions

Model configuration

The following model configuration changes were required for the analysis:

- general security shares for A and B were reduced to zero using an input set
- base case model reserves are increased by 1.33 times the volume of high security licences created at Boggabilla
- new high security demand created at Boggabilla
- high security demand spread uniformly across the year.

Key assumptions

Ownership

All options evaluated assume that any new high security licences entitlements created at Boggabilla are completely owned by NSW.

New demands

Any new high security licence demands have been assumed to use all available allocation, with demand distributed uniformly over the year. This implies that users will seek to use all their allocation every year either through trade or storage in on-farm infrastructure.

Constraints

Three constraints were considered when creating additional high security volumes. These were:

1. end-of-year allocation reliability for any remaining products must not drop below the base case
2. total diversions must not exceed the base case diversion limit
3. end-of-system flows must not drop below the base case.

Modelling results

Alterations in NSW and Queensland licensed diversions

Results of diversion changes as a result of creating new high security allocations and increasing the essential supply reserve are presented in Table 46. As can be seen, the amount of high security allocations created increases as other license products are progressively eliminated. An example of the variation in annual high security diversions is presented in Figure 26 for option 31a. Annual diversions are always above 95% of the share amount.

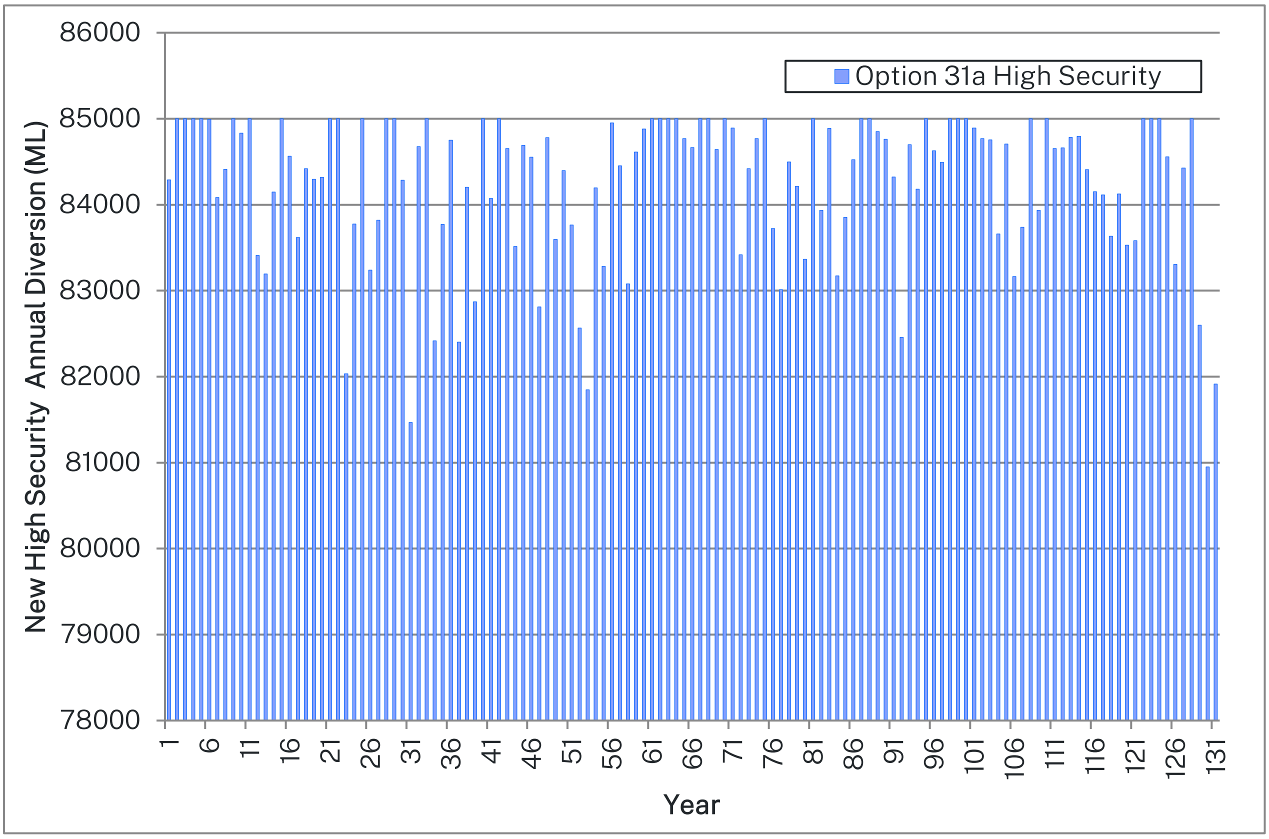
Constraints in the amount of high security allocations are based on end-of-system flow maintenance for option 31a. No constraints have been applied for option 31b. Results for option 31b indicate that if the conversion rate for option 31a (0.32) is used to determine the general security reduction amount, there is a risk that diversions will exceed the diversion limit, albeit by a negligible amount.

Table 46. NSW and Queensland long-term average diversions by licence category— use licence conversion to create new high security licences: 85 GL (option 31a), 4 GL (option 31b)

Annual average diversions	Base case	Option 31a	Option 31b
NSW diversions (GL/year)			
Ashford town water supply	0.10	0.11	0.10
Boggabilla town water supply	0.20	0.20	0.20
Mungindi town water supply	0.28	0.28	0.28
General security diversions	93.74	0.33	91.48
Supplementary diversions	70.49	61.54	70.50
Floodplain harvesting (excluding rainfall harvesting)	34.26	35.63	34.26
Rainfall harvesting	10.89	9.25	10.87
Newly created high security		84.25	3.89
Total	**209.96**	**191.58**	**211.58**
Queensland diversions (GL/year)			
High priority water allocations (town water supply)	2.59	2.60	2.59
Medium priority water allocations	51.85	53.06	51.80
Off-allocation	91.96	91.89	91.76

Annual average diversions	Base case	Option 31a	Option 31b
Water harvesting	59.55	59.59	59.58
Overland flow take	17.23	18.27	17.23
Total	**223.18**	**225.42**	**222.95**

Figure 26. Use licence conversion to create 85 GL new high security licences (option 31a) — new high security annual diversions



Alterations in NSW allocation reliability

Start- and end-of-year average allocations for newly created high security allocations and any remaining general security A and B allocations are presented in Table 47 and in the form of exceedance plots for remaining general security A and B allocations in Figure 27 to Figure 29. As can be seen from Table 47, newly created high security allocations have a high start- and end-of-year allocation. Although in some instances — as seen by a comparison of the diversions in Figure 26 with the end of water year allocation for option 31a — allocation increases occur later in the water year at a time when demand cannot fully use it.

Application of the option 31a conversion rate (0.32) to option 31b created high security volumes that appear to result in average allocation improvements for remaining general security B users, and no change to general security A.

Table 47. NSW start and end of water year allocation reliability by licence category - use licence conversion to create new high security licences: 85 GL (option 31a), 4 GL (option 31b)

NSW effective allocation (%)	Base case	Option 31a	Option 31b
New and existing high security 1/7	100.0	100.0	100.0
New and existing high security 30/6	100.0	100.0	100.0
General security A 1/7	30.2	0.0	31.7
General security A 30/6	93.6	0.0	93.0
General security B 1/7	44.9	0.0	46.2
General security B 30/6	76.8	0.0	79.5

Figure 27. Use licence conversion to create 4 GL new high security licences (Option 31b) — general security A end of water year (30th June) effective allocation

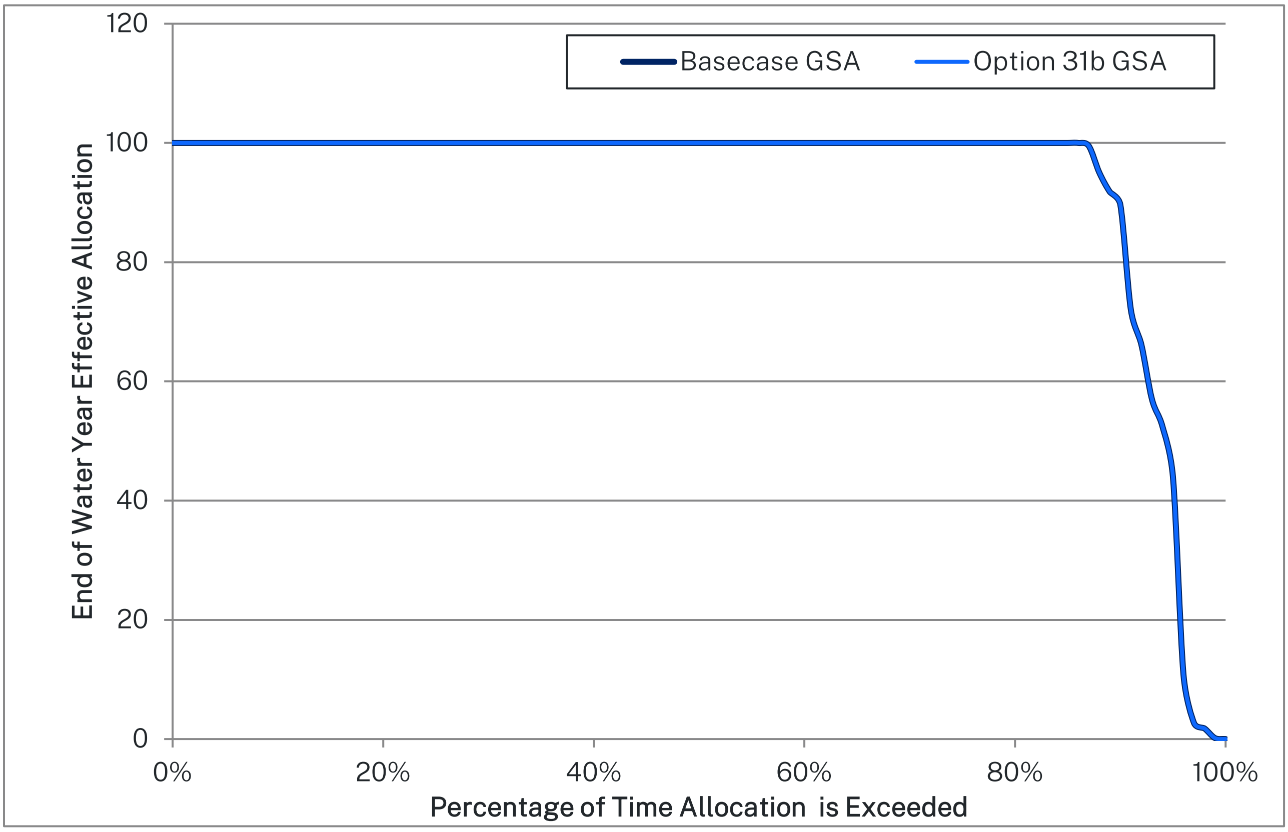


Figure 28. Use licence conversion to create 4 GL new high security licences (Option 31b) — general security B end of water year (30th June) effective allocation

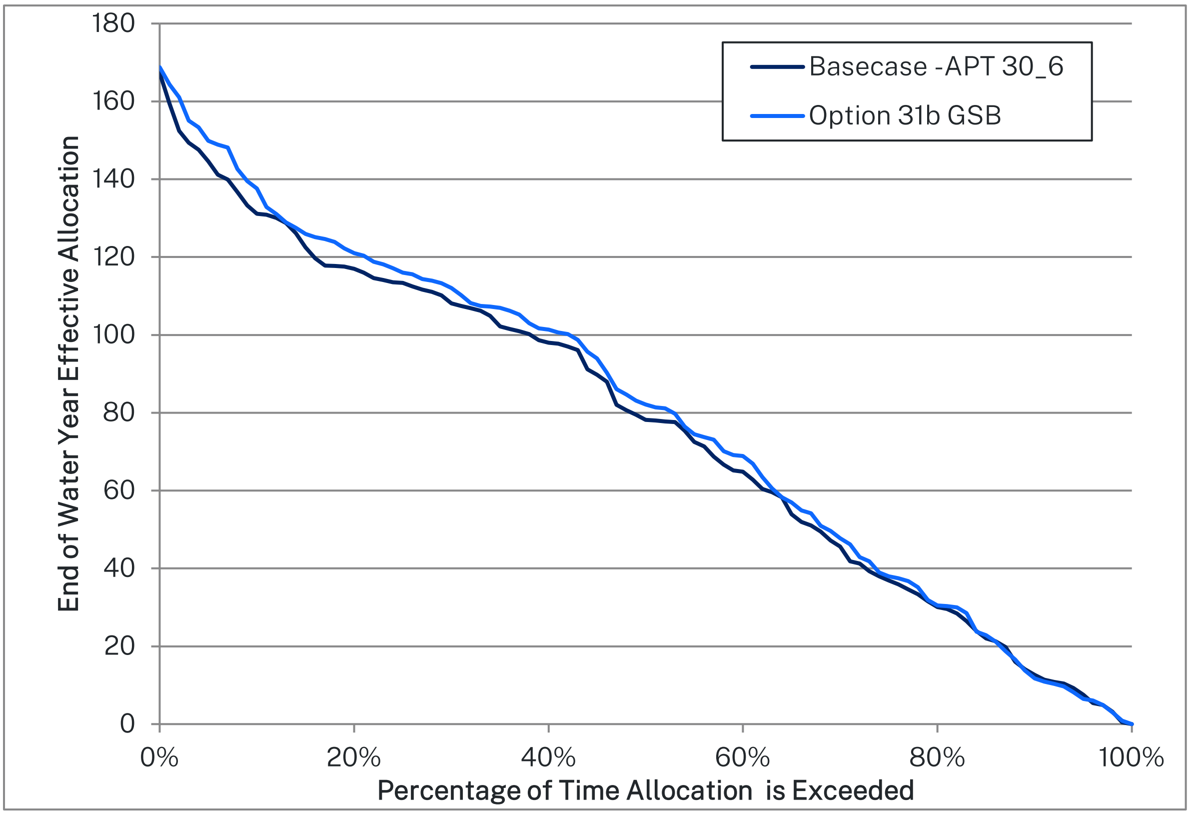
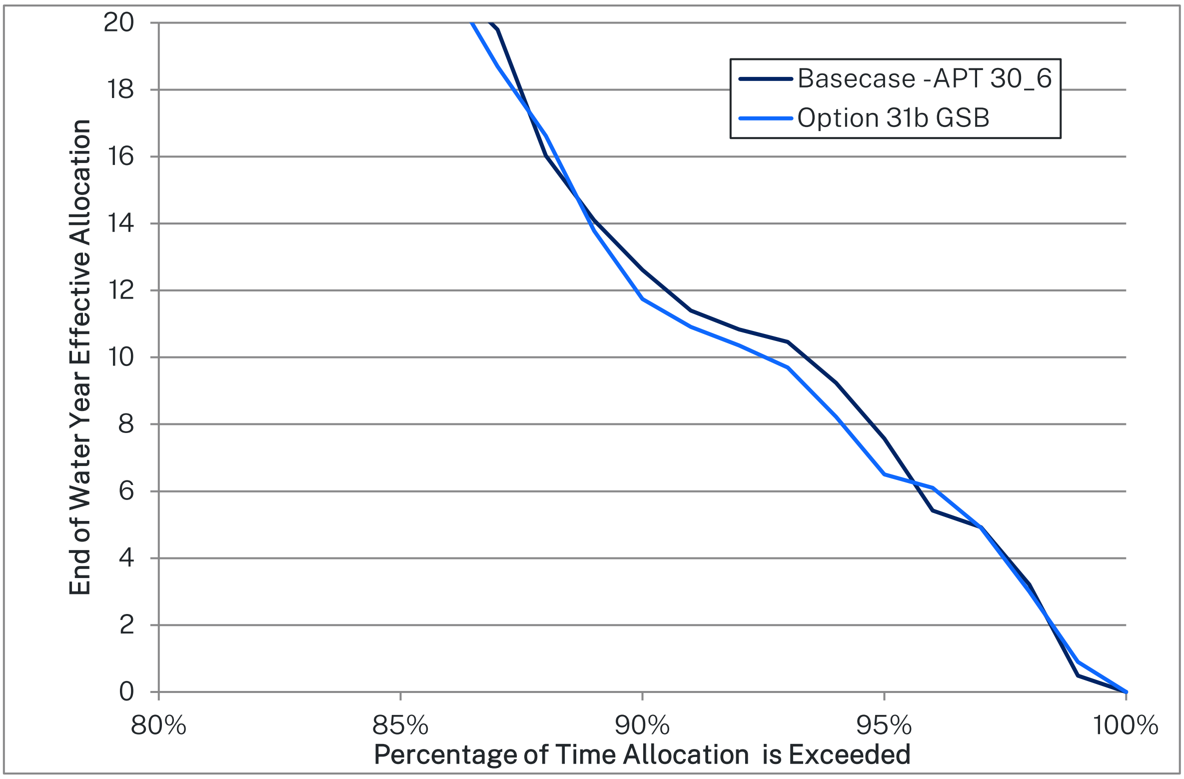


Figure 29. Use licence conversion to create 4 GL new high security licences (Option 31b) — general security B end of water year (30th June) effective allocation (lower range magnified)



Alterations in storage behaviour

Alterations in storage behaviour as a result of creating additional high security allocations and increasing the reserve are presented in Table 48, and Figure 30 to Figure 33. The results show that both Pindari Dam and Glenlyon Dam have greater stored volumes than under the base case. This increases with greater created high security volumes due to the volume of reserve being set aside increasing.

Table 48. Storage behaviour — use licence conversion to create new high security licences: 85 GL (option 31a), 4 GL (option 31b)

Storage behaviour	Base case	Option 31a	Option 31b
Percent of time that Pindari Dam storage volume is:			
At full supply level (FSL: 312.3 GL)	8.2%	20.8%	8.4%
below 50%	66.0%	5.8%	65.7%
below 10%	27.7%	0.0%	27.4%
below 5%	20.1%	0.0%	19.7%
below dead storage volume (0.5 GL)	0.7%	0.0%	0.8%
Percent of time that Glenlyon Dam storage volume is:			
At full supply level (FSL: 254.3 GL)	3.8%	7.1%	3.9%
below 50%	46.4%	0.7%	44.3%
below 10%	0.2%	0.0%	0.2%
below 5%	0.1%	0.0%	0.1%
below dead storage volume (0.2 GL)	0.0%	0.0%	0.0%
Percent of time that Coolmunda Dam storage volume is:			
At full supply level (FSL: 69.1 GL)	4.7%	4.7%	4.7%
below 50%	57.6%	57.6%	57.6%
below 10%	16.6%	16.6%	16.6%
below 0.2 GL	6.8%	6.8%	6.8%
Percent of time that total system storage volume is:			
below 500 GL	81.1%	20.8%	80.9%
below 10 GL	12.9%	5.8%	12.4%

Figure 30. Pindari Dam storage behaviour base case— use licence conversion to create 85 GL new high security licences (option 31a)

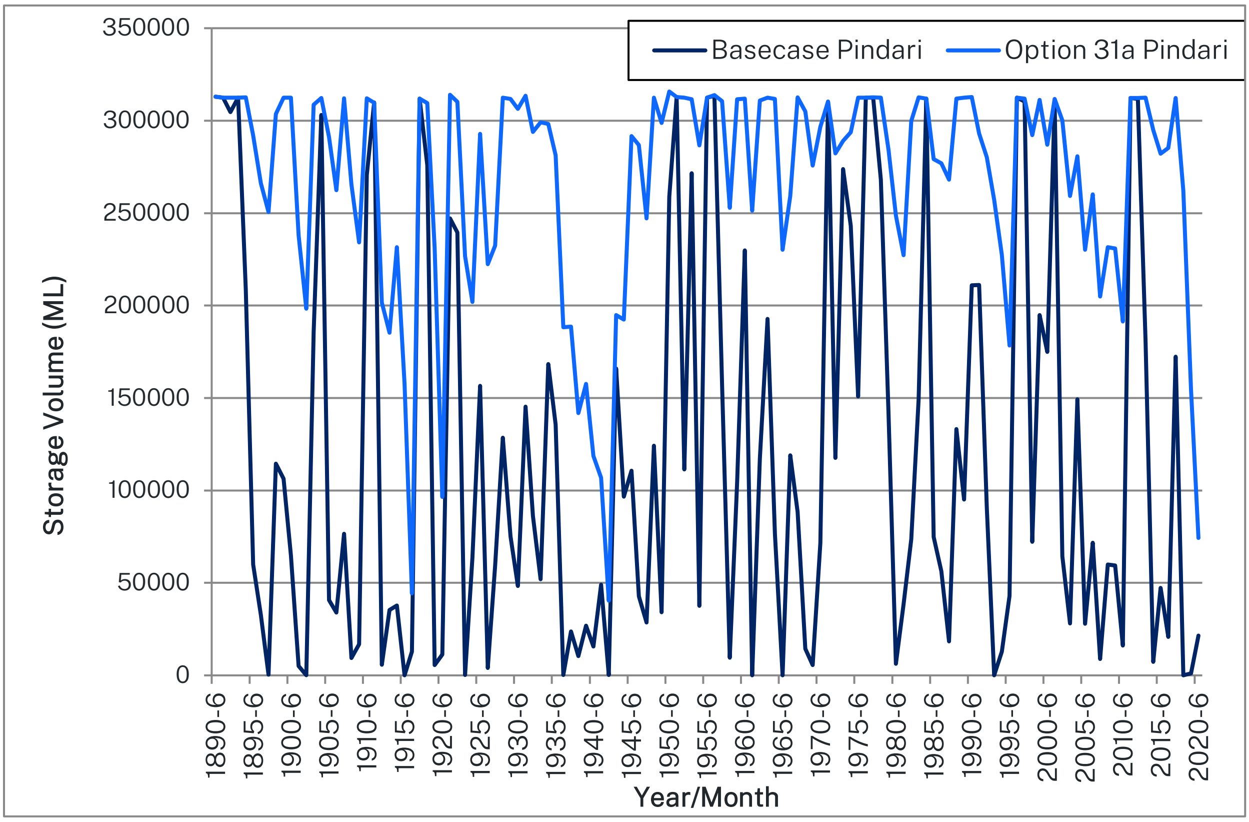


Figure 31. Glenlyon Dam storage behaviour base case— use licence conversion to create 85 GL new high security licences (option 31a)

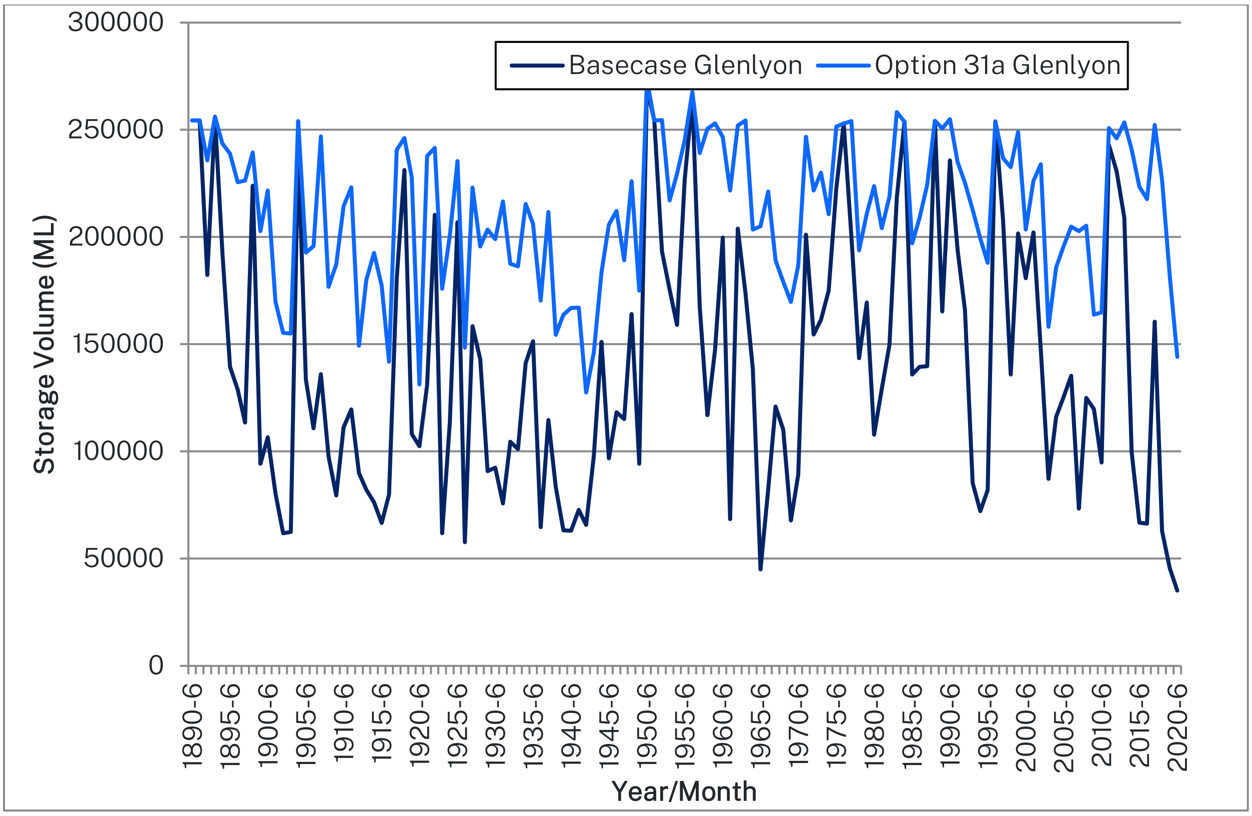


Figure 32. Pindari Dam storage behaviour base case — use licence conversion to create 4 GL new high security licences (option 31 b)

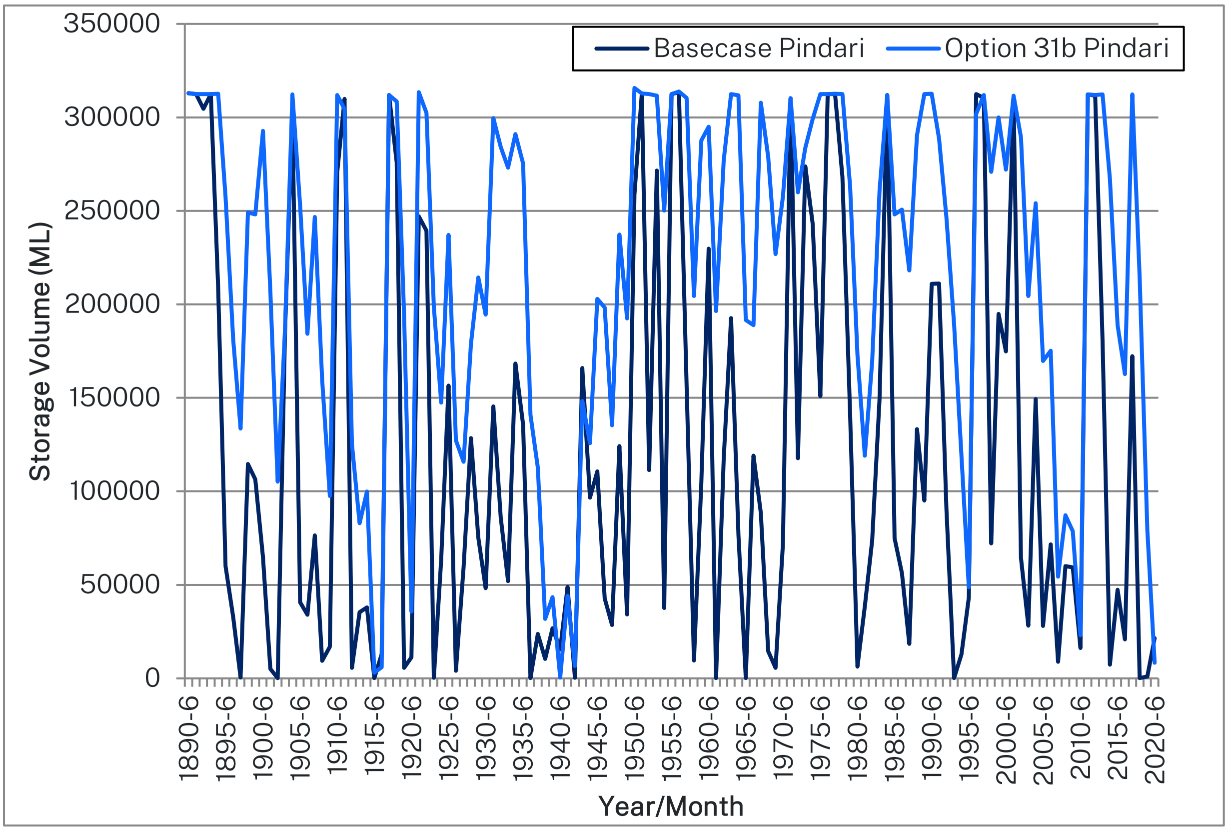
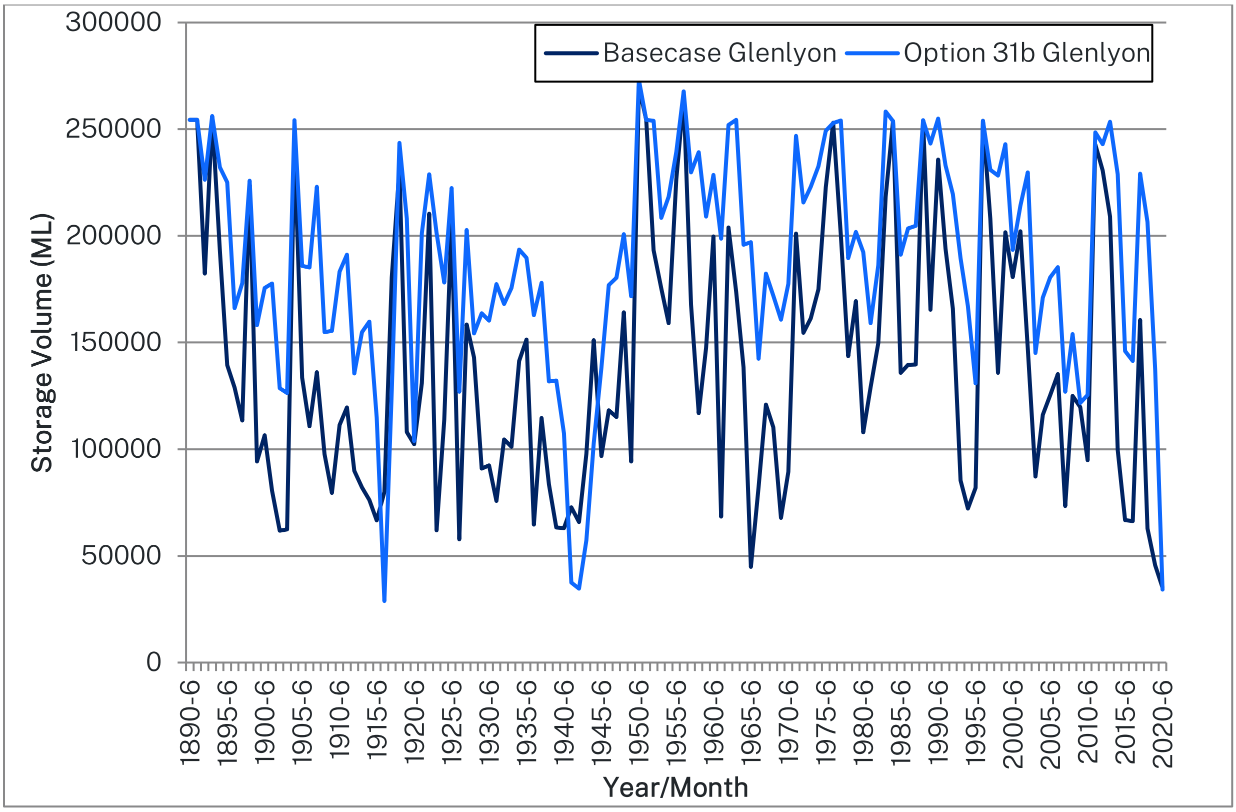


Figure 33. Glenlyon Dam storage behaviour base case — use licence conversion to create 4 GL new high security licences (option 31 b)



Alterations in river flows

End-of-system changes in the flow regime as a result of option 31a, and 31b are shown inTable 49. The results show a slight increase in end-of-system flow as a result of higher reserves and reduced general security use.

Table 49. Mean annual flow changes — use licence conversion to create new high security licences: 85 GL (option 31a), 4 GL (option 31b)

Mean annual streamflow (GL/year)	Base case		Option 31a	Option 31b
End of system	590.9		590.3	590.0

12. Combined option —

Combined option description

The combined option assessed is presented in Table 50 and combined conversion of all existing general security A and B to create new high security allocations at Boggabilla with construction of a new dam on the Mole River to create additional high security allocations.

Table 50. Combination option description

Option	Description
Combined option	Option — Mole 150 GL — All NSW — Existing entitlements no general security A or general security B and 85 GL new high security at Boggabilla and 34 GL new high security from Mole River dam. Supplementary shares reduced by 40% to maintain diversion limit. Mole River delivery loss and translucency release included.

Model assumptions

Mole River delivery losses or environmental flow releases.

Ownership

Inflows into Mole River dam and Clarence River transferred water is assumed to be owned by NSW as this represents the maximum possible contribution the new dam could provide for NSW water users.

New demands

Two additional demands have been created: one downstream of the Mole River dam, and one at Boggabilla. An adjustment to the reserve account was required to account for the creation of additional high security allocation at Boggabilla.

Constraints

Two constraints were considered when creating additional high security volumes:

1. end-of-year allocation reliability for other licensed products must not decrease below the base case
2. end-of-system flows must not decrease below the base case.

Modelling results

Alterations in NSW and Queensland licensed diversions

Combining conversion of all general security A and B licenses and creation of new high security in conjunction with a 150 GL Mole River dam results in 117 GL of high security allocations being able to be created (Table 51).

Table 51. NSW and Queensland long-term average annual diversions by licence category — combined option (150 GL Mole River Dam plus conversion of all general security A and B licences)

Annual average diversions	Base case	Combined option
NSW diversions (GL/year)		
Ashford town water supply	0.10	0.27
Boggabilla town water supply	0.20	0.20
Munginditown water supply	0.28	0.20
General security diversions	93.74	0.34
Supplementary diversions	70.49	44.78
Floodplain harvesting (excluding rainfall harvesting)	34.26	36.06
Rainfall harvesting	10.89	9.41
New high security (at Boggabilla and Mole River)		117.00
Total	**209.96**	**208.25**
Queensland diversions (GL/year)		
High priority water allocations (town water supply)	2.59	2.60
Medium priority water allocations	51.85	52.17
Off-allocation	91.96	90.24
Water harvesting	59.55	59.57
Overland flow take	17.23	18.04
Total	**223.18**	**222.62**

Alterations in NSW allocation reliability

Start- and end-of-year average allocations for newly created high security allocations and any remaining and existing products are presented in Table 52

Table 52. NSW start 1st July (1/7) and end of water year 30th June (30/6) allocation reliability by licence category — combined option (150 GL Mole River Dam plus conversion of all general security A and B licences)

NSW effective allocation (%)	Base case	Combined option
High security Mole 1/7		92.5
High security Mole 30/6		97.0
High security EA1/7	100.0	100.0
High security EA 30/6	100.0	100.0
General Security A EA 1/7	30.2	0.0
General Security A EA 30/6	93.6	0.0
General Security B EA 1/7	44.9	0.0
General Security B EA 30/6	76.8	0.0

Alterations in storage behaviour

Alterations in storage behaviour for the combined option are presented in Table 53. Creation of additional high security allocations, removal of general security and supplementary shares and increases in storage reserves means that storages are fuller more frequently than under the base case.

Table 53. Storage behaviour — combined option (150 GL Mole River Dam plus conversion of all general security A and B licences)

Storage behaviour	Base case	Combined option
Percent of time that Pindari Dam storage volume is:		
At new full supply level		
At full supply level (FSL: 312.3 GL)	8.2%	20.8%
below 50%	66.0%	6.1%
below 10%	27.7%	0.1%
below 5%	20.1%	0.0%
below dead storage volume (0.5 GL)	0.7%	0.0%
Percent of time that Glenlyon Dam storage volume is:		
At full supply level (FSL: 254.3 GL)	3.8%	7.0%
below 50%	46.4%	0.5%
below 10%	0.2%	0.0%
below 5%	0.1%	0.0%
below dead storage volume (0.2 GL)	0.0%	0.0%
Percent of time that Coolmunda Dam storage volume is:		
At full supply level (FSL: 69.1 GL)	4.7%	4.7%
below 50%	57.6%	57.6%
below 10%	16.6%	16.6%
below 0.2 GL	6.8%	6.8%

Storage behaviour	Base case	Combined option
Percent of time that Proposed Mole River dam storage volume is:		
At 100 GL or more		73.4%
below 50 GL		11.8%
below 10 GL		0.3%
below 5 GL		0.5%
below 0.2 GL		0.0%
Percent of time that total system storage volume is:		
below 500 GL	81.1%	18.1%
below 10 GL	12.9%	0.0%

Alterations in river flows

Changes in the flow regime as a result of the combination options are presented for mean annual flows in Table 54.

Table 54. Mean annual flow changes — combined option (150 GL Mole River Dam plus conversion of all general security A and B licences)

Mean annual streamflow (GL/year)	Base case	Combined option
Macintyre River at Goondiwindi (416201a): downstream flow	794.5	706.7
Gauge: 0112 M Barwon River at Mungindi (416001): downstream flow	365.3	361.1
End of system	590.9	589.8

13. Stochastic and NARCliM assessment

Description

The preferred options considered for stochastic and NARCliM modelling assessment are presented in Table 55. In total, four options have been evaluated.

Table 55. Regional water strategy portfolio options

Regional water strategy Portfolio #	Number	Portfolio Description
Base case		
Portfolio 1	Combined option	Option — Mole 150 GL — All NSW — Existing entitlements no general security A or general security B and 85 GL new high security at Boggabilla and 34 GL high security from Mole River dam. Supplementary shares reduced by 40% to maintain diversion limit. Mole Delivery Loss and translucency release included.
Portfolio 2	1b	Mole 100 GL — All NSW — 27GL new high security on Mole River (30% Delivery Loss, 30% reserve, translucency release) with growth in use (supplementary shares reduced by 60% to achieve base case diversions).
Portfolio 3	31b	General security A and general security B reduced by 100% (242.12GL) 85GL high security created at Boggabilla.
Portfolio 4	30	System reserve increase from 41.1GL to 62.2GL (two-year reserve).

Modelling results

Results are presented for three climatic periods:

- instrumental record: the past 130 years with all inflows simulated
- stochastic: 10,000 years
- NARCliM: 10,000 years.

Comparison of total diversions (highlighted in yellow in Table 56) for these three periods indicate that:

- Diversions for each portfolio over the instrumental period are greater than for over the stochastic period, indicating that the full extent of climatic variability has not been seen over the historic period.
- Diversions are reduced under a climate change scenario (modelled with NARCliM) in the range of 20–35%. This reduction is greater for options in which general security remains (for Portfolios 2 and 4) due to increased use of smaller allocations.

Performance of high security entitlements is largely unaffected over the stochastic period. However, under a climate change scenario, portfolio 3 suffers an average 12% reduction in June 30 effective allocation. This indicates that the amount of high security allocations that could be created under a changed climate is likely to be less than 85 GL.

Table 56. Regional water strategy portfolio option results (instrumental, stochastic and NARCliM climate)

		Mean Annual - WY				
Climate inputs	**Modelled output**	**Basecase**	**Portfolio 1**	**Portfolio 2**	**Portfolio 3**	**Portfolio 4**
	Supplied NSW HS (existing assets) (ML/yr)	250	354	268	349	251
	Supplied GS (ML/yr)	91,881		94,566		89,088
	Supplied NewHS Boggabilla (ML/yr)		83,981		83,533	
	Supplied HSEC (Mole) (ML/yr)		33,052	26,616		
	NSW RH_nonexempt (ML/yr)	5,196	4,945	5,360	4,807	5,217
	NSW RH_Exempt (ML/yr)	5,508	4,303	5,395	4,334	5,456
	NSW Overbank Harvesting (ML/yr)	34,638	35,873	35,987	35,565	34,631
	NSW Supplementary (ML/yr)	70,319	45,592	37,126	61,986	70,304
	Total Diversions	207,791	208,101	205,318	190,575	204,948
	NSW HS total allocation on 30the June (%)	100	100	100	99	100
	NSW GSA total allocation on 30the June (%)	93	0	92	0	93
	NSW GSB total allocation on 30the June (%)	76	0	73	0	74
Instrumental	HS Mole HS total allocation 30th June (%)		98	99		
	Supplied NSW HS (existing assets) (ML/yr)	248	354	263	341	250
	Supplied GS (ML/yr)	87,346	0	92,074	0	84,541
	Supplied NewHS Boggabilla (ML/yr)		82,650		81,863	
	Supplied HSEC (Mole) (ML/yr)		32,003	25,909		
	NSW RH_nonexempt (ML/yr)	4,004	3,922	4,120	3,801	3,999
	NSW RH_Exempt (ML/yr)	4,540	3,674	4,453	3,680	4,512
	NSW Overbank Harvesting (ML/yr)	33,127	34,257	34,382	33,754	33,161
	NSW Supplementary (ML/yr)	66,272	42,182	34,335	58,697	66,238
	Total Diversions	195,537	199,042	195,535	182,137	192,701
	NSW HS total allocation on 30the June (%)	100	100	100	98	100
	NSW GSA total allocation on 30the June (%)	87	0	85	0	86
	NSW GSB total allocation on 30the June (%)	72	0	70	0	70
Stochastic	HS Mole HS total allocation 30th June (%)		96	97		
	Supplied NSW HS (existing assets) (ML/yr)	281	337	294	306	283
	Supplied GS (ML/yr)	54,339	0	52,548	0	52,163
	Supplied NewHS Boggabilla (ML/yr)		72,565		70,414	
	Supplied HSEC (Mole) (ML/yr)		25,775	22,493		
	NSW RH_nonexempt (ML/yr)	3,242	3,220	3,312	3,148	3,239
	NSW RH_Exempt (ML/yr)	3,350	3,019	3,318	3,005	3,335
	NSW Overbank Harvesting (ML/yr)	22,804	23,020	23,773	22,746	22,820
	NSW Supplementary (ML/yr)	44,448	30,365	25,378	41,194	44,462
	Total Diversions	128,464	158,301	131,116	140,813	126,301
	NSW HS total allocation on 30the June (%)	100	99	100	86	100
	NSW GSA total allocation on 30the June (%)	71		67	0	70
	NSW GSB total allocation on 30the June (%)	40		37	0	38
NARCliM	HS Mole HS total allocation 30th June (%)		81	88		

Appendix 1. Mole Dam storage characteristics

Table 57. Valve spillway relationship

Level (m)	Discharge (ML/D)	Level (m)	Discharge (ML/D)
471	0	482.5	487333.2
471.5	3920.832	483	521810.2
472	11152.512	483.5	556910.2
472.5	20642.688	484	592056.9
473	32034.528	484.5	628022.6
473.5	45129.312	485	665029.4
474	59812.992	485.5	703678.8
474.5	75766.752	486	743230.9
475	93050.208	486.5	781291
475.5	111640.032	487	821577.6
476	131324.544	487.5	862642.7
476.5	151662.24	488	904554.4
477	173662.272	488.5	948563.1
477.5	196817.472	489	993451.4
478	221109.696	489.5	1039211
478.5	246522.528	490	1084260
479	273043.008	490.5	1130053
479.5	300660.768	491	1176584
480	329362.848	491.5	1224534
480.5	359036.064	492	1273289
481	389632.896	493	1372755
481.5	421254.432		
482	453838.464		

Table 58. Valve discharge relationships

Level (m)	Discharge (ML/D)
0	0
430.1	0
430.2	10000
471	10000

Figure 34. Mole Dam storage characteristics