Walcha Council

Walcha Water Security Options Assessment Report

March 2018

Executive summary

Background and Setting

Walcha is a small town located approximately 64km south of Armidale in the New England Tablelands, with an urban population of approximately 1,600. Town water is extracted from an 80ML off-river storage, which is supplied with pumped water sourced from the Macdonald River (in the upper reaches of the Namoi catchment). In recent years, Council has been intermittently unable to extract water from the river due to low flows. Council completed a secure yield study in July 2015. This study has confirmed that, based on growth projections and climate variability considerations and in accordance with DPI Water's draft "Assuring Future Urban Water Security" guidelines, there is a need for additional storage to secure water supply for Walcha into the future.

In 2016 the Federal Government announced the allocation of $100,000 to investigate the potential for growth in demand and water security for both by the township and the catchment more broadly, including for irrigated agriculture. Consideration was to be given for the potential for water security solutions within the Apsley catchment, including a dam on the Apsely River. These funds are managed by DPI Water, with Walcha Council completing the investigations in consultation with DPI Water.

Study Stages

The study has been completed under four separate appointments, with this report being the final.

Regional Development Australia Northern Inland NSW was appointed to prepare an economic benefit study. Their report is titled "Apsley Dam: Economic Benefit Study" (September 2017). This study indicates that, given a firm supply of water, there is significant scope to diversify and grow Walcha's economy, by attracting new enterprises (intensive agriculture and processing) and increasing the output of existing enterprises (livestock, fodder and aged-care facilities). This will increase local gross regional product and employment.

Hunter H2O, in association with Douglas Partners, was appointed to undertake an initial engineering (desktop) assessment of the feasibility of constructing a dam on the Apsley River and to identify suitable sites for storage dams. Their report is titled "Apsley River Dam Sites: Desktop Assessment" (July 2017). Initially eight sites were identified, based on a high-level assessment of topographical information. A walkover field inspection enabled the identification of four preferred sites from the initial eight, which were progressed to the options development phase. The study recommended that two sites be taken forward for further evaluation, namely Site 1, a 25GL storage located on the Apsley River and Site 5, an 800ML off-stream storage on a small tributary of the Apsley.

NSW Urban Water Resources was appointed to investigate the yield available from dams located on Site 1 and Site 5. Their report is titled "Yield Assessment of Apsley River Options: Summary Report" (December 2017). The yield from Site 1 was disappointing, while the yield from Site 5 was, under certain modelling scenarios and assumptions, found to improve reliability of supplies.

Conclusions

This "Options Assessment Report" draws together the findings of the above mentioned reports into a stand-alone report and makes recommendations in regard to future stages. A high-level cost estimate has been prepared for both dam options, together with their associated pipeline

and pumping station infrastructure. Based on the available information, an initial cost benefit analysis has been undertaken.

Based on various assumptions, as detailed further in this report, the benefit cost analysis has provided the following results:

Dam Site	PV of costs	PV of benefits	NPV	Benefit Cost Ratio
Site 1	$150.5m	$25.2m	($125.3m)	0.17
Site 5	$67.7m	$13.2m	($54.5m)	0.20

The benefit cost analysis for the Site 5 "Town Water Supply Only Option" (excluding additional water for agricultural development) has not been assessed since the purpose of this option is to secure water supplies for the town and human consumptive activities.

Based on $/ML, the costs and benefits for the two projects are as follows:

Costs and Benefits	Site 1	Site 1 - $PV per ML of additional yield	Site 5	Site 5 - $PV per ML of additional yield
Total PV of costs	$150.5m	$140,955	$67.7m	$117,806
Total PV of benefits	$25.2m	$23,602	$13.2m	$22,989

Based on the above results, Site 5 returns a slightly higher BCR and has a lower present value cost per ML of secure yield.

At this stage it is considered, from an engineering perspective, that it will be feasible to construct dams at the two sites, however, additional confirmatory studies, including site investigations will be required. Previous reports have also expressed the following opinions:

- A large dam on the Apsley River is likely to result in major impacts on the downstream reaches of the Apsley River, particularly the Apsley Gorge including the National Park and World Heritage Area.
- The economic benefit of constructing a large dam on the Apsley River was considered to be marginal, at best.

The Benefit Cost Analysis outcome supports the second conclusion.

Regional Development Australia suggested that securing the town water supply is a key priority, and one which DPI Water appear most likely to support. A less ambitious proposal is likely to be a much easier task to take through the regulatory process. GHD supports this opinion and suggests that securing water supplies for human consumption (i.e. a Town Water Supply only option) will receive greater support, even if the Benefit Cost ratio is low.

The above executive summary should be read in conjunction with the rest of this report, particularly the limitations provided at the back of this document and the notes covering the infrastructure cost estimates that are provided in Section 3 this report. In particular, the cost estimates are considered high level and not based on detailed designs. The costs estimates provided in this report are intended to provide a relative cost comparison between the options. No guarantee can be provided that the project can be constructed for the estimated costs developed at this stage and the final costs may vary as additional studies and design phases are completed.

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1. Introduction

Walcha Council appointed GHD to prepare an options summary report (this Report) to encapsulate the findings of various studies aimed at improving water supplies to the town. In addition, the report includes a high-level construction cost estimate and Cost Benefit Analysis for two dam sites, namely Dam Site 1 (a 25,000 ML dam, located on the Apsley River) and Dam Site 5 (an 800 ML off-channel storage dam). These two dam sites were identified in previous studies as the preferred sites for storage dams based on a high-level dam site location study.

1.1 Background

Walcha is a small town located approximately 64km south of Armidale in the New England Tablelands, with an urban population of approximately 1,600. Town water is extracted from an 80ML off-river storage, which is supplied with pumped water sourced from the Macdonald River (in the upper reaches of the Namoi catchment). In recent years, Council has been intermittently unable to extract water from the river due to low flows. Council completed a secure yield study in July 2015. This study has confirmed that, based on growth projections and climate variability considerations and in accordance with DPI Water's draft "Assuring Future Urban Water Security" guidelines, there is a need for additional storage of approximately 170ML to secure water supply for the future.

In 2016 the Federal Government announced the allocation of $100,000 to investigate the potential for growth in demand and water security for both by the township and the catchment more broadly, including for irrigated agriculture. Consideration was to be given for the potential for water security solutions within the Apsley catchment, including a dam on the Apsely River. These funds are managed by DPI Water, with Walcha Council completing the investigations in consultation with DPI Water.

1.2 Objectives of the Project

The key objective of this project is to assess options for enhanced water security for the Walcha region that could have the potential to drive job opportunities and economic growth in the future. An additional objective for this project is to assess options for water security for town supply to ensure the future stability and prosperity of the Walcha community.

1.3 Completed stages

1.3.1 Stage 1- Economic benefit study

This study indicates there is significant scope for additional water to diversify and grow Walcha's economy, attracting new enterprises (intensive agriculture and processing), increasing the output of existing enterprises (livestock, fodder and aged-care facilities), and therefore increasing local gross regional product and employment. The economic returns per ML of additional water have been estimated for several existing and potential new enterprises' with the results summarised in terms of Gross Returns per ML, Gross Margins per ML, Extra Jobs per ML and Extra Value-Added per ML.

1.3.2 Stage 2 – Apsley River Dam

The initial engineering (desktop) assessment of the feasibility of constructing a dam on the Apsley River initially identified eight sites based on a high level assessment of topographical information. A walkover field inspection enabled the identification of four preferred sites from the initial eight, which were progressed to the options development phase.'

Of the sites identified, Site 1 and Site 3 are on-stream storages on the Apsley River suitable for dams up to 25GL in capacity. Site 1 is considered superior to Site 3 simply due to its larger catchment area and closer proximity to Walcha for connection to the existing water supply system and was the single 25 GL capacity site included in Stage 3 the secure yield investigations.

Sites 4 and 5 were considered off-stream storages, located on smaller tributaries of the Apsley River, offering options with potentially lower environmental and social impacts. Site 5, is considered superior to Site 4 due to its close proximity to existing infrastructure and its potential to store water sourced from both the Apsley and Macdonald Rivers. As such, Site 5 was chosen to be included in Stage 3 of the project.

1.3.3 Stage 3 - Secure yield investigations

Secure yield investigations for Site 1 & Site 5 with consideration of both urban needs and potential to supply additional water to industry and agriculture.

1.3.4 Stage 4 – Options Assessment Report (This Report)

The envisaged scope of works for Stage 4 is to deliver a summary assessment study that:

- Summarise the outcomes from the first 3 stages so the final report is stand-alone. The completed reports are to form the basis of this report.
- Details any existing constraints and issues that could affect the feasibility of the options.
- Provides pre-feasibility level budget cost estimates of the options.
- Based on the pre-feasibility cost estimates, generate a high-level cost benefit analysis, i.e. cost of additional water delivered vs potential economic benefits.

1.4 Purpose of this report

This report is intended to act as a stand-alone report, summarising the findings of the previous 3 Stages of the study (refer to Section 1.4.1 below) related to the securing and improvement of water supplies to the town of Walcha, NSW. This report also includes a pre-feasibility budget cost estimate, cost benefit analysis and identification of possible project constraints.

1.4.1 Previous reports

Reports relevant to the supply of water that have previously been prepared include the following:

1. Apsley River Dam Sites: Desktop Assessment, Hunter H2O & Douglas Partners, July 2017
2. Apsley Dam: Economic Benefit Study, Regional Development Australia Northern Inland NSW, Sept 2017
3. Yield Assessment of Apsley River Options: Summary Report, NSW Urban Water Resources, Dec 2017

Other relevant reports include the following:

1. Walcha Water Supply: Yield Study. NSW Urban Resources, July 2015
2. Summary of Stage 3 Apsley River Secure Yield Analysis, Engineering Services, Walcha Council, 13 December 2017

2. Findings of previous reports

The following sections summarise the findings of previous reports.

2.1 Apsley River Dam Sites: Desktop Assessment

A total of 8 potential dam sites were identified, based on a high level desktop study. The study was based on topographic information sourced from the Geoscience Australia "Elevation Information System" (ELVIS), in particular the Shuttle Radar Topography mission (SRTM) derived 1-second (30 m grid) Digital Elevation Model (DEM) topographic information was used. The location of the Dam Sites identified are shown in Figure 1 below.

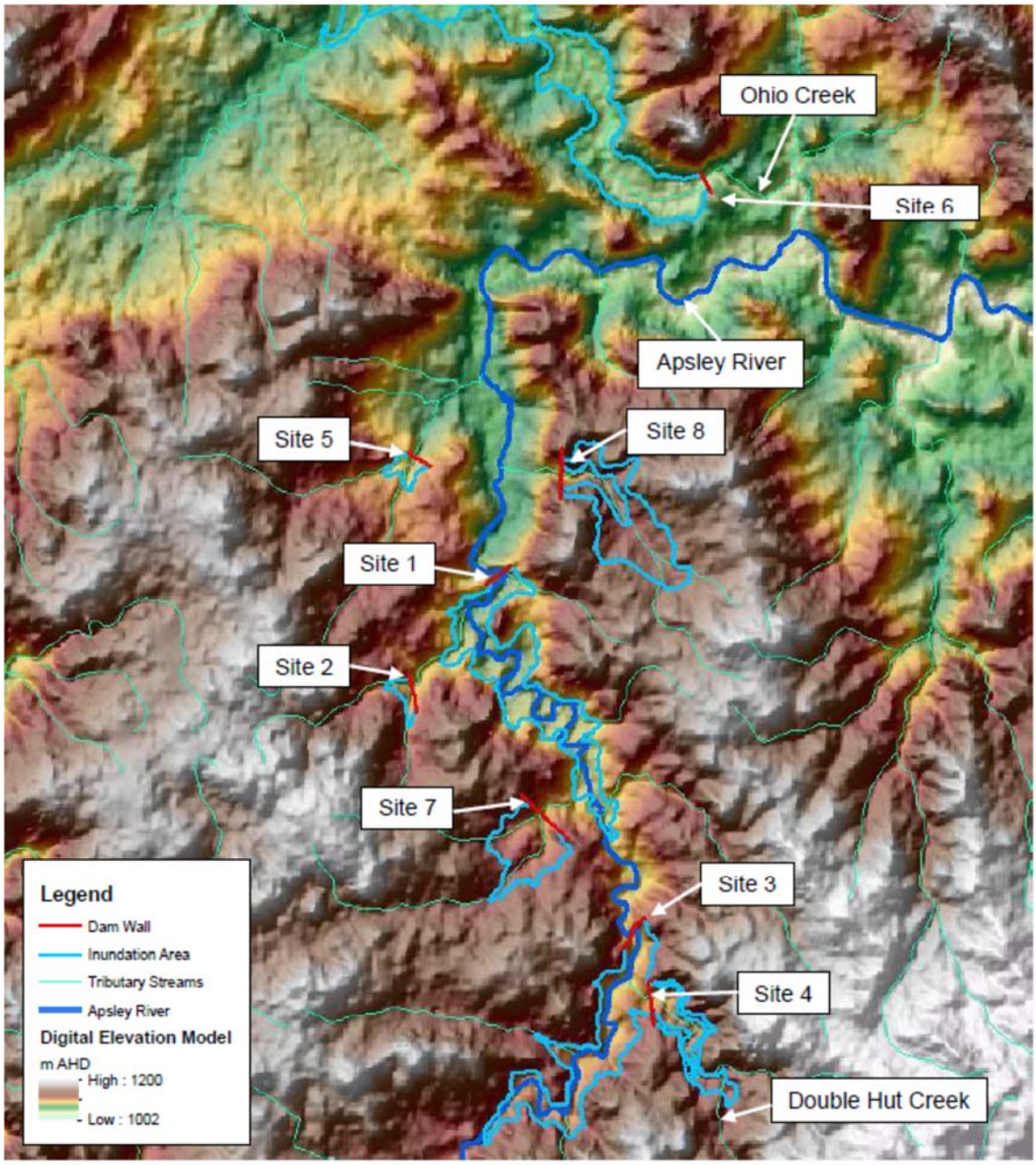


Figure 1 Location of potential Dam sites

Ref: Apsley River Dam Sites: Desktop Assessment, Hunter H2O & Douglas Partners, July 2017

An additional two off-stream dam sites that had previously been identified were also considered.

A walkover field inspection of the eight sites was undertaken, after which a workshop involving representatives from Hunter H2O, Douglas Partners, DPI Water and Walcha Council was conducted. At the conclusion of the workshop, Site 1, Site 3, Site 4 and Site 5 were taken forward for a more detailed evaluation. Arising out of the more detailed evaluation, Site 1 and Site 5 were shortlisted as the most appropriate to be considered in future phases of the project. A summary comparison of the two sites is provided in Table 1 below.

Table 1 Comparision of Dam Site 1 and Dam Site 5

Attribute	Dam Site 1	Dam Site 5
Potential Maximum Storage	25,000 ML	800 ML
Catchment Area	185 km^2	13 km^2
Location	Apsley River	Unnamed creek
Site Geology	Phyllite	Basalt
Preliminary Geotechnical Constraints	No comments, however will require further investigation	Concealed fault, will require further investigations into the fault and site in general
Potential suitability as a dam site	Yes, requires further investigation/evaluation	Yes, requires further investigation/evaluation
Potential Social Impacts and constraints	Potential impacts on Apsley Falls impacting tourism	Close to local residences, may cause noise disruption during construction
Potential Environmental Impacts and constraints	Potential impacts on flows through downstream World Heritage Listed National Park Environmental releases likely to be a key factor May need to consider fish migration	Least environmentally sensitive option
Potential Dam Safety implications	Likely High Consequence Category Dam.	Likely lower Consequence Category Dam
Connection to existing system	Pipeline with Booster Pumping Station	River Intake Pumping Station with potential weir on Apsley River with connecting pipeline to storage. Potential gravity feed pipeline to existing storage.
Advantages	Large storage possible, relatively close to Walcha	Close to existing storage and Walcha. Potential to store water sourced from either the Apsley or Macdonald Rivers Portion of site located on Crown Land Road reserve access for construction and pipelines

Attribute	Dam Site 1	Dam Site 5
Disadvantages	Potentially high Dam Safety consequences Will require booster pumping station. Acquisition of private land required for the pipeline, dam and 1:100 flood levels.	Concealed fault mapped that requires further investigation. Requires pumping from the Apsley or Macdonald Rivers to the storage and from the storage to the WTP

The report commented that the diversification of water sources for a town water supply between the Macdonald River and the Apsley River has the potential for improved supply outcomes, by facilitating greater flexibility with extractions. (Site 5 lends itself to this type of arrangement.)

2.1.1 Dam Site 1

The location on the Apsley River of Dam Site 1, approximately 4.5 km south of Walcha, is shown in Figure 2 below. The proposed dam wall will be located between two spurs projecting into the Apsley River valley. The existing river bed level at the site is estimated to be RL1061.5 mAHD. The catchment area for the dam is estimated to be approximately 185km^2.

The dam site and storage area are located on land used as pasture for grazing. Access is via Thunderbolts way to approximately 1.3 km west of the dam site and then via an existing gravel road to the property.

The storage volume plot of the dam is shown in Figure 3. The proposed storage level at RL1083 mAHD would result in a storage volume of approximately 25,000 ML with total embankment height of approximately 29 m, assuming a freeboard of 7.5 m to accommodate flood discharges over the spillway. Smaller storage volumes could also be accommodated at the site.

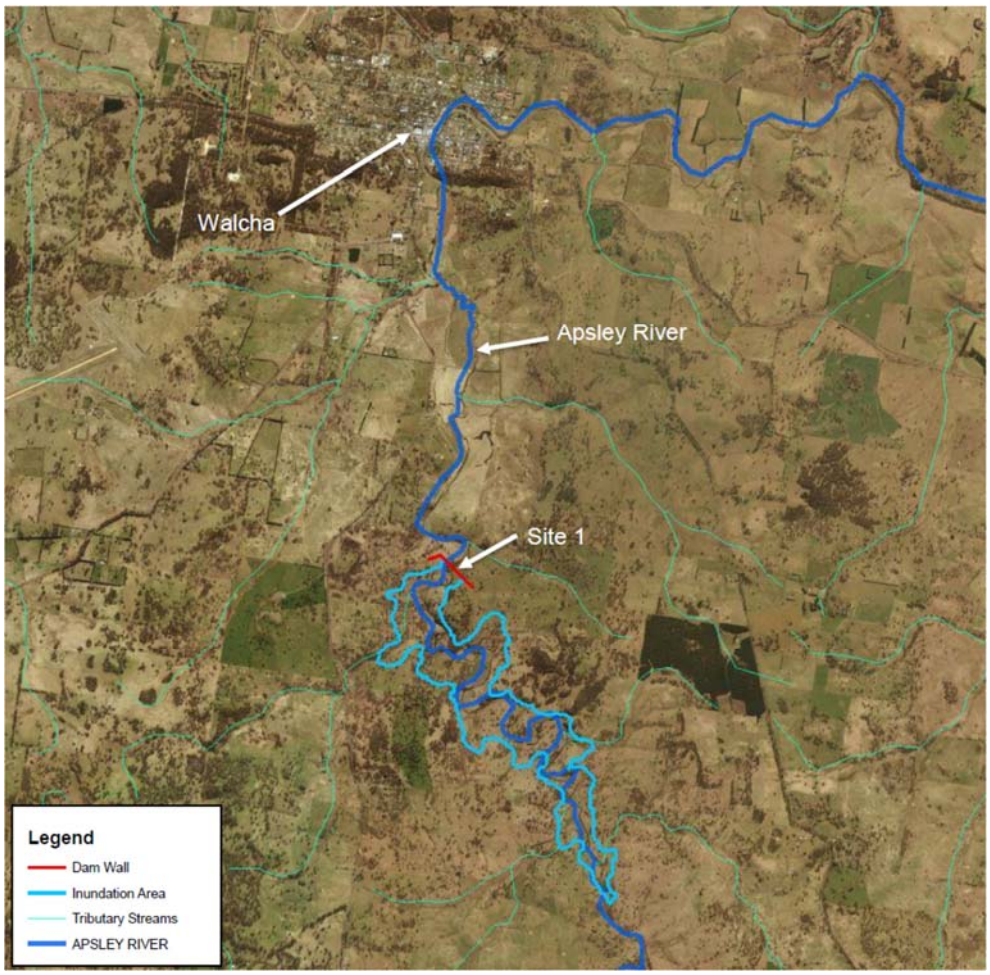


Figure 2 Location of Dam Site 1

Ref: Apsley River Dam Sites: Desktop Assessment, Hunter H2O & Douglas Partners, July 2017

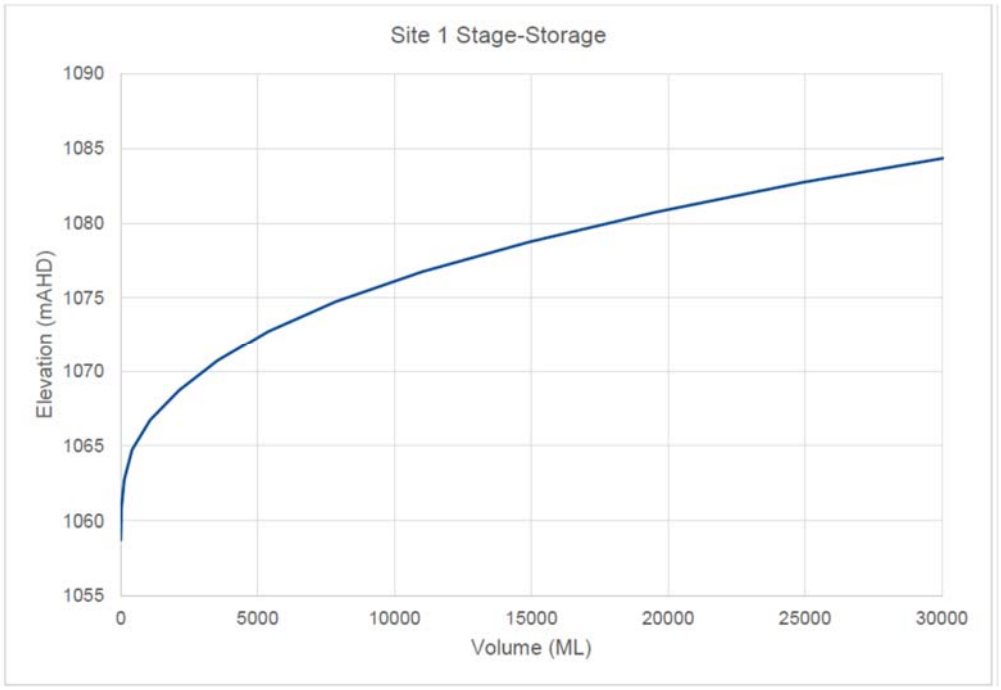


Figure 3 Storage volume relationship for Dam Site 1

Ref: Apsley River Dam Sites: Desktop Assessment, Hunter H2O & Douglas Partners, July 2017

2.1.1.1 Geology

Regional geology

Reference to the 1:250,000 Geological sheet compiled by Geological Survey of NSW indicates that the proposed dam wall is underlain by Palaeozoic aged Myra Beds, which typically comprise chist, phyllite, greywacke and slate. Areas to the west and east of the proposed wall alignment (possibly also within the upstream storage area) are mapped as being underlain by the Cainozoic, tertiary aged Comboyne Basal, which typically comprises basalt or dolerite. No known faults, synclines or anticlines are shown in the geological mapping in the immediate vicinity of the site.

Site features and observed geology

The following observations were noted in the report:

Apsley River and general dam area

- Apsley River is about 5 m to 10 m wide at the proposed dam embankment alignment location.
- Soils exposed at the surface in the vicinity of the river included dark grey or dark brown silty clay.
- An outcrop of bedrock is present approximately 100 m upstream of the approximate embankment alignment. The outcrop is about 20 m to 40 m in height and appears to expose high to very high strength phyllite. Numerous voids and areas of undercutting were observed within this outcrop. Two major joint orientations were observed within this outcrop, as follows:
  - 75°/030° at 0.5 m to 1.5 m spacing.
  - 60°/300° at 0.05 m to 1.0 m spacing.
  - Apertures within these observed discontinuities varied but were up to 50 mm.

Right abutment

- The right abutment is characterised by gently sloping, planar ground, rising to the west at slopes in the order of 7° to 10° (refer Figure 4-7);
- Only minor signs of erosion were noted during the inspection of this area;
- An outcrop of rock was exposed approximately 60 m downstream of the approximate wall alignment;
- The exposed rock in this outcrop was generally consistent with the upstream outcrop, with similar jointing.

Left abutment

- The left abutment is characterised by a steep slope (estimated to be in the order of 40° to 60°), which appears to have been partly excavated into the slope to form an access track.
- The steep slope was estimated to be about 12 m in height and exposed red brown clayey soils with rounded cobbles.

Identified potential constraints and recommended additional investigations

The report recommended that detailed investigation, including drilling of test bores and excavation of test pits, and seismic survey, both within the proposed embankment alignment, including abutments together with throughout the reservoir area of the proposed dam should be undertaken to assess the subsurface conditions at the site. The report made the following observations:

- The steep sloping ground on the left embankment, will require excavation into the hill slope. The depth to and strength of the bedrock should be assessed to assist with the design of bulk excavation and the embankment design.
- The characteristics of the bedrock, particularly the discontinuities, permeability and strength to assist with foundation design must be assessed.
- The characteristics of the soil profile, including potential for erosion, reactivity and strength needs to be assessed particularly within the embankment footprint.
- Subsurface conditions in the vicinity of the proposed spillway, once identified should be confirmed.

Based on the desktop assessment, the report indicated that no constraints were identified that would adversely impact the construction of a dam at Site 1. This will however, be subject to further field investigations as the project progresses.

2.1.1.2 Connection to the existing system

The report provided the following opinion (Section 4.2.7).

Depending on the final Full Supply Level of the storage, it is unlikely to be possible to feed under gravity from Site 1 to the existing water storage. The Full Supply Level of a 25 GL storage at Site 1 is approximately RL 1083 m AHD, while the river bed level at Site 1 is approximately RL 1061.5 m AHD. This results in a static head range of between +10 m and -18 m from Site I to the existing storage.

The ability to feed under gravity for the upper portion of a large dam will be dependent on pipeline alignment and required flow rates. Based on the final alignment and size of a dam at Site 1, along with the selected pipeline alignment, a booster pumping station will be required especially if water levels within the storage are at lower levels, or if water is required to be supplied directly to the WTP.

The lead-in strategy for connection to the existing system should be confirmed during future investigations, once the size of the dam is confirmed.

2.1.2 Dam Site 5

Site 5 is located on an unnamed tributary of the Apsley River approximately 3 km from the centre of Walcha, and approximately 1.5 km from the existing raw water storage. The location is shown in Figure 4. The site is located in the vicinity of, but downstream of the old quarry site, and offers a storage option close to the existing raw water mains from the Macdonald River source, potentially enabling water to be stored either from the Macdonald or the Apsley River. The parcel of land that the storage is located on forms part of a travelling stock route (TSR) and as such is Crown Land.

Based on available topographical information, the creek bed level in the vicinity of the proposed dam site is approximately RL 1073 m AHD. Dam Site 5 has a catchment area of approximately 13.3 km^2.

Access to Dam Site 5 is via Aberbaldie Road to within 500 m of the dam site. A haulage road would be required to be constructed to access the site. A road easement exists between Aberbaldie Road and Thunderbolts Way passing immediately south of the potential site. There may be potential for this easement to be utilised for access to the site and also for pipelines, both from the river and connecting to the existing Macdonald River pipelines.

The stage storage plot is shown Figure 5 below.

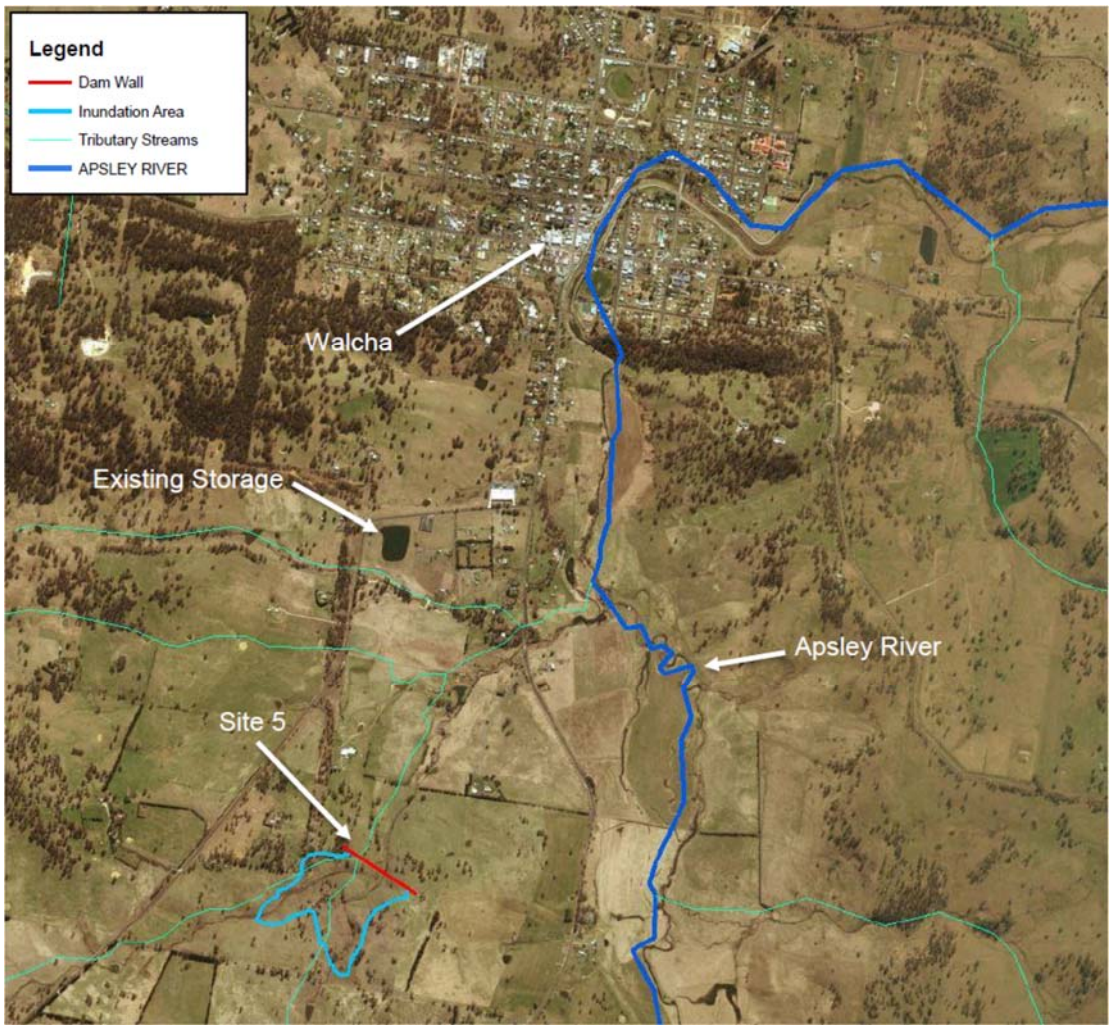


Figure 4 Location of Dam Site 5

Ref: Apsley River Dam Sites Desktop Assessment, Hunter H2O & Douglas Partners, July 2017

A Full Supply Level of approximately RL1089 mAHD would provide a storage of approximately 790 ML. A saddle dam would be required for a dam in excess of this size, due to a low lying area on the left abutment. Alternatively the dam wall would need to be relocated, which would likely result in an increase in construction materials. At a Full Supply Level of RL1089 mAHD, the crest length at FSL would be approximately 340 m while the water depth would be 16 m. Assuming a flreeboard allowance to accommodate floods of 5.0m, the total dam height would be approximately 21 m. This needs to be confirmed in future studies.

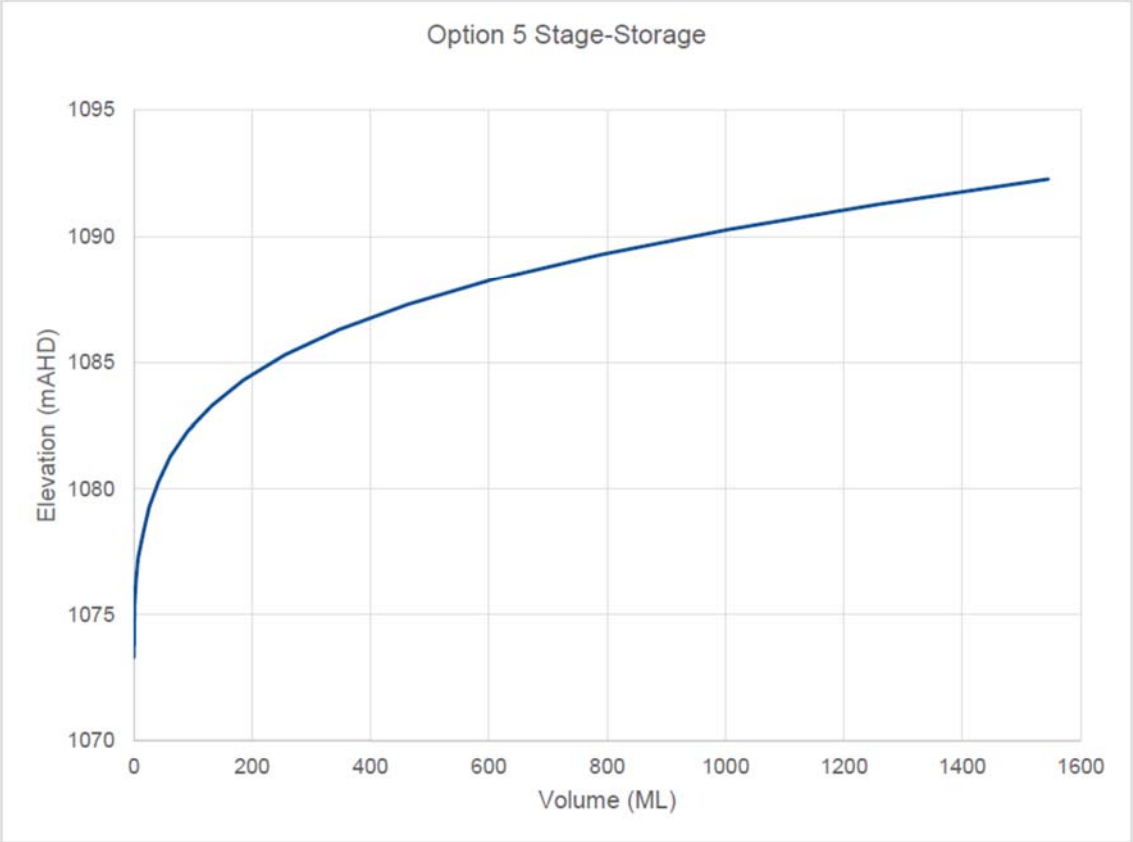


Figure 5 Stage storage relationship for Site 5

Ref: Apsley River Dam Sites: Desktop Assessment, Hunter H2O & Douglas Partners, July 2017

2.1.2.1 Geology

Regional geology

Reference to the 1:250 000 Geological sheet compiled by the Geological Survey of NSW indicates that the proposed dam wall alignment is underlain by the Cainozoic, tertiary aged Comboyne Basalt, which typically comprises basalt or dolerite.

Areas to the north of the proposed wall alignment are mapped as being underlain by the Palaeozoic aged Myra Beds, which typically comprise schist, phyllite, greywacke and slate.

The report noted that a concealed fault is mapped as being present in the area. It was recommended that further investigation for the presence of this mapped fault be undertaken at this site.

Site features and observed geology

The pertinent site features observed during a site inspection by a Principal Geotechnical Engineer from Douglas Partners Pty Ltd, were noted as follows:

Creek Alignment and General Dam Area

- The identified embankment alignment spans between two rounded hill crests with a broad, moderately steep valley between.
- The creek is less than 1 m in width at this site.
- Rocky ground was observed along the sides of the valley and adjacent to the creek. Soil cover, where present, appeared to be red brown, residual, silty clay.
- No obvious signs of instability were observed during the inspection.

- Numerous outcrops of basalt bedrock were observed within the creek line and adjacent banks.
- Measurement of joint orientations within this exposed rock was not possible owing to the degree of fracturing of the bedrock.
- Reference to the NSW OEH Soil and Land Information System indicated the nearest soil profile is located to the north-west of the site within a gully and that soils in the region may be:
  - 'silty clay loam' texture.
  - without obvious signs of surface cracking.
  - very high incidence or erosion was noted in the soil report at this location.

Right abutment

- The right abutment is characterised by a moderately steep slope, with large areas of exposed bedrock.
- Access to the right abutment was not possible at the time of inspection.
- The slope of this area appeared to be in the order of 40° to 60° with local relief estimated to be around 20 m to 25 m.

Left abutment

- The left abutment is characterised by a slightly convex slope which rises to the west at about 5° to 10° with numerous outcrops of rock exposed within this area.
- Only minor signs of erosion were noted during the inspection of this area.

Identified Potential Constraints and Recommended Additional Investigations

Detailed investigation, including drilling of test bores and excavation of test pits, and seismic survey, both within the proposed embankment alignment, including abutments together with throughout the reservoir area of the proposed dam should be undertaken to assess the subsurface conditions at the site. However, the pertinent site features observed during a site inspection by a Principal Geotechnical Engineer from Douglas Partners Pty Ltd, are as follows:

- The possible presence of faulting at the site. This should be assessed by investigation drilling and excavation of large test pits within the proposed embankment location.
- The characteristics of the bedrock, particularly the discontinuities, permeability and strength to assist with foundation design [must be assessed]. It is noted that excavation into the steep right abutment will be required for the dam embankment.
- The characteristics of the soil profile, including potential for erosion, reactivity and strength needs to be assessed particularly within the embankment footprint.
- Subsurface conditions in the vicinity of the proposed spillway, once identified.

The desktop assessment identified a concealed fault in the vicinity of Dam Site 5. Though it was considered unlikely that this fault is active, it was recommended that it should be investigated during subsequent phases of this project. Despite the location of the fault, this Dam Site should not be ruled out at this stage of the project.

2.1.2.2 Connection to the existing system

The report provided the following opinion (Section 4.5.7):

> *In order to fill a dam at Site 5, water would be required to be pumped from the Apsley River utilising either a deeper section of the river or by the construction of a small weir to provide a pumping pool. An intake pumping station and connecting pipeline would also be required.*

The advantage of Site 5 is its location near to the existing raw water main from the Macdonald River source, enabling it to store water sourced from either the Macdonald or Apsley Rivers. Similar to the existing raw water storage, flow from the dam would be required to be pumped to the WTP.

A road easement exists in the vicinity of the proposed site which would enable access for pipelines for the river intake and also connection to the existing Macdonald River raw water pipeline.

The strategy for connection to the existing system should be confirmed during future stages.

2.1.3 Dam safety considerations

The report indicated that Dams in NSW fall under the regulation of the NSW Dams Safety Committee (DSC). Local Water Utilities (LWU) are required to obtain Ministerial approval for the construction of LWU dams which could conceivably cause a significant threat to public safety in the event of a failure, regardless of the dam height or storage volume.

The LWU/Dam owner would be required to provide suitable options studies / investigations, which may include, but not be limited to:

- A dambreak study.
- A structural analysis and design.
- A geotechnical investigation.
- A flood study.
- A secure yield analysis (now completed).
- Independent peer reviews, where required by the DSC.

The report recommended that the LWU/Dam owner involve the DSC in the early stages of the options study / investigations in order to address all their requirements.

The DSC utilise a dam 'consequence category' in order to define the safety standards that are required to be met, including an Acceptable Flood Capacity (AFC) and Acceptable Earthquake Capacity (AEC), along with setting required surveillance and monitoring standards, among other things.

The dam consequence category is a function of the magnitude of adverse consequences downstream of the dam if it were to fail. Determination of consequence categories takes into consideration:

- Loss of life.
- Community impacts.
- Environmental effects.
- Total cost of damages.

The greater a dam wall height and the greater the stored volume, the greater the consequences of failure are likely to be. Dams of height greater than 15 m are automatically 'prescribed' under the Dam Safety Act and must, therefore, meet the requirements of the DSC.

The location of a dam in relation to a downstream Population at Risk (PAR) is a key component, and sites where there are minimal impacts on downstream populations are preferable.

In relation to this study, it is likely that the large on-stream storage proposed for Dam Site 1 would be prescribed as a High consequence category dam. Among other things, this would result in the dam requiring routine surveillance between 3 times per week and daily, depending

on consequences, along with requiring annual inspections and comprehensive dam surveillance inspections every 5 years.

Although the off-stream storage option Dam Site 5 will not be as large as Dam Site 1, this does not necessarily mean that its consequence category will be lower. This will be a function of the location of properties downstream. This should be assessed as the project progresses.

These aspects should be given due consideration during subsequent stages.

2.1.4 Access to water

The report provides the following opinion (Section 6):

Access to water is a key component that needs to be considered for the planning for a new dam. The Apsley River is covered by the Water Sharing Plan (WSP) for the Macleay Unregulated and Alluvial Water Sources (Department of Primary Industries Water, 2016). The current WSP commenced on 1 July 2016 and has a term of 10 years.

The WSP sets the rules for protecting the environment, water extractions, managing licence holders' water accounts and water trading in the plan area.

The WSP prevents the granting of new unregulated river access licences, along with preventing trade into the Apsley River water source, beyond the existing level of entitlements, from downstream water sources. Therefore, any new commercial development must purchase entitlements from existing access licences consistent with the dealing rules defined in the WSP. This would be the mechanism by which any irrigators wishing to access water from a new dam would be required to utilise.

The Water Management Act 2000 allows for the granting of LWU access licences to support the growth of regional communities. Therefore, Walcha Council, in looking to secure the town water supply could apply to access water under the Macleay WSP. However, it should be noted that large industrial users may be excluded from this licence if it is considered that they should hold their own water extraction licence.

The following limited water entitlements in the Apsley River water source, which includes the Apsley River upstream of Apsley Falls, exist:

- *326 units of unregulated surface water access (1 unit = approximately 1 ML/a).*
- *4.5 ML/a of Domestic & Stock (D&S) access.*
- *Approximately 205 units of Basic Landholder Rights (BLR) – mainly D&S.*

There is some ability within the WSP to convert existing unregulated entitlements to "high flow only access licences", with a conversion rate of 5 units of high flow water to 1 unit of unregulated water. This high flow access commences at the 50th percentile (i.e. the flow that is exceeded on 50% of days). High flow water was 0 at the commencement of the WSP and is limited to 429 units in total. Under this scenario, it would be possible to convert 86 units of unregulated entitlements to 429 units of high flow entitlements, leaving 240 units of unregulated entitlements.

Even with this conversion in entitlements within the Apsley River water source, there remains limited water available to warrant the construction of a large dam for irrigation purposes. Providing a project has a strong business case, there may be some ability to apply for, and negotiate changes to the WSP, assuming the environmental and social impacts of the project (particularly with respect to water resources) are acceptable. In the case of a large dam on the Apsley River, there are likely to be major impacts on the downstream reaches of the Apsley River, particularly the Apsley Gorge including the National Park and World Heritage Area. In

addition, the economic benefit of constructing a large dam on the Apsley River is considered to be marginal at best.

For a town water supply (only) project, there is the potential for improved environmental outcomes by splitting the town water demand between the Apsley and Macdonald rivers. Note that both source are likely to be subject to similar climatic conditions due to similar locations (adjacent catchments) and similar elevations (edge of tablelands / escarpment) and therefore will likely both be stressed in extended drought periods. However, the Macdonald River does have a higher mean discharge/km^2 and larger catchment area to extraction point (therefore would likely remain the primary source).

For a town water supply project, Walcha Council could apply for a change to the LWU access licence to allow extraction from either the Macdonald River or Apsley River, within current Macdonald River licence limit of 379 ML/a.

2.1.5 NSW Government approvals

The report commented that there are two broad approaches that may be relevant for the construction of a dam on the Apsley River or within the Apsley River valley. The first is relevant for a town water supply only dam, while the second would be relevant for a larger regional scheme involving potential irrigators.

The report discussion on these pathways is included in the following sections.

2.1.5.1 Section 60 Approvals for local water utility dam works

Under Section 60 of the Local Government Act 1993, LWUs are required to obtain Ministerial approval for any significant modifications to or construction of local water utility dams, which could conceivably cause a significant threat to public safety in the event of a failure, regardless of the dam's height or storage volume.

The Section 60 approvals provide an independent review of the proposed works to ensure they are fit for purpose and provide robust, safe, cost-effective and sound solutions that meet environmental and regulatory requirements.

The key steps involved in applying for Section 60 approval are summarised below.

1. Initial Consultation – early involvement of DPI Water (now believed to be Crown Lands and Water Department) and the NSW Dams Safety Committee.
2. Options Study / Investigation Report – commissioning of dams engineers / specialists to prepare an options study or investigation reports.
3. Concept Design.
4. Tender Process.
5. Detailed Design.

A summary of the above steps are included in the NSW Department of Primary Industry Section 60 approval process for local water utility dam works document which is contained in Appendix B.

Approval would be required for in-stream works (weir, intake pump station) and may need to consider fish passage and minimum flow requirements (cease to pump rules).

It should also be noted that on 16th September 2015, a new Dams Safety Bill was assented to by Parliament. The Bill introduced important reforms to the regulatory framework for dam safety in NSW, including the introduction of new standards.

The new Dams Safety Bill removes sections 60 and 61, in so far as they relate to dams, from the Local Government Act 1993 (LG Act). Once a new Dams Safety Act is fully implemented, a new entity entitled Dams Safety NSW will be formed, and this new entity will be responsible for reviewing and compliance auditing against its safety requirements for new and existing declared dams.

2.1.5.2 NSW Treasury gateway review process

For larger regional projects with state funding, such as the community proposed 25 GL dam, the NSW Treasury Gateway Review process is likely to be required.

Under this process, project justification is primarily tied to the preparation of a comprehensive business case, which would include feasibility / options studies, financial / economic appraisal, environmental impact assessment (or EIS), social impact assessment and sustainability assessment. The key stages for funding approval are:

- Gate 0 – Initiation / Need Confirmation / Justification Review
- Gate 1 – Needs Analysis / Strategic Review (Preliminary Business Case)
- Gate 2 – Funding approval based on full Business Case Review
- Gate 3 – Project Procurement and Delivery Plan (Pre-tender / Pre-execution)
- Gate 4 – Service Provider Selection / Tender Evaluation
- Gate 5 – Contract Management / Pre-commissioning
- Gate 6 – Procurement Evaluation / Post implementation

Additional details of the above Gateway Review Process is contained in Appendix C of the Hunter H2O report.

2.2 Hydrological Yield Study

2.2.1 Introduction to Hydrological Yield Study

Walcha Council commissioned NSW Urban Water Services Pty Ltd to prepare a hydrological yield study for Dams located on Site 1 and Site 5 (refer to Figure 1 for location of the dam sites). The study was based on the following assumptions:

1. A 25,000 ML dam was modelled at Site 1.
2. A 800 ML Dam was modelled at Site 5.
3. The yield assessment essentially used the methodology given in NSW Office of Water's Draft (December 2013) guidelines "Assuring future urban water security - Assessment and adaption guidelines for NSW local water utilities".
4. Transfer rate from Macdonald River of 2.16 ML/d with 24 hours/ 7 days pumping was assumed for the options summarised below.
5. Existing storages of 86.145 ML and 5 ML (town storage) have been included in the assessment of Dam Site 5.

The summary conclusions given in the report are as follows:

Site 5 Storage including Macdonald River Abstractions (Macdonald River only)

For this case it is assumed that the existing rolling cap average of 379 ML/a is allowed to be extracted from the Macdonald River over 3 years, with a maximum of 758 ML/a, together with the Environmental Flow Rule (EFR) 1 Case. For this scenario, the future town demand target of 287 ML/a can almost be met by the Macdonald River abstractions and the 800 ML offstream storage at Site 5 (shortfall of 33 ML/a).

Site 5 Storage including abstractions from both Macdonald and Apsley Rivers

If the existing Walcha water supply system is augmented by the 800 ML offstream storage at Site 5 and abstractions occur from both the Macdonald and Apsley Rivers, the town water demand target of 287 ML/a is met. An additional demand of 288 ML/a (combined 575 ML/a) can be met

Note: a yield of 288 ML/a has been allocated to the creation of additional agricultural output in the Benefit Cost Analysis (refer to Section 4 of this report).

Secure Yield Estimates for Site 1 Storage on the Apsley River

Results suggest that the 25,000 ML storage on the Apsley River at Site 1 may only result in an additional 500 to 600 ML/a in Secure Yield compared to the 800 ML offstream storage at Site 5 with the rolling Macdonald average cap and nominated EFR conditions. However, it is suggested that this is unlikely to be achieved due to limitations on water that can be extracted from the Apsley River.

Note: a yield of 788 ML/a has been allocated to the creation of additional agricultural output in the Benefit Cost Analysis (refer to Section 4 of this report).

2.2.2 Observations

25,000 GL Apsley Dam at Dam Site 1

Information for Annual extractions (Summary Report 3) give the following figures:

- Run 316: For the various runs given in Attachment A, the secure yield is between 1186 and 2553 ML/a. This represents between 5% and 10% of the capacity of the dam. Figure

7 of the report states the average annual supply is 1482 ML, which is a yield of just below 6% of the dam capacity.

- Run 314: For the various runs given in Attachment A, the secure yield is between 1054 and 2182 ML/a. This represents between 4.2% and 8.7% of the capacity of the dam. Figure 8 of the report states the average annual supply is 1497 ML, which is a yield of approximately 6% of the dam capacity.

Table 3 from the Hydrology Yield study is shown below. This provides the estimated yields from the dam under various assumptions and for different modelling "Runs".

Table 3: Secure Yield Estimates for Site 1 Onstream Storage on Apsley River

Total Storage Size ML	Run No	EFR Case	Flow Case	Historic Secure Yield ML/a	Adjustment Factor for Climate Change	Secure Yield with 1 °C Climate Warming ML/a
	WTP Unconstrained with rolling Macdonald average cap of 379 ML/a:					
25091	316	1 plus 30/30	Set5	**1844**	0.57906	**1068**
	314	1 plus 30/30	Set3	**1859**	0.60594	**1126**

(Yield Assessment of Apsley River Options: Summary Report, NSW Urban Water Resources, Dec 2017)

800 GL Dam at Dam Site 5

Information for Annual extractions (Summary Report 3) give the following figures:

- Run 315: The secure yield is given as 287 ML/a. This includes the yield achieved by the continued operation of the 86.1 and 5 GL dams, which already exist. Annual extractions from the Macdonald River for this scenario fall approximately between 120 GL and 570 GL. No water extractions from the Apsley River are included in this run.
- Run 357: The secure yield for this scenario, which includes abstractions from both the Macdonald and Apsley Rivers is given as 782 ML/a. Extractions from the Macdonald River again range between 120 GL and 570 GL, while extractions from the Apsley River range between approximately 210 GL and 1050 GL.

Table 2 from the Hydrological Yield Study is included below, which shows the dam yield results for Run 357.

Table 2: Secure Yield Site 5 Offstream Storage with Apsley River

Site 5 Offstream Storage Size ML	Case Run No	EFR Case	Flow Case	Historic Secure Yield ML/a	Adjustment Factor for Climate Change	Secure Yield with 1 °C Climate Warming ML/a
With rolling Macdonald average cap of 379 ML/a and WTP Unconstrained:						
800	357	1 plus 30/30	Set6	**782**	0.7361	**575**

(Yield Assessment of Apsley River Options: Summary Report, NSW Urban Water Resources, Dec 2017)

Comment:

The yield from Dam Site 5 considering extractions from only the Macdonald River (Run 315) is approximately 36% of the capacity of the dam. A slightly smaller dam may be appropriate under this operating scenario.

The yield from Dam Site 5 (Run 357), considering extractions from both the Macdonald and Apsley Rivers, and assuming the rules for extraction will be permitted, is approximately 98% of the capacity of the dam. A larger dam may provide some additional yield, however, based on available topographical information, there will be challenges to construct a larger storage on this site.

2.2.3 Percentile Flows

The report (Table 5) provided a comparison of the flows in the Macdonald and Apsley Rivers. The comparison is shown in Table 2 below.

Table 2 Comparative flows

Target	Macdonald River at Woolbrook Gauging Station ML/d	Modelled Equivalent at Macdonald River Offtake ML/d	Apsley River at Offtake for Site 5	
			Series6 Flows ML/d	Series8 Flows ML/d
80%ile	31.8	24.17	0.83	1.29
90%ile	17.13	13.02	0.25	0.36
95%ile	7.34	5.58	0.05	0.08

(Yield Assessment of Apsley River Options: Summary Report, NSW Urban Water Resources, Dec 2017)

Comment

Based on Table 2 above, it is clear that the flows in the Macdonald River are significantly higher than those in the Apsley River. A greater water flow should be possible from the Macdonald compared to the Apsley River. However, at face value, the hydrology Run 357 indicates that the yields from the two rivers are similar. **The reason for this is that abstractions from the Macdonald River have been capped in line with the existing licence conditions.**

2.3 Economic Benefit Study

The following information has been extracted from the Apsley Dam Economic Benefit Study, prepared by Regional Development Australia, dated September 2017.

2.3.1 Benefits

The report included the following potential benefits for the 25,000 ML dam on the Apsley River. The principal benefits were assumed to accrue to a 20 ha tomato glasshouse, and boosting of beef cattle production, dairy, turf and summer potatoes. Increases in trout fishing tourism were included, while the activities associated with aged care were doubled. The table assumes that at least 16,500 ML/a is available for increased economic activity (note: based on the outcomes of the hydrology yield study, this figure will not be achieved – refer to Section 2.2).

The following table is extracted from the report (Table 8 of the Economic Benefit Study Report).

Enterprise	Area (ha)	Extra Water use (ML/pa)	Additional gross output ($M)	Additional gross regional product ($M)[1]	Additional jobs
Tomato glasshouse	20	280	26.4	14.1	85
Beef cattle	2,000	9,000	5.9	2.3	18
Dairy	900	4,068	3.2	1.2	9
Turf	200	2,200	1.2	0.65	4
Potatoes	300	900	0.81	0.43	3
Fishing tourism[2]	285	n/a	1.3	0.56	6
Double aged care[3]	n/a	5	4.4	3.4	31
TOTAL	**3,420**	**16,453**	**43.2**	**22.5**	**156**

(Apsley Dam: Economic Benefit Study, Regional Development Australia Northern Inland NSW, Sept 2017)

Notes associated with the above table:

1. Value added from REMPLAN has been used as a proxy for GRP.
2. Results in an extra 5,500 visitor days.
3. Current gross output is $5.8 M for residential care and social assistance. Assumed this increases another $3M in gross revenue.
4. Assumed that the additional profit margins for irrigated beef and dairy warrant its uptake at these levels.

The report commented that, "*for a 25 GL Dam where two-thirds of the dam volume were available for production uses could significantly boost Walcha's GRP by 22.5M (an 11% increase) and employment by 156 jobs (a 12% increase)*".

2.3.2 Conclusions from Study

The study provided the following comment and conclusions (Section 6):

There appear to be three main issues to consider regarding a dam on the Apsley River:

1. *Securing the town water supply, as the current supply from the Macdonald is inadequate. The secure yield of 0.108GL/pa means the town water supply 5/10/10 rule is breached.*

2. *Climate change has agricultural producers concerned about their future ability to maintain current production levels and profitability. Access to adequate volumes of irrigation water for pastures and fodder could alleviate these concerns.*

3. *More available water would provide the opportunity to diversify the Walcha economy by attracting new industries and expanding existing industries.*

Securing the town water supply is a key priority, and one which DPI Water appear most likely to support. A less ambitious proposal (e.g. putting a weir across a 2nd order creek/gully) is likely to be a much easier task to take through the regulatory process than a dam on a 3rd or 4th order stream (e.g. the Apsley River).

The second issue – supporting production on local grazing farms – is problematic from several angles:

- *There are likely only a small number of producers and a small total land area (less than 21,408ha) in the LGA which may benefit from access to irrigation water unless water can cheaply be piped large distance;*
- *Even if only 25% of this area were irrigated, at 3.5ML/ha it would use up most of the water (19GL) in a 25GL dam. It is unlikely DPI Water would allow this much water to be used;*
- *The economic impact of any resulting extra production is relatively small compared to some intensive water-use enterprises which use less water in total;*
- *The economics of irrigating pasture is doubtful given the likely costs of the water and the irrigation operating/capital expenditure;*
- *Regardless, if a dam were built, it is likely most of the available water would be used to irrigate pasture or fodder crops, as realistically only one or two alternative intensive enterprises are likely to be attracted to the region, and they alone would only use a small proportion of the 25GL. As shown in Table 8 (of the report), this situation could still provide a significant economic boost to the Walcha LGA.*

Regarding the third issue, this is where most of the potential economic benefit lies. There are certainly more intensive uses of the dam water which would provide a much larger boost to the Walcha economy than watering pasture or fodder crops. However, it will require a significant effort by the council and community to attract such a business or cluster of businesses to the region.

The attractiveness of those alternative enterprises has been rated based on their economic return per ML of water used and a range of other industry factors. Intensive glasshouse production of vegetables and/or fruits appears to be one of the most feasible options, but the specifics require further investigation with companies who work in that industry. As one of these companies has already invested in the region (Costa's at Guyra) and others are examining options in the Gwydir Shire, this improves the chance of success.

While medicinal cannabis production provides the largest economic return per ML of water, the limited market and other hurdles mean it is a long-shot, and more likely to be located near where existing Australian companies are cultivating/manufacturing the product (in Victoria and WA).

The most productive strategy would be to pursue an option which secures the town water supply, while leaving sufficient water to boost existing business expansion, or attract a significant new enterprise to the area. If a larger water supply can be developed, that water can be used on more traditional extensive agricultural activities to further increase local economic activity.

2.3.3 Observations

The study has assumed that the annual yield from the dam would be close to the storage capacity of 25,000 ML. The hydrological study has determined the yield of the dam (assuming 1% warming climate change scenario) between 1,068 ML/a and 1,126 ML/a (Table 3 of the Hydrology Yield Study). The total benefits suggested by the Economic Benefit Study will therefore not materialise and the benefits will be significantly reduced. The reduced benefits have been modelled in the GHD Benefit Cost Analysis (refer to Section 4 of this report).

3. Cost estimates

3.1 Introduction

For the purpose of developing outline cost estimates for the dams and associated infrastructure, high-level designs for the structures were prepared. The designs were based on topographical information sourced from Geoscience Australia's Elevation Information System (ELVIS). The highest resolution available for the study area was the Shuttle Radar Topography Mission (SRTM) 1 second (30 m grid) Digital Elevation Model (DEM). This topographical information is unsuitable for detailed design and the associated cost estimates and will need to be refined for later stages of the project.

3.2 Dam design and construction quantities

The assumptions associated with the development of outline designs and associated construction quantities for each of the dams are described below. Layout drawings for the two dams are included in Appendix B.

3.2.1 Dam at Site 1

For the concept design and associated schedule of construction quantities associated with this dam, the following assumptions have been made.

- **Spillway design**. The estimated spillway design flow has been based on the estimated spillway design flow used on a dam in an adjacent catchment approximately 50 km south west of the site. The spillway flow has been based on the Probable Maximum Flood of the adjacent catchment, factored for the relative catchment area of the two sites. A 10 m deep, 120m wide concrete lined spillway will be constructed. A stilling basin will be provided at river level to return the spillway flow to the Apsley River.
- **Dam type**. Based on the relatively wide valley, it is assumed that an earthfill embankment will be constructed at the site. The embankment will have a central impervious core, filters to resist piping erosion and shoulders of random fill. Embankment slopes will be 3H:1V upstream and 2.5H:1V downstream.
- **Construction materials**. It has been assumed that earthfill for the embankment will be sourced from within the dam basin. Rip rap and other rockfill will be obtained from essential excavations, such as the spillway.
- **Intake tower and outlet works**. A 6m diameter reinforced concrete intake tower will be provided with intakes at various levels. A valve house will be provided downstream of the dam to release water to the Apsley River or to pump water to the existing water treatment infrastructure. An outlet conduit will link the intake tower and the valve house (refer below).
- **River diversion and outlet conduit**: A 5m diameter concrete outlet conduit has been provided to facilitate river diversion during construction and to provide a permanent link between the intake tower and valve house. An upstream and downstream coffer dam, integral with the main embankment will be provided to facilitate working within the river foundation section in the dry.
- **Dam foundations**. It has been assumed that excavation of insitu material to a depth of 1.0m will be required beneath the dam footprint. The core excavation depth will be an additional 4 m. A single line grout curtain will be provided to a nominal depth of 2/3 of the depth of water, with a minimum of 6.0 m.

3.2.2 Dam at Site 5

Similar assumptions have been made for this dam to those made for the dam at Site 5. The major differences between the two sites are as follows:

- **Spillway design**. For this site, a 5.0 m deep, 30 m wide concrete lined spillway will be provided.
- **Dam foundations**. Insitu material will be excavated to a depth of 1.0 m beneath the dam footprint. The core excavation depth will be an additional 2 m.
- **Intake tower**. The intake tower will have an internal diameter of approximately 5.0 m.

3.3 Pipelines and pump stations

The following additional infrastructure has been included in the estimates for Dam Site 1:

- A 250 mm pipeline from Dam Site 1 to the existing off -channel storage dam.
- A pump station at the dam to pump the water through the pipeline.

The following additional infrastructure has been included in the estimates for Dam Site 5:

- A 250 mm pipeline from the existing Macdonald water transfer system to Dam Site 5.
- A weir, pump station and 250 mm diameter pipeline to pump water from the Apsley River to Dam Site 5.
- A pump station at the dam to pump water through the pipeline to the existing off-channel storage dam.

3.4 Schedule of quantities and cost estimate

The schedule of quantities and associated cost estimates for the two dam sites are included in Appendix A. Similar rates to those established for a dam site located 50 km south west of Dam Site 1 and Dam Site 5 have been applied for development of the cost estimates.

The following costs have been estimated (refer to notes on cost estimates below):

Table 3 Summary of Construction Cost estimates

Item	Description	Cost ($ million)
1	Dam at Site 1 (25,000 ML)	180.2
2	Dam at Site 5 (800 ML)	68.2
3	Pipelines associated with the Dam at Site 1	10.9
4	Pipelines and pump station for existing Macdonald abstractions only	9.4
5	Pipelines, pump station and weir associated with existing Macdonald abstractions and abstractions from Apsley River associated with the Dam at Site 5	18.1

3.4.1 Notes on cost estimates

The following notes apply to the cost estimates developed.

- An earthfill embankment dam type is assumed. If insufficient quantities of suitable earthfill are not present on the site and rockfill of suitable quality is present, either a clay core

rockfill dam or a concrete faced rockfill dam could be constructed at the site, for a comparable cost to the earthfill embankment dam.

- Foundation conditions are unknown. This affects items such as excavation depth, grouting and sealing of foundation, foundation permeability (e.g. fault at site 5), etc.
- Sources of embankment construction materials are unknown and would need to be confirmed to provide greater accuracy for cost estimation. Materials would be required for embankment dam core, shoulders, rip rap and filters (crushed rock and/or natural sands) and for concrete aggregates. (**note**: if suitable materials do not exist for construction of an embankment dam, alternative dam types would need to be considered, e.g. concrete faced rockfill dam or concrete dam).
- Flood hydrology for spillway design has been based on an estimate for a dam in an adjacent catchment approximately 50 km away from the sites. The spillway for Dam Site 1 will be a major structure.
- Topography has been based on Geoscience Australia's Elevation Information System (ELVIS). The highest resolution available for the study area is the Shuttle Radar Topography Mission (SRTM) 1 second (30 m grid) Digital Elevation Model (DEM). The accuracy of this information is not appropriate for detailed design.
- Assumptions made for river diversion, intake tower, outlet house, pump stations, pipelines. Pipeline sizes and pump capacity have been assumed and would need to be properly designed once the design flows are determined.
- Environmental studies and Environmental Impact Assessment have been excluded.
- No allowance has been made for a fishway.
- Rates for construction items are typical, rather than site specific.
- Future cost increases (inflation) are excluded.
- The contingency allowance included in the estimate is 50% of direct construction cost items. Other allowances have also been included.

The cost estimates are HIGH LEVEL and not based on detailed designs. No guarantee can be provided that the project can be constructed for the estimated costs developed. These cost estimates should not be used for accurate budgeting purposes.

4. Benefit cost analysis

4.1 Introduction

This section provides an analysis of the costs and benefits of the project options compared to the Base Case, or “without project” case.

Benefit cost analysis (BCA) is a technique used to systematically assess the economic, social and environmental costs and benefits of a project in order to ultimately determine if it will lead to an improvement in community welfare. To aid in the comparison of project options, where possible, identified benefits and costs are quantified in dollar terms. Where this is not possible, costs and benefits are discussed qualitatively to ensure that the full range of impacts are identified and considered in the decision making process.

A project is deemed to be desirable from a whole of community perspective, if the present value of the benefits of the project exceeds the present value of its costs.

Alternatively, a Benefit Cost Ratio (BCR) can be used to assess the merits of the project by determining the ratio of the present value (PV) of its benefits to the present value of its costs. A BCR of greater than one indicates that the present value of the benefits are greater than the present value of the costs.

i.e. BCR = PV (Benefits) / PV (Costs)

Consistent with the NSW Government’s Guide to Cost Benefit Analysis (TPP17-03), the BCA for the Walcha Water Security Options project has involved the following key steps:

- Consideration of the project objectives.
- Definition of the base case and project options.
- Identification of costs and benefits.
- Quantification of the costs and benefits.
- Identification of qualitative factors and distributional impacts.
- Assessment of project risks and testing sensitivities.

4.2 Project objectives

The objectives of the Walcha Water Security Options project are summarised as follows:

- To assess options for enhanced water security for the Walcha region that could have the potential to drive job opportunities and economic growth in the future.
- To assess options for water security for town supply to ensure the future stability and prosperity of the Walcha community.

4.3 Base case and project options

To date, there have been three stages of the broader Walcha Water Security Study, being:

- Stage 1 - The Apsley Dam Economic Benefit Study
- Stage 2 - The Apsley River Dam Sites, Desktop Assessment
- Stage 3 - The Apsley River Secure Yield Study

The outcome of these previous investigations was a recommendation that two dam sites be investigated further in the current project. The options evaluated are summarised in Table 4.

Table 4 Summary of base case and options considered in the BCA

Option	Description of option
Base case – without the project	Under the base case, Walcha will continue to source its town water supply from the Macdonald River. Water restrictions will continue to be put in place.
Option 1 (Site 1)	A new 25,000ML dam storage on the Apsley River. Pipeline with Booster Pumping Station.
Option 2 (Site 5)	A new 800ML dam storage is located off stream, in a location that is close to existing infrastructure and the Aberbaldie Road. River Intake Pumping Station with potential weir on Apsley River with connecting pipeline to storage. Potential pumping station and pipeline to existing storage.

4.4 Identifying the costs and benefits

A range of costs and benefits associated with the project options are considered for inclusion in the BCA as summarised in Table 5. To warrant inclusion in the BCA model to assess the merits of each option, the identified costs and benefits must be incremental to the base case.

Table 5 Summary of project costs and benefits

Costs	Benefits
Capital costs (including investigative works and approvals, dam construction, roads and access, contingency, etc.) for dam and pipeline	Avoided capital expenditure on existing water supply infrastructure – all existing infrastructure will remain in place, therefore there will be no change in these O&M costs relative to the base case
Decommissioning and rehabilitation costs of existing storage site / infrastructure – the BCA assumes no infrastructure will be decommissioned, and therefore these costs are assumed to be zero	Improved town water security and levels of service for Walcha residents and businesses (including aged care)
Augmentation of existing Water Treatment Plant (WTP) – it is understood that the enlargement of the WTP may be required, however this has not been costed as part of this study	Increased value of agricultural production from additional water volume available for irrigation
Increase in annual operating and maintenance costs associated with new dam and pipeline infrastructure	Residual value of new dam and pipeline infrastructure

Costs	Benefits
Potential offset costs associated with environmental impacts – the cost of offsets has not been calculated as part of this study	Improved amenity and recreational benefits – unable to be quantified for the purposes of the BCA, however likely to be more relevant for Site 1 due to larger dam size
Potential dam safety issues – the BCA assumes these to be zero as any new dam infrastructure will be designed to meet modern dam safety requirements	Potential employment growth – excluded from BCA but discussed in Section 2.3 above
Potential noise disruption to local residences during construction – unable to be quantified for the purposes of the BCA	
Potential impacts on Apsley Falls impacting tourism – unable to be quantified for the purposes of the BCA	

It is noted that each of the costs and benefits of the project will accrue to different sections of the community. For example:

- We have assumed that upfront capital costs will be met through State and Federal funding arrangements.
- We have assumed Walcha Council will be responsible for annual operating costs as well as renewal and replacement, which will be recovered through town water charges.
- Businesses and residents in Walcha will benefit from improved water security.
- Irrigators and any current or prospective water dependent industries will benefit from increased water reliability.

4.5 Valuing the costs and benefits

Consistent with NSW Treasury Guidelines, the BCA is based on a 30-year analysis period. Design and construction costs for new infrastructure are assumed to occur in the first 5 years of the analysis period, followed by 25 years of operations.

4.5.1 Costs

Estimated capital costs

The estimated capital costs associated with each site are detailed in Section 3 of this report. For the purposes of the BCA, these costs and their associated timing are summarised in Table 6.

Table 6 Summary of estimated capital costs associated with each site

Option	Capital cost	Timing
Site 1	Dam: $180.2m Pipeline: $10.9m	Dam: $2.6m in each of years 1 and 2 for design works Remaining costs spread over years 3 to 5 for construction Pipeline: $0.2m in each of years 2 and 3 for design work Remaining costs spread over years 4 to 5 for construction

Option	Capital cost	Timing
Site 5	Dam: $68.2m Pipeline: $18.1m	Dam: $1m in each of years 1 and 2 for design works Remaining costs spread over years 3 to 5 for construction Pipeline: $0.3m in each of years 2 and 3 for design work Remaining costs spread over years 4 to 5 for construction

Source: GHD estimates

The costs presented in Table 6 assume:

- No land acquisition costs.
- No decommissioning and rehabilitation costs.
- No augmentation of the existing Water Treatment Plant.

Estimated operating and maintenance costs

The increase in annual operating and maintenance (O&M) costs associated with the new infrastructure is assumed to be incurred from Year 6 onwards (i.e. following the construction of the new infrastructure). The BCA assumes the increase in:

- Dam O&M annual cost is approximately 0.25% of new dam capital costs
- Pipeline O&M annual cost is approximately 0.35% of new pipeline capital costs

Table 7 presents the estimated increase in annual O&M costs associated with each site.

Table 7 Estimated increase in annual O&M costs associated with each site

Option	New dam O&M cost (p.a.)	New pipeline O&M cost (p.a.)
Site 1	$450,599	$38,016
Site 5	$170,556	$63,287

Source: GHD estimates

Environmental impact / offset costs

The construction of new works associated with each of the project options is likely to result in impacts to terrestrial and aquatic ecology relative to the base case. NSW regulation may require the terrestrial ecology impacts to be offset in accordance with the *Biodiversity Conservation Regulation (2017).* Offsets can be provided via the following options.

- Establishment of a Stewardship site.
- Purchase and retire credits from an existing Stewardship site.
- Payment into the Biodiversity Conservation Fund.

The preferred offsetting mechanism would need to be confirmed during subsequent phases of the project and this would involve considering the feasibility of alternative offsetting options. For this reason offset costs have been excluded from the BCA.

Noise during construction

There are likely to be noise impacts to nearby residents during any construction activities, however these are unable to be quantified for the purposes of the BCA.

Tourism impacts

There may be tourism impacts associated with the project options, however, these are unable to be quantified for the purposes of the BCA.

Summary of costs quantified

A summary of the costs that have been quantified in the BCA is provided in Table 8. The present values have been determined using a 7% discount rate and a 30 year analysis period.

Table 8 Summary of Present Value of costs quantified

Costs	Site 1	Site 1 - $PV per ML of additional yield	Site 5	Site 2 - $PV per ML of additional yield
Capital costs – dam	$138.4m	$129,618	$52.4m	$91,127
Capital costs – pipeline	$8.0m	$7,535	$13.4m	$23,300
O&M costs – dam	$3.7m	$3,506	$1.4m	$2,465
O&M costs – pipeline	$0.3m	$296	$0.5m	$915
Total PV of costs	**$150.5m**	**$140,955**	**$67.7m**	**$117,806**

4.5.2 Benefits

Avoided capital expenditure on existing infrastructure

The BCA assumes all existing infrastructure will remain in place, regardless of whether Site 1 or Site 5 proceeds, therefore there is no change in these O&M costs relative to the base case.

Improved town water security

Typically, the value the community places on long-term town water security is greater than the cost of providing this service. From an economic point of view, this is considered a non-market value and therefore non-market valuation methods such as Willingness to Pay studies are required to quantify this benefit[1].

Improved town water security for the specified project options is difficult to ascertain in the absence of a formal Willingness to Pay study directed at residents and businesses in Walcha. However, benefit transfer[2] can be used to estimate the possible magnitude and/or range of values for improved town water security based on previous Willingness to Pay studies undertaken in Australia. These studies typically determine a value per annum per household and/or per business for a given population.

A summary of previous studies undertaken in Australia using Willingness to Pay and deprival approaches is provided in Appendix C. All figures have been escalated to 2017/18 dollars.

[1] Non-market valuation techniques, when used correctly, are accepted by NSW Treasury. Refer to the NSW Government's Guide to Cost Benefit Analysis (TPP17-03) for further details.
[2] Benefit transfer is an approach that can be used to provide an estimate of non-market values. This involves 'borrowing' values from a relevant 'study site' to apply to the policy site in question. The approach is only limited by the availability of relevant studies.

The NSW Department of Industry – Lands & Water has advised that the NSW Government has agreed to accept a Willingness to Pay figure of $218 to assess the benefits associated with projects that provide improved town water security. To determine the benefits of increased water security to Walcha, the Willingness to Pay estimate of $218 per annum has been applied to 1,593 households and 608 businesses (based on ABS 2016 Census data) in the Walcha Local Government Area (LGA). This benefit is applied to both Site 1 and Site 5 as the future town water demand target of 287 ML/a is met in the hydrological assessment of both project options.

The BCA assumes the benefits of improved town water security are realised from Year 6 onwards (i.e. the year following construction) and there is no change to the Walcha population over the 30 year model period.

Increased value of agricultural production

As discussed in Section 2.2.1, the BCA assumes the following water volumes are available for increased irrigated agricultural production relative to the base case:

- Site 1: 788ML per annum
- Site 5: 288ML per annum (for abstractions from both the Macdonald and Apsley Rivers)

The Apsley Dam Economic Benefit Study (2017) reports grazing gross margins of $314 per ML of additional water, which has been used to estimate the increased value of annual irrigated agricultural production in the BCA.

Residual value of new dam and pipeline infrastructure

NSW Treasury (2017) advises that for assets with a life that exceeds the BCA period, a residual value for the asset should be calculated and assigned as a benefit in the BCA model. This recognises the future use (and therefore value) of the asset.

The estimated residual value of the new dam and pipeline infrastructure associated with each option is presented in Table 9. The residual values are represented as a benefit in year 30 in the BCA model. The residual values assume a:

- New dam asset life of 120 years
- New pipeline asset life of 80 years

Table 9 Residual value of dam and pipeline infrastructure in Year 30

Option	Dam	Pipeline
Site 1	$138.6m	$7.3m
Site 5	$52.5m	$12.1m

Source: GHD estimates

Improved amenity and recreational value

Any changes in amenity and recreational value were unable to be quantified for the purpose of this study. In reality, there may be some marginal benefits associated with Site 1 due to the larger dam size.

Potential employment growth

Employment impacts have been excluded from the BCA and are instead discussed in Section 2.3.

Any increases in employment can only be included in a BCA if "the labour resources employed by the project were previously unemployed or underemployed, or if the actual wage increased above the reservation wage. Where this is not the case, any employment would represent a displacement of otherwise employed resources, which should not be considered as a net increase in social welfare" (NSW Treasury, 2017).

Summary of benefits quantified

A summary of the benefits that have been quantified as part of this assessment is provided in Table 10. The present values have been determined using a 7% discount rate and a 30 year analysis period.

Table 10 Summary of Present Value of benefits quantified

Benefits	Site 1	Site 1 - $PV per ML of additional yield	Site 5	Site 5 - $PV per ML of additional yield
Improved town water security	$4.0m	$3,733	$4.0m	$6,933
Increased value of agricultural production	$2.1m	$1,925	$0.8m	$1,307
Residual value of new dam	$18.2m	$17,051	$6.9m	$11,988
Residual value of new pipeline	$1.0m	$893	$1.6m	$2,761
Total PV of benefits	**$25.2m**	**$23,602**	**$13.2m**	**$22,989**

4.6 Results

The BCA is undertaken over a 30 year time period using a discount rate of 7% as recommended in the NSW Government Guide to Cost-Benefit Analysis (TPP17-03). The results of the BCA are presented in Table 11. The results indicate that for both Site 1 and Site 5, the present value of the costs relative to the base case are greater than the present value of benefits. Site 5 is the preferred option as it has the highest, albeit negative, NPV.

Table 11 Summary of BCA results

Dam Site	PV of costs	PV of benefits	NPV	BCR
Site 1	$150.5m	$25.2m	($125.3m)	0.17
Site 5	$67.7m	$13.2m	($54.5m)	0.20

The results of the BCA expressed per ML of secure yield for each project option are presented in Table 12.

Table 12 BCA results presented per ML of additional yield

Dam Site	PV of costs per ML of additional yield	PV of benefits per ML of additional yield	NPV per ML of additional yield
Site 1	$140,955	$23,602	($117,353)
Site 5	$117,806	$22,989	($94,818)

4.7 Project risks and sensitivities

Sensitivity analysis allows the results of the BCA to be tested against major project risks and/or changes in key assumptions and parameters, holding all other model variables constant.

GHD has undertaken the following sensitivity tests:

1. Increased water volume for irrigated agriculture is used for intensive horticulture (tomatoes with a gross margin of $10,446 per ML of additional water, as per Apsley Dam Economic Benefit Study) rather than grazing.
2. Capital costs decrease by 20%.
3. Discount rates of 3% and 10% (as per recommendations by NSW Treasury).

The sensitivity analysis has been undertaken using Site 5 as it has a higher BCR than Site 1 and is summarised in Table 13 below. The present value of costs is greater than the present value of benefits for all of the sensitivities undertaken. The use of increased water volumes for intensive horticulture rather than grazing has a positive effect on the BCR, as does reducing the discount rate to 3%. Reducing capital costs by 20% has a marginal effect on the BCR.

Table 13 Sensitivity analysis for Site 5

Variable	Benefits	Costs	NPV	BCR
Intensive horticulture	$37.5m	$67.7m	($30.3m)	0.55
Capital costs decrease by 20%	$11.5m	$54.2m	($42.7m)	0.21
Discount rate of 3%	$35.2m	$80.1m	($45.0m)	0.44
Discount rate of 10%	$6.9m	$60.3m	($53.4m)	0.11

5. Conclusions and recommendations

5.1 Water supply options

5.1.1 Water Storage options

If Site 1 or Site 5 are taken forward as potential solutions to securing water supply to Walcha, a staged storage approach could be considered by either constructing smaller storages or deferring the construction of the Apsley abstraction (Site 5 only). This may reduce up-front expenditure and postpones a portion of the expenditure to a later date. Total costs may increase marginally, but this is offset by constructing a more affordable structure initially. If it is resolved that a major storage providing (limited) irrigated agriculture opportunities is not viable, additional investigations may be required to assess smaller alternative sites to secure the town water supply.

5.1.2 Apsley River abstraction

Deferral of this option or alternative locations at which abstractions from the Apsley occur for Dam 5 could be investigated. For example, there may be merit in evaluating abstraction locations further downstream in the river (i.e. downstream of Walcha), where a larger catchment area results. However, water quality issues may be of concern downstream of Walcha and the cost of the pipeline and pumping infrastructure required to provide water to existing or new infrastructure may increase.

5.1.3 Reuse of effluent

It is understood that effluent from the Sewage Treatment plant is presently returned to the Apsley River. If these flows are significant, Council could consider re-use of this water, e.g. for irrigation of fields, golf course, etc. Significant quantities of re-cycled/treated effluent water have historically been mixed with fresh water for human consumption in cities such as London and Windhoek (Namibia). Council could consider the benefits offered by upgrading their sewage treatment plant to treat effluent to an improved quality for re-use, even if not for human consumption at this stage. Implementation of this would need to be canvassed in IWCM to consider if it is viable.

5.1.4 Provision of water for agriculture

The future of the town depends to a large extent on a vibrant and successful farming community. Droughts affect the livelihood of the farming community and the reduction of the number of farmers due to the lack of water will result in reduced numbers of farmers in the community. A dam at Site 1 offers marginally greater opportunity to supply water for agriculture than does Site 5.

However, the Apsley River is covered by the Water Sharing Plan (WSP) for the Macleay Unregulated and Alluvial Water Sources (Department of Primary Industries Water, 2016). The current WSP commenced on 1 July 2016 and has a term of 10 years. The WSP prevents the granting of new unregulated river access licences, along with preventing trade into the Apsley River water source, beyond the existing level of entitlements, from downstream water sources. Therefore, any new commercial development must purchase entitlements from existing access licences consistent with the dealing rules defined in the WSP. Irrigators wishing to access water from a new dam would be required to utilise this mechanism.

The limitation on the number of licences, would therefore limit the alleviation of water shortages on farms.

In addition, the yield investigations have confirmed that the amount of water available from the Apsley system at viable storage locations is extremely limited and unlikely to be capable of delivering the significant additional volumes of water required to justify the required investment.

5.1.5 Benefit cost analysis

When considering the results of the BCA it is important to note:

- The BCA ignores hydrology and water sharing plan rules, which would potentially reduce the volume of additional water, and therefore the associated benefits to irrigated agriculture.
- There was no opportunity to ground-truth the desktop information that has been relied on for the purposes of the BCA modelling, in particular the Apsley Economics Benefits Study.
- The analysis excludes land acquisition costs.
- The analysis excludes pumping costs.
- The analysis excludes environmental impacts and associated offset costs.
- The analysis excludes the cost of water licences and any new infrastructure required for irrigated agricultural production.

The project has a high capital cost for a relatively small increase in water availability, therefore based on current agricultural benefits the project is unlikely to be justified for agricultural purposes only. The project would need to attract a higher value industry (high intensity agriculture) and/or have social merit (be it through tourism, aged care, etc.) to be worthwhile.

The analysis has not evaluated the Town Water Supply only option for the dam at Site 5, since the purpose of such a dam would be to secure water supplies and would not be aimed at generating additional income (although this may result to a small extent from such a project). Should a Town Water Supply only option be pursued, the capacity of the Dam at Site 5 would need to be evaluated carefully, as it is possible that a smaller dam could provide the secure yield required.

5.2 Conclusions

Hunter H2O expressed the following opinions:

- A large dam on the Apsley River is likely to result in major impacts on the downstream reaches of the Apsley River, particularly the Apsley Gorge including the National Park and World Heritage Area
- The economic benefit of constructing a large dam on the Apsley River was considered to be marginal, at best.

The Benefit Cost Analysis outcome supports the second conclusion.

Regional Development Australia suggested that securing the town water supply is a key priority, and one which DPI Water appear most likely to support. A less ambitious proposal is likely to be a much easier task to take through the regulatory process than a large dam such as Dam 1 on the Apsley River, the regulatory approval process for which is likely to take at least 10 years. GHD supports this opinion and suggests that securing water supplies for human consumption (i.e. a Town Water Supply only option) will receive greater support, even if the Benefit Cost ratio is low.

5.3 Recommendations regarding subsequent project stage

The next stages any water security project for Walcha would include the following:

- Resolve if future solutions that include provision of water for irrigated agriculture are to be pursued .
- Negotiate conditions for abstractions from the Macdonald River with DoI Water. This could include a rolling cap and/or higher abstractions during periods of high flow. It would be worth Council consolidating their understanding of constraints for abstractions from the Apsley River at the same time.
- Complete any additional secure yield and site investigations required. Investigations should also include consideration of improved transfer capacity from the MacDonald River.
- Resolve a preferred site and commence Site investigations, including seismic refraction tomography survey of the preferred sites and, based on the results of this survey, implement a targeted site investigation including drilling (for core samples), test pitting (to evaluate foundation depths across the dam site, embankment construction materials, rockfill, etc.) and identification of concrete aggregates and embankment filter materials.
- Negotiations for entry onto land and possibly secure an option for the purchase of land for the dam.
- Environmental impact assessment (desktop, followed by detailed).
- Concept design, including evaluation of the dam type (earthfill, rockfill, concrete faced rockfill, concrete), as appropriate to the site topography and materials availability. Consider options for staging of construction of the dam. Further detailing of any river diversion that may be required.
- Evaluate appropriate spillway layouts – the dam type may materially affect this.
- Hydrology study to support design of any spillway and river diversion that may be required.
- If siltation is considered an issue, this should also be evaluated.
- Desktop Consequence Category Assessment (spillway design and earthquake design requirements depend on the Consequence Category).
- Detailed survey of the dam and storage area (Lidar is normally employed, depending on the area size this may be able to be achieved by drone survey).
- Pump station and pipeline concept designs.
- Investigations for enlargement of water treatment facilities (if required).
- Completion of business case including detailed cost estimates and cost benefit analysis.

Scope and limitations

This report: has been prepared by GHD for Walcha Council and may only be used and relied on by Walcha Council for the purpose agreed between GHD and the Walcha Council as set out in Section 1.4 of this report.

GHD otherwise disclaims responsibility to any person other than Walcha Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. These assumptions have been based on documents prepared by others and on other available published information. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Walcha Council and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in this report which were caused by errors or omissions in that information.

GHD has prepared the preliminary cost estimate set out in Section 3 of this report ("Cost Estimates") using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD, as detailed in Section 3.

The Cost Estimates have been prepared for the purpose of comparing Dam Site 1 against Dam Site 5 to inform decisions in regard to the most appropriate site to consider in future stages of the project and must not be used for any other purpose.

The Cost Estimates are preliminary estimates only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimates and may change. Unless as otherwise specified in this report, no detailed quotations have been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the water infrastructure can or will be undertaken at a cost which is the same or less than the respectve Cost Estimates.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected commensurate with the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

Appendices

Appendix A – Cost Estimates

Cost Estimate - Site 1 Dam 25,000 ML

Item	Item Description	Quantity	Unit	Rate	Cost
1	**Preliminary and General**			Sub Total	$ 4,550,000
2	**Environmental Controls**			Sub Total	$ 1,000,000
3	**Construct and Maintain Access Roads**			Sub Total	$ 2,000,000
4	**Reservoir Clearing**			Sub Total	$ 2,750,000
5	**Coffer Dam- Upstream**			Sub Total	$ 4,178,000
6	**Coffer Dam Downstream**			Sub Total	$ 1,046,000
7	**Foundation**			Sub Total	$ 2,208,000
8	**Quarry**			Sub Total	$ -
9	**Dam Embankment**	TE		Sub Total	$ 20,652,000
10.00	**Spillway**			Sub Total	$ 49,110,000
11.00	**River Diversion**			Sub Total	$ 1,016,000
12.00	**Offtake tower**			Sub Total	$ 7,393,000
13.00	**Fish Passage**			Sub Total	$ -
14	**Lump Sum Items**			Sub Total	$ 6,800,000
15	**Public Roads and Private Properties**			Sub Total	$ -
	Total Contract Cost			**Total**	**$ 102,703,000**
16	**Other Costs**			Sub Total	**$ 77,541,000**
16.01	Profit	5.0%	% of total	$ 5,135,150	$ 5,135,000
16.02	Detailed Design	5.0%	% of total	$ 5,135,150	$ 5,135,000
16.03	Site Supervision	12.0%	% of total	$ 12,324,360	$ 12,324,000
16.06	Owners Representative Services	2.5%	% of total	$ 2,567,575	$ 2,568,000
16.07	Contingency	50.0%	% of total	$ 51,351,500	$ 51,352,000
16.08	Legal Costs (%Dam Costs)	1.0%	% of total	$ 1,027,030	$ 1,027,000
	Total Cost			**Total**	**$ 180,244,000**

Cost Estimate - Off-Channel Site 5 Dam 800 ML

Item	Item Description	Quantity	Unit	Rate	Cost
1	**Preliminary and General**			Sub Total	$ 3,800,000
2	**Environmental Controls**			Sub Total	$ 750,000
3	**Construct and Maintain Access Roads**			Sub Total	$ 1,600,000
4	**Reservoir Cleaning**			Sub Total	$ 180,000
5	**Coffer Dam- Upstream**			Sub Total	$ 2,545,000
6	**Coffer Dam Downstream**			Sub Total	$ 531,000
7	**Foundation**			Sub Total	$ 2,047,000
8	**Quarry**			Sub Total	$ -
9	**Dam Body**	TE		Sub Total	$ 6,814,000
10	**Spillway**			Sub Total	$ 9,046,000
11	**River Diversion**			Sub Total	$ 516,000
12	**Offtake tower**			Sub Total	$ 5,420,000
13	**Fish Passage**			Sub Total	$ -
14	**Lump Sum Items**			Sub Total	$ 5,625,000
15	**Public Roads and Private Properties**			Sub Total	$ -
	Total Contract Cost			**Total**	**$ 38,874,000**
16	**Other Costs**			Sub Total	**$ 29,351,000**
16.01	Profit	5.0%	% of total	$ 1,943,700	$ 1,944,000
16.02	Detailed Design	5.0%	% of total	$ 1,943,700	$ 1,944,000
16.03	Site Supervision	12.0%	% of total	$ 4,664,880	$ 4,665,000
16.06	Owners Representative Services	2.5%	% of total	$ 971,850	$ 972,000
16.07	Contingency	50.0%	% of total	$ 19,437,000	$ 19,437,000
16.08	Legal Costs (%Dam Costs)	1.0%	% of total	$ 388,740	$ 389,000
	Total Cost			**Total**	**$ 68,225,000**

SITE 1 PIPLINE

Cost estimate

	Item Description	Material/Rating	Unit	Quantity	Rate	$	Comments
	Pipeline						
	DN250 pipeline	DICL PN35 or SCL	m	6400	900	5,760,000	Dam 1 to Off Channel Storage
	Drainage crossings		No	5	50,000	250,000	Allowance
	Connection at Dam		No	1	75,000	75,000	Allowance
	SUBTOTAL DIRECT COSTS					6,085,000	

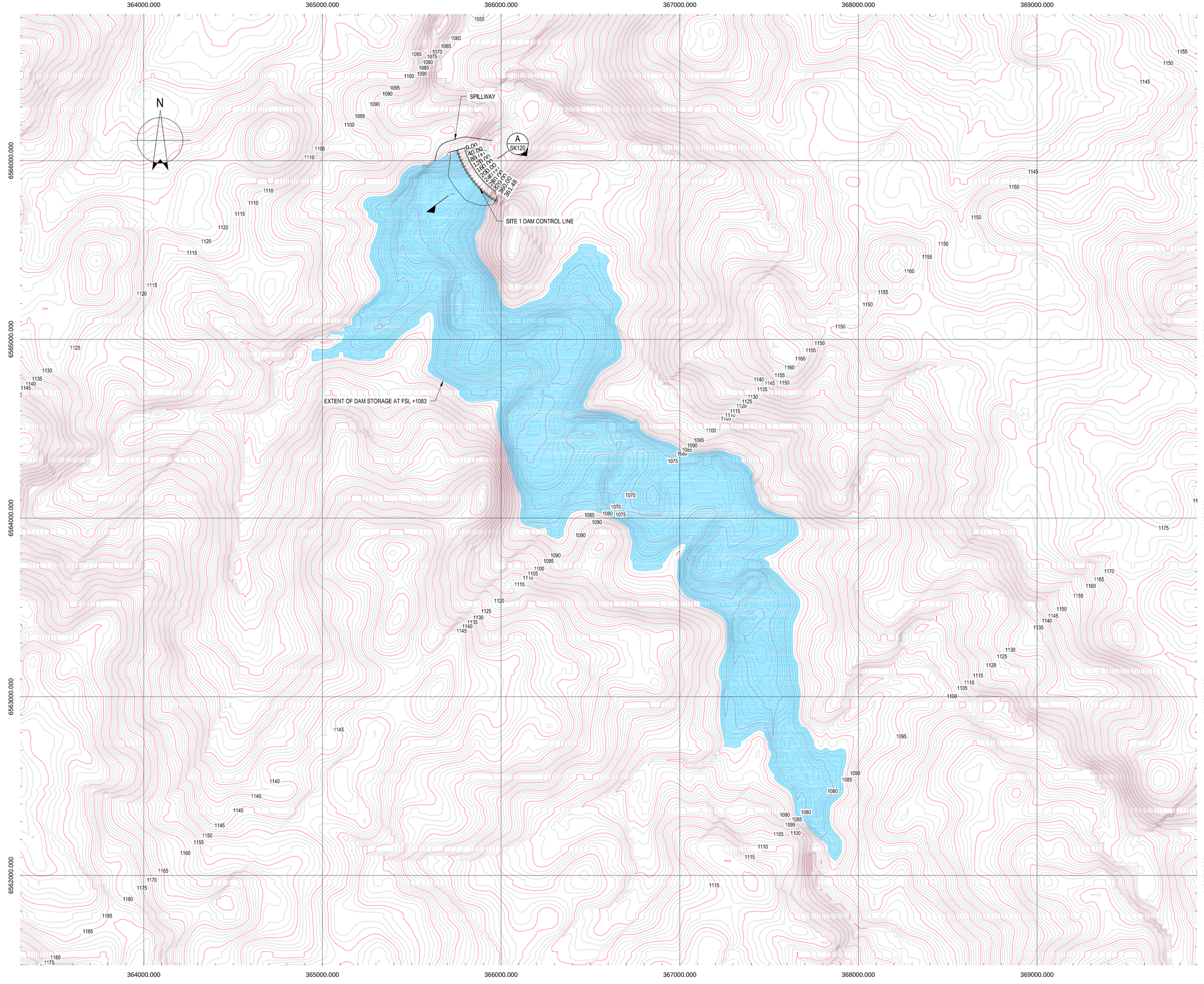
	Other Costs					
	Profit	5.0%	% of total		304,250	
	Detailed Design	5.0%	% of total		304,250	
	Site Supervision/Prelims	15.0%	% of total		912,750	
	Owners Representative Services	2.5%	% of total		152,125	
	Contingency	50.0%	% of total		3,042,500	
	Legal Costs (% Costs)	1.0%	% of total		60,850	
	TOTAL				**10,862,000**	

SITE 5 PIPELINES, PUMPSTATIONS AND WEIR
Cost estimate

Item Description	Material/Rating	Unit	Quantity	Rate	$	Comments
Pipeline						
DN250 pipeline	DICL PN35 or SCL	m	4700	900	4,230,000	Pipes to/from Site 5
Weir at Apsley River						
Weir		No	1	2,500,000	2,500,000	
Pumping Stations at Apsley Weir						
Pumping station at Apsley River			1	2,000,000	2,000,000	Building, power supply, variable speed drive, LV switchboard, 1 pumpsets
Incoming power & comms			1	1,000,000	1,000,000	Allowance
Access Road			1	250,000	250,000	Allowance
Surge protection at pumping station		LS	1	150,000	150,000	
SUBTOTAL DIRECT COSTS					**10,130,000**	

Other Costs					
Profit	5.0%	% of total		506,500	
Detailed Design	5.0%	% of total		506,500	
Site Supervision/Prelims	15.0%	% of total		1,519,500	
Owners Representative Services	2.5%	% of total		253,200	
Contingency	50.0%	% of total		5,065,000	
Legal Costs (% Costs)	1.0%	% of total		101,300	
TOTAL				**18,082,000**	

Appendix B – Layout Drawings



GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.
2. LEVELS ARE IN AUSTRALIAN HEIGHT DATUM (AHD)
3. COORDINATES ARE IN MAP GRID94 OF AUSTRALIA (MGA)
4. THIS DESIGN IS BASED ON SURVEY MAPPING DOWNLOADED FROM GEOSICENCE AUSTRALIA (ELVIS-ELEVATION INFORMATION SYSTEM).
5. ALL INFORMATION IS INDICATIVE AND SHALL BE VERIFIED DURING SUBSEQUENT STAGE.

LEGEND

EXISTING CONTOUR LINES AT 1.0 INTERVAL

DAM STORAGE EXTENT

0 100 200 300 400 500m

SCALE 1:10,000 AT ORIGINAL SIZE

CONCEPT

rev	description	app'd	date
A	ISSUED FOR REPORT	JM	26.02.18

WALCHA COUNCIL

WALCHA WATER SECURITY PROJECT-FINAL OPTIONS ASSESSMENT REPORT

WALCHA SITE 1
OVERALL LAYOUT PLAN

29 Christie Street St Leonards NSW 2065 Australia
Locked Bag 2727 St Leonards NSW 1590
T 61 2 9462 4700 **F** 61 2 9462 4710
E atnmail@ghd.com **W** www.ghd.com

scale 1 : 10000 for A1 job no. 22-19312

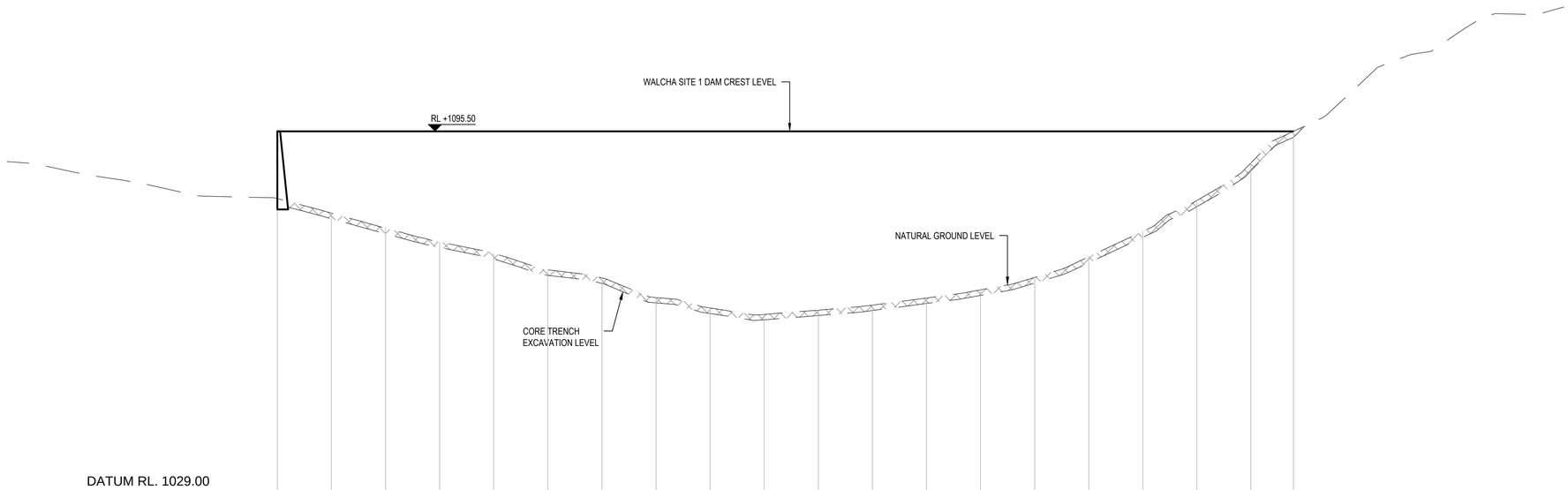
date FEBRUARY 2018 rev no. A

approved (PD) - SK100

Plot Date: 26 February 2018 - 5:36 PM Plotted by: Mohammad Gharib Cad File No: G:\22\19312\CADD\Drawings\Sketches\22-19312-SK100-SK200.dwg

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.
2. LEVELS ARE IN AUSTRALIAN HEIGHT DATUM (AHD)
3. THIS DESIGN IS BASED ON SURVEY MAPPING DOWNLOADED FROM GEOSICENCE AUSTRALIA (ELVIS-ELEVATION INFORMATION SYSTEM).
4. ALL INFORMATION IS INDICATIVE AND SHALL BE VERIFIED DURING SUBSEQUENT STAGE.



DATUM RL. 1029.00

DESIGN SURFACE LEVEL	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50	1095.50
EXISTING SURFACE LEVEL	1083.04	1080.37	1077.60	1075.00	1072.90	1069.87	1068.40	1064.76	1062.83	1061.63	1062.42	1063.36	1064.67	1066.17	1068.48	1072.29	1076.98	1082.69	1089.63	1095.50	
CHAINAGE	0.00	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	375.73	

LONGITUDINAL SECTION - CONTROL LINE SITE 1

HORZ 1:1000 VERT 1:500

LONGITUDINAL SECTION

VERTICAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

HORIZONTAL 1:1000 AT ORIGINAL SIZE 0 10 20 30 40 50m

CONCEPT

rev	description	app'd	date
A	ISSUED FOR REPORT	JM	26.02.18

WALCHA COUNCIL

WALCHA WATER SECURITY PROJECT-FINAL OPTIONS ASSESSMENT REPORT

WALCHA SITE 1 LONGITUDINAL SECTION

29 Christie Street St Leonards NSW 2065 Australia
Locked Bag 2727 St Leonards NSW 1590
T 61 2 9462 4700 **F** 61 2 9462 4710
E atnmail@ghd.com **W** www.ghd.com

scale AS SHOWN for A1 job no. 22-19312

date FEBRUARY 2018 rev no. A

approved (PD) - SK110

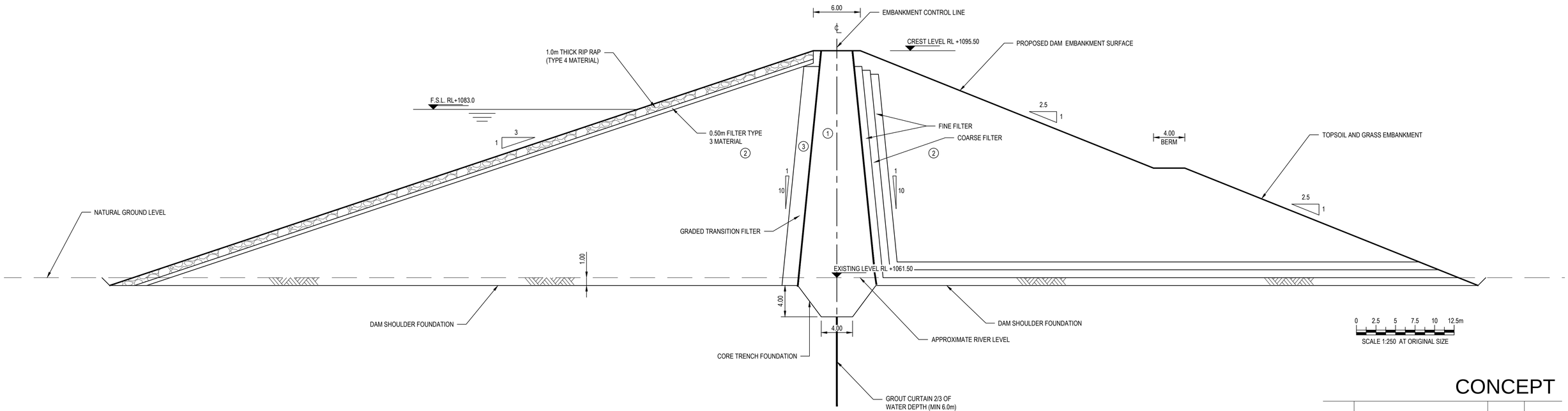
Plot Date: 26 February 2018 - 5:35 PM Plotted by: Mohammad Gharib Cad File No: G:\22\19312\CADD\Drawings\Sketches\22-19312-SK110-SK210.dwg

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.
2. LEVELS ARE IN AUSTRALIAN HEIGHT DATUM (AHD).
3. THIS DESIGN IS BASED ON SURVEY MAPPING DOWNLOADED FROM GEOSICENCE AUSTRALIA (ELVIS-ELEVATION INFORMATION SYSTEM).
4. ALL INFORMATION IS INDICATIVE AND SHALL BE VERIFIED DURING SUBSEQUENT STAGE.

LEGEND:

(1) CORE
(2) SHOULDER
(3) FILTER
(4) RIP RAP



A SK100 TYPICAL SECTION THROUGH DAM (SITE 1)
SCALE 1 : 250

CONCEPT

rev	description	app'd	date
A	ISSUED FOR REPORT	JM	26.02.18

WALCHA COUNCIL
WALCHA WATER SECURITY PROJECT-FINAL OPTIONS ASSESSMENT REPORT

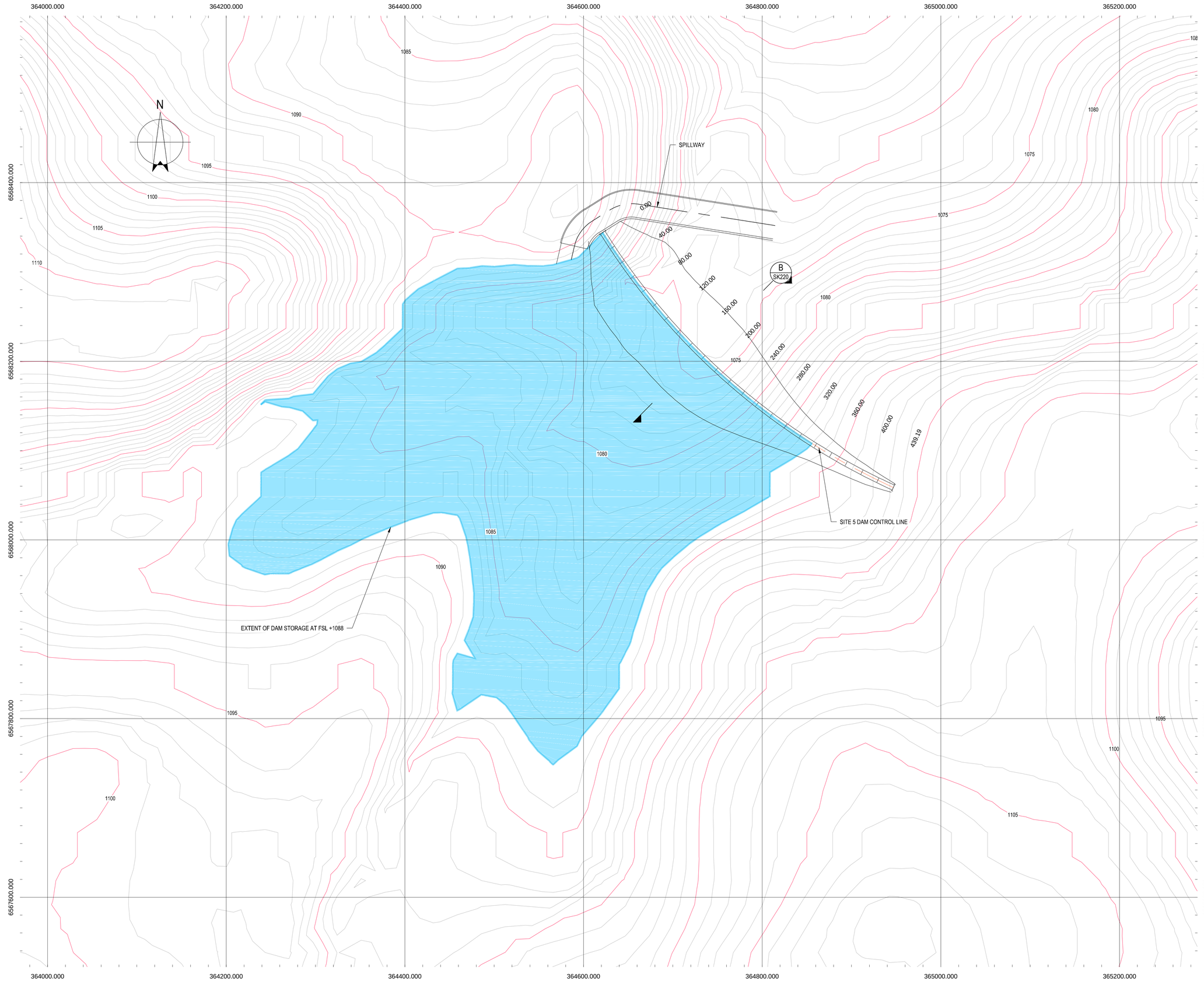
WALCHA SITE 1
DAM TYPICAL SECTION

29 Christie Street St Leonards NSW 2065 Australia
Locked Bag 2727 St Leonards NSW 1590
T 61 2 9462 4700 **F** 61 2 9462 4710
E atnmail@ghd.com **W** www.ghd.com

scale 1 : 250 for A1 job no. 22-19312
date FEBRUARY 2018 rev no. A

approved (PD) SK120

Plot Date: 26 February 2018 - 5:34 PM Plotted by: Mohammad Gharib Cad File No: G:\22\19312\CADD\Drawings\Sketches\22-19312-SK120-SK220.dwg



GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.
2. LEVELS ARE IN AUSTRALIAN HEIGHT DATUM (AHD)
3. COORDINATES ARE IN MAP GRID94 OF AUSTRALIA (MGA)
4. THIS DESIGN IS BASED ON SURVEY MAPPING DOWNLOADED FROM GEOSICENCE AUSTRALIA (ELVIS-ELEVATION INFORMATION SYSTEM).
5. ALL INFORMATION IS INDICATIVE AND SHALL BE VERIFIED DURING SUBSEQUENT STAGE.

LEGEND

EXISTING CONTOUR LINES AT 1.0 INTERVAL

DAM STORAGE EXTENT

0 20 40 60 80 100m

SCALE 1:2000 AT ORIGINAL SIZE

CONCEPT

rev	description	app'd	date
A	ISSUED FOR REPORT	JM	26.02.18

WALCHA COUNCIL

WALCHA WATER SECURITY PROJECT-FINAL OPTIONS ASSESSMENT REPORT

WALCHA SITE 5
OVERALL LAYOUT PLAN

29 Christie Street St Leonards NSW 2065 Australia
Locked Bag 2727 St Leonards NSW 1590
T 61 2 9462 4700 **F** 61 2 9462 4710
E atnmail@ghd.com **W** www.ghd.com

scale 1 : 2000 for A1 job no. 22-19312

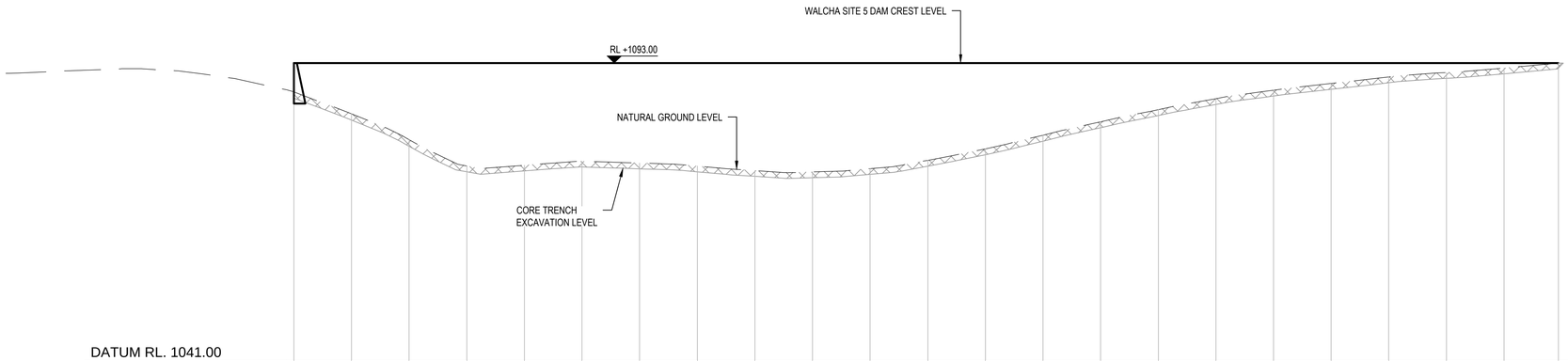
date FEBRUARY 2018 rev no. A

approved (PD) - SK200

Plot Date: 26 February 2018 - 5:38 PM Plotted by: Mohammad Gharib Cad File No: G:\22\19312\CADD\Drawings\Sketches\22-19312-SK100-SK200.dwg

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.
2. LEVELS ARE IN AUSTRALIAN HEIGHT DATUM (AHD)
3. THIS DESIGN IS BASED ON SURVEY MAPPING DOWNLOADED FROM GEOSICENCE AUSTRALIA (ELVIS-ELEVATION INFORMATION SYSTEM).
4. ALL INFORMATION IS INDICATIVE AND SHALL BE VERIFIED DURING SUBSEQUENT STAGE.



DATUM RL. 1041.00

DESIGN SURFACE LEVEL	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00	1093.00
EXISTING SURFACE LEVEL	1088.00	1084.19	1079.72	1075.14	1075.28	1075.96	1075.65	1075.13	1074.34	1074.11	1074.68	1076.13	1078.12	1080.49	1082.81	1084.93	1086.84	1088.29	1089.47	1090.61	1091.37	1092.16	1093.00	
CHAINAGE	0.00	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	438.86	

LONGITUDINAL SECTION - CONTROL LINE SITE 5

HORZ 1:1000 VERT 1:500

VERTICAL 1:500 AT ORIGINAL SIZE 0 5 10 15 20 25m

HORIZONTAL 1:1000 AT ORIGINAL SIZE 0 10 20 30 40 50m

CONCEPT

rev	description	app'd	date
A	ISSUED FOR REPORT	JM	26.02.18

WALCHA COUNCIL

WALCHA WATER SECURITY PROJECT-FINAL OPTIONS ASSESSMENT REPORT

WALCHA SITE 5 LONGITUDINAL SECTION

29 Christie Street St Leonards NSW 2065 Australia
Locked Bag 2727 St Leonards NSW 1590
T 61 2 9462 4700 **F** 61 2 9462 4710
E atnmail@ghd.com **W** www.ghd.com

scale AS SHOWN for A1 job no. 22-19312

date FEBRUARY 2018 rev no. A

approved (PD) SK210

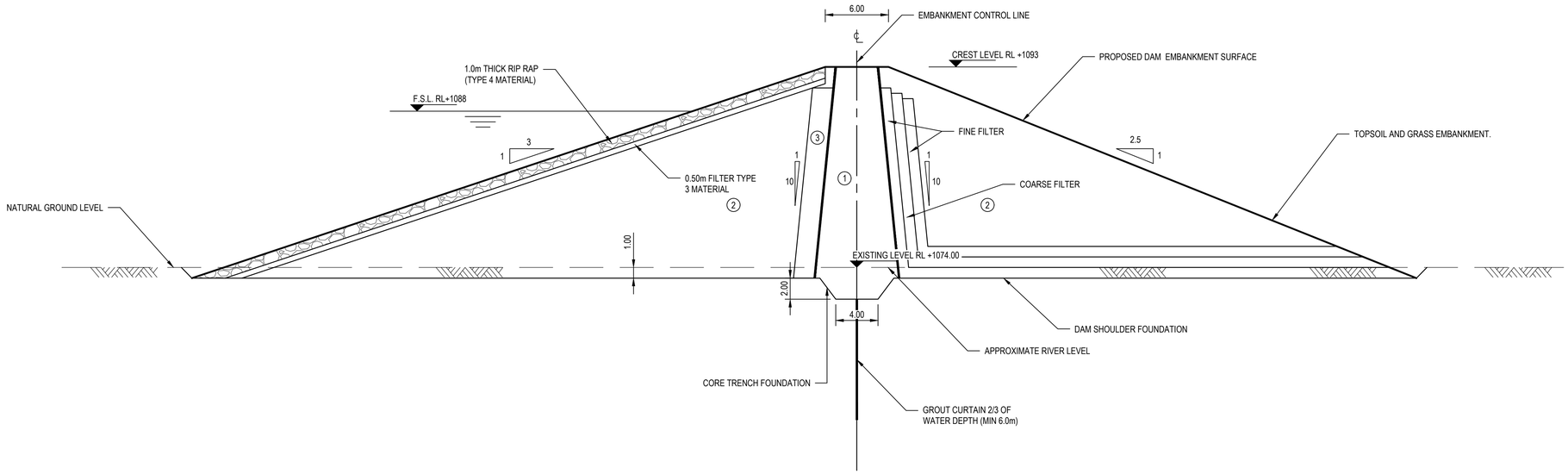
Plot Date: 26 February 2018 - 5:35 PM Plotted by: Mohammad Gharib Cad File No: G:\22\19312\CADD\Drawings\Sketches\22-19312-SK110-SK210.dwg

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.
2. LEVELS ARE IN AUSTRALIAN HEIGHT DATUM (AHD).
3. THIS DESIGN IS BASED ON SURVEY MAPPING DOWNLOADED FROM GEOSICENCE AUSTRALIA (ELVIS-ELEVATION INFORMATION SYSTEM).
4. ALL INFORMATION IS INDICATIVE AND SHALL BE VERIFIED DURING SUBSEQUENT STAGE.

LEGEND:

(1) CORE
(2) SHOULDER
(3) FILTER
(4) RIP RAP



B SK200 TYPICAL SECTION THROUGH DAM (SITE 5)
SCALE 1 : 250

0 2.5 5 7.5 10 12.5m
SCALE 1:250 AT ORIGINAL SIZE

CONCEPT

rev	description	app'd	date
A	ISSUED FOR REPORT	JM	26.02.18

WALCHA COUNCIL
WALCHA WATER SECURITY PROJECT-FINAL OPTIONS ASSESSMENT REPORT

WALCHA SITE 5
DAM TYPICAL SECTION

29 Christie Street St Leonards NSW 2065 Australia
Locked Bag 2727 St Leonards NSW 1590
T 61 2 9462 4700 **F** 61 2 9462 4710
E atnmail@ghd.com **W** www.ghd.com

scale 1 : 250 for A1 job no. 22-19312
date FEBRUARY 2018 rev no. A

approved (PD) - SK220

Plot Date: 26 February 2018 - 5:29 PM Plotted by: Mohammad Gharib Cad File No: G:\22\19312\CADD\Drawings\Sketches\22-19312-SK120-SK220.dwg

Appendix C – Willingness to Pay studies

Summary of previous studies that quantify the value of improved security of town water supply

Reference	Parameter	Estimate (escalated to 2017 values based on historical CPI)	Comments
CIE 2005, reported in Allen Consulting 2007	Willingness to pay to avoid water restrictions	$251 - $975 per household, per annum	Based on WTP study of Canberra households
Blamey & Bell 2007, reported in Dharmaratna & Gangadharan, 2011	Willingness to pay for increased water supply reliability	$70 - $221 per household per annum	Based on WTP study in South East Queensland (Brisbane, Gold Coast, Sunshine Coast and Toowoomba)
Molino Stewart 2012, reported in WaterNSW, 2014	Investments in ensuring water security for towns	$896/ML - $11,593/ML of security improvement per annum	Estimates are capital and operation costs, discounted over time, for investments in Central West NSW
Deloitte Access Economics, 2013	Economic value of groundwater use for urban water supply	$1,080 - $3,241/ML per annum (mid-point of $2,000)	Based on publically available information regarding most likely alternatives for urban water supply[1]
	Economic value of groundwater use by households	$1,512 - $6,914/ML per annum (adjusted mid-point estimate of $2,500)	Based on the cost of the next best alternative, e.g. $1,000 for urban water supply, $6,400 for a rainwater tank)
Marsden Jacobs and Associates 2012, reported in Deloitte Access Economics, 2013	Economic use value of groundwater for water supply	$2,197 - $4,394/ML per annum (Australia)	Use value for Australia as a whole, based on the deprival method[2] and a series of case studies

[1] E.g. Short distance pipelines estimated at $1,000 to $3,000/ML
[2] That is, the cost of the next best alternative water source in the absence of groundwater

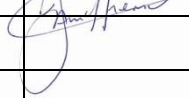
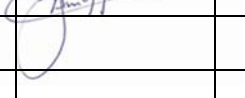
Reference	Parameter	Estimate (escalated to 2017 values based on historical CPI)	Comments
	Economic use value of groundwater for households	$1,978/ML per annum (Gnangara, WA)	Use value for Australia as a whole, based on the deprival method[3] and a series of case studies
RMCG 2008, reported in Deloitte Access Economics, 2013	Economic use value of groundwater for urban supply	$2,856/ML per annum (Daly River, NT)	Use value of groundwater for Victoria, based on the deprival method
	Economic use value of groundwater for stock and domestic	$1,099 - $5,493/ML per annum (Australia)	Use value of groundwater for Victoria, based on the deprival method

[3] That is, the cost of the next best alternative water source in the absence of groundwater

GHD
Suite 8, Atrium Business Centre
345 Peel Street
TAMWORTH NSW 2340
T: 61 2 4979 9900 F: 61 2 4979 9988 E: ntlmail@ghd.com

2219312-74375/https://projects.ghd.com/oc/newcastle1/wscwatersecurityproj/Delivery/Documents/2219312-REP-0_ Walcha Water Security Options Summary Report.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	PB/ER	J McPherson		J McPherson		19/03/18

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