AN ECONOMIC ANALYSIS OF THE URANNAH DAM PROJECT

Prepared for on behalf of the Mackay Conservation Group

Abstract

This report analyses the benefits of the proposed Urannah Dam project and investigates alternative methods to supply and deliver water to end users. It compares the costs of delivering water from the proposed Urannah dam with the Burdekin Falls Dam. This report shows that the same economic benefits of building the Urannah dam can be achieved at a fraction of the monetary and environmental cost by increasing the height of the Burdekin falls dam wall. This report also undertakes a high level social cost benefit analysis and determines that the Urannah dam project will yield a $0.75 return on every dollar invested.

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Executive Summary

This report undertakes a cost analysis of the Urannah dam and compares this with providing the same economic outcome through the raising of the Burdekin Falls Dam wall. This report also undertakes a high level social cost benefit analysis of the Urannah dam. Its findings are:

- The Urannah dam is a more expensive option to deliver water for irrigation, the Galilee basin, and for the Bowen region;
- The Urannah dam is a cheaper option to supply water to the Bowen basin, however, there does not appear to be enough additional demand for water supply to warrant construction of another water source in the near future;
- The Burdekin Falls Dam costs $11.5M per annum less than the proposed Urannah dam at delivering the same economic outcome;
- The Urannah dam provides a return of $0.75 for every dollar invested assuming full consumption of water by agriculture and mining.

The Cost analysis compares the costs of providing water infrastructure and then delivering it to likely customers. It compares the Urannah dam and the Burdekin falls dam. It only considers market based costs.

The social cost benefit analysis takes into account the employment benefits, the economic output from irrigated farming, the cheaper water supply to industry in the Bowen basin and the environmental costs of the loss of natural assets and the run-off water pollution caused by agriculture.

Table of Contents

Table of Figures:

Table of Tables:

Definitions

AEC – annual equivalent cost

AHD – Australian Height Datum

BBWSS – Bowen Broken Water Supply Scheme

BCR – benefit cost ratio

BFD – Burdekin Falls Dam

BHWSS – Burdekin Haughton Water Supply Scheme

CBA – cost benefit analysis

CEA – cost effectiveness analysis

CPI – consumer price index

DIN – dissolved inorganic nitrogen

Disc. - discount

DNRMW – Department of Natural Resources Mines and Water

GBR – Great Barrier Reef

HP – high priority water allocation

ha – hectare

IRR – internal rate of return

MAD – mean annual diversion

MP - medium priority water allocation

ML – mega litres

ML/a – mega litres per annum

$M – millions of Australian dollars

$M/a – millions of Australian dollars per annum

NPV – net present value

PV – present value

TSS – total suspended solids

1. Introduction

The Mackay Conservation Group (MCG) has commissioned an independent economic analysis to investigate the benefits and costs associated with the Urannah dam project and its alternatives. This report undertakes two separate analyses; (i) a **cost analysis** of the Urannah project and the alternative of raising the Burdekin falls dam and, (ii) a high level **social cost benefit analysis** of the Urannah project.

The cost analysis determines the annual equivalent cost (AEC) of undertaking the Urannah project and compares this with the alternative of raising the Burdekin falls dam in order to deliver the same economic outcome and benefit. The social cost benefit analysis compares the present value of the costs to the present value of the benefits in order to determine whether a net benefit or loss is delivered by undertaking the project.

Much work has been completed previously on the Urannah dam including feasibility studies, cost benefit analyses and economic impact analyses. Refer to appendix 13.10 for a detailed list of previous work completed. A brief discussion of previous work is given in section 3. This report builds on this previous work however, addresses some of the gaps that were missing. Most noticeably, environmental costs, employment benefits and benefits of water allocation to non-agricultural industries are included in the cost-benefit analysis.

The limitations of this report are:

- It is based on publicly available information. As such, assumptions for variables have been based on limited information. Variables such as pipe costs, pumping distance and pumping power costs are based on high level engineering calculations and assumptions. Assumptions regarding productivity of farming, infrastructure requirements are based on previous reports.
- A detailed discounted cash flow has not been undertaken for the cost benefit analysis of the Urannah project. Instead it relies on previous present value of costs and benefits from previous work.
- Environmental costs have been estimated using the benefit transfer method and is subject to the inaccuracies of this method.
- No efficiency pricing has been included in the cost benefit analysis.
- Individual stakeholder groups' costs and benefits have not been determined.
- Results of this report are indicative only. A thorough social cost benefit analysis based on thorough environmental impact studies, supply/demand modelling, employment opportunities and detailed costs and engineering design, is required to be undertaken.
- This report has not considered the cost of supply of water from the proposed Nathan dam and Connors River dam and the existing Fairbairn dam for the Galilee basin and Moranbah as an alternative to the Urannah dam.

2. Methodology

In this report, a **cost analysis** has been undertaken to compare what costs there are for alternative options to achieve the same economic outcome (or benefit). This report looks at the annual equivalent cost (AEC) for Urannah dam and compares it with raising the Burdekin falls dam wall by 2m. This report also undertakes a **social cost-benefit analysis**. A social cost benefit analysis is different from a conventional cost benefit analysis in that is analyses non-market benefits and costs from the whole of society's perspective. The Queensland government now acknowledges the benefit of social cost benefit analyses through its Project Assessment Framework guidelines.

A **sensitivity analyses** has also been undertaken for the cost analysis and a **scenario analysis** undertaken for the cost-benefit analysis**.** Throughout the cost benefit analysis a *with minus without* approach has been used. This takes into consideration the opportunity cost of undertaking the project. In other words it compares the outcomes of the project with what would have happened had the project not proceeded.

2.1. Economic model

Refer to appendix 13.13 for an economic input/output model of the Urannah project. Inputs into the dam project include land, capital (finance) and labour. The outputs of the dam is water which can be consumed through various industries. The largest consumer of the water is expected to be irrigated agriculture in the Broken/Bowen River valley downstream from the dam. Other users could be coal mining in the Bowen Basin and the Galilee Basin, the Collinsville power plant (which is currently in care and maintenance), irrigation and industry surrounding Bowen and domestic use for the township of Collinsville and Scottville.

Shown in appendix 13.14 is the cost/benefits flow diagram for the project.

2.2. Key Assumptions

Assumptions are discussed throughout the report. Below are some of the main assumptions.

- All prices in this report are based on 2015 prices
- All old prices have been inflated using the RBA official inflation figures

Cost analysis:

- Asset life is considered to be 50 years. At which time major upgrades would be required. The residual value of all capital at this stage is assumed to be zero.
- It is assumed that the benefit cash flow (present value of the benefit) is the same for both options in the cost analysis. This is most likely not the case and underestimates the present value benefit for the Burdekin falls dam. This project would be completed earlier than the Urannah project and benefits could be realised earlier.
- The environmental cost of building Urannah dam would exceed the cost of raising the BFD wall. This assumption is considered valid due to the fact that most of the environmental damage due to the BFD already exists.
- The cost analysis only looked at market based costs.
- Finance or insurance costs have not been factored into the cost analysis.
- Cost of pipe per kilometre is the same for Urannah and BFD. This might not be the case as the requirements for pumps and pump stations will be greater for BFD than for Urannah due to its lower elevation. However, conversely there exists current infrastructure and an existing corridor for BFD.
- Construction duration of two years for all infrastructure.

Cost-benefit Analysis:

- Project life of 30 years
- All water supplied by the Urannah dam is consumed. I.e. the underlying demand for water has not been considered.

- Environmental costs of non-agricultural industries that accept water from Urannah are not included. It is assumed that these industries' level of output is not impacted if the project proceeds or not. If Urannah dam was not built they would source their water elsewhere.

2.3. Decision Making Criteria

The cost benefit analysis uses the **Net Present Value** (NPV) and the **Benefit Cost Ratio** (BCR). These tools take into consideration the time value of money and are based on the cash flow of the costs and benefits in the project. The decision making criterion used for the cost analysis is the **Annual Equivalent Cost** (AEC). The AEC can be considered as the present value of the costs in 2015 dollars which is then annualised over the life of the project. It can be thought of like an annuity payment of the net costs over the life of the project similar to a regular mortgage repayment to a bank. All of these criteria use a discount factor. For the base case a 10% real discount rate has been used. The **NPV** is the present value of benefits less the present value of the costs. The **BCR** provides the return for every dollar invested. It is the ratio of the present value of the benefits over the present value of the costs.

3. Previous reports

Urannah Dam has been investigated since the 1960's. The first report was completed in October 1967. Since then various engineering, agronomic, geological, hydrological, financial, economic, social, and environmental studies have been completed on this dam, refer to appendix 13.10 for a full list of previous reports.

Below is a summary of the reports that have been completed which outline the costs and benefits of the dam. The most comprehensive financial and economic report to date is the MacArthur report completed in 2001. This report found no financial or economic justification for proceeding with the dam at the time. This report has been used as the basis for most benefits and costs in the cost-benefit analysis.

Report	Crop	BCR	2015 NPV ($M)	2015 Costs ($M)	2015 Benefits ($M)
MacArthur Business, 2001	Cotton	0.98	-$10.74	$ 534.7	$ 523.9
WWF, 2014	Sugar	0.68	-$192.47	$ 599.5	$ 407.0

Table 1: Results from previous CBAs

There have been three methods employed in determining economic benefit in the previous reports completed:

- **Economic impact analysis - c**onsiders the total economic impact in a region through adding the costs and the benefits. It does not consider what financial return has been made on the investment. It takes no account of time value of money or when the economic benefit would be realised, no consideration for cost effectiveness, and economic efficiency and no account of opportunity cost.
- **Financial analysis of project costs to determine output water price** – the water price has then been used as an input into a model farm to determine if the new farm enterprise could afford to pay for the water. In two separate reports it was determined that farms cannot afford to

pay for full cost recovery prices of water (cotton and sugar). This means that water will need to be subsidised for irrigators to be able to afford the water and make a profit on their farm.

- **Cost- benefit analysis** – to date only basic analyses have been completed. Previous reports have the following short comings. No report has:
  - Considered multi-use consumption and incorporated HP water (which would generate higher revenue) as a benefit;
  - Used shadow/efficiency prices or considered opportunity costs (e.g. employment rents due to employment);
  - Analysed which stakeholder groups receive benefits or costs;
  - Looked into the underlying demand for the agricultural products that would be generated, the impact on prices and whether they would be sold on the world market or domestic market;
  - Considered the financial implications of environmental degradation due to dam construction. Only one report has considered the environmental costs of farming on the GBR.
  - Undertaken a risk analysis.

4. Costs

Costs can be broken into two groups, upfront costs and ongoing costs. These costs are then further broken into two categories, market based costs, and non-market based costs. Non-marketed items do not have a market in which to trade and as such, assigning a monetary value to these costs is difficult. Generally, environmental costs are non-marketed costs. The cost analysis only looks at goods that have a market where the cost can be easily obtained (market based goods/costs).

Upfront costs (market based):

- Capital cost of the dam & associated infrastructure
- Capital cost of piping/reticulation & associated infrastructure
- Land resumption
- Farming infrastructure (on-farm) – setup costs, buildings, machinery and irrigation equipment – development of the land, installation of roads, clearing, earthworks
- Farming infrastructure (off-farm) – supply infrastructure (pipe or channel), electricity supply, sewerage supply, road networks, improved services in Collinsville to cater for an increase in population
- Existing road needs to be rerouted
- Relocation of Urannah homestead

Ongoing costs (market based):

- Pumping cost (cost of delivery)
- Maintenance – of all infrastructure and capital investments
- water resource charges
- Financing/interest

Externalities:

- Loss of water from Burdekin Haughton Supply Scheme (BHSS) (water flowing into downstream Burdekin river), they would need more water release from Burdekin Falls Dam to supplement lower river flow coming from the Broken/Bowen River
- Loss of output from currently operating farms – from additional infrastructure
- unallocated water (needs to be purchased as per Qld requirements and cost passed onto consumers)

4.1. Value of existing natural asset & costs of alteration

Urannah would inundate and affect approximately 10,500ha of land. It would flood nationally listed Urannah Creek, Massey Creek and Broken River riparian wetland affecting 68 km of river and streams and their aquatic values including the endemic Irwin's Turtle which would lose most of its remaining habitat. Habitat for threatened species would also be lost e.g. Eucalyptus raveretiana; Squatter pigeon; koala; northern spotted quoll; black-throated finch; powerful owl, masked owl; rainbow bee-eater; star finch; red goshawk; glossy black-cockatoo and migratory species e.g. spectacled monarch; black-faced monarch; cicada bird. Increased salinity, toxic algal blooms (droughts and very low flow years) and are likely.

According to the total economic value principal, environmental capital or assets provide a service which has a value. Total economic valuation incorporates the values that people place on environmental resources through direct use and also the value that non-users place on the conservation of such resources. General types of environmental goods and services valued include:

- **Direct values**: extractive/consumptive & non-extractive/non-consumptive uses
- **Indirect values** including ecological functions (e.g. regulating water quality)
- **Option values**: the ability to use that resource in the future
- **Existence & bequest values**: the utility and benefit that individuals get from knowing that an environmental asset exists and is preserved and/or the ability to bequest it to the next generation

The environmental/natural assets in this instance are:

- The Broken river, Urannah creek and downstream river systems
- The physical land that will be inundated
- The flaura, fauna and ecosystems that will be impacted and destroyed by the construction of the dam and the irrigated agriculture that the dam will support
- The Great Barrier Reef that will be impacted

Refer to Table 2 below for the values associated with the Urannah region.

The natural environmental resource is being depleted and altered through two ways:

- Through the building of the dam and the consequential flooding of the river systems, and the blockage of the natural river flow.
- Through the impacts of irrigated agriculture. Irrigated agriculture has demonstrated that farm run off – including soil and fertiliser impacts the GBR.

Using benefit transfer methods from a study in Canada, it has been estimated the existing natural environment's present value is approximately $179.3M or $147.7M (excluding recreation). Refer to section 13.4 for more information. On top of this there is an approximate $91M of damage caused by pollutant run off from irrigated agriculture and land clearing. Therefore, total environmental damage has been estimated at $270.3M. It is considered that this estimate is conservative in that it does not take into account the non-use or optional value of the asset. It is also conservative when compared to a study in Korea where is was calculated that a dam construction would incur US$233.1M (AUD$ 319M) of environmental and social damage (Envri website). Similarly, a Chilean dam was estimated at causing US$205M (AUD$281M) of aesthetic and recreational damage. Refer to Table 18 for a list of studies that have been conducted on environmental valuation.

This estimate of $179.3M only includes direct and indirect uses, highlighted below in red.

Direct Use value	Indirect use value	Option value	Existence & Bequest value (non-use)
Provision of water to downstream water users (either direct from river or indirect to water table)	The natural flow of the river prevents erosion, salinity, blue-green algae outbreaks	Grazing/productive land/forestry	Biodiversity – Fauna & flora
Fishing	Provides and sustains healthy ecosystems downstream including the GBR	Eco-tourism industry/camping e.g. walking tracks, hiking, bird watching etc.	Indigenous bequest value – leaving the traditional land to the next generation.
Access to land by indigenous people	Habitat for rare species (e.g. Irwin's turtle ad Eucalyptus raveretiana).	Study of unique ecosystems and animals/plants (e.g. Irwin's turtle & Eucalyptus raveretiana)	
Recreation e.g. bird watching, hiking, camping etc		Archaeological discoveries of indigenous artefacts	

Table 2: Total Economic Value of existing natural resource at Urannah

5. Benefits

The output of building Urannah dam is a large supply of water which could improve the reliability of water supply to users in the region, provide water to a new irrigation area in the lower Bowen River valley and the potential cheaper supply of water to mining/industrial users in the Bowen and southern Galilee basin.

It is also possible that the Urannah dam could supply water into the Broken River Weir and replace the releases currently occurring from the Eungella dam (excluding minimum environmental releases). An increase in water from Eungella dam could be allocated to users in the Bowen basin (subject to sufficient pipe capacity). It is likely that an upgrade to the existing pipelines or a new pipeline would be required to service the region due to the higher water flow (Sunwater, 2011).

The specific benefits of constructing Urannah dam are:

- Revenue from irrigated farming
- Revenue from selling water to HP users
- GST to government
- Use of dam for recreational purposes e.g. camping, boating, fishing
- Lower risk of running out of water for existing medium priority water users in the Lower Burdekin region during times of drought (assuming there is unallocated surplus water from Urannah. This has not happened during the BHWSS).
- Economic output of the irrigated agriculture industry supported by water from Urannah (however, the same benefit can be achieved through the BFD at a similar cost)
- Reduced operating and capital piping costs for the Bowen Basin mining sector due to closer proximity to the Bowen Basin and Urannah dam's height
- Ability to meet increased demand that may not be met by the BFD or other sources (e.g. increased demand from Townsville, Bowen farming, Abbott Point, Bowen mining, power station, Galilee Basin). There would need to be a huge increase in demand for this to happen and this is highly unlikely in the medium term.
- Job creation – reduction in unemployment benefits & employment rents. Apparently 6,000 jobs according to the Mackay Regional Water Study Strategy completed in 1996. The MacArthur Agribusiness report in 2001 reported contribution to employment (long term) of 100-120 employees to service the irrigated farms, 4 employees managing the dam and irrigation infrastructure and 10 employees at a gin plus an additional 40-50 during the season.

5.1. Expanded Irrigated agriculture

41,000 ha of suitable land was identified in the Collinsville Irrigation Soil Survey (Hyder Consulting, 1998). Of this, only 28,600 ha is suitable due to riparian zones, infrastructure and marginal land). Refer to the figure below. The green hatched area in the figure below is the likely area of irrigated agriculture in the Bowen/Broken River valley. The total area able to be irrigated has been estimated to be approximately 12,925 ha of land (for the small Urannah dam) with an application rate of approximately 9.15ML/ha/a (with distribution losses of around 10% in-stream and 10% reticulation losses) (DNRM, 1999). For the larger dam option irrigated land is approximately 15,660 ha (DNRM, 1999). This assumes that all water is committed to irrigation which is highly unlikely. Table 3 below summarises these figures.

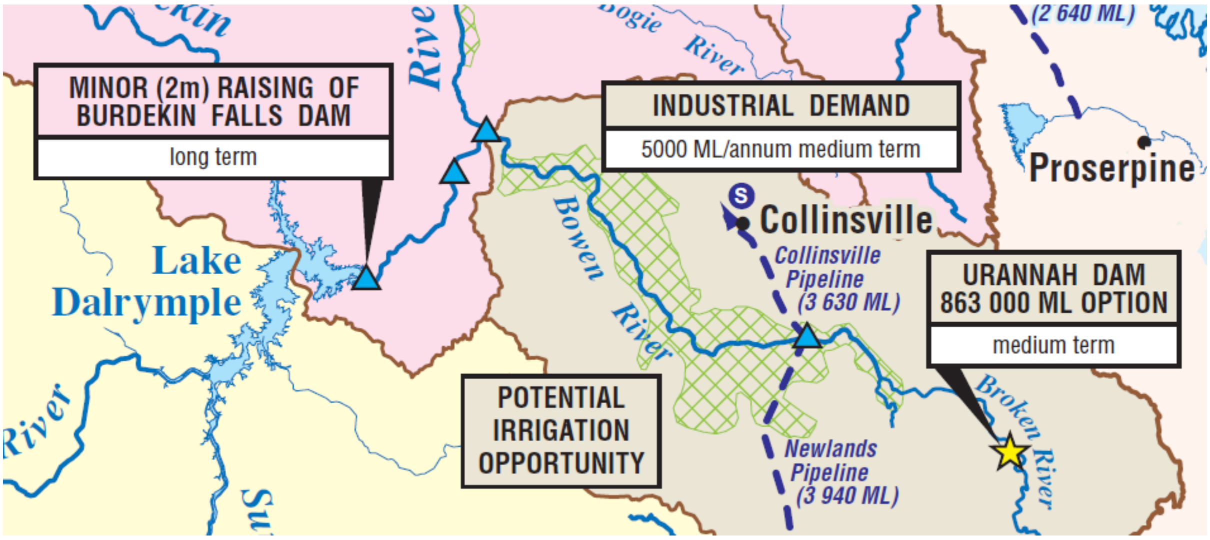

Figure 1: Location of Bowen River irrigation area

Scoping Study of Water Infrastructure Options in the Burdekin River Catchment (DNRMW, 1999) proposed the crop mix based on the outcome of a soil survey which is shown in Appendix 13.2.

Project	Capacity (ML)	Avg annual yield (ML/a)	Irrigated area (ha)
Urannah dam small	863,000	146,000	13,300ha without losses 12,925 with losses – DNR 1999
Urannah dam large	1,500,000	176,900	16,100 without losses 15,660 with losses– DNR 1999
Burdekin Fall Dam (spare capacity + 2m increase in wall)	2,022,977ML existing + 590,000ML additional	200,000	

Table 3: Potential supply and irrigation area

5.2. Lower pumping costs

The main benefit of Urannah over other sources of water supply is its higher elevation and its proximity to the Bowen basin, the Collinsville agricultural area and any other downstream industrial user in the Bowen river valley. The figure below compares the heights of different water sources and places of consumption.

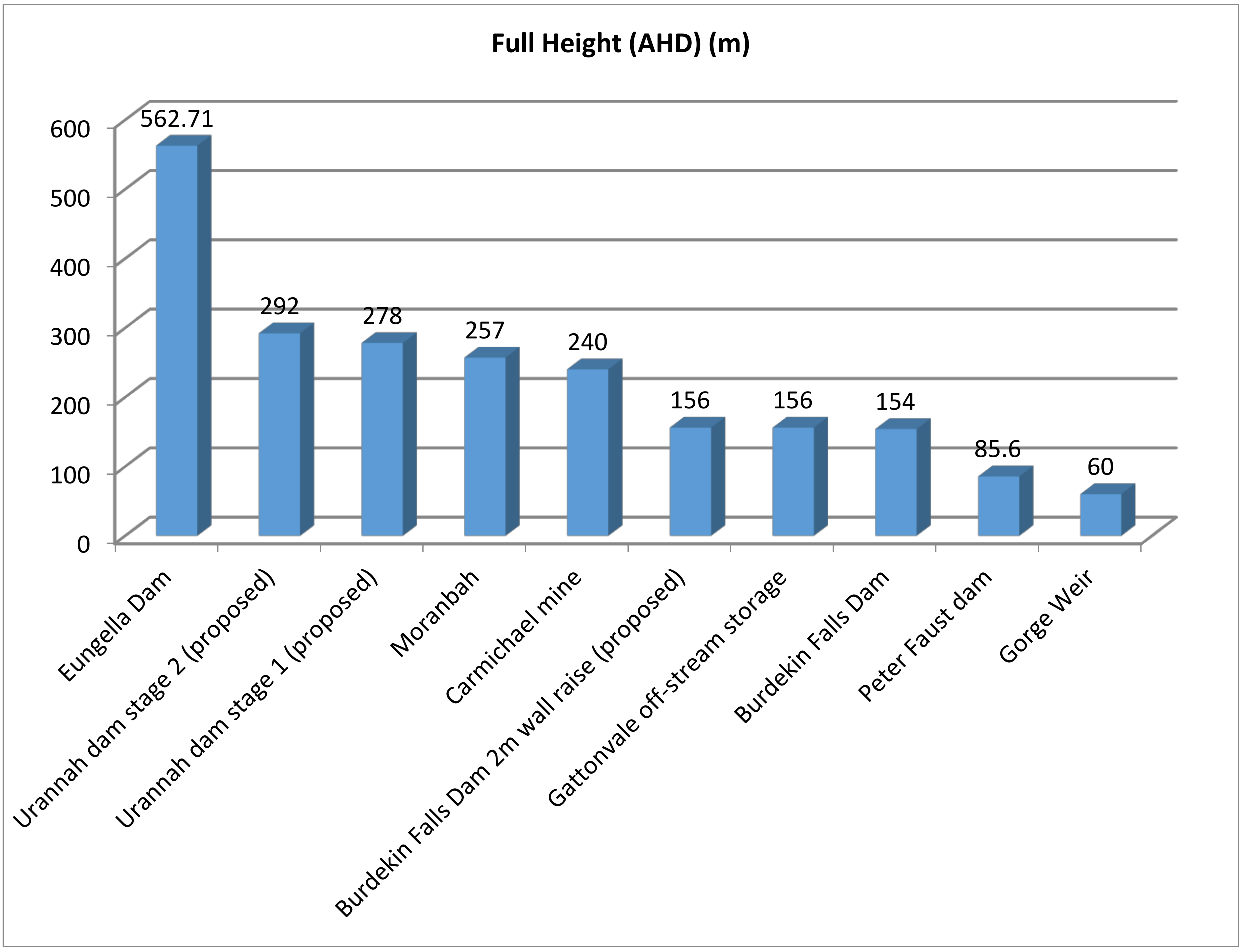

Figure 2: Water source and AHD height

- Static head between Gorge Weir (Burdekin River) & Moranbah = 197m uphill; distance = 215 km (currently supplying 23,000ML/a to Moranbah)
- Static head between Urannah Dam & Moranbah = 278m – 257m = -23m i.e. downhill. Distance = 155km
- Static head between BFD & Carmichael (Galillee basin) = 86m uphill; Distance = 160 km
- Static head between Urannah & Carmichael (Galillee basin) = - 38m i.e. downhill; Distance = 240km
- Static head between Urannah & BFD = 278m – 154m = 124m

The benefit of Urannah dam can be seen in the figure below where there is a negative head (i.e. a fall) to Moranbah and Carmichael mine.

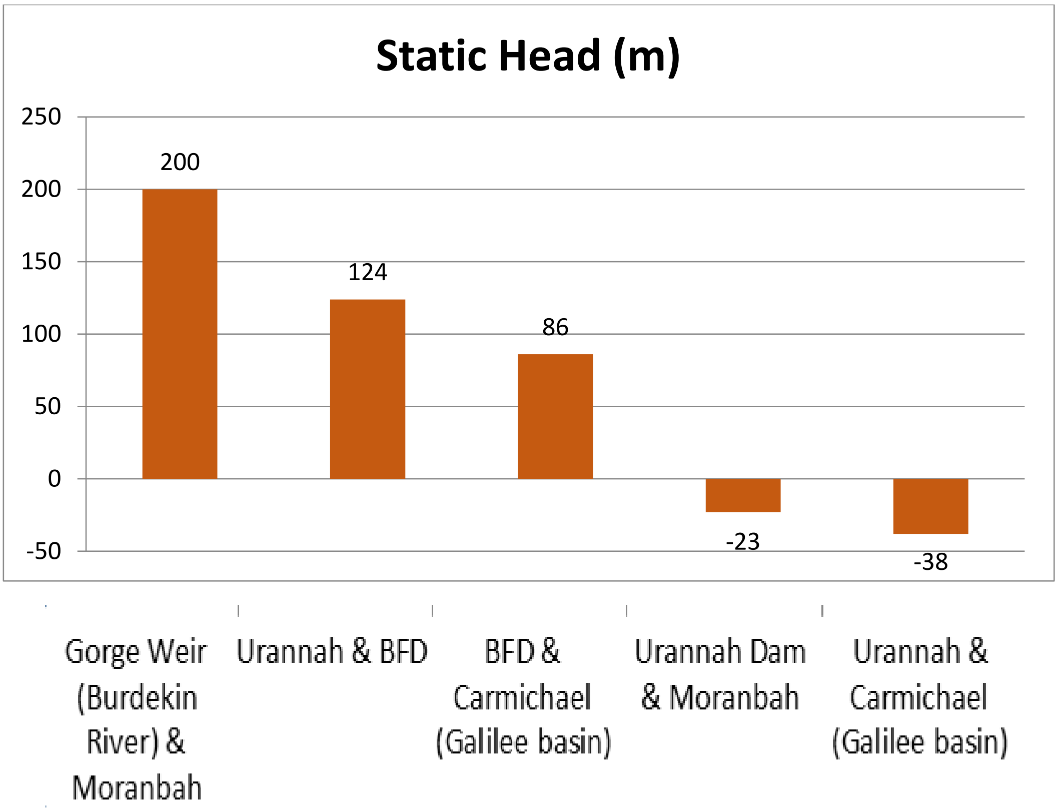

Figure 3: Static head between supply and consumption locations

Urannah has clear benefits for supplying water to the Bowen basin over the BFD. However, Sunwater have recently built a pipe from the Gorge weir to Moranbah, to deliver 23,000 ML per annum which has reduced water demand from the northern Bowen basin.

Despite Urannah having a further distance to pump water to the northern Galilee basin than the BFD, because of its head, pumping costs are reduced. Despite the lower pumping costs, capital cost outweighs the benefits and the overall AEC is cheaper for BFD (Section 8.1).

Downstream users of water in the Bowen river valley clearly stand to gain. This includes the township of Collinsville, the coal-fired power station, northern Bowen basin coal mines, existing irrigators, and land owners/lessees. However, as is discussed below, there currently exists limited demand for large volumes of water in this area and demand would have to be high to justify the expense of another dam on the Broken River.

6. Supply and Demand

This section looks at what demand there is for additional water and which supply sources could satisfy that demand. It has been shown that if full cost recovery pricing is used then the price will be too high and it is unlikely that irrigators could afford to pay. As a result, irrigation water needs to be subsidised so that farmers can afford to consume. Industrial users and residential users have different consumption/price characteristics and as a result can afford to pay higher prices.

6.1. Supply

6.1.1. Proposed Supply to meet future demand

Dam/water source	Storage (ML)	Annual yield	Full Height (AHD)	Capital Cost ($M)
Urannah dam stage 1	863,000	146,000 ML	278 m	$250M
Urannah dam stage 2	1,500,000	176,900 ML	292 m	$300M total
Burdekin Falls Dam 2m wall raise		150,000 ML	156 m	$15M to increase wall height
Connor River Dam & pipe project	373,000 ML	50,000 ML		$316M for the dam & $508M for pipe

Table 4: Additional water supply

NB: capital costs do not include reticulation or distribution costs. Access road and power connection costs are included in Urannah cost. BFD already has this infrastructure in place.

It is assumed that the Eungella dam has reached its full allocation and cannot supply anymore water. It is also assumed that it is financially unfeasible to increase the height of the Eungella dam wall to increase annual yield (DRNM, 1999).

BFD currently has 50,000 HP of unallocated water. There are a further 66,000 ML/a of water savings that could occur in the lower Burdekin region (DNRM, 2002). It is unknown if these water savings have been implemented or not. Therefore, there is potential for 116,000ML/a of additional water that could be committed elsewhere in the region. A 2m raising of the BFD would also yield an additional 150,000ML/a of water resulting in a potential 266,000 ML/a of increased water supply. Assuming that the water efficiency measures have already been undertaken in the lower Burdekin region, there is a potential 200,000 ML/a of additional water that can be committed elsewhere. This exceeds the amount that the Urannah dam could supply.

6.2. Demand

The Burdekin falls dam has the potential to supply the Bowen basin, the Galilee basin and the increased demand from Townsville. It is assumed that the water demand from Townsville will only be during dry periods to supplement their existing water supply from the Ross River dam. Demand from mining operations will be more static however, again it is assumed that their demand will also increase during periods of dry as mine site water (self-captured) water is reduced.

There could be an additional substantial demand for “make good” water to compensate landowners whose aquifers are adversely affected by coal seam gas operators dewatering activities to remove water above coal seam gas resources.

6.3. Other sources of potential demand

- Collinsville power station – currently in care and maintenance – it is being considered to upgrade this plant to a photovoltaic power station in which case water demand will be very small
- Collinsville township – it is unlikely that the Collinsville township would grow without the Urannah dam going ahead; or the mining industry recovering in the region. Water supplies

for Scottville and Collinsville are currently from Eungella Dam and they will have priority rights for Eungella Dam water as communities in need

- Water boards (north and south Burdekin) – there are currently potential improvements in efficiency which could actually reduce demand from these stakeholders.
- Bowen farmers – provided some form of delivery was in place i.e. pipe or open channel
- Abbott Point and other industrial users – likewise above, delivery is required.
- Anticipated growth in demand of water – refer to report by Sunwater. Water growth in the Bowen basin is expected to increase by 50,000ML pa over the long term. However, this was is an optimistic outlook that was forecast during the mining boom.

7. Alternative irrigation areas

According to the DNRM, 2006 "*there are still opportunities for expansion of irrigation areas on both the left and right banks of the river in the Lower Burdekin. However, there currently does not appear to be a major underlying driver of demand for expansion because of the state of the sugar industry at present and in the foreseeable future. There is a relatively small, but increasing, amount of diversification out of sugar and into alternative crops such as horticulture. If there were to be additional demands for water and expansion into new areas in the Lower Burdekin over the next 10 years, there would be sufficient water currently held by SunWater without an end user to meet most potential demand scenarios. However, it needs to be noted that further expansion of irrigated areas in the Lower Burdekin is a possibility in the future. For example, winter cotton is currently being trialled in the Lower Burdekin and the Cotton CRC has identified both the Lower Burdekin as a high priority area for further cotton research and development (RidgePartners 2005). Assessments were based on a number of criteria including availability of land and water, stakeholder attitudes, environmental issues and deployment of infrastructure.*"

To achieve the same outcome of irrigated land as the proposed Urannah dam, there are other areas that could be irrigated for a similar cost of the Bowen/Broken River valley. Refer to Table 5 and Figure 4 below. The table below shows that there is sufficient land available that either has direct access to water or can be accessed easily with minimal piping/irrigation channel within the BHWSS.

In a 2002 report conducted by DNRM, it identified an additional 23,200 ha of agricultural land that could be irrigated in the lower Burdekin River region. A 2006 DNRM report also discussed the potential for irrigating additional agricultural land in the lower Burdekin region. Most of this land is between Home Hill and Bowen and has been the subject of recent discussions with Sunwater looking at the feasibility of extending the Elliott main channel. This Water for Bowen project was found to be unfeasible due to lack of HP water consumers and the inability of irrigators to afford the price of water (Sunwater, 2011). For the sake of this cost analysis exercise it is assumed that there is sufficient demand in this region from irrigators who are willing to pay for water.

Region	Area (ha)	Access requirements
Region 1 (adjacent to Upper Burdekin river)	1,500	Riparian access pumped directly onto property
Region 2 (next to Home Hill & Gumlu)	12,000	Access with 40km extension to Elliott main channel or pipe
Region 3 (next to Haughton balancing station)	4,000	Supplied from existing channel infrastructure
TOTAL (supplied from the BHWSS)	19,500 ha	

Table 5: Irrigation area and delivery requirements

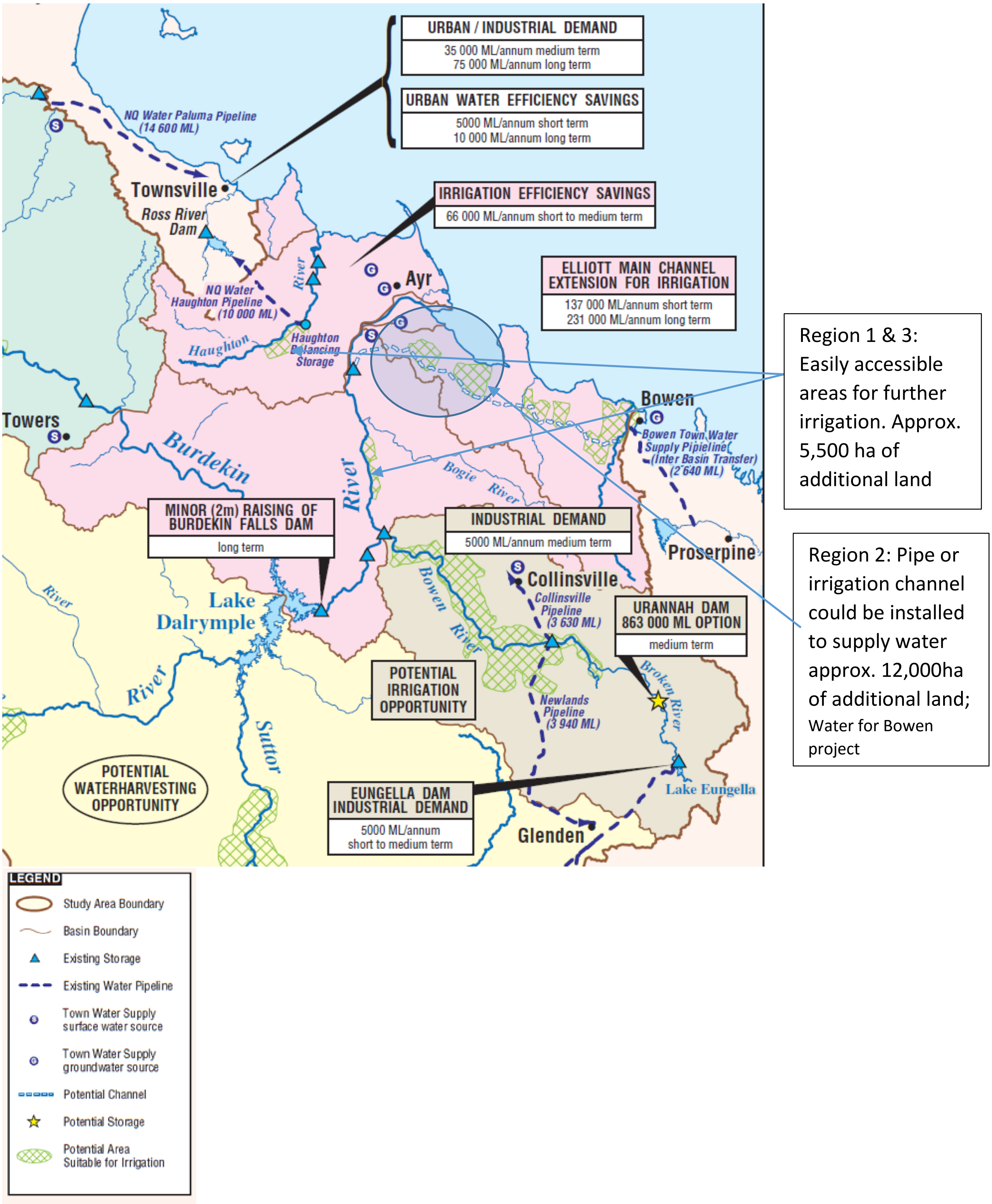

Figure 4: Map of potential irrigation areas

8. Results of the cost analysis

An analysis of the costs to deliver water to each of the consumers was undertaken. The capital, maintenance and pumping costs have been converted to an annual equivalent cost (AEC). This cost is an annual cost that is averaged out over the life of the project (50 years). It includes capital costs, maintenance costs and a return on capital expenditure. The results of the analysis are shown below. The capital and maintenance costs of the Urannah dam and for raising the BFD has been proportionally allocated to each user depending on the level of water consumption. No allowance has been made for non-market based costs such as environmental costs.

Destination	Urannah	BFD	Water ML/a	Priority
Irrigation (9,110 ha) (various locations)	$15.1	$18.1	100,000	MP
Bowen basin (Moranbah)	$55.9	$74.1	25,000	HP
Northern Gallillee basin (Carmichael mine)	$86.3	$65.0	25,000	HP
Irrigation area & Industrial (Bowen)	$43.0	$31.5	25,000	12500 - HP, 12500 - MP
TOTAL	**$200.3**	**$188.7**	**175,000**	

Table 6: AEC of delivery

8.1. Scenario development - Urannah

Previous reports propose that a staged development of Urannah would occur, with stage one being constructed which can supply 146,000 ML/a MAD water. It is assumed that the majority of this water would be for irrigation which could service approximately 9,110 ha of land (with an allocation of 100,000 ML at an average consumption rate of 11ML/ha/a) and a further allocation of 25,000ML for HP use in the Bowen basin and 25,000ML for mixed use in the Bowen region, a total of 150,000ML of water allocation. Following this, stage 2 could be undertaken to increase water allocations. MAD would increase to 176,900 ML/a. Additional HP allocation could supply Galilee basin, when/if this development occurs (an additional 25,000 ML in total). Total allocations would sum to 175,000ML. Approximately 2/3rds LP and 1/3 HP.

8.2. Discussion of the results

The results in the table above show that it is possible to achieve the same outcome in terms of benefits with the BFD but with $11.6M p.a. of less cost. This amounts to a present value of $114M. The results do not include environmental costs, such as CO2 emissions, loss of habitat, biodiversity and river systems and an increase in weed invasion. As discussed previously the main benefit of Urannah is that it can deliver water to Moranbah (Bowen basin) for approxiamately $18.2M p.a. less cost than BFD. This is because of Urannah's higher elevation and shorter pumping distance than the BFD.

The results for the irrigation scenario show that Urannah could potentially supply slightly cheaper water. This is because it can utilise the existing Bowen/Broken water course to supply water to potential users if issues regarding adverse impacts on aquatic species can be resolved. What has not been factored in is the additional infrastructure that would need to be installed, i.e. roads, sewerage, power to service the new farms surrounding the Collinsville area. Another factor that has not been included is that the BFD could supply water immediately, thereby generating benefit a return immediately. Because there is land which is suitable for irrigation and with immediate access to available water yet is not being used suggests there is no underlying demand from this industry. In addition BFD can supply an additional 25,000 ML per annum more than Urannah dam.

BFD is able to better supply the needs of northern Galilee basin (i.e. the Carmichael Mine) because of its closer proximity. Despite Urannah having a greater elevation (and hence lower pumping costs) this is outweighed by the need to install additional length of pipe which incurs greater capital cost.

Supplying water to Bowen from Urannah is proposed to be done via a 50km pipe to the headwaters of the Don River (DNRM, 1999). A weir along the Don River is most likely to be required to control the release of this water. Additional pipe would be required from the weir to supply industrial and irrigation users. In the case of BFD it is assumed that the Elliot main channel would be extended. In the Irrigation scenario it was assumed that 40km would be installed to irrigate agricultural land surrounding Gumlu. Therefore, the length of additional pipe required to supply Bowen is reduced to an additional 80km making this option cheaper than the Urannah pipeline and Don River weir option.

8.3. Sensitivity Analysis

Variables were adjusted by 50% to determine the ones that had the greatest impact on AEC for the Urannah and BFD options. Variables that had the greatest impact on project cost were Discount rate and the Cost of pipe. Other variables which had moderate impact where capital cost of Urannah dam, electricity cost and the maintenance cost of pipework. All other variables were insignificant i.e. they had an impact of less than 2%. The full results are displayed in Appendix 13.8.

8.3.1. Discount rate

The effect of discount rate on AEC for both Urannah and BFD projects is shown below.

	Real discount rate			
	5%	7.5%	10%	12.5%
Total AEC - Urannah	$120.6M	$159.5M	$200.3M	$241.4M
Total AEC - BFD	$118.9M	$153.0M	$188.7M	$224.8M

Table 7: Real discount rate and project AEC

8.3.2. Urannah dam capital cost

	Capital cost of Urannah Dam stage 1 ($M)			
	$200M	$250M	$300M	$400M
Total AEC - Urannah	$195.0M	$200.3M	$205.5M	$216.1M
Total AEC - BFD	$188.7M	$188.7M	$188.7M	$188.7M

Table 8: Capital cost of Urannah dam and project AEC

The base case used estimates from the Sunwater scoping study completed in 2001, of $135M. These figures were updated in 2004 to $150M (DNRMW, 2006). A discussion on the merits of this price is included in the Burdekin Basin Draft Water Resource Plan (DNRMW, 2006). The confidence level of this estimate is unknown, however, given that the Burnett River Dam cost $240M in 2005 ($311M, 2015 $) the cost seems quite low. In 2012 Sunwater estimated that the cost of building the Connors River Dam & pipeline (144km) that would yield 50,000 ML at $1.4 billion. The Nathan dam was estimated at $430M for the dam only by Sunwater in 2012. Therefore, there is most likely a higher chance of dam capital cost overrun than underrun.

This is confirmed by the DNRM report which considers the cost could increase due to:

- Spillway re-design
- No allowance for fish passage infrastructure or catch and release program (estimated at $12M, Paradise Dam, 2006)
- Increased outlet design capacities required for environmental flows
- Vegetation offsets have not been allowed for
- Risk of resource constraints which leads to underestimation of large capital projects

8.3.3. Pipe/channel cost

Pipe/channel cost includes engineering design, procurement/fabrication of pipe & pump stations, and installation of pipe and pump stations. It is difficult to estimate the cost of pipe without a detailed engineering design which considers flow rates, pipe diameters, terrain, pump station requirements and pipe/channel distances. All of these variables affect project cost and consequently the per kilometre cost. The estimates used in this analysis have been based on similar projects such as the BFD to Moranbah pipeline, and the Elliot open channel, refer to Table 16 for more detailed information.

The table below shows that the increase in pipeline cost affects BFD project more than the Urannah project. This is due to BFD's reliance on greater piping distances to where the water will be consumed. However, access to BFD is better than for Urannah because infrastructure such as the BFD to Moranbah pipeline is already in place. This variable, apart from the discount rate, has the largest influence over the project outcome.

	Pipe/channel capital cost ($M/km)			
	1	2	3	4
Total AEC - Urannah	$97.2M	$148.7M	$200.3M	$251.8M
Total AEC - BFD	$75.7M	$132.2M	$188.7M	$245.2M

8.3.4. Cost of pumping

Cost of pumping is determined by the cost of electricity, the dynamic losses within the pipe and the static head which is governed by the elevation at the suction point and the discharge point. Electricity prices have been based on Tarriff 48 and Tarriff 47 (High voltage). These tariffs are only available for large consumers of power. They incorporate a large fixed component of the price. An averaged power charge of approximately $150/MWh was calculated which was based on the demand charge per month and the variable charge. The access charge was not included, as it amounted to an insignificant amount and would most likely already be incurred by the dam anyway.

To determine pump power requirements, Darcy's formula has been used along with calculation of static head. To simplify the calculations, dynamic losses due to friction created by bends and pipe fittings have been ignored. Therefore, the stated pipe losses and consequently the total cost of pumping could be slightly underestimated. However, it was considered that these losses were insignificant when compared to friction losses due to the pipe wall and static head which has been included. Only the cost of electricity was included in the sensitivity analysis.

	Cost of electricity ($/MWh)			
	$100	$125	$150	$175
Total AEC - Urannah	$198.1M	$199.2M	$200.3M	$201.4M
Total AEC - BFD	$182.9M	$185.8M	$188.7M	$191.7M

9. Results of the social cost benefit analysis

Two scenarios have been considered for the social cost benefit analysis (i) full consumption of water output from the Urannah dam by downstream irrigation (ii) partial consumption by irrigation (LP) and partial consumption by Bowen basin coal mining companies (HP). A cost benefit analysis is shown below for 15,660 ha of irrigation i.e. large dam. A scenario analysis is also included. This analysis takes a pessimistic point of view and an optimistic point of view. Pessimistic is defined as being from the point of view of the project not being feasible.

The results of the CBA align themselves with the WWF (2014) report (BCR of 0.68) and the MacArthur report which had a BCR of 0.98. The main difference with the MacArthur report is the inclusion of environmental costs, employment benefits and industrial (HP) consumption. Only in the optimistic scenario with the inclusion of the benefit of water delivery to Moranbah is the project able to deliver a positive NPV.

Scenario	LP allocation	HP allocation	Irrigated area
Large dam – full allocation of water to irrigation	176,900 ML	0	15,660 ha
Large dam – partial allocation of water to irrigation and 25,000 ML to HP (Bowen Basin)j	151,900 ML	25,000 ML	13,450 ha

Table 9: Assumptions for cost benefit analysis

PV ($M)	Base Case	Pessimistic	Optimistic
Benefits	$577.8	$433.3	$729.3
Costs	$955.2	$1,194.0	$781.0
NPV	-$377.5	-$760.7	-$51.7
BCR	$0.60	$0.36	$0.93

Table 10: Summary of project benefits – full irrigation consumption scenario

PV ($M)	Base Case	Pessimistic	Optimistic
Benefits	$667.6	$500.7	$835.8
Costs	$888.4	$1,110.5	$740.4
NPV	-$220.8	-$609.8	$95.3
BCR	$0.75	$0.45	$1.13

Table 11: Summary of project benefits - partial irrigation and partial HP

9.1. Inclusion of industrial use

Based on the outcome of the AEC cost analysis performed in section 8 it is obvious that the only benefit to industry would be for mining in the Bowen Basin, and any downstream users, i.e. mining in the northern Bowen basin region, the township of Collinsville, the power station near Collinsville and existing downstream land owners/lessees. It is highly unlikely that there will be an increase in water consumption from Collinsville, therefore any benefit attributed to increased water supply is not included. The power station is currently in care and maintenance. There are discussions of transforming this power station to a solar photovoltaic or a solar thermal unit. Water consumption would be minimal if a solar PV upgrade is undertaken. It is unlikely that water demand will revert back to previous levels. As such it is considered that current supply from the Eungella dam is sufficient to meet the demand of Collinsville, the power station and any coal mining activity in the northern Bowen basin region.

The main benefit to users located around Moranbah will be the difference in costs between Urannah dam and BFD. This will be the difference between the AEC of water delivery discussed in section 8**Error! Reference source not found.**. Therefore, on an annual cost basis Urannah would save for the elivery of 25,000 ML in the order of $18.2M per annum over the life of the project. This equates to a present value of (using a discount rate of 10% over a project life of 30 years), $171M.

9.2. Employment benefit

Employment benefit of the dam and infrastructure construction was considered along with permanent employment benefit due to jobs supported by the increase in irrigated agriculture. Previous reports have suggest 6000 jobs would be created. This figure is considered to be greatly exaggerated and optimistic. In addition at an unemployment rate of 6.9% for the Mackay region this equates to 414 newly employed people. Many of these positions would only be for the construction phase of the project.

For the purposes of this report it was assumed that 105 people were previously unemployed and now received work as a result of the construction phase, and 40 people permanently as a result of agriculture. The construction phase was assumed to continue for three years.

9.3. Environmental costs

Environmental costs were broken into run off costs associated with water pollution and reef damage associated with the irrigated agriculture and the loss of environmental value due to dam and infrastructure construction. These costs for the base case came to a present value of $90.6M and $179.3M. Refer to section 4.1 for further information.

10. Project Risks

A full risk analysis (using Monte Carlo analysis) has not been undertaken in this report. However, the main sources of project risk are discussed below. For the purposes of this section a high risk variable is considered to be one that has a high impact on project outcome (identified through the sensitivity analysis) and one that has a high level of variability. Two of the risks identified affect the revenue (benefit) side of the project and the third risk, environmental impact and value, affects the cost side of the project.

10.1. Water reliability and yield (supply)

Since 1992 there have been no larger rainfall events (>440mm) comparable to such events 1939-1991. It takes approximately a 440 mm rainfall event to top up Eungella Dam in drier years. Changing rainfall patterns under changing climate will need to be assessed to quantify just how often, if ever, a dam at Urannah might reach capacity, and be able to meet environmental flow needs as well as any needed irrigation, industry or community needs. That risk assessment needs to be done as part of the justification of need for a dam at Urannah. This risk will affect the rate at which the dam fills and hence the ability of the dam to supply the water to consumers and long term yields which could potentially fall as rain events become more sporadic and less reliable.

10.2. Water uptake (demand)

This is affected by demand for the water and the rate of increase in demand once the Urannah project is completed and water supply is available for consumption.

10.3. Environmental impact and value

The true cost of the dam from an environmental perspective would not be fully known until years after construction completion if the dam was to be built. It is therefore difficult to estimate with any accuracy the true environmental costs. Likewise it is difficult to estimate the value of the existing natural assets in terms of indirect use and non-use values (e.g. value to indigenous people, ecosystem value).

10.4. Long term demand from coal mining

This is mainly the case for the Galilee basin where this coal is predominantly thermal coal. Given the recent move away from thermal coal powered steam turbines for electricity generation this poses significant risk for long term demand from these coal mines.

11. Conclusions

This report shows that the construction of the Urannah dam is not necessary. Economic benefits such as employment as a result of agriculture can be achieved more cheaply through utilising existing water sources such as the Burdekin Falls Dam. However, the fact that there exists available water in the BFD which is only priced at operating cost and available land nearby to irrigate suggests that there is little financial incentive for farmers to invest capital in establishing new farms. Therefore, if the Urannah dam was built it could be assumed there would be little financial incentive for farmers to invest in new farms.

The return on the proposed Urannah dam is in the range of $0.6 to $0.93 if all the water is devoted to irrigation and $0.75 to $1.13 when some water is sold to mines in the Bowen basin region. There is more chance of achieving a negative return on investment than a positive return especially when the risks of reduced yield due to drier conditions and the rate of water uptake are considered.

The advantage of Uranah dam over the BFD is that it can supply water more cheaply (on an operating cost basis) to the Bowen/Broken river valley and into the Moranbah network. However, there is not enough demand from this industry alone to make the Urannah project economically feasible. It is estimated there would need to be approximately 75,000ML/a demand in Bowen River valley from a corporate cotton farm (or similar) and 70,000ML/a of HP demand in the Moranbah region for there to be sufficient demand to make the building of the small version of the Urannah dam economically feasible (yield of ~146,000ML/a).

The most efficient outcome would be to use existing water supply assets more effectively rather than build new ones. For example, Bowen weir, Eungella dam, BFD and Fairbairn Dam. This can be achieved through encouraging water efficiency with the existing consumers of water and pricing water at its true cost of supply which includes environmental costs.

12. References

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13. Appendix

13.1. Sources of demand

Source of demand	Existing supply	Future Demand	Supply Options
Bowen Basin coal mines	Eungella Dam – BMA Eungella pipeline, 6,200ML p.a. BFD – Moranbah pipeline = 23,000ML p.a.	50,000ML p.a.	BFD, Eungella dam, Urannah dam
Northern Bowen Basin coal mines	Eungella Dam – Bowen river Weir	Included in above	BFD, Urannah, Eungella dam
Collinsville township	"	0	"
Collinsville Power station	Eungella Dam – 0ML pa (currently in care and maintenance)	2,500 ML – or potentially 0 if PV station installed	"
Collinsville pipeline – supply Collinsville, power station and norther Bowen basin mines	5,000ML/annum	Included in above	
Collinsville Irrigation	Eungella dam (BBWSS)	0 – unless cheap water is supplied	BBWSS, BHSS
North & south BWB, Irrigators in BHSS	BHWSS	?	BFD
Bowen township	Peter Faust dam?	?	Urannah, BFD
Townsville township	130ML per day (currently have 10,000ML pa allocation)	Potential to build a second pipeline capable of drawing 198ML per day (assume allocation to increase of 15,000ML)	Haughton supplied through the BHWSS
Gallillee Basin coal mining	?	Northern Galilee – 23,000ML p.a. Southern Galilee - 25,000ML p.a.	Moranbah-Gallillee pipeline, BFD – Gallillee pipe, Urannah – Gallillee pipe
TOTAL		88,000ML not incl south Galilee	

Table 12: Sources of demand

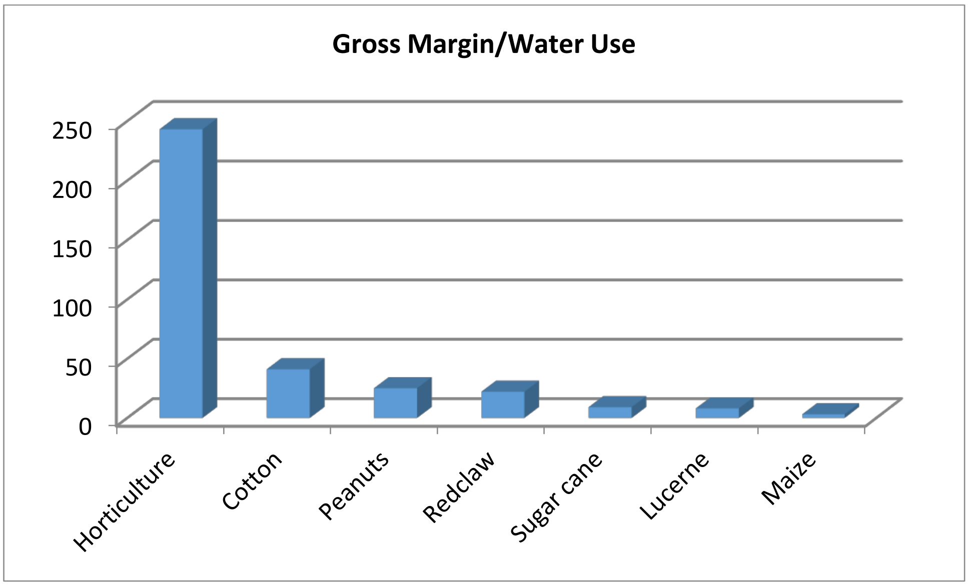
13.2. Cropping mix

Crop	Suitable Potential Area
Sugar Cane 59%	16,730 ha
Cotton 29%	8,210 ha
Horticulture (various) 5%	1,460 ha
Mixed broad acre (peanuts, leguminous pulses, maize) 6%	1,600 ha
Lucerne hay 1%	90 ha
Redclaw aquaculture 2%	510 ha
TOTAL	**28,600 ha**

Table 13: Potential cropping in Bowen River irrigation area

Enterprise	Water Use (ML/ha)	Estimated Crop Area (ha)	Total water demand ML	Gross Margin per ML
Sugar Cane	13	9,338	121,394	$120 (avg)
Peanuts	6	402.5	2,415	$147
Maize	7	402.5	2,817.5	$23
Cotton	6	4,669	28,014	$222
Horticulture*	7.4	805	5,957	$1801
Redclaw	43.5	322	14,007	$716
Lucerne	14	161	2,254	$96
TOTAL		**16,100**	**176,858.5**	

Table 14: Water consumption with full allocation to irrigation



13.3. Cost Summary

Type	Cost	Source	Inflation factor	2015 cost
Cost of dam (small)	$150M	DNRM, 2006	1.25	$188M
Cost of dam (large)		Based on 30% premium to small dam capital cost		$245M
Reticulation costs	$40M	DNRM, 1999	1.57	$62.8M
Roads	$29.5M	WWF, 2014	1.02	$30M
Fish ladder	$12M	DNRM, 2006 (based on 2004 price from Paradise Dam)	1.33	$16.0M
On farm reticulation (Cost to farmers)				$350M

Table 15: Dam & associated infrastructure capital costs

Pipeline	BFD to Northern Galilee	Moranbah to Alpha	Fairbairn (202m elv) to Alpha	Haughton Balancing Weir to Ross River head water	Burdekin Gorge Weir to MBH
ML pa	23,000	25,000	25,000	72,270	23,000
Pipe dia (mm)				1290	800+ 4 pumping stations
Total cost ($)	$ 550,000,000	$ 680,000,000	$ 600,000,000	$ 160,000,000	$ 700,000,000
Distance (km)	190	265	230	38	218
Cost per km (2012 costs)	$ 2,894,737	$ 2,566,038	$ 2,608,696	$ 4,210,526	$ 3,211,009
Source	Sunwater	Sunwater	Sunwater	Townsville Councill	Sunwater

Table 16: Basis of estimate for pipe costs

13.4. Estimate of environmental value

Environmental costs include:

- Loss of habitats in a nationally listed wetland with threatened and endemic on species;
- Deterioration of river and creeks (physical and ecological health and lower biodiversity;
- Downstream adverse impacts on the Outstanding Universal Values of the World Heritage Great Barrier Reef wetland ecosystem;
- CO^{2} emissions from construction & decomposing plant matter in flooded area
- Biodiversity and vegetation offset costs;
- Managing blue green algae outbreaks during low flow periods (common in existing Eungella Dam upstream)
- Increased salinity
- Increased rates of erosion
- Reduced water flow downstream to landowners and aquatic life
- Costs of managing increases in downstream salinity which is now avoided by inflow from Urannah and Massey Creeks
- Loss of aesthetic beauty
- Impact of industry – on flow of river, on reef
- Decommissioning/ End of life costs
- Freshwater delivery for estuarine/coastal fisheries
- Flood flows
- Sediment delivery to sensitive and internationally important coastal environments

Table 7. Average wetland ecosystem service values from wetland valuation meta-analysis		
Wetland function	US Dollar/hectare/year (2000$)	Canadian Dollar/hectare/year (2002$)
Flood control	$464	$571.02
Recreational fishing	$374	$460.27
Amenity/recreation	$492	$605.48
Water filtering	$288	$354.43
Biodiversity	$214	$263.36
Habitat nursery	$201	$247.36
Recreational hunting	$123	$151.37
Water supply	$45	$55.38
Materials	$45	$55.38
Fuel wood	$14	$17.23
Total	$2,260	$2,781.28
Notes:		

Table 17: List of costs taken from Canadian study

Ref: https://www.evri.ca/Global/Splash.aspx

Calculation of PV of environmental costs:

0.854 CAD to AUD (2002).

Using Amenity/recreation, water filtering, biodiversity, habitat nursery = $1,471/ha/year (CAD) = 1722/ha/year (AUD, 2002) => $2,413/ha/yr (AUD 2015).

Using only water filtering, biodiversity, habitat nursery = $865.15/ha/year (CAD) = 1013/ha/year (AUD,2002) => $1,419/ha/yr (AUD 2015)

Using 10,500 ha (inundated area for large dam option) total environmental value and consequently cost = $18.1M/annum OR $14.9M/annum (excl. recreation)

AF (10%, 50yrs) = 9.915. Therefore, present value of environmental costs = $179.3M OR $147.7M (excl. recreation)

Study title	Value	Location	Specific Environmental Goods and Services and Environmental Asset:
"Measuring the Total Economic Value of Restoring EcoSystem Services in an Impaired River Basin: Results from a Contingent Valuation Survey	US$29.5 to US$113.7M	A 45-mile easement along the South Platte River, downstream of Greeley.	Services that would be restored along the South Platte River include: dilution of wastewater; purification of water; erosion control; and habitat for fish and wildlife.
Valuing Environmental Impacts of Large Dam Construction in Korea: An Application of Choice Experiments"	209.9B Won151.0 to 269.9 billion Won 233.1M US$	South Koran, Kangwon Province, Tong River	General Environmental Assets: Man-Made Environment / Infrastructure cultural monuments Animals endangered species Plants rainforest
Assessment of Indirect Use Values of Forest Biodiversity in Yaoluoping National Nature Reserve, Anhui Province	$85.8M yuan per year The total indirect value is 25 times higher than the opportunity cost for regular timber production in the reserve.	China, Yaoluoping National Nature Reserve	Indirect use values of six ecological functions and services of forest biodiversity in Yaoluoping National Nature Reserve, including soil protection, water conservation, CO2-fixation, nutrient cycling, pollutant decomposition, and disease and pest control
Estimating the Economic Value of Landscape Losses Due to Flooding by Hydropower Plants in the Chilean Patagonia	The economic loss, associated with the landscape impacts for people living in urban area of the country, is found to be approximately US$ 205 million (in US Dollars)	Baker River Basin, located in the northern area of the Chilean Patagonia	Value of landscape in an area with recognized biodiversity and environmental richness
Valuation of the Environmental Impacts of Kayraktepe Dam/ Hydroelectric Project, Turkey: An Exercise in Contingent Valuation	USD 8,885,464 per year (in 1992 US Dollars) 73.55 US/AUD 1992 ($21.7 M AUD)	Kayraktepe Dam and Hydroelectric Power plant project, Turkey Göksu River is located in the Taseli Peninsula, Southern Turkey	Three major external costs of the Project: 1) loss of agricultural income from the existing fields and trees in the reservoir area; 2) loss of value from the national forests which will be inundated; and 3) the non-use values placed on the environment by the local people.

Table 18: List of studies on environmental valuation (Evri website)

13.5. Environmental pollution

Crop	TSS/annum	DIN/annum
Sugar cane	>13800 tonnes	119 tonnes
Cotton	>115 tonnes	0.75 tonnes
Horticulture	>766 tonnes	6.1 tonnes
Peanuts, legumes, maize	>22 tonnes	0.1 tonnes
Lucerne	>1 tonne	Minimal
Red-claw crayfish	>7 tonnes	Minimal
TOTAL	**>15,000 tonnes**	**130 tonnes**

Source: Waters et al 2014 & Mainstream Economics, 2014

Table 19: Costs of farming on the GBR

13.6. Calculations

Cost Analysis of water supply to consumption location					
Universal Variables					
Discount rate	10.0%				
Maintenance ratio (dam)	1.0%				
Maintenance ratio (pipe)	0.75%				
Maintenance cost ($/km/a)	$ 22,500				
Cost of Urannah dam (stage 1)	$ 250,000,000				
Maintenance of Urannah dam ($/a)	$ 2,500,000				
Construction (yrs)	2				
Cost of raising BFD wall by 2m	$ 15,000,000				
Maintenance of BFD - increased cost ($/a)	$ 150,000				
Construction (yrs)	1				
Cost of pipe ($/km)	$ 3,000,000				
Electricity cost ($/MWh)	150				
Total supply of water (ML/a) Urannah	175,000				
Total supply of water (ML/a) BFD	200,000				
Irrigation (9,110 ha) (various locations)					
	Urannah - supplied from Bowen Weir	**BFD (Haughton, Elliott Main Channel, Burdekin River)**			
Pipe length (km)	0			40	
Pipe nb (mm)	1200			2500	
Flow rate (ML/annum)	100,000			100,000	
friction factor (f)[1]	0.012			0.012	
Head (m) - static (Z)	0			0	
Pump efficiency (ew)	66			66	
Specific gravity	1.01			1.01	
Pipe id (mm)	1174.6			1174.6	
Pipe area (m2)	1.08			1.08	
Flow rate (m3/s) Q	3.2			3.2	
Flow velocity (m/s)	2.9			2.9	
Head (m) - friction[2]	0			84	
Total head (m) (Hw)	0			84	
Electricity peak power - pumping (MW)[3]	-			4.0	
Peak annual electricity consumption (GWh)				35	
Capital cost ($)	$ -			$ 120,000,000	
Pumping cost ($/annum)	$ -			$ 5,238,601	
Maintenance cost ($/annum)	$ -			$ 900,000	
1 - taken from a friction graph, Warman Slurry Pumping Handbook					
2 - Darcy's formula = QxHwxSm/(1.02 x em)					
3 - at the shaft of the pump = QxHwxSm/(1.02 x em)					

Mining Bowen basin (Moranbah)					
	Urannah			BFD (Gorge Weir)	Source:
Pipe length (km)	155			218	Sunwater
Pipe nb (mm)	900			900	
Flow rate (ML/annum)	25,000			25,000	
friction factor (f)[1]	0.012			0.012	
Head (m) - static	-23			197	
Pump efficiency	66			66	
Specific gravity	1.01			1.01	
Pipe id (mm)	875			875	
Pipe area (m2)	0.60			0.60	
Flow rate (m3/s)	0.8			0.8	
Flow velocity (m/s)	1.3			1.3	
Head (m) - friction[2]	183			257	
Total head (m)	160			454	
Electricity consumption - pumping (MWh)[3]	1.90			5.41	
Capital cost ($)	$ 465,000,000			$ 654,000,000	
Pumping cost ($/annum)	$ 2,501,649			$ 7,102,726	
Maintenance cost ($/annum)	$ 3,487,500			$ 4,905,000	
1 - taken from a friction graph, Warman Slurry Pumping Handbook					
2 - Darcy's formula = Hf = f x L/D x V^2/2g					
3 - at the shaft of the pump = QxHwxSm/(1.02 x em)					

Mining Northern Gallillee basin (Carmichael mine)			
	Urannah		**BFD**
Pipe length (km)	240		190
Pipe nb (mm)	900		900
Flow rate (ML/annum)	25,000		25,000
friction factor (f)[1]	0.012		0.012
Head (m) - static	-38		200
Pump efficiency	66		66
Specific gravity	1.01		1.01
Pipe id (mm)	875		875
Pipe area (m2)	0.60		0.60
Flow rate (m3/s)	0.8		0.8
Flow velocity (m/s)	1.3		1.3
Head (m) - friction[2]	283		224
Total head (m)	245		424
Electricity consumption - pumping (MWh)[3]	2.92		5.05
Capital cost ($)	$ 720,000,000		$ 570,000,000
Pumping cost ($/annum)	$ 3,836,215		$ 6,632,768
Maintenance cost ($/annum)	$ 5,400,000		$ 4,275,000
1 - taken from a friction graph, Warman Slurry Pumping Handbook			
2 - Darcy's formula = Hf = f x L/D x V^2/2g			
3 - at the shaft of the pump = QxHwxSm/(1.02 x em)			

Irrigation area & Industrial (Bowen region)	require a weir to control the flow of water into don river	
	Urannah - via Don River & Elliott main channel	**BFD via Elliott Main Channel**
Pipe length (km)	105	100
Pipe nb (mm)	1200	1200
Flow rate (ML/annum)	25,000	25,000
friction factor (f)[1]	0.012	0.012
Head (m) - static	30	0
Pump efficiency	66	66
Specific gravity	1.01	1.01
Pipe id (mm)	1175	1175
Pipe area (m2)	1.08	1.08
Flow rate (m3/s)	0.8	0.8
Flow velocity (m/s)	0.7	0.7
Head (m) - friction[2]	29	27
Total head (m)	59	27
Electricity consumption - pumping (MWh)[3]	0.70	0.32
Weir capital cost	$ 20,000,000	
Pipe Capital cost ($)	$ 315,000,000	$ 300,000,000
Pumping cost ($/annum)	$ 915,868	$ 425,738
Maintenance cost ($/annum)	$ 2,362,500	$ 2,250,000
Maintenance cost of weir	$ 200,000	
1 - taken from a friction graph, Warman Slurry Pumping Handbook		
2 - Darcy's formula = Hf = f x L/D x V^2/2g		
3 - at the shaft of the pump = QxHwxSm/(1.02 x em)		

13.7. Cash flow – Cost Analysis

Year	0	1	2	3	4	5	6	7	8	9	10	40	41	42	43	44	45	46	47	48	49	50
Delivery to agriculture (100,000ML/a)																						
Urannah																						
Water supply	100000																					
Capital proportion	57%																					
Capital outlay	$ 71.4	$ 71.4																				
Pipe capital		$ -																				
Pumping costs			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Maintenance cost - dam			$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4
Maintenance cost - pipe			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TOTAL	$ 71.4	$ 71.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4	$ 1.4
PV Cost	$149.23																					
AEC	-$15.05																					
Alternative - BFD																						
Water supply	100000																					
Capital proportion	57%																					
Capital outlay	$ 8.6																					
Pipe capital	$ 60.0	$ 60.0																				
Pumping costs			$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2	$ 5.2
Maintenance cost - dam			$ 0.09	$ 0.09	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09	$ 0.09	$ 0.09	$ 0.09	$ 0.09	$ 0.09	$ 0.09	$ 0.09	$ 0.09	$ 0.09	$ 0.09	$ 0.09
Maintenance cost - pipe			$ 0.90	$ 0.90	$0.90	$0.90	$0.90	$0.90	$0.90	$0.90	$0.90	$ 0.90	$ 0.90	$ 0.90	$ 0.90	$ 0.90	$ 0.90	$ 0.90	$ 0.90	$ 0.90	$ 0.90	$ 0.90
TOTAL	$ 68.6	$ 60.0	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2	$ 6.2
PV Cost	$179.17																					
AEC	-$18.07																					

Delivery to moranbah (25,000ML/a)																						
Urannah																						
Water supply (ML/a)	25000																					
Capital proportion	14%																					
Capital outlay	$ 17.9	$ 17.9																				
Pipe capital	$ 242.5	$242.5																				
Pumping costs			$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5	$ 2.5
Maintenance cost - dam			$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4
Maintenance cost - pipe			$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5	$ 3.5
TOTAL	$ 260.4	$260.4	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3	$ 6.3
PV Cost	$554.20																					
AEC	-$55.90																					
			$180																			
Alternative - BFD																						
Water supply	25000																					
Capital proportion	14%																					
Capital outlay		$ 2.1																				
Pipe capital	$ 327.0	$327.0																				
Pumping costs			$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1	$ 7.1
Maintenance cost - dam			$ 0.02	$ 0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02
Maintenance cost - pipe			$ 4.91	$ 4.91	$4.91	$4.91	$4.91	$4.91	$4.91	$4.91	$4.91	$ 4.91	$ 4.91	$ 4.91	$ 4.91	$ 4.91	$ 4.91	$ 4.91	$ 4.91	$ 4.91	$ 4.91	$ 4.91
TOTAL	$ 327.0	$329.1	$ 12.0	$ 12.0	$12.0	$12.0	$12.0	$12.0	$12.0	$12.0	$12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0
PV Cost	$734.55																					
AEC	-$74.09																					

Delivery to Northen Galillee basin (Carmichael Mine) 25,000ML/a																						
Urannah																						
Water supply	25000																					
Capital proportion	14%																					
Capital outlay	$ 42.9	$ 42.9																				
Pipe capital	$ 360.0	$ 360.0																				
Pumping costs			$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8
Maintenance cost - dam			$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4
Maintenance cost - pipe			$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4	$ 5.4
TOTAL	$ 402.9	$402.9	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6
PV Cost	$855.49																					
AEC	-$86.28																					
Alternative - BFD																						
Water supply	25000																					
Capital proportion	14%																					
Capital outlay	$ 2.1																					
Pipe capital	$ 285	$ 285																				
Pumping costs			$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6	$ 6.6
Maintenance cost - dam			$ 0.02	$ 0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02
Maintenance cost - pipe			$ 4.28	$ 4.28	$4.28	$4.28	$4.28	$4.28	$4.28	$4.28	$4.28	$ 4.28	$ 4.28	$ 4.28	$ 4.28	$ 4.28	$ 4.28	$ 4.28	$ 4.28	$ 4.28	$ 4.28	$ 4.28
TOTAL	$ 287.1	$285.0	$ 10.9	$ 10.9	$10.9	$10.9	$10.9	$10.9	$10.9	$10.9	$10.9	$ 10.9	$ 10.9	$ 10.9	$ 10.9	$ 10.9	$ 10.9	$ 10.9	$ 10.9	$ 10.9	$ 10.9	$ 10.9
PV Cost	$644.66																					
AEC	-$65.02																					

Delivery to Bowen and Homehill to Bowen irrigation area 25,000ML/a																						
Urannah																						
Water supply	25000																					
Capital proportion	14%																					
Capital outlay	$ 17.9	$ 17.9																				
Capital outlay - Weir	$ 30.0	$ 30.0																				
Pipe capital	$ 157.5	$157.5																				
Pumping costs			$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9	$ 0.9
Maintenance cost - Weir			$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2
Maintenance cost - dam			$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4
Maintenance cost - pipe			$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4	$ 2.4
TOTAL	$ 205.4	$205.4	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8	$ 3.8
PV Cost	$426.59																					
AEC	-$43.03																					
Alternative - BFD																						
Water supply	25000																					
Capital proportion	14%																					
Capital outlay	$ 2.1																					
Pipe capital	$ 150.0	$150.0																				
Pumping costs			$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4	$ 0.4
Maintenance cost - dam			$ 0.02	$ 0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02
Maintenance cost - pipe			$ 2.25	$ 2.25	$2.25	$2.25	$2.25	$2.25	$2.25	$2.25	$2.25	$ 2.25	$ 2.25	$ 2.25	$ 2.25	$ 2.25	$ 2.25	$ 2.25	$ 2.25	$ 2.25	$ 2.25	$ 2.25
TOTAL	$ 152.1	$150.0	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7	$ 2.7
PV Cost	$312.80																					
AEC	-$31.55																					

13.8. Sensitivity Analysis

Variables	% Change[1]	Impact level[2]
Discount rate	30%	Large
Maintenance ratio (dam)	1%	Insignificant
Maintenance ratio (pipe)	3%	Medium
Cost of Urannah dam (stage 1)	7%	Medium
Cost of raising BFD wall by 2m	1%	Insignificant
Cost of pipe ($/km)	32%	Large
Electricity cost ($/MWh)	8%	Medium

Notes:

[1] input variables were changed by +50%

[2] Resultant changes in NPV were coded as follows (Impact level):

- < 2% - insignificant
- 3-10% - medium
- >10% - high

13.9. Results of the Social CBA

13.9.1. Full irrigation

PV Costs ($M)	Base case	Pessimistic	% change	Optimistic	% change	Source - base case
Dam + off farm infrastructure	$300.0	$375.0	25%	$285.0	-5%	Full dam construction including contigencies for growth of cost
Farm costs	$325.0	$406.3	25%	$243.8	-25%	MacArthur Report
Land Development	$58.0	$72.5	25%	$43.5	-25%	MacArthur Report
Opportunity cost	$2.3	$2.9	25%	$1.7	-25%	MacArthur Report
Environmental - run off	$90.6	$113.3	25%	$72.5	-25%	WWF - prorated
Environmental - use value	$179.3	$224.1	25%	$134.5	-25%	Estimated from Canadian estimates
TOTAL	$955.2	$1,194	25%	$781.0	-18%	

Table 20: Present value of costs - full irrigation consumption scenario

PV Benefits ($M)	Base case	Pessimistic	% change	Optimistic	% change	Source - base case
Farm production + Cotton gin	$561.1	$420.8	-25%	$701.4	25%	MacArthur report
Recreation	$1.2	$0.9	-25%	$1.7	138%	MacArthur report
Timber extraction	$0.7	$0.5	-25%	$0.9	25%	MacArthur report
Employment benefits (permanent)	$7.8	$5.9	-25%	$9.8	25%	Estimate based on Macarthur report
Employment benefits (construction)	$6.9	$5.2	-25%	$15.6	125%	Estimate
TOTAL	$577.8	$433.3	**-25%**	$729.3	**26%**	

Table 21: Present value of benefits - full irrigation consumption scenario

13.9.2. Partial Irrigation

PV Costs ($M)	Base case	Pessimistic	% change	Optimistic	% change	Comments
Dam + off farm infrastructure	$300.0	$375.0	25%	$285.0	-5%	
Farm costs	$279.1	$348.9	25%	$209.4	-25%	Prorated full irrigation scenario by 83%
Land Development	$49.8	$62.3	25%	$37.4	-25%	Prorated full irrigation scenario by 83%
Opportunity cost	$2.3	$2.9	25%	$1.7	-25%	MacArthur Report
Environmental - run off	$77.8	$97.3	25%	$72.5	-25%	Prorated full irrigation scenario by 83%
Environmental - use value	$179.3	$224.1	25%	$134.5	-25%	
TOTAL	**$888.4**	**$1,110.5**	**25%**	**$740.4**	**-17%**	

Table 22: Present value of the costs – partial irrigation scenario

PV Benefits ($M)	Base case	Pessimistic	% change	Optimistic	% change	Comments
Gross margin to farmers	$481.9	$361.4	-25%	$602.3 9	25%	Prorated full irrigation scenario by 83%.
Tourism	$0.3	$0.2	-25%	$1.7	553%	
Timber	$0.7	$0.5	-25%	$0.9	25%	
Employment benefits (permanent)	$6.7	$5.1	-25%	$8.4	25%	Prorated full irrigation scenario by 83%
Employment benefits (construction)	$6.9	$5.2	-25%	$8.7	25%	
Industrial benefit - 25,000ML/a	$171.0	$128.3	-25%	$213.8	25%	Based on a PV of $171M (supply to Moranbah)
TOTAL	$667.6	$500.7	-25%	$835.8	25%	

Table 23: Present value of the benefits – partial irrigation scenario

13.10. Previous reports on Urannah Dam

Report author	Report title	Pub. date	Type & description of report	Comments - Outcome of report/analysis
Queensland Irrigation and Water Supply Commission	Report on Bowen-Broken Irrigation Scheme	October 1967	Engineering focused pre-feasibility report.	Original study on the dam
Snowy Mountains Engineering Corporation	Staged construction of Urannah Dam	April 1978		Provides detailed on preliminary design
Connell Wagner	Urannah Dam Scheme	Early 90s	Economic Impact Assessment of large dam option (1,500,000ML) – this report probably fed into the Mackay regional water resources strategy stage II report.	Gross regional output of > $1 Billion and employment of 6,000 people. Claimed 30,000 – 100,000 ha of land would be irrigated in the Bowen/Broken river valley alone. Water would also supplement groundwater supplies at Bowen either through the Elliott Open channel or via Don River.
Connell Wagner for Mackay Tourism and Development Bureau	Mackay Regional Water Resources Strategy: Volume 1 Main Report	1996		
Qld state government	Water Infrastructure Task Force	1998/1996		
Hyder Consulting	Collinsville Irrigation Soil Survey	1998	Soil survey	41,000Ha of suitable land, of this only 28,600 Ha is usable. 25,000ha is suited to a wide range of crops and 7,900 ha is suited to cane only, 7,100 ha to cereals, trees crops and hay only.
	Mackay Regional Water Resources Strategy Stage II	1998	Economic Impact Assessment of small dam option (863,000ML)	Economic output per dollar invested of $16 to $26, using a 6% discount rate. NPV of $1056M, (including non-agricultural use). – not a proper NPV or economic appraisal. Assumptions have also been made that all water will be consumed which in reality is unlikely. The price that the water has been sold for has been ignored and distributions of benefits has been neglected.
Dept. of Natural Resources	A Scoping Study of Water Infrastructure Options and Related Issues in the Burdekin River Catchment	Sept, 1999		NPV of $564.8M of agricultural activity alone. Did not consider time value of money and left out a lot of capital costs. Did not consider environmental costs.
Dept Primary Industries submitted to Dept. of Natural Resources, Regional Infrastructure Development, North Region	Burdekin Agroeconomic study	June, 1999		Predicted the likely cropping scenario for stage II of Urannah Dam ref, BCE 2002 report. Estimated gross return for crops grown in Collinsville region. The DNRMW report in 1999 which showed a positive NPV under-reported the capital costs of infrastructure investment required to implement an agricultural industry in the Bowen/Broken river valley. For example, roads, power supply, reticulation of water

				delivery, sewerage, and farm establishment costs have been left out of the estimation of the capital costs. In addition land resumption, forest offsetting (offsets for the loss of threatened species habitat (e.g. koalas and northern spotted quoll) and endemic species (Irwin's turtle) and relocation of the Urannah homestead have been left out. Benefits are overly optimistic with assumptions about full water allocation within the second year of the project life and there is no data to show if and how often the dam might fill. Construction has also been assumed to be completed in one year. No financing costs have been allowed for. This report, which has been used by supporters of the Urannah dam as a justification for the dam to be built, performed these calculations "not to rigorously define an option's costs and benefits, rather it is intended as an indicator of relative worth, within and between options identified in this study", (DNRM, 1999).
Qld State Government - DNRM	Burdekin Basin Water Supply Planning Study Report	June, 2000		Referenced in Whitsunday Region Growth Corridor – submission to the Joint Standing Committee on Northern Australia
Macarthur agribusiness – commissioned by the Qld Dept of State Dev.	Economic and Financial Pre-feasibility Analysis of the Urannah Project	August, 2001	NPV framework of several options. Financial analysis estimated avg water price of $184/ML to achieve IRR 15%	Found no economic or financial net benefit due to sugar or cotton industries being unable to afford water cost. Financial viability of the dam is highly sensitive to changes in irrigation development timing and the applied discount rate. Also undertook a CBA with a NPV of -$7.45M and a BCR of 0.98 (@10.44% disc rate) Only for agriculture. Also excludes environmental costs.
Sunwater Engineering Services	Review of Urannah Dam Proposals: Scoping Study	2001	Engineering options analysis and cost estimate	
Bowen Collinsville Enterprise	Smart Water for the Smart State - Urannah Dam: Water for the new millennium	April 2002		Provides a cost-benefit analysis but excluding environmental costs and assumes full water uptake, NPV of $280.6M for stage 1 and $323.2M for stage II.
Origin Securities – commissioned by the Qld Dept of State Dev. & Innovation	Urannah Project Agricultural Investment Study	2003		
Connell Wagner – commissioned by the QLd Dep of State Dev. & Innovation	Urannah Project Environmental Investigation	2003		Looked at similar environmental issues as the MacArthur Agriculture report but in greater detail.

Hatte & Harrington – commissioned by the Qld Dept of State Dev & Innovation	A Scoping Study and Desktop Review of Indigenous Cultural Heritage Issues Associated with the Proposed Urannah Dam Project	2003	Indigenous issues	
Dept. Natural Resources, Mines & Water	Burdekin Basin – draft water resource plan – economic and social assessment stage 2	February 2006	Cost benefit analysis of smaller dam. Determined an annualised cost of water. This was then used an as input into a cotton farm model.	Urannah Dam is not economically or financially viable with a cotton industry. Water was priced at $105/ML (2004 prices) to return an NPV of 0. Cotton farming was breakeven. No consideration of environmental costs or efficiency pricing was undertaken. Looks at the ability of a cotton industry to be able to pay full price for water. Does not consider additional benefits of employment, environmental consequences, or flow on benefits.
Mainstream Economics – World Wildlife Fund	Cost-benefit analysis of current and proposed dams in GBR catchments	2014	Cost benefit analysis of sugar cane farming in the Collinsville area.	NPV of -$188.8M and BCR of 0.68. Also quantified the environmental degradation to the reef as a result of new farming activity. Did not quantify the envinronmental loss of building the dam.

Table 24: List of some of the prior work completed on Urannah Dam

13.11. Summary of previous reports and NPV, costs and benefits

Report	Crop	Dam size	2015 NPV ($M)	2015 Costs ($M)	2015 Benefits ($M)	2015 Crop returns/Gross margin (avg $/ha)	Disc rate	Notes
DNRMW report, 1999	Mixed	0.863M ML	$440.54	$ 291.2	$ 731.8	$ 4,113.4	6%	Excluded land acquisition costs & environmental externalities. Did not take into consideration time value of capital construction, financing costs, uptake rate. Etc. Costs where understated, did not include road infrastrcuture and environmental considerations. benefits overstated because they assumed 100% uptake straight away.
DNRMW report, 1999	Mixed	1.5M ML	$507.42	$ 379.3	$ 886.7	$ 4,113.4	6%	"
MacArthur Business, 2001	Cotton		-$10.74	$ 534.7	$ 523.9	$ -	10.44%	Excludes mining benefits
DNRMW report, 2006,	Cotton		$0.00	$ -	$ -	$ -	7.50%	uses cost output from financial analysis and applies this to a model cotton farm.
WWF, 2014	Sugar	1.5M ML	-$192.47	$ 599.5	$ 407.0	$ 2,040.0	7.7% real to water infrastructure & externalities & 13.1% to farm operating surpluses	Included environmental externality of GBR impact but no costing of dam impact; crop return includes water charges

Table 25:Summary of previous reports CBA

Report	**WWF - large dam**	**Infalation factor (2014 - 2015)**	**2015 $**	**MacArthur Argi business**	**inflation factor (2001 - 2015)**	**2015 $**	**DNRM, 2006**	**infalatio n factor (2006-2015)**	**2015 $**	**DNRM, 1999/BCE,2002**		**2015 $**
Assumed irrigation area (ha)	28,600									13,300 or 16,100 ha		
Gross Margin ($/ha/a)	$ 2,000.0	101.50%	$ 2,030.0									
Employment	$ -	101.50%	$ -									
PV Benefits - large dam	$ 399.0	101.50%	$ 405.0			$ 525.0				$ 466.1	159.7%	$ 744.4
PV - Benefits - small dam												
Capital cost - large dam	$ 152.0	101.50%	$ 154.3				$ 195.00	125.3%	$ 244.3	$ 149.30	159.7%	$ 238.43
Capital cost - small dam						$ 136.9	$ 150.00	125.3%	$ 188.0	$ 113.10	159.7%	$ 180.62
Roads and other infrastructure - large dam (PV $)	$ 29.5	101.50%	$ 29.9									
Roads and other infrastructure($/ha)	$ 1,100.0	101.50%	$ 1,116.5									
Capital cost to farmers (PV $)	$ 279.4	101.50%	$ 283.6			$ 324.8						
purchase and est costs ($/ha)	$ 10,400.0	101.50%	$ 10,556.0									
TOTAL cost - dam + roads + operating costs (large) PV			$ 184.2				230.958	*125.3%*	*$ 289.4*			
TOTAL cost - dam + roads + operating costs (small) PV						$ 139.2	*$ 177.66*	*125.3%*	*$ 222.6*			
TOTAL cost - farmers (large)			$ 283.6			$ 396.6				*$ 92.30*	*159.7%*	*$ 147.40*
TOTAL cost - farmers (small)										*$ 72.40*	*159.7%*	*$ 115.62*
Environmental costs	$ 126.9	101.50%	$ 128.8									
PV Costs - large dam	*$ 587.7*	*101.50%*	*$ 596.5*			$ 535.8				$ 241.60	159.7%	$ 385.84
PV Costs - small dam										$ 185.50	159.7%	$ 296.24
NPV	*-$ 188.8*	*101.50%*	*-$ 191.6*									
BCR	*0.68*						0.98					

13.12. Arial view of Urannah dam location

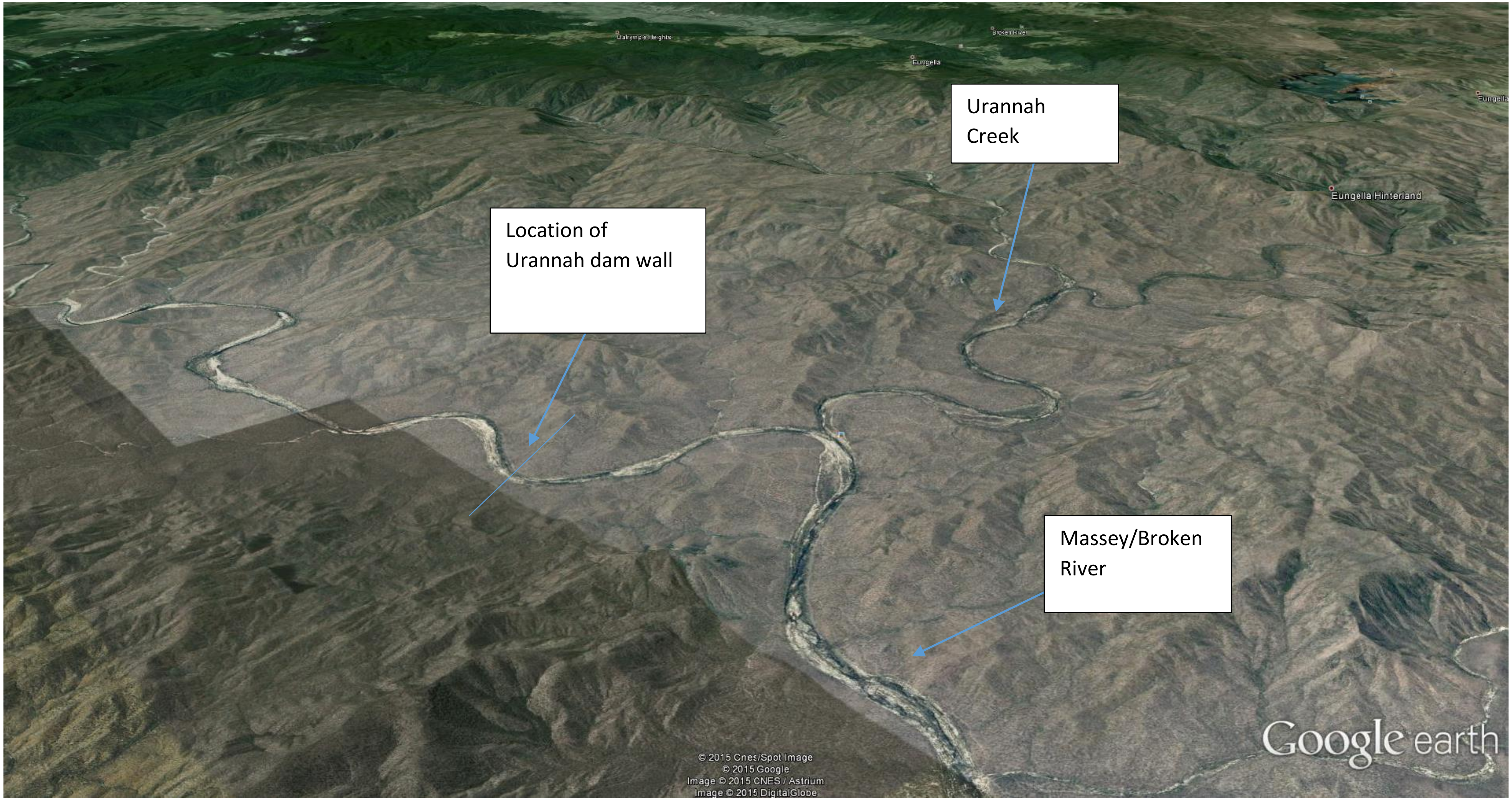


Figure 5: Google Earth image of dam location

13.13. Flow diagram of the resource input and output

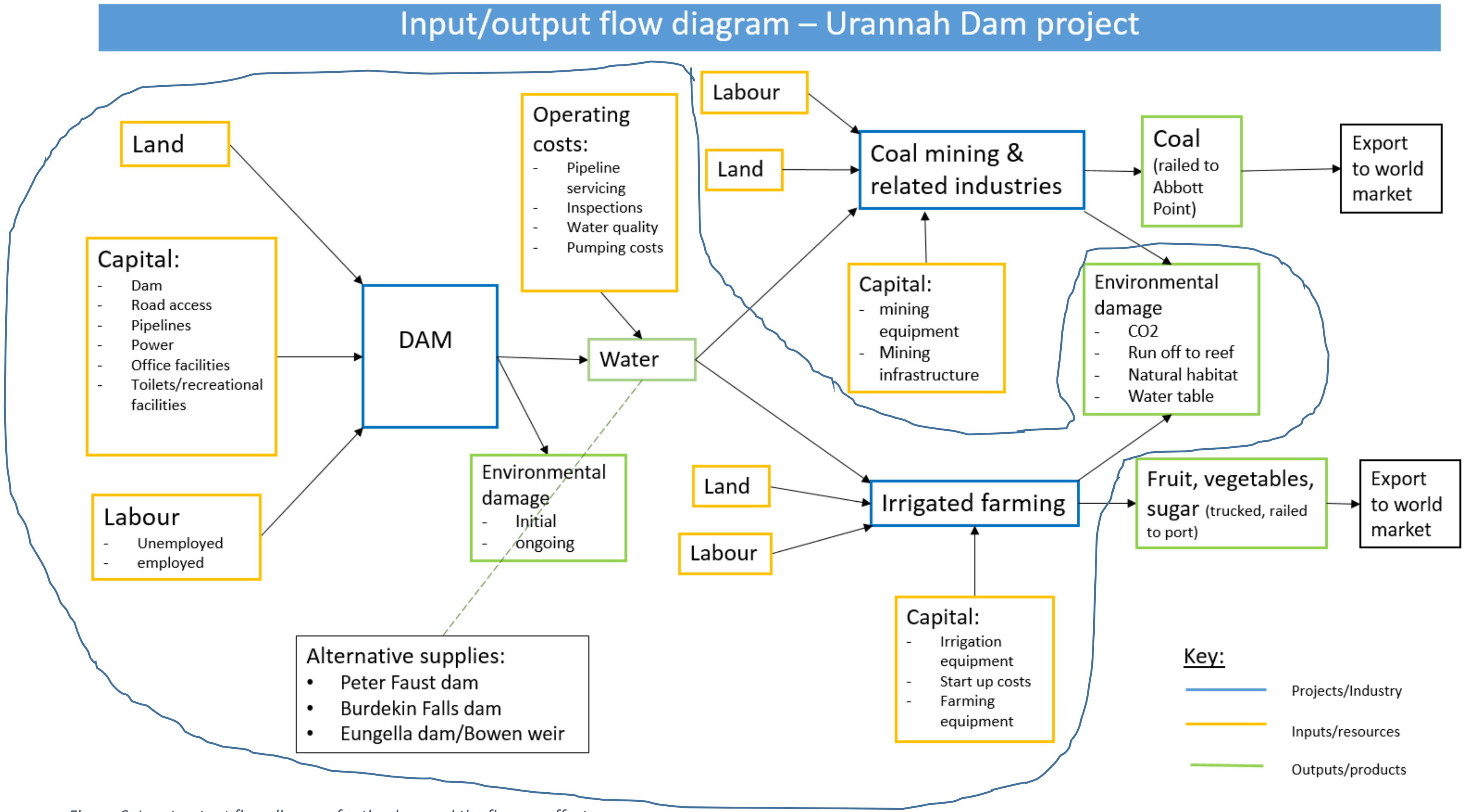


Figure 6: Input output flow diagram for the dam and the flow on effects

13.14. Project costs and benefits flow diagram

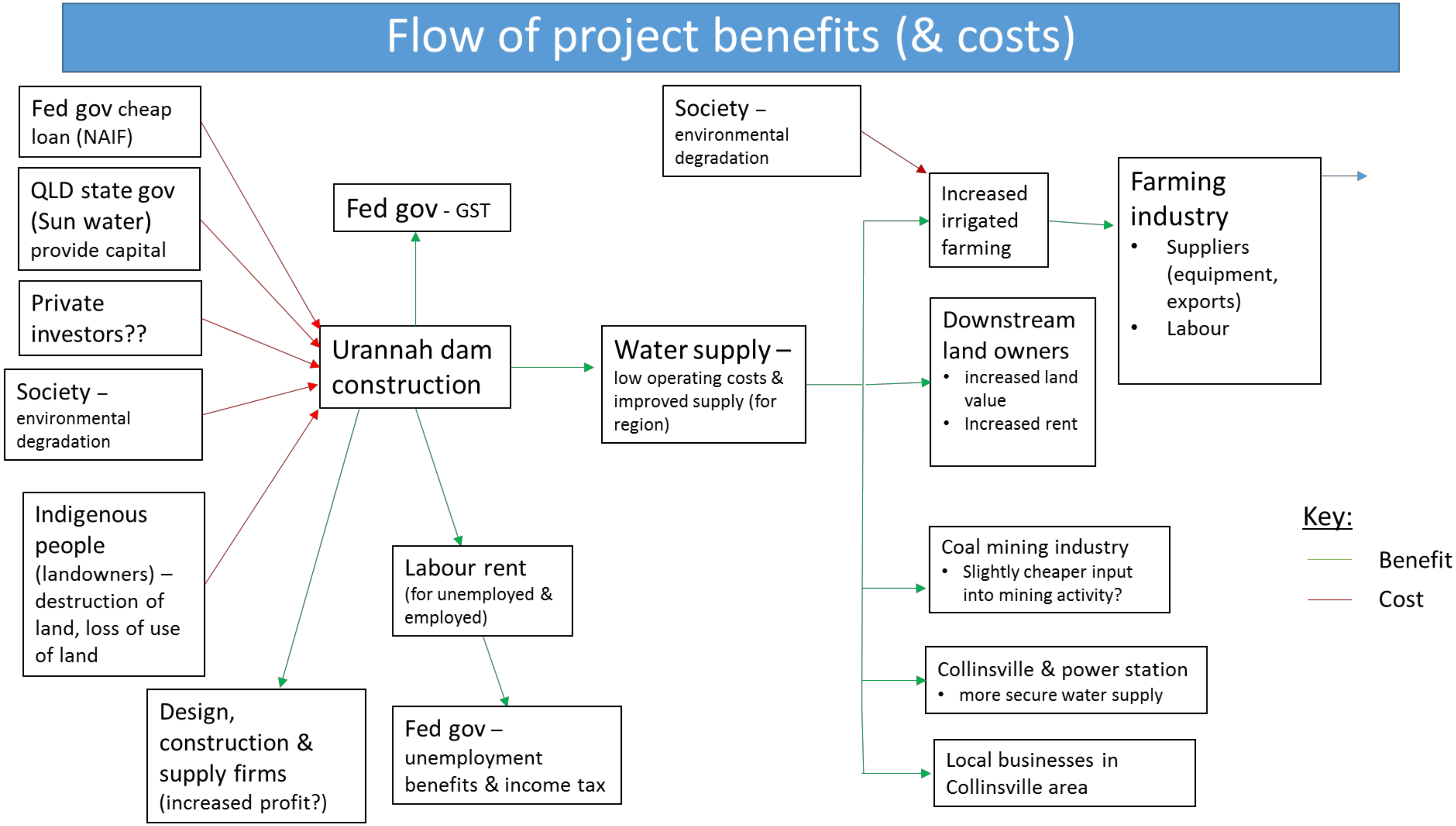


Figure 7: Diagrammatic representation of the costs and benefits

13.15. Maps

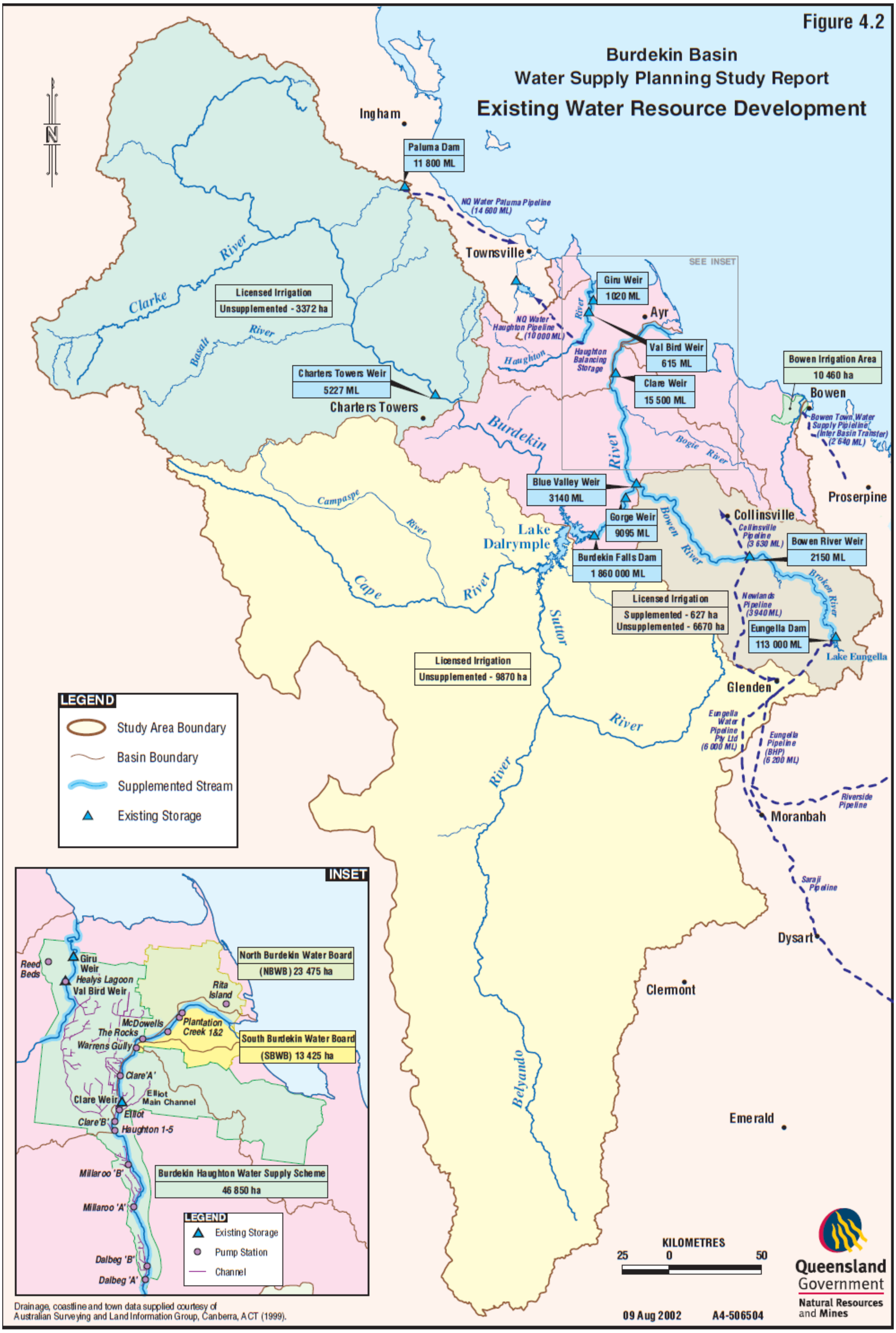


Figure 4.2
Burdekin Basin
Water Supply Planning Study Report
Existing Water Resource Development
N
Ingham
Paluma Dam
11 800 ML
NQ Water Paluma Pipeline
(14 600 ML)
Townsville
SEE INSET
Giru Weir
1020 ML
Ayr
NQ Water
Haughton Pipeline
(10 000 ML)
Haughton
Haughton Balancing Storage
Val Bird Weir
615 ML
Clare Weir
15 500 ML
Bowen Irrigation Area
10 460 ha
Bowen
Bowen Town Water Supply Pipeline (Inter Basin Transfer) (2 640 ML)
Proserpine
Clarke
River
Licensed Irrigation
Unsupplemented - 3372 ha
Basalt
Charters Towers Weir
5227 ML
Charters Towers
Burdekin
River
Bogie
Blue Valley Weir
3140 ML
Gorge Weir
9095 ML
Bowen
Collinsville
Collinsville Pipeline (3 630 ML)
Bowen River Weir
2150 ML
Campaspe
Lake
Dalrymple
Burdekin Falls Dam
1 860 000 ML
Cape
Licensed Irrigation
Supplemented - 627 ha
Unsupplemented - 6670 ha
Newlands Pipeline (3 940 ML)
Broken River
Eungella Dam
113 000 ML
Lake Eungella
Suttor
Licensed Irrigation
Unsupplemented - 9870 ha
Glenden
Eungella Water Pipeline Pty Ltd (6 000 ML)
Eungella Pipeline (BHP) (6 200 ML)
Riverside Pipeline
Moranbah
Saraji Pipeline
Dysart
Clermont
Belyando
Emerald
LEGEND
Study Area Boundary
Basin Boundary
Supplemented Stream
Existing Storage
INSET
Reed Beds
Giru Weir
Healys Lagoon
Val Bird Weir
North Burdekin Water Board
(NBWB) 23 475 ha
Rita Island
McDowells
The Rocks
Warrens Gully
Plantation Creek 1&2
South Burdekin Water Board
(SBWB) 13 425 ha
Clare 'A'
Elliot Main Channel
Clare Weir
Elliot
Clare 'B'
Haughton 1-5
Millaroo 'B'
Burdekin Haughton Water Supply Scheme
46 850 ha
Millaroo 'A'
LEGEND
Existing Storage
Pump Station
Channel
Dalbeg 'B'
Dalbeg 'A'
KILOMETRES
25 0 50
Queensland Government
Natural Resources and Mines
Drainage, coastline and town data supplied courtesy of Australian Surveying and Land Information Group, Canberra, ACT (1999).
09 Aug 2002
A4-506504

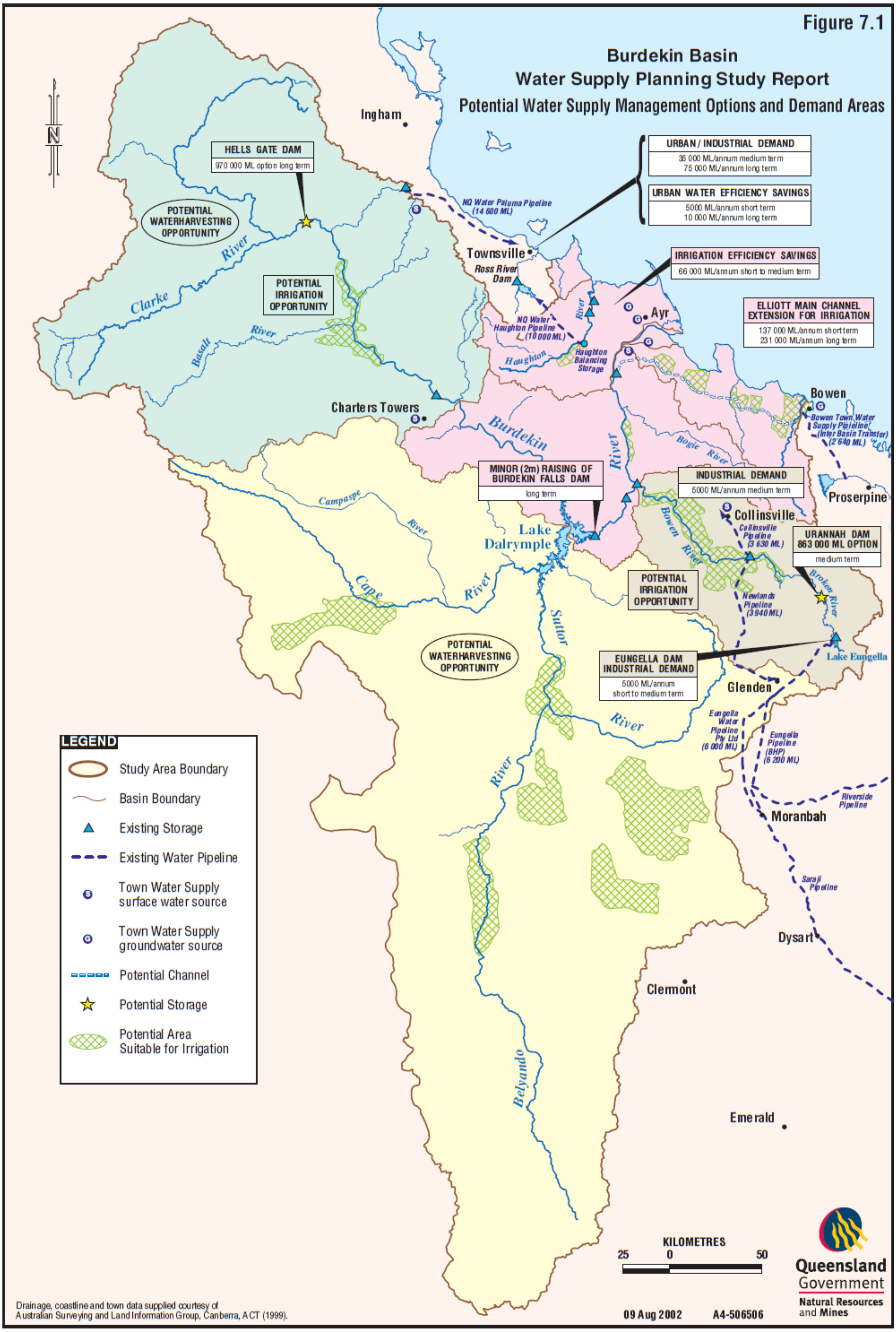


Figure 7.1
Burdekin Basin
Water Supply Planning Study Report
Potential Water Supply Management Options and Demand Areas
N
Ingham
HELLS GATE DAM
970 000 ML option long term
POTENTIAL WATERHARVESTING OPPORTUNITY
Clarke River
Basalt River
POTENTIAL IRRIGATION OPPORTUNITY
NQ Water Paluma Pipeline (14 600 ML)
URBAN / INDUSTRIAL DEMAND
35 000 ML/annum medium term
75 000 ML/annum long term
URBAN WATER EFFICIENCY SAVINGS
5000 ML/annum short term
10 000 ML/annum long term
Townsville
Ross River Dam
IRRIGATION EFFICIENCY SAVINGS
66 000 ML/annum short to medium term
Ayr
NQ Water Haughton Pipeline (10 000 ML)
Haughton
Haughton Balancing Storage
ELLIOTT MAIN CHANNEL EXTENSION FOR IRRIGATION
137 000 ML/annum short term
231 000 ML/annum long term
Charters Towers
Burdekin River
Bogie River
Bowen
Bowen Town Water Supply Pipeline (Inter Basin Transfer) (2 640 ML)
Proserpine
MINOR (2m) RAISING OF BURDEKIN FALLS DAM
long term
INDUSTRIAL DEMAND
5000 ML/annum medium term
Campaspe River
Lake Dalrymple
Collinsville
Collinsville Pipeline (3 630 ML)
URANNAH DAM 863 000 ML OPTION
medium term
Bowen River
Broken River
Cape River
POTENTIAL IRRIGATION OPPORTUNITY
Newlands Pipeline (3 940 ML)
Suttor River
POTENTIAL WATERHARVESTING OPPORTUNITY
EUNGELLA DAM INDUSTRIAL DEMAND
5000 ML/annum short to medium term
Lake Eungella
Glenden
Eungella Water Pipeline Pty Ltd (6 000 ML)
Eungella Pipeline (BHP) (6 200 ML)
Riverside Pipeline
Moranbah
Saraji Pipeline
Dysart
Clermont
Belyando River
Emerald
LEGEND
Study Area Boundary
Basin Boundary
Existing Storage
Existing Water Pipeline
Town Water Supply surface water source
Town Water Supply groundwater source
Potential Channel
Potential Storage
Potential Area Suitable for Irrigation
KILOMETRES
25 0 50
Drainage, coastline and town data supplied courtesy of Australian Surveying and Land Information Group, Canberra, ACT (1999).
09 Aug 2002
A4-506506
Queensland Government
Natural Resources and Mines

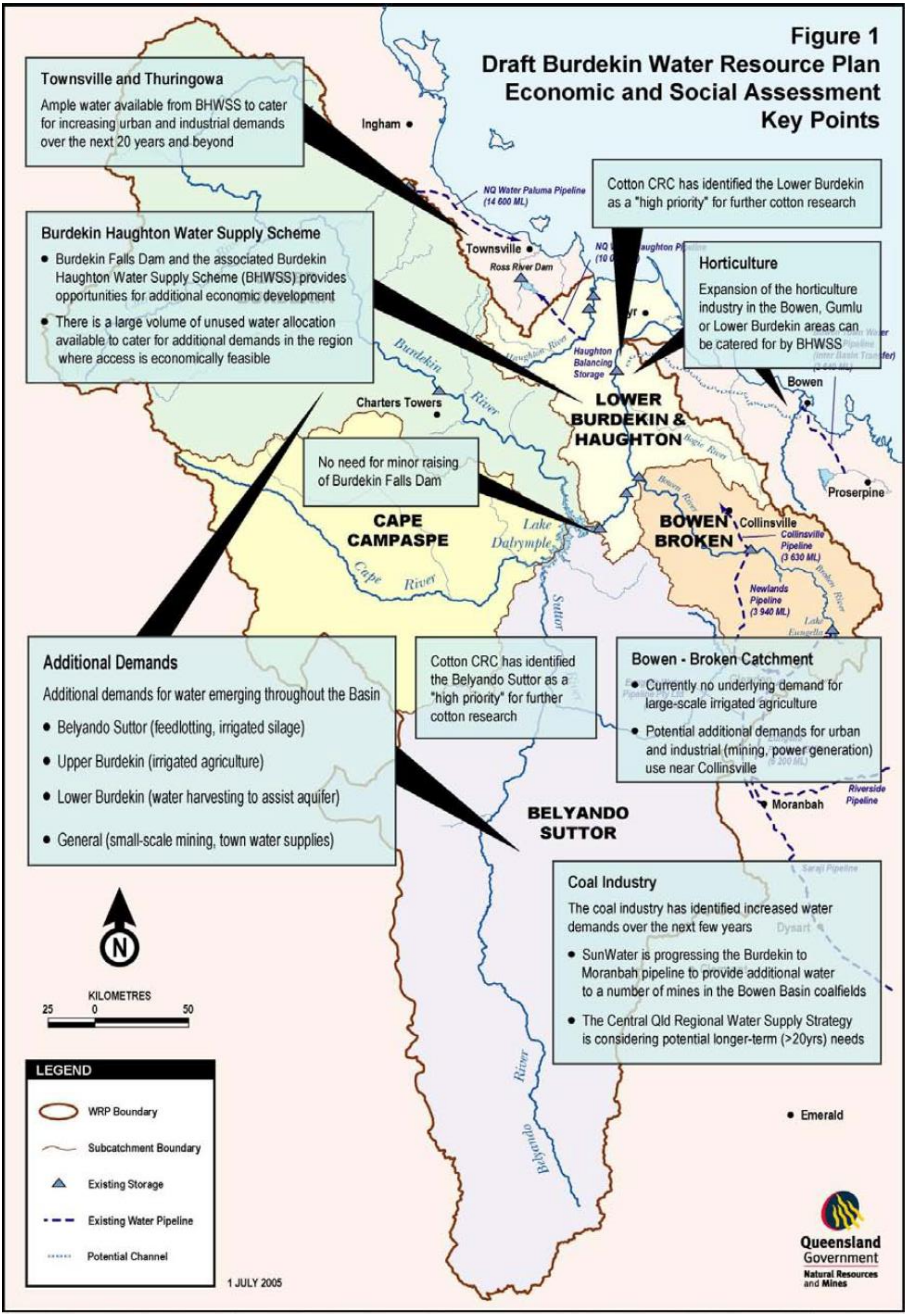


Figure 1
Draft Burdekin Water Resource Plan
Economic and Social Assessment
Key Points
Townsville and Thuringowa
Ample water available from BHWSS to cater for increasing urban and industrial demands over the next 20 years and beyond
Burdekin Haughton Water Supply Scheme
• Burdekin Falls Dam and the associated Burdekin Haughton Water Supply Scheme (BHWSS) provides opportunities for additional economic development
• There is a large volume of unused water allocation available to cater for additional demands in the region where access is economically feasible
Cotton CRC has identified the Lower Burdekin as a "high priority" for further cotton research
Horticulture
Expansion of the horticulture industry in the Bowen, Gumlu or Lower Burdekin areas can be catered for by BHWSS
No need for minor raising of Burdekin Falls Dam
Additional Demands
Additional demands for water emerging throughout the Basin
• Belyando Suttor (feedlotting, irrigated silage)
• Upper Burdekin (irrigated agriculture)
• Lower Burdekin (water harvesting to assist aquifer)
• General (small-scale mining, town water supplies)
Cotton CRC has identified the Belyando Suttor as a "high priority" for further cotton research
Bowen - Broken Catchment
• Currently no underlying demand for large-scale irrigated agriculture
• Potential additional demands for urban and industrial (mining, power generation) use near Collinsville
Coal Industry
The coal industry has identified increased water demands over the next few years
• SunWater is progressing the Burdekin to Moranbah pipeline to provide additional water to a number of mines in the Bowen Basin coalfields
• The Central Qld Regional Water Supply Strategy is considering potential longer-term (>20yrs) needs
Ingham
NQ Water Paluma Pipeline
(14 600 ML)
Townsville
Ross River Dam
Haughton Balancing Storage
Bowen
Charters Towers
LOWER BURDEKIN & HAUGHTON
Proserpine
CAPE CAMPASPE
Lake Dalrymple
Cape River
Burdekin River
Haughton River
Bogie River
Bowen River
BOWEN BROKEN
Collinsville
Collinsville Pipeline
(3 630 ML)
Newlands Pipeline
(3 940 ML)
Broken River
Lake Eungella
Suttor
Moranbah
Riverside Pipeline
BELYANDO SUTTOR
Saraji Pipeline
Dysart
Emerald
Belyando River
KILOMETRES
25
0
50
LEGEND
WRP Boundary
Subcatchment Boundary
Existing Storage
Existing Water Pipeline
Potential Channel
1 JULY 2005
Queensland Government
Natural Resources and Mines

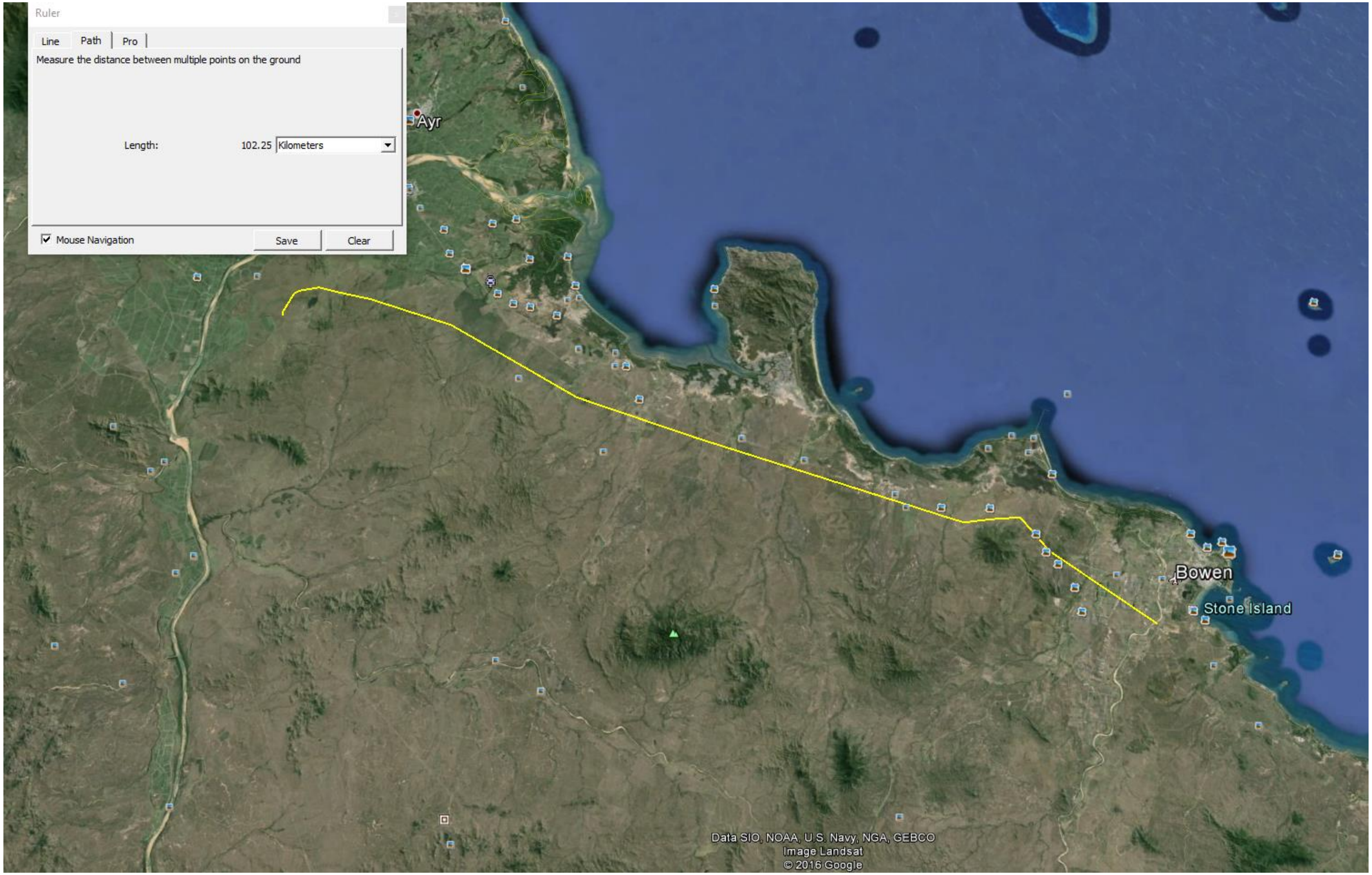


Figure 8: Elliot main channel to Bowen

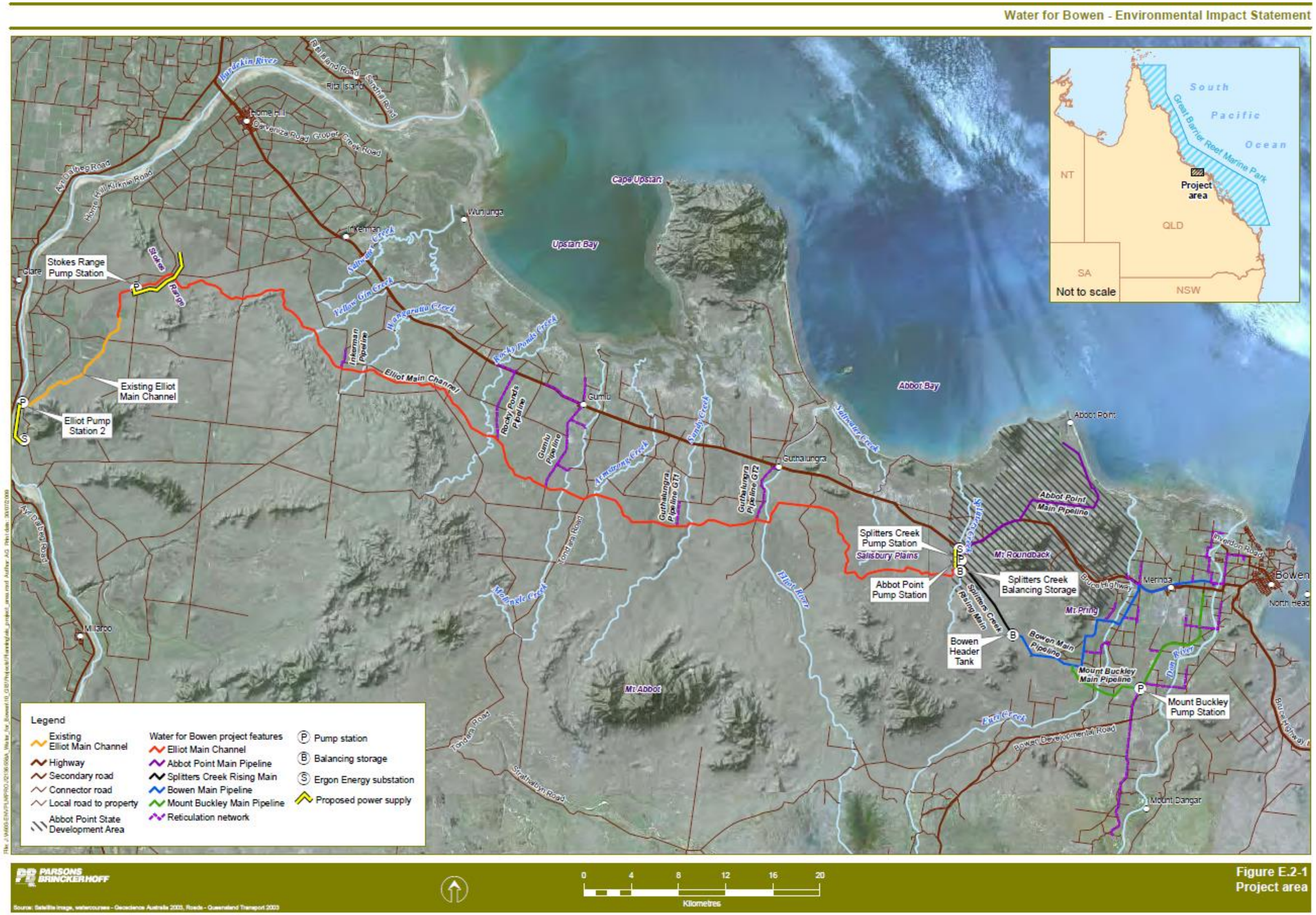


Figure 9: Water for Bowen project route

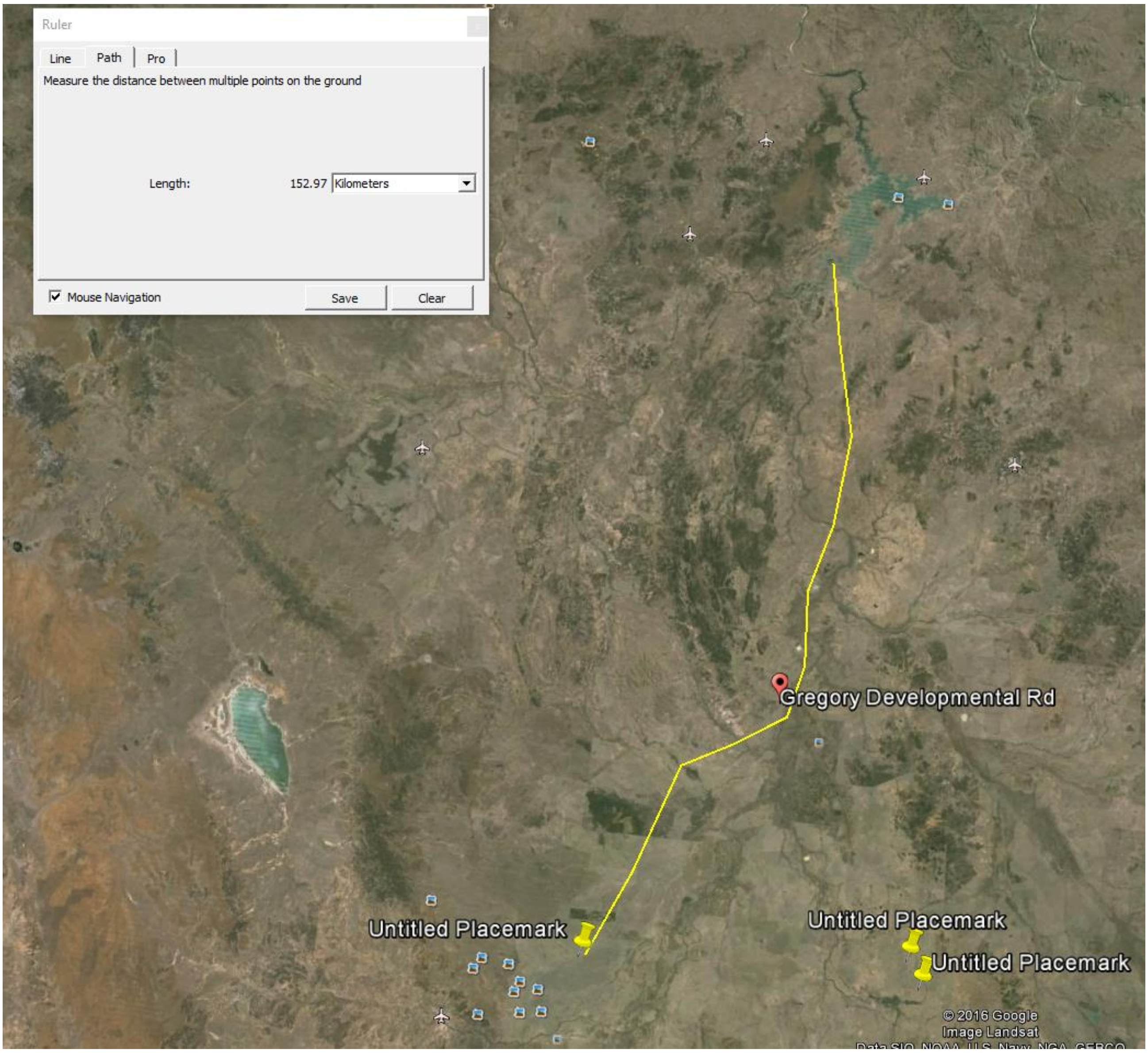


Figure 10: BFD to Carmichael mine (Northern Galilee basin)

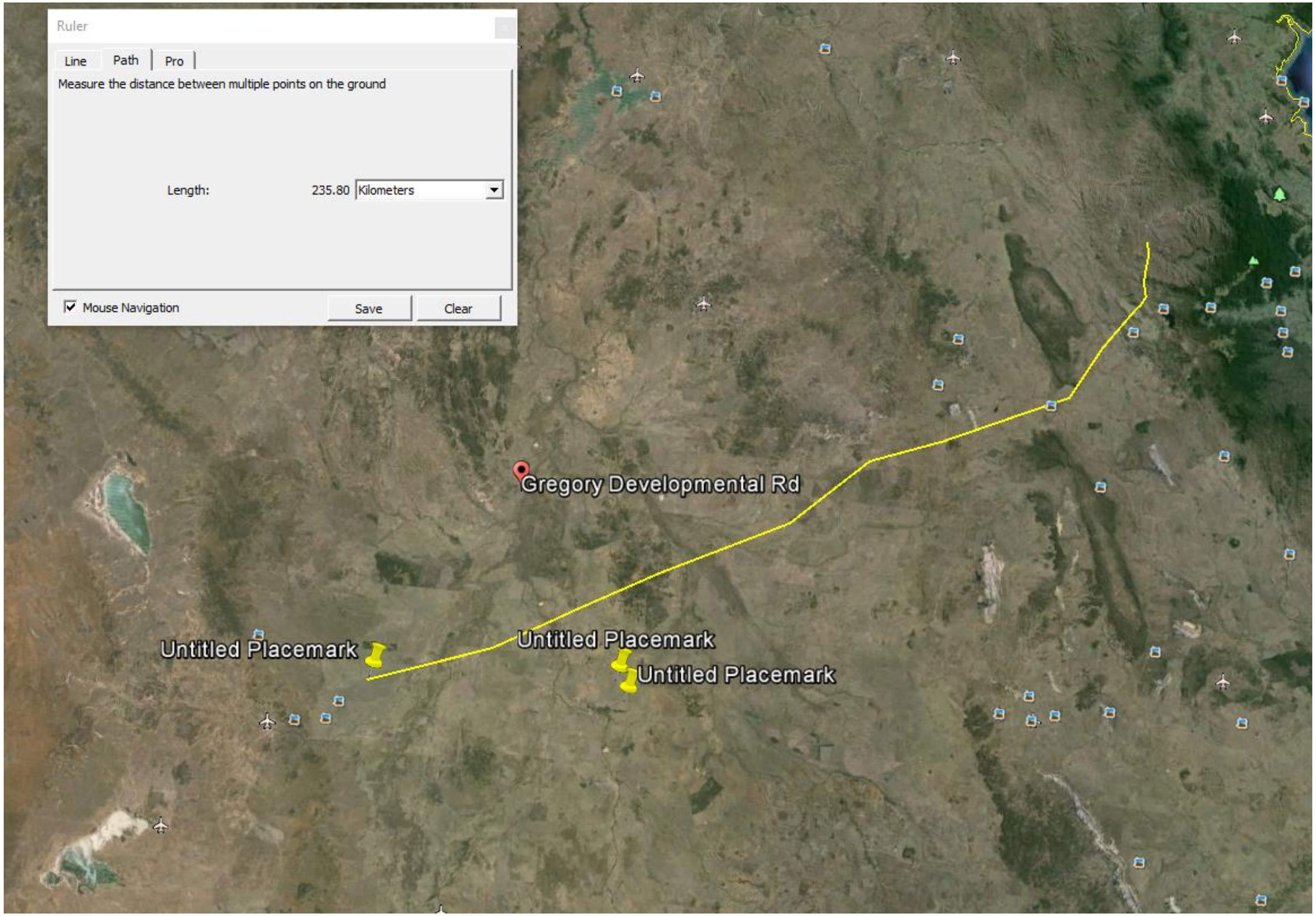


Figure 11: Urannah dam to Carmichael mine (northern Galilee basin)

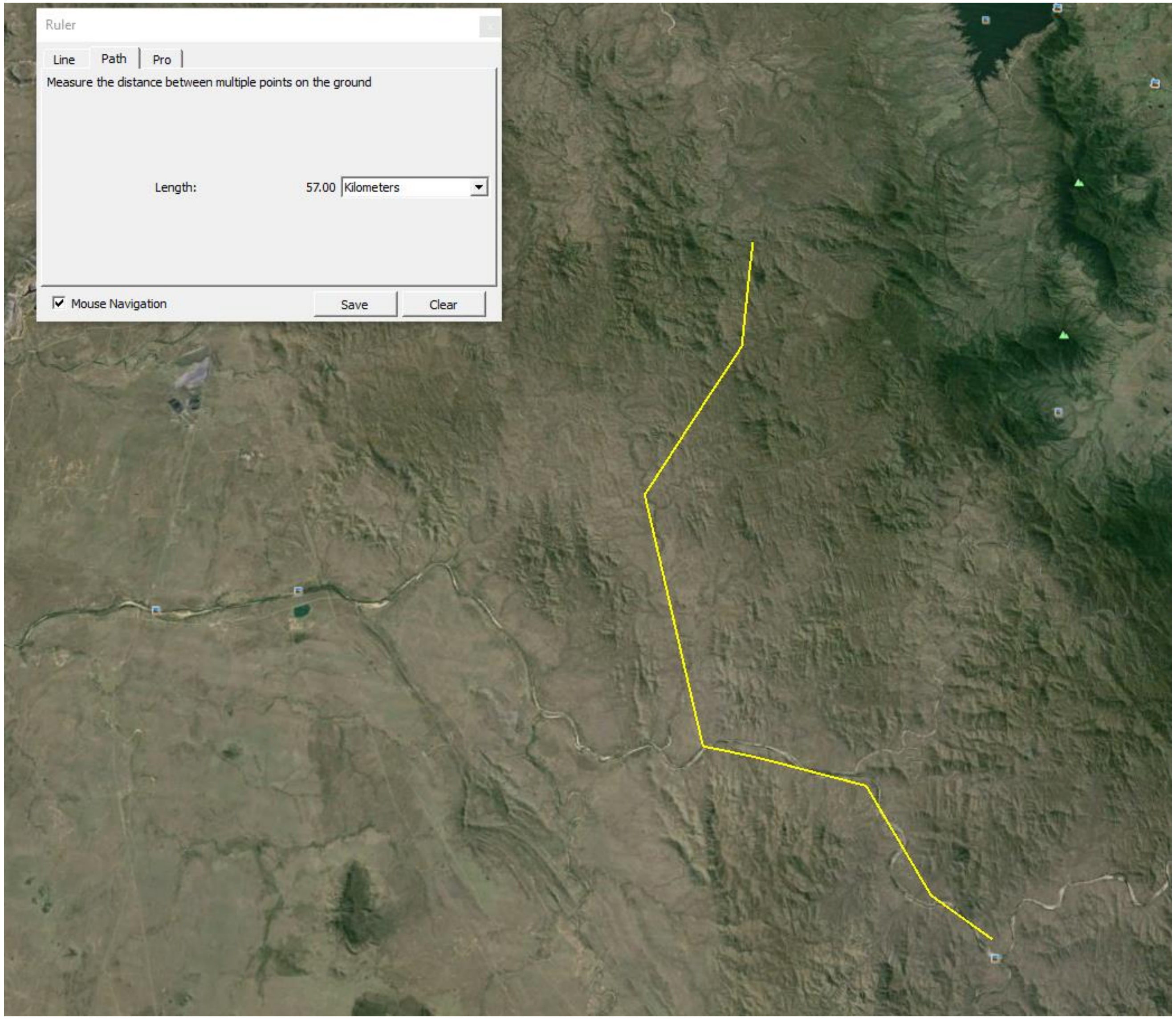


Figure 12: Urannah dam to head of Don River

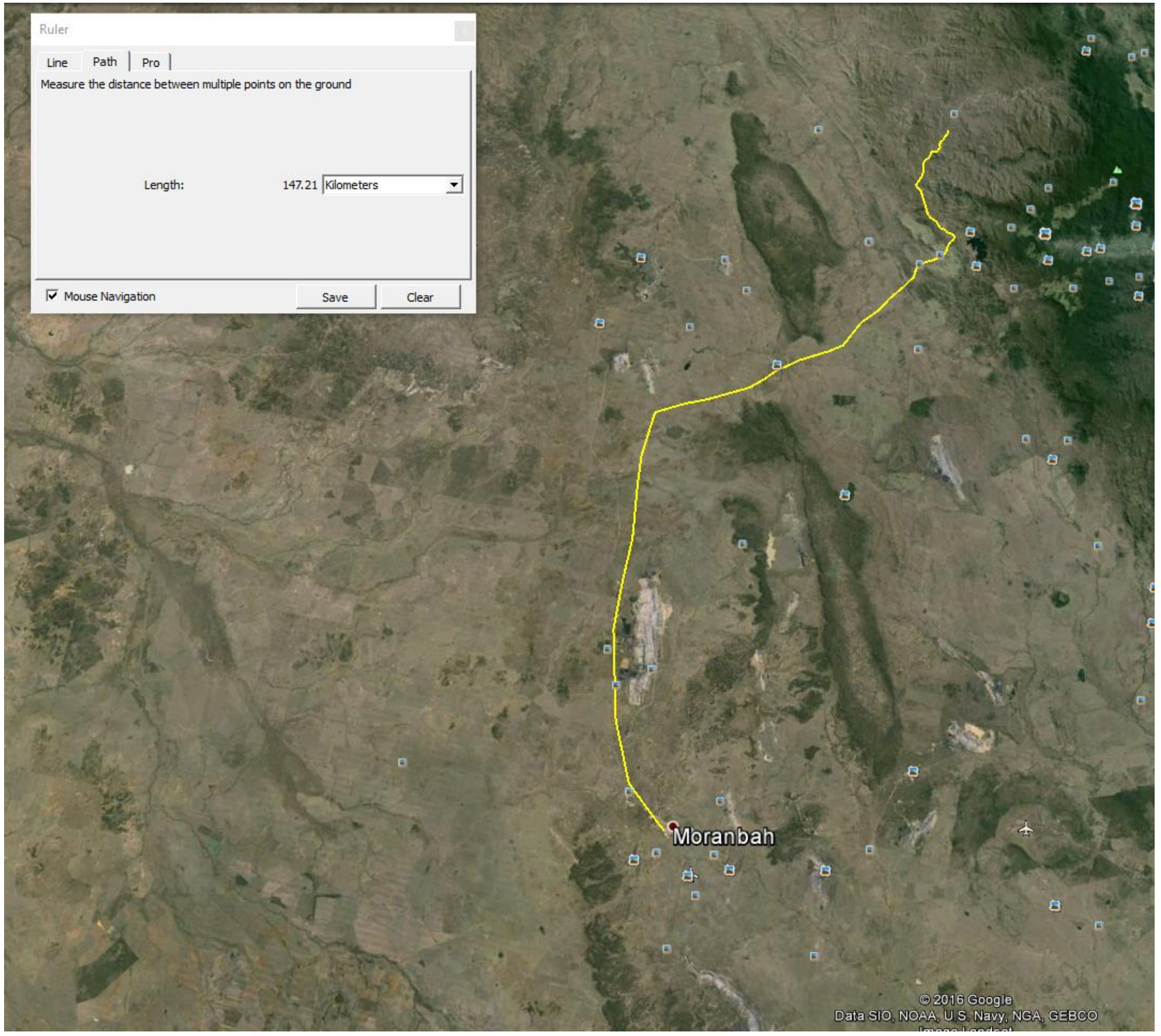


Figure 13: Urannah dam to Moranbah (via Eungella dam)

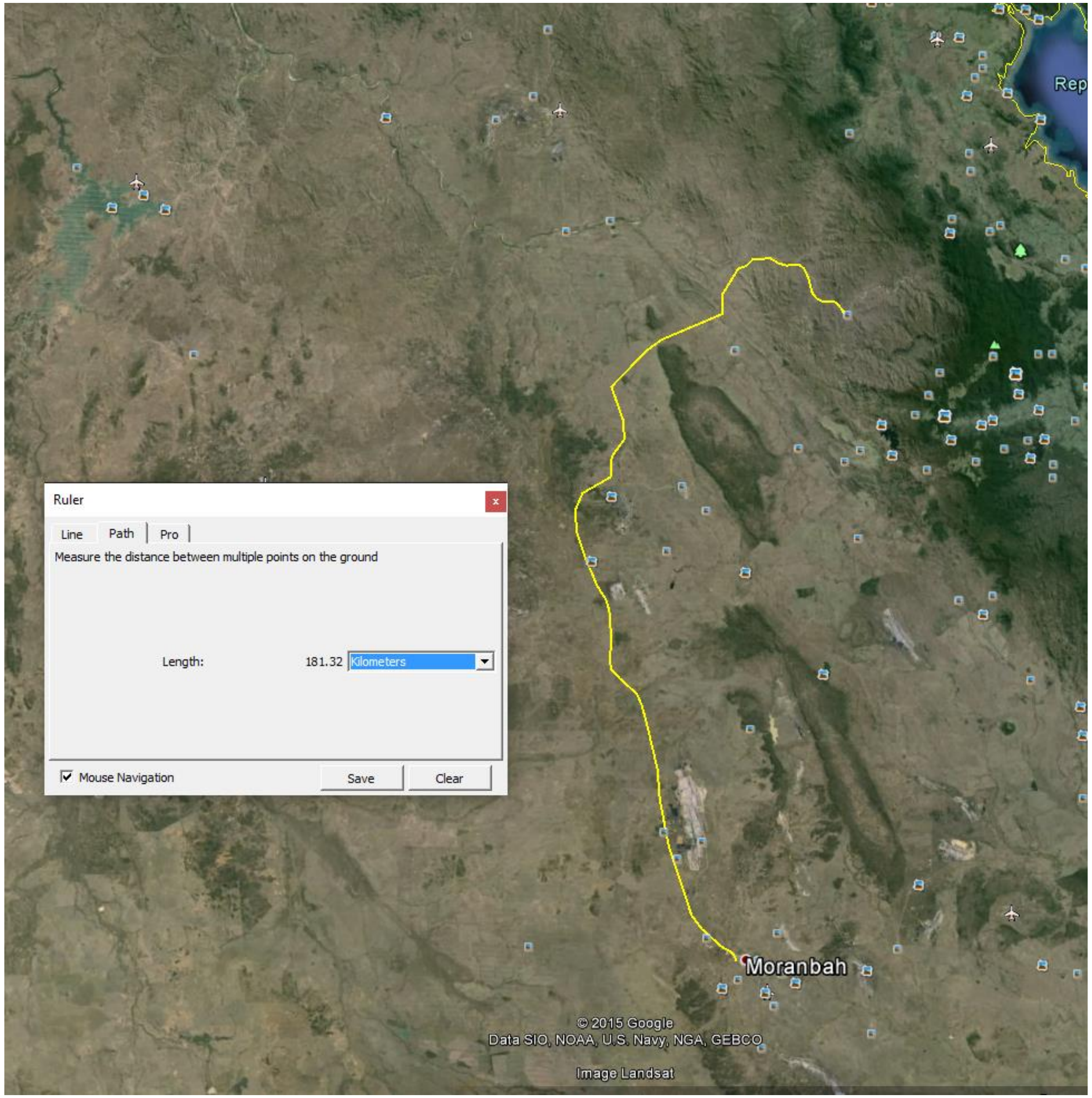


Figure 14: Urannah dam to Moranbah (via downstream Broken river)