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Granite Belt Water Limited (GBWL)

Strategic water update: Emu Swamp Dam

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Key Points

Badu Advisory was engaged by Granite Belt Water Limited (GBWL) to provide strategic advice and guidance in relation to updated hydrologic modelling of the Emu Swamp Dam (ESD) undertaken by Barma Water Resources (BWR).

The results of BWR's model runs suggest that:

- Achieving a long-term monthly reliability for the project of 90% is possible[1] but contingent on:
  - reducing the total nominal volume of upstream water allocations (i.e. by purchasing / reconfiguring / absorbing them into the supplemented water allocations for ESD) by around 2,300 ML and
  - reducing (again by purchasing / reconfiguring / absorbing them into the supplemented water allocations for ESD) the nominal volume of the Southern Downs Regional Council's (SDRC's) water allocations at Storm King Dam (SKD) by at around 400 ML.
- Modelling suggests that bypassing flows through ESD also appears to be important for maintaining the performance of downstream allocations. However, purchasing upstream water allocations of the volumes contemplated above would result in an increase in the number of days that flows would be bypassed through ESD and water allocations just downstream of ESD accessing more water than the base case.
- Given this, a slight reduction in the bypass flow release volume through the dam may potentially be possible which may, in turn, allow a slight reduction in the volume of upstream water allocations that may need to be acquired to achieve a long-term monthly reliability for the project of 90%. For example, sensitivity analysis suggests that reducing the bypass flow release volume through the dam from 30 ML/d to 25 ML/d might reduce the required upstream acquisitions by 15% (from 2,300 ML to around 2,000 ML).
- The strategy of reducing the existing passing flow condition from 25 ML/d to 1 ML/d for unsupplemented water allocations in node 1332 appears to be important for maintaining the performance of those allocations.
- Modelling indicated that if all project water were taken over 180 days (instead of 350 days) the long-term monthly reliability would increase slightly.
- Sensitivity analysis indicated that whilst the effect of a dry climate change scenario as at 2070 might to reduce long-term monthly reliability to just 65.1%, modelling also showed that the same climate change scenario as at 2030 might actually improve monthly reliability to 97.0%. This illustrates the uncertainty inherent with quantifying, and seeking to mitigate, the potential effects of future climate change.

[1] The long-term monthly reliability reported for model run 5-7 was 89.6% and for model run 7 was 90%.

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Figures and Tables

1 Introduction

1.1 Background

Badu Advisory was engaged by GBWL to provide strategic advice and guidance in relation to updated hydrologic modelling of the Emu Swamp Dam that was undertaken by BWR.

GBWL separately engaged BWR to undertake this in the first half of 2020. BWR was commissioned to refresh the hydrologic modelling of the project to incorporate the updated project design parameters as well as GBWL's latest thinking about options for securing water for the project.

Modelling assumptions and cases applied by BWR were initially guided by the proposed logic and recommendations in Badu Advisory's previous report dated 24 December 2019[2]. BWR undertook the modelling in a number of steps and progressively refined the specification of model cases in liaison with Badu Advisory and GBWL after the results of each phase became available.

1.2 Purpose of this report

This report summarises the results of BWR's modelling (in tabulated format) and provides brief commentary and observations in relation to those results.

2 Results

2.1 Description of model runs

A brief description of the sequence of model runs completed by BWR is provided in Table 1.

Table 1 - Description of model runs

Model run / series	Description
1-1	Base Case – Existing water plan and water allocations including raised Storm King Dam as per SDRC current strategy
1-0	Sensitivity run – as per Run 1-1 but without raising Storm King Dam (and maintaining SKD allocation at 1150 ML/a)
2 series	Sensitivity runs to assess the response of ESD monthly reliability to the reduction in total nominal volume of upstream unsupplemented water allocations
3	Sensitivity run to assess the effect of reducing bypass flows on the extent of the reduction required in the total nominal volume of upstream unsupplemented water allocations to achieve a monthly reliability of 90%
5-1	As per Run 1-1 but with ESD and 3900 ML added, up to 30 ML/d pass flows, and total nominal volume of upstream unsupplemented water allocations nominal volume reduced by 2400 ML (includes some reduction in unsupplemented water allocations upstream of SKD)
5-2	As per Run 5-1 with ESD pass flows reduced to 27 ML/d
5-3	As per Run 5-2 but with SKD at current height and SKD NV reduced from 1150 to 750 ML/a
5-4	(Replaces 5-1) – As per Run 5-1 but without reduction of 74 GL of water allocations upstream of SKD that was in Runs 2 through 5-3
5-5	As per Run 5-4 but with SKD at current height and SKD NV reduced from 1150 to 750 ML/a, ESD pass flows reduced to 15 ML/d and total nominal volume of upstream unsupplemented water allocations reduced
5-6	As per Run 5-4 but with volume of downstream water allocations reduced (and less reduction in total nominal volume of upstream unsupplemented water allocations) and ESD pass flows reduced to 22 ML/d
5-7	As per Run 5-4 but with SKD at current height and SKD NV reduced from 1150 to 750 ML/a.
5-7-1	As per Run 5-7 but with the 1ML threshold for node 1332 restored from 1 ML/d to 25ML/d
5-8	As per Run 5-4 but with SKD at current level but ESD NV maintained at 1150 ML
7	As per Run 5-7 but with annual demand taken over 180 days instead of 350 days

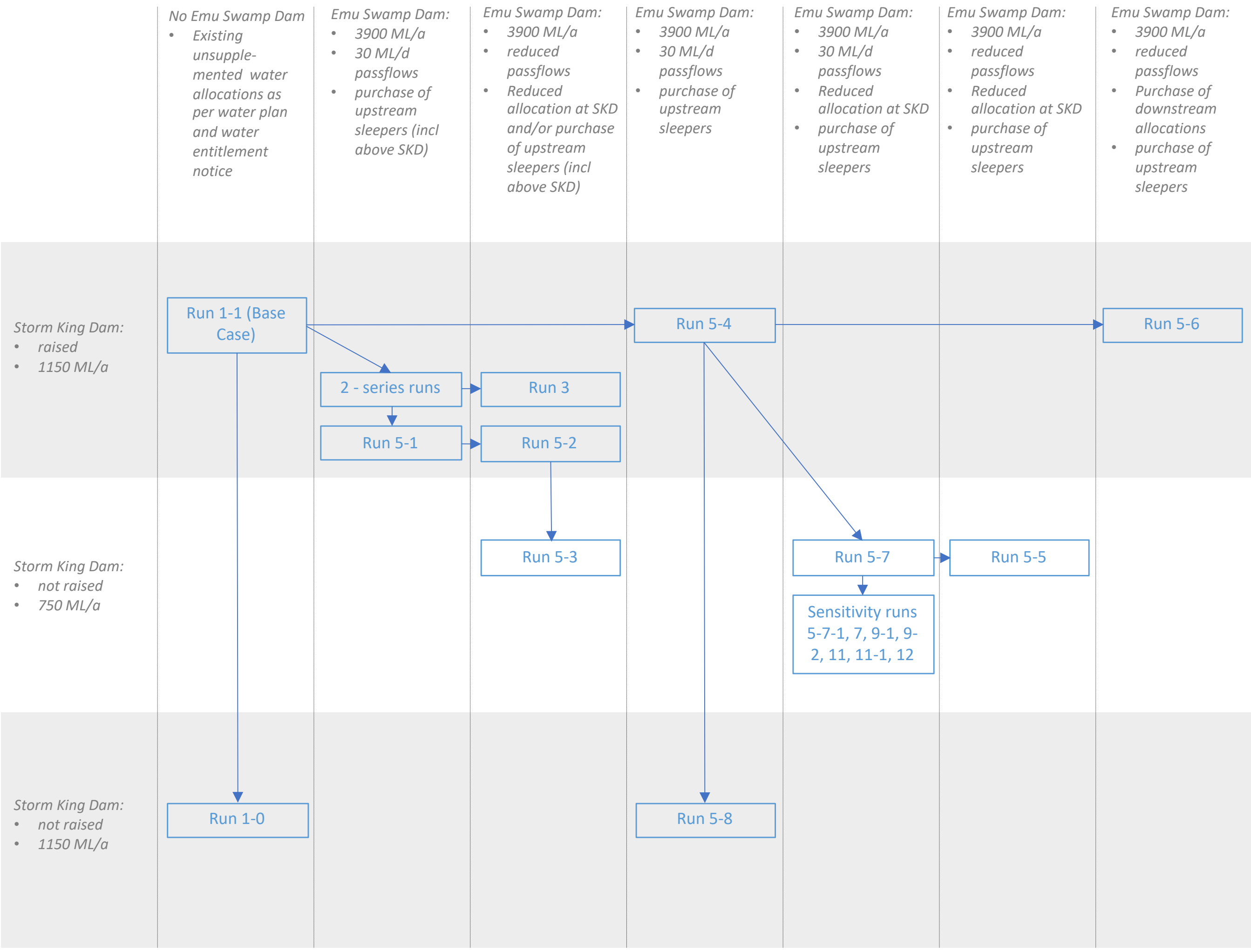
[2] *Updated water strategy for the proposed Emu Swamp Dam*, Report for GBWL prepared by Badu Advisory, 24 December 2019.

Model run / series	Description
9-1	As per Run 5-7 but with annual demand from ESD reduced to 66%
9-2	As per Run 7 but with annual demand from ESD reduced to 66%
11	As per Run 5-7 but with 2070 dry climate change inflows scenario using GCM-2ACCESS1_3Q to represent the 10th percentile projected annual rainfall scenario at 2070 under RCP8.5
11-1	As per Run 11 but with all unsupplemented water allocations upstream of ESD switched off
12	As per Run 11 but with 2030 climate change inflows (using GCM-2ACCESS1_3Q to represent the 10th percentile projected annual rainfall scenario at 2030 under RCP8.5)

When examining model results it is important to interpret hydrologic performance in terms of the *relative changes* between *comparable* model options rather than in terms of absolute values. A schematic illustrating the relationship between the model runs is presented in

Figure 1. The arrows indicate the model runs between which direct comparisons are considered valid.

Figure 1 - Relationship between model runs



2.2 Summary of model results

A summary of the results of the model runs is provided in Table 2[3].

[3] Extracted from BWR's model output summary spreadsheet *Granite Belt Build Sheet 2020 05_26_TV_DB.xlsx*. BWR have also provided a full set of model run system files to DNRME.

Table 2 - summary of model results

Model run / series	SKD height	ESD d/s pass flows	Unsupp NV reduction u/s SKD	Supp NV reduction at SKD [from NV = 1150]	Unsupp NV reduction upstream ESD (excl SKD but incl unsupp NV u/s SKD)	Unsupp NV reduction d/s ESD	Flow condition threshold for node 1332	ESD usage behaviour		ESD monthly reliability – demand months only (extended period)	MAD MS1A (water plan period) [NV = 277 ML]	MAD MS1B (water plan period) [NV = 552 ML]	MAD MS1C (water plan period) [NV = 312 ML]	% reduction MAD MS1A compared to base case 1-1	% reduction MAD MS1B compared to base case 1-1	% reduction MAD MS1C compared to base case 1-1
		ML/d	*ML*	*ML*	*ML*	*ML*	*ML/d*	*% NV/a*	*d/a*	*%*	*ML/a*	*ML/a*	*ML/a*	*%*	*%*	*%*
1-1	Raised	n/a	-	0	0	0	25	-	-	-	253.5	406.1	212.7	-	-	-
2 series	Raised	30	74	0	129 302 1022 2157 2402 4495	0	1	100%	350	85.3% 85.6% 86%% 87.6% 88.2% 90.0%	-	-	-	-	-	-
3	Raised	25	74	0	3812	0	1	100%	350	90.0%	-	-	-	-	-	-
5-1	Raised	30	74	0	2402	0	1	100%	350	88.7%	251.5	399.8	199.2	99.2%	98.5%	93.7%
5-2	Raised	27	74	0	2402	0	1	100%	350	88.8%	249.0	398.2	198.4	98.3%	98.1%	93.3%
5-3	Current	27	74	400	2402	0	1	100%	350	89.6%	273.3	430.0	220.4	107.8%	105.9%	103.6%
5-4	Raised	30	0	0	2328	0	1	100%	350	88.6%	251.1	397.9	199.2	99.1%	98.0%	93.7%
5-5	Current	15	0	400	1927	0	1	100%	350	89.2%	248.7	419.1	209.7	98.1%	103.2%	98.6%
5-6	Raised	22	0	0	2095	277	1	100%	350	88.1%	-	392.8	196.8	-	96.7%	92.5%
5-7	Current	30	0	400	2328	0	1	100%	350	89.6%	273.4	428.6	219.6	107.9%	105.5%	103.3%
5-7-1	Current	30	0	400	2328	0	25	100%	350	89.6%	232.8	428.6	219.6	91.9%	105.5%	103.3%
5-8	Current	30	0	0	2328	0	1	100%	350	89.2%	260.8	419.7	212.5	102.9%	103.45%	99.9%
7	Current	30	0	400	2328	0	1	100%	180	90.0%	273.4	428.5	219.5	107.9%	105.5%	103.2%
9-1	Current	30	0	400	2328	0	1	66%	350	96.2%	274.4	428.6	220.2	108.2%	105.5%	103.5%
9-2	Current	30	0	400	2328	0	1	66%	180	96.7%	274.8	428.6	220.1	108.4%	105.5%	103.5%
11	Current	30	0	400	2328	0	1	100%	350	65.2%	197.8	302.2	134.8	78.0%	74.4%	63.4%
11-1	Current	30	0	400	5875	0	25	100%	350	74.1%	0.0	0.0	0.0	0.0%	0.0%	0.0%
12	Current	30	0	400	2328	0	1	100%	350	97.0%	300.0	480.0	252.2	118.4%	118.2%	118.6%
1-0	Current	n/a	-	0	0	0	25	-	-	-	261.1	411.0	214.9	103.0%	101.2%	101.0%

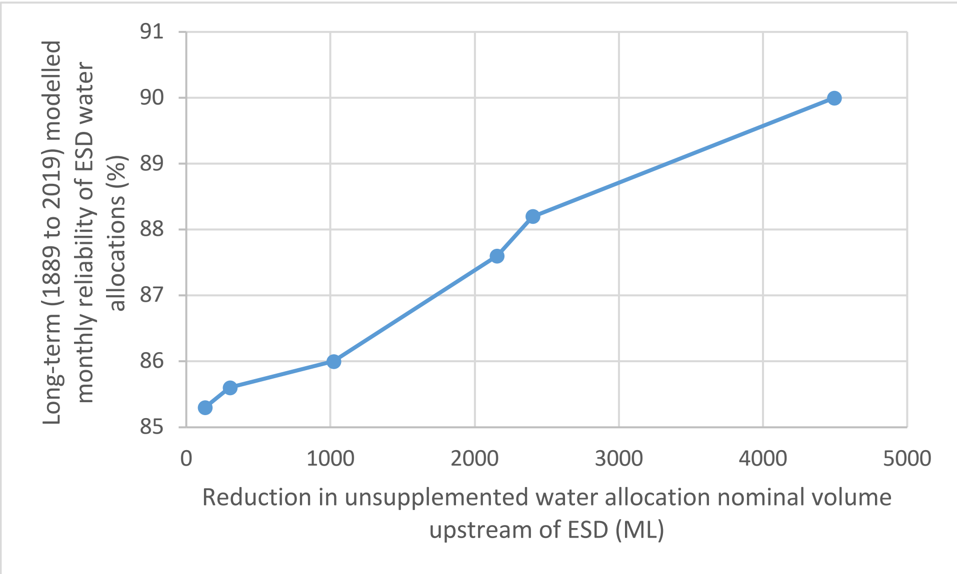
3 Observations

This section presents a series of observations and findings drawn from the results of BWR's modelling.

Sensitivity of the project's hydrologic performance to removing unsupplemented water allocations upstream of ESD

The '2-series' model runs illustrated the sensitivity of the relationship between the total volume of upstream water allocations that might be purchased by the project (i.e. reconfigured/absorbed into the supplemented water allocations) and the hydrologic performance of the project (i.e. long-term monthly reliability) assuming full utilisation of all remaining entitlements.

Figure 2 - Sensitivity of the project's hydrologic performance to the volume of water allocations purchased by the project (based on 2-series model runs)



The 2-series runs indicated that:

- the project's modelled long-term monthly reliability without purchasing any upstream water allocations would be around 85.3%
- purchasing approximately 2,400 ML of upstream unsupplemented water allocations would results in a 2.9% improvement in modelled long-term monthly reliability for the project (to 88.2%)
- increasing modelled long-term monthly reliability for the project from 88.2% to 90% would require the purchase of a further 2,000 ML of upstream unsupplemented water allocations.

However, it should be noted that the 2-series model runs:

- were based on a raised SKD that was assumed as taking its full entitlement of 1,150 ML/a
- included a volume of purchased water allocations located upstream of Storm King Dam (i.e. not related to SDRC's water allocations)
- resulted in more inflows to, and flows bypassed downstream of, ESD as the purchased volume increased (i.e. the hydrologic benefit of upstream purchases were shared between ESD and some downstream unsupplemented water allocations).

Subsequent model runs were designed to investigate these and other aspects further as discussed below.

Sensitivity of the project's hydrologic performance to reduced water allocations supplied from SKD

Comparison of model run 5-4 and model run 5-7 illustrated the sensitivity of project reliability to reducing the nominal volume of water allocations at SKD by 400 ML (i.e. from 1,150 ML to 750 ML) coupled with maintaining SKD at its current level.

Modelling indicated that project reliability would increase from 88.6% (for model run 5-4) to 89.6% (rounded to 90%) for model run 5-7.

Note that model run 5-7 again resulted in more inflows to, and flows bypassed downstream of, ESD which led to some downstream unsupplemented water allocations actually performing better than in base case (model run 1-1).

Sensitivity of not changing the passflow conditions of unsupplemented downstream water allocations in node 1332

Model run 5-7-1 and model run 5-7 illustrated the sensitivity of changing the passing flow conditions of the downstream unsupplemented water allocations in node 1332. In model run 5-7, the water allocations in this node had an assumed passing flow condition of 1 ML/d (which is modified from the current condition as assumed in all other model runs) whereas in model run 5-7-1 the passing flow condition was set at 25 ML/d.

Modelling indicated that the hydrologic performance of the water allocations at this node is highly sensitive to the changed flow condition. It suggests that changing the passing flow condition to 1 ML/d for the unsupplemented water allocations represented in node 1332 will be an important strategy for minimising project impacts on the performance of these water allocations.

Sensitivity of the project's hydrologic performance to reducing ESD daily bypass flows

Model run 3 examined the sensitivity on project reliability to reducing ESD's daily bypass flows (i.e. releases made downstream of ESD) from up to 30ML/d to 25ML/d.

Modelling indicated that the volume of upstream water allocations that would need to be purchased to achieve 90% modelled long-term monthly reliability for the project would reduce from 4,500 ML to 3,812 ML i.e. a 700 ML (or 15%) reduction in the purchased volume.

Note that model run 3 had similar assumptions and limitations to the 2-series runs mentioned above.

Sensitivity of the project's hydrologic performance to reducing upstream and downstream water allocations coupled with a reduction in ESD daily bypass flows

The sensitivity of project reliability to reducing ESD's daily bypass flows was further examined through comparison of model run 5-7 and model run 5-5 which reduced ESD's daily bypass flows from 30ML/d to 15ML/d coupled with reducing the total nominal volume of purchased upstream unsupplemented water allocations by 400 ML.

This had the effect of curtailing the increase in the performance of downstream unsupplemented water allocations (to a level similar to that of base case 1-1) but also of reducing the reliability of ESD to 89.2%.

Comparison of model runs 5-4 and 5-6 further illustrated the sensitivity of project performance from:

- reducing the nominal volume of upstream unsupplemented water allocations from 2,328 ML (model run 5-4) by 233 ML to 2,095 ML (model run 5-6) and
- reducing the nominal volume of downstream unsupplemented water allocations by 277 ML (in model run 5-6) and
- reducing ESD's daily bypass flows from 30 ML/d (model run 5-4) to 22 ML/d (model run 5-6).

This had the effect of reducing the reliability of ESD by 0.5% to 89.2%.

Modelling illustrated that increasing the monthly reliability of ESD appears to be more responsive to (and dependent on) the reduction in nominal volumes of water allocations upstream of ESD rather than downstream water allocations (even when coupled with a reduction in bypass flows downstream of ESD).

Sensitivity of the project's hydrologic performance to the raising of SKD

Model run 5-4 and model run 5-8 illustrated the sensitivity of project performance to the raising of SKD (all other aspects being held equal including the nominal volume of water allocations at SKD being held at 1,150 ML).

This indicated that the impact of raising SKD on ESD long-term reliability would be around 0.6%.

Sensitivity of the project's hydrologic performance to the number of months over which water is taken

Model run 5-7 and model run 7 illustrated the sensitivity of project performance to reducing the number of months over which water is taken by the project each year from being spread over 350 days (model run 5-7) to being distributed over 180 days (model run 7).

Modelling indicated that if all project water were taken over 180 days (instead of 350 days) the long-term monthly reliability[4] would increase by 0.4% (from 89.6% in model run 5-7 to 90% in model run 7).

Sensitivity of project's hydrologic performance to the extent to which ESD water users choose to take their water

Model runs 9-1 and 9-2 may be compared to model runs 5-7 and 7 respectively to illustrate the improvement in monthly reliability should water users choose to only take 66% of their available water supplies each year and save the remainder for future years. Note that each individual water user in the project would be free to choose the extent that they use versus save their water and then individually enjoy their resulting improvement in reliability (without impact on, or being impacted by, the choices of others). Water users being provided with such choice is a feature of the continuous sharing water accounting and sharing system upon which the project is based.

Modelling indicated that saving (and not taking) 34% of water supplies each year would have the effect of increasing their long-term monthly reliability by about 6.6%.

Sensitivity of project's hydrologic performance to climate change

Model runs 11 and 12 may be compared to model run 5-7 to illustrate the effect of an extreme dry future climate change scenario on the project's monthly reliability.

Model run 11 indicated that the effect of a dry climate change scenario as at 2070 might to reduce long-term monthly reliability to just 65.1%. Model run 11-1 showed that purchasing additional water allocations over and above the volumes discussed above might partly mitigate this impact.

However, model run 12 indicated that the same climate change scenario as at 2030 might actually improve monthly reliability to 97.0%. This illustrates the uncertainty inherent with quantifying, and seeking to mitigate, the potential effects of future climate change.

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[4] Note that monthly reliability was reported by BWR for each model run in terms of the percentage of the number of non-zero demand months that monthly demands were met.