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Executive Summary

Armidale experienced its driest and warmest year on record in 2019. Level 3 water restrictions were enforced across the entire Local Government Area in April 2019 and level 5 restrictions were introduced in October 2019 and were not eased until September 2020. As part of the Integrated Water Cycle Management (IWCM) planning, an options assessment was undertaken to evaluate and shortlist options to improve the long-term security of the Armidale and Guyra water supply.

The water security issue

A water cycle analysis was completed to forecast the 30-year unrestricted annual extraction using a Council nominated growth rate of 1.065% for Armidale City and 1% for Guyra (1.06% for the combined serviced population). The forecast unrestricted annual extraction requirements are provided in Table S1.

Table S1: Forecast unrestricted annual extraction requirements for Armidale and Guyra

	2021	2026	2031	2036	2041	2046	2048
Armidale (ML/year)	3,546	3,788	4,064	4,337	4,628	4,939	5,066
Guyra (ML/year)	603	621	639	661	685	712	

The capacity of the existing Armidale and Guyra water supply headworks was estimated to be 2,428 ML/year on a secure yield basis using the DPIE Water's draft guidelines "*Assuring future urban water security, Assessment and Adaption guidelines for NSW local water utilities*". For a total 2048 unrestricted annual extraction of 5,778 ML/year, there is a shortfall of 3,349 ML/year and water security is not achieved

Malpas dam raising

As the existing Malpas dam storage was found to be insufficient, an augmentation with 3.0m and 6.5m dam raising options were considered. The secure yield analysis however showed that these augmentations would not be sufficient with a shortfall of 2,734 ML/year for the 3.0m raising and 2,088 ML/year for the 6.5m raising. This indicates that the water resource yield from the Gara River may be at the limit and additional sources from different catchments, that could supplement the yield from the Gara River catchment, would need to be identified. These sources could supplement the existing source either by pumping in to a raised Malpas dam, or by pumping into a new storage.

Alternate surface water sources

The new water sources included the Gwydir River in the Moredun Creek Water Source, the Aberfoyle River in the Aberfoyle River Water Source (within the Clarence River Catchment), the Gara River Water Source, the Salisbury Water Source, the Styx River Water Source and the Chandler River Water Source within the Macleay River Catchment. Extraction locations (for pumping stations) and On-river and Off-River storage sites were identified. The long list of extraction locations and storage sites were shortlisted through an objective assessment process. The top ten shortlisted scheme options are provided in Table S2.

Table S2: Shortlisted surface water schemes

Storage	Source 1	Source 2	Source 3
St Helena Creek	Styx River U/S of Kempsey Road	None	None
St Helena Creek	Styx River U/S of Kempsey Road	Chandler River D/S of Grafton Road	None
St Helena Creek	Styx River U/S of Kempsey Road	Chandler River D/S of Grafton Road	Bakers Creek U/S of Grafton Road
Styx River	Styx River	None	None
Chandler River	Styx River U/S of Kempsey Road	None	None
Raised Malpas dam	Styx River U/S of Kempsey Road	None	None
Raised Malpas dam	Styx River U/S of Kempsey Road	Chandler River D/S of Grafton Road	None
Raised Malpas dam	Styx River U/S of Kempsey Road	Chandler River D/S of Grafton Road	Bakers Creek U/S of Grafton Road
Nowlands Backwater	Aberfoyle River at Goonyal	None	None
Raised Malpas dam	Aberfoyle River at Goonyal	Nowlands Backwater (NB)	None

The shortlisted schemes were assessed to determine if the secure yield from the schemes would make-up the shortfall in the existing scheme. If extraction from the main source (Source 1) did not provide the required secure yield, the secondary sources were progressively added to the scheme. The shortlisted schemes that would meet the shortfall in secure yield, either by pumping to a raised Malpas dam or pumping to a new storage, are provided in Table S3.

Table S3: Shortlisted schemes that meet the secure yield shortfall

Scheme	Water Source(s)	New works
Raised Malpas dam (MD)	Styx River U/S of Kempsey Road	6.5m raised MD 50 ML/d transfer from Styx River
Raised Malpas dam (MD)	Aberfoyle River at Goonyal & Nowlands Backwater (NB)	6.5m raised MD 50 ML/d transfer from Aberfoyle and NB
Storage on Chandler River	Styx River U/S of Kempsey Road	3,552 ML On-River storage 50 ML/d transfer from Styx

Oaky River dam

Oaky River Dam was a hydroelectric dam owned by Essential Energy located on Oaky River, approximately 3 km downstream of Kempsey Road. The right embankment of the dam failed during an extreme flood event on 22 February 2013. The estimated total capital cost to repair the dam and upgrade it to meet the Dam Safety requirements is \$8 M.

Essential Energy does not plan to repair the dam as power generation is no longer their core business. The dam is within one of the NSW Government's renewable energy zones. Therefore,

there is the potential that the site could be acquired to be part of the water supply scheme. The Oaky river source is expected to have the same yield as the Styx River source. The Oaky River dam has therefore also been considered as an alternate surface water source. Further secure yield modelling will be required using the Oaky River stream flows once the flows are obtained from Essential Energy.

Groundwater

A groundwater investigation identified four production bores. Council estimated a total yield of 1,512 kL/d from these bores for 16 hours pumping. This amounted to about 550 ML/year.

In order to meet the entire shortfall in secure yield about 30 to 50 more production bores would be required. The risks of developing such a borefield include:

- finding the number of bores required with sufficient yield
- obtaining approval for the bore construction
- negotiating the land and access requirements for the scheme

Considering the above risks and challenges, the development of a borefield to supply to entire shortfall in yield, has not been considered. Instead, only the four production bores that have already been drilled are considered as a reliable supplementary source to the surface water. For this assessment, a conservative groundwater yield of 200 ML/year has been considered as a reliable supplementary source to the surface water.

Scheme Options

Following the identification of the schemes that would meet the shortfall in secure yield, further analysis was undertaken to optimise the scheme components and to determine the scheme requirements for the different Malpas dam raising options that have been assessed. Those options that were close or able to meet the shortfall in secure yield, are outlined in Table S4.

Table S4: Works required for scheme options that meet the secure yield shortfall

No	Malpas dam raising	Additional source/storage	Works required
1	No	25 ML/d from Styx River	74 km of 600mm diameter pipeline, 2 pumping stations (1060kW & 840kW)
2	No	10 ML/d from Styx River + 7.8 GL on-stream Storage on Chandler River	66 km of 375mm diameter pipeline 2 pumping stations (400 kW & 540 kW) 1 dam 7.8 GL
3	3m	15 ML/d from Styx River	74 km of 450mm diameter pipeline 2 pumping stations (680 kW & 590 kW) Raise Malpas Dam 3m
4	6.5m	10 ML/d from Styx River	74 km of 375mm diameter pipeline 2 pumping stations (470 kW & 420 kW) Raise Malpas 6.5m
5	6.5m	10 ML/d from Aberfoyle River and 10 ML/d from Nowlands Backwater	13 km of 375mm diameter pipeline 44 km of 525mm diameter pipeline 3 pumping stations (90 kW, 730 kW and 270 kW) Raise Malpas 6.5m
6	No	25 ML/d from Oaky River Dam	Restore and upgrade Oaky River Dam Transfer to Malpas Dam 67 km of 600mm diameter pipeline, 2 pumping stations (880kW & 840kW)

Armidale water supply – water security options

No	Malpas dam raising	Additional source/storage	Works required
7	3m	15 ML/d from Oaky River Dam	Restore and upgrade Oaky River Dam 67 km of 450mm diameter pipeline 2 pumping stations (560kW & 590kW) Raise Malpas Dam 3m
8	6.5m	10 ML/d from Oaky River Dam	Restore and upgrade Oaky River Dam Transfer to Malpas Dam 67 km of 375mm diameter pipeline 2 pumping stations (380kW & 420kW) Raise Malpas dam by 6.5 m

All the short-listed options meet the secure yield for the Armidale and Guyra water supply. The schemes, staging costs and, triple bottom line assessment and ranking of the schemes are provided in Table S5.

Table S5: Scheme options – staging and cost estimates

Works	Staging	Capital Cost (\$M)	Annual O&M Cost (\$M)	30-year PV (\$M)	Non-cost Score	TBL Score Non-cost NPV	Rank
25 ML/d from Styx River	None	111	1.30	95.53	52.8	0.55	6
10 ML/d from Styx River + 7.8 GL Storage on Chandler River	None	99	0.95	84.35	37.2	0.44	8
15 ML/d from Styx River + 3m raising	None	102	1.08	87.85	52.5	0.60	5
	Styx River transfer – 2025 Raise Malpas dam – 2033	102	1.10	80.98		0.65	4
10 ML/d from Styx River + 6.5 m raising	None	95	0.91	80.98	31.2	0.38	9
10 ML/d from Aberfoyle and 10 ML/d from NB + 6.5m raising	None	97	0.86	81.72	16.4	0.20	10
25 ML/day from Oaky River to Malpas	None	111	1.22	94.94	65.7	0.69	3
15 ML/day from Oaky River to Malpas + 3m raising	None	95	1.07	81.92	67.0	0.82	1
	Oaky River transfer – 2025 Raise Malpas dam – 2033	106	1.07	83.28		0.81	2
10 ML/d from Oaky River to Malpas + 6.5m raising	None	100	0.87	83.98	41.9	0.50	7

Council's aspirational growth strategy

In February 2022 the newly elected Council held a Mayoral Summit and updated the base case population projection and introduced an aspirational population projection. The water demand projections for these three projections are graphed in Figure S1.

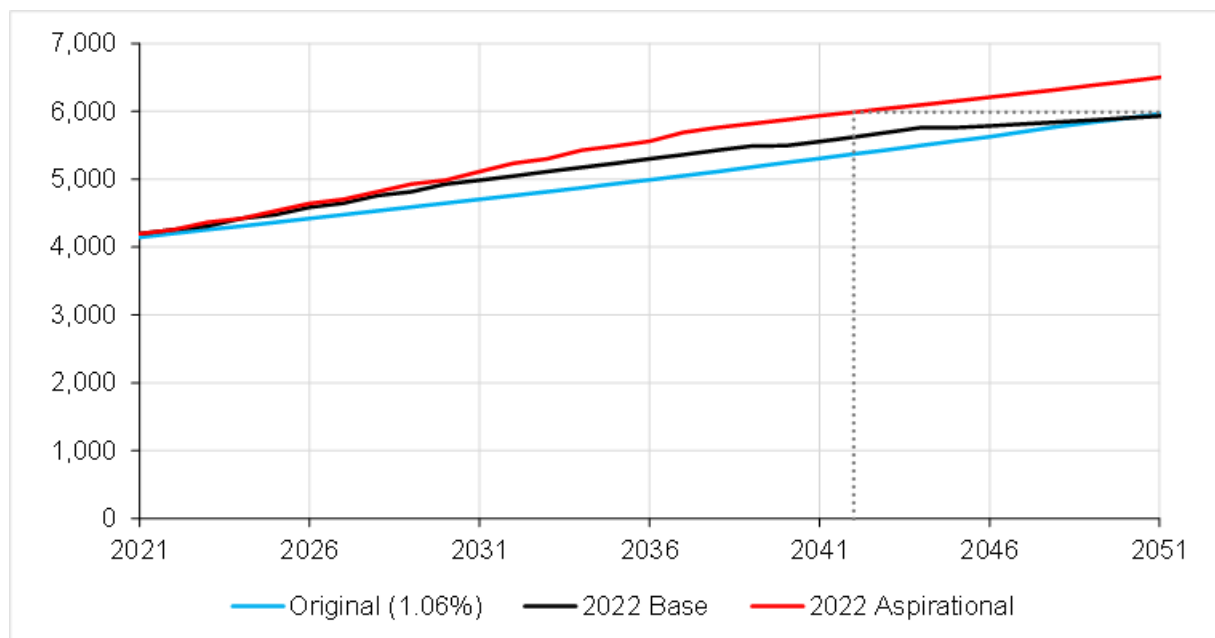


Figure S1: Unrestricted annual demand (ML/year)

As shown in Figure S1, if the Aspirational Growth is realised, the original 2051 Unrestricted annual demand (ML/year) will occur around 2042. The recommended scheme options to accommodate the Aspirational Growth are summarised in in Table S6.

Table S6: Scheme options for Aspirational Growth – staging and cost estimates

Works	Staging	Capital Cost (\$M)	Annual O&M Cost (\$M)	30-year PV (\$M)
Option 1 25 ML/d from Oaky River + 6.5m raising	Oaky River transfer 2025 Raise Malpas 2042	137	1.24	101
Option 2 25 ML/d from Styx River + 6.5m raising	Styx River transfer 2025 Raise Malpas 2042	146	1.33	109

The Option comprising Oaky River dam as the alternate source is the preferred option. However, if Council are unsuccessful in acquiring the Oaky River dam then the Styx River is the next preferred alternate source option.

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1. Introduction

Armidale Regional Council (ARC) commissioned Public Works Advisory (PWA) to prepare Council's Integrated Water Cycle Management (IWCM) Strategy. The first phase was the completion of the IWCM Issues Paper which identified the water supply and sewerage system issues. Water security was identified as significant issue in the IWCM Issues Paper.

Armidale experienced its driest and warmest year on record in 2019. The rainfall total for 2019 of 306.6 mm was 475 mm lower than the annual average and is the driest on record. Level 3 water restrictions were enforced across the entire Local Government Area in April 2019 and level 5 restrictions were introduced in October 2019 and were not eased until September 2020.

As part of the IWCM planning, an options assessment was undertaken to evaluate and shortlist options for the long-term security of the Armidale and Guyra water supply. The options assessment included:

- quantification of the issue
- assessment of Malpas dam raising options
- identification of alternate catchments and schemes
- formulation and assessment of scheme options
- staging and cost estimates.

This report presents the outcomes of the water security options assessment.

2. Water supply schemes

Armidale Regional Council operates two water supply schemes the Armidale water supply scheme and the Guyra water supply schemes.

A schematic diagram of the Armidale Water supply scheme is shown in Figure 2-1.

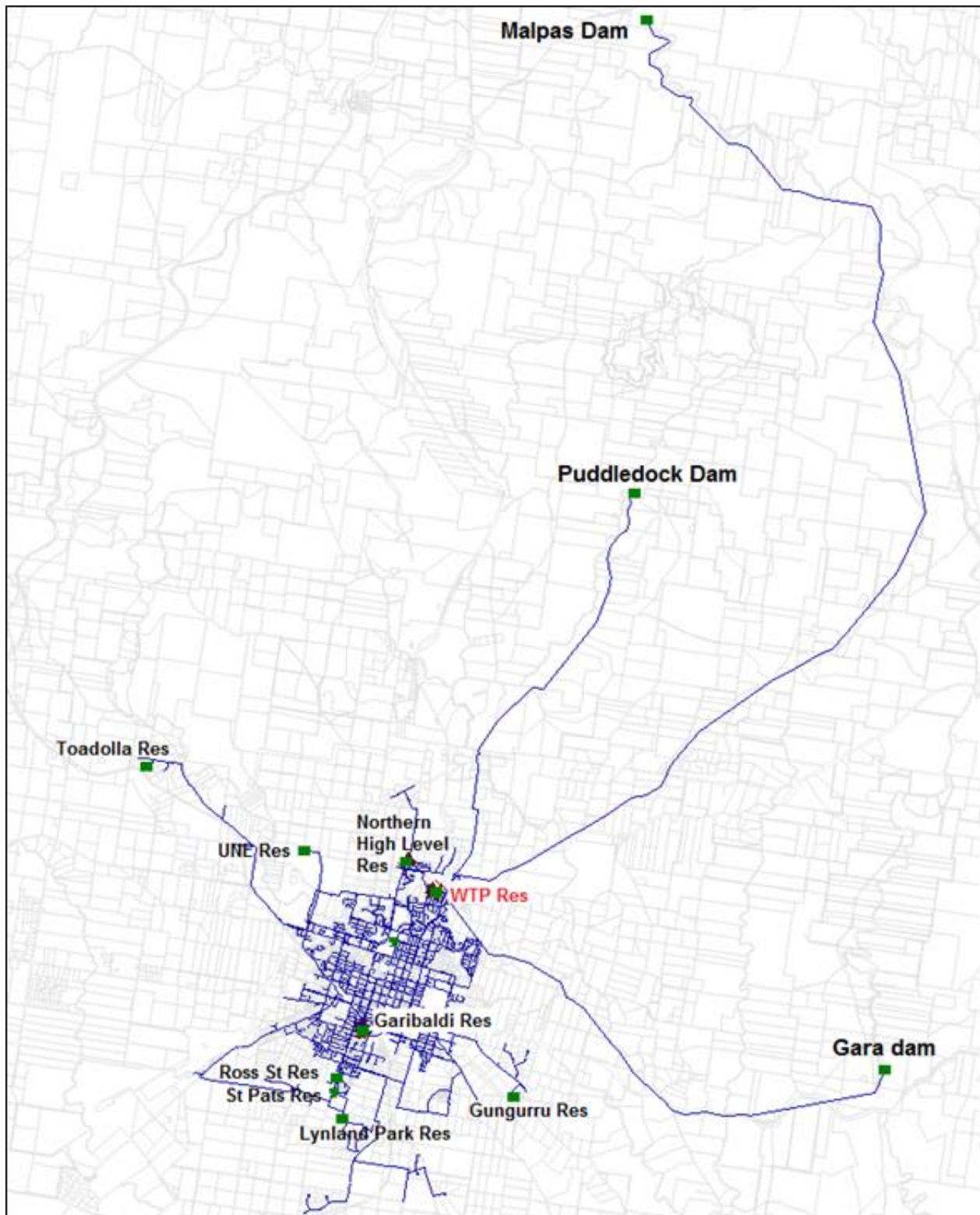


Figure 2-1: Armidale water supply scheme overview

The primary source for the Armidale water supply scheme is the Malpas dam with backup supply from Puddledock dam. The Gara Dam transfer infrastructure is not currently operational.

A schematic diagram of the Guyra water supply scheme is shown in Figure 2-2:.

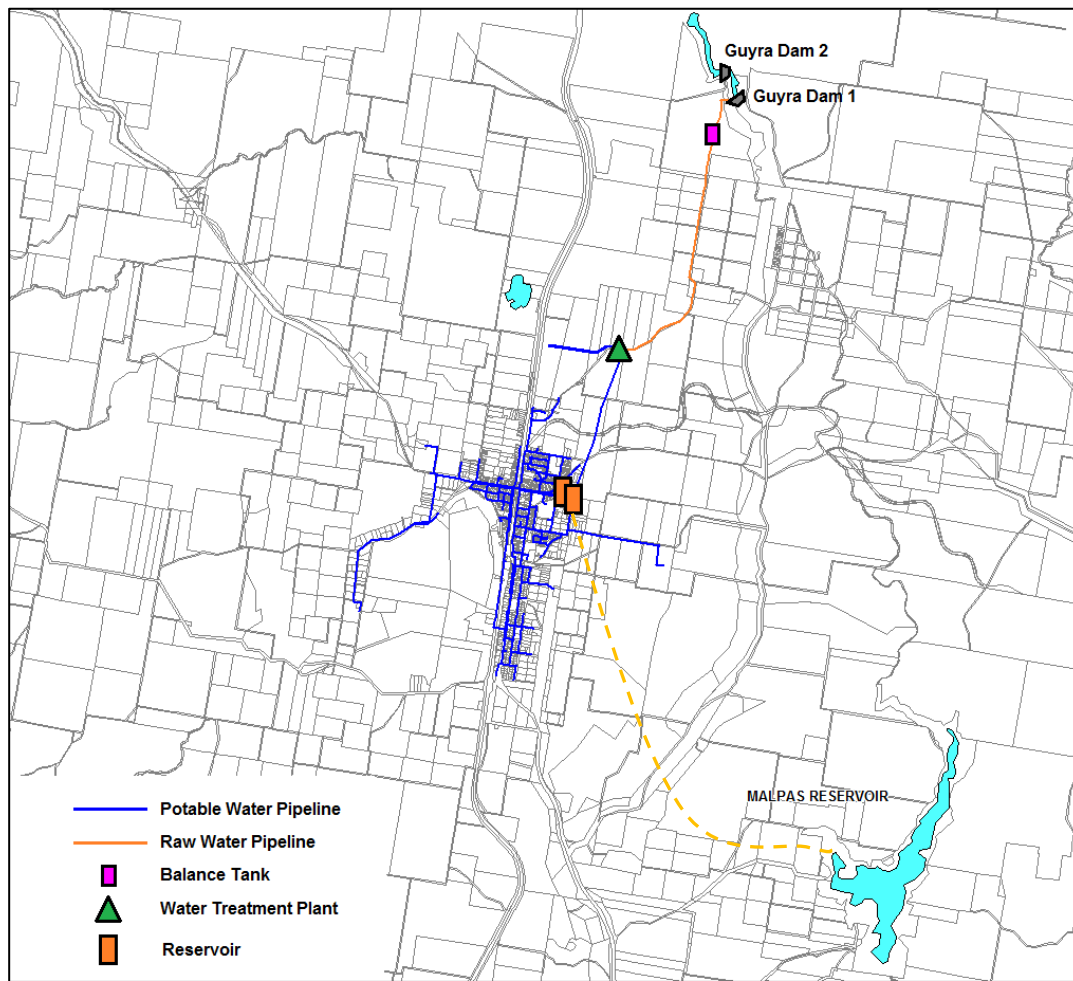


Figure 2-2: Guyra water supply scheme overview

The water supply for Guyra is sourced from two dams on the Gara River approximately 8 km north of the town. The upper dam (Dam 2) is located immediately upstream of the lower dam (Dam 1) so that any overflow from Dam 2 flows directly into Dam 1. A pipeline connecting the Malpas Reservoir to Guyra was completed in October 2019.

3. Water security assessment

3.1 Identifying the issue

A water cycle analysis was completed for the Issues Paper. This included an analysis of the historical water production and metered consumption information to estimate the unrestricted annual water extraction requirements for the Armidale and Guyra water supply schemes. The unrestricted extraction requirements were then forecast for a 30-year planning period using a Council nominated population growth rate of 1.06% for Armidale City and 1% for Guyra. The forecast unrestricted annual extraction requirements are provided in Table 3-1.

Table 3-1: Forecast unrestricted annual extraction requirements for Armidale and Guyra

	2021	2026	2031	2036	2041	2046	2048
Armidale (ML/year)	3,546	3,788	4,064	4,337	4,628	4,939	5,066
Guyra (ML/year)	603	621	639	661	685	712	

To understand the behaviour of the existing Malpas dam storage when supplying the current and 30-year forecast demand, a simple water balance was undertaken between the daily inflow to and outflow from Malpas dam. The analysis was then hindcast to 1890 to simulate the behaviour of the Malpas storage for the historical droughts on record. The drawdown of the Malpas dam when supplying the 2021 and the 2048 annual unrestricted extraction for the historical climate, is shown in Figure 3-1 and Figure 3-2.

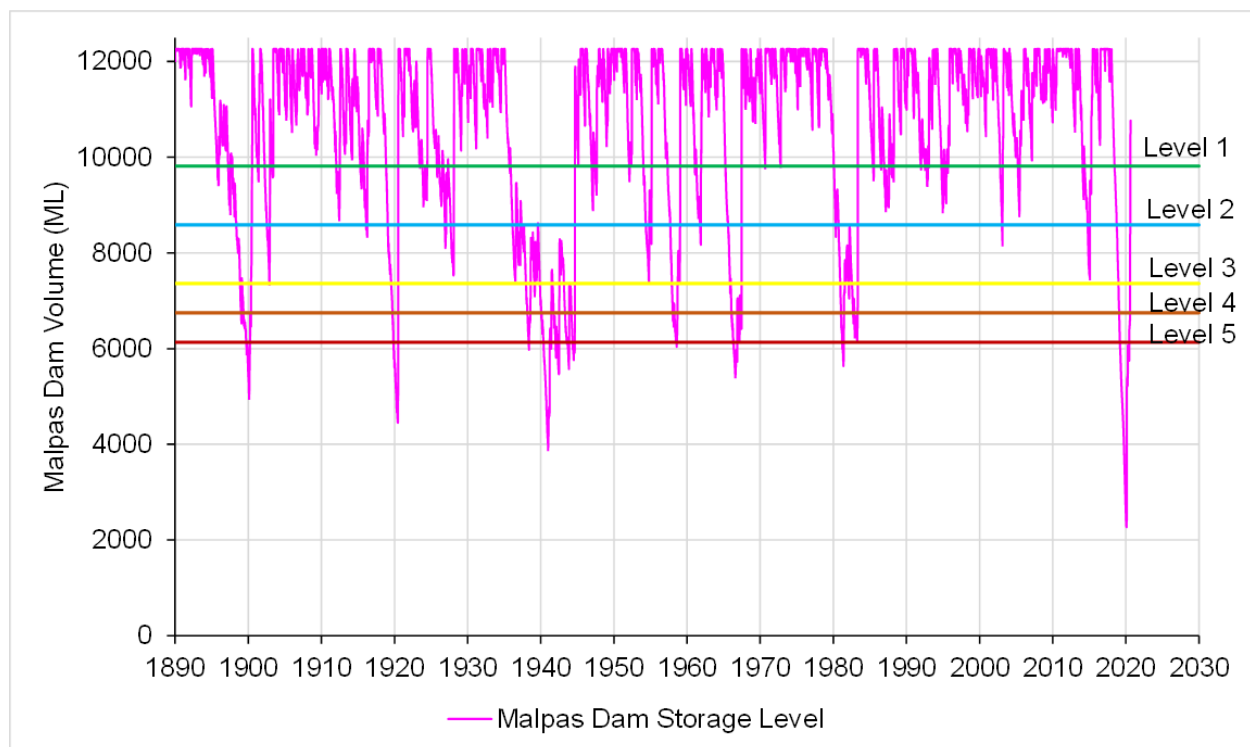


Figure 3-1: Storage behaviour of Malpas dam hindcast when supplying 2021 demand

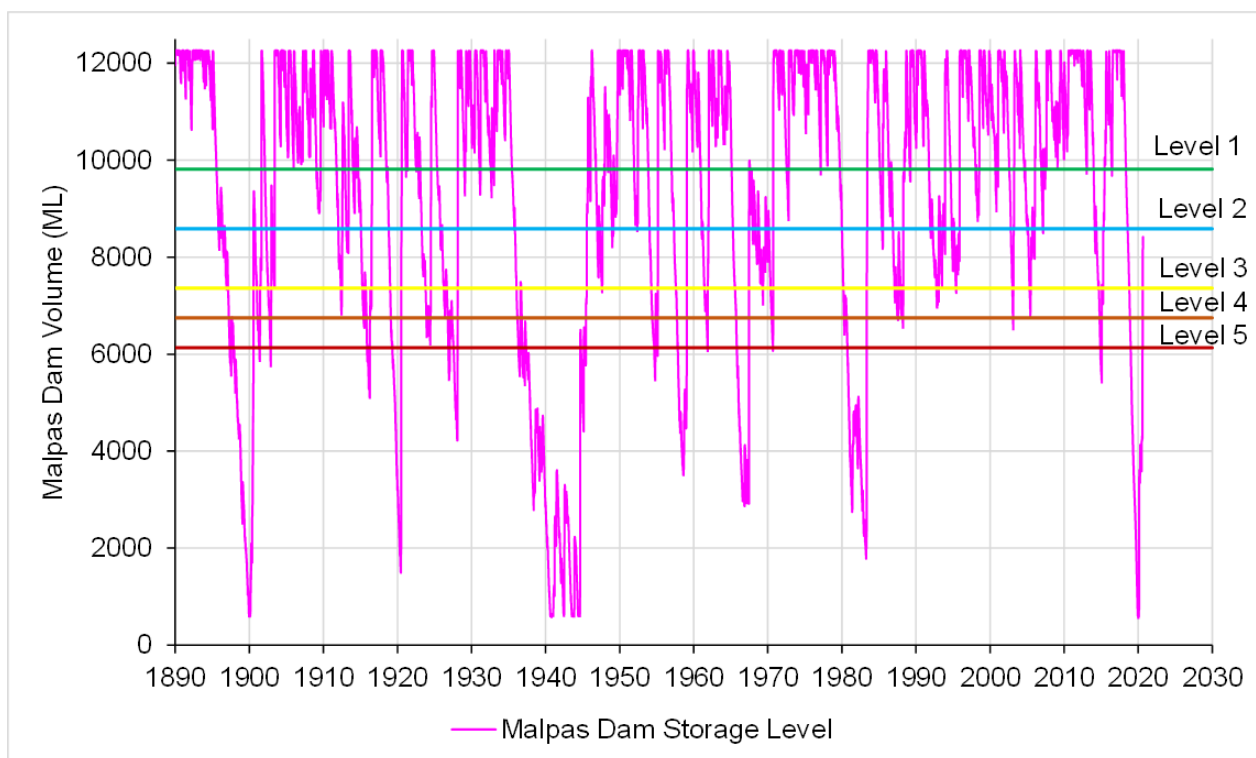


Figure 3-2: Storage behaviour of Malpas dam hindcast when supplying 2048 demand

Figure 3-1 and Figure 3-2 shows how often Level 5 restrictions would be imposed when supplying the 2021 and 2048 demands, with the storage emptying for the Federation, World War and 2019 droughts. This situation would be further exacerbated due to future climate change which is expected to further reduce the yield of the Malpas dam catchment.

3.2 Quantifying the issue

In order to quantify the water security issue, the capacity of the existing system needs to be defined. The capacity of the existing headworks is defined as the annual demand that can be supplied on a secure yield basis. Water security is then achieved if the secure yield of a water supply headworks is at least equal to the forecast unrestricted annual demand estimated in Table 3-1.

'Secure yield' is estimated in accordance with DPIE Water's draft guidelines "*Assuring future urban water security, Assessment and Adaption guidelines for NSW local water utilities*". Secure yield is defined as the highest annual water demand that can be supplied from a water supply headworks system while meeting the '5/10/10 design rule'. This rule dictates that water restrictions must not be too severe, not too frequent, nor of excessive duration, hence under the NSW Security of Supply requirement, water supply headworks systems are normally sized so that:

- Duration of restrictions does not exceed 5% of the time; and
- Frequency of restrictions does not exceed 10% of years
- Severity of restrictions does not exceed 10%. Systems must be able to meet 90% of the unrestricted annual water demand through simulation of the worst drought on record, commencing with the storage drawn down to the level at which restrictions need to be imposed to satisfy a) and b) above at the time restrictions are introduced.

This enables water utilities to operate their systems without restrictions until the volume of stored water approaches the restriction volume. The above rule is typical of what is being used by Local Water Utilities across Regional NSW as a service standard for water security. Council could

consider variations to this rule to see what impact it has on the town water security and the infrastructure needs.

The secure yield of the water supply system estimated for the historical climate and for the 1°C climate warming scenario for the 5/10/10 rule, is provided in Table 3-2.

Table 3-2: Secure yield estimates for Armidale and Guyra water supplies

	Secure yield for historic climate	Secure yield for 1°C climate warming
Armidale (ML/year)	3,428	2,333
Guyra (ML/year)	175	95

For a total 2048 unrestricted annual demand of 5,778 ML/year and a total climate change secure yield of 2,428 ML/year, there is a shortfall of 3,350 ML/year and water security is not achieved for the 5/10/10 rule.

4. Augmentation of Malpas dam capacity

As the existing Malpas dam storage was found to be insufficient, the option of augmenting the storage by raising Malpas dam was considered. Council engaged PWA to investigate options for raising Malpas dam considering the existing safety levels of the dam and meeting the requirements of the Australian National Committee on Large Dams (ANCOLD) and Dams Safety NSW (DSNSW). The investigation included the following three (3) options:

1. Dam upgrade with current FSL;
2. Dam upgrade with FSL raised by 3.0m; and
3. Dam upgrade with FSL raised by 6.5m.

To test if this storage augmentation would be sufficient, further modelling was undertaken to assess the water security of the system with the Malpas dam raised by 3.0 m and 6.5 m. The results are presented in Table 4-1.

Table 4-1: Secure yield estimates for raised Malpas dam

	Secure yield for 1°C climate warming
Guyra + 3.0m raised Malpas dam + Puddledock	3,044
Guyra + 6.5m raised Malpas dam + Puddledock	3,690

The results showed that even with an augmented storage provided by a 6.5 m raising of the Malpas dam wall, the secure yield would still be insufficient to meet the forecast 30-year extraction requirements. This indicates that the water resource yield from the Gara River may be at the limit and raising Malpas dam alone will not secure the water supply.

To meet the shortfall and achieve water security, the current Malpas dam source needs to be augmented and potentially supplemented by an additional/alternate water source.

5. Alternate source options

The following long list of source options that could supplement the current scheme, were considered:

- Surface water
- Groundwater

- Recycled effluent
- Sea water
- Managed Aquifer Recharge
- Rainwater
- Stormwater

A description of these sources is provided below.

Surface water

The new surface water sources were identified using information on stream gauges, provided by DPIE Water. These included: the Gwydir River in the Moredun Creek Water Source, the Aberfoyle River in the Aberfoyle River Water Source (within the Clarence River Catchment) and the following water sources within the Macleay River Catchment:

- Gara River Water Source
- Salisbury Waters Water Source
- Styx River Water Source
- Chandler River Water Source.

Groundwater

In July 2019 Armidale Regional Council (ARC) engaged Hydroilex to undertake an investigation to provide an assessment of the potential for groundwater in the Guyra region. The investigation (Hydroilex, 2019) identified 10 test bore sites of which four were deemed to have sufficient yield for production bores. Council estimated a total yield of 1,512 kL/d from these bores for 16 hours pumping. This amounted to about 550 ML/year.

Council made an application to the Natural Resource Access Regulator (NRAR) for a Local Water Utility (LWU) category Specific Purpose Access License (SPAL) for 512 ML/year. DPIE Water Hydrogeologist recommended NRAR approve an extraction of about 200 ML/year. The primary concern was the potential impact in the neighbouring bores. There is potential for higher allocation if monitoring bores with data loggers are placed in strategic locations and Council agrees to reduce the allocation if potential adverse impacts are identified in the monitoring bores.

Recycled effluent

Recycled effluent can be used as a water source and can also be used to reduce the potable water demand by substitution for some applications such as lawn irrigation. The source water options for recycled effluent are direct and indirect potable reuse, and as environmental flow substitution.

Direct and indirect potable reuse

Direct Potable Reuse (DPR) can be defined as either the injection of recycled water directly into the potable water supply distribution system downstream of the water treatment plant, or into the raw water supply immediately upstream of the water treatment plant.

Indirect potable reuse (IPR) can be defined as the treatment and eventual return of sewage effluent into the current/natural water cycle well upstream of the drinking water treatment plant.

To date, DPR and IPR have not been done anywhere in Australia and the regulatory framework in this regard has not been developed. Recycled effluent as DPR and IPR has therefore not been considered further as a source option.

Environmental flow substitution

Currently there are some operating rules on Council's Water Access License that require releases to be made in the Malpas Dam Water Source, as environmental flows. Using recycled effluent to

provide the environmental flows (e-flows), thereby maintaining the water in the dam, would provide an increase in the yield of the current headworks.

A higher effluent quality would be required if the effluent is to be used as an e-flow substitute. This will require an upgrade/augmentation of the Armidale sewage treatment plant to an activated sludge-based process. A typical cost of this upgrade based on an Intermittently Decanted Extended Aeration (IDEA) activated sludge process, is about \$30M. The government policy and regulatory framework has also not been developed for this use of recycled effluent and hence the process for obtaining regulatory approval is unknown.

Sea water

Desalinated sea water provides a climate independent source. However, Armidale and Guyra being located inland, the transfer of sea water and the disposal of brine would be significant challenge. Hence sea water has not been considered further as a source option.

Managed Aquifer Recharge

Managed Aquifer Recharge (MAR) is a mechanism to store water and supply it later, in the future, when needed. Depending on the approach to getting water into the aquifer, additional treatment can also be affected. If MAR is found acceptable, it can be used to store water from various sources, including urban storm water, treated sewage effluent, desalinated seawater, rainwater, or even rural runoff.

Where suitable aquifers are available, subsurface storage is beneficial to projects that involve indirect reuse of recycled water. The hydraulic retention time within the storage is important to allow for required water quality improvements.

MAR is akin to 'Water Banking', where water is stored for later use and does not quite meet the requirement of being an alternate source for Armidale. The regulatory framework for this process has not yet been developed. MAR has therefore not been considered further as a source option.

Rainwater

Rainwater can be harvested using rainwater tanks installed at individual dwellings and other commercial, institutional and community premises. Rainwater tanks are already included in most new residential developments in order to achieve the BASIX aims to reduce the average potable water consumption of new residential developments. However, the yield from rainwater tanks during drought is not reliable and hence it has not been considered further as an alternate source option.

Stormwater

Stormwater harvesting requires construction of significant infrastructure. However, like rainwater tanks, the stormwater yield during drought is not reliable and hence it has not been considered further as an alternate source option.

6. Alternate surface water sources

The identification and preliminary assessment of new water sources was done using information on stream gauges, provided by DPIE Water. These included: the Gwydir River in the Moredun Creek Water Source, the Aberfoyle River in the Aberfoyle River Water Source (within the Clarence River Catchment) and the following water sources within the Macleay River Catchment:

- Gara River Water Source
- Salisbury Waters Water Source
- Styx River Water Source
- Chandler River Water Source.

The stream gauge information obtained from DPIE Water, along with the location of the gauges, are provided in Appendix A. Once the catchments were assessed, extraction points were located, and storage sites were identified.

6.1 Location of extraction points

Locations for extraction points (pumping stations) in the selected water sources were identified based on the following criteria:

- outside of national parks and nature reserves
- reasonably accessible by vehicles
- have a large catchment area
- be a potential storage site.

The extraction locations and the associated catchment boundaries are provided in Table 6-1 and shown in Figure 6-1.

Table 6-1: Extraction locations on new water sources

Catchment	Area (km ²)	Elevation (mAHD)	Major catchment
Aberfoyle River at Goonyal	250	1,065	Clarence River
Nowlands Backwater at Riverview	170	995	Clarence River
Bakers Creek U/S of Grafton Road	130	965	Macleay River
Chandler River D/S Grafton Road	310	915	Macleay River
Junction of Commissioners Waters and Gara River	900	905	Macleay River
Salisbury Waters U/S of Dangars Falls	630	965	Macleay River
Styx River U/S of Kempsey Rd	160	810	Macleay River
Wollomombi River U/S Grafton Road	390	920	Macleay River
Gwydir River at Bundarra	4,290	760	Gwydir River
Gwydir River at Yarrowyck	850	660	Gwydir River

In the 1956, Council considered sourcing water from Serpentine Creek, near the junction of Serpentine Creek and Back Creek. This option has been excluded as the right bank of Serpentine Creek is the eastern boundary of the Serpentine Nature Reserve.

Armidale water supply – water security options

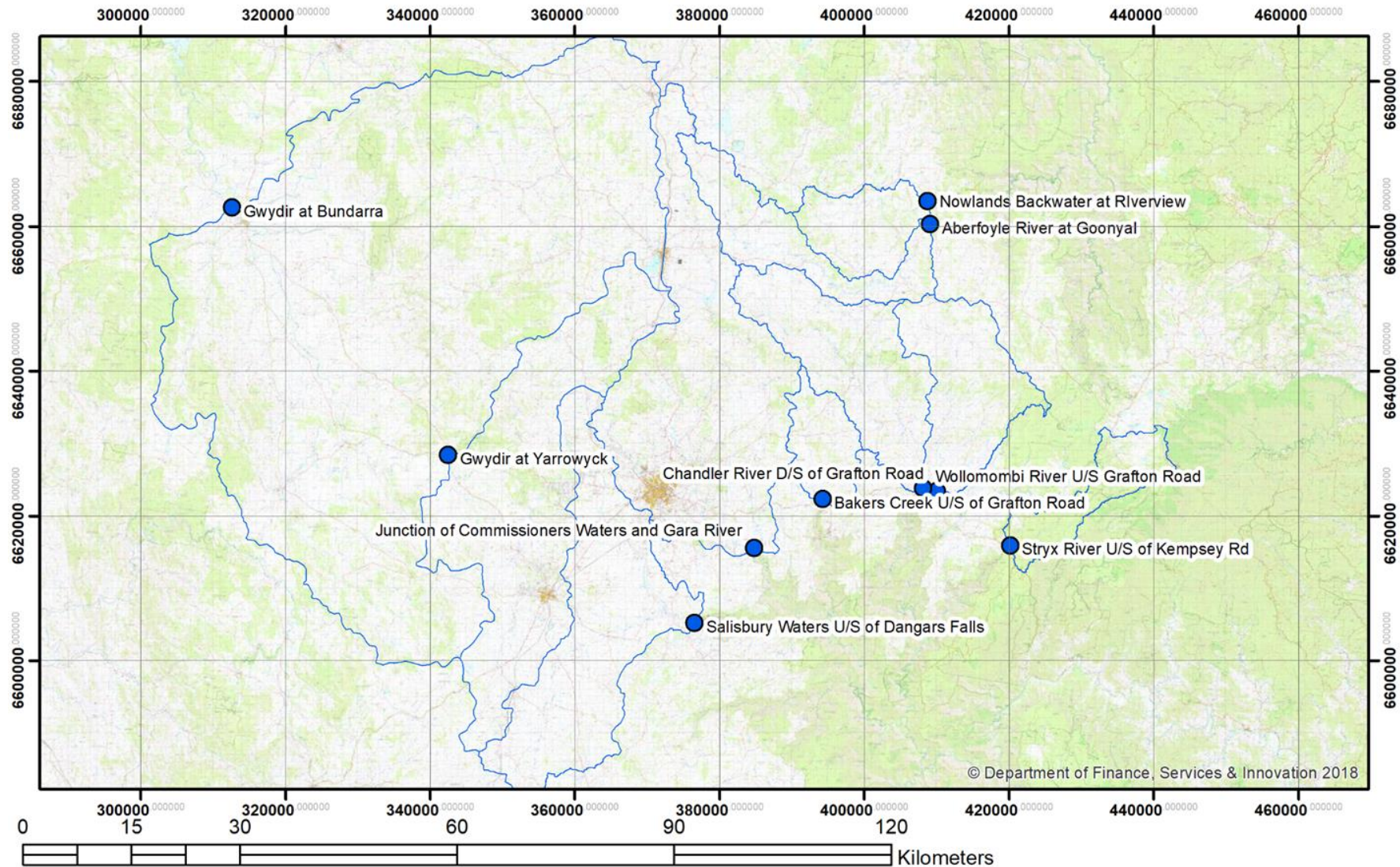


Figure 6-1: Potential pump station locations and catchment boundaries

6.2 Identification of storage sites

A number of sites were also identified for storage options. They were classified as:

- On river – traditional dams that capture most of the local runoff that is physically possible
- Off river – small storages in small catchments that store water transferred in from major waterways
- Hybrid – a combination of the above two options.

The storage sites were chosen to require short dam walls, store a large volume of water and have large relatively deep lakes. The storages were classified as small (between 4 and 11 GL) and large (greater than 20 GL) storages. The guidelines used in the selection of the storage sites, the methods used to calculate the wall height, the storage volume and the efficiency are provided in Appendix B. The small and large storages identified, are provided in Table 6-2 and Table 6-3.

Table 6-2: Small storages

Name	Volume (ML)	Wall height* (m)	Wall length (m)	Surface area (ha)	Volume stored per volume of wall	Higher wall acceptable	Local catchment area (km ²)	Comment
Boorolong Creek (small)	6,333	25	300	76	22.52	Yes	290	Hybrid
Devils Hill	10,583	25	600	127	18.81	Yes	7.13	Off river
Cooney Creek	4,333	25	209	52	22.12	Yes	46.4	Off river
Grose Creek	7,750	25	635	93	13.02	No	30.8	Hybrid
Jeogla Creek	5,300	30	274	53	14.33	Yes	22.5	Off river
St Helena Creek	8,460	27	520	94	14.88	No	8.6	Off river
Wyatts Creek	7,400	30	418	74	13.11	No	12.1	Hybrid

Table 6-3: Large storages

Name	Volume (ML)	Wall height* (m)	Wall length (m)	Surface area (ha)	Volume stored per volume of wall	Suitable for use in major transfer	Lower wall acceptable	Higher wall acceptable	Catchment area (km ²)
Aberfoyle River	20,300	35	420	174	26.30	No	Yes	No	136
Boorolong Creek	32,700	45	533	218	20.20	No	Yes	No	160
Chandler River	36,850	55	705	201	11.52	No	Yes	No	146.8
Gara River	33,183	55	460	181	15.90	Yes	Yes	Yes	253.8
Mehi Creek	65,400	45	1275	436	16.89	No	Yes	No	41.9
Nowlands Backwater	72,417	55	570	395	28.00	Yes	Yes	Yes	169.7

Armidales water supply – water security options

Name	Volume (ML)	Wall height* (m)	Wall length (m)	Surface area (ha)	Volume stored per volume of wall	Suitable for use in major transfer	Lower wall acceptable	Higher wall acceptable	Catchment area (km ²)
Styx River	76,400	60	490	382	28.87	Yes	Yes	No	131
Toms Creek	88,000	55	902	480	21.50	Yes	Yes	Yes	91.9
Wollomombi River	37,917	35	382	325	54.02	Yes	Yes	No	344.6

The locations of the storages (excluding Devils Hill) are shown in Figure 6-2 and Figure 6-3. The maps of individual storages are provided in Appendix C. The Devils Hill site is approximately 13km south-southwest of Bundara and 58km northwest of Uralla.

Armidale water supply – water security options

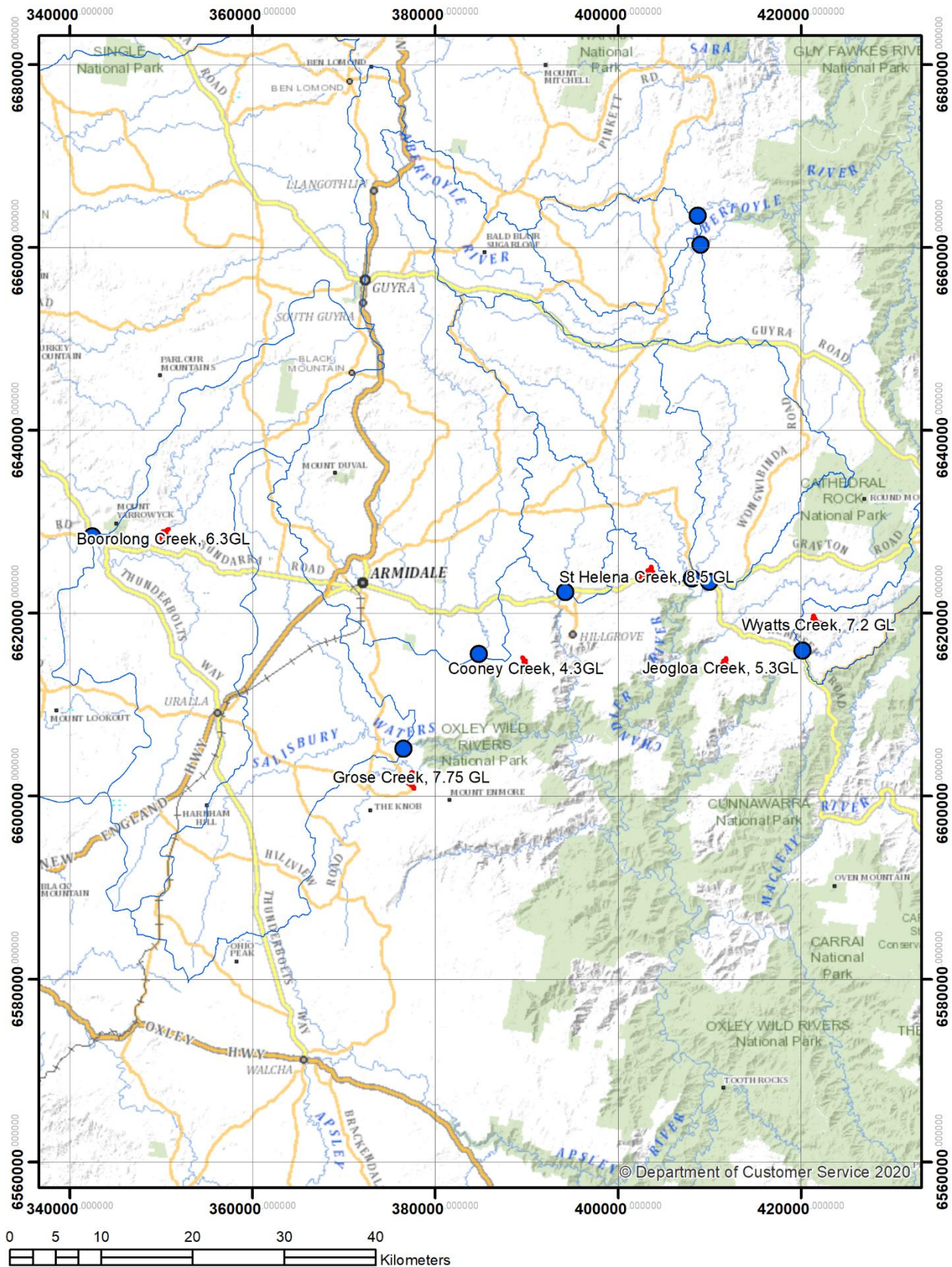


Figure 6-2: Locations of small storages excluding Devils Hill

Armidale water supply – water security options

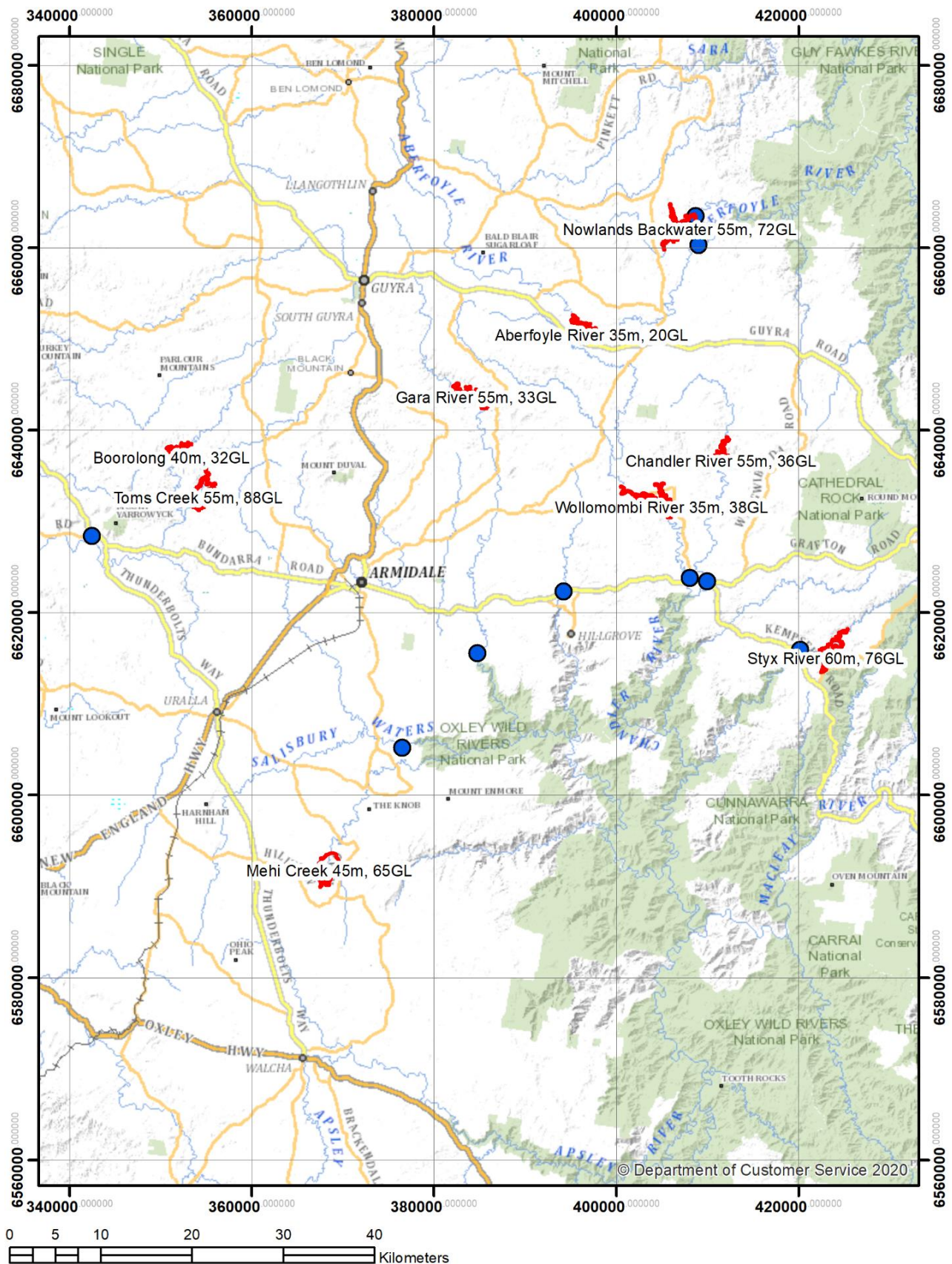


Figure 6-3: Locations of large storages

6.3 Shortlisting of schemes

The long list of extraction locations and storage sites were shortlisted through an objective assessment process. The 'Themes' and categories within these Themes, that were used for the assessment of the extraction and storage options, are provided in Table 6-4.

Table 6-4: Assessment criteria used for shortlisting of extraction and storage sites

Theme	Category	Basis	Fail Criteria
Water security	Storage volume	Total volume of Malpas and Guyra dams is 13 GL	<5 GL
	Mean discharge	Estimated mean discharge for Malpas is 67 ML/day	<60 ML/day
Potential future risk management	Ability to augment storage	Same as storage volume	None
	Catchment land use up to intake or storage	Minimise pathogen and hazardous chemical risk pathways	Close to known point sources of pollution
Land use	Environmental value of inundated area	Minimise ecological damage to natural ecosystems	> 2km ² in high natural value forest
	Number of private land holders of the inundated area	Relative between options	None
	Heritage - Aboriginal (AIHMS sites results) (inc. pumpstation locations)	Relative between options	None
	Highest environmental and terrestrial value of downstream water courses	The distance to National Park	None
	Downstream river distance to National Park from storage and pump stations	Relative between options	None
Engineering Challenge	Steep terrain at dam site	Relative between options (Malpas 31m high, 500m long, ratio = 16)	None
	Accessibility to site (distance to B-Double Route)	Relative between options	None
	Complexity	Relative between options	None
	Distance from Armidale WTP	Relative between options	None

The following options were excluded due to the fail criteria:

- Located in Gwydir Catchment - Boorolong Creek (small), Boorolong Creek (large), Devils Hill, Toms Creek
- Did not meet minimum storage volume– Cooney Creek

- Hazardous chemicals – Gara River below junction with Commissioners Waters (pumping station location), Wollomombi River storage and Wollomombi River pumping station are all downstream of former mines sites known to be contaminated with arsenic and/or antimony.

The detailed scoring criteria and outcomes of the assessment are provided in Appendix D. The top ten shortlisted scheme options are provided in Table 6-5.

Table 6-5: Shortlisted scheme options

Storage	Source 1	Source 2	Source 3
St Helena Creek	Styx River U/S of Kempsey Road	None	None
St Helena Creek	Styx River U/S of Kempsey Road	Chandler River D/S of Grafton Road	None
St Helena Creek	Styx River U/S of Kempsey Road	Chandler River D/S of Grafton Road	Bakers Creek U/S of Grafton Road
Styx River	Styx River	None	None
Chandler River	Styx River U/S of Kempsey Road	None	None
Raised Malpas dam	Styx River U/S of Kempsey Road	None	None
Raised Malpas dam	Styx River U/S of Kempsey Road	Chandler River D/S of Grafton Road*	None
Raised Malpas dam	Styx River U/S of Kempsey Road	Chandler River D/S of Grafton Road	Bakers Creek U/S of Grafton Road
Nowlands Backwater	Aberfoyle River at Goonyal	None	None
Raised Malpas dam	Aberfoyle River at Goonyal	Nowlands Backwater	None

The storages on the Styx River, Aberfoyle River and Nowlands Backwater are prohibited under the Water Sharing Plans.

6.4 Assessment of shortlisted schemes

The shortlisted schemes were assessed to determine if the secure yield from the schemes would make-up the shortfall in the existing scheme. The three main water sources in the shortlisted schemes are the Styx River U/S of Kempsey Road, the Aberfoyle River at Goonyal, and the Chandler River D/S of Grafton Road, with Nowlands Backwater and Bakers Creek as secondary sources.

6.4.1 Environmental flow rules

Any augmentation of the existing water supply works could trigger the inclusion of additional operating rules on Council's water access license (WAL). The objectives of these rules are to comply with the principles of the Water Management Act, manage downstream third party impacts, and to protect the health of the rivers and their instream ecology.

Current operating rules

Currently there are some operating rules on Council's WAL which are based on the requirements of the Water Sharing Plan (WSP).

WSP access rule – CI 28 Releases in the Malpas Dam Water Source

(2) Subject to subclause (3), when inflows to Malpas Dam, as measured at the Gara River at Willow Glen gauge (206035), are:

- a) less than 1 ML/day, a release equal to or greater than the inflows plus 1 ML/day, must be made from Malpas Dam, or
- b) equal to or greater than 1 ML/day and less than or equal to 6 ML/day, a release of 2 ML/day or greater, must be made from Malpas Dam, or
- c) greater than 6 ML/day, a release of 3 ML/day or greater, must be made from Malpas Dam.

(3) Subclause (2) does not apply when the Malpas Dam is less than or equal to 55% (6,724 ML) of the dam's storage capacity.

Proposed operating rule

For the augmented scheme options, the following operating rule is proposed.

for Styx, Aberfoyle, and Chandler Rivers:

1. January to July can only transfer/store when flow is above the 90th percentile
2. August to December can only transfer/store when flow is above the 80th percentile
3. Can only extract 30% of the flow above the 80th percentile flows.
4. If Malpas dam less than 60% full then above 90th percentile is relaxed to 95th percentile and 80th percentile relaxed to 90th percentile
5. Existing Malpas Dam WSP rule remains with 55% of existing dam volume.

The above proposed operating rule is typical and based on experience in other projects. Additional environmental assessments and studies by eco-hydrologists will need to be done to gather more specific information which will be reviewed by DPIE Water. The final environmental flow rules will be determined and approved by the Natural Resources Access Regulator (NRAR).

6.4.2 Secure yield analysis

The secure yield was initially estimated for the following schemes:

1. St Helena Creek off-stream storage (8,460 ML) sourced from Styx River
2. Chandler River on-stream storage sourced from Chandler River and Styx River
3. Pumping from Styx River to raised Malpas Dam
4. Pumping from Aberfoyle River to raised Malpas Dam

If extraction from the main source did not provide the required secure yield, the secondary sources were progressively added to the scheme. If, with the addition of the secondary sources, the schemes did not provide the required secure yield then the storage on Styx River and Nowlands Backwater, currently not permitted under the WSP rules, would be considered. The shortlisted schemes that would meet the shortfall in secure yield, either by pumping to a raised Malpas dam or pumping to a new storage, are provided in Table 6-6.

Table 6-6: Shortlisted schemes that meet the secure yield shortfall

Scheme	Water Source(s)	New works
Raised Malpas dam (MD)	Styx River U/S of Kempsey Road	6.5m raised MD 50 ML/d transfer from Styx River
Raised Malpas dam (MD)	Aberfoyle River at Goonyal & Nowlands Backwater (NB)	6.5m raised MD 50 ML/d transfer from Aberfoyle River and NB.
Storage on Chandler River	Styx River U/S of Kempsey Road	3,552 ML On-River storage 50 ML/d transfer from Styx

6.5 Oaky River Dam

Oaky River Dam was a hydroelectric dam owned by Essential Energy located on Oaky River, approximately 3 km downstream of Kempsey Road. The dam was built between 1951 and 1956 and has a catchment area 200 km², which is mostly pasture and which is larger than the 160 km² Styx River catchment being considered. The dam had a gross storage capacity of about 2,700 ML at Full Supply Level and stored water was used to power 5 turbines with a combined output of 12 MW.

The right embankment of the dam failed during an extreme flood event on 22 February 2013. In October 2014, George Samios and Steve Gough presented a paper to the annual ANCOLD conference on the failure of Oaky River Dam and the cost of repair. The estimated direct cost to repair the dam and upgrade it to meet the Dam Safety requirements at the time was \$5.96 M ex GST, applying the relevant capital cost factor from the NSW Reference Rates Manual (1.12), the current estimated direct cost of the repairs and upgrades is \$6.675 M ex GST and the total capital cost is \$8 M ex GST.

Essential Energy does not plan to repair the dam as power generation is no longer their core business. The dam is within one of the NSW Government's renewable energy zones. Therefore, there is the potential that the site could be sold or transferred to another organisation for re-development into a pumped hydroelectric scheme.

From Council's perspective, if the site can be obtained, it has several advantages:

- access to site and power supplies have already been constructed
- the existing site use means that the environmental impact is lower
- the site is expected to have similar flow characteristics to the Styx River, therefore the potential yield is expected to be similar
- the water sharing plan allows for dams in the Oaky River Water Source
- the river is 50m above the Styx River source considered and about 8km closer to Armidale reducing both the pumping power required and the pipeline cost.

The Oaky River Dam source is expected to have the same flow as the Styx River source. This is a reasonable assumption given:

- the catchment is slightly larger, (Oaky River 210 km², Styx River 160 km²)
- the catchment is mostly pasture, this generally leads to more initial runoff and less initial infiltration, this in turn leads to less flow during droughts
- the dam will hold more water than the pool in the Styx, therefore it is expected that water will be available for pumping on more days.

Given the 2700 ML instream storage of Oaky River Dam, the yield is likely to be greater than pumping high flows from a smaller natural pool on the Styx River. A secure yield analysis needs to be undertaken for the Oaky River dam, which would need to consider the following:

- 25, 15 and 10 ML/d transfers from Oaky River Dam direct to Malpas Dam for the 2,700 ML instream storage (with the option to bypass Malpas Dam during periods of poor water quality).
- 25, 15 and 10 ML/d transfers from Oaky River Dam direct to Armidale WTP as a base load supplemented by transfers from Malpas Dam
- 25 and 15 ML/d transfers from Oaky River Dam direct to Armidale WTP as a base load supplemented by transfers from Malpas Dam with excess transfers from Oaky River Dam transferred up to Malpas Dam.

7. Groundwater

A groundwater investigation undertaken by Hydroilex identified 10 test bore sites with a recommendation to construct all bores that have an indicative yield of greater than 3 L/s. Of the ten test bores, four were deemed to have sufficient yield for production bores. Council estimated a total yield of 1,512 kL/d from these bores for 16 hours pumping. This amounted to about 550 ML/year.

In order to meet the shortfall in secure yield of 3,350 ML/year about 25 to 30 more production bores would be required. Further, if the license issued by NRAR imposes a condition that restricts the extraction from the bore to 50 percent of its capacity, then about 50 bores would be required. The bores would be located at least 500m apart which would extend to about 25 km for 50 bores, with the associated transfer system. The risks of developing such a borefield include:

- finding the number of bores required with sufficient yield
- obtaining approval for the bore construction
- negotiating the land and access requirements for the scheme

Considering the above risks and challenges, the development of a borefield to supply to entire shortfall in yield, has not been considered. Instead, only the four production bores that have already been drilled are considered in the following two options:

- as a reliable supplementary source to the surface water
- as an alternate drought contingency source

For this assessment, a conservative groundwater yield of 200 ML/year has been considered as a reliable supplementary source to the surface water.

8. Scheme options

Following the identification of the alternate surface water options that would meet the shortfall in secure yield, further analysis was undertaken to develop the scheme options. The following scheme options were assessed:

No Malpas dam raising

- Transfer from the Styx River
- Transfer from the Aberfoyle River and Nowlands Backwater
- Chandler River storage
- Transfer from Oaky River to Malpas Dam

3m Malpas dam raising

- Transfer from the Styx River

- Transfer from the Aberfoyle River and Nowlands Backwater
- Transfer from Oaky River to Malpas Dam

6.5m Malpas dam raising

- Transfer from the Styx River
- Transfer from the Aberfoyle River and Nowlands Backwater
- Transfer from Oaky River to Malpas Dam

Those of the above options that exceeded or were close to the target of 5,778 ML/year, are outlined in Table 8-1. The works required in each of these options (including the Oaky River Dam options) are provided in Table 8-2.

Table 8-1: Scheme options that meet the secure yield shortfall

Storages	Malpas dam raising	Additional source/storage
Guyra + Malpas + Puddledock	No	25 ML/d from Styx River
	No	15 or 25 ML/d from Oaky River
	No	7.8 GL on-stream Storage on Chandler River, plus pumping from the Styx River to the Chandler River
	3m	15 ML/d from Styx River
	3 m	10 or 15 ML/d from Oaky River
	6.5m	10 ML/d from Styx River
	6.5 m	10 ML/d from Oaky River
	6.5m	10 ML/d from Aberfoyle and 10 ML/d from NB

Table 8-2: Works required for the scheme options

No	Malpas dam raising	Additional source/storage	Works required
1	No	25 ML/d from Styx River	74 km of 600mm diameter pipeline, 2 pumping stations (1060kW & 840kW)
2	No	10 ML/d from Styx River + 7.8 GL on-stream Storage on Chandler River	66 km of 375mm diameter pipeline 2 pumping stations (400 kW & 540 kW) 1 dam 7.8 GL
3	3m	15 ML/d from Styx River	74 km of 450mm diameter pipeline 2 pumping stations (680 kW & 590 kW) Raise Malpas Dam 3m
4	6.5m	10 ML/d from Styx River	74 km of 375mm diameter pipeline 2 pumping stations (470 kW & 420 kW) Raise Malpas 6.5m

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No	Malpas dam raising	Additional source/storage	Works required
5	6.5m	10 ML/d from Aberfoyle River and 10 ML/d from Nowlands Backwater	13 km of 375mm diameter pipeline 44 km of 525mm diameter pipeline 3 pumping stations (90 kW, 730 kW and 270 kW) Raise Malpas 6.5m
6	No	25 ML/d from Oaky River Dam	Restore and upgrade Oaky River Dam Transfer to Malpas Dam 67 km of 600mm diameter pipeline, 2 pumping stations (880kW & 840kW)
7	3m	15 ML/d from Oaky River Dam	Restore and upgrade Oaky River Dam 67 km of 450mm diameter pipeline 2 pumping stations (560kW & 590kW) Raise Malpas Dam 3m
8	6.5m	10 ML/d from Oaky River Dam	Restore and upgrade Oaky River Dam Transfer to Malpas Dam 67 km of 375mm diameter pipeline 2 pumping stations (380kW & 420kW) Raise Malpas dam by 6.5 m

A map showing the locations of the pipelines and pumping stations for the options, is provided in Figure 8-1.

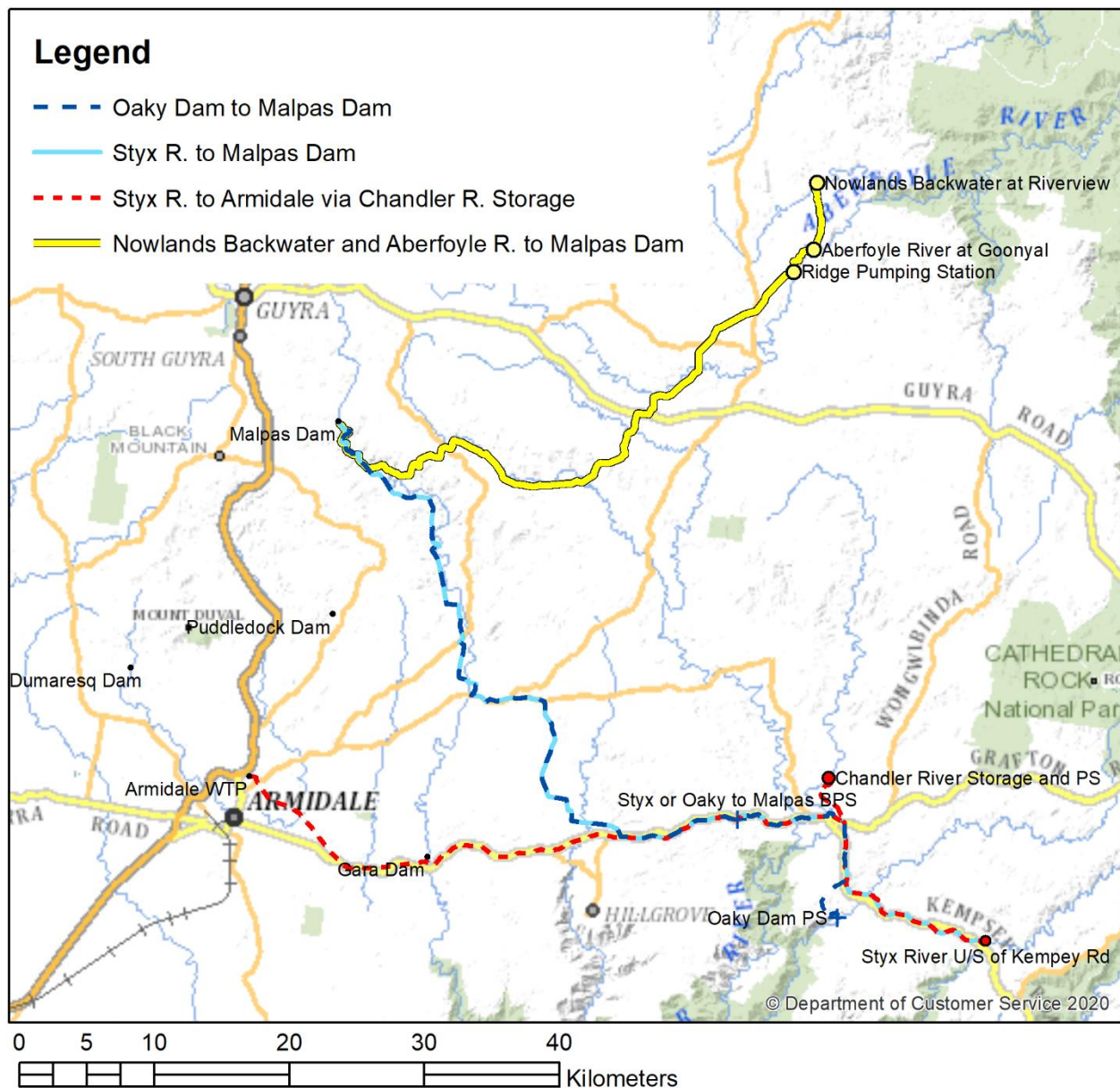


Figure 8-1: Locations of pipelines and pumping stations for the selected scheme options

8.1 Assessment of scheme options

A non-cost assessment was used to rank the shortlisted surface water options. The criteria and their weightings, are provided in Table 8-3, and the scores and rankings are in Table 8-4.

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Table 8-3: Non-cost assessment criteria used for ranking scheme options

Category	Criteria	Discussion	% of category score	% of final score
Total environmental impact (40%)	Environmental value of extraction point	Scores calculated from the sum of the scores for each river extraction point or storage. The scoring system was: Highly modified, area already disturbed for extensive river structures, 3 points Moderately modified, cleared pasture up to the riverbank, 4 points Slightly modified, wooded pasture with livestock excluded from the bank or State Forest up to bank, 5 points	25%	10%
	Additional area inundated	Score calculated using $0.1 \times (\text{additional area inundated (ha)})$	35%	14%
	Land clearing for pipeline and roads	Score calculated using $0.25 \times (\text{length of clearing required (km)})$	20%	8%
	Annual electricity use	Score calculated using $0.005 \times (\text{annual electricity consumption (kWh/year)})$, this resulted in scores ranging from 3.3 to 7.9.	20%	8%
Planning and regulatory approval (20%)	Existing catchment protection	Score calculated per river no new structures in waterways, 0 points structures in sub-catchments where dams are allowed, 2 points minor structures in sub-catchments where dams are prohibited, 4 points	40%	8%
	Approvals required	Score calculated using $2 \times (\text{number of rivers} + \text{number of dams} + 1 \text{ pipeline/road})$.	40%	8%
	Inter-catchment transfer	Score of 4 given if inter-catchment transfer required	20%	4%
Flexibility and future risk management (20%)	Potential for future storage augmentation	Scores assigned: Additional storage available at storage site equivalent to Malpas being raised from current height 6.5m, 4 points Additional storage available at storage site equivalent to Malpas being raised from 3m above current to 6.5m above current, 8 points No additional storage available, 20 points	100%	20%

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Category	Criteria	Discussion	% of category score	% of final score
Constructability (20%)	Rugged terrain	Scores assigned: Less than 2km of steep terrain, 2 points Less than 5km of steep terrain, 3 points More than 5km of steep terrain, 5 points	20%	4%
	Proximity to HV power	Score calculated as (1.7 x distance to closest power pole) + (0.425 length of existing power lines to be upgraded to reach an 11kV 3 phase supply)	55%	11%
	Proximity to main roads	Score calculated as (0.25 x distance to closest B-Double route).	25%	5%

Table 8-4: Non-cost scoring and rank

Scheme Description		25 ML/d from Styx River	10 ML/d from Styx River + 7.8 GL Storage on Chandler River	15 ML/d from Styx River + 3m MD raising	10 ML/d from Styx River + 6.5 m MD raising	10 ML/d from Aberfoyle and 10 ML/d from NB + 6.5m MD raising	25 ML/day from Oaky River to MD	15 ML/d from Oaky River + 3m MD raising	10 ML/d from Oaky River to Malpas + 6.5m MD raising
Environmental impact	River extraction points	5	1	5	5	2	7	7	7
	Additional inundation area	14	1	10	3	3	14	10	3
	Land clearing for pipeline and roads	1	1	1	1	5	2	2	2
	Annual electricity consumption	0	1	0	2	5	1	5	2
	Total	20	4	15	10	14	24	23	14

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Scheme Description		25 ML/d from Styx River	10 ML/d from Styx River + 7.8 GL Storage on Chandler River	15 ML/d from Styx River + 3m MD raising	10 ML/d from Styx River + 6.5 m MD raising	10 ML/d from Aberfoyle and 10 ML/d from NB + 6.5m MD raising	25 ML/day from Oaky River to MD	15 ML/d from Oaky River + 3m MD raising	10 ML/d from Oaky River to Malpas + 6.5m MD raising
Planning/ regulatory approval	Catchment protection	4	2	4	4	0	6	6	6
	Approvals required	2	0	2	2	0	2	0	0
	Inter-catchment transfer	4	4	4	4	0	4	4	4
	Total	10	6	10	10	0	12	10	10
Flexibility and future risk management		3	4	4	0	0	3	4	0
Constructability	Rugged terrain	0	2	0	0	0	0	0	0
	Proximity to HV power	7	5	7	7	1	10	10	10
	Access to main roads	1	1	1	1	1	3	3	3
	Total	8	8	8	8	2	12	12	12
Total non-cost		53	37	53	31	16	66	67	42
Rank		3	6	3	7	8	2	1	5

The options with the 6.5m raising of Malpas Dam receive relatively low non-cost scores due to a lack of future flexibility and increased inundation area.

8.2 Staging and cost estimates

Once the scheme options were identified, potential opportunities for staging of the works were assessed for each option. Staging of the works reduces the life cycle cost of the option. Additionally, if the construction of any new infrastructure can be deferred it allows for the timing of this construction to be reviewed in line with anticipated growth. A construction period of 4 years has been allowed for all augmentations and the groundwater works have been included in stage 1 for all schemes. The staging of the works for the selected scheme options, is shown in Figure 8-2 to Figure 8-6.

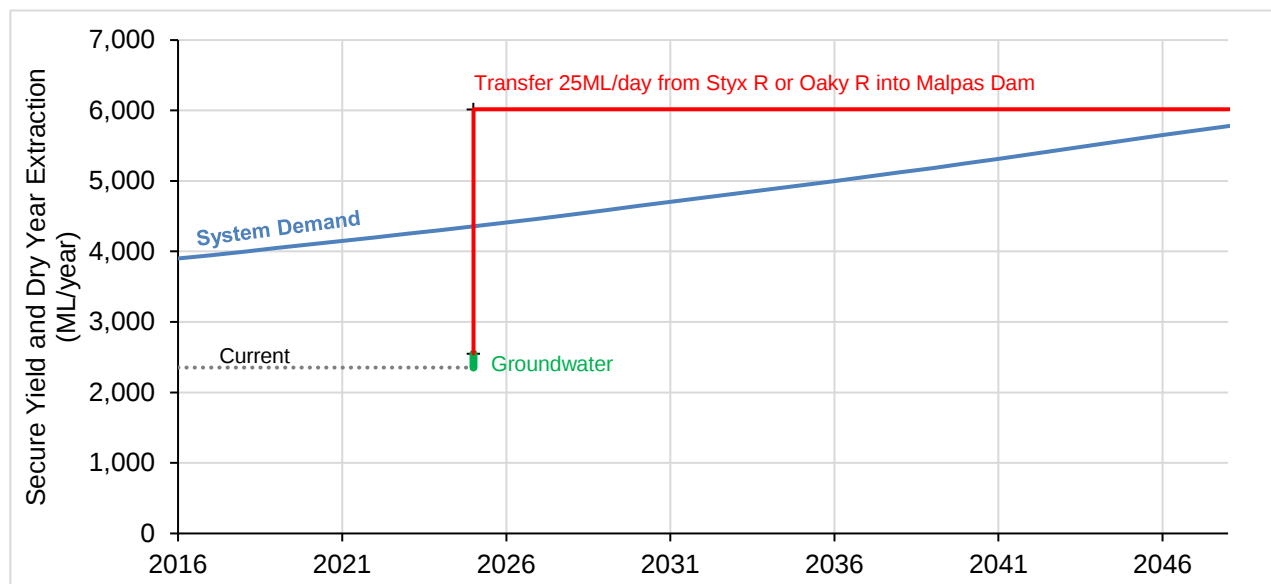


Figure 8-2: Staging – 25 ML/d transfer from Styx River or Oaky River dam

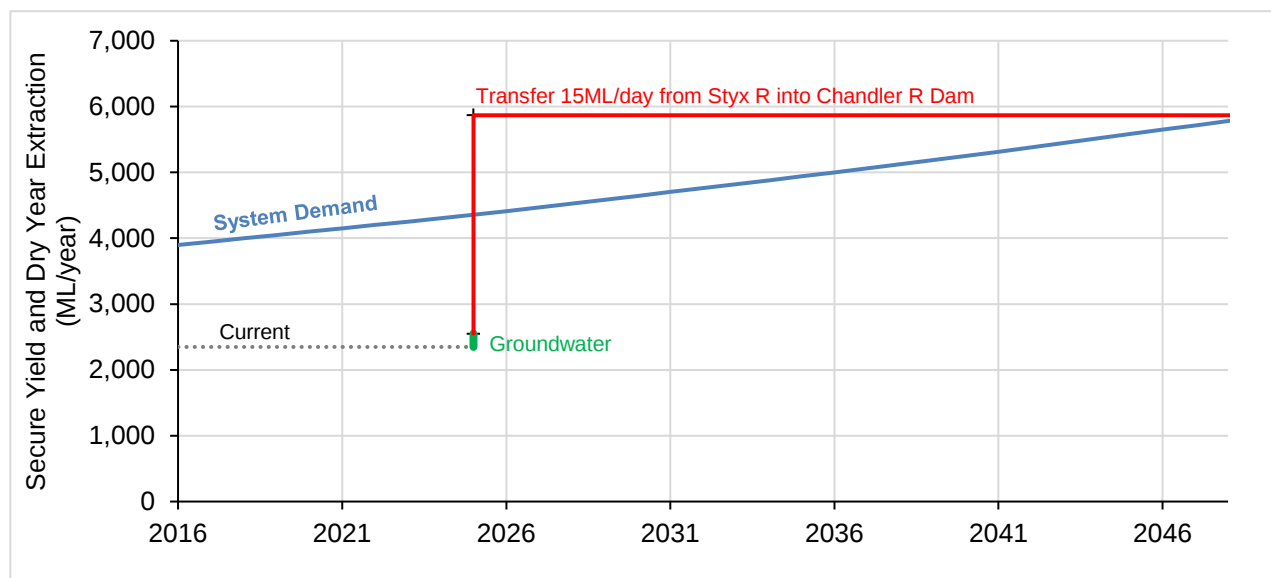


Figure 8-3: Staging – 10 ML/d transfer from Styx River Chandler River storage

Armidale water supply – water security options

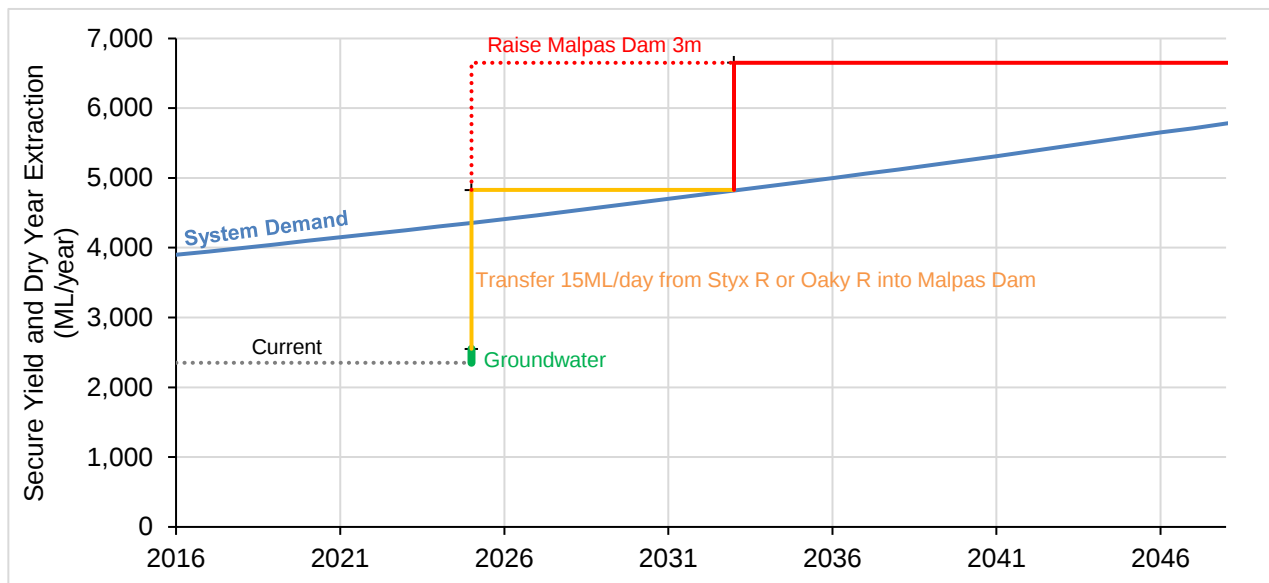


Figure 8-4: Staging – 3m Malpas dam raising and 15 ML/d transfer from Styx River or Oaky River Dam

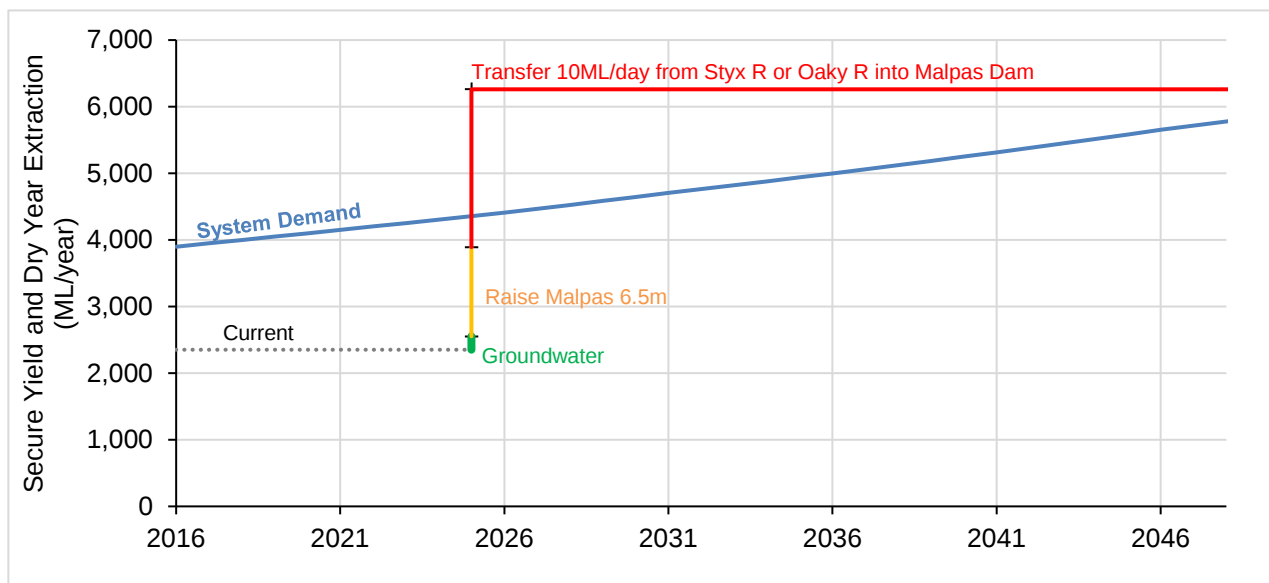


Figure 8-5: Option 4 staging – 6.5m Malpas dam raising and 10 ML/d transfer from Styx River or Oaky River Dam

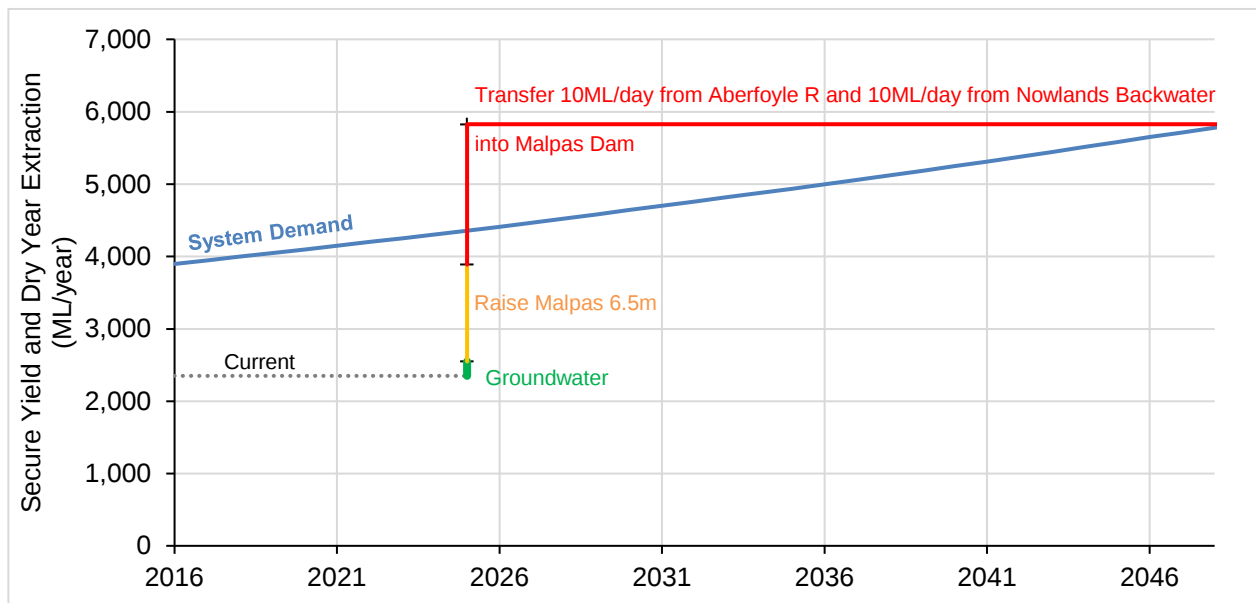


Figure 8-6: Option 5 staging – 6.5m Malpas dam raising 10 ML/d transfer from Aberfoyle and Nowlands Backwater

The 30-year present value (PV) of the scheme options along with the staging sub-options, is provided in Table 8-5. Detail cost estimate spreadsheets are provided in Appendix E.

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Table 8-5: Scheme options cost estimates and TBL score

No	Works	Staging	Capital Cost (\$M)	Annual O&M Cost (\$M)	30-year PV (\$M)	Non-cost Score	TBL Score Non-cost NPV	Rank
1	25 ML/d from Styx River	None	111	1.30	95.53	52.8	0.55	6
2	10 ML/d from Styx River + 7.8 GL Storage on Chandler River	None	99	0.95	84.35	37.2	0.44	8
3	15 ML/d from Styx River + 3m raising	None	102	1.08	87.85	52.5	0.60	5
		Complete Styx River transfer in 2025, raise Malpas by 2033	102	1.10	80.98		0.65	4
4	10 ML/d from Styx River + 6.5 m raising	None	95	0.91	80.98	31.2	0.38	9
5	10 ML/d from Aberfoyle and 10 ML/d from NB + 6.5m raising	None	97	0.86	81.72	16.4	0.20	10
6	25 ML/day from Oaky River to Malpas	None	111	1.22	94.94	65.7	0.69	3
7	15 ML/day from Oaky River to Malpas + 3m raising	None	95	1.07	81.92	67.0	0.82	1
		Complete Oaky River transfer in 2025, raise Malpas by 2033	106	1.07	83.28		0.81	2
8	10 ML/d from Oaky River to Malpas + 6.5m raising	None	100	0.87	83.98	41.9	0.50	7

For the preferred option, a further refinement for the alternate source options would be to transfer from the alternate source directly to the Armidale water treatment plant (WTP). During off-peak demand periods, when the demand on the Armidale WTP is less than the transfer from the alternate source, the excess water would be pumped to Malpas dam using the existing pipeline which gravitates water from the Malpas dam to the Armidale WTP. This refinement would provide the following benefits:

- a shorter pipeline route from the alternate source, making use of existing assets
- an alternate water source enabling Malpas Dam to be taken off-line for maintenance or if there are water quality issues in the dam

The Malpas Dam to Armidale WTP raw water trunk main is mostly constructed of 450 mm steel pipe with sections of 525 mm and 600 mm pipe closer to the dam. If this pipeline is in good condition, then the maximum transfer capacity from Armidale WTP to Malpas dam is estimated to be about 15-20 ML/day.

The 2048 forecast off-peak water demand for Armidale is estimated to be about 9 ML/day. Therefore, the transfer from Armidale WTP to Malpas dam would only be considered for options transferring more than 10 ML/day from the alternate source.

9. Council's aspirational growth strategy

In February 2022 the newly elected Council held a Mayoral Summit and updated the base case population projection and introduced an aspirational population projection. The serviced community population forecasts for the original (1.06%), updated baseline, and aspirational growth rates are shown in Figure 9-1.

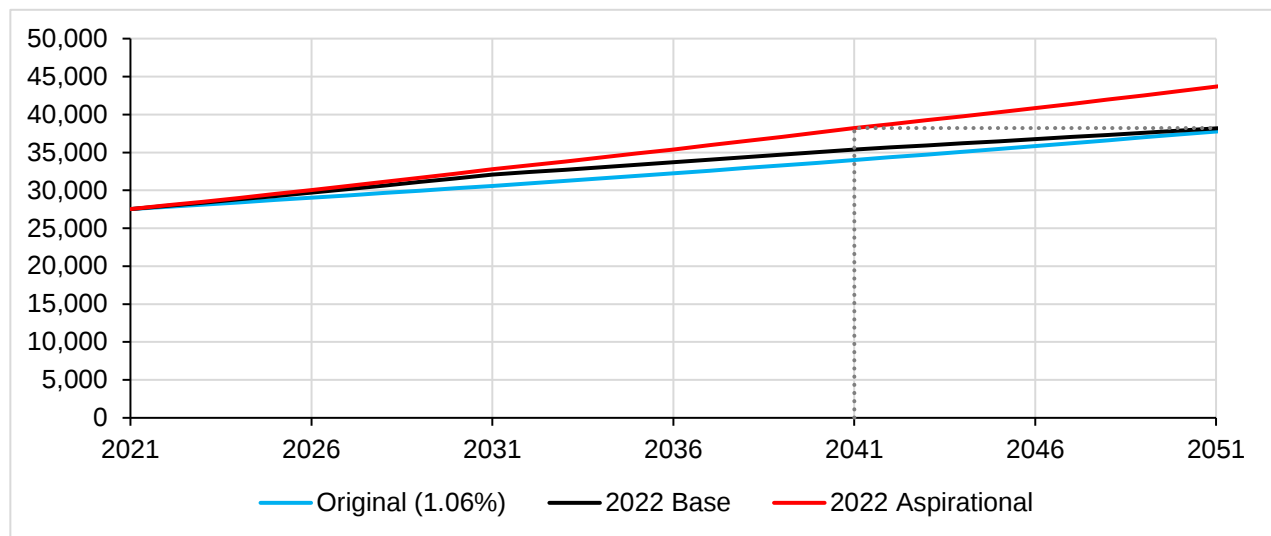


Figure 9-1: Serviced population projection

The details of the original, 2022 base and 2022 aspirational forecasts are provided in Appendix F. The forecast unrestricted annual extraction requirements for each growth forecast are shown in Figure 9-2.

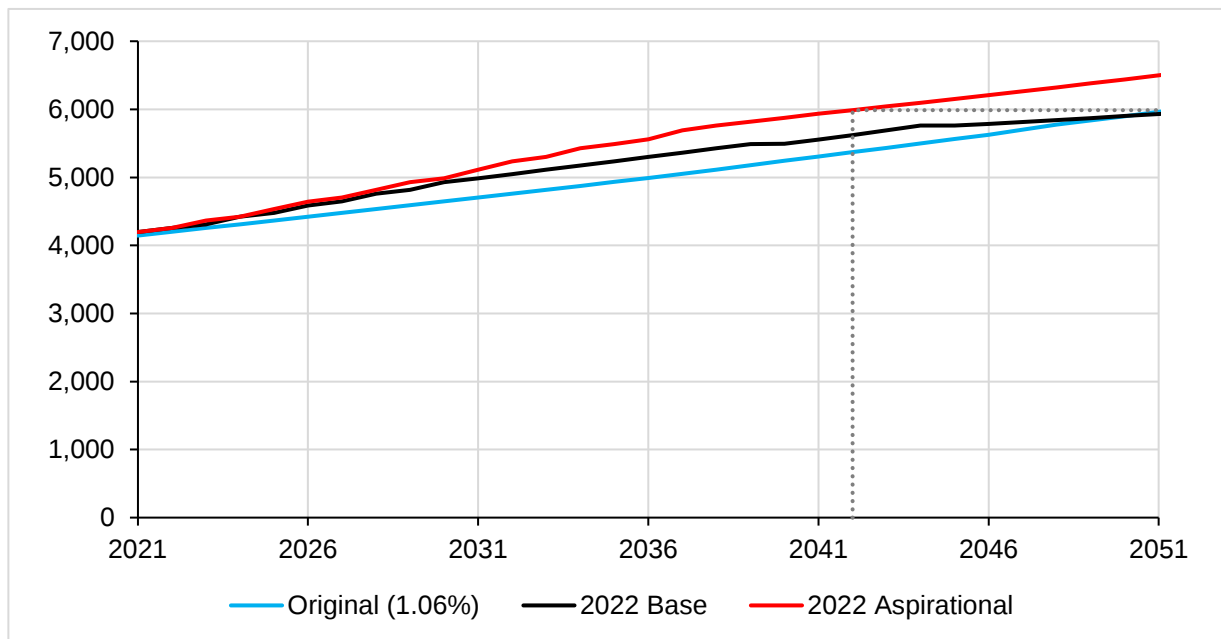


Figure 9-2: Unrestricted annual demand (ML/year)

It can be seen from the above figures that the 30-year population and the unrestricted water extraction requirement for the 1.06% growth rate would be realised in 20 years at the aspirational growth rate. Hence the water security option selected to cater for the 1.06% growth, would need an augmentation in about 15 years.

To accommodate the aspirational growth, the following option is recommended with a staged implementation (which will allow for an adaptive planning approach):

- Stage 1 – construct a 25 ML/d transfer capacity from the Oaky River Dam immediately
- Stage 2 – raise Malpas dam by 6.5m by 2042.

Council is currently negotiating with Essential Energy to acquire the Oaky River Dam. If Council cannot acquire the dam, then the Styx River source will become the preferred option as follows:

- Stage 1 – construct a 25 ML/d transfer capacity from the Styx River immediately
- Stage 2 – raise Malpas dam by 6.5m by 2042.

The secure yield and dry year demand are graphed in Figure 9-3 and the costing of these works is summarised in Table 9-1, an un-staged option is included for reference.

Armidale water supply – water security options

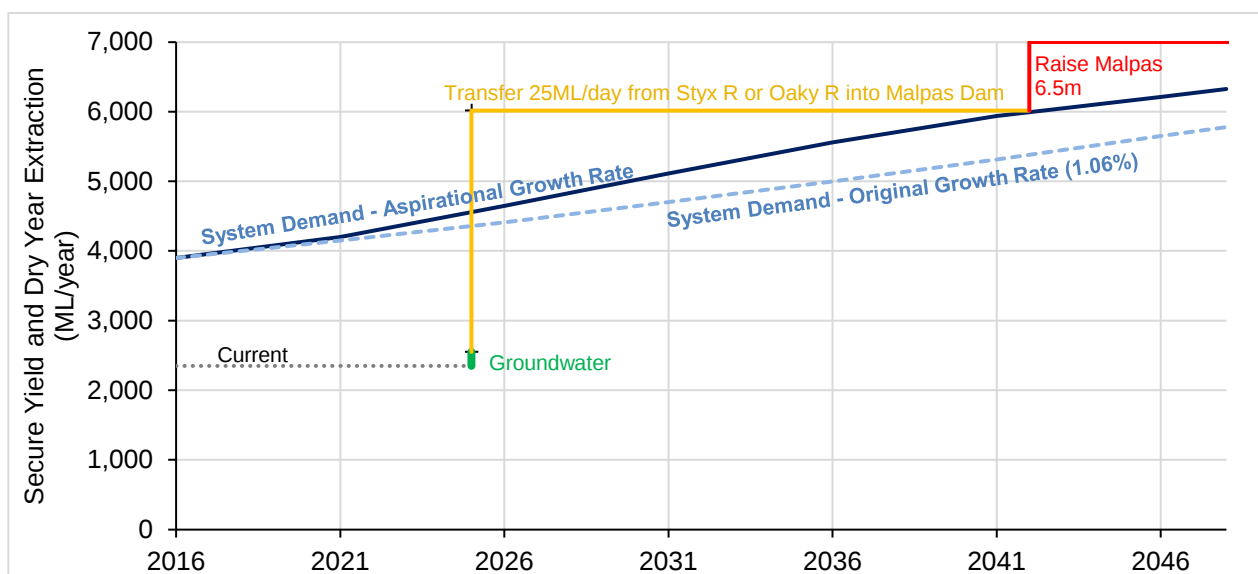


Figure 9-3: Aspirational Case - secure yield and unrestricted annual demand

Table 9-1: Aspirational Case scheme option and cost estimates

Works	Staging	Capital Cost (\$M)	Annual O&M Cost (\$M)	30-year PV (\$M)
Option 1 25 ML/d from Oaky River + 6.5m raising	Oaky River transfer 2025 Raise Malpas 2042	137	1.24	101
Option 2 25 ML/d from Styx River + 6.5m raising	Styx River transfer 2025 Raise Malpas 2042	146	1.33	109

The advantage of the staged approach is that Council can defer the construction of the Malpas Dam raising until there is evidence of sufficient growth in water demand to warrant the additional yield. This approach minimises the risk of over capitalisation.

The main advantage of bringing the second source online before raising Malpas Dam is that the Armidale demand can be supplied by second source greatly reducing the demand on Malpas Dam during construction, enabling the level in the dam to be reduced (making the work easier and safer) and then enabling the dam to be refilled faster after the works are complete.

10. References

Hydroilex, 2019. *Hydrogeological Investigation Guyra – Emergency Town Water Supply*, Molong, NSW: Hydroilex.

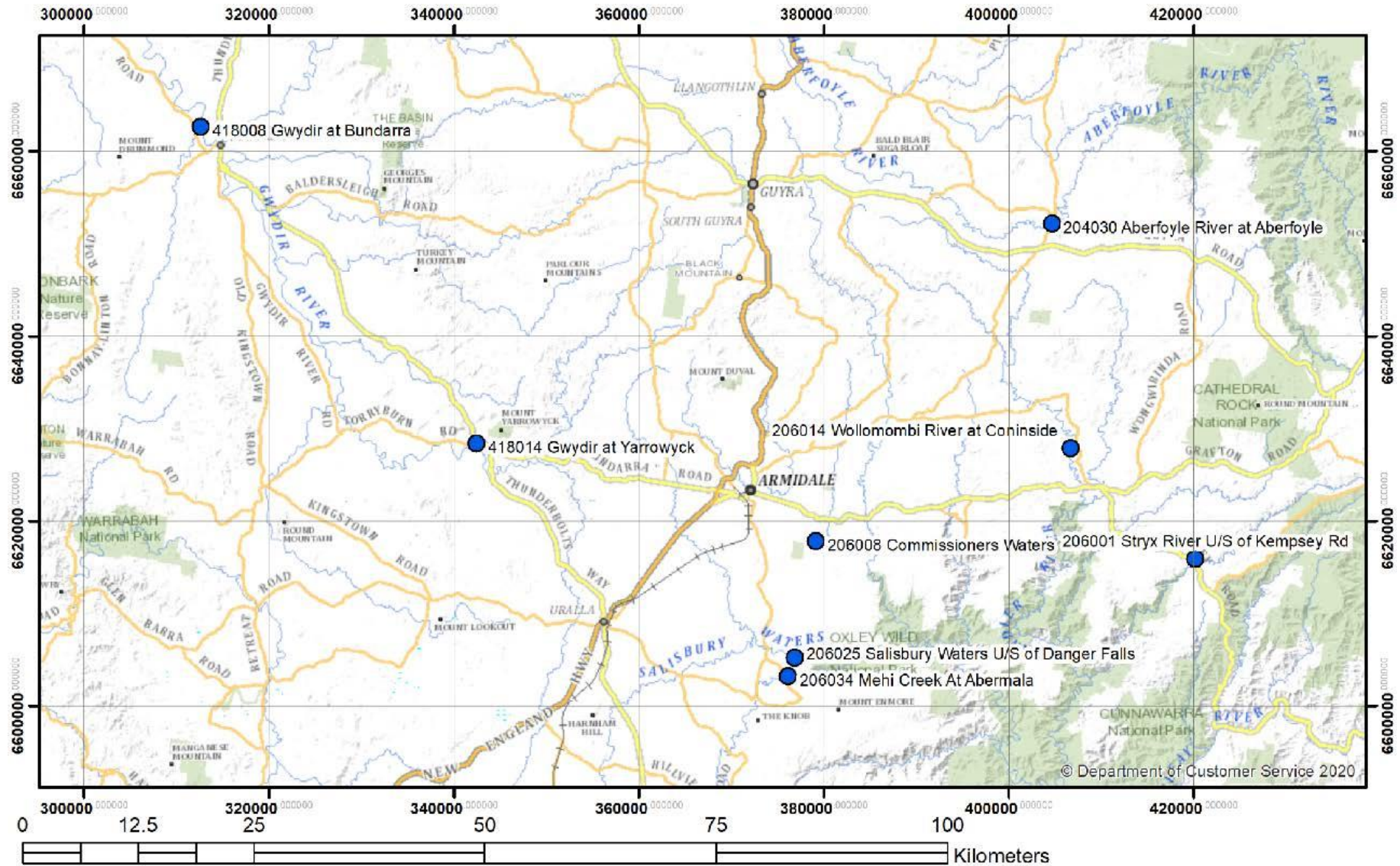
Samios, G. & G. S., 2014. *Oay River Dam Failure*. Canberra, Australian National Committee on Large Dams (ANCOLD).

Appendix A Stream Gauges – Location and Information

Appendix Table

Gauge number	Gauge name	Catchment area (km ²)	Specific Mean Discharge, (ML/day/km ²)	Mean Discharge (ML/day)	Major Catchment	Gauge zero
418014	Gwydir River at Yarrowyck	855	0.194	165.9	Gwydir	758.5m AHD
418008	Gwydir River at Bundarra	3,990	0.221	881.8	Gwydir	663.9m AHD
204030	Aberfoyle River at Aberfoyle	200	0.255	51.0	Clarence	955.9m AHD
206008	Commissioners Waters at Tiverton (earrhorpe)	362	0.21	76.0	Macleay	938.5m AHD
206001	Styx River at Jeogla	163	1.245	202.9	Macleay	808.5m AHD
206025	Salisbury Waters near Dangar Falls	594	0.12	71.3	Macleay	955.9m AHD
206014	Wollomombi River at Coninside	376	0.268	100.8	Macleay	Estimated 955m AHD

Armidale water supply – water security options



Appendix Figure A-1: Map of gauging stations

Appendix B Criteria for selection and calculation of storage volumes

The guidelines used in the selection of the storage sites are provided in Table B1.

Table B1: Guidelines used in selection of storage sites

Volume (GL)	Wall height (m)	Wall Length (m)
4	15	400
10	25	600
20	40	
60	50	
70	60	

Topology

The storage sites were chosen to:

- require short dam walls
- store a large volume of water
- have large relatively deep lakes.

Calculation methods

The wall height was estimated based on the contour maps.

The following parameters were calculated using ArcGIS:

- surface areas were calculated based on the contour chosen as the top water level.
- wall length was calculated by measuring the distance between the top water level contours at the selected dam wall location (intermediate points were added if required by the topography).

The storage volume was estimated using the following equation

$$\text{Stored Volume} = \frac{1}{3} \times \text{area} \times \text{height}$$

Wall volume was estimated using the following equation

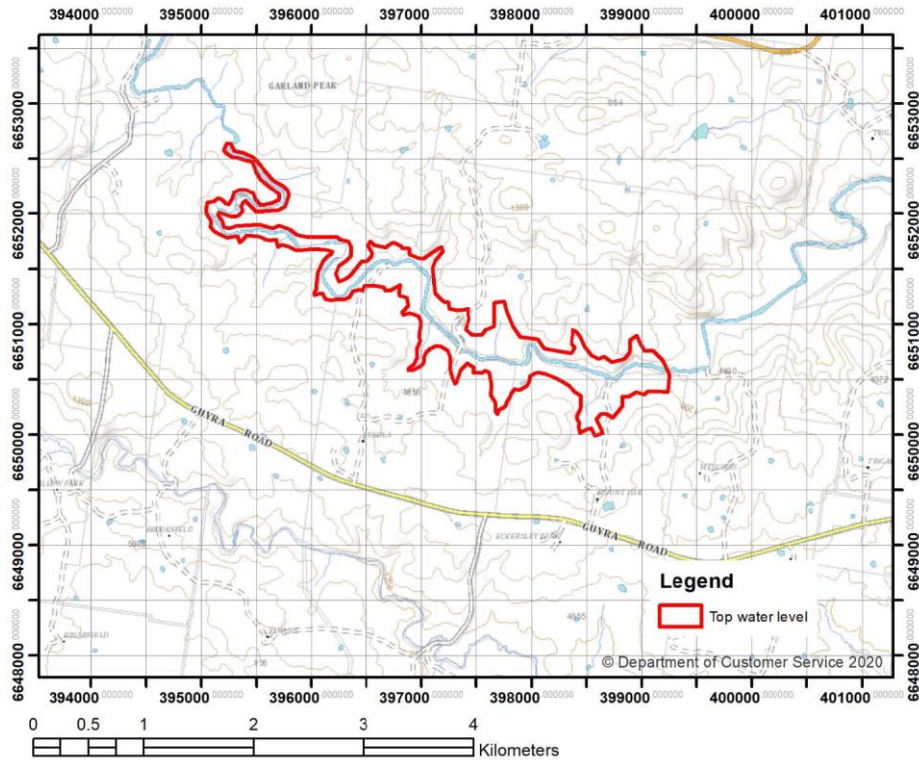
$$\text{Wall Volume} = 1.5 \times \text{length} \times \text{height}^2$$

The efficiency was estimated using the following equation

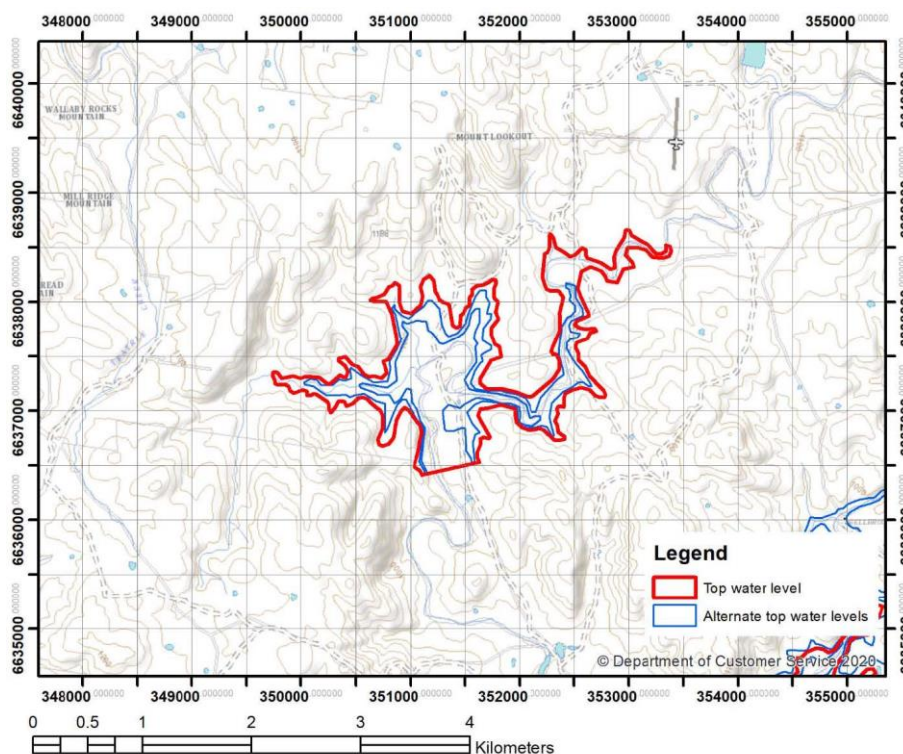
$$\text{efficiency} = \frac{\text{Stored volume}}{\text{Wall volume}}$$

Appendix C Maps of individual storages

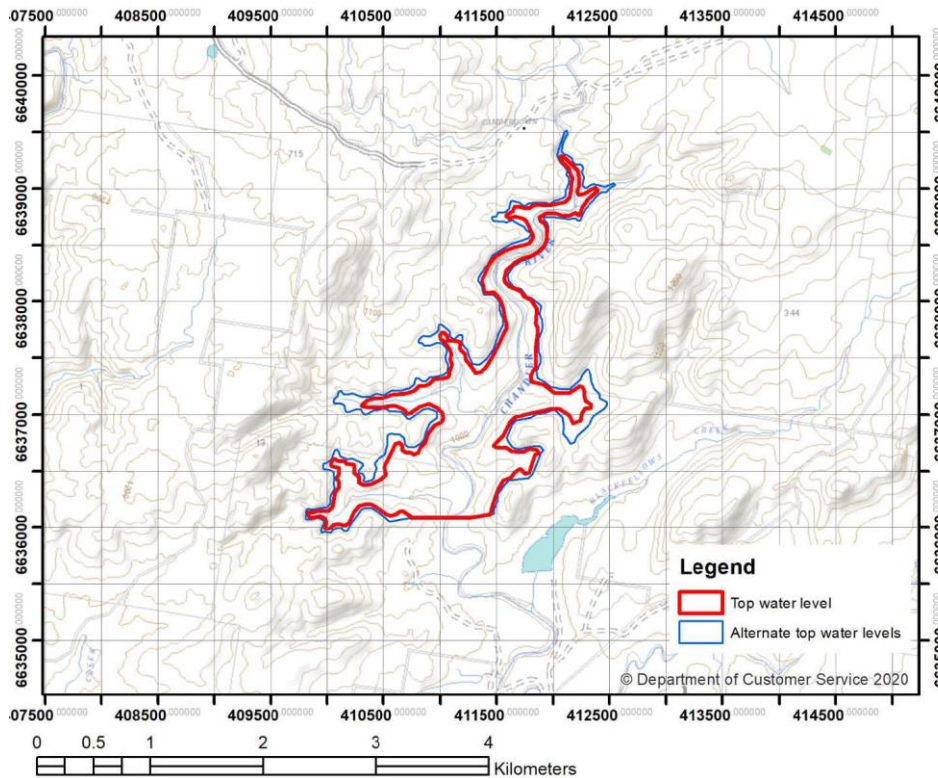
C.1 Large Storages



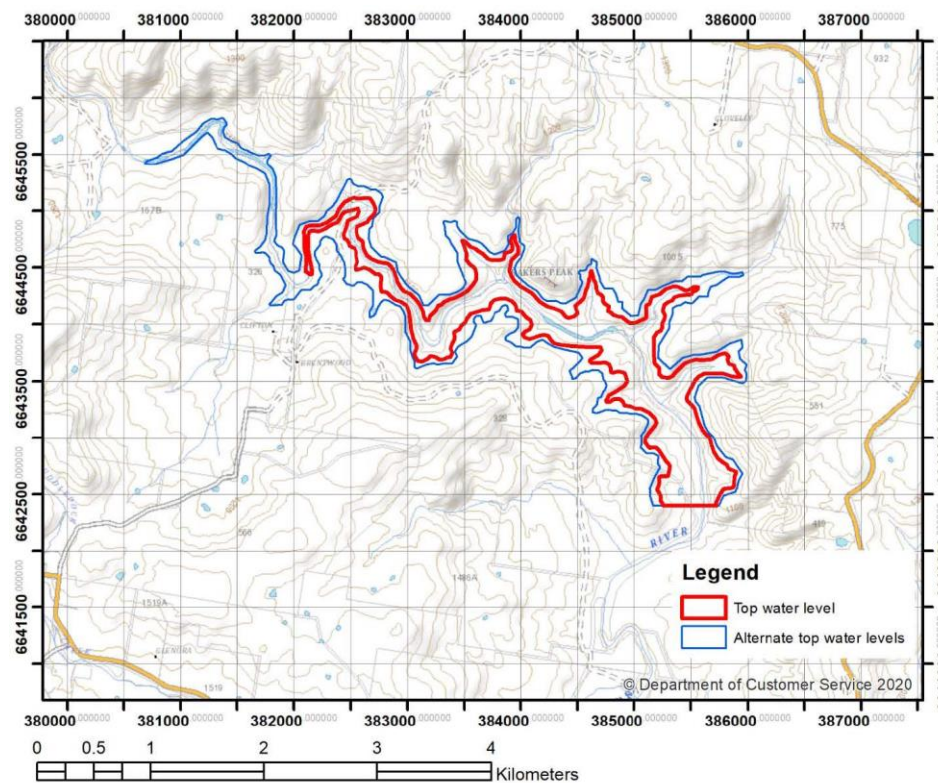
Appendix Figure C-1: Aberfoyle River



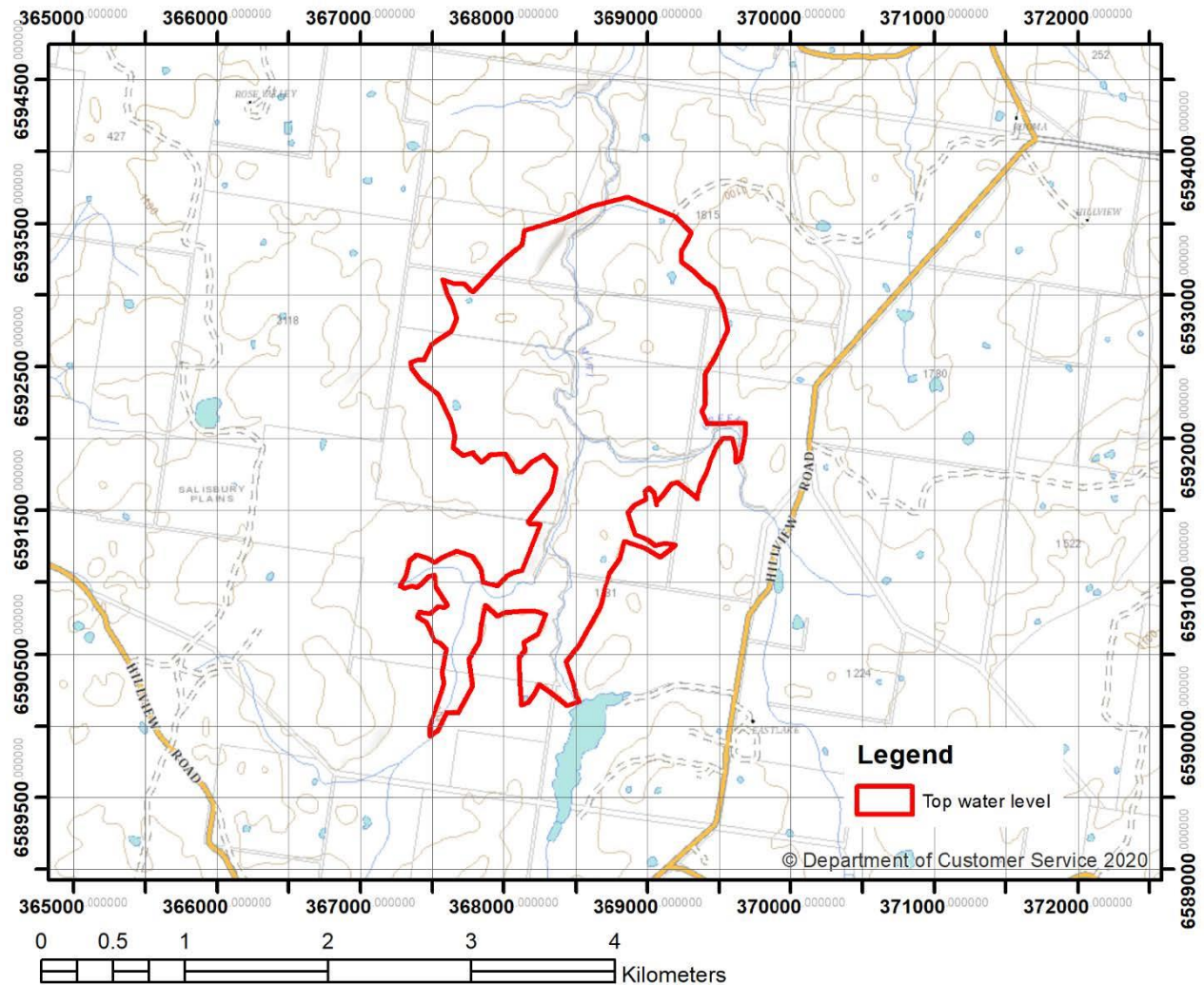
Appendix Figure C-2: Boorolong Creek



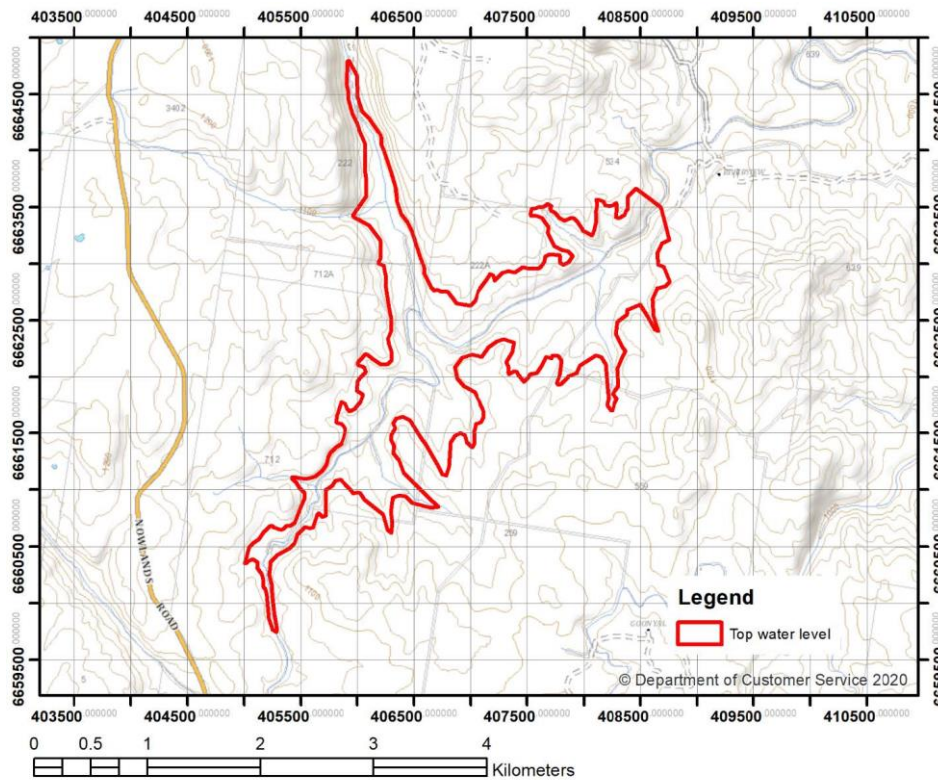
Appendix Figure C-3: Chandler River



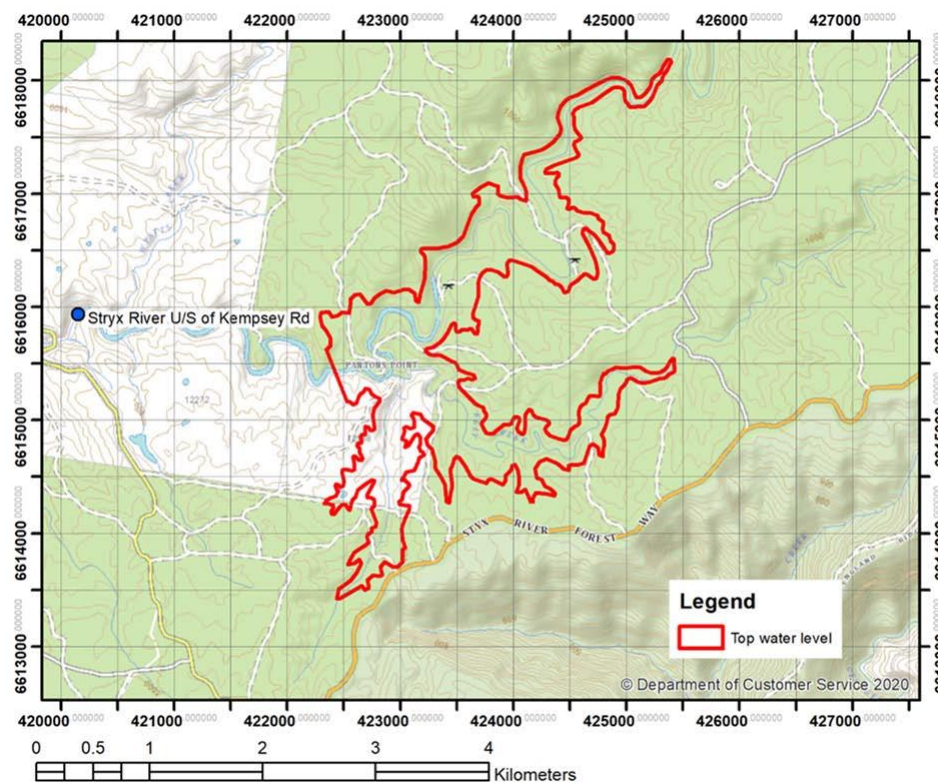
Appendix Figure C-4: Gara River



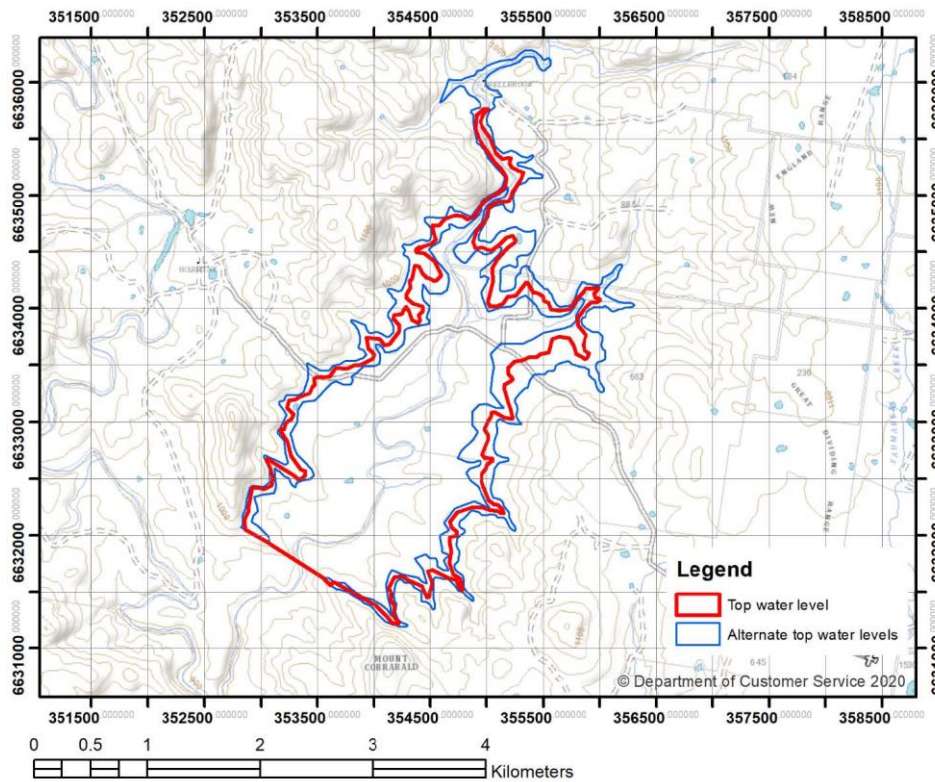
Appendix Figure C-5: Mehi Creek



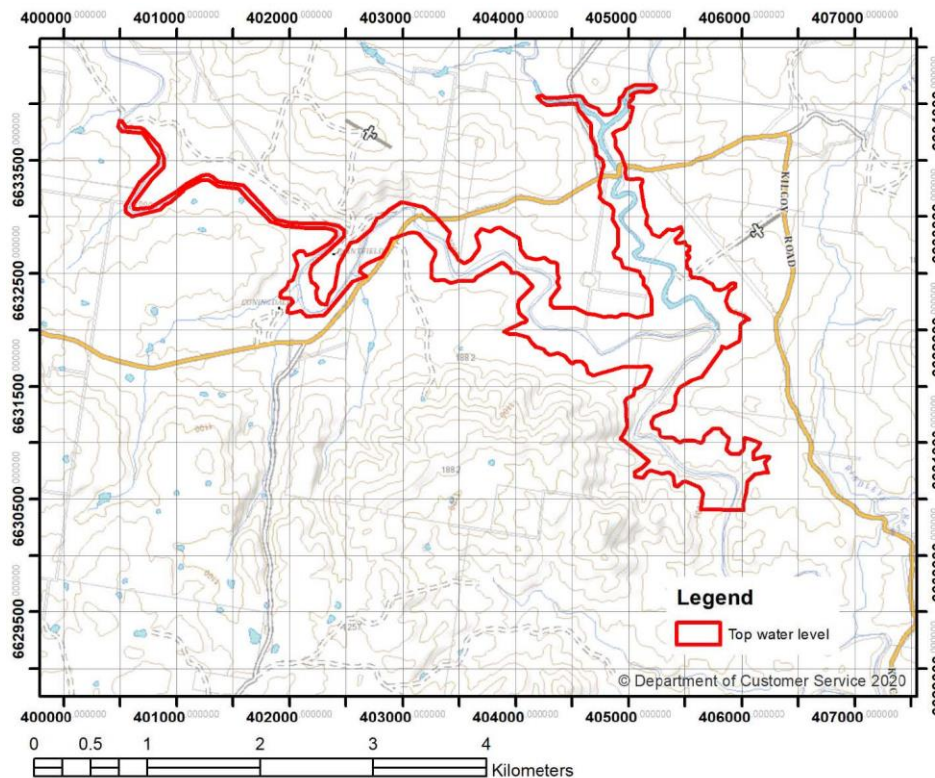
Appendix Figure C-6: Nowlands Backwater



Appendix Figure C-7: Styx River

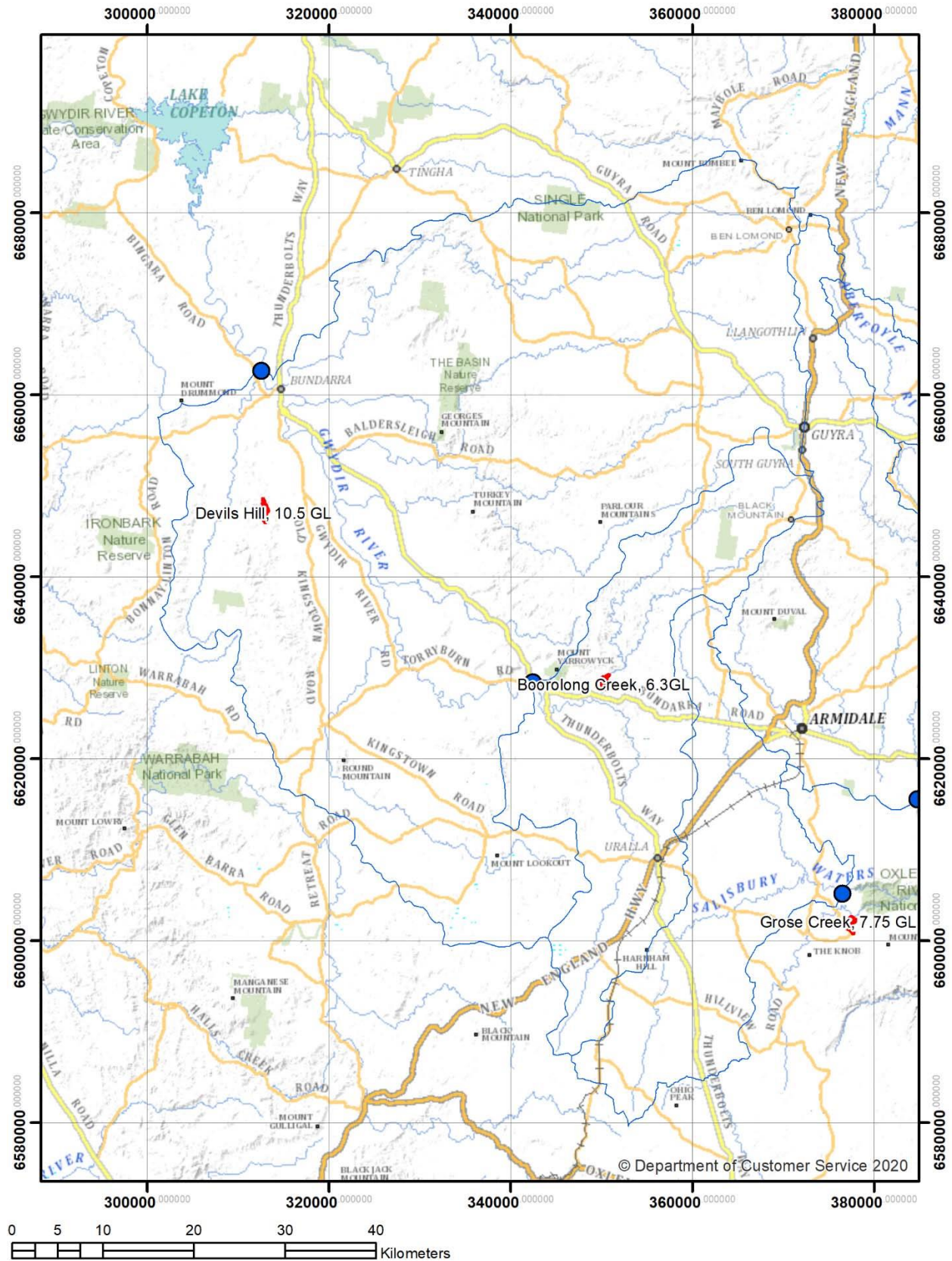


Appendix Figure C-8: Toms Creek

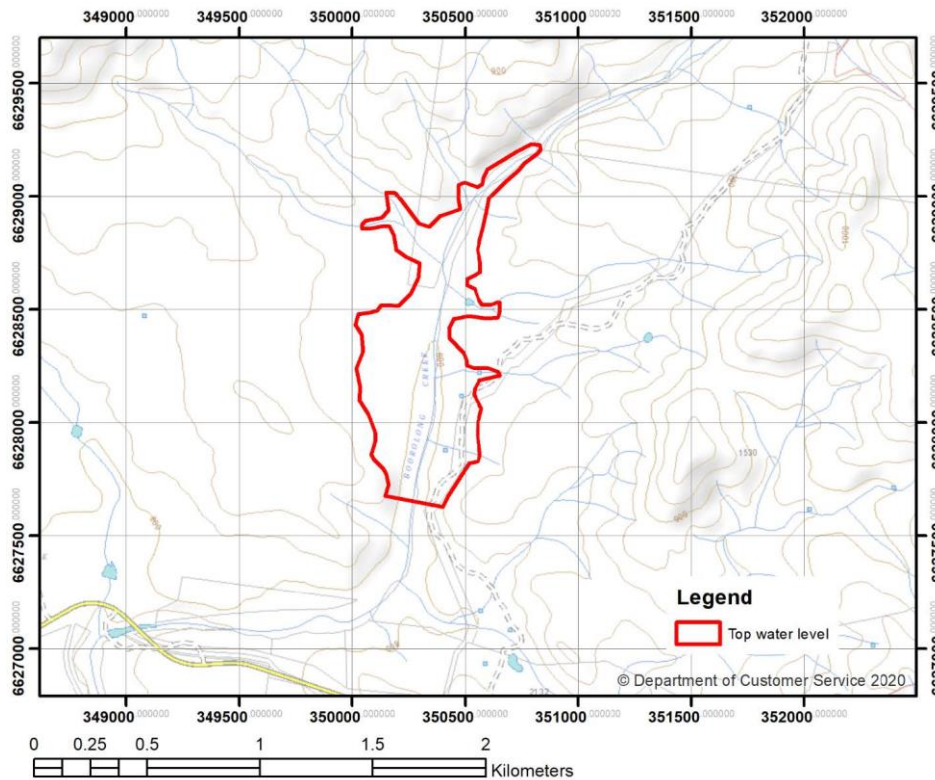


Appendix Figure C-9: Wollomombi River

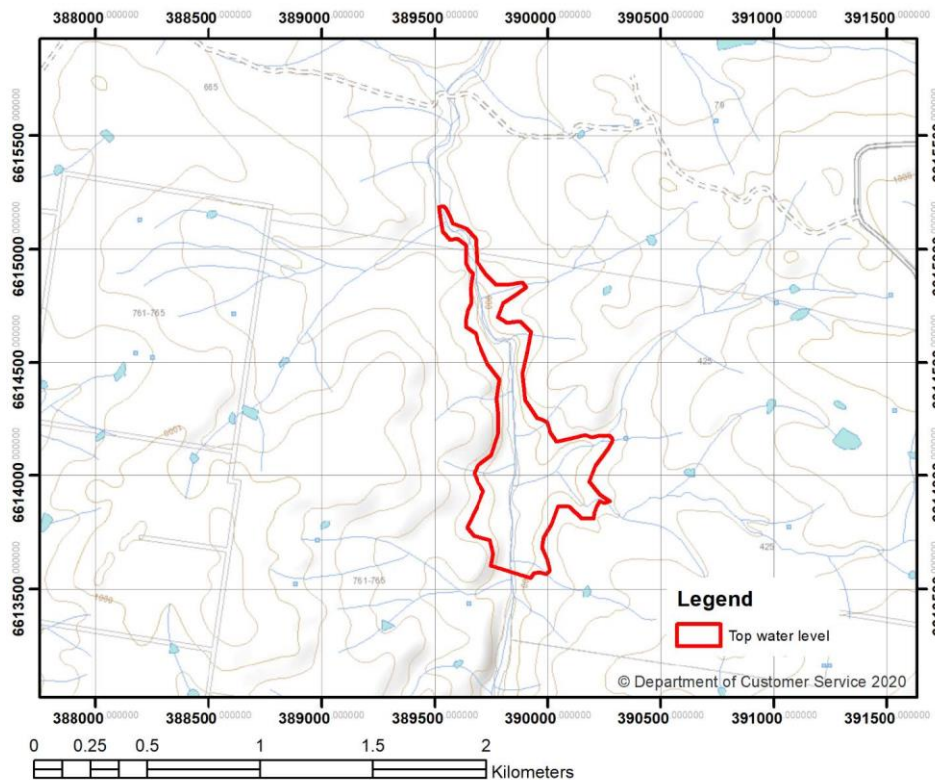
C.2 Small storages



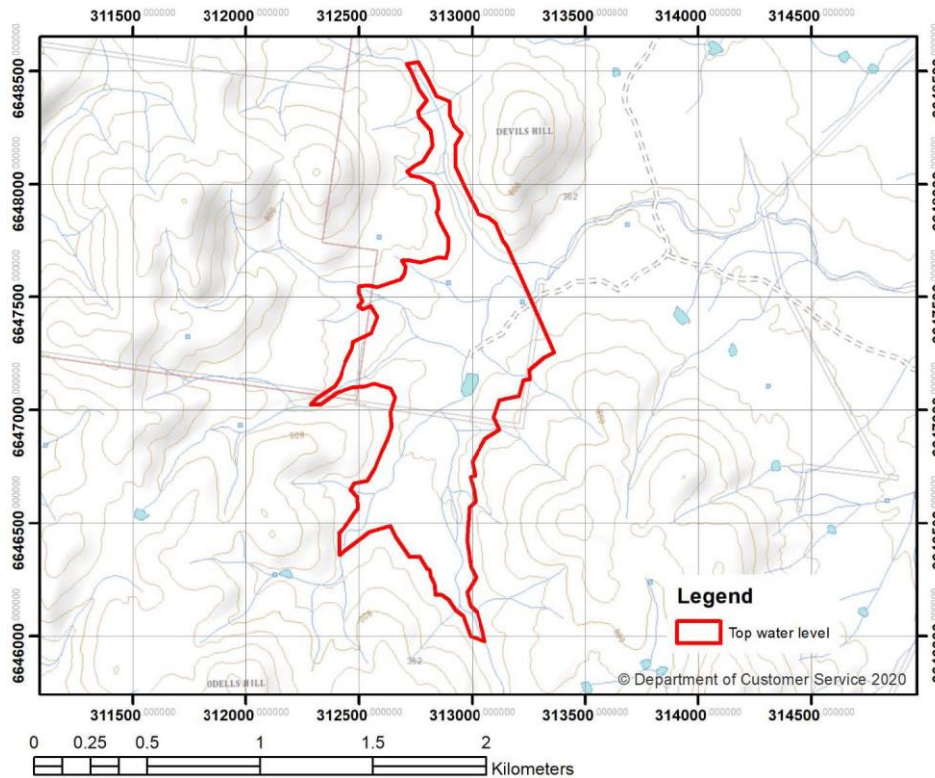
Appendix Figure C-10: Devils Hill regional map



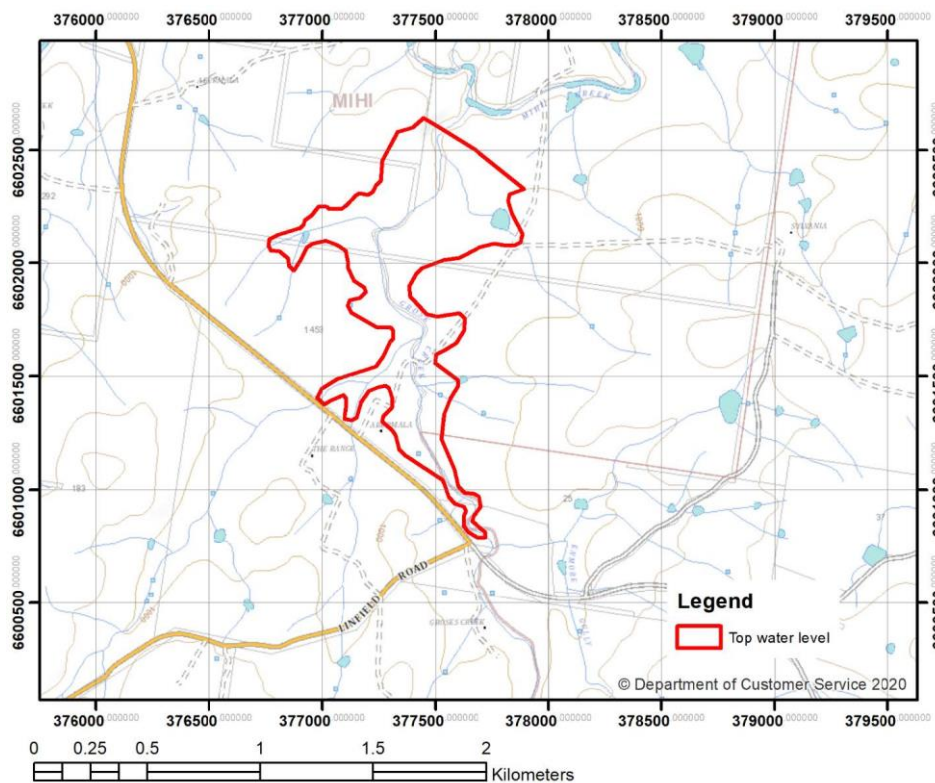
Appendix Figure C-11: Boorolong Creek



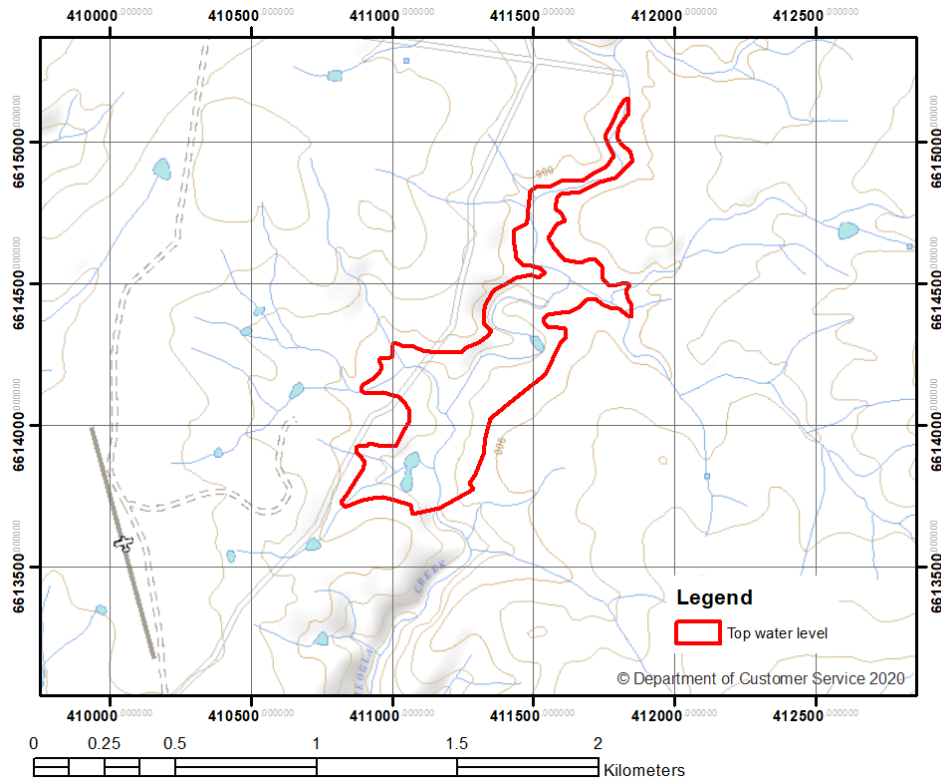
Appendix Figure C-12: Cooney Creek



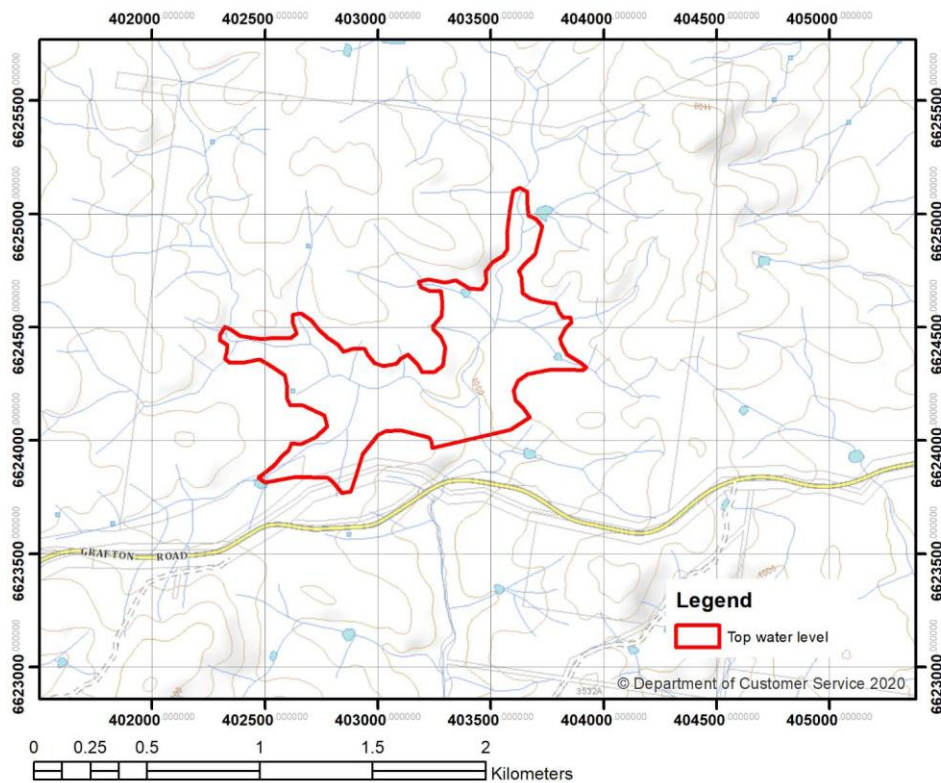
Appendix Figure C-13: Devils Hill



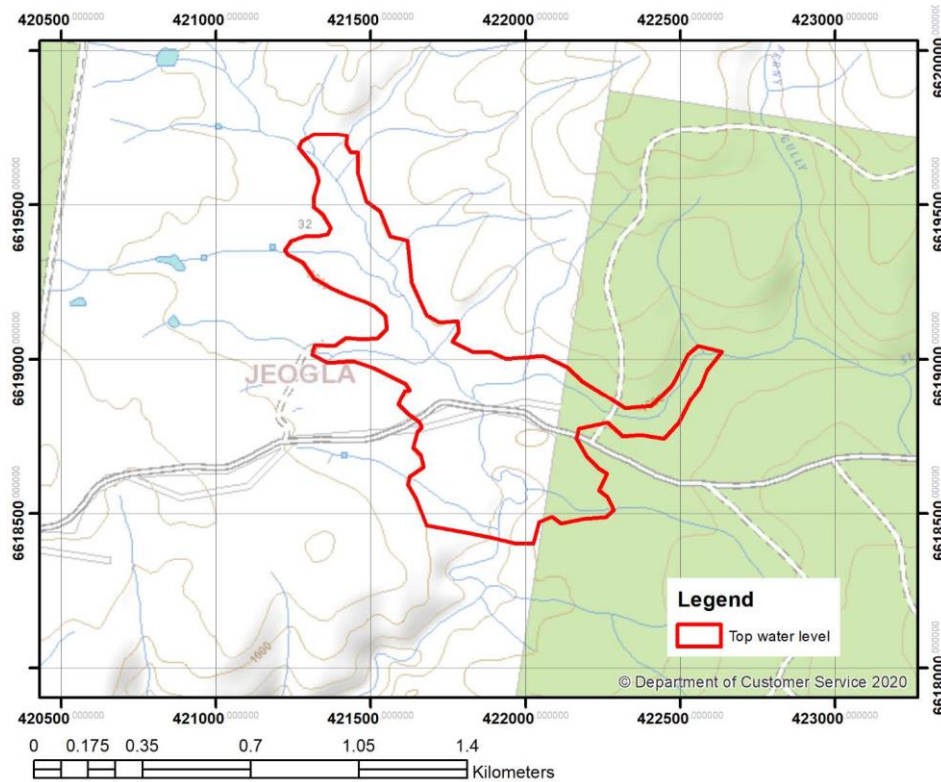
Appendix Figure C-14: Grose Creek



Appendix Figure C-15: Jeogla Creek



Appendix Figure C-16: St Helena Creek



Appendix Figure C-17: Wyatts Creek

Appendix D Assessment Criteria for Shortlisting Extraction and Storage sites

Armidalet water supply – water security options

Storage	Storage allowed under WSP	Source 1	Source 2	Source 3	Scores												Total score if mean discharge score >0
					Storage score	Mean Discharge of scheme	Flexibility	Complexity	Land holders	Water quality risk due to catchment land use	Inundated area - environmental value	Aboriginal Heritage	River Distance to National Park	Steep terrain at dam site (wall length over height)	Accessibility to site (distance to B-Double Route)	Distance of storage to Armidalet WTP	
St Helena Creek	Yes	Styx River U/S of Kempsey Rd			1	5	0	4	4	2	5	4	3	4	4	3	39
St Helena Creek	Yes	Styx River U/S of Kempsey Rd	Chandler River D/S Grafton Road,		1	5	0	3	4	2	5	3	3	4	4	3	37
St Helena Creek	Yes	Styx River U/S of Kempsey Rd	Chandler River D/S Grafton Road,	Bakers Creek U/S of Grafton Road	1	5	0	2	4	2	5	3	3	4	4	3	36
St Helena Creek	Yes	Bakers Creek U/S of Grafton Road			1	0	0	1	4	2	5	4	3	4	4	3	
St Helena Creek	Yes	Chandler River D/S Grafton Road,			1	0	0	1	4	2	5	4	3	4	4	3	
St Helena Creek	Yes	Chandler River D/S Grafton Road,	Bakers Creek U/S of Grafton Road		1	0	0	1	4	2	5	3	3	4	4	3	
Styx River	No				5	5	0	5	4	5	2	4	4	1	1	1	37
Jeogla Creek	No	Styx River U/S of Kempsey Rd			1	5	1	4	4	2	5	2	3	2	1	2	32
Wyatts Creek	No	Styx River U/S of Kempsey Rd			1	5	0	4	4	2	2	4	3	3	1	1	30
Wyatts Creek	No	Styx River U/S of Kempsey Rd	Wollomombi River U/S Grafton Road		1	5	0	3	4	2	2	3	3	3	1	1	28
Wyatts Creek	No	Styx River U/S of Kempsey Rd	Chandler River D/S Grafton Road,		1	5	0	3	4	2	2	3	3	3	1	1	28
Chandler River	Yes				5	0	0	5	3	2	4	4	5	3	1	2	
Chandler River	Yes	Chandler River D/S Grafton Road,			5	1	0	4	3	2	4	3	3	3	1	2	31
Chandler River	Yes	Chandler River D/S Grafton Road,	Bakers Creek U/S of Grafton Road		5	4	0	3	3	2	4	3	3	3	1	2	33
Chandler River	Yes	Styx River U/S of Kempsey Rd			5	5	0	4	3	2	4	4	3	3	1	2	36
Chandler River	Yes	Styx River U/S of Kempsey Rd	Chandler River D/S Grafton Road,		5	5	0	3	3	2	4	3	3	3	1	2	34
Chandler River	Yes	Styx River U/S of Kempsey Rd	Chandler River D/S Grafton Road,	Bakers Creek U/S of Grafton Road	5	5	0	2	3	2	4	2	3	3	1	2	32
Gara River	Yes				5	0	5	5	3	2	3	5	5	1	1	4	
Gara River	Yes	Chandler River D/S Grafton Road,	Bakers Creek U/S of Grafton Road		5	2	5	2	3	2	3	3	3	1	1	4	34
Gara River	Yes	Styx River U/S of Kempsey Rd			5	5	5	2	3	2	3	4	3	1	1	4	38
Gara River	Yes	Styx River U/S of Kempsey Rd	Chandler River D/S Grafton Road,		5	5	5	2	3	2	3	3	3	1	1	4	37
Gara River	Yes	Styx River U/S of Kempsey Rd	Chandler River D/S Grafton Road,	Bakers Creek U/S of Grafton Road	5	5	5	2	3	2	3	3	3	1	1	4	37
Mehi Creek	Yes				5	0	0	5	2	2	3	5	5	5	5	3	

Armidale water supply – water security options

Storage	Storage allowed under WSP	Source 1	Source 2	Source 3	Scores												Total score if mean discharge score >0
					Storage score	Mean Discharge of scheme	Flexibility	Complexity	Land holders	Water quality risk due to catchment land use	Inundated area - environmental value	Aboriginal Heritage	River Distance to National Park	Steep terrain at dam site (wall length over height)	Accessibility to site (distance to B-Double Route)	Distance of storage to Armidale WTP	
Mehi Creek	Yes	Salisbury Waters U/S of Dangars Falls			5	0	0	4	2	2	3	2	3	5	5	3	
Nowlands Backwater	No				5	0	5	5	0	2	3	4	5	2	0	1	
Nowlands Backwater	No	Aberfoyle River at Goonyal			5	4	5	4	0	2	3	4	5	2	0	1	35
Aberfoyle River	No				4	0	0	5	0	2	5	5	5	3	4	2	
Aberfoyle River	No	Aberfoyle River at Goonyal			4	0	0	4	0	2	5	4	5	3	4	2	
Aberfoyle River	No	Aberfoyle River at Goonyal	Nowlands Backwater		4	3	0	3	0	2	5	4	5	3	4	2	35
Oaky River	Yes				0*	5	0	5	4	2	5	5	2	5	2	2	37
Maximum Score																	39

* Oaky River Dam fails the minimum storage volume criteria

Appendix E Present value cost estimates

1 Styx River 25 ML/day pipeline to Malpas Dam

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E-3

Armidales water supply – water security options

2 Styx River 10 ML/day pipeline to new Chandler River Dam then direct to Armidale																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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Armidales water supply – water security options

3 Styx River 15 ML/day pipeline to Malpas Dam, raise Malpas 3m (concurrent)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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E-4

Armidales water supply – water security options

4 Styx River 10 ML/day pipeline to Malpas Dam, raise Malpas 6.5m																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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 Developments | Buildings | Water Infrastructure | Roads + Bridges | Coastal | Waste | Emergency Management | Surveying
 E-6

Armidaled water supply – water security options

6 Oaky River 25 ML/day pipeline to Malpas Dam																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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Armidale water supply – water security options

Oaky River 15 ML/day pipeline to Malpas Dam, raise Malpas 3m in 2033																																									
ITEM	DESCRIPTION	[UNIT]	[QTY]	[RATE]	AMT	PRESENT WORTH (\$K)																																			
				\$ / Unit	\$K	4%	7%	10%	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051		
Pipe cost (supply and lay)																																									
	Oaky to Grafton Rd PS MSCL - welded thin 450mm diameter	m	16334	\$ 660	\$ 10,785	\$9,219	\$8,228	\$7,366	\$ -	\$ -	\$ -	\$ -	\$ 10,785	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
	Grafton Rd PS to Malpas Dam MSCL - welded thin 450mm diameter	m	50830	\$ 660	\$ 33,561	\$28,688	\$25,604	\$22,923	\$ -	\$ -	\$ -	\$ -	\$ 33,561	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Pumping Stations																																									
	Oaky River PS 560 kW	Item	1	\$ 1,124,800	\$ 1,125	\$961	\$858	\$768	\$ -	\$ -	\$ -	\$ -	\$ 1,125	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
	Grafton Road PS 590 kW	Item	1	\$ 1,183,200	\$ 1,183	\$1,011	\$903	\$808	\$ -	\$ -	\$ -	\$ -	\$ 1,183	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
River Intakes																																									
	Oaky River	Item	1	\$ 400,000	\$ 400	\$342	\$305	\$273	\$ -	\$ -	\$ -	\$ -	\$ 400	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Balance Tank																																									
	0.3 ML	Item	1	\$ 750,000	\$ 750	\$641	\$572	\$512	\$ -	\$ -	\$ -	\$ -	\$ 750	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Malpas Dam																																									
	6.5m raising	Item	1	\$ 13,201,800	\$ 13,202	\$8,246	\$5,862	\$4,207	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 13,202	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Oaky River Dam																																									
	Restoration and safety upgrade	Item	1	\$ 6,675,200	\$ 6,675	\$5,706	\$5,092	\$4,559	\$ -	\$ -	\$ -	\$ -	\$ 6,675	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Prime Costs					\$67,681	\$54,815	\$47,424	\$41,416	\$0	\$0	\$0	\$0	\$54,479	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$13,202	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	
	General Contingency	% of Prime Cost	30%		\$20,304	\$16,444	\$14,227	\$12,425	\$ -	\$ -	\$ -	\$ -	\$ 16,344	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 3,961	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Direct Costs					\$87,985	\$71,259	\$61,651	\$53,841	\$ -	\$ -	\$ -	\$ -	\$ 70,823	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 17,162	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
	Design & Preconstruction Activities		10%		\$8,799	\$7,126	\$6,165	\$5,384	\$ -	\$ -	\$ -	\$ -	\$ 7,082	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 1,716	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
	Construction Activities		10%		\$8,799	\$7,126	\$6,165	\$5,384	\$ -	\$ -	\$ -	\$ -	\$ 7,082	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 1,716	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
TOTAL CAPITAL COST					\$105,582	\$85,511	\$73,981	\$64,610	\$0	\$0	\$0	\$0	\$84,987	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$20,595	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	
OPERATION & MAINTENANCE COSTS																																									
Pumping Cost																																									
	Oaky River PS	\$/KWh	\$0.26			\$2,417	\$1,596	\$1,107	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177	\$ 177		
	Grafton Road PS					\$2,558	\$1,689	\$1,171	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187	\$ 187		
Maintenance and renwals																																									
	Maintenance Civil	% of Capital Cost	0.50%		\$10,140	\$5,328	\$3,518	\$2,440	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390		
	Maintenance Mech + Elec + Telemetry	% of Capital Cost	4.00%		\$3,465	\$1,821	\$1,203	\$834	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133	\$ 133		
	Renewals - Telemetry, every 10 years								\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 1,315	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 1,315	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
	Renewals - Mechanical and Electrical (20y)								\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 2,017	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
TOTAL OPERATION & MAINTENANCE COSTS					\$27,719	\$14,319	\$9,304	\$6,343	\$0	\$0	\$0	\$0	\$0	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$2,203	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$4,220	\$887	\$887	\$887	\$887	\$887	\$887	\$887	
TOTAL PRESENT VALUE						\$133,301	\$99,830	\$83,284	\$70,952	\$0	\$0	\$0	\$0	\$84,987	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$21,482	\$2,203	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$4,220	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$887

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E-10

Armidaled water supply – water security options

9 Aspirational - Oaky River 25 ML/day pipeline to Malpas, raise Malpas 6.5m																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
ITEM	DESCRIPTION	[UNIT]	[QTY]	[RATE]	AMT	PRESENT WORTH (\$K)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

Armidale water supply – water security options

[illegible]

Appendix F Comparison of population growth scenarios

Serviced population forecast

		2021	2026	2031	2036	2041	2046	2048	2052
Original	Armidale	25,426	26,809	28,267	29,805	31,426	33,135	33,845	33,989
	Guyra	2,108	2,216	2,329	2,448	2,573	2,704	2,758	2,870
	Total serviced	27,534	29,025	30,596	32,252	33,999	35,839	36,603	36,859
2022 Base	Armidale	25,426	27,456	29,669	31,181	32,763	34,046	34,571	35,646
	Guyra	2,108	2,254	2,411	2,515	2,623	2,710	2,745	2,817
	Total serviced	27,534	29,710	32,079	33,696	35,386	36,756	37,316	38,463
2022 Aspirational	Armidale	25,426	27,759	30,323	32,769	35,394	37,874	38,909	41,062
	Guyra	2,108	2,277	2,458	2,631	2,815	2,988	3,061	3,210
	Total serviced	27,534	30,036	32,781	35,400	38,209	40,863	41,969	44,273

Annual population growth rates

		2021-26	2026-31	2031-36	2036-41	2041-46	2046-52
Original	Armidale	1.065%	1.065%	1.065%	1.065%	1.065%	1.065%
	Guyra	1.000%	1.000%	1.000%	1.000%	1.000%	1.000%
	Total serviced	1.060%	1.060%	1.060%	1.060%	1.060%	1.060%
2022 Base	Armidale	1.55%	1.56%	1.00%	0.99%	0.77%	0.77%
	Guyra	1.35%	1.35%	0.85%	0.85%	0.65%	0.65%
	Total serviced	1.53%	1.55%	0.99%	0.98%	0.76%	0.76%
2022 Aspirational	Armidale	1.77%	1.78%	1.56%	1.55%	1.36%	1.36%
	Guyra	1.55%	1.55%	1.37%	1.37%	1.20%	1.20%
	Total serviced	1.75%	1.76%	1.55%	1.54%	1.35%	1.34%



Public Works Advisory

12 Darcy Street, Parramatta NSW 2150
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