Department of Climate Change, Energy, the Environment and Water

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Gwydir Regional Water Strategy

Detailed ecological analysis

November 2022

Acknowledgement of Country

The Department of Climate Change, Energy, the Environment and Water acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Contents

Introduction

The NSW Government is developing 12 regional water strategies and 2 metropolitan strategies that bring together the best and latest climate evidence, with a wide range of tools and solutions to plan and manage each region's water needs over the next 20 to 40 years.

The draft Gwydir Regional Water Strategy, including a long list of options, was released in September 2020. A rapid assessment process was used to review the long list of options and develop a high priority short list[1], as documented in the 'Draft Regional Water Strategy. Gwydir.: Shortlisted Actions – Consultation Paper'[2] This included asking experts across NSW agencies what their initial assessment of risk or benefit for the environment was for each option[3].

Options that passed the rapid ecological and economic assessments were then examined to understand the risks and opportunities that they presented, particularly whether there was potential to affect economic and/or ecological values within the region. How these short list options were developed is discussed in Attachment 4 *Options assessment process* within the draft Gwydir Regional Water Strategy, with the complete options assessment process described in the Options Assessment Process Overview[4]. Figure 1 provides an overview of the options assessment process.

Four shortlisted options were selected for ecological analysis. As such, the ecological assessments in this report use river hydrology time series models to estimate how the various options might affect current flow conditions in the Gwydir River region, as well as future conditions under different climate change scenarios. These results are compared to expert estimates of ecological risk or benefit in the earlier rapid assessment process and then discussed.

[1] Attachment 1 of "Draft Regional Water Strategy. Gwydir.: Shortlisted Actions – Consultation Paper, June 2022" at: https://www.dpie.nsw.gov.au/__data/assets/pdf_file/0003/514092/short-list-actions.pdf

[2] https://www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/what-we-heard/gwydir-regional-water-strategy

[3] The rationale for these scores is described in this document, at Appendix A (p. 36).

[4] See www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/identifying-and-assessing

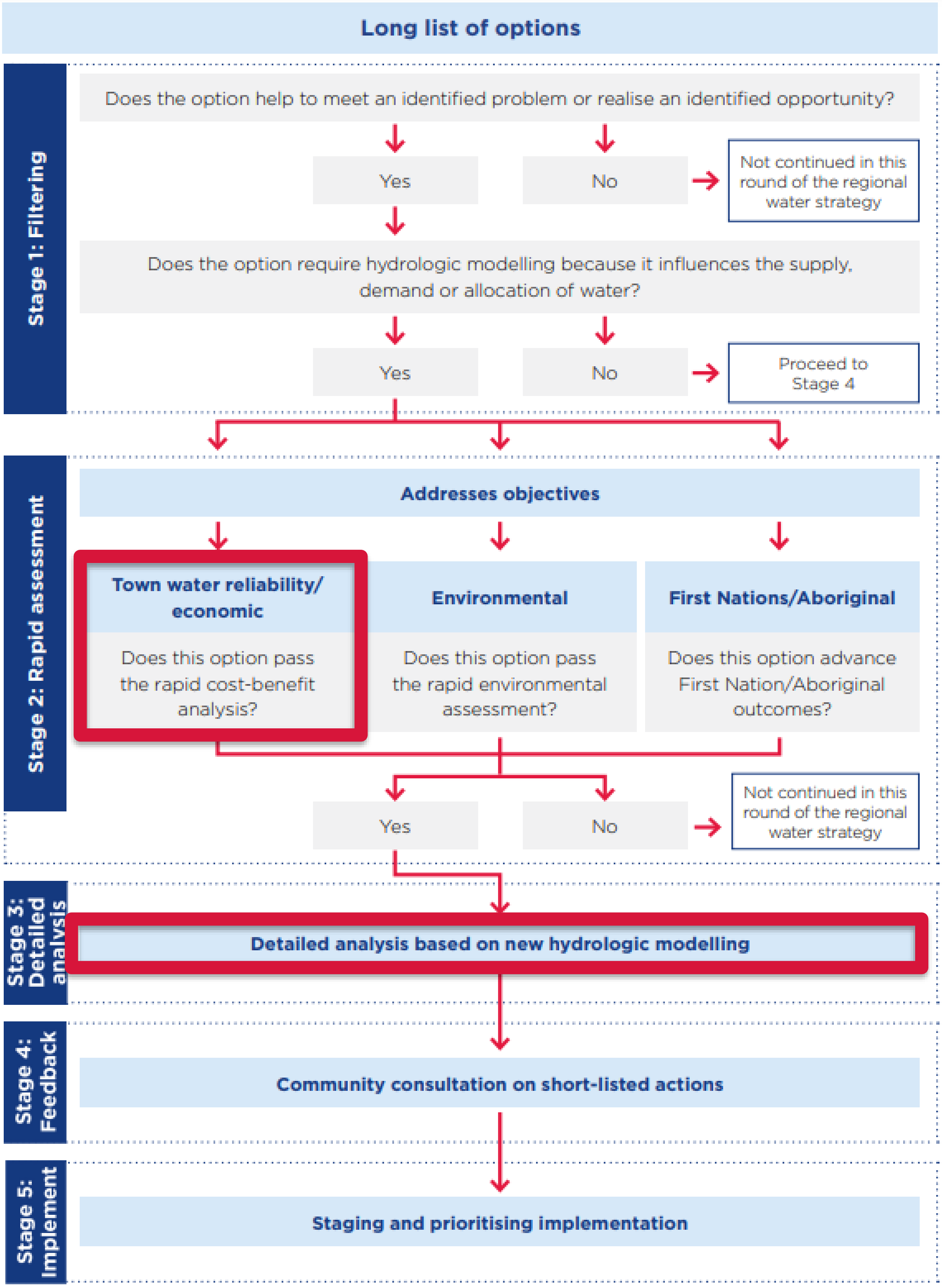

Figure 1: Options assessment process as outlined in the detailed economic assessment for the Gwydir region[5]. This document represents the environmental component of stage 3.

[5] DPE (2022). Draft Gwydir Regional Water Strategy. Detailed economic analysis. NSW Department of Planning and Environment (https://www.dpie.nsw.gov.au/__data/assets/pdf_file/0016/541042/gwydir-regional-water-strategy-economic-detailed-assessment.pdf).

Purpose of the ecological analysis

The NSW Government is developing 12 regional water strategies and 2 metropolitan water strategies that bring together the best and latest climate evidence with a wide range of tools and solutions to plan and manage each region's water needs over the next 20 to 40 years.

This ecological analysis describes the results of the hydrologic modelling for the relevant options put forward in the Draft Gwydir Regional Water Strategy. The hydrologic modelling in the Gwydir region will cover the observed historical (instrumental), long-term paleoclimate (Stochastic or long-term variability) and climate change (NARCliM) model predictions. We have 10,000 years of data in each Stochastic and NARCliM data set.

This ecological analysis is an expansion and improvement on the ecological analyses that were done for the Gwydir Regional Water Strategy consultation paper[6]. This analysis shows the effects of the options using Gwydir Long Term Water Plan[7] flow metrics. How these options potentially impact future hydrology and the some of the key ecological assets in this region are reported. The differences between baseline conditions versus models where option effects were added were used to assess likely change. Two baseline conditions were developed. One assumed the flow variation observed under long-term variability using the Stochastic models. Additional baseline conditions were developed under future climate change using the NARCliM models. The average and extreme ecological effects of these options are reported and discussed in relation to the commentary in the rapid assessments.

Options modelled were:

1. Enlarge the Tareelaroi Weir (draft Gwydir Regional Water Strategy, Option 1)
2. Increase the storage reserve in Copeton Dam (Draft Gwydir Regional Water Strategy, Option 28)
3. Bulk licence conversion (Draft Gwydir Regional Water Strategy, Option 29 a), and
4. Partial licence conversion (Draft Gwydir Regional Water Strategy, Option 29 b)

[6] DPIE (2022). Draft Regional Water Strategy. Gwydir: Shortlisted Actions – Consultation Paper. NSW Department of Planning and Environment (www.dpie.nsw.gov.au/__data/assets/pdf_file/0003/514092/short-list-actions.pdf).

[7] DPIE (2020). Gwydir Long Term Water Plan. Parts A and B. NSW Department of Planning, Industry and Environment (www.environment.nsw.gov.au/topics/water/water-for-the-environment/planning-and-reporting/long-term-water-plans/gwydir)

Key ecological values and assets

The Gwydir catchment supports a range of water-dependent ecosystems, including instream aquatic habitats, riparian forests, floodplain watercourses, woodlands and wetlands[8]. Downstream of Moree, the channels and streams of the Gwydir River form the Gwydir Wetlands, which include the Gingham and lower Gwydir watercourses, the Mehi River, Mallowa and Moomin Creeks and the extensive floodplains associated with these watercourses. The Gwydir Wetlands are a mosaic of wetland types, ranging from semipermanent marshes and waterholes to floodplain woodlands only inundated by large floods. Although highly modified by agricultural development and water management, these wetlands retain high ecological and cultural values.

The Gwydir Rivers region (Figure 2) is in northern NSW, bounded by the Border Rivers region to the north, the western slopes of the Great Dividing Range to the east, the Namoi catchment to the south and the Barwon River to the west. It covers more than 26,000 km^2 and is located within the traditional lands of the Gomeroi/Kamilaroi Nation.

[8] DPIE (2020). Gwydir Long Term Water Plan. Parts A and B. NSW Department of Planning, Industry and Environment (https://www.environment.nsw.gov.au/topics/water/water-for-the-environment/planning-and-reporting/long-term-water-plans/gwydir), and DECCW (2011). Gwydir Wetlands Adaptive Environmental Management Plan. Synthesis of information projects and actions. Department of Environment, Climate Change and Water NSW (https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Water/Water-for-the-environment/gwydir-wetlands-adaptive-environmental-management-plan-110027.pdf)

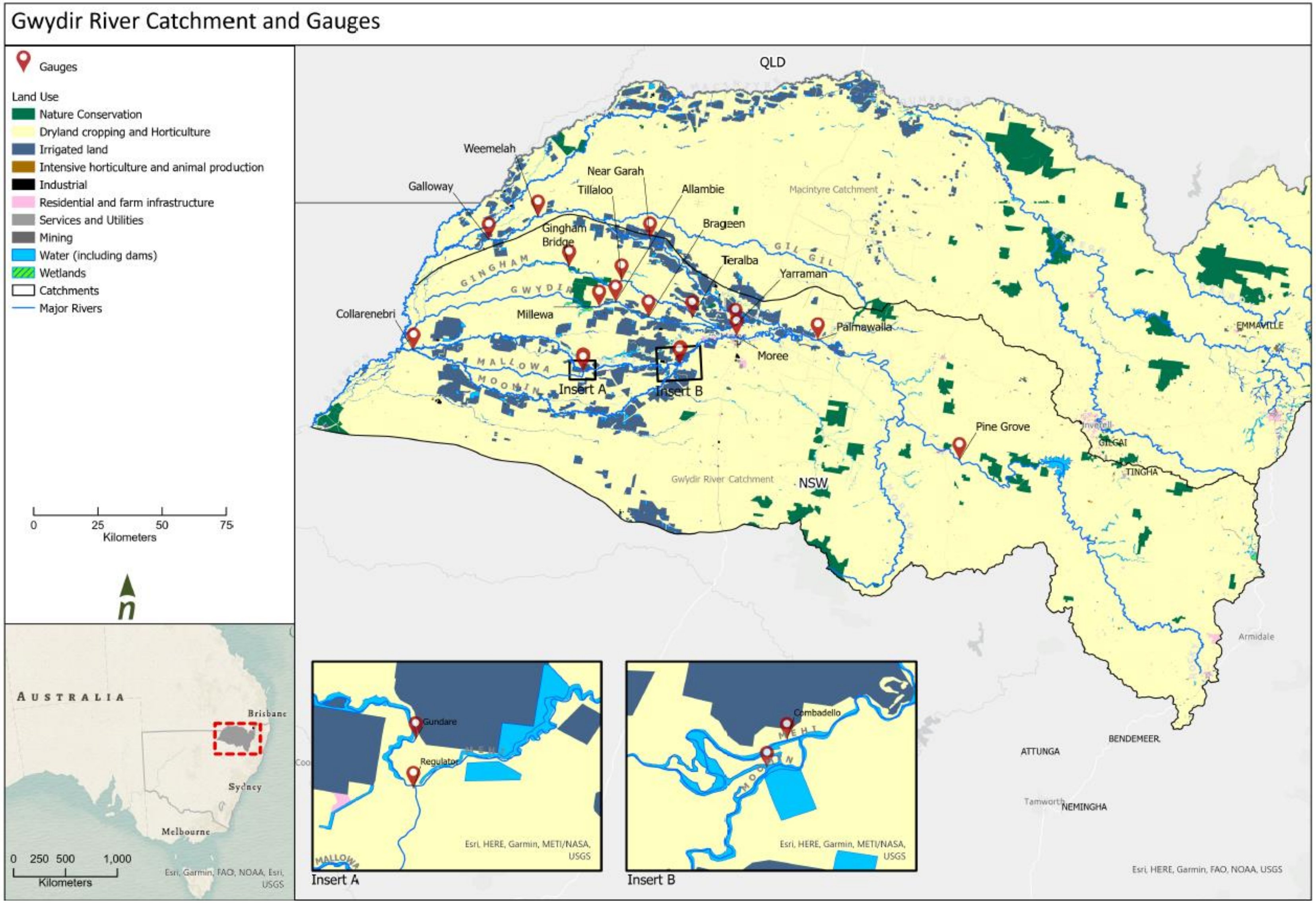

Figure 2. Map of the Gwydir region

Four wetland areas comprising 823 hectares on the lower Gwydir and Gingham watercourses are internationally recognised under the Ramsar Convention. These are 'Windella', 'Crinolyn' and 'Goddard's Lease' on the Gingham Watercourse and 'Old Dromana' on the Lower Gwydir Watercourse.

The semi-permanent core wetland areas of the Gwydir Wetlands support marsh club rush and water couch. River cooba and lignum shrublands are common in and around the margins of these wetlands. Additionally, coolibah woodlands are an important feature of the floodplain, fringing the wetlands and forming extensive woodlands on less frequently flooded floodplain areas.

The Gwydir Wetlands are a major site for waterbirds and water-dependent woodland birds. Heavy rainfall and floodwaters that reach the lower catchment can trigger colonial nesting waterbirds (including straw-necked ibis, intermediate egrets, glossy ibis and nankeen night-herons) to nest in large colonies in the wetlands. The Gwydir region, in particular the Gwydir Wetlands, has been identified as an area where restoration of waterbird habitats can contribute to the recovery of waterbird populations across the Murray-Darling Basin.

The native fish community in the Gwydir catchment consists of 15 native fish species. These include several threatened species such as the purple spotted gudgeon, silver perch, Murray cod, freshwater catfish and the Endangered olive perchlet. The Gwydir River below Copeton Dam and the Mehi River near Moree support a diverse native fish community in relatively good condition.

Any improvements or impacts resulting from the options will take effect in an already modified system, as the Gwydir is already in poor ecosystem health[9],[10]. The Gwydir Long Term Water Plan states that the most impacted flow components of the Gwydir region are cease-to-flow periods, low flows and freshes. Reductions in small freshes occur in autumn to spring and reduced large freshes and overbank flows occur are captured by Copeton Dam. Reduced periods of zero flow, increased base flows and small freshes over late spring to autumn are associated with irrigation deliveries. Larger flow events are gradually less impacted further downstream, mainly because water extraction is a small portion of the larger flows. However, the construction of Copeton Dam and associated changes in water management has impacted the natural hydrology and biodiversity of the wetlands at end of this system[11]. This includes a high risk of not being able to deliver the environmental flow requirements of the Gwydir and Gingham wetlands[12]. The analyses in this document focuses on these aspects of the flow regime.

[9] Davies *et al.* (2008). A report on the ecological health of rivers in the Murray-Darling Basin, 2004-2007. Murray–Darling Basin Commission (https://www.mdba.gov.au/sites/default/files/archived/mdbc-sra-reports/1-SRA_Report_1_tech_full.pdf)

[10] DPI (2018). Risk assessment for the Gwydir Surface Water Resource Plan Area (SW15). NSW Department of Industry

[11] Wilson *et al.* (2009). Managing environmental flows in an agricultural landscape: the Lower Gwydir floodplain. Final Report to the Australian Government Department of the Environment, Water, Heritage and the Arts. September 2009.

[12] DPI (2018). Risk assessment, as cited above.

Method and rationale behind the detailed ecological analysis

The flow regime is the one of the key determinants of river and floodplain wetland ecosystem health[13]. River ecosystems depend on a wide range of flow conditions to maintain the diversity of plants, animals and microorganisms over the long term. Periodically high flows support wide-scale movement of biota, provide water for vegetation along riverbanks and sustain off-river billabongs and pools (Figure 3 and Table 1). Smaller flows can stimulate breeding or dispersal, maintain healthy water quality and support population diversity.

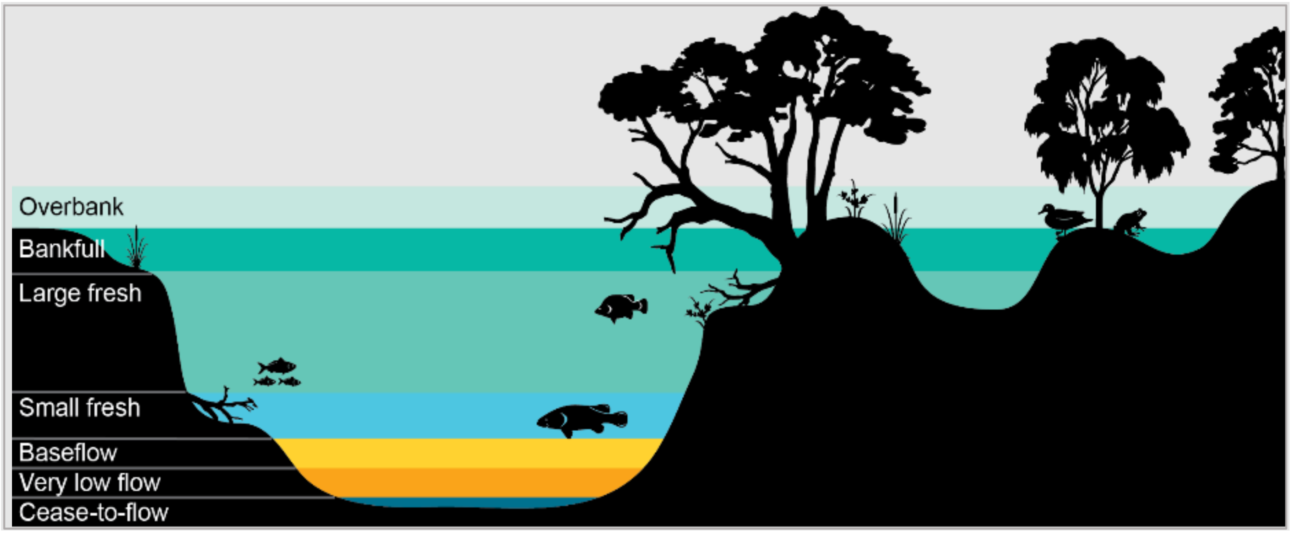

Figure 3. Conceptual model of commonly used ecological flow components

We used river hydrology models to estimate the effect that each option could have by looking at how their implementation could change commonly used ecological flow metrics, and metrics from the Gwydir Long Term Water Plan (LTWP)[14]. The LTWP metrics represent environmental flow regime requirements from no flows and low flows to high, infrequent flows. Long Term Water Plans were prepared as part of Basin Plan implementation. The ecological objectives of these plans are grouped into four themes: native fish, waterbirds, native vegetation and ecosystem function. The EWRs cover a range of flows and are determined by the specific flow or inundation needs of target plants, animals and processes. Critical flow components are described in terms of their timing, duration, frequency and maximum inter-flow or inter-event period for specific gauges within planning units.

We analysed the hydrologic time series model outputs for 40 flow gauges. These gauges provided a good representation of how flow conditions can change along the Gwydir region when the inflows from different valleys are also changed. The gauges also reflect the geographic spread within the LTWP, which breaks the catchment up into smaller planning units, each referenced to a specific gauge.

We modelled the percentage change in flow metrics between the modelled scenarios and a 'base case' model. Base case models estimate current flow conditions based on flow data, patterns of rainfall, inflows

[13] Bunn, S. E., & Arthington, A. H. (2002). Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environmental management*, 30(4), 492-507.

[14] As described in DPE (2022). Hydrologic analysis of options for the Gwydir Regional Water Strategy. Regional Water Strategies Program, Department of Planning and Environment. June 2022 (www.dpie.nsw.gov.au/__data/assets/pdf_file/0003/541659/hydrologic-analysis-of-options-for-the-gwydir-regional-water-strategy.pdf).

and water use under the current water sharing plan rules. We used the base case model as a benchmark of current conditions, and then estimated how flows would change under the different options scenarios.

The extent and direction of percentage change was then classified on an eleven-point scale from 'extreme improvement' to 'extreme impact' (Table 3). Whether a percentage change was an improvement, or an impact varied depending on the flow metric. For example, a decrease in the 'mean duration of cease-to-flow events' metric is a beneficial outcome for the environment, whereas a decrease in the 'mean duration of fresh events' metric is a detrimental outcome. Our interpretation of beneficial or detrimental change for each metric is explained in Table 2. This captures many of the potential ecological changes associated with an option, but we acknowledge that there are many that cannot be detected. For example, any increase in supply or reliability of water for agricultural use enabled within a storage can also result in further downstream use and diversion of water over time[15].

Because of the considerable detail within the Long-Term Watering Plan and the need to present a communicable level of detail some metrics were often aggregated. For example, for small freshes, the frequency for all classes of fresh from SF1 to SF3 were combined.

Some of these metrics sound like they are the same, but are not, and are based on the logic of the Long-Term Watering Plans. In particular, the ' frequency of over-extended time between events' metrics tell a complementary story to frequency metrics. This is because a frequency requirement can be met, but because flow components (such as freshes and base flows) can preferentially cluster together during specific flow sequences, there can be different flow sequences where the time between these components are too far apart.

[15] E.g., see Wilson *et al.* (2009), as already cited.

Table 1. Generic ecological flow component definitions and codes used in the Gwydir Long Term Watering Plan

Flow components (code)	Description
No flow, or cease-to-flow (CF)	Partial or total drying of the channel. Stream contracts to a series of disconnected pools. No surface flows. For a specific gauge this can sometimes be a non-zero reading as it ties back to no flow conditions at the target location.
Very Low Flows (VF)	Minimum flow in a channel that prevents a cease to flow. Provides connectivity between some pools.
Base Flows (BF)	Provides connectivity between pools and riffles and along channels. Provides sufficient depth for fish movement along reaches.
Small fresh (SF)	Improves longitudinal connectivity. Inundates lower banks, bars, snags and in-channel vegetation. Trigger for aquatic animal movement and breeding. Flushes pools. May stimulate productivity/food webs.
Large fresh (LF)	Inundates benches, snags and inundation-tolerant vegetation higher in the channel. Supports productivity and transfer of nutrients, carbon and sediment. Provides fast-flowing habitat. May connect wetlands and anabranches with low commence-to-flow thresholds.
Bankfull Flows (BK)	Inundates all in-channel habitats and connects many low-lying wetlands. Partial or full longitudinal connectivity. Drown out of most small in-channel barriers (e.g., small weirs).
Overbank flows (OB) / Wetland flows (WL)	Provide lateral connectivity with floodplain and wetlands. They support nutrient, carbon and sediment cycling between the floodplain and channel, and promote large-scale productivity. Overbank flows are used to describe flows when they are above bankfull. Wetland inundation flows are used to describe: • flows that fill wetlands via regulating structures below bankfull over weeks or sometimes months (i.e., longer than a typical fresh/pulse), or • flows that are required to inundate wetlands in areas where there are very shallow channels or no discernible channels exist (e.g., terminal wetlands).

Table 2. Ecological flow metrics derived from the Gwydir Long Term Watering Plan metrics in Table 1 that were used for comparing base case and scenario models.

Ecological flow metric	Description	Beneficial % change
No flow (CF) frequency	The number of no flow periods (or cease-to-flow periods, as defined in the LTWP) per 130 years, where the no flow (or cease-to-flow) event is defined for each planning unit in the LTWP up to a maximum duration of 60 days. The frequency of no flow events is originally calculated for the 10,000-year modelling period, but then expressed as the number of events/ 130 years (the length of the reference Instrumental period).	Decrease
No flow (CF) duration	The average duration of no flow events (days)	Decrease
Very Low flow (VF) - frequency of years not met	The number of years (per 130 years) the specified minimum number of days per year for very low flows (as defined in the LTWP) is not met.	Decrease
Base flow (BF) - frequency of years not met	The number of years (per 130 years) the specified minimum number of days per year for base flows (BF1-BF2 as defined in the LTWP) is not met.	Decrease
Bankfull (BK) flow frequency	Frequency of bankfull flows recorded that meet the criteria for minimum frequency as defined in the LTWP	Increase
Overbank flow (OB) (frequency of over-extended time between events)	The number of events (per 130 years) where the specified maximum allowable years between large fresh events (for OB1-OB5 as defined in the LTWP) is exceeded.	Increase
Wetland flow frequency (WL)	Frequency of wetland flows (WL1-WL4 combined, per 130 years) that meet the criteria for minimum frequency as defined in the LTWP	Increase
WL – Mallawa Creek (PU17)	WL, as above, for Planning Unit 17 (based on the Mallawa Creek at regulator gauge) only	Increase
WL – Central Gingham (PU9)	WL, as above, for Planning Unit 9 (based on Gingham Channel at Tillaloo) only	Increase
WL – Central Lower Gwydir (PU6)	WL, as above, for Planning Unit 6 (based on Gwydir at Allambie (418078) and Millewa (418066)) only	Increase
WL – Upper Gingham (PU8)	WL, as above, for Planning Unit 8 (based on 418074 Gingham Channel at Teralba) only	Increase

Ecological flow metric	Description	Beneficial % change
WL – Lower Gingham (PU10)	WL, as above, for Planning Unit 10 (based on 418079 Gingham at Gingham Bridge) only	Increase
Small Fresh (CF) (frequency of over-extended time between events)	The number of events (per 130 years) where the specified maximum allowable years between small fresh events (for SF1-SF3 as defined in the LTWP) is exceeded.	Decrease
Large fresh (LF) (frequency of over-extended time between events)	The number of events (per 130 years) where the specified maximum allowable years between large fresh events (for LF1-LF6 as defined in the LTWP) is exceeded.	Decrease
Freshes frequency (FF)	Frequency of fresh flows (all small and large fresh metrics combined, per 130 years) recorded that meet the criteria for minimum frequency as defined in the LTWP	Increase
FF – Lower Gwydir (PU4)	Freshes frequency, as above, for Planning Unit 4 (based on 418063 Gwydir River ds Tyreel offtake) only	Increase
FF – Lower Mehi (PU14)	Freshes frequency, as above, for Planning Unit 14 (based on 418085 Mehi DS Gundare) only	Increase
FF – Upper Gingham (PU8)	Freshes frequency, as above, for Planning Unit 8 (based on 418074 Gingham Ch at Teralba) only	Increase

Table 3 Categories that were used to classify potential improvements or impacts that could occur under shortlisted options and commitments.

Stage 1 category	Stage 2 category	Estimated percentage change in hydrology/ecology
Major/extreme impact	Extreme impact	More than 30% change in a detrimental direction
	Major impact	More than 20% change in a detrimental direction
Minor/moderate impact	Moderate impact	More than 10% change in a detrimental direction
	Minor impact	More than 3% change in detrimental direction
No/little change	Little impact	Less than 3% change in a detrimental direction
	No change	0%, rounded to the nearest whole percentage point
	Little improvement	Less than 3% change in a beneficial direction
Minor/moderate improvement	Minor improvement	More than 3% change in a beneficial direction
	Moderate improvement	More than 10% change in a beneficial direction
Major/extreme improvement	Major improvement	More than 20% change in a beneficial direction
	Extreme improvement	More than 30% change in a beneficial direction

Climate models used in the ecological analysis

In addition to the Long-Term Watering Plan metrics, this assessment uses enhancements to river hydrology models that enable us to assess option effects under past and future flow regimes. We have used two different modelling approaches to develop the flow regimes. These two modelling approaches improves our confidence that we are considering a more accurate range of possible past and future flow scenarios in the assessment. The two approaches were Stochastic flow modelling and NSW and ACT Regional Climate Modelling (NARCliM) models.

Long-term historic climate projections (Stochastic data) assume that our future climate is like what the science is indicating our long-term paleoclimate was like and are based on a 10,000-year dataset. Stochastic modelling is based on an extended historical climate record that has integrated weather data, data from tree rings, ice cores, cave deposits and coral growth. The modelling has then enabled the generation of a dataset covering up to 10,000 years, which enables us to describe patterns of natural variability and extremes (drought and flood) in our regions since the last major global climate shift with more certainty than was previously possible.

Dry climate change scenario (NARCliM modelling) assumes that there is a dry, worst-case climate change scenario in the future and is also based on a 10,000-year dataset. NARCliM uses results from four broad scale Global Climate Models (GCMs) and combines these with information on local topography and coastal processes to develop finer resolution Regional Climate Models (RCM). The regional models provide forecasts on a range of climate characteristics including temperature, rainfall and soil moisture for areas of

100 km^2. The NARCliM project is a NSW Government led partnership that now includes the ACT and South Australian Governments and the Climate Change Research Centre at the University of NSW.

Ecological analyses

Option 1: Enlargement of Tareelaroi Weir

Option description

Tareelaroi Weir and the Mehi Regulator are located along the Gwydir River. The structures act as regulating water storages that assist with water diversions to the Mehi River system.

This option includes enlargement of Tareelaroi Weir and modifications to the adjoining Mehi Regulator to form an increased mid-system water storage. By raising the full supply level from 219.3 m AHD to 222 m AHD (a 2.7 m rise), an estimated 4 GL increase in storage volume can be achieved. The current weir pool at full supply level has a volume of approximately 2.5 GL, thus resulting in a total storage post raising of 6.5 GL. This new full supply level governs the height of the proposed weir and regulator, which will both need to be reconstructed with increased height to accommodate the higher full supply level.

There were two different versions of the hydrological representation of this option. This analysis uses the growth-in-use scenario where Tareelaroi Weir is enlarged, and where diversions are maintained at base case by reducing supplementary shares by 10%[16]. In both versions of the model the weir enlargement was conceptualised as an off-river storage. It was assumed that only flows above 3 T (tributary) and 50:50 sharing of supplementary requirements are available for capture, and that water orders up to the volume held in the re-regulating storage are assumed to be delivered from the re-regulating storage, and that remaining orders are met from Copeton Dam.

Summary of results

- Minor to moderate environmental impacts are predicted under this scenario, such as on freshes in the Mehi River, which experiences no effect to a moderate impact, depending on the specific fresh flow requirement as required under the Long Term Watering Plan.
- Many fresh flow targets were protected under these scenarios, including a general improvement in freshes for the Gwydir River at Tyreel under both climate scenarios.
- Wetland flows were generally unaffected. There would be some minor to moderate loss of wetland flows in the Mallowa wetlands across the two scenarios.
- Cease-to-flow events could occur more frequently, especially under the long-term variability scenario, and for longer in some locations.

[16] DPE (2022). Hydrologic analysis of options for the Gwydir Regional Water Strategy, as previously cited.

- Seasonal flow and flow frequency plots, and comparison with the full conversion of General to High Security option results indicates this option is trending towards a more managed flow regime (Appendices B and C).

Interpretation of results, and comparison with the rapid assessment

The agency hydrological predictions of this option's effect was an overall major-to-extreme impact which included (paraphrased from Table 8, Appendix A) ceased or much reduced flows upstream of the weir for tens of kilometres upstream, reduced overall flow variability, and a dampening of high flows. The overall results do not suggest an overall major impact, but some of the local effects are consistent with the predictions. There were also some modelled improvements in low flows and some wetland flows. The general prediction for more cease-to-flow periods is realised in the long-term variability (Stochastic) model output, but the effects on cease to flow varied from a moderate improvement to major impact depending on the location. These effects are on average less under the climate change (NARCliM) scenario, but the range of effects is similar.

The other effect that was partly predicted was impact on high flows. Not overbank flows, but on specific fresh and wetland flows. This was focused on fresh frequency in the Lower Mehi (PU14) planning unit that showed a 5 (12 to -2) or 6 (14 to -2) % reduction in flow frequency for long-term variability and climate change scenarios respectively. There was a mixed story for Mallowa Creek wetlands that showed greater impacts under the long-term variability scenario. That is, an 8 (19 to -0.2) or -0.6 (10 to -16) % reduction in flow frequency for long-term variability and climate change scenarios respectively.

This analysis did not look at variability specifically, but with a reduction in fresh and wetland flows some loss of flow variability (e.g., across affected months and locations) might be expected.

The improvements in flows were generally only minor. These occurred for cease to flows under the climate change scenario which could be attributed to more managed flows from the enlarged dam. The time between fresh events did improve on average under the climate change scenario, but for both long-term variability and climate scenarios these effects varied from a major or extreme improvement to extreme impacts. There was also an average minor improvement for lower Mehi freshes. It might be that the dam modification allows for preservation of small freshes, and especially in the lower Mehi. The fresh metrics used in these analyses specified the seasonal requirements outlined in the Long-Term Watering Plan, which increases the chance that some of these changes are beneficial.

This option shows some weak similarities to the full conversion of general security to high security option results, and so it is trending towards a similar, more managed flow regime (Appendices B and C). Flows from July to January at the lowland site of Allambie are generally higher than the base case under the Stochastic scenario, and there is also a slight trend for all lower flows (about 100 ML/d and less) to be less common under both climate scenarios at Collarenebri.

Table 4. Modelled ecological change (average (minimum to maximum)) under Option 1: Enlargement of Tareelaroi Weir*

Metric	Stochastic	NARCliM
	Average (Min-Max)	
No flow (CF) duration	no effect (major improvement - moderate impact)	minor improvement (extreme improvement - moderate impact)
No flow (CF) frequency	minor impact (moderate improvement - extreme impact)	no effect (moderate improvement - extreme impact)
Very Low flow (VF) - frequency of years not met	no effect (minor improvement - minor impact)	no effect (minor improvement - minor impact)
Base flow (BF) - frequency of years not met	no effect (minor improvement - moderate impact)	no effect (minor improvement - moderate impact)
Small Fresh (SF) - frequency of over-extended time between events	no effect (major improvement - extreme impact)	minor improvement (extreme improvement - extreme impact)
Large fresh (LF) - frequency of over-extended time between events	no effect (minor improvement - major impact)	no effect (major improvement - major impact)
Bankfull (BK) flow frequency	no effect (minor impact - no effect)	no effect (minor impact - no effect)
Overbank flow (OB) - frequency of over-extended time between events	No effect	No effect
Wetland flow frequency (WL)	no effect (moderate impact - no effect	no effect (minor impact - no effect
WL – Mallowa Creek (PU17)	minor impact (moderate impact - no effect	no effect (minor impact - moderate improvement
WL – Central Gingham (PU9)	No effect	No effect
WL – Central Lower Gwydir (PU6)	No effect	no effect (no effect - minor improvement)
WL – Upper Gingham (PU8)	No effect	No effect
WL – Lower Gingham (PU10)	No effect	No effect
Freshes frequency (FF)	no effect (moderate impact - moderate improvement)	no effect (moderate impact - major improvement)
FF – Lower Gwydir (PU4)	minor improvement (no effect - moderate improvement)	minor improvement (no effect - major improvement)
FF – Lower Mehi (PU14)	minor impact (moderate impact - no effect)	minor impact (moderate impact - no effect)
FF – Upper Gingham (PU8)	no effect (no effect - minor improvement)	no effect (no effect - minor improvement)

*Notes: (i) The ecological effect is calculated as the percentage change against the base case for long term variability (Stochastic) and future climate change (NARCliM) scenarios; (ii) All results are from averaged effects over time for each site, so the ranges represent the range of time-averaged values across sites, not the entire variability represented over time at the site or regional level and (iii) The changes within little impact to little improvement correspond to changes at or less than 3% and are not considered significant. Changes greater than 3 up to 10, 10 to 20, 20 to 30, and greater than 30% are categorised as minor, moderate, major and extreme respectively.

Option 28: Increase the storage reserve in Copeton Dam

Option description

Involves increasing the Gwydir storage reserve by one year, bringing the entire reserve to three years' worth of water. The 111 GL reserve set aside in the Gwydir model covers two years of water for essential supplies. The assessed option would see an extra year of reserve (55.5 GL) added and then the changes to water security would be evaluated. The result is a trade-off between higher security for towns and communities and less water available for agriculture.

Summary of results

- On average, no impacts to minor impact was observed across the region for each environmental flow type, but there considerable variation in impact or improvement varied across sites.
- Some locations had more cease-to-flow events. The general (average) effect was a minor impact under both climate scenarios, but with extreme impacts at some sites. For example, the Mehi River at Collarenebri (site 418055) had 33% more cease-to-flow events.
- Wetlands were generally unaffected, but there were minor impacts to minor improvements to meeting the flow requirements at the Mallowa Creek wetlands, which averaged out to no effect.

Interpretation of results, and comparison with the rapid assessment

This option's effect falls under the category 'New drought operational rules (Gwydir River region) '(original option 27, Table 8, Appendix A). In "Draft Regional Water Strategy. Gwydir: Long list of options" document this option describes a need to "Improve water delivery and maintain effective reserves for high priority needs (regional towns, stock and domestic users and high-security entitlement holders) during extreme events"[17]. The ecological concern among the agency experts for this was that it would have a major to extreme impact and "has the potential to have detrimental consequences of aquatic species in parts of the system that are essentially cut off during dry periods."

The overall ecological effects in these results do not suggest a major impact (as defined in

[17] Page 39 in DPIE (2020). Draft Regional Water Strategy. Gwydir: Long list of options. September 2020. NSW Department of Planning, Industry and Environment.

Table 3) in every category. However, the hydrological prediction that would arise from this would be that greater impacts associated with no flow and low flow metrics, and this is generally supported by the results. That is, the strongest pattern is on-average minor effects associated with low flows. This includes proportional increases in the frequency of no flow periods and more instances where the required minimum time between very low and small fresh events is exceeded.

While these effects are on average minor, extreme effects are recorded for at least one site for very low flow and small fresh inter-event failures and no flow frequency. These extreme effects, however, can often come off a small base. For example, the site Mehi at Collarenebri (418055) shows a 33% increase from 3.9 to 5.3 cease-to-flow events every 100 years under the Stochastic scenario. When assessing these results, however, it should be noted that each site value is based on averaged effects over time. So, it is highly likely there would be specific flow sequences at Mehi at Collarenebri where the cease-to-flow frequency is much higher than 33% above the base case model, especially during drought-dominated periods. It should also be noted that the risks associated with the ability to deliver high flows (1.5 to 5 years average recurrence interval) flows for environmental needs into the Mehi at Collarenebri planning unit are already considered high under the Surface Water Risk Assessment[18].

[18] DPI (2018). Risk assessment for the Gwydir Surface Water Resource Plan Area (SW15). NSW Department of Industry.

Table 5. Modelled ecological change (average (minimum to maximum)) under Option 28: Increase the storage reserve in Copeton Dam*

Metric	Stochastic	NARCliM
	Average (Min-Max)	
No flow (CF) duration	no effect (major improvement - major impact)	minor improvement (major improvement - major impact)
No flow (CF) frequency	minor impact (moderate improvement - extreme impact)	minor impact (no effect - extreme impact)
Very Low flow (VF) - frequency of years not met	minor impact (no effect - minor impact)	minor impact (no effect - minor impact)
Base flow (BF) - frequency of years not met	no effect (no effect - minor impact)	no effect (no effect - minor impact)
Small Fresh (SF) - frequency of over-extended time between events	minor impact (no effect - extreme impact)	minor impact (minor improvement - extreme impact)
Large fresh (LF) - frequency of over-extended time between events	no effect (no effect - minor impact)	no effect (no effect - minor impact)
Bankfull (BK) flow frequency	No effect	No effect
Overbank flow (OB) - frequency of over-extended time between events	No effect	No effect
Wetland flow frequency (WL)	no effect (no effect - minor improvement)	no effect (minor impact - no effect
WL – Mallowa Creek (PU17)	no effect (minor impact - minor improvement)	no effect (minor impact - minor improvement)
WL – Central Gingham (PU9)	No effect	No effect
WL – Central Lower Gwydir (PU6)	No effect	No effect
WL – Upper Gingham (PU8)	No effect	No effect
WL – Lower Gingham (PU10)	No effect	No effect
Freshes frequency (FF)	No effect	No effect
FF – Lower Gwydir (PU4)	No effect	No effect
FF – Lower Mehi (PU14)	No effect	No effect
FF – Upper Gingham (PU8)	No effect	No effect

*Notes: (i) The ecological effect is calculated as the percentage change against the base case for long term variability (Stochastic) and future climate change (NARCliM) scenarios; (ii) All results are from averaged effects over time for each site, so the ranges represent the range of time-averaged values across sites, not the entire variability represented over time at the site or regional level, and (iii) The changes within little impact to little improvement correspond to changes at or less than 3% and are not considered significant. Changes greater than 3 up to 10, 10 to 20, 20 to 30, and greater than 30% are categorised as minor, moderate, major and extreme respectively.

Option 29a. Bulk licence conversion

Option description

This is implemented by retaining water in dams for future years (called the reserve) for the high security licences, rather than allocating that water for immediate use. General security licences do not have a reserve set aside, meaning that in droughts they typically receive no or a very low part of their entitlement. High security licences have enough water reserved so they would receive their full allocation even through a repeat of the worst droughts present in the historic climate data records.

The impact of converting general security licences to high security licences is that there is more water in the dams for longer, and less need for drought operation measures. This can have social benefits as dams and rivers are often used for recreation and social purposes.

This option could also allow environmental water holders to convert some of their general security holdings to high security to change their portfolio mix and improve the protection of water for the environment that is retained for critical environmental needs during times of shortage. While the NSW and Commonwealth environmental water holder's use carryover to help meet a range of environmental demands across multiple years in the Gwydir region, there have been times when they could not order water because there was not enough system water to deliver it to critical assets or ecosystems.

Under bulk conversion, prior (non-ecological) modelling indicates that all current general security licences (408GL) would be converted to high security licences (179GL) within the region. These new high security licences are estimated to be 98% reliable. With all general security licences converted, Copeton Dam would be always maintained at or above 25% full under the historic climate, 95% of the time under the longer-term climate and 78% of the time under a dry climate.

Summary of results

- This scenario had the greatest number of impacts, more extreme impacts and especially on cease-to-flow events, base flows and very low flows for the four scenarios modelled. For example, for the Mehi River near Collarenebri (gauge 418055), cease-to-flow events went from almost never (0.04) to rarely (1.1 events per 130 years) under the Stochastic model.
- Very low flows and base flows were usually extremely impacted. For example, Moomin Creek at Combadello went from 7 to 104 days a year when significant base flow periods (30 or more ML/day, for 150 days or more during September to March, as required under the Long-Term Watering Plan) did not occur. Similarly, Carole Creek (418011) went from 4 to 59 % years where significant very low-flow periods (20 or more ML/day, for 230 days or more a year) did not occur.
- There was an overall impact on freshes, especially small freshes, but this varied considerably across sites.
- There was no general improvement in wetland flows, and on average a minor impact under the long-term dry climate change model. In particular, the wetlands at Allambie and Millewa (within the Long-Term Water Planning unit 6) were moderately impacted.
- There was a dramatic reduction in seasonal variability presumably because of the greater impacts of irrigation demand which is not strongly evident for other options. This resulted in markedly lower flows during late spring to summer, and higher flows during the cold months, and especially in upland sections (Appendix B). There was also a dramatic change in flow frequency in the upper reaches, with mid-range flows becoming much more common and which also suggested a greater proportion of delivered flows (Appendix C). These seasonal shifts indicate a greater impact on environmental flows than the simple frequency statistics (discussed above) imply, as it means that when freshes and wetland flows are being delivered they are more likely not at times that are not beneficial.

Interpretation of results, and comparison with the rapid assessment

There was no agency consensus for this option's effect, where predictions varied from 'no/little change' to 'major / extreme impact' (Table 8, Appendix A), but concerns were raised about the potential impacts on the ability to reliably deliver environmental water. These results better support the 'major / extreme impact' prediction, with major to extreme impacts on environmental flows across most flow classes. This option also has by the most impacts out of the four options with extreme impacts for no flows through to base flows, for the ability to deliver freshes often enough and on the frequency of wetland fill, especially in the lower Gwydir planning unit. However, although the impacts on the small flow classes, from no flow to small fresh, showed on average an extreme impact, the base flow and small fresh statistics also have site-based examples that showed extreme improvement. The only metric that improved overall was the bankful flow frequency metric, which could result from the more managed flows being more often being delivered at bankful by the river operator during wetter flow sequences.

This option had by far the most impact on seasonal changes in flow, especially in upland sections, presumably because of the greater impacts of user demand. There was a dramatic reduction in seasonal variability that resulted in markedly lower flows during November to January, and higher flows from April to August in upland sections of the Gwydir catchment; as indicated by plots at Pinegrove under both climate scenarios (Appendix B). In lowland areas represented by the Allambie site there was a similar, but less strong pattern with greater flows from June to October and fewer flows during November to January under the Stochastic scenario. The NARCLiM scenario showed quite a different pattern at this site, with slightly lower flows from April to June, and also during November to January. At another lowland site Collarenebri, however, there were no strong differences in seasonal flow patterns.

Flow frequency plots also suggested greater effects of managed flows. There was also a dramatic change in flow frequency with mid-range flows becoming much more common in the upland reaches (Appendix C). In particular, at Pinegrove under future climate change the more probable (80-100%) flows shifted from 12-100 ML/day to about 10-600 ML/day, and very large flows from about 5000-8000 ML/day became far less common. By comparison in the lower reaches all medium to small flows were reduced in frequency. This was especially evident at Allambie under future climate change where all flows from about 500 ML/day are reduced in frequency.

Table 6. Modelled ecological change (average (minimum to maximum)) under Option 29a. Bulk licence conversion*

	Stochastic	NARCliM
Metric	Average (Min-Max)	
No flow (CF) duration	extreme impact (major impact - extreme impact)	extreme impact (extreme impact - extreme impact)
No flow (CF) frequency	extreme impact (no effect - extreme impact)	extreme impact (no effect - extreme impact)
Very Low flow (VF) - frequency of years not met	extreme impact (extreme impact - extreme impact)	extreme impact (extreme impact - extreme impact)
Base flow (BF) - frequency of years not met	extreme impact (extreme improvement - extreme impact)	extreme impact (extreme improvement - extreme impact)
Small Fresh (SF) - frequency of over-extended time between events	extreme impact (extreme improvement - extreme impact)	extreme impact (extreme improvement - extreme impact)
Large fresh (LF) - frequency of over-extended time between events	major impact (extreme improvement - extreme impact)	minor impact (extreme improvement - extreme impact)
Bankfull (BK) flow frequency	moderate improvement (moderate improvement - major improvement)	moderate improvement (minor improvement - major improvement)
Overbank flow (OB) - frequency of over-extended time between events	no effect (minor impact - extreme improvement)	no effect (no effect - extreme improvement)
Wetland flow frequency (WL)	no effect (moderate impact - moderate improvement	minor impact (extreme impact - moderate improvement
WL – Mallowa Creek (PU17)	minor improvement (moderate impact - extreme improvement	moderate impact (extreme impact - minor improvement
WL – Central Gingham (PU9)	no effect (moderate impact - moderate improvement	no effect (moderate impact - moderate improvement
WL – Central Lower Gwydir (PU6)	minor impact (major impact - moderate improvement)	moderate impact (major impact - minor improvement)
WL – Upper Gingham (PU8)	no effect (moderate impact - moderate improvement)	no effect (moderate impact - moderate improvement)
WL – Lower Gingham (PU10)	minor improvement (minor impact - moderate improvement)	no effect (moderate impact - minor improvement)
Freshes frequency (FF)	moderate impact (extreme impact - moderate improvement)	moderate impact (extreme impact - major improvement)
FF – Lower Gwydir (PU4)	major impact (extreme impact - no effect)	major impact (extreme impact - no effect)
FF – Lower Mehi (PU14)	moderate impact (extreme impact - no effect)	moderate impact (extreme impact - no effect)
FF – Upper Gingham (PU8)	minor improvement (minor impact - moderate improvement)	no effect (moderate impact - major improvement)

*Notes: (i) The ecological effect is calculated as the percentage change against the base case for long term variability (Stochastic) and future climate change (NARCliM) scenarios; (ii) All results are from averaged effects over time for each site, so the ranges represent the range of time-averaged values across sites, not the entire variability represented over time at the site or regional level and (iii) The changes within little impact to little improvement correspond to changes at or less than 3% and are not considered significant. Changes greater than 3 up to 10, 10 to 20, 20 to 30, and greater than 30% are categorised as minor, moderate, major and extreme respectively.

Option 29b. Partial licence conversion

Option description

Option 29b was previously listed as Option 29 in the draft Gwydir Regional Water Strategy and is a policy-related change requiring minimal capital costs.

This option is like Option 29a but would involve the partial conversion (10%) of licences, not all of the licences. Under this option, 41 GL of current general security licences would be converted to create an additional 18 GL of high security licences within the region to facilitate the growth of high-value crops that require a higher level of water reliability for establishment and ongoing production.

Summary of results

- This scenario showed extreme impacts to extreme improvements for no flow frequency, with the average effect an extreme impact. In the most extreme case, the Gingham Channel at Teralba showed a 60% increase in no flow events under long-term dry climate change.
- Otherwise, there were many moderate or minor impacts distributed across the region.
- The minor impacts included impacts on very low, base and fresh flows in the Mehi River. These changes would likely contribute to the cumulative impacts of flow regulation in the Mehi River.
- Very low flows were highly impacted. For example, the number of years the very low flow metric was not met increase by approximately 90% for the Mehi River downstream of Combadello (418037, from 3.5 to 6.6 events /130 years) under the long-term Stochastic model.

Interpretation of results, and comparison with the rapid assessment

This option falls under the same option 29 in the rapid assessment long list for which there was no agency-consensus for this option's effect, where predictions varied from 'no/little change' to 'major / extreme impact' (Table 8, Appendix A), but concerns were raised about the potential impacts on the ability to reliably deliver environmental water. Unsurprisingly this option showed less environmental impact than the full licence conversion. The main impacts were again in the no flow to base flow classes under both climate scenarios with the range of site-based effects often ranging from extreme impact often to major or extreme improvement. The most extreme impacts occurred on the ability to avoid no flow periods and the related ability to maintain very low flows. There were also some minor impacts on wetlands in Mallowa Creek and freshes in the Lower Gwydir under the climate change scenario.

Table 7. Modelled ecological change (average (minimum to maximum)) under Option 29b. Partial licence conversion*

Metric	Stochastic	NARCliM
	Average (Min-Max)	
No flow (CF) duration	moderate impact (extreme improvement - extreme impact)	minor impact (major improvement - extreme impact)
No flow (CF) frequency	extreme impact (extreme improvement - extreme impact)	extreme impact (extreme improvement - extreme impact)
Very Low flow (VF) - frequency of years not met	extreme impact (major impact - extreme impact)	extreme impact (moderate impact - extreme impact)
Base flow (BF) - frequency of years not met	minor impact (extreme improvement - extreme impact)	minor impact (major improvement - extreme impact)
Small Fresh (SF) - frequency of over-extended time between events	no effect (extreme improvement - major impact)	no effect (extreme improvement - major impact)
Large fresh (LF) - frequency of over-extended time between events	no effect (no effect - major impact)	no effect (minor improvement - major impact)
Bankfull (BK) flow frequency	No effect	No effect
Overbank flow (OB) - frequency of over-extended time between events	No effect	No effect
Wetland flow frequency (WL)	No effect	no effect (no effect - no effect
WL – Mallowa Creek (PU17)	No effect	minor impact (moderate impact - no effect)
WL – Central Gingham (PU9)	No effect	No effect
WL – Central Lower Gwydir (PU6)	No effect	No effect
WL – Upper Gingham (PU8)	No effect	No effect
WL – Lower Gingham (PU10)	No effect	No effect
Freshes frequency (FF)	no effect (minor impact - no effect)	no effect (minor impact - no effect)
FF – Lower Gwydir (PU4)	no effect (minor impact - no effect)	minor impact (minor impact - no effect)
FF – Lower Mehi (PU14)	No effect	No effect
FF – Upper Gingham (PU8)	No effect	No effect

*Notes: (i) The ecological effect is calculated as the percentage change against the base case for long term variability (Stochastic) and future climate change (NARCliM) scenarios; (ii) All results are from averaged effects over time for each site, so the ranges represent the range of time-averaged values across sites, not the entire variability represented over time at the site or regional level and (iii) The changes within little impact to little improvement correspond to changes at or less than 3% and are not considered significant. Changes greater than 3 up to 10, 10 to 20, 20 to 30, and greater than 30% are categorised as minor, moderate, major and extreme respectively.

Appendix A. Rapid ecological assessment: key agency points

The rapid environmental assessment (Table 8) involved a high-level assessment of the environmental impact or improvement of each of the options in the long list of the draft Regional Water Strategy. The assessment was based on expert opinion of scientists from Department of Planning and Environment (DPE) Water – Water Science, DPE - Environmental and Heritage Group and Department of Regional NSW – DPI Fisheries.

The environmental assessment was undertaken separately by each agency and then the assessments are combined for an overall result for each option. In developing their rankings, the scientists were asked to consider how the option might impact:

- geomorphology (bed and bank erosion and sediment transport)
- floodplain and riparian vegetation
- wetland ecology
- fish breeding, recruitment and movement
- water quality (temperature, dissolved oxygen, nutrients, refuge pool conditions) river hydraulics (availability of flowing water and other diverse habitats)
- food web impacts (eg. inputs of nutrients from overland and tributary flows, quality of water release from dams and weirs)
- availability of held environmental water and potential impacts on planned environmental water

The purpose of this was to assess whether the options that aimed to improve outcomes for the environment should proceed to the next stage. This assessment did not rule out options that were aimed at improving outcomes for towns or industries.

The ranking system the agencies were asked to apply were the stage 1 categories in Table 3.

A summary of the rapid ecological assessment outcomes can be found in the "Draft Regional Water Strategy. Gwydir.: Shortlisted Actions – Consultation Paper".[19] A summary of the commentary by the agencies which informs how they came to score the options is provided in Table 8 below.

Table 8. Rapid ecological assessment – agencies scores with key points made in their commentary against the options

[19] Attachment 1 of "Draft Regional Water Strategy. Gwydir.: Shortlisted Actions – Consultation Paper, June 2022" at: https://www.dpie.nsw.gov.au/__data/assets/pdf_file/0003/514092/short-list-actions.pdf

Draft strategy option	Combined score	Key points made in commentary
1. Enlargement of Tareelaroi Weir	Major / Extreme impact	Fish passages would need to be included. Raising the weir wall by 2.7 m will create a large weir pool that will transform the river into a still pond for many 10s kms upstream. This will trap sediment and nutrients, affecting the downstream trophic dynamics; will further alter the flow regime, reducing variability and dampening high flows. If it were to proceed operational management of the weir would need to be revised with respect to EWRs of the river and wetlands. Anticipate direct and indirect impacts on (native fish) functional groups, from Copeton downstream.
2. New Lower Gravesend Dam on the Gwydir River downstream of Warialda Creek	Major / Extreme impact	Near complete loss of natural flow variability downstream of the structure. Increased loss of small freshes downstream. Decreased flow peaks. Particular attention to dry year impacts is needed.
3. Reuse, recycling and stormwater projects	No/little change	In drought times could be relatively major positive impact.
4. Managed aquifer recharge	Minor / Moderate impact	Local and regional impacts could vary depending on scale of activity. Needs to identify any impacts to groundwater dependent ecosystems including Stygofauna. Risks may include overcharging that may cause- flooding in unintended areas, aquifer collapse, aquifers breaking into other aquifer, water quality and contamination (salt, heavy metals etc), treatment of stormwater to required standards may be cost prohibitive.
5. Reliable access to groundwater by towns	No/little change	Relies on groundwater resources not being overallocated to begin with. Imperative need to understand connectivity from groundwater to surface water for impact on river flows. Not enough info is known of connection between groundwater and surface water in the Gwydir.
6. Town water security planning and investment for Gwydir Shire	Minor / Moderate impact	Potential for varying degrees of impact. Assessment made on basis of continued groundwater extraction, impact from construction, how pipeline will be operated, and reduction of inflow to Copeton or extraction from Copeton.
7. Town water security planning and investment for Uralla Shire	Minor / Moderate impact	Potential for varying degrees of impact. Raising of Kentucky Dam wall would have local, downstream impacts on hydrology and ecology.
8. Reliable access to groundwater for the Moree Special Activation Precinct	Average at Minor / Moderate impact, but with no majority view	Moree already highly dependent on groundwater. Recommend Option 14 adopted as essential precursor to additional groundwater development.

Draft strategy option	Combined score	Key points made in commentary
9. Removal of system constraints in the Gwydir catchment to improve flows reaching the Gwydir wetlands	Major / Extreme improvement	Increased capacity to deliver larger volumes to environmental assets. Improve environmental watering of wetlands and floodplain habitats
10. NSW Fish Passage Strategy	Major / Extreme improvement	Improved connection to different habitats for native fish. Particularly valuable for golden perch moving upstream from the Barwon.
11. Ability to directly access supplementary flows	Minor / Moderate improvement	Increased ability to deliver water to priority assets. This could be especially valuable during bird breeding events.
12. Cold water pollution mitigation measures	Major / Extreme improvement	Would cause major improvement of instream conditions for fish and invertebrates. Increase window for fish spawning in area impacted by cold water pollution.
13. Diversion screens to prevent fish extraction at pump offtakes	Major / Extreme improvement	Decreased larval and juvenile fish mortality and loss of individuals from the system
14. Improved understanding of groundwater processes	No/little change	Necessary for sustainable extraction rules. Probably beneficial to mid-catchment and unregulated streams.
15. Sustainable access to groundwater by all users	Average at No / Little change, but with no majority view	Increasing sustainability of current access regime would be a good thing but increasing access to more users would further strain the limited resource and potentially impact groundwater dependent ecosystems. Probably beneficial to mid-catchment and unregulated streams.
16. Improved clarity in managing groundwater resources sustainability	Average at Minor / Moderate improvement, but with no majority view	Need clarity on how this proposal differs in intent to Option 15.
17. Active management to share flows between consumptive and other uses	Minor / Moderate improvement	Has capacity to be improved overtime. Existing policy scope could be improved by better considering HEW and PEW protection together.

Draft strategy option	Combined score	Key points made in commentary
18. Modification and/or removal of existing priority flood work structures causing adverse impacts	Major / Extreme improvement	Does depend on the structure and event.
19. River Ranger Program	No/little change	Could result in minor environmental improvement but would be dependent on how well aligned with other activities it is.
20. Investigation of water quality mitigation measures	Minor / Moderate improvement	Benefits could be greater depending on scope of works and sustained level of investment. Real time water quality loggers at key infrastructure is beneficial for operational and environmental water, but not a mitigation measure in and of itself. Would need to be integrated with LTWPs and operational management so that flushing flows or sufficient low flows can moderate water quality.
21. Secure flows for water-dependent cultural sites	No/little change	Environmental benefit likely to vary on a site-by-site basis.
22. Water efficiency projects (towns and industries)	No/little change	Degree of change depends on scale, and clarity regarding on what is done with the saved water.
23. Review of water markets in the Gwydir region	Average at Minor / Moderate impact, but with no majority view	Potential for negative and severe impacts (e.g., if trading between areas changes or water becomes cheaper, and more sleeper licences become activated). The review should be partly considered within the context of recommendations of the Final Report by the Australian Competition and Consumer Commission inquiry into MDBA water markets.
24. Connectivity with downstream systems	Major / Extreme improvement	This should avoid providing less water to the wetlands. Depending on strategy, potential to provide significant enhancement for environmental assets and support investigation of opportunities to improve System Scale Connectivity.
25. Review urban water restriction policy	No/little change	Reduced water use during dry periods would reduce impacts to both ground and surface water ecosystems. Potential improved outcomes where LWUs share the same water resources and may have positive outcomes if relieves pressure on PEW.
26. Addressing inefficient delivery system management	Major / Extreme impact	Potentially major environmental impacts. Could mean loss of surface flows and therefore support to env that has developed on the current hydrographic environment. But insufficient information to make a comprehensive assessment.

Draft strategy option	Combined score	Key points made in commentary
27. New drought operational rules (Gwydir River region)	Major / Extreme impact	This has the potential to have detrimental consequences of aquatic species in parts of the system that are essentially cut off during dry periods.
28. Review surface water accounting and allocation	Average of 'No/ little change', but with no majority view	May have positive environmental outcomes but only if priorities directed as per the *Water Management Act 2000* and include environmental water considerations.
29. Investigation of licence conversions	Average of 'Minor / Moderate impact', but with no majority view	Rules for environmental water need to be adjusted if distribution of water use is changed. Potentially very significant environmental impacts. Changes the reliability of environmental water.
30. Improved data collection and storage	No/little change	The more data the better, but much better under improved planning, coordination and funding of water quality and MER across the state. Scope of proposal needs to incorporate ecological needs, funding, governance, issues related to suitable platforms for storing data and real time data access.
31. Training and information sharing programs	No/little change	Do not believe it will result in improvements to environmental condition without changes to assessment frameworks and decision making to support application of knowledge and capacity.
32. Land use change impact on water resources	Average of 'No/ little change', but with no majority view	Not clear, potential to have adverse environmental impacts.
33. Culturally appropriate water knowledge program	No/little change	Need an account balance for aboriginal/cultural water to work with.
34. Water-dependent cultural practices and site identification	No/little change	No comments
35. Shared benefit project (environment and cultural outcomes)	Average of 'No/ little change', but with no majority view	Effective shared benefit arising requires effective consultation. Potential minor/moderate improvement if additional water is made available for cultural outcomes. Water for cultural purposes needs to be in addition to environmental water, not allocated from environmental water volumes.

Draft strategy option	Combined score	Key points made in commentary
36. Regional Cultural Water Officer employment program	No/little change	No comments
37. Regional Aboriginal Water Advisory Committee	No/little change	No comments
38. Water portfolio project for Aboriginal communities	Average of 'No/ little change', but with no majority view	Benefits to environment may be site specific and need to be balanced against impacts of developing and operating infrastructure.
39. Co-management investigation of Travelling Stock Reserves	Average of 'No/ little change', but with no majority view	Proposed environmental outcomes for river /wetland management are unclear.
40. Aboriginal cultural water access licence review	Average of 'No/ little change', but with no majority view	Cultural water is already provisioned for within WSPs and is a stand-alone entitlement, separate from environmental water. Improving Aboriginal access rights to water, allocations and management of that water requires active Aboriginal water management in each valley to support meaningful outcomes. Should be combined with Options 35 and 38.
New Option 41. Water security for discrete communities	**Insufficient information to assess**	If water is going to be provided to a location that previously didn't have water, there would need to be some assessment on the impact of where that water came from. Even if it is "new " water or an additional volume to an existing entitlement, we would need to determine the impact on existing risk assessment developed to support the WSP/WRP
New Option 42. New option: New and improved farming practices	**Insufficient information to assess**	Would need to investigate the interaction of option with existing water sharing arrangements to determine environmental implications from new practices (both direct and indirect).
New Option 43. New option: Water use efficiency for non-town-based industries	**Insufficient information to assess**	Would need to investigate the interaction of option with existing water sharing arrangements to determine environmental implications from new practices (both direct and indirect).
New Option 44. New option: Take the final steps to implement the Floodplain Harvesting Policy	Minor / Moderate improvement	There are more steps required in implementing healthy floodplains reform following licensing and works approvals, including removing unapproved works, including return flows in models, and investigating access rules. More work and ongoing MER is needed to quantify the environmental implications of FPH implementation.

Appendix B. Seasonal hydrology plots by option

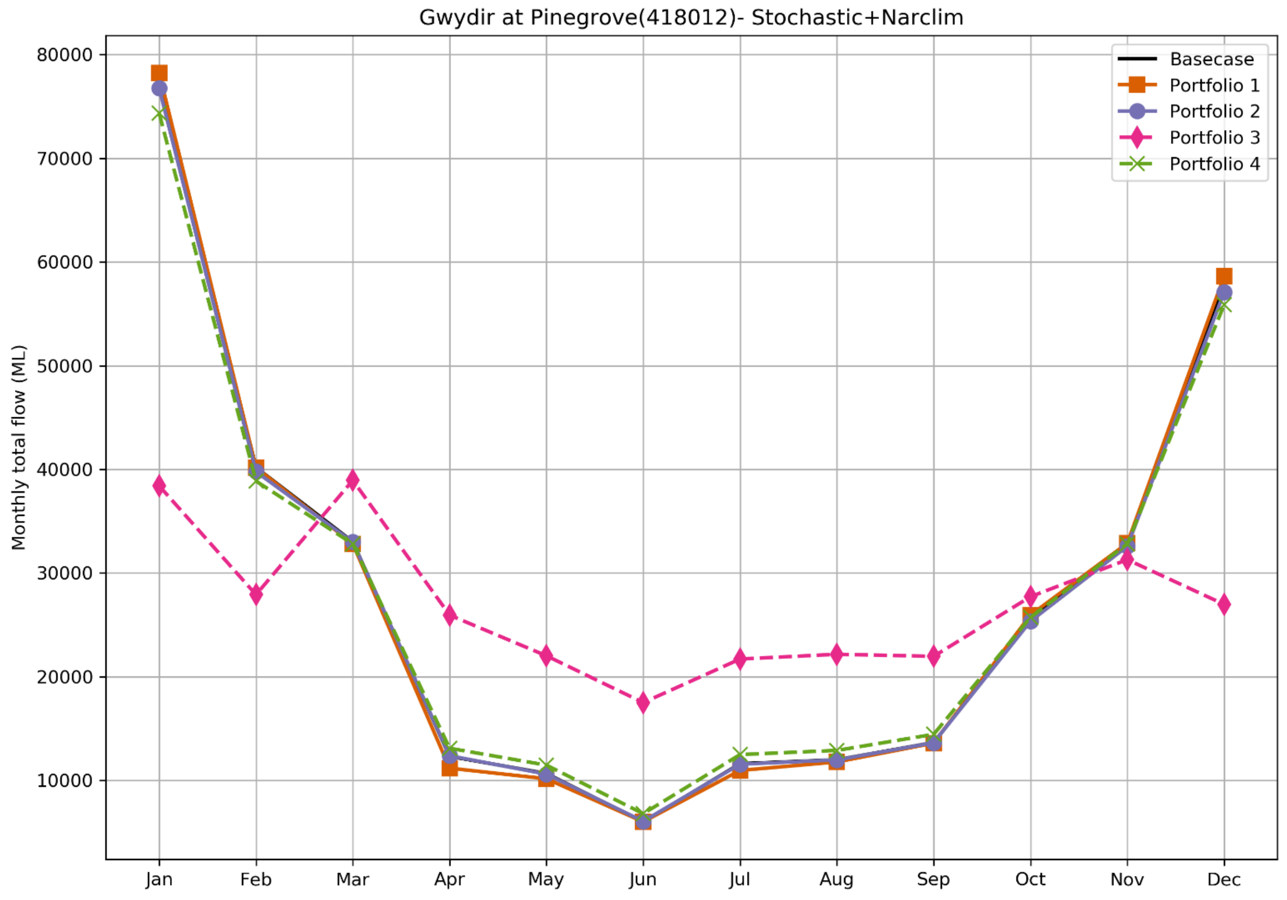

Figure 4: Seasonal difference in average discharge (ML/day) across the base case and four options (portfolios) under the NARCLiM scenario for the Gwydir River at Pinegrove (upland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.

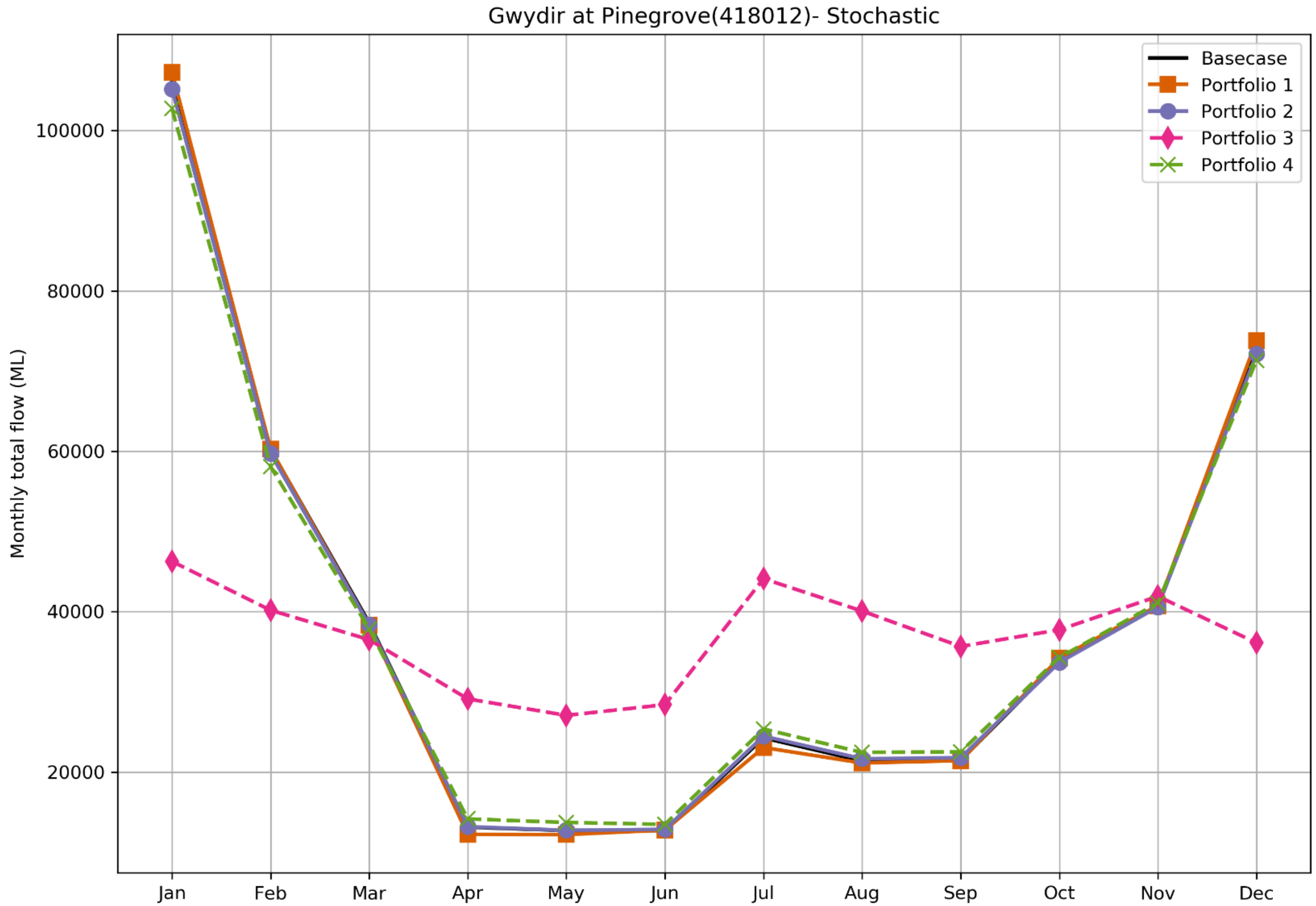

Figure 5: Seasonal difference in average discharge (ML/day) across the base case and four options (portfolios) under the Stochastic scenario for the Gwydir River at Pinegrove (upland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.

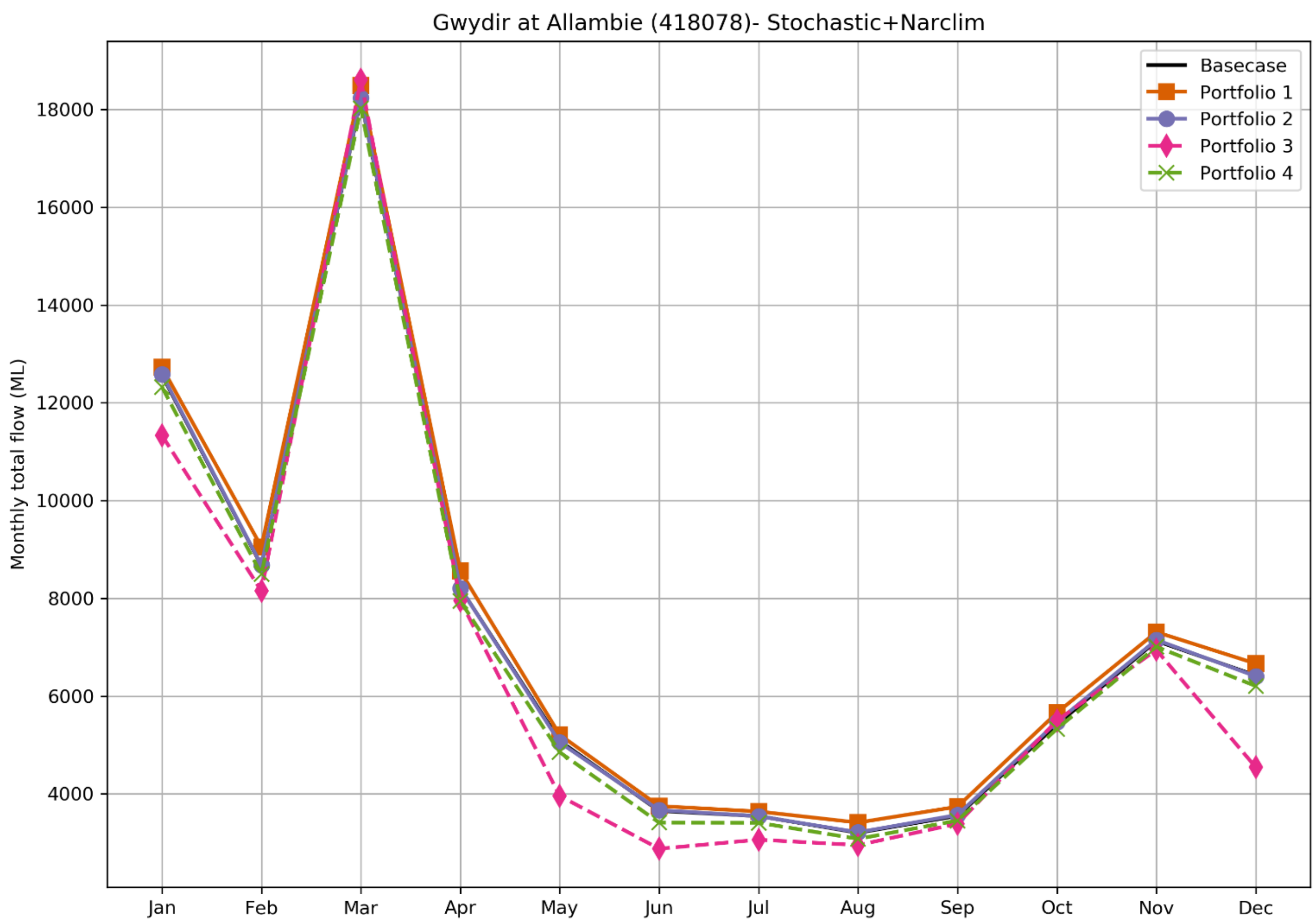

Figure 6: Seasonal difference in average discharge (ML/day) across the base case and four options (portfolios) under the NARCLiM scenario for the Gwydir River at Alambie (lowland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.

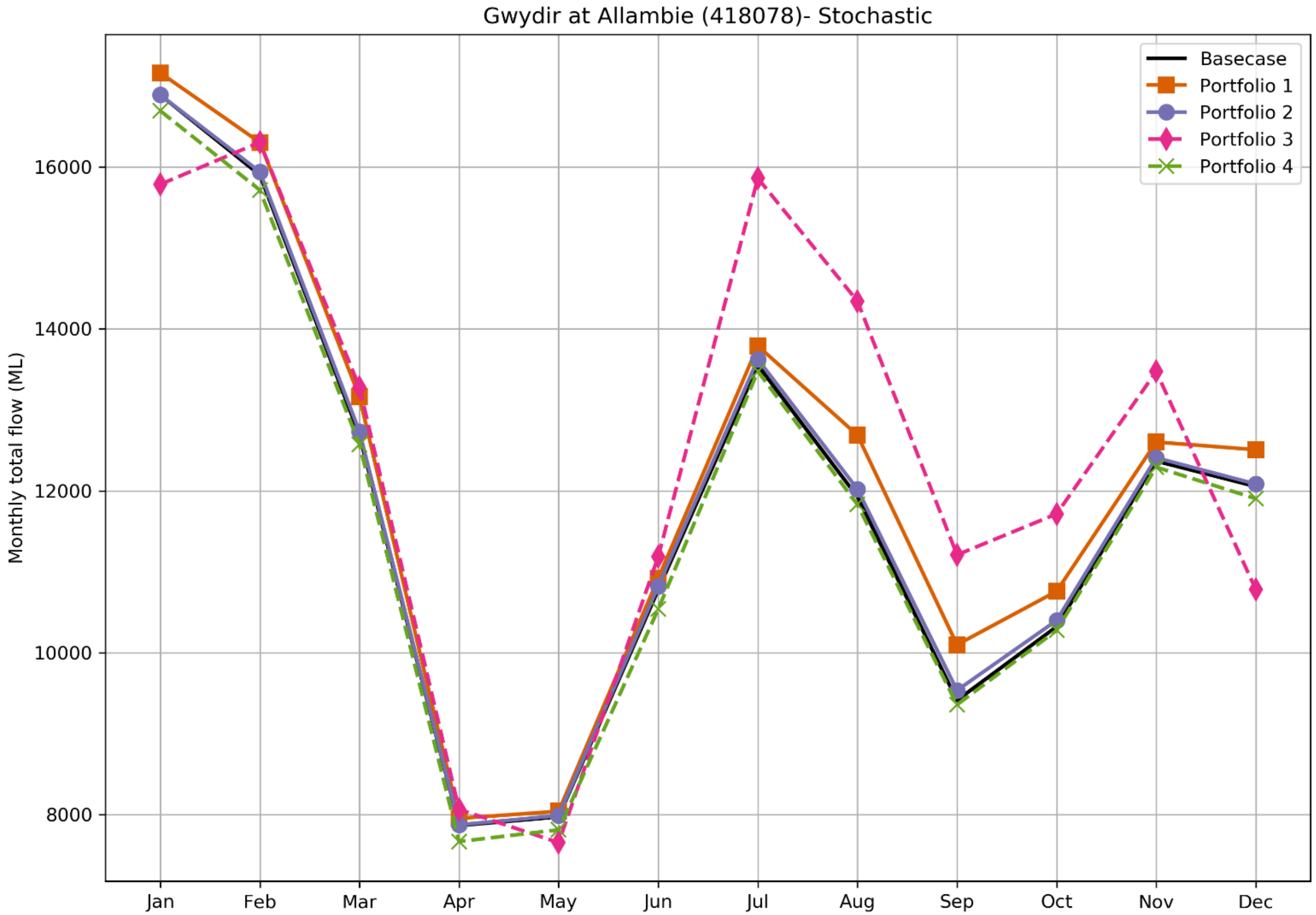

Figure 7: Seasonal difference in average discharge (ML/day) across the base case and four options (portfolios) under the Stochastic scenario for the Gwydir River at Alambie (lowland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.

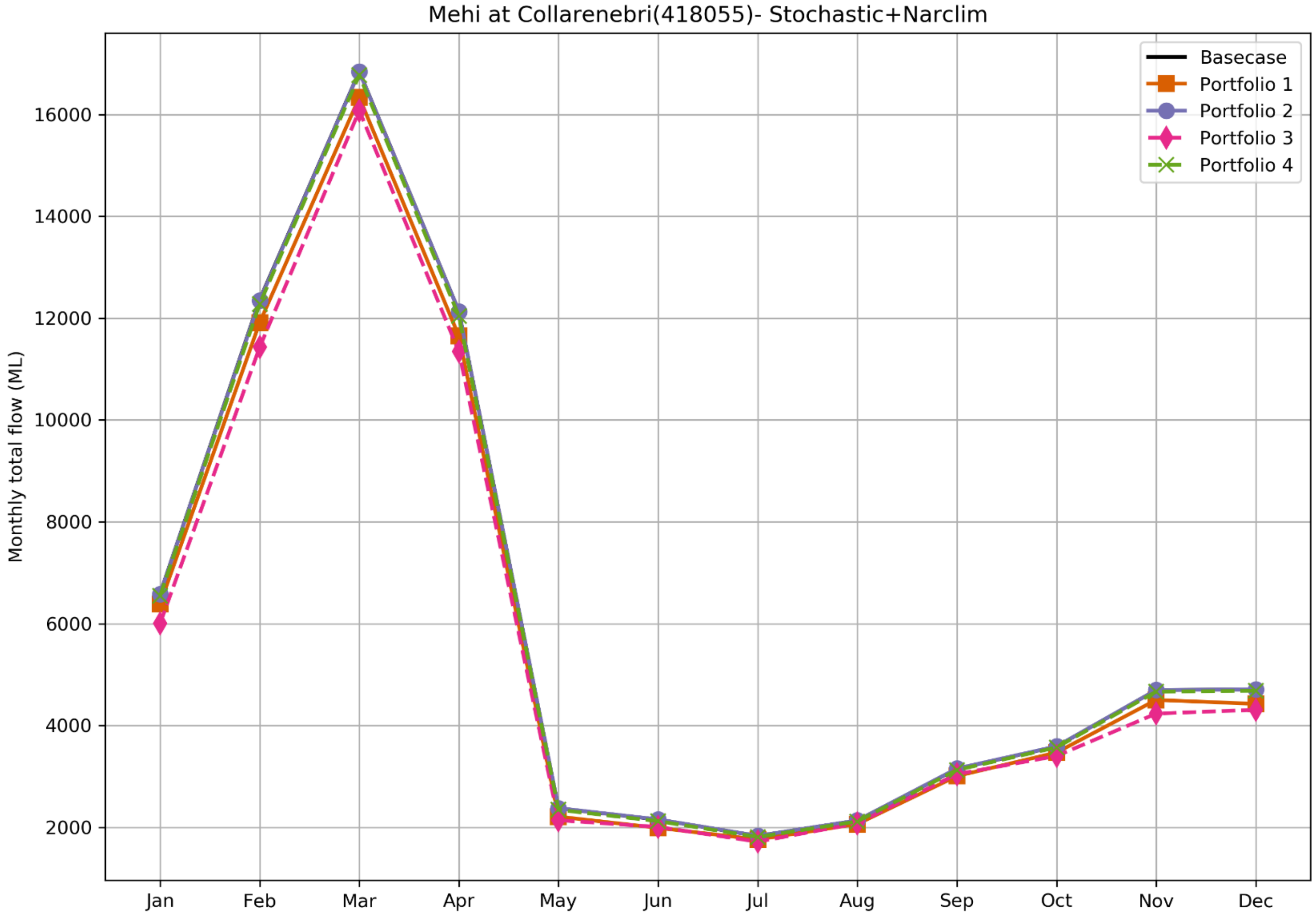

Figure 8: Seasonal difference in average discharge (ML/day) across the base case and four options (portfolios) under the NARCLiM scenario for the Gwydir River at Collarenebri (lowland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.

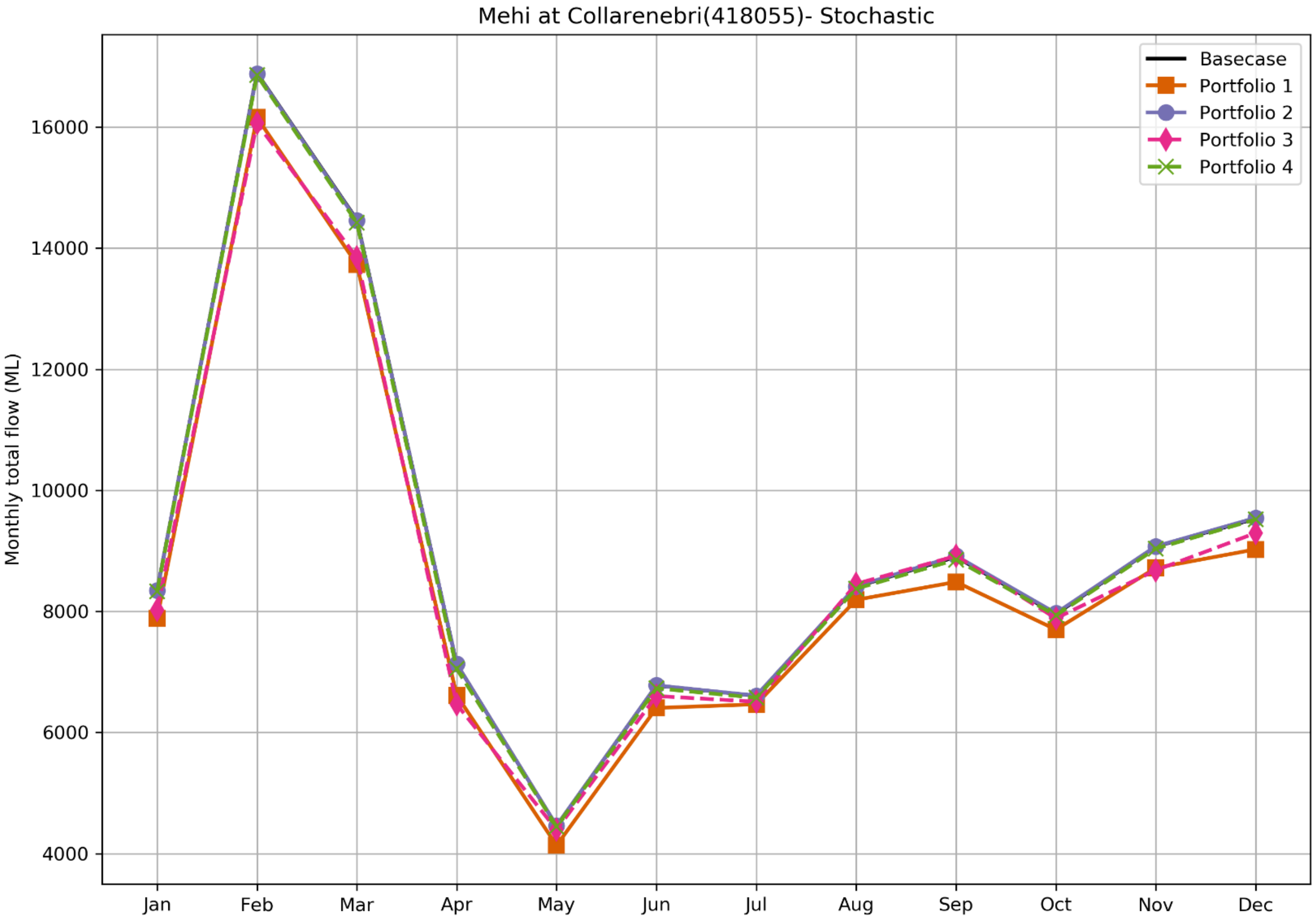

Figure 9: Seasonal difference in average discharge (ML/day) across the base case and four options (portfolios) under the Stochastic scenario for the Gwydir River at Collarenebri (lowland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.

Appendix C. Flow frequency plots by option

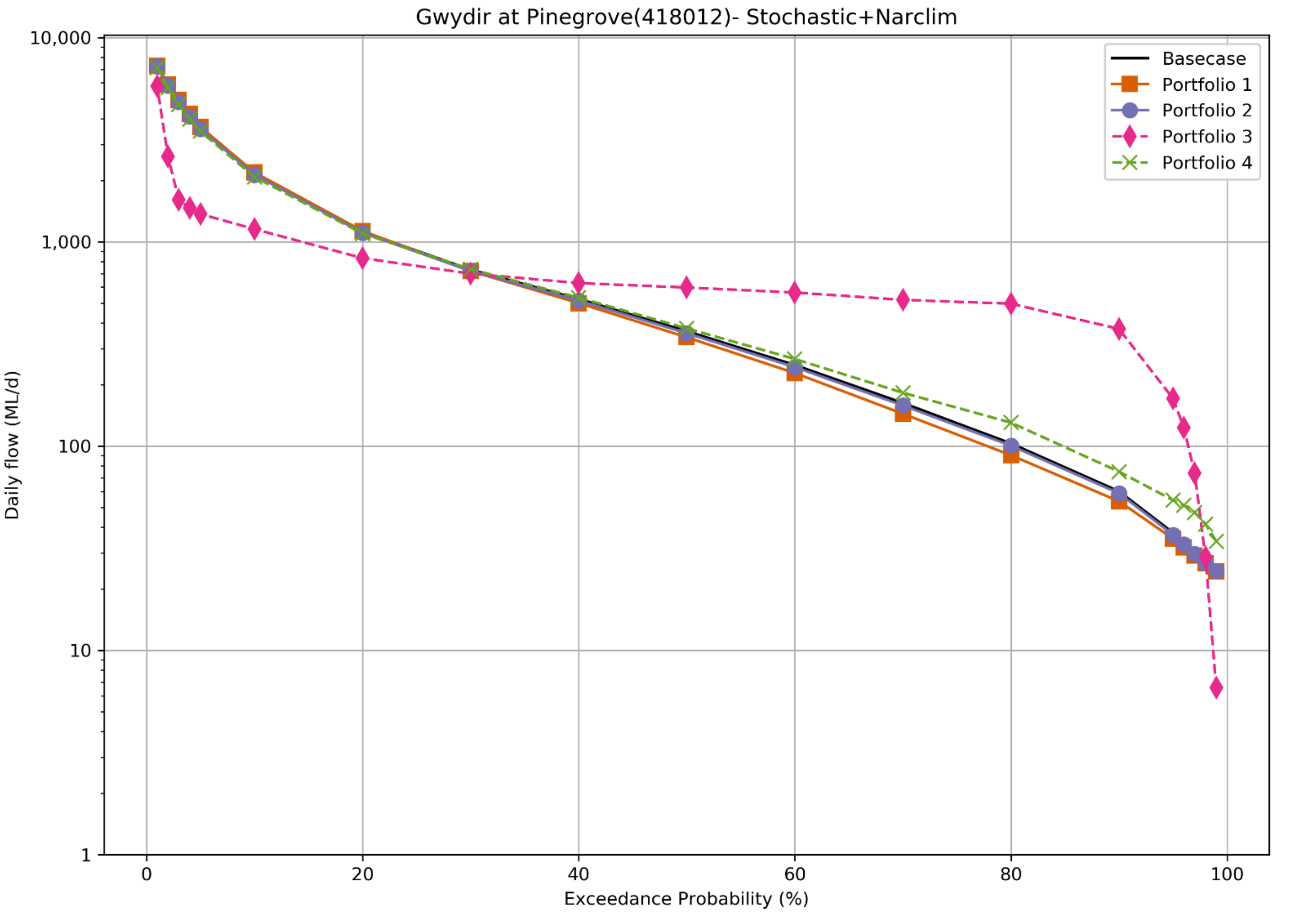

Figure 10: Flow frequency plot for daily discharge (ML/day) across the base case and four options (portfolios) under the NARCLiM scenario for the Gwydir River at Pinegrove (upland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.

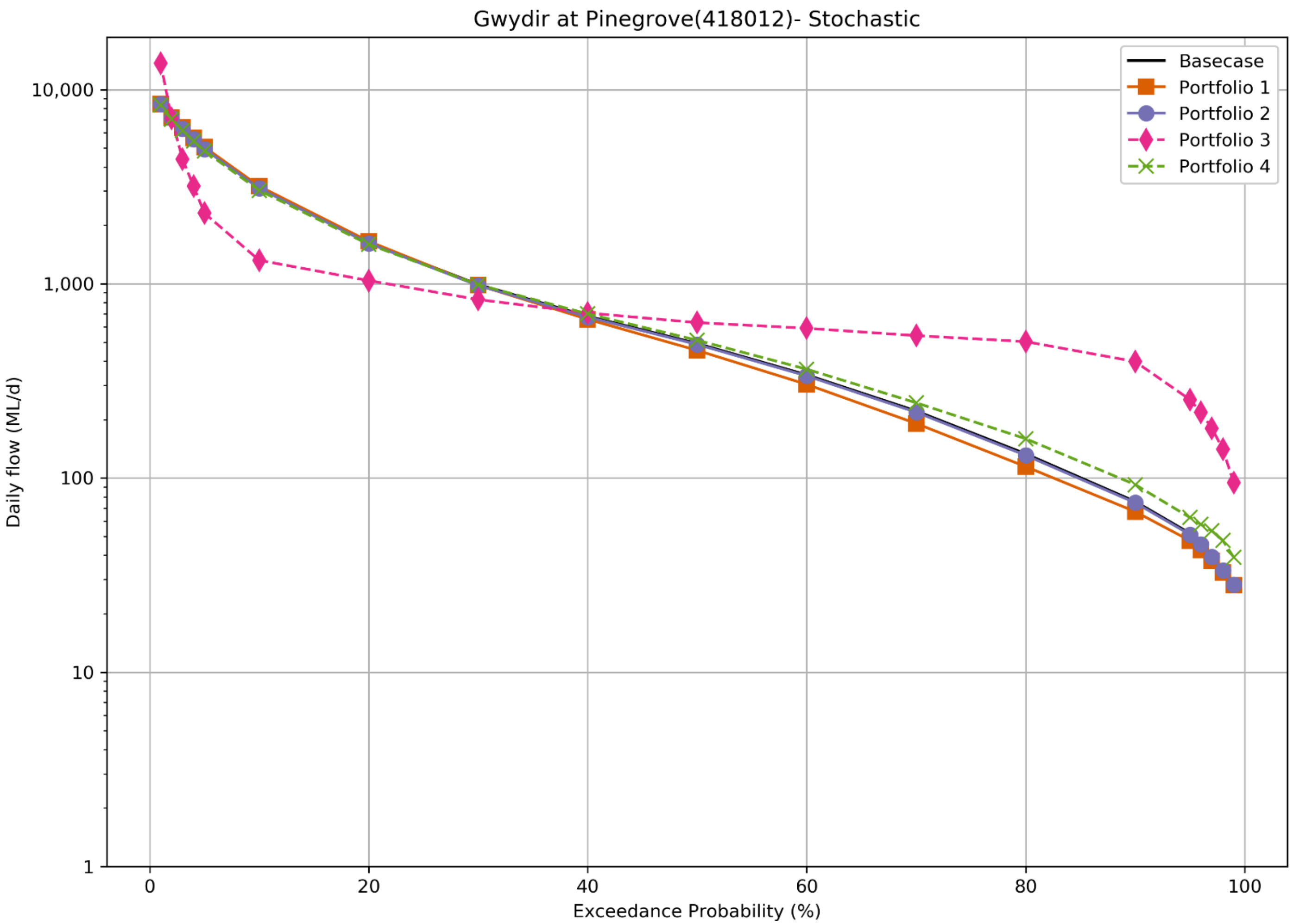

Figure 11: Flow frequency plot for daily discharge (ML/day) across the base case and four options (portfolios) under the Stochastic scenario for the Gwydir River at Pinegrove (upland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.

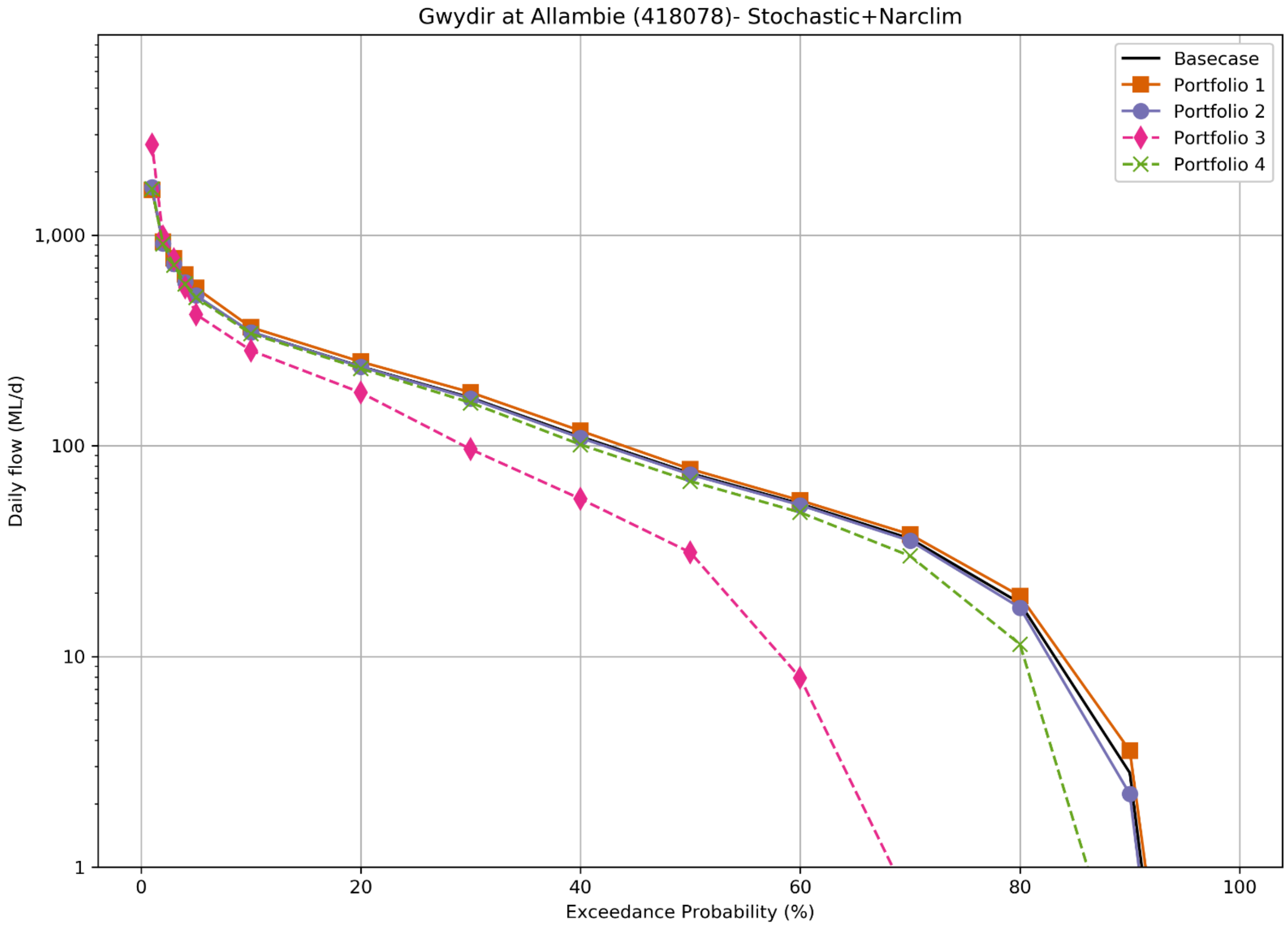

Figure 12: Flow frequency plot for daily discharge (ML/day) across the base case and four options (portfolios) under the NARCLiM scenario for the Gwydir River at Alambie (lowland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.

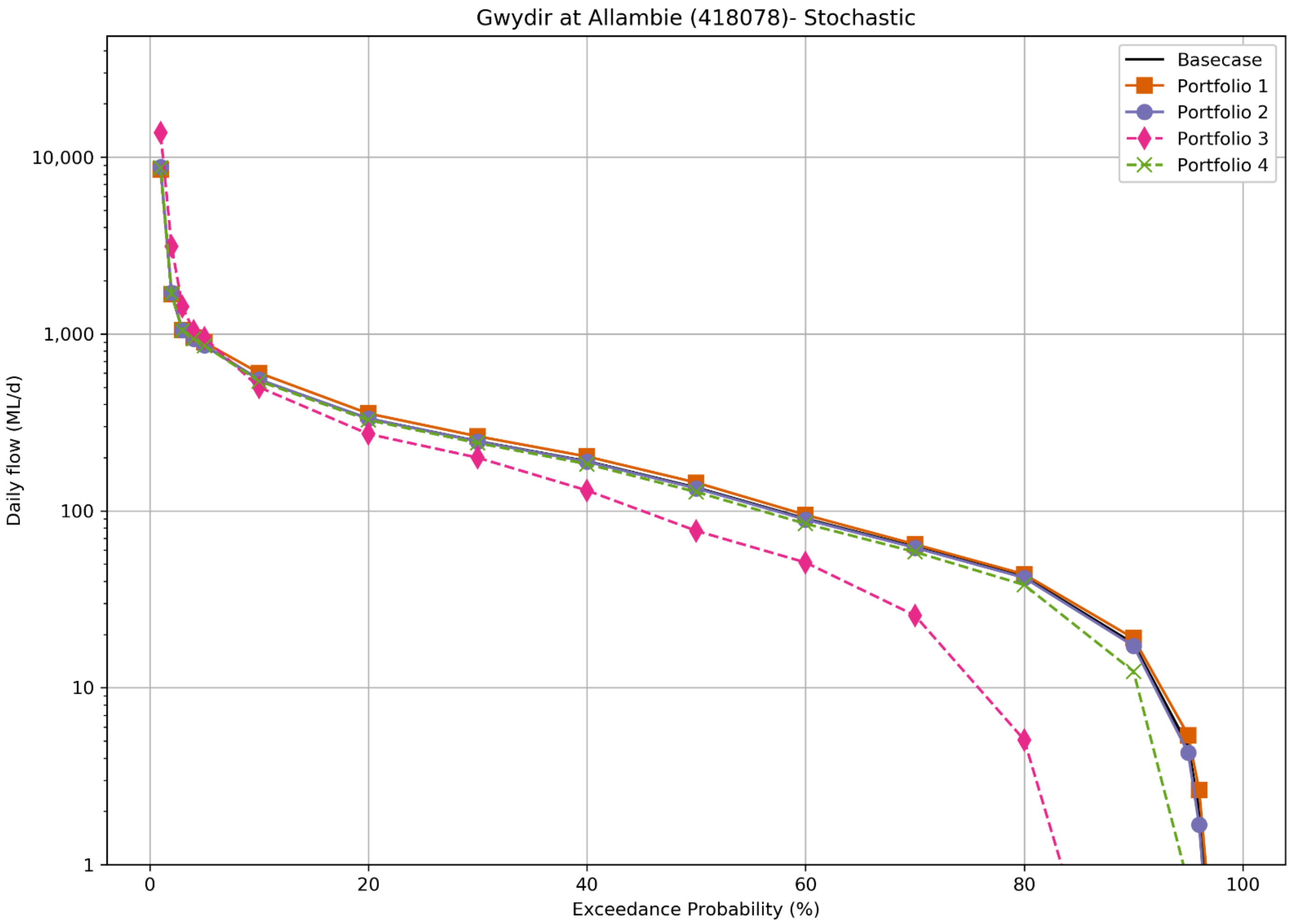

Figure 13: Flow frequency plot for daily discharge (ML/day) across the base case and four options (portfolios) under the Stochastic scenario for the Gwydir River at Alambie (lowland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.

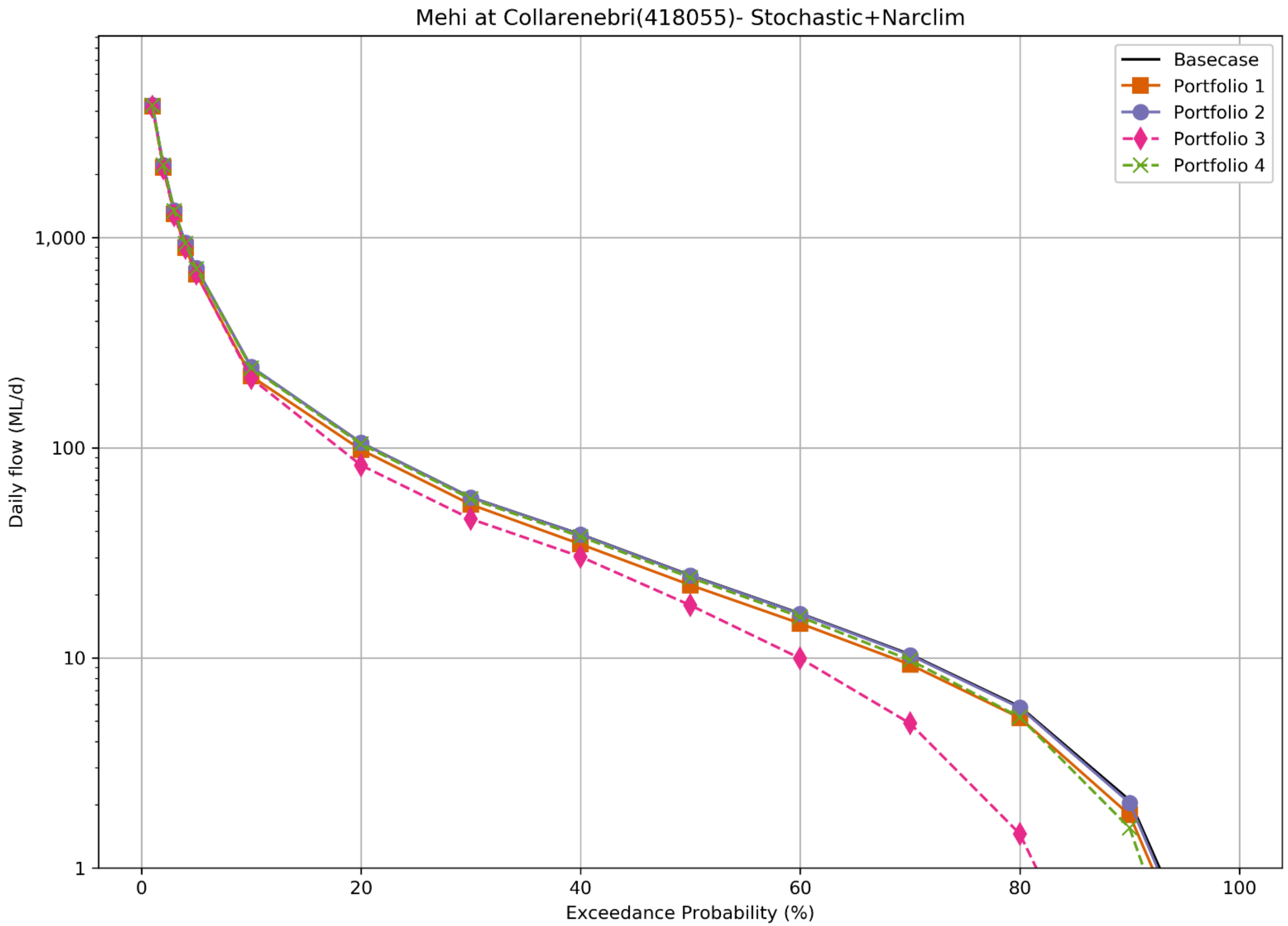

Figure 14: Flow frequency plot for daily discharge (ML/day) across the base case and four options (portfolios) under the NARCLiM scenario for the Gwydir River at Collarenebri (lowland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.

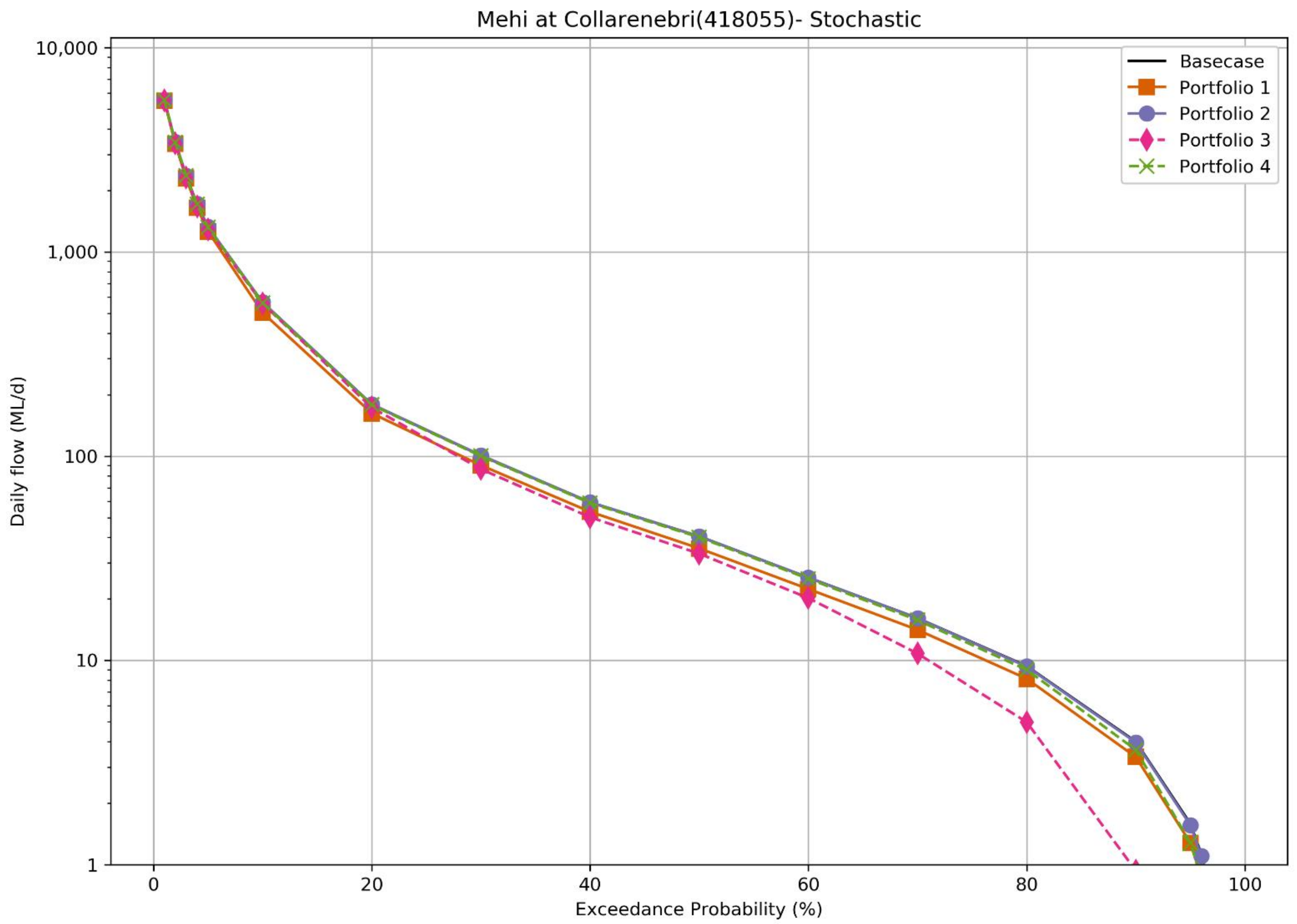

Figure 15: Flow frequency plot for daily discharge (ML/day) across the base case and four options (portfolios) under the Stochastic scenario for the Gwydir River at Collarenebri (lowland site). The four portfolios are Portfolio 1: Option 1. Enlargement of Tareelaroi Weir, Portfolio 2: Option 28: Increase the storage reserve in Copeton Dam, Portfolio 3: Option 29a. Bulk licence conversion and Portfolio 4: Option 29b. Partial licence conversion.